The first definitely record of Dicroidium Gothan (seed fern) in China

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Abstract

Dicroidium is a widely distributed seed ferns in the Triassic floras of Gondwana, exhibiting considerable variation in leaf morphology with forked rachises being a key characteristic (Anderson and Anderson, 2003). *Dicroidium* was considered as a Gondwana plant distributed in the Triassic until Abu Hamad et al. (2008) found some specimens from the late Permian sediments of the Jordan, which is located in the northern edge of the Gondwana (Blomenkemper et al., 2022). However, this genus has never been unequivocal recorded in the Laurasia. Recently, a new species of this genus, *Dicroidium sinensis* Sun et Deng sp. nov., described from the Middle Triassic Tongchuan Formation in the Ordos Basin of Northwestern China based on macromorphology and cuticular structures. This is the first definite record of *Dicroidium* in China, indicating that this genus is not only unique to Gondwana. Our specimens exhibit large fronds, a robust primary axis, and a dichotomously furcated rachis, as well as an amphistomatic cuticle, absent papilla, haplocheilic stomata, and polar subsidiary cells. We assigned these specimens to *Dicroidium* based on the simple dichotomous bifurcation of the rachis, a key diagnostic feature for the genus (Anderson et al., 2019), and micromorphological similarities to other *Dicroidium* species (Bomfleur and Kerp, 2010). Our specimens differ considerably from all the known Gondwana species in leaf morphology and microstructures of cuticles, and therefore, a new species, *Dicroidium sinensis* Sun et Deng sp. nov. is proposed.

Up to now, as the oldest unequivocal representatives of *Dicroidium* appeared in the Late Permian of Dead Sea region-Jordan, the genus seems to have originated in the palaeotropics and later migrated southward and northward. During the Olenekian age of Early Triassic, it was distributed in the Southern Hemisphere such as Australia, South Africa and Antarctica. During the Middle Triassic, the genus occurred in both the Gondwana and Laurasia. After then, during the Late Triassic, *Dicroidium* was suggested only in the Gondwana, and it was the dominant genus of the Gondwana floras. Recent reports of some *Dicroidium* from the Lower Jurassic of the Antarctica indicates that it survived the end-Triassic mass-extinction event (Rees and Cleal, 2004; Bomfleur et al. 2018). As no any fossil remains have been found from the Middle Jurassic and younger sediments so far, this genus might disappear in the Early Jurassic (Bomfleur et al. 2018). How did a genus flourishing in the Triassic Gondwana floras appear in the Laurasia? We suppose that Pangea was present from Permian to

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Triassic, making it possible for the South *Dicroidium* to migrate the Laurasia. The genus *Dicroidium* thrived in warm and humid environments, and the climate of the Ordos Basin in the Middle Triassic was warm and humid, providing suitable conditions for Dicroidium to grow. Some circular to slightly elliptical galls found in the leaf of *Dicroidium sinensis* proved the interaction between plants and insects.

Keywords: Middle, Late Triassi, Seed fern, Dicroidium, Cuticular analysis, Insect galls, North China