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Ichnologic Note
Asteriacites lumbricalis von Schlotheim 1820: Ophiuroid Trace Fossils from the Lower Triassic Thaynes Formation, Central Utah

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Several trace fossils of burrowing ophiuroids, *Asteriacites lumbricalis* von Schlotheim 1820, occur on slabs of thinly-bedded silty limestone in the lower Spathian part of the Lower Triassic Thaynes Formation in central Utah. This is the first record of *Asteriacites* in the Lower Triassic of North America. Their occurrence adds information to studies of the recovery of marine faunas following the Permian extinctions, including the oxygenation of benthic sediments.

Keywords: Asteriacites, ophiuroids, Lower Triassic, Thaynes Formation, Utah, extinction recovery

INTRODUCTION

Trace fossils of burrowing ophiuroids are relatively rare in the Lower Triassic, following the major extinction event at the end of the Permian. Thus, the discovery of moderately well-preserved examples of such traces in the Lower Triassic Thaynes Formation in central Utah is significant.

LOCATION AND STRATIGRAPHY

The fossiliferous beds occur in a relatively new roadcut along U.S. Highway 6–89 in Spanish Fork Canyon, in the southern Wasatch Mountains of central Utah (Fig. 1). Lower cyclic marine and nonmarine beds of the formation are exposed at approximately 580 m (1900 feet) north and 885 m (2900 feet) east of the southwest corner of Sec. 17, T. 9 S., R. 4 E., on the Spanish Fork Peak 7.5-minute quadrangle in central Utah. The productive beds are exposed 40–50 m west of the east end of a high roadcut immediately northwest of the junction of the Diamond Fork road with the highway.

The Thaynes Formation was named by Boutwell (1907, p. 448) in the Park City mining district, to the north in the Wasatch Mountains. It was mapped in the Spanish Fork Canyon area by Rawson (1957), Baker (1972), and Young (1976). The section where the trace fossils were recovered was studied by James (1980) as part of a paleoenvironmental investigation of the formation, and he provides the most detailed documentation of the immediate section. The traces were recovered in float from the section between his units 65 and 75 (Fig. 2), in a regressive platy to rippled, thin-bedded, silty limestone and siltstone sequence, above one of the thick, cherty,

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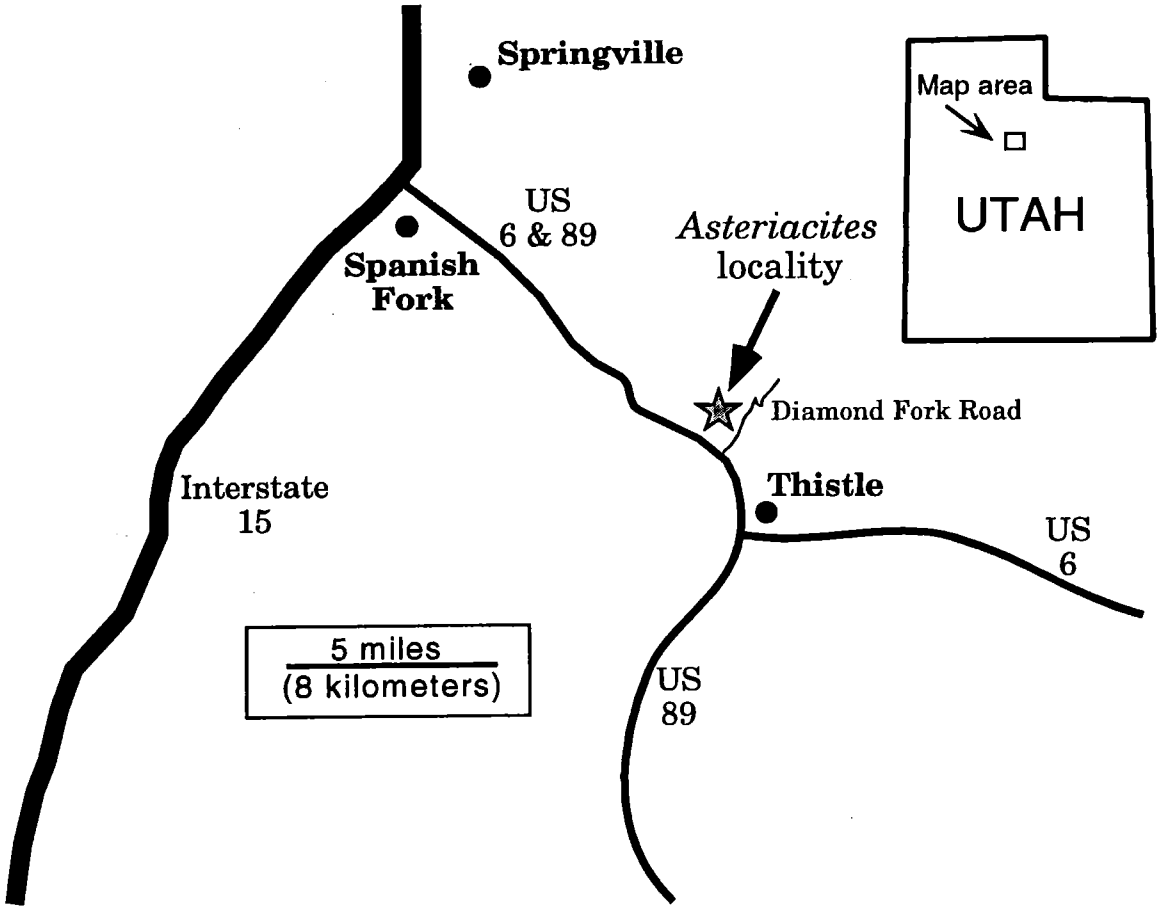

