Review of Palaeobotany and Palynology 241 (2017) 70–84

Contents lists available at ScienceDirect

Review of Palaeobotany and Palynology

journal homepage: www.elsevier.com/locate/revpalbo

Research papers

Medulloprotaxodioxylon triassicum gen. et sp. nov., a taxodiaceous conifer wood from the Norian (Triassic) of northern Bogda Mountains, northwestern China

Mingli Wan [a,b,c], Wan Yang [c,d], Peng Tang [b], Lujun Liu [a,b], Jun Wang [a,b,*]

[a] Department of Palaeobotany and Palynology, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
[b] State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China and University of Chinese Academy of Sciences, Beijing 100049, China
[c] Geology and Geophysics Program, Missouri University of Science and Technology, Rolla, MO 65409, USA
[d] Key Laboratory of Petroleum Resources Research, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

ARTICLE INFO

Article history:
Received 7 September 2016
Received in revised form 13 February 2017
Accepted 14 February 2017
Available online 24 February 2017

Keywords:
Fossil wood
Medulloprotaxodioxylon triassicum gen. et sp. nov.
Taxonomy
Triassic
Xinjiang

ABSTRACT

A permineralized coniferous wood, *Medulloprotaxodioxylon triassicum* Wan, Yang, Tang, Liu et Wang gen. et sp. nov., is described from the Norian (Late Triassic) Huangshanjie Formation in the Dalongkou Section, Jimsar County, Xinjiang Uygur Autonomous Region, northwestern China. The fossil wood is composed of the pith, primary and secondary xylem. The pith is solid, circular, heterocellular, with numerous isolated or clustered secretory cells, and parenchyma. Secretory cells commonly form a network in a radial view. The pith is surrounded by numerous primary xylem strands and about 22 distinctive leaf traces. The primary xylem is endarch. Tracheids of primary xylem have helical and scalariform thickenings. The secondary xylem is pycnoxylic, composed of tracheids, rays and axial parenchyma. The general aspect of the tracheids and rays, presence of taxodioid cross-field pits, and abundant axial parenchyma, indicate *M. triassicum* can be related to the taxodiaceous Cupressaceae sensu lato. By comparison with fossil and extant species of the Cupressaceae, *M. triassicum* is most comparable to *Sequoiadendron giganteum* (Lindley) Buchholz. It is hypothesized that *M. triassicum* represents an ancestral form of the Sequoioideae Saxton based on the anatomical characteristics of the pith and secondary xylem. The occurrence of *M. triassicum* would indicate that the taxodiaceous conifers had already individualized within the Cupressaceae during the Late Triassic.

1. Introduction

Systematic studies on fossil woods are improving the knowledge of the composition of past vegetation (Yang et al., 2013). The Mesozoic is an important time interval for the diversification and radiation of woody plants (Wang et al., 2009; Yang et al., 2013). However, in most cases, only the secondary xylem of Mesozoic woods is preserved (Zheng et al., 2008). The pith structure has been proven as a valuable additional criterion in the identification of species and genera of conifers (Kräusel, 1928; Doyle and Doyle, 1948). Relatively few fossil woody axes with a preserved pith, primary and secondary xylem have been described from the Mesozoic of China (Vozenin-Serra and Pons, 1990; Cui and Liu, 1992; Duan, 2000; Zhang et al., 2000; Jiang et al., 2012; Shi et al., 2015).

Fossil woods with taxodioid cross-field pits, abundant axial parenchyma, and abietinean or a mixture of abietinean and araucarian radial tracheidal pitting are attributed to a group of fossil conifers (Yang and Zheng, 2003; Zheng et al., 2008), of which the wood is thought to be similar to that of extant taxodiaceous Cupressaceae sensu Farjon (2005), including the former Taxodiaceae without *Sciadopitys* Siebold et Zuccarini. Taxodiaceous and Taxodiaceae-like woods have mainly been identified from Jurassic to Cenozoic deposits (e.g., Philippe, 1994; Yang and Zheng, 2003; Vozenin-Serra et al., 2011; Yi et al., 2013). So far, in China no fossil wood of this group older than Jurassic has been found. Worldwide, only few taxodiaceous woods with both the pith and primary xylem preserved have been described from the Mesozoic (Page, 1973; Meijer, 2000).

