Lester Park: Global "Type Locality" for Stromatolite Fossils

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Lester Park and Stark's Knob in eastern New York State are the oldest outdoor scientific parks in North America. These Saratoga County sites were donated by local citizens to the New York State Regents via the New York State Museum during World War I to preserve them from development and for their use in education as "Scientific Reservations" (Flick, 1929). Much later (2019), they were designated New York State Geoparks by the state legislature. Lester Park and Stark's Knob illustrate distinct intervals in the geologic evolution of eastern North America (e.g., Landing, 2022).

Figure 1. "*Cryptozoon* ledge" at Lester Park. Letters A and B mark 10 cm step made by glacial plucking of upper part of stromatolite domes; W–E shows roughly west–east alignment of stromatolite bases and erosion enhanced joints. Photo credit: Ed Landing.

Lester Park (Fig. 1) features shallow marine rocks of the Laurentian ("ancestral North American"), early Paleozoic, passive tropical margin (then ~35° south latitude). Stark's Knob provided the first record of volcanism on a subducting slab as NE Laurentia approached the trench in the Late Ordovician Taconian orogeny (locally ca. 460 Ma), with the Laurentian margin fracturing to release submarine pillow basalts (Landing et al., 2003; Schoonmaker et al., 2016; Landing and Bartholomew, 2024).

Not maintained for decades, both sites were restored (by EL) with removal of overgrowth and trees with the help of scout groups and volunteers, and interpretive signs were installed (Landing, 2004). Both Geoparks can be visited year-round. They must be seen as irreplaceable—do not damage or collect anything.

LOCATION

Lester Park was deeded to the State Regents in 1915 in honor of the local lawyer Willard Lester. The park features a gently (5°) west-dipping carbonate rock succession (11.35 m thick) exposed on both sides of Lester Park Road. The broad (~500 m^2) bedding surface on the east side of Lester Park Road (43° 05′ 32.14″ N, 73° 50′ 53.42″ W) is low in the Hoyt Member of the Little Falls Formation and has hundreds of light gray weathering stromatolite domes (Fig. 1). This is the traditional *Cryptozoon* ledge (Cushing and Ruedemann, 1914). It is 2.75 m above dolomitic sandstones of the Galway Formation and ~100 m above the nonconformity of Potsdam Formation sandstone with Mesoproterozoic, Grenville high-grade metamorphic rocks of the Adirondack massif (Landing, 1979, 2007).

This stromatolite-rich surface (Fig. 1) extends at least 1.0 km south to Petrified Sea Gardens, a long-closed tourist attraction now owned by Pompa Bros., Inc., a stone company. Slightly higher strata are exposed on the gentle curve just south on Lester Park Road, with the section continuing into the old Hoyt quarry in the woods ~75 m west of Lester Park Road. This limestone quarry was developed in the late 1800s by the Hoyt family for rock that was burned in

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the now tumble-down kiln on the west side of Lester Park Road. The lime was used to improve the local sandy soils for agriculture. (In Landing et al. [2021], Upper/Late Cambrian is a precisely defined, proposed subsystem/subperiod that replace the undefined, subsystem-level terms "upper"/"late" Cambrian of many authors.)

GEOLOGIC SIGNIFICANCE

Lester Park offers a window into the primary depositional features of the lower Paleozoic of eastern New York and adjacent western New England and southern Quebec and Ontario. Throughout much of this region, carbonates of the middle Upper Cambrian–lower Middle Ordovician Beekmantown Group have commonly undergone hydrothermal dolomitization that obliterated primary textures and fossils. Field studies show that this dominant facies of massive, relatively featureless dolostones is laterally transitional into weakly to non-dolomitized limestones. The Lester Park area escaped this strong diagenetic overprint apparently associated with the Late Ordovician Taconic orogeny (e.g., Landing, 2007, and references therein).

But for fractures and tiny faults filled with white calcite and brownish dolostone spar, the Lester Park sequence resembles coeval North American Mid-continent successions. However, the Lower Paleozoic of eastern New York has been exposed with the removal of ~7.5 km of younger rock. This burial depth included ~1.0 km of strata through the upper Middle Devonian in the Catskill Mountains to the south. A further ~6.5 km of burial are shown by the anthracitic plant remains and clay mineralogy of the Catskill highlands (Friedman and Sanders, 1982). This ~7.5 km of burial meant burial temperatures of at least 200 °C. Even higher burial temperatures are likely, as O'Reilly and Parnell (1999) suggested greater heat sources with maximum burial in the late Paleozoic Alleghenian orogeny (Heizler and Harrison, 1998). The fine internal lamination of the domes on the Lester Park surface (e.g., Hall, 1884; Lee and Riding, 2021a, b; Neuweiler et al., 2023) and delicate preservation of the Hoyt Member and underlying Galway Formation trilobites (Ludvigsen and Westrop, 1983) survived late burial metamorphism.

