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PALEONTOLOGY OF NONMARINE CRETACEOUS—NOT MARINE TRIASSIC—LIMESTONE IN THE SALT ANTICLINE, SOUTHEASTERN UTAH

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Abstract—A thin limestone in the Salt Valley, northeast of Moab, Utah, was assigned to the Early Triassic Sewemup Member of the Moenkopi Formation based on the supposed presence of juvenile specimens of the Smithian ammonoid *Meekoceras*. Most workers view this outcrop as the easternmost extent of the Sinbad Formation, and thus the eastern limit of the Smithian seaway. We collected silicified micro- and macrofossils from this unit. The planorbid freshwater gastropod *Gyraulus veternus* superficially resembles juvenile specimens of *Meekoceras*, and dominates the assemblage. Other macrofauna includes the gastropods *Reesidella, Mesopyrgium, Physa* and *Zaptychius?* and the bivalve *Unio?*. Microfossils are the charophytes *Atopochara trivolvis* and cf. *Obtusochara* and the ostracods *Cypridea compta, Bisulcocypris persulata* and *Cyclocypris?*. These fossils are clearly of freshwater origin and indicate an Early Cretaceous (Aptian) age. Age and lithology suggest the limestone in the Salt Valley is in the Cedar Mountain Formation. The easternmost extent of the Sinbad Formation is along the Colorado River in the Canyonlands, 39 km southwest of the Salt Valley.

INTRODUCTION

The eastern limit of the Lower Triassic Sinbad Formation (Thaynes Group) has long been been placed in the Salt Valley northeast of Moab in T22S, R20E, Grand County, Utah (e.g., Blakey et al., 1993, fig. 8) (Fig. 1). This is because Dane (1935) and Shoemaker and Newman (1959) identified a thin limestone there as Sinbad based on the putative presence of juvenile *Meekoceras*, an index ammonoid of Smithian time. We relocated and collected fossils from this limestone and determined that the *"Meekoceras"* specimens are actually nonmarine gastropods of the genus *Gyraulus*. In addition, the limestone contains other gastropods, bivalves, charophytes and ostracods that confirm it is of nonmarine origin and of Early Cretaceous age. Biostratigraphy and lithostratigraphy indicate this limestone is part of the Lower Cretaceous Cedar Mountain Formation, not the Sinbad Formation. The eastern extent of the Sinbad Formation thus is not in the Salt Valley, but 39 km to the southwest in the Canyonlands, so paleogeographic maps of the Early Triassic Sinbad sea need revision. NMMNH refers to the New Mexico Museum of Natural History and Science, Albuquerque.

PREVIOUS STUDIES

Dane (1935, p. 43) first reported supposed marine Triassic fossils from the Salt Valley. He stated that McKnight collected these fossils from "sandy shales in Salt Valley" but provided no more precise provenance. Dane (1935, p. 43) quoted G. H. Girty as follows:

> This lot [from McKnight's locality] contains trails, plant fragments, and enigmatic objects of several sorts. Aside from these I find only one fossil type of any significance—concentrically coiled shells that occur in considerable abundance. Although none of the specimens collected shows sutures or other diagnostic structures, it seems highly probable not only that these are cephalopods but that they are ammonoids rather than nautiloids. Smooth ammonoids of the same general appearance are rather characteristic of the Lower Triassic of this region. This fact, together with the absence of any Paleozoic types of fossils and other attendant circumstances leads me to believe that the horizon is Lower Triassic.

In 1959, Shoemaker and Newman revised the stratigraphy of the Triassic Moenkopi strata of the Salt Anticline region of Utah-Colorado. They reported Triassic ammonites from a thin limestone in the Salt Valley that were identified by J. B. Reeside, Jr., and were of the opinion that this was the same locality mentioned by Dane (1935). (Note that Dane's collections may have come from float, hence his description of the fossiliferous stratum as "sandy shales" rather than limestone). Shoemaker and Newman (1959, p. 1849) quoted Reeside as follows:

> The specimen from the Salt Valley anticline in T. 22, 23 N., R. 19, 20 E., Grand County, Utah (USGS Mesoz. loc. 23869) contains an abundance of juvenile ammonites and gastropods. The ammonites appear to be *Meekoceras*, though too small for certain determination. The combination is widespread in the Sinbad Member of the Moenkopi Formation and not known at any other level in the region. It can be placed with great confidence in the Lower Triassic.