In this contribution, we describe fossil wood with taxodiaceous secondary xylem with a pith and primary xylem from the Norian (Late Triassic) of the Dalongkou Section, northern Bogda Mountains, Xinjiang Uygur Autonomous Region, northwestern China. Our specimens are the first evidence of taxodiaceous fossil wood from the Triassic. Comparisons with extant taxodiaceous Cupressaceae sensu Farjon (2005) show that our fossil wood is similar to the species of the extant

* Corresponding author at: Department of Palaeobotany and Palynology, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China.
E-mail address: jun.wang@nigpas.ac.cn (J. Wang).

http://dx.doi.org/10.1016/j.revpalbo.2017.02.009
0034-6667/

Sequoioideae, especially *Sequoiadendron giganteum* (Lindley) Buchholz that shows this combination of secondary xylem and pith structure. It is hypothesized that the fossil wood from the Norian of Xinjiang represents an ancestral form of taxodiaceous conifers that, had already evolved within the Cupressaceae during the Late Triassic.

2. Geological setting, material and methods

Several permineralized fossil woods were collected from two sandstone beds in the Huangshanjie Formation in the Dalongkou Section, which were deposited in the southern Junggar Basin and, at the present, are exposed in northern Bogda Mountains, Xinjiang Uygur Autonomous Region, northwestern China (Fig. 1A, B). Mesozoic non-marine deposits are well exposed in the research area, with abundant plant and animal remains (e.g., Zhou and Zhou, 1986; BGMRX, 1993; Deng et al., 2000; Sun et al., 2010). Palaeophytogeographically, the Late Triassic flora from the Junggar Basin belongs to the "Northern China Flora" (*Danaeopsis-Bernoullia* Flora; Zhou and Zhou, 1986; Sun et al., 2010). Plant fossils from the Huangshanjie Formation in the Dalongkou Section were briefly reported (Zhou and Zhou, 1986). However, few fossil woods with well-preserved anatomical characteristics were studied in detail (Shi et al., 2015; Wan et al., 2016b).

The palaeolatitude of the Junggar Basin for the Triassic-Jurassic was approximately 60° N (Fig. 1C), constrained by recent palaeomagnetic data (Choulet et al., 2013; Sha et al., 2015). Generally in the Late Triassic, Junggar Basin had warm and humid climates according to the macrofossil (Sun et al., 2001, 2010) and palynological data (Yin, 1994; Liu, 2001; Ashraf et al., 2004, 2010), which is consistent with that of many early Mesozoic Northern Hemisphere high-latitude sedimentary basins (Ashraf et al., 2004).

In the Dalongkou Section, the Huangshanjie Formation conformably overlies the Anisian to Carnian Karamay Formation and conformably underlies the Rhaetian Haojiagou Formation (Fig. 1D; Li et al., 1986; BGMXR, 1993; Shi et al., 2014b). The Huangshanjie Formation is composed of gray, grayish-green, and dark gray sand- and mudstones, with a thick carbonaceous shale at the base that were deposited in a lacustrine environment (Li et al., 1986; BGMRX, 1993; Wu et al., 2002). The age of the Huangshanjie Formation in the southern Junggar Basin is considered to be Norian (Late Triassic) on the basis of palynological (Ashraf et al., 2010), palaeobotanical (Sun et al., 2010), and palaeozoological data (BGMRX, 1993; Chen, 1995).

In this study, for the description and discussion of anatomical features of the fossil wood, the terminology of IAWA Committee (2004) and Philippe and Bamford (2008) is used.

A thin-section microscopic study of the wood indicates that it is well silicified. Large specimens were photographed with a Nikon D800 digital single-lens reflex camera. Images were taken using a Leica DM5000 compound microscope and Leica DC 500 digital microscope camera system. The fossil wood (PB22277) and the slides (PB22277-1 to PB22277-8) are stored in the Palaeobotanical Collection of the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences.

3. Systematics

Fossil-Coniferopsida

Genus *Medulloprotaxodioxylon* Wan, Yang, Tang, Liu et Wang gen. nov.

Type species: *Medulloprotaxodioxylon triassicum* Wan, Yang, Tang, Liu et Wang sp. nov.

