

LETTER TO THE EDITOR

**“PROTOTAXITES WAS NOT A TAPHONOMIC ARTIFACT”**

*Prototaxites* Dawson 1859 is an enigmatic Late Paleozoic cylindrical fossil that ranges in size up to 8.8 m long and 1.4 m in diameter, with most specimens showing concentric layering in transverse section. Its internal anatomy consists of 20–45 µm diameter tubes embedded within a weft of smaller septate tubes. After comparing mats created under carefully controlled laboratory conditions with a fragment of a *Prototaxites* specimen from Ontario and selected published literature, Graham et al. (2010) proposed that *Prototaxites* represents mats of rolled-up liverworts intermixed with fungal and cyanobacterial associates, interpreting the large tubes as liverwort rhizoids and the smaller tubes as separate fungal components. Although creative, this hypothesis can be firmly rejected: (1) no natural taphonomic mechanism could account for such large and tightly rolled mats; (2) the internal anatomy of *Prototaxites* is a highly ordered fabric that bears no resemblance to the manufactured roll-ups illustrated in fig. 3A–C of Graham et al. (2010). Our comments on anatomy that follow are based on observations of the globally extensive collection of *Prototaxites* specimens at the National Museum of Natural History, Washington, D.C.

Natural production of tightly rolled mats of such size is beyond the range of plausibility. Their example of a rolled liverwort mat was made by hand, and they offered only vague reference to “wind, water, or gravity” for their natural formation. Everything from soft sediment slumping (Allen, 1984) to the common experience of seeing a tarp or tablecloth in the wind all indicate irregular folds should be expected from these processes, not a tight spiral. Small roll-ups are occasionally found in shallow-water cyanobacterial mats, but these structures are on the centimeter-scale and involve no more than a few loose and elliptical revolutions of a spiral (Demicco and Hardie, 1994). Furthermore, a larger *Prototaxites* specimen would have been more than 10 000 kg if hydrated (and dry mats would have been too brittle to roll, except gingerly by hand). The hurricane-level force their movement would require would rip and fragment the mat before it could be rolled, as seen in the geologic record with rip-up clasts of microbial mats in storm deposits (Allen, 1984). Gravity could perhaps propagate an existing roll-up but could not provide for its initiation, and such a roll-up would have to be already far larger than could be accounted for by other processes before gravity would be sufficient to take over. A larger *Prototaxites* specimen would require a long and uninterrupted topographic gradient steep enough to maintain the mat rolling continuously for more than a kilometer—such an incline is inconsistent with the deposition of the coal horizon in which the New Brunswick specimen figured by Graham and colleagues (their online appendix S7) was found in situ. The onus is on the authors either to provide evidence that such massive roll-ups have occurred with some frequency in the geologic past (none exists to our knowledge) or provide flume or other laboratory experiments that demonstrate circumstances for their generation without direct human intervention.

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Putting aside how problematic their formation would be, the mat roll-up interpretation can be tested directly with several anatomical expectations that the hypothesis requires—and the roll-up interpretation fails these tests on all counts. (1) The large tubes interpreted by Graham et al. (2010) as rhizoids should have no preferred orientation unless aligned during uprooting perpendicular to the long axis of the roll and tangential to the roll’s surface. In reality, these tubes are consistently aligned along the long axis of the trunk, not perpendicular to it [see plates II, III, and V in Hueber, 2001]. (2) If a rolled mat, then the layering should form a single continuous spiral in transverse section. In reality, single increments form closed, concentric rings (online appendix S7 Graham et al., 2010). These concentric rings cannot form in a rolled mat. Furthermore, the rings consist of longitudinally oriented, slightly smaller diameter and more densely packed large tubes indicating a continuous tissue, rather than “resistant layers” as noted by Graham et al. (2010). (3) The thickness of individual layers in a rolled mat should be limited by that of the original unrolled mat. However, the ring thickness in some *Prototaxites* specimens can be close to 2 cm—far greater than the 2.6 mm thick mats in Graham et al. (2010). (4) If *Prototaxites* were a rolled mat, sediment particles adhering to the mat should have been entrained between the mat layers and additional sediment should have filled gaps between the layers after burial. On the contrary, well-preserved specimens of *Prototaxites* are sediment free and tightly packed with regularly oriented tubes from the center to the periphery. (5) If a rolled mat, no tube or other structure should pass from one layer through the next. However, structures called “medullary rays” (closely analogous to a wood ray) commonly do so (plate V in Hueber, 2001). The unitary construction of *Prototaxites* trunks is real and is evidence of a coherent tissue produced by a discrete organism.

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