(SS11) Paleozoic Plant Physiology

Date: August 29 (poster), 30 (oral)
Place: Room 5336 (oral), Room 6302 (poster)
Organizers: Walton Green & Cindy Looy
Contact email address: wagreen@bricol.net
Purpose: Since their disciplinary origins, paleontology and paleobiology have been concerned with basic questions of uniformitarian onus: whether the past should be assumed to be the same as the present (unless proven otherwise) or whether, if some changes have been observed, comparable changes in variables that cannot be directly observed should be assumed. Physiology is a particularly difficult area in this regard because it is seldom directly observable without experimental manipulation. In this session we hope to foster a debate about what characteristics of physiology should be considered constant throughout the Phanerozoic and when an 'upward outlook' and receptivity to non-analog arguments is needed. Our focus will be on Paleozoic plant ecosystems, but we welcome contributions from different eras, organisms, or ecosystems that are thematically related to the question of what is uniform about physiology.

Oral Presentation

Aug. 30 [AM1] Room: 5336

Chair: Cindy V Looy

9:00-9:20 **An aneurophytalean plant from the Middle Devonian of North Xinjiang, China** SS11-O01 (217)

Qing Jiang, Yi Wang, Hong-He Xu

9:20-9:40 **On the worldwide success of the lycopod genus *Pleuromeia* after the end-Permian biotic crisis** SS11-O02 (110)

I.A.P. Duijnstee, C.V. Looy, J.H.A. Van Konijnenburg-Van Cittert

9:40-10:00 **Mathematical and geochemical approaches to the physiology and biomechanics of Paleozoic plants** SS11-O03 (573)

Jonathan P. Wilson

10:00-10:20 **Diversity of the tree fern *Psaronius* from Upper Permian sediments of Yunnan Province, southwest China and its palaeoecological significance** SS11-O04 (108)

Ashalata D'Rozario

Poster Presentation

Aug. 29 [PM1] Room: 6302

13:30-14:30 **Reinvestigation of *Minarodendron cathaysiense* from the Middle Devonian, South China** SS11-P01 (291)

Le Liu, De-Ming Wang

Dark and disturbed or sunny and bright: A new approach to determine early angiosperm habitat SS11-P02 (264)

Alexandra Lee, Garland Upchurch Jr, Erik Murchie, Barry Lomax

A view of the early Early Carboniferous flora of South China SS11-P03 (579)

Honghe Xu, Yi Wang

SS11-O01 (217)

An aneurophytalean plant from the Middle Devonian of North Xinjiang, China

Qing Jiang[1, 2], Yi Wang[1], Hong-He Xu[1]

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An aneurophytalean progymnosperm attributed to *Anuerophyton pubescens* Krausel & Weyland, 1932 is reported from the Middle Devonian of North Xinjiang, China and is comparable to *Aneurophyton germanicum* var. *pubescens* Schweitzer et Giesen, 2002 from Germany. It sheds new light on the Devonian progymnosperm morphology. The plant has four orders of axes attached with both sterile and fertile ultimate units. The axis gives rise to the next orders spirally or dichotomously. It is observed that the second-order axes are arranged spirally along the first-order axis in pairs, while the second-order axes and the subsequent orders give rise to the other orders in the fashion of equal bifurcation. In the fertile system, the second-order axes are attached by single or paired third-order axes spirally. Sterile units, small three-time three-dimensional branching system 7.0-13.0 mm long, are attached spirally to the third-order and the terminal axes in pairs with their bases decurrent to these axes. Fertile units, 3.7-8.0 mm long and 2.3-11.2 mm wide, are borne spirally on the third-order and the terminal axes just as sterile units are. Fertile units are composed of pinnately arranged fertile arms, up to three orders. Fertile arms bear sessile, elliptical sporangia on the adaxial sides. Sporangia are symmetrical and rather plump once they are matured, but twist a bit after they split longitudinally through a single suture. Spines are slender, in the length of 0.5-1.5 mm, covering on the surface of every order of axes and of ultimate units.

Keywords: *Aneurophyton pubescens*, progymnosperm, Devonian, Xinjiang.

