Ultrastructure of Middle Devonian Spores from New York State

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Abstract
An assemblage of fossil plant spores from the Middle Devonian of New York state (approx. 375,000,000 years old) was extracted using standard palynological techniques, including a final sieving through a 100µm nylon mesh. Measurements of these spores uncovered a size range of 141-206µm. A previously reported spore size range from nearby deposits of 86-166µm was of spores putatively produced by the enigmatic plant *Calamophyton*. One variety of spores, probably not associated with *Calamophyton*, has long spines. Individual images of these spores were captured using the scanning electron microscope (SEM). The aim of this project is to use transmission electron microscopy (TEM) to: 1) examine the spiny specimens for variations in wall thickness, layering, staining, and overall substructure, 2) compare these spores with contemporaneous varieties putatively associated with *Calamophyton*, and 3) identify any ultrastructural characters that might be used to determine what plant might have produced these isolated spores. Little is known of the fine structure of spores of this geologic age since none have been examined with the TEM. Any information gathered will ultimately contribute to the understanding of plant diversity in this time of active plant evolution.

Techniques and results
1. Specimens were examined and photographed with the SEM (scanning electron microscope) at both low and high magnifications (Figure 1).

![Figure 1](image1.png)

**Figure 1**
The images above show both high and low magnification. Image A is at 300x and B is at 1500x.

2. Following embedment in Spurr resin, sections of specimens were cut, placed on a grid, stained, and examined with the TEM, in an attempt to determine if the spiny specimens have variations in wall thickness, layering, or staining at the ultrastructural level.

![Figure 2](image2.png)

**Figure 2**
The images are SEM images at 300x. Image A is a distal view and image B is a proximal view showing the trilete mark formed from four spores developing against one another.

![Figure 3](image3.png)

**Figure 3**
The image is a TEM image of a wall cross section at 600x from the spore in figure 1.

These spores are the highly resistant coverings of single celled dispersal bodies. As such, they are hollow spheres. When compressed during fossilization, two sets of opposing walls are brought together and appear as one in the TEM. The line of separation between the proximal and distal walls (the space formerly occupied by the spore protoplast) is frequently discernable in the final image.

The specimens have a wall thickness that is approximately 10µm. The wall structure, though compressed, has occasional spaces and could be described as somewhat spongy.

![Figure 4](image4.png)

**Figure 4**
The images are TEM images of a wall cross section from the spore in figure 2. Image A is at 200x and image B is at 800x.

Conclusions
This study will provide baseline data on spore wall ultrastructure from a little studied geologic period. This will also allow future comparison with spores of known affinity once they are examined.

The spines appear to be solid as shown by the arrows in the cross section in Figure 3. If the top of the specimen in Figure 4A would have continued it would have connected with the bottom of the specimen. Figure 4B shows how Figure 4A would have connected if it was not hidden by a grid bar. The arrow in Figure 4B is showing the trilete mark, this is known because of the gap in the specimen.

There are few studies of spores of this size from the Middle Devonian Period. The only studies to compare with are of larger spores from the Late Devonian Period. At this point in time, there is a larger difference in size between mega- and micro-spores. These larger megaspores have a more pronounced spongy ultrastructure than those examined for the present study.

Future Work
Analysis of additional specimens from later in the Devonian will help determine when very spongy-walled megaspores first appeared.

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