FIGURE 1 Index map for the *Asteriacites* locality in Spanish Fork Canyon, central Utah

open-marine transgressive limestones in the lower part of the formation.

Beds in which the trace fossils were found occur within uppermost Conodont Zone 11 or lowermost Conodont Zone 12, in the lower part of the Spathian-age rocks of the formation. These beds occur 18–22 m above limestones of "unit 23" (James, 1980, p. 83) that contain *Platyvillosus asperatus*, which locally marks the top of Conodont Zone 10.

SYSTEMATIC ICHNOLOGY

Specimens described here are deposited in the collections of the United States National Museum (USNM) in Washington, D.C.

Ichnogenus *Asteriacites* von Schlotheim 1820

Asteriacites von Schlotheim 1820, p. 324; non von Schlotheim, 1822, p. 71; Seilacher, 1953, see p. 93 for synonymies prior to 1953; non Chamberlain, 1971, pl. 30, figs. 11, 12; Häntzschel, 1975, fig. 26,4, see p. W42 for synonymies prior to 1975.

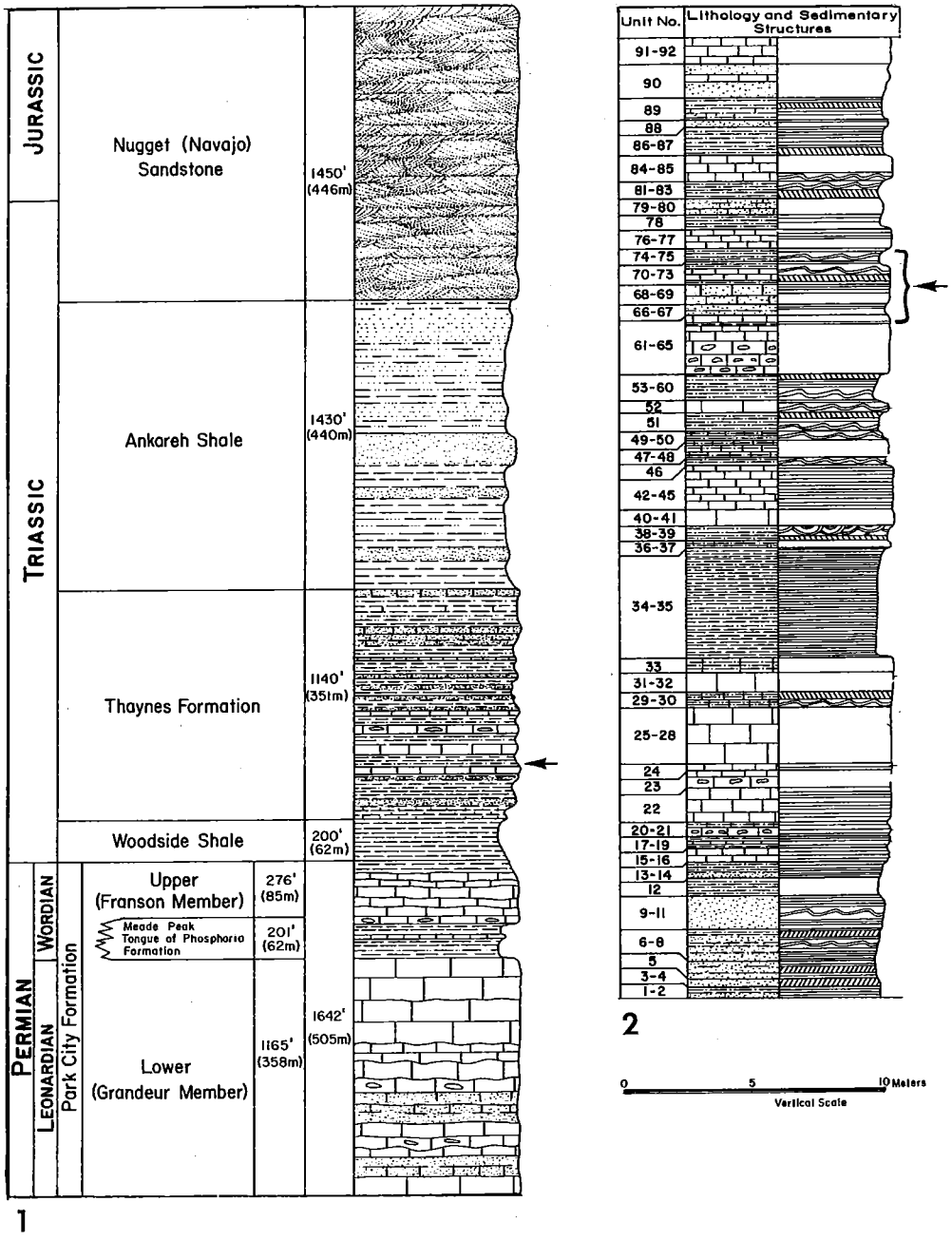

FIGURE 2 1, Stratigraphic section of upper Permian to Jurassic rocks exposed in Spanish Fork Canyon in the southern Wasatch Mountains, central Utah, showing the position of the *Asteriacites*-bearing units (arrowed) within the Lower Triassic Thaynes Formation (modified from James, 1980, fig. 2); 2, Detailed stratigraphic section of the lower part of the Thaynes Formation exposed in roadcuts along U.S. Highway 6–89 in Spanish Fork Canyon and in canyon walls in the tributary Diamond Fork Canyon. Bracket and arrow indicate beds from which *Asteriacites* traces were collected (modified from James, 1980, fig. 4)