SS11-O02 (110)

On the worldwide success of the lycopod genus *Pleuromeia* after the end-Permian biotic crisis

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The Mesozoic biosphere had a very rough start as the end-Permian mass extinction (~251 Ma ago) profoundly altered ecosystems worldwide. In the humid climatic zones of supercontinent Pangea, for instance, the widespread peat forests disappeared due to dieback of woody vegetation. In the equatorial Euramerican realm, the dominant conifer taxa became extinct. Palynological and

paleobotanical records worldwide indicate that during this turmoil and millions of years to follow, lycopods played the lead role in floras. The absence of arborescent competitors paved the way for a remarkable expansion of especially isoetalean lycopsids. In a dramatic loss of floral provinciality, dense populations of a single genus, *Pleuromeia*, are recorded worldwide; occupying habitats ranging from semi-arid to tidal, dominating paleofloras globally for millions of years. Re-examination of plant fossils collected in the 19th and 20th century and comparisons between the fossils and extant isoetalean representatives suggest the existence physiological and life history properties that could explain the resilience of Isoetales during the biotic crisis and their extraordinary success during Early Triassic repopulation.

SS11-O03 (573)

Mathematical and geochemical approaches to the physiology and biomechanics of Paleozoic plants

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The biochemical and biophysical nature of plant physiology means that functional information can be read directly from anatomy preserved in the fossil record. Fossil plants' hydraulic properties can be quantified through the application of mathematical models to xylem structure, and their architecture can be reconstructed using chemical analysis of fossil plant tissues. Mathematical models of fluid flow through fossil plant xylem provide strong constraints on fossil plant function, and have shown that a diverse number of early seed plants (including *Callistophyton*, *Medullosa*, and *Lyginopteris*) contained xylem adapted for high water transport rates, at the cost of reduced biomechanical support and embolism resistance. Recent analysis of some early vascular plants from the trimerophyte and lycophyte clades has shown a similar prioritization of high flow rates over support and embolism resistance, suggesting parallel selective pressures in early vascular plant and early seed plant evolution. In addition to mathematical modeling, direct geochemical analysis, specifically stable carbon isotope analysis, provides an independent perspective on fossil plant physiology and biomechanics by measuring the spatial distribution of lignin, the key structural biopolymer in vascular plants. Tissue-specific analysis can be made by differencing unambiguously lignified tissue (i.e., xylem) from other tissues in the same plant. Extraxylary tissue that is lignified (e.g., sclerenchyma) will have a $^{12}C/^{13}C$ ratio that closely resembles wood, rather than carbohydrate-rich tissue such as pith, matrix, or ground tissue. Results from analysis of stem and petiole tissue of the Carboniferous Period seed plant *Medullosa anglica* suggest that the chemical composition of cortical tissues more closely resembles that of unlignified tissue, rather than wood. An advantage of the stable carbon isotope method is the ability to quantify lignin content in extraxylary tissue: in *Medullosa anglica*, cortical tissue contained no more than 11% lignin--comparable with peripheral tissues of *Zea mays* (corn) and other extant monocotyledonous angiosperms. Such a low lignin content implies that cortical tissues of stem and petiole samples are composed of collenchymatous, rather than sclerenchymatous or fibrous, cells, which would be more characteristic of a climbing habit than a self-supporting morphology. Taken together, these methods provide two new perspectives on the function and life history of fossil plants.

Keywords: water transport, lignin, coal ball, modeling, carbon isotopes.

SS11-O04 (108)

Diversity of the tree fern *Psaronius* from Upper Permian sediments of Yunnan Province, southwest China and its palaeoecological significance

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The Upper Permian Xuanwei Formation of Housuo Coal Mine, Fuyuan County, Yunnan Province, southwest China, has a large deposit of the petrified remains of the marattialean tree fern *Psaronius*. Ranging in distribution from earliest Pennsylvanian to Triassic period they are important constituents of the Late Carboniferous and Permian flora of the tropical and subtropical regions of both the Northern and Southern Hemispheres. Their unique stelar structures and pattern of leaf trace development are of special significance. Several such permineralized stems were collected and their study reveals a polycyclic dictyostele, with well preserved root mantle. The leaf traces vary in the different specimens and range from five to six arranged in a helical manner. Vascular bundles are oriented in 4-6 concentric rings. Tracheids of the stem have scalariform to pitted thickenings. The outer part of the stem consists of a sclerenchyma sheath. In some specimens, the roots appear to be radially compressed. Roots are actinostelic, xylem exarch, polyarch, with 8–10 protoxylem strands. Tracheids have simple to multiseriate scalariform or pitted thickenings. Cellular features of the roots are well preserved. The tracheids of the root are found to be infected by fungal hyphae. In some specimens, the ground tissue of the stem is replaced with coprolites and sediments, indicating well developed plant–animal interaction during the Late Permian. The evolutionary pattern of leaf trace development is described for taxonomic placement and its possible ecological significance. The preponderance of several tree ferns in the late Palaeozoic Cathaysian flora of China, among which *Psaronius* is of common occurrence, coupled with the diminishing status of the lycopsids may be due to the change in environmental conditions. Cool, dry, glacial phases favoured vegetation dominated by tree ferns, cordaitaleans and pteridosperms, whereas warm wet interglacial phases were lycopsid dominated (Falcon-Lang, 2006). It may thus be inferred that *Psaronius* grew in a dry habitat.

