Paleoecology of a large Early Cambrian bioturbator

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LETHAIA

Hagadorn, J.W., Schellenberg, S.A. & Bottjer, D.J. 2000 09 15: Paleoecology of a large Early Cambrian bioturbator. *Lethaia*, Vol. 33, pp. 142–156. Oslo. ISSN 0024-1164.

The Lower Cambrian Poleta Formation in the White-Inyo Mountains of eastern California contains well-preserved and laterally extensive exposures of the large looping and meandering trace fossil *Taphrhelminthopsis nelsoni* n.isp. Such traces are typical features on upper bed surfaces of Lower Cambrian shallow marine sandstones and occur with Ediacaran fossils at other localities. Morphologic, sedimentologic and goniogram analyses suggest that the inferred tracemaker was a large soft-bodied echinozoan- or mollusc-grade animal with a volume greater than 14 cm^3 that actively grazed or ingested sediment at the sediment–water interface. Although portions of these traces appear to reflect relatively 'complex' behavior, looping patterns are not periodic as expected for a systematic foraging strategy. *T. nelsoni* traces are patchy in distribution and commonly associated with suspect-microbial features, suggesting that tracemakers may have been targeting microbial-based or related concentrations of food resources. Such behavioral patterns are typical of shallow late Neoproterozoic–early Cambrian settings, and like suspect-microbial structures are later restricted to deep marine or stressed settings. □ *Cambrian, Poleta, Taphrhelminthopsis, trace fossils.*

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Trace fossils provide important information about the Proterozoic–Phanerozoic transition by recording the temporal and paleoenvironmental evolution of early animal habits (see summaries in Crimes & Droser 1992; Bottjer & Droser 1994; Crimes & Fedonkin 1996). Among the many trace fossils characterizing this interval, *Taphrhelminthopsis nelsoni* is important because it is one of the larger meandering traces predominant in early Cambrian shallow marine siliciclastic settings, together with *Cruziana* and ichnomorphs ascribed to *Plagiogmus* and *Psammichnites* (hereafter referred to as *Plagiogmus*; after McIlroy & Heys 1997). Unlike *Cruziana* and *Plagiogmus* (Seilacher 1970, 1995, 1997; McIlroy & Heys 1997), little is known about the paleobiology and paleoecology of the organism which produced *T. nelsoni*. Furthermore, *Taphrhelminthopsis* is one of only two early Cambrian trace fossils documented to occur with Ediacaran fossils (Jensen *et al.* 1998; Hagadorn & Waggoner 2000), indicating the tracemaker occupied environments suitable for Ediacaran soft-body preservation.

The paleobiology and paleoecology of early soft-bodied, trace-producing animals, such as the producer of *T. nelsoni*, is often poorly known (but see Seilacher 1970, 1997; Jensen 1990; Yochelson & Fedonkin 1993; McIlroy & Heys 1997). This gap stems from difficulty identifying specific tracemakers with their traces (e.g. Osgood 1970) and thereby inferring the behavioral processes preserved as sedimentary patterns. However, innovative approaches have been utilized to extract such information from the trace fossil record, and provided insight on early animal behavior, body size and ecologic strategies (Seilacher 1967a, 1970, 1974, 1977, 1995, 1997; Hofmann & Patel 1989; Hofmann 1990; Crimes 1992; Yochelson & Fedonkin 1993; McIlroy & Heys 1997). A similar approach is presented here by evaluating behavior recorded in well-preserved examples of *T. nelsoni* to provide paleobiologic, paleoethologic and paleoecologic information on large, and presumably soft-bodied, unknown early Cambrian metazoans.

Vendian-Lower Cambrian sequences in the White-Inyo Mountains of eastern California (Fig. 1) are well known for their diverse and well-preserved trace fossil assemblages, many of which have been the focus of taxonomic and stratigraphic studies (Alpert 1973, 1974, 1975, 1976a, b, 1977; Langille 1974). Among the many well-preserved ichnotaxa in the Poleta Formation, *T. nelsoni* is notable because of its large size, exceptional preservation and occurrence on a number of accessible, laterally extensive bedding plane exposures; at several of these exposures, trace-bearing and overlying strata can be examined and sampled *in situ*. Traces are typically ~5 cm wide and several meters long, making them significantly larger and longer than other contemporaneous trails in the region.