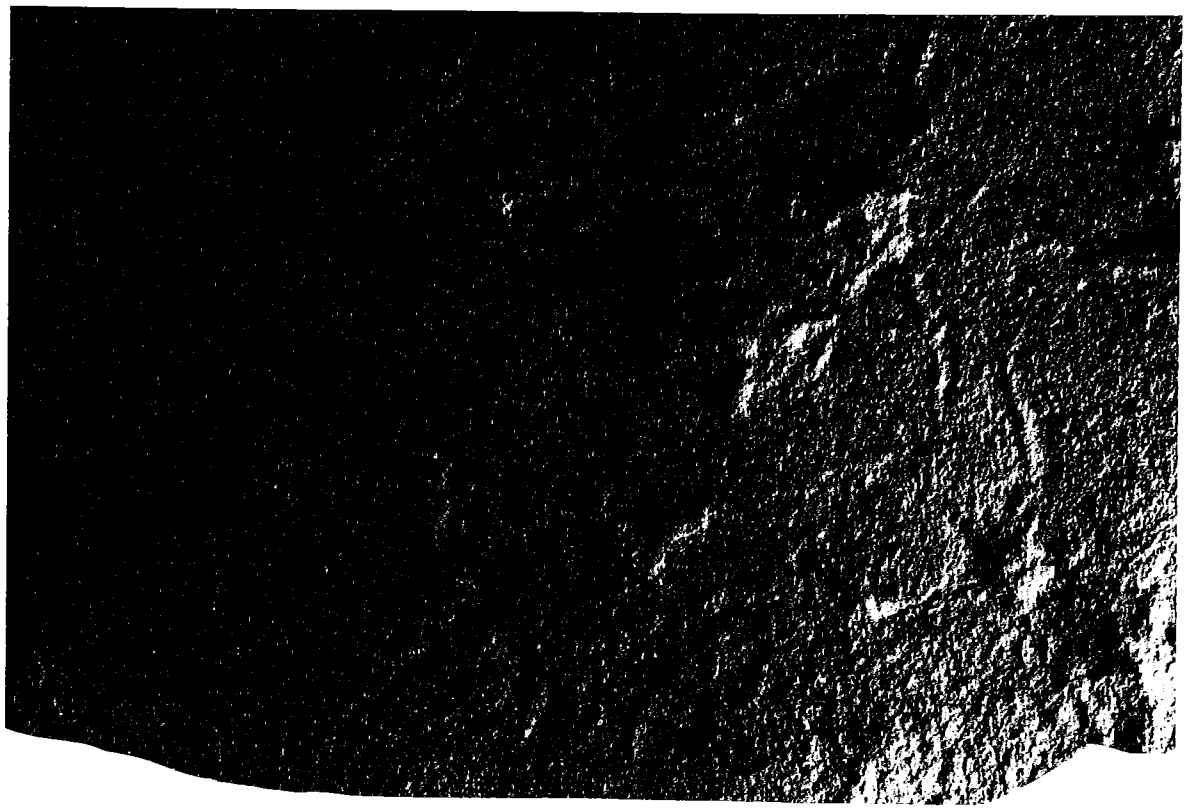

FIGURE 3 Bedding plane of the slab that includes several specimens of *Asteriacites lumbricalis* von Schlotheim, 1820. USNM 480602, from the Lower Triassic Thaynes Formation, Spanish Fork Canyon, Wasatch Mountains, central Utah, X1.65

Type Ichnospecies

Asteriacites lumbricalis von Schlotheim 1820 by subsequent designation (Seilacher, 1953, p. 93).

Diagnosis

Stellate trace fossils in the form of asteroid or ophiuroid echinoderms; often but not always with transversely sculptured arms (after Seilacher, 1953; Häntzschel, 1975).

Asteriacites lumbricalis von Schlotheim 1820; Seilacher, 1953, pls. 7–9, see p. 94 for synonymies prior to 1953; non Chamberlain, 1971, pl. 30, figs. 11,12; Häntzschel, 1975, fig. 26,4; Mikulás, 1990, figs. 2,3; Twitchett and Wignall, 1996, fig. 3a; Wilson, 1997, fig. 3.

Diagnosis

Asteriacites with transverse striations on the arms (Seilacher, 1953).

Description

Star-shaped traces 3.8 to 5.6 cm in longest dimensions (arm tip to arm tip); five arms projecting outward from a central area; central area circular or star-shaped, 0.8 to 1.0 cm in diameter;

arms gently curved, decreasing in width from approximately 0.3 cm at their bases to pointed or truncated tips; some arms have faint transverse striations; surface texture of traces same as surrounding matrix (silt particles); preserved as convex hyporelief and concave epirelief.