LESTER PARK OFFERS A WINDOW INTO THE PRIMARY DEPOSITIONAL FEATURES OF THE LOWER PALEOZOIC OF EASTERN NEW YORK AND ADJACENT WESTERN NEW ENGLAND AND SOUTHERN QUEBEC AND ONTARIO.

THE "CLASSIC" STROMATOLITE

Steele (1825) first reported the isolated and coalesced domal structures of what is now called the Hoyt Member as nonbiologic concretions, and he recognized alternating dark blue to black "compact" and white "granular" laminae. James Hall, the workaholic head of the New York Geologic Survey and dominant nineteenth-century North American paleontologist, initially accepted this interpretation but changed his interpretation to "organic" and then "sea plants" in the 1840s. Hall (1884) finally came to believe the domes were colonial animals similar to the fossil hydrozoan *Stromatopora*. Thus, he named them *Cryptozoön proliferum*, or "proliferating hidden animal," with the lateral coalescence of the *Cryptozoon* domes (Fig. 2) suggesting the closely juxtaposed underground bulbs of the onion *Allium proliferum*. The caption of Hall's (1884, pl. 6) *C. proliferum* illustration refers to the Hoyt farm, which means that Lester Park, and not the Petrified Sea Gardens, was the source of his material.

Subsequently, finely laminated, biologically produced structures such as those at Lester Park were understood to be produced by sediment trapping, binding, and/or cementation by microbes (Walcott, 1914; Wieland, 1914), primarily cyanobacteria (commonly and incorrectly called "blue-green algae"). They are the oldest (ca. 3.4 Ga) body fossils on Earth and persist in modern aqueous environments (see thorough review in Grey and Awramik, 2020). These laminated biologic build-ups were termed "stromatoliths" by Kalkowsky (1908), which was anglicized to "stromatolite." This made *Cryptozoon proliferum* the first of many stromatolites given a Linnean (binomial) name. The Lester Park bedding surface is the "type locality" for this classic form.

DEPOSITIONAL SETTING (NO GLACIAL EROSION) OF BUILD-UPS

The internal growth laminae of *C. proliferum* are exposed on the large bedding surface at Lester Park because the stromatolite domes have been truncated

Figure 2. Truncated *Cryptozoon* domes show internal growth laminae, with overlying coarse, brown weathering sandstone with stromatolite clasts (gray) and depressions of weathered clasts within yellow oval. Hammer 30 cm long. Photo credit: Ed Landing.

(Fig. 2). This truncation has been repeatedly and incorrectly explained by some sort of beveling by Pleistocene glacial activity (Goldring, 1938; Stauffer, 1945; Friedman, 2000, 2012; Lee, 2019; Lee and Riding, 2021a). However, continental ice sheets do not significantly grind down rocks, unlike mountain glaciers, and their primary method of erosion is that of plucking. A 10-cm step between the north and south parts of the Lester Park surface reflects this plucking (Fig. 1) and has detached the broader tops of the domes from their narrower bases on the southern end of the surface.

The actual truncation of the Lester Park *Cryptozoon* domes took place with shoaling and progradation of a thin (to 10 cm) coarse-grained quartz sandstone that was moved by waves and currents to abrade the *Cryptozoon* domes (Landing, 1979). This brownish sandstone is best seen at the north end of the Lester Park surface, where it has stromatolite fragments in it (Fig. 2). Burne and Moore (1993) compared the flat-topped *C. proliferum* domes at Lester Park with "micro-atoll" build-ups of thrombolites (noted below) in Western Australia. This interpretation is not valid, as their micro-atolls are not abraded and do not show internal laminae on their upper surfaces, which have grown up to the high tide level. The flat-topped Lester Park specimen they compared with their modern "micro-atolls" shows truncation of growth laminae on its top and sides and is embedded in a coarse sandstone with *Cryptozoon* fragments.

THE PRESERVATION OF STARK'S KNOB AND LESTER PARK AS SCIENTIFIC RESERVATIONS HAS NOT ONLY ASSURED THEIR USE IN EDUCATION AND SCIENTIFIC FIELD TRIPS BUT ALSO ALLOWED OPPORTUNITIES FOR NEW RESEARCH.

The Lester Park stromatolite surface is the top of a shoaling-up cycles. As noted above, the broad Lester Park surface was truncated by wave and current activity that moved sand across the domes. The abruptly overlying dark dolomitic mudstone with linguloid brachiopods at the base of the road cut further south at the curve on Lester Park Road reflects deepening. These mudstones shoal up into current cross-bedded dolomitic limestones with low (to 10 cm high) undulatory stromatolites (i.e., form species *Cryptozoon undulatum*; see Goldring, 1938) near the top of a second shoaling-up cycle.