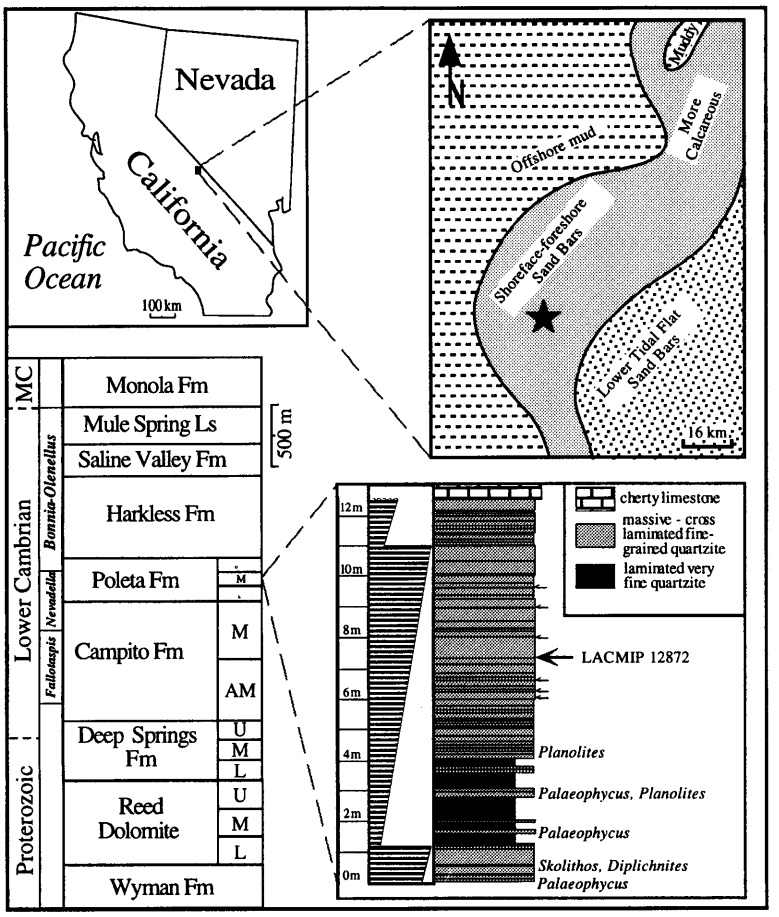

Fig. 1. Stratigraphic, geographic, and paleoenvironmental context of studied *Taphrhelminthopsis* traces. Traces occur at a variety of horizons (arrows) and are laterally extensive at one study section (lower right inset), where they extend for tens of meters. The thick arrow (4th of 7 arrows) indicates horizon illustrated in Fig. 2F (LACNHM 17188) where holotype (LACMIP 12872) was collected. Generalized paleoenvironmental context of study region in the White–Inyo Mountains is noted with a star in upper right inset diagram (modified from Moore, 1976b). Generalized regional lithostratigraphy (lower left inset) based on Nelson (1976) and Corsetti & Kaufman (1994).

Previous research

Alpert (1974) noted trails from the Poleta Folds area of the White-Inyo Mountains which cover large bedding surfaces, commonly cross themselves, form distinctive loops and lack transverse markings. These trace fossils are very common on bed tops of Cambrian strata in California, Nevada, Utah and elsewhere. Although he did not formally figure these fossils or section them in his thesis studies, Alpert (1974) ascribed these ichnofossils to *Scolicia*, and suggested the *nomen provisorium*, *S. nelsoni*. At that time, *Scolicia* were thought to be formed by shell-less gastropod-like molluscs crawling or grazing horizontally on or within the substrate (see summaries in Häntzschel 1975; Smith & Crimes 1983). *Scolicia*, however, are typically preserved in convex hyporelief on bed soles and in concave epirelief on bed surfaces (Häntzschel 1975; Uchman 1995), whereas the trace fossils from the White-Inyo Mountains (noted in Alpert (1974) and described herein) are preserved in full relief and concave epirelief on bed surfaces. Furthermore, after Alpert's original studies, Smith & Crimes (1983) suggested that use of the ichnogenus *Scolicia* be restricted to traces produced by spatangoid echinoids. Uchman (1995) expanded the usage of *Scolicia* to include forms such as *Laminites, Subphyllochorda* and *Taphrhelminthopsis*, which sometimes reflect preservational variants of *Scolicia*. Given the Jurassic origination of irregular echinoids and lack of *Scolicia*-specific morphologic features, the White-Inyo ichnofossils are not *Scolicia*. In their gross surface morphology, these fossils are very similar to *Taphrhelminthopsis circularis*, except that they occur on bed surfaces, rather than on bed soles. Because the internal morphology and mode of formation of these fossils differ significantly from previously described ichnospecies, a new ichnospecies name is required.

Systematic paleontology

Specimens are reposited in the invertebrate paleontology collections (LACMIP) of the Los Angeles County Natural History Museum, under holotype number 12872. All specimens were collected from Los Angeles County Natural History Museum (LACNHM) locality number 17188, which is located in a deep northwest-trending ravine in the NE 1/4, SW 1/4, NE 1/4, section 25, T7S, R35E of the Deep Springs Lake, California 7.5 minute quadrangle, USA.