Material

USNM specimens 480602 and 480603, part and counterpart.

Occurrence

Thaynes Formation (Lower Triassic, Spathian), units 65–75, uppermost Conodont Zone 11 or lowermost Conodont Zone 12 (James, 1980, p. 83); Spanish Fork Canyon, Wasatch Mountains, central Utah.

Canyon, Wasatch Mountains, central Utah.

Discussion

Seilacher (1953) recognized two ichnospecies of *Asteriacites*. *A. lumbricalis* von Schlotheim, 1822, is the smaller of the two, with narrow arms showing transverse striations, apparently made by the tube feet of ophiuroids as they burrowed into the sediment. *A. quinquefolius* (Quenstedt, 1876) is generally the larger form with broader arms and a "shaggy" (zottig) appearance rather than with transverse striations. Seilacher (1953) considered *A. quinquefolius* to be more likely the trace of asteroids rather than ophiuroids. Osgood (1970) removed *A. stelliforme* (Miller and Dyer, 1878) from synonymy with *A. lumbricalis*, where Seilacher (1953) had previously placed it. *A. stelliforme* is characterized by chevron-shaped striations and broad arms, distinguishing it from the other two ichnospecies. The trace fossils from the Thaynes Formation described here easily fit within Seilacher's (1953) original definition of *Asteriacites lumbricalis*. They have relatively narrow arms and faint striations.

