



Unusual trace fossil assemblage from the upper Cretaceous Paguate Member of the Dakota formation in the Ojito Wilderness, Sandoval County, New Mexico

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UNUSUAL TRACE FOSSIL ASSEMBLAGE FROM THE UPPER CRETACEOUS PAGUATE MEMBER OF THE DAKOTA FORMATION IN THE OJITO WILDERNESS, SANDOVAL COUNTY, NEW MEXICO

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ABSTRACT—A slab of sandstone of the Upper Cretaceous (Cenomanian) Paguate Member of the Dakota Formation has a highly unusual ichnoassemblage preserved on the surface. The traces are: (1) abundant *Thalassinoides* that form branching, polygonal networks; (2) several trails of *Cruziana*; (3) four specimens of *Zoophycos*; and (4) an area with undertracks of the horseshoe crab walking trace *Kouphichnium*. Some *Thalassinoides* crosscut *Cruziana* and one of the *Zoophycos* traces, so this suggests at least two episodes of trace formation. This ichnoassemblage from the Paguate Member clearly was preserved in a shallow, well-oxygenated marine setting at or slightly above wave base. Indeed, the assemblage can readily be assigned to the *Cruziana* ichnofacies, which is characteristic of shallow marine settings. Nevertheless, *Zoophycos* has long been accepted as an indicator of deep and/or poorly oxygenated marine waters, so it is “out of place” among traces typical of the *Cruziana* ichnofacies. The Paguate ichnoassemblage thus presents evidence that *Zoophycos* is a facies-crossing ichnotaxon that should not be associated with an archetypal ichnofacies.

DESCRIPTION AND DISCUSSION

The Dakota-Mancos succession of Upper Cretaceous (Cenomanian) strata in the southeastern San Juan Basin represents deposition of relatively shallow marine sands (Dakota members) and offshore muds (Mancos members; e.g., Molenaar, 1983; Sealey and Lucas, 2019). The two thick, shallow marine sandstone members of the Dakota, the Cubero and Paguate, are extensively bioturbated, mostly by the well-known crustacean burrows *Ophiomorpha* and *Thalassinoides*. Here we report an extremely unusual trace-fossil assemblage (ichnoassemblage) from the Paguate Member in the Ojito Wilderness Area near San Ysidro in Sandoval County. This ichnoassemblage is on the top bedding plane of a 0.1- to 0.3-m-thick sandstone bed. The sandstone is medium-grained and quartzose and has symmetrical ripples on the trace-fossil-bearing surface (Fig. 1A). It is from a stratigraphic level ~3 m above the base of the Paguate Member.

Four ichnogenera of traces (we do not attempt ichnospecific identifications here) are present:

- 1) Abundant *Thalassinoides* (Fig. 1A, B) that have the characteristic morphology of cylindrical, unlined burrows with structureless fill that are parallel to the bedding and have Y- or T-shaped branches (e.g., Howard and Frey, 1984). They form horizontal networks or polygons on the bedding plane (no vertical tubes are present). Burrow courses are as long as 80 cm, and burrow diameters are 0.8 to 1.7 cm.
- 2) Several trails of *Cruziana* (Fig. 1C), a well-known arthropod locomotion trace that is a bilaterally symmetrical, straight to sinuous trail with a medial furrow flanked by raised, serial ridges that are oblique to transverse in relation to the furrow (e.g., Keighley and Pickerill, 1996). Trail courses are as much as 15 cm long, and widths are 0.5 to 0.7 cm.

- 3) Undertrack fallout of the horseshoe crab walking trace *Kouphichnium* (Fig. 1D). These are scratch marks, some bifid, that are often parallel to each other and measure 4 to 7 mm long. Such scratch marks are a common extramorphological variant of *Kouphichnium* trackways (e.g., Goldring and Seilacher, 1971; King et al., 2019).
- 4) Four specimens of *Zoophycos*, a well-known feeding trace likely produced by an annelid worm (Fig. 1A, E, F). The *Zoophycos* in the Paguate Member are relatively simple, planar forms that are spirally coiled with a large, vertical axial tunnel and spreiten on the lobes. Maximum diameters range from 17.5 to 22 cm. They are readily assigned to the *Zoophycos* group of traces (e.g., Miller, 1991; Zhang et al., 2015).

On the Paguate bedding plane, some *Thalassinoides* crosscut *Cruziana* and one of the *Zoophycos* traces, so this suggests at least two episodes of trace formation. This ichnoassemblage from the Paguate Member clearly was preserved in a shallow, well-oxygenated marine setting at or slightly above wave base. Indeed, the assemblage can readily be assigned to the *Cruziana* ichnofacies, which is characteristic of shallow marine settings (e.g., Buatois and Mángano, 2011).