Figure 3. Ellipses outline thrombolites in middle of Hoyt quarry section. Hammer is 30 cm long. Photo credit: Ed Landing.

THROMBOLITES AT LESTER PARK

A second type of microbial build-up at Lester Park is very large (to 1.5 m high) domes in the middle of the Hoyt quarry (Fig. 3). These build-ups were reported as *Cryptozoon ruedemanni* by Rothpletz (1916) and Goldring (1938) but do not have the fine growth laminae of *Cryptozoon*. Rather, they show the weakly to nonlaminated clotted fabric that distinguishes the microbial build-ups termed a "thrombolite" by Aitken (1967; "clotted" rock). The terminology assigned to microbialite build-ups is frequently vague and even contradictory (Grey and Awramik, 2020), but "thrombolite" must include build-ups that show Aitken's cm-scale cavities to mm-sized voids (Riding, 2011). Thus, the term "stromatolite" is not appropriate for many modern microbial build-ups, including most of the build-ups in hypersaline facies in Shark Bay, Western Australia; the domal build-ups in fresh water at Green Lakes State Park near Syracuse, New York; and large build-ups in tidal channels in the Bahamas and in coastal Saudi Arabia (Vahrenkamp et al., 2024). All of these build-ups have well-developed internal cavities and should be termed "thrombolites" as Burne and Moore (1993) recognized.

The thrombolites in the Hoyt quarry are surrounded by fossiliferous limestone granule, and ooid-rich limestone that is well burrowed and the primary bedding is disrupted. This limestone is banked against the margins of the thrombolite build-ups, which indicates the tops of the thrombolites formed low domes on the Late Cambrian sea floor.

The rock surrounding the "*Cryptozoon* ledge" stromatolites and the thrombolites in the Hoyt quarry has an abundant fauna with current and wave-fragmented trilobites, echinoderm sclerites, and calcareous and rarer phosphatic brachiopods. The occurrence of stromatolites in normal marine facies at Lester Park illustrates the interpretation that diverse and abundant metazoan grazers, which would have destroyed microbial mats and limited stromatolites to hypersaline or freshwater habitats, had not appeared by the Late Cambrian.

MODERN RESEARCH

The preservation of Stark's Knob and Lester Park as Scientific Reservations has not only assured their use in education and scientific field trips but also allowed opportunities for new research. Collecting is prohibited at Lester Park, but the New York State Museum (NYSM) allows material in museum collections, such as its trilobites (Ludvigsen and Westrop, 1983), to be put into geological context.

The alternating black-and-white lamination described by Steele (1825, noted above) has fueled a controversy as to whether the "type" stromatolite *C. proliferum* is not merely a microbial consortium. An alternative explanation is that *C. proliferum* includes a non-spiculate (keratose) sponge that formed the black laminae with a distinctive microfabric of curved, vesicular areas of calcite spar in micritic limestone (Lee, 2019; Lee and Riding, 2021a, b). This would mean that the origin of *Cryptozoon* is tied to the origin of early metazoans in the Cambrian Evolutionary Radiation. Alternatively, a similarly vesicular microfabric extends into far older Proterozoic stromatolites before the origin of metazoans (e.g., Grey and Awramik, 2020). Thus, the vesicular and micritic texture is also viewed as diagenetic in origin (Neuweiler et al., 2023) or reflects an origin that cannot be assigned with certainty to biotic or diagenetic controls (Kershaw et al., 2021).

Further work on legacy slabbed pieces and thin sections made by Goldring (1938) of *C. proliferum* in the NYSM by F. Neuweiler (Université Laval) and colleagues has involved optical petrology, cathodoluminescence, fluid inclusion analysis, and U-Pb dating of primary carbonate fabrics and several generations of carbonate (calcite and dolomite) cements. The results (unpublished data) illuminate the burial history and tectonics of Lester Park and eastern New York. As might be predicted (Landing, 2007), hydrothermal dolomite provides U-Pb ages which range through much of the Late Ordovician and reflect the local age of the Taconian orogeny. Surprisingly, vein calcite has early Silurian ages which may be related to late Taconian or the early part of "Salinic" events. Finally, Late Devonian and early Carboniferous (Tournaisian) ages on microcrystalline calcite overlap the end of the Acadian orogeny. At present, no petrographic evidence is known that corresponds to the greatest burial depth of the Appalachian region during the Alleghenian orogeny and Permian.

Watch a fascinating video about this geoheritage site. **https://bit.ly/3Mhxt6H**

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