Asteriacites lumbricalis is readily interpreted as the work of burrowing ophiuroids. Not only does the trace closely resemble the morphology of a typical ophiuroid, but also its transverse striations are what would be expected from the burrowing action of tube feet. In addition, ophiuroid body fossils have been found associated with *Asteriacites lumbricalis* in the Ordovician of Czechoslovakia (Mikulás, 1990) and the Carboniferous of North America (West and Ward, 1990).

ASTERIACITES AND THE TRIASSIC RECOVERY FAUNA

The Early Triassic was a critical time in the history of life as the biosphere recovered from the mass extinction at the end of the Permian. The end-Permian event is estimated to have caused the extinction of up to 90% of marine genera (Erwin, 1993). Life began to slowly rediversify during the Early Triassic. The patterns of this Triassic recovery may reveal not only the mechanisms by which entire ecosystems respond to dramatic changes, but also constrain the possible causes of the mass extinction itself (Erwin, 1993, 1994).

The Triassic Recovery in the shallow seaways of the Western Interior was "slow and incomplete" (Bottjer and Schubert, 1997, p. 17). Diversity levels were low throughout the North American Early Triassic, with most communities represented by species-poor groups of bivalves and crinoids, with even sparser gastropods, brachiopods and echinoids. Paleoecological analyses show a steady recovery of guild structures through the Early Triassic record, but ecological diversity is still far below Permian and later Triassic and Jurassic levels (Schubert and Bottjer, 1995; Bottjer et al., 1996). This paper records the first evidence of asterozoans in the Early Triassic of North America, thus adding to the paleoecological data for the biotic recovery.

The slowly changing marine communities in western North America are recorded in a series of transgressions through the seaways, each leaving shallow marine sediments, particularly limestones. The Dinwoody Formation of Montana, Wyoming, Idaho and north-central Utah was deposited by the first of these transgressions in the Griesbachian (Carr and Paull, 1983). The lower parts of the Moenkopi and Thaynes formations were deposited during the Nammalian transgression throughout the western interior. The part of the Thaynes Formation which contains the ophiuroid trace fossils described here was formed during the early part of the third transgression, that of the Spathian.

The earliest global record of Triassic *Asteriacites* is described by Twitchett and Wignall (1996) from the "Gastropod Oolite Member" of the Werfen Formation in the Dolomites of northern Italy. These traces (*A. lumbricalis*) are found in mid-ramp storm sands deposited during the Nammalian, and thus they slightly predate the *Asteriacites* of this paper. The only other confirmed record of Triassic *Asteriacites* is the description of *Asteriacites* sp. from the Upper Middle Triassic (Upper *Ceratite* Beds) in Thuringia, Germany (Müller, 1980). Hess (1983, p. 513) found *Asteriacites* (again, *A. lumbricalis*) in the usually unfossiliferous sandstone "Prebichl-Beds" of "Permoskythan" age in Austria. Although Hess (1983) suggested that these fossils were earliest Triassic, their stratigraphic position below the Werfen Formation makes them more likely to be latest Permian. The earliest fully-documented Triassic ophiuroid body fossils thus far are of *Praeaplocoma hessi*_found in the Lower Triassic (Werfenian) Costabella Group in the Dolomites of northern Italy (Broglio-Loriga and Berti-Cavicchi, 1972). Schubert and Bottjer (1995) noted but did not describe or collect an ophiuroid from the Virgin Limestone Member of the Moenkopi Formation in southern Utah, which would be approximately the same Early Triassic (Spathian) age as the *Asteriacites* here described from the Thaynes Formation.

Asteriacites and other trace fossils are typically used to indicate normal marine depositional conditions with full oxygenation (Müller, 1980; Mikulás, 1992; Twitchett and Wignall, 1996). Since widespread oceanic anoxia has been suggested as one of the causes of the Permian extinctions (Erwin, 1994), the occurrence of *Asteriacites* in the lower part of the Thaynes Formation may be useful for constraining the duration and extent of this anoxia in western North America.

Acknowledgements

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