Records kept by the U.S. Geological Survey in Reston, Virginia, give no more precise information about USGS Mesozoic locality 23869. They list

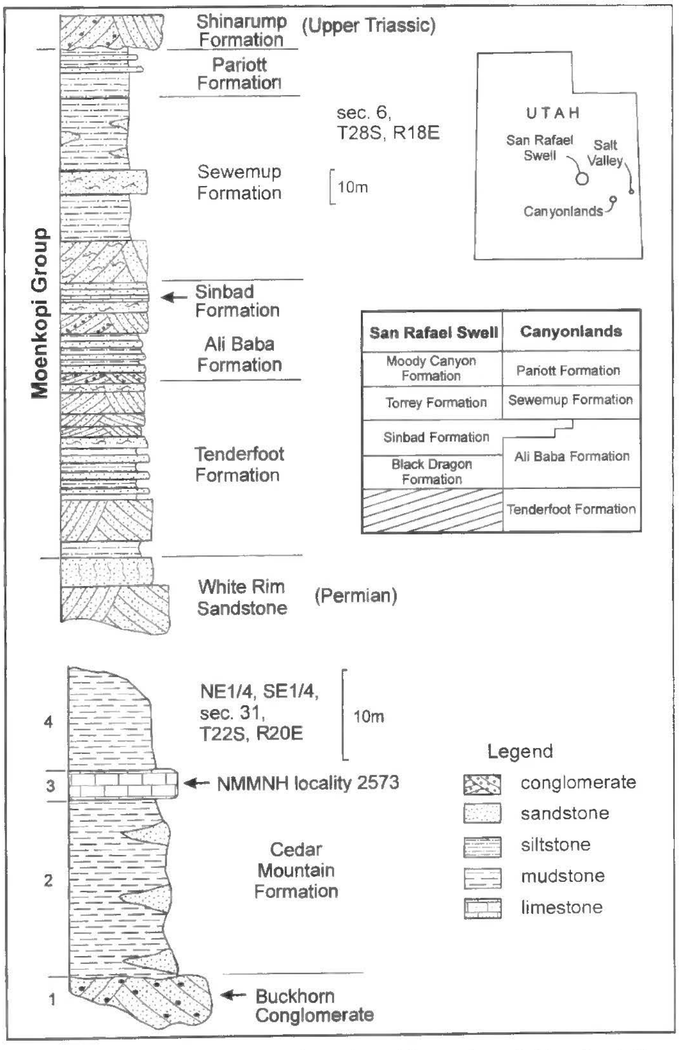

FIGURE 1. Index map, measured stratigraphic section of Moenkopi Group strata at Steer Mesa in the Canyonlands (sec. 6, T28S, R18E), correlation of Moenkopi Group formations between the San Rafael Swell and Canyonlands, and stratigraphic section at NMMNH locality 2573. See Appendix for description of stratigraphic section.

only "lowermost part of Salt Valley anticline, in T. 22 and 23 N., R. 19 and 20 E., Grand County, Utah—same as locality recorded by E. T. McKnight" (L. Wingord, written commun., 1997).

Stewart et al. (1972) and Blakey (1974) used this record to infer that the Sewemup Member of the Moenkopi Formation contains the eastward extent of the Sinbad transgression. The Sinbad represents the maximum flooding of the Pangean western shoreline during the early Smithian (Goodspeed, 1996).

STRATIGRAPHY

NMMNH locality 2573 is in the NE1/4 SE1/4 sec. 31, T22S, R20E, Grand County, Utah, at UTM 4300920N, 609275E, Zone 12 (Fig. 1). It is in a 2.8-m-thick yellowish brown limestone that forms a ledge in a green, bentonitic mudstone slope (Fig. 1). The limestone is 21 m stratigraphically above a 5+-m-thick conglomerate with clasts of black and gray chert and quartzite.

Doelling (1985) mapped the strata including and around NMMNH locality 2573 as Cedar Mountain Formation. Young (1960, fig. 6) illustrated a measured section of the Cedar Mountain Formation nearby in sec. 28, T22S, R20E. In this section, a similar conglomerate ("Lower Cedar Mountain sandstone" of Young [1960]; = Buckhorn Conglomerate Member of Stokes [1944, 1952]) is overlain by green mudstone of the upper part of the Cedar Mountain Formation. Therefore, we are confident that NMMNH locality 2573 is a limestone bed in the Cedar Mountain Formation.