Keywords: marattialean plant, permineralized stem, polycyclic dictyostele, root mantle, anatomy.

SS11-P01 (291)
Reinvestigation of *Minarodendron cathaysiense* from the Middle Devonian, South China

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Minarodendron is a lycopsid genus previously described from the late Middle Devonian of China. Based on specimens collected from Qujing District of Yunnan Province, China, we are able to reinvestigate some morphological and anatomical features of this genus. Compared to *M. cathaysiense* studied by Li (1990), the new specimens demonstrate the thicker stem and the dichotomously and repeatedly branched axes. The leaves possess entire margins and straight laminae. The variations in leaf shape may provide a complement to the diagnoses of the genus *Minarodendron* and the species *M. cathaysiense*. We regard *M. cathaysiense* as a tree-like plant assigned to the Protolepidodendrales of the Lycopsida.

Keywords: lycopsid, Protolepidodendrales, tree-like plant.

SS11-P02 (264)
Dark and disturbed or sunny and bright: A new approach to determine early angiosperm habitat

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Whether the earliest angiosperms functioned with high or low photosynthetic gas exchange capabilities remains a key debate in the on-going research into angiosperm origins. The high gas exchange hypothesis supports the notion that the first angiosperms existed as opportunistic weedy species favoured in exposed sunny environments. Conversely, the low gas exchange hypothesis would infer that the earliest angiosperms existed in understory forest canopies with low transpirational demands. We have devised a novel method to test these competing hypotheses through developing a leaf energy balance model capable of predicting leaf temperature as a function of air temperature, radiation load and stomatal conductance. The modelled solution of leaf temperature will help to determine the environmental tolerance of the early angiosperms and whether – given that their low stomatal conductance would limit their transpirational cooling capacity - the earliest angiosperms could have survived the exposed sunny environments of the Aptian when temperatures would have ranged from 38-43°C. Furthermore, full stomatal closure would likely occur at midday so regardless of baseline conductance, whether the small size of early angiosperms leaves was enough to avoid heating to lethal temperatures is fundamental as to whether the angiosperms could have survived out of the shade. Determining the environmental tolerance of the early angiosperms will help place these enigmatic fossils within an ecophysiological framework.

Keywords: gas exchange hypotheses, leaf energy balance model, environmental tolerance, leaf temperature.

SS11-P03 (579)
A view of the early Early Carboniferous flora of South China

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The early Early Carboniferous flora of South China for a long time has been named as *Sublepidodendron mirabile* - *Lepiodendropsis* sp. assemblage, which include lycopsids *Sublepidodendron mirabile*, *S. grabaui*, *Lepidodendronpsis hirmeri*, *Stigmaria ficoides*, and *Bothrodendron fuyangense*; sphenopsids *Archaeocalamites* cf. *subtenerrimum*, and *Hamatophyton verticilatum*, and early ferns / seed ferns *Rhodeopteridium* sp., *Sphenotperis* sp., and *Sphenopteridium* sp.. However, most of these plants were studied by poorly preserved materials and contribute little to understanding the Carboniferous flora and diversity, especially of the South China late Paleozoic flora that is dominated by endemic members. Recently several well preserved plants, the early ferns *Helicophyton dichotomum*, *Multifurcatus tenellus* and *Coenosophyton tristichus* and a new species of herbaceous lycopsid, were reported from the Upper Member of the Wutung Formation, which is a near-shore sedimentary facies and ranges in age from the Upper Devonian to

the earliest Carboniferous (Tournaisian) by dispersed spores. These plants, though only preserved as compressions and impressions, show us a distinct view of the Early Carboniferous flora. The Early Carboniferous flora of South China is comprised of not only tree-like lycopsids, but a number of herbaceous and slender plants, such is different from the previous knowledge of the flora.

Keywords: Carboniferous, flora, Wutung Formation, lycopsid, South China.