Generic diagnosis: Fossil wood with pith, primary and secondary xylem. Eustele consisting of numerous discrete xylem strands and leaf traces arising at the periphery of the pith. Pith solid, heterocellular, with a number of secretory cells. Primary xylem strands endarch. Secondary xylem pycnoxylic; tracheids commonly with uni- to multiseriate bordered pits arranged alternately or oppositely, contiguous or separated. Cross-field pits taxodioid. Rays commonly uniseriate, parenchymatous. Isolated or vertically aligned axial parenchyma cells present. Leaf trace mesarch, diverging from pith margin as single bundle.

Etymology: The generic epithet indicates that the fossil wood is composed of the pith and *Protaxodioxylon* type secondary xylem.

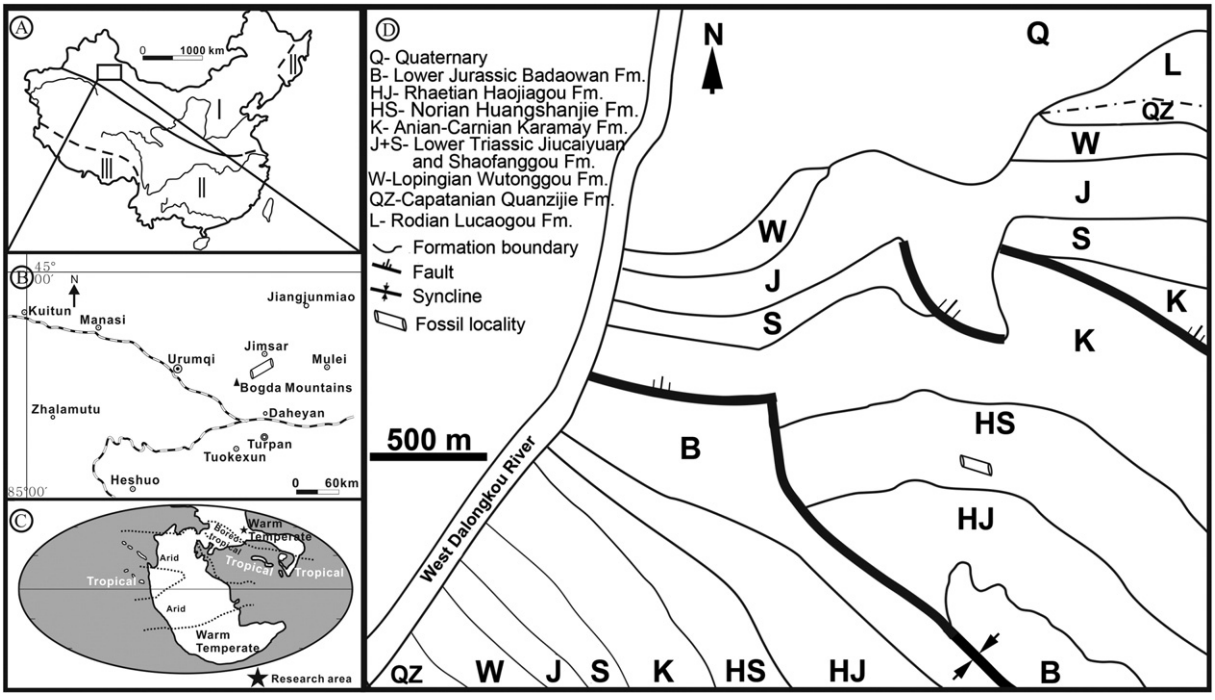

Fig. 1. A and B. Maps showing the location of study area. The Late Triassic phytogeoprovince map (A) is modified after Sun et al. (1995). I – Northern China Flora Province; II – Southern China Flora Province; III – Yarlung Zangbo River Province. The collection site is shown by the wood stem symbol in (B), which is in the Late Triassic Northern China phytoprovince (Zhou and Zhou, 1986; Sun et al., 1995). C. Palaeogeographic map during the Late Triassic showing the fossil site (star) at the high-latitude NE Pangaea (Boucot et al., 2013; Choulet et al., 2013; Sha et al., 2015). D. Geological map of the Dalongkou area showing the fossil collection site (wood stem symbol).