We collected bulk samples of the limestone at NMMNH locality 2573. The samples were broken down in 1–15% glacial acetic acid, and the residues were sieved. They yielded silicified fossils of charophytes, ostracods, and molluscs (gastropods and bivalves).

PALEONTOLOGY

Here, we provide a preliminary description of the fossils recovered from the acid residues.

Charophytes

***Atopochara trivolvis* Peck, 1938** (Fig. 2A–C)

The most common charophyte from locality 2573 is represented by 30 specimens. These specimens are medium-sized utricles with approximately equal lengths and widths (about 800μm). They are trihedral, consisting of three units of 12 cells each, and have a circular basal opening and a circular apical opening surrounded by three cells. They closely resemble specimens of *Atopochara trivolvis* Peck, to which they are assigned (see, for example, Feist and Grambast-Fessard, 1982; Soulié-Märsche, 1994, fig. 5.2). *A. trivolvis* is considered an Aptian index fossil (e.g., Soulié-Märsche, 1994; Feist and Wang, 1995; Riveline et al., 1996). It is widely known from the Lower Cretaceous of North America, including Aptian records in Canada, South Dakota, Montana, Idaho, Wyoming, Florida and Texas (Peck, 1941, 1957; Loranger, 1957; Peck and Craig, 1962; Soulié-Märsche, 1994).

cf. *Obtusochara* sp. (Fig. 2D)

A dozen small (about 500–700 μm long and 440–500 μm long) gyrogonites of psilocharoid morphology have a nearly flat (but not depressed) apex and spiral cells that meet each other. In these features they closely resemble *Obtusochara* Mädler, 1952 (Peck, 1957, pl. 6, fig. 1–8; Peck and Craig, 1962, pl. 1, fig. 27). However, as Peck (1957) and Feist and Grambast-Fessard (1982) pointed out, the status of this genus is problematic; some species previously assigned to *Obtusochara* belong in *Chara* and others in *Lamprothanium* (also see Soulé-Märsche, 1994). The specimens from locality 2573 lack a depressed apex, so they are not *Lamprothanium*. However, until the taxonomy of *Obtusochara* is clarified, we only tentatively refer our material to the genus. Charophytes like these, generally assigned to *Obtusochara*, are known from the Lower Cretaceous of Wyoming (Peck, 1941, 1957).

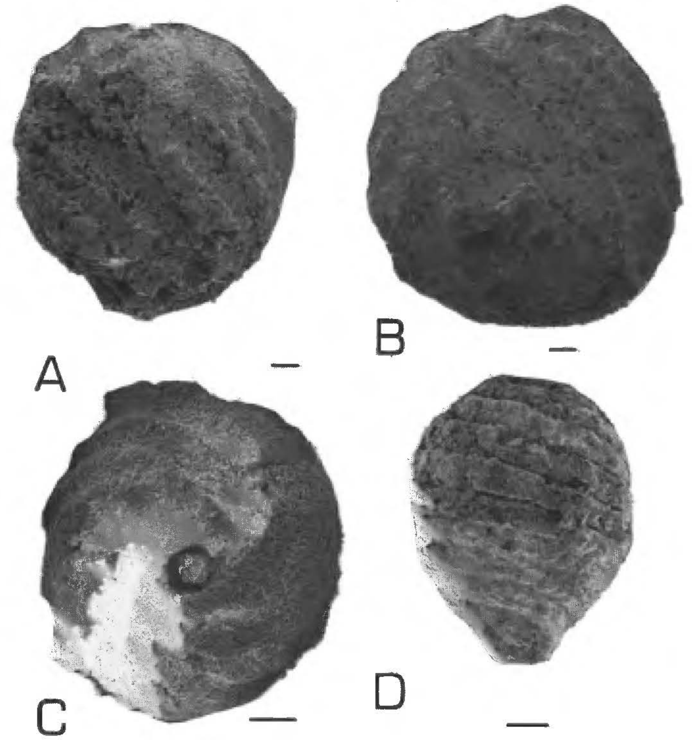

FIGURE 2. Selected charophytes from NMMNH locality 2573. A–C, *Atopochara trivolvis* Peck, NMMNH P-20832, lateral, abapical and apical views. D, cf. *Obtusochara* sp., NMMNH P-20828, lateral view. Bar scales = 100 μm.