CONCLUSIONS

Zoophycos gave its name to an archetypal ichnofacies traditionally associated with deep, poorly oxygenated sea bottoms (Seilacher, 1967), although the paleoenvironments in which the namesake ichnotaxon occurs have shifted through time (Ekdale, 1988; Miller, 1991). *Zoophycos* commonly occurs in shallow-water facies during the Paleozoic, but it became primarily a deep-sea trace from the Mesozoic onward (e.g., Miller, 1991; Zhang et al., 2015). Therefore, *Zoophycos* is known from different depositional environments ranging from

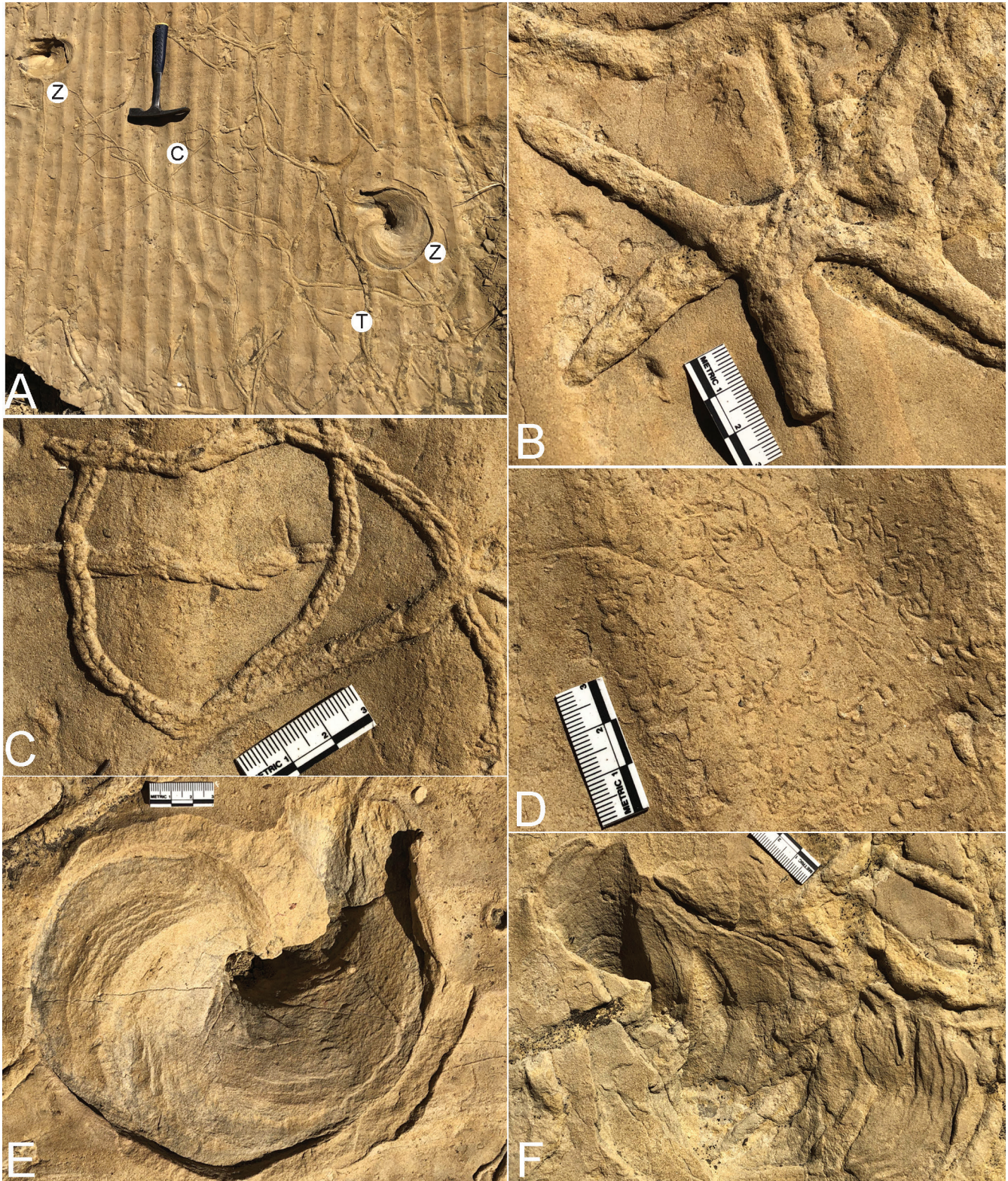


FIGURE 1. Unusual ichnoassemblage in the Cretaceous Paguate Member of the Dakota Formation, Ojito Wilderness Area, Sandoval County, New Mexico. (A) Overview of much of the trace-bearing sandstone; C = *Cruziana* trails; T = *Thalassinoides* networks; Z = *Zoophycos*. (B) Close-up of representative *Thalassinoides*. (C) Close-up of representative *Cruziana*. (D) Close-up of representative *Kouphichnium* undertrack fallout. (E), (F) Close-ups of two specimens of *Zoophycos*. Traces in A and D–F are preserved in concave epirelief, whereas traces in B and C are preserved in convex hyporelief. Rock hammer in A is 28 cm long. The other scale bars are in mm and cm.

the shelf (sublittoral) to the deep sea (bathyal), so it is present in different lithofacies. The Paguate ichnoassemblage thus presents further evidence that *Zoophycos* is a facies-crossing ichnotaxon that should not be associated with an archetypal ichnofacies.

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View of tan/yellow sandstones of the Paguate Member of the Dakota Formation above gray, shale-dominated slopes of the Clay Mesa Member of the Mancos Formation in the Ojito Wilderness along Pipeline Road near San Ysidro. *Photo by Spencer G. Lucas*