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Fifty years of spore wall ultrastructure: what good is all this?

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Plant spores were among the first biological specimens to be sectioned and examined with the transmission electron microscope. From a heyday in the 70s and 80s, other techniques that analyze lower and lower levels of biological organization (i.e., chemistry) have mostly replaced ultrastructure as the subject of research focus. This is true everywhere but in the realm of paleontology. Cells and soft tissues decay, and the effects of diagenesis severely complicate reliable chemical analyses of biological materials that can persist. This uncertainty, combined with the extreme resistance of biomolecules like sporopollenin to diagenetic alteration, has kept ultrastructural data on fossils relatively more important than chemical as a source of information. A condensed historical survey of the contributions of spore wall ultrastructure in the past fifty years serves to illustrate the value of this approach. This survey will include: the initial realization that fossil spore walls preserve their ultrastructure for hundreds of millions of years; the fact that ultrastructural features in spore walls can be highly conserved in some lineages, thus serving as indicators of affinity of even dispersed spores; the utility of immature and aborted fossil spores for gaining insights on developmental phenomena; and the discovery of distinct and taxonomically diagnostic ultrastructural features in the walls of spores whose affinities were previously unknown, and in some cases predate any macrofossil record. In all of these cases, data from fossils add the element of time – often deep time – that serves to provide the context to analyses involving extant spores. Moreover, the widespread dispersal of spores and pollen has introduced them throughout the fossil record to an extent unparalleled by any other type of fossil. Thus, their various uses can become even more significant due to a sort of temporal and spatial multiplier effect. Additions to the data base of fossil and extant spore wall ultrastructure will ensure a continuing expansion of the knowledge and utility of this information, including but not limited to: reconstructions of earth's earliest terrestrial ecosystems, and furnishing additional characters (or dating points) for phylogenetic analyses.

Keywords: palynology, paleopalynology, phylogeny.

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Morphology and ultrastructure of *Wodehouseia* pollen

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The characteristic genus of the Aquilapollenites Province such as *Wodehouseia* represents an extinct group of plants of uncertain botanical affinity (most having became extinct at the K–T boundary). This distinctive pollen is sometimes referred to as 'oculate' pollen. Dispersed pollen grains *Wodehouseia spinata* Stanley were studied from the palynological assemblage from the sediments of Furao Formation widely-distributed on right bank of Heilongjiang (Amur) River. The deposits were drilled by borehole XHY2008 near the Xiaoheyan area. The palynomorphs belong to assemblage *Aquilapollenites stelkii* - *Pseudointegricorpus clarireticulatus* having the Late Maastrichtian age with dominating of angiosperm pollen (48%) and are represented by the taxa of 21 angiosperms, 7 gymnosperms, and 4 pteridophytes (Markevich et al., 2011). Pollen grains were picked up from the residue and individual specimens were subsequently studied in LM, SEM and (for a number of specimens) in TEM. The combined analysis has shown that among studied material pollen is 16.26x29.7 μm on average, ellipsoidal, flanged, with four slit-like pores on each side in pairs. The sculpture is spinulate with spines of three different size ranges, the surface between the spines is smooth and perforated. Large spines are few and disposed in the central part of the compressed pollen, such a type of the spine is present at the pore margin, though sometimes they are broken and cannot be observed. Next to the periphery middle-sized spines are disposed and the smallest spines are on the flange, these two types are more numerous. Spine dimensions vary, but on average, the large ones are from 1.7 to 3 (sometimes more) μm high and 0.6-0.8 μm in diameter, middle-sized – from 1.0 to 1.8 μm high and 0.25-0.3 μm in diameter and the small ones – less than 1 μm high and less then 0.2 μm in diameter. The ectexine is columellate with a thin tectum. The endexine is thick, looks homogeneous, being about two times thinner at the flange region. A combination of pollen characters observed by LM, SEM and TEM confirms an angiosperm affinity of the species with highly specialized morphology and ultrastructure, unknown for extant plants. Further EM study of other *Wodehouseia* species will help to reveal the diversity of this kind of pollen.