Ostracods

***Cypridea compta* Peck, 1941** (Fig. 3A–B)

Twenty specimens are present. In lateral view they are nearly subrectangular, with a pronounced rostrum at the anterior ventral margin. The dorsal and ventral margins are straight to very slightly convex. The anterior and posterior margins are rounded; the anterior more abruptly than the posterior. In dorsal view they are wedge shaped, tapering anteriorly and posteriorly, but more abruptly to the posterior. Posterior and anterior ends are separated by a sulcus. Prominent spine molds are present on the slightly inflated posterior central region with another smaller spine slightly farther to the posterior and closer to the dorsal margin. Greatest width is at the prominent spines.

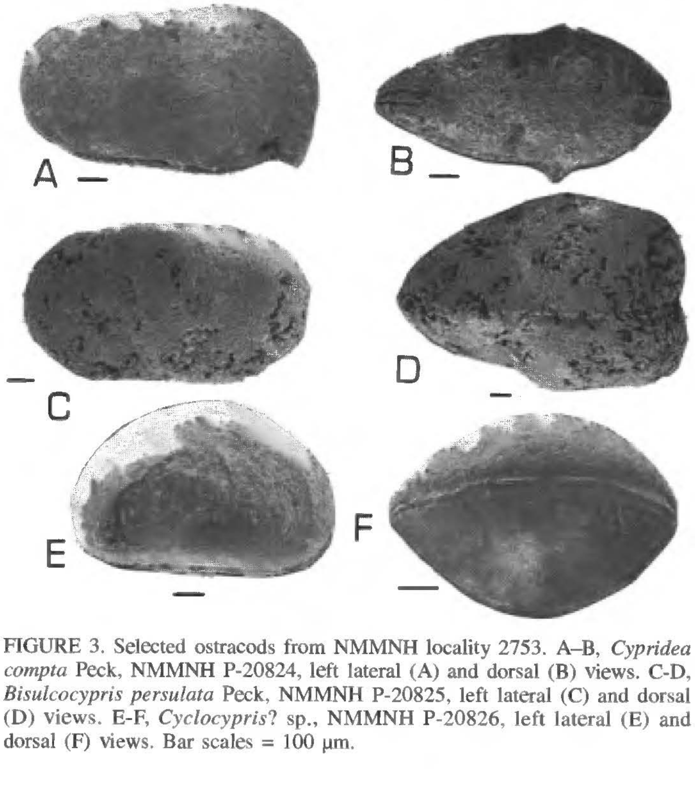

FIGURE 3. Selected ostracods from NMMNH locality 2753. A–B, *Cypridea compta* Peck, NMMNH P-20824, left lateral (A) and dorsal (B) views. C-D, *Bisulcocypris persulata* Peck, NMMNH P-20825, left lateral (C) and dorsal (D) views. E-F, *Cyclocypris*? sp., NMMNH P-20826, left lateral (E) and dorsal (F) views. Bar scales = 100 μm.

The well developed lateral spines help identify this ostracod despite its poor preservation due to silicification. It differs little from specimens of *Cypridea compta* from the Cretaceous Bear River Formation of Wyoming (Peck, 1941).

***Bisulcocypris persulata* (Peck, 1941)** (Fig. 3C–D)

Two silicified steinkerns have valves that are suboval in lateral view with a straight dorsal margin, convex ventral margin and rounded anterior and posterior margins. The posterior is highly inflated, and the anterior is slightly inflated, so they are separated by a weak sulcus. This ostracod is wedge shaped in dorsal view with a subrectangular posterior end. The posterior margin is abruptly rounded; greatest width and height are near midpoint. No surface features (nodes or spines) are present.

The distinctive shape in dorsal view separates this species from most others. The morphologically closest named species (note especially the shape in dorsal view and lack of nodes or spines) is *Bisulcocypris persulata* from the Lower Cretaceous Draney Limestone (Gannett Group) of Wyoming (Peck, 1941).

***Cyclocypris?* sp.** (Fig. 3E–F)

Five steinkerns are suboval with a strongly convex dorsal margin and a slightly convex ventral margin. The anterior and posterior margins are rounded. In dorsal view, the valves are wedge shaped, tapering to the anterior and posterior from the inflated convex lateral margins. The posterior tapers more abruptly than the anterior. There is no surface ornamentation.

The identity of these ostracods is uncertain. They are similar to *Cyclocypris* sp. from the Lower Cretaceous but differ in