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华南晚泥盆世石松植物巢湖小孢穗和葛利普亚鳞木

的小孢子叶球、营养结构及生活习性

孟美岑

合 作 导 师 姚建新（研究员）

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Vegetative Characters, Growth Architecture and Microsporangiate
Strobilus of *Minostrobus Chaohuensis* and *Sublepidodendron grabaui*
(Lycopsida) from the Upper Devonian of South China

博 士 后 姓 名 孟美岑

流动站（一级学科）名称 中国地质科学院地质研究所地质学

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内 容 摘 要

石松类是维管植物较早出现的类群之一，始现于志留纪晚期，在石炭纪多样性达到高峰，以高大乔木为主的广义水韭目成为沼泽森林生态系统的优势类群。分支系统学研究表明，具单性孢子叶球的双孢子叶球亚目是广义水韭目中演化程度最高的类群。该类群起源于晚泥盆世，但化石材料少，研究程度低，影响了对其谱系演化的认识。亚鳞木 *Sublepidodendron* 和小孢穗 *Minostrobus* 是华南晚泥盆世重要的双孢子叶球亚目石松植物，然而，由于化石保存或研究方法的原因，这两个属中某些种的小孢子叶球、营养结构和生活习性等方面的特征仍未得到清楚的认识。

基于安徽巢湖五通组擂鼓台段的巢湖小孢穗 *Minostrobus chaohuensis* 和浙江长兴五通组观山段的葛利普亚鳞木 *Sublepidodendron grabaui* 的新标本，本文运用标本修雕、包埋切片、连续磨片、扫描电镜、酸浸解等方法对这两种植物进行了详细的形态学、解剖学等方面的研究，得到如下主要结果：

Minostrobus chaohuensis 的营养轴等二分枝。主干直径可达 55 mm，具有螺旋排列的叶座。主干和较粗枝具有长纺锤形叶座，间隔带可见纵向纹饰。叶座上可见叶舌穴，倒披针形叶痕以及维管束痕。末级枝宿存有披针形的营养叶，叶基呈菱形。小孢子叶球圆柱形，孢子叶包

括具翅的叶柄和长三角形的叶片。孢子囊具有单层柱状细胞构成的囊壁，内含亚孢原垫。小孢子具赤道环。通过与其他相关广义水韭目植物的比较，限定了叶座、叶基、叶痕、假叶痕等术语的使用范围，确定了 *Minostrobus chaohuensis* 的乔木性状，其多次等二分叉的分枝系统为研究广义水韭目生活习性的演化提供了新的材料。

Sublepidodendron grabau 同时具有等二分叉和假单轴的分枝系统。假单轴分枝的母轴没有次生生长，中柱具髓，枝迹呈不规则螺旋排列。侧枝具实心外始式初生木质部。假单轴分枝可能属于树冠或者是主干侧枝的一部分。小孢子叶球包含 *Lycospora granulata* 类群的小孢子。*Sublepidodendron grabau* 具单性孢子叶球的性状得到确认，进一步支持了将亚鳞木科归入双孢子叶球亚目的分类意见。*Lycospora granulata* 类群的小孢子被证明即可产生于双性孢子叶球也可产生于单性的小孢子叶球。

关键词：华南，晚泥盆世，巢湖小孢穗，葛利普亚鳞木，乔木状石松植物，单性孢子叶球

Abstract

As one of the earlier lineages of vascular plants, the lycopsids appeared in Late Silurian, and attained maximum diversity in the Carboniferous when the Isoëtales *sensu lato* with arborescent habit were the most conspicuous plants of the coal-swamp ecosystem. Heterosporous lycopsids with monosporangiate strobili (Dichostrobiles) are proposed by cladistic analysis to be the most derived clade within the Isoëtales *sensu lato*. This clade had originated from the Late Devonian, but its phylogeny and evolution remain poorly known because of limited material and few studies. *Sublepidodendron* and *Minostrobus* are important dichostrobileans from the Late Devonian of South China. Due to fossil preservation or research methods, however, some species of these two genera were not clear in the microsporangiate strobilus, vegetative axes and growth architecture. New specimens of *Minostrobus chaohuensis* and *Sublepidodendron songziense* were collected from the Leigutai Member, Wutong Formation, Chaohu City, Anhui Province, and Guanshan Member, Wutong Formation, Changxing County, Zhejiang Province, respectively. Based on dégagement, section, serial grinding, SEM observation, acid maceration of specimens and cladistic analysis, the morphology and anatomy of the two species are studied in detail. Main results are as follows:

The vegetative axis of *Minostrobus chaohuensis* is isotomously branched. The stem is up to 55 mm in diameter, with helically arranged

leaf cushions. Stems and thick branches bear long fusiform leaf cushions and interareas with vertical linear ornamentations. Ligule pit, oblanceolate leaf scar and vascular bundle scar appear on the leaf cushion. Distal axes have persistent lanceolate leaves and rhombic leaf bases. The microsporangiate strobilus is cylindrical in shape, possesses sporophyll with alate pedicel and long triangular lamina, uniseriate sporangial wall, subarchesporial pad inside the sporangium, and microspore with cingulum. Based on comparisons with other isoetaleans, the usage of the terms “leaf cushion” and “leaf base” is discussed, and *Minostrobus chaohuensis* is considered as a tree-like lycopsid. The multi-dichotomous branching system of *Minostrobus* provides new data on the evolution of growth architecture in rhizomorphic lycopsids.

The pseudomonopodial axis of *Sublepidodendron grabau* without secondary xylem bears medullated stele and branch traces arranged in irregular helices. The lateral branch possesses solid exarch primary xylem. This pseudomonopodial branching system possibly belongs to the crown or cauline lateral branch. The microsporangiate strobilus contains microspores belonging to the *Lycospora granulata* Group. The monosporangiate nature of *Sublepidodendron grabau* is confirmed, and the classification of Sublepidodendraceae into the suborder Dichostrobiles is supported. The *Lycospora granulata* Group microspores are suggested to occur not only in bisporangiate strobili but also in monosporangiate

strobili.

Keywords: South China, Late Devonian, *Minostrobus chaohuensis*,
Sublepidodendron grabau, arborescent lycopsid, monosporangiate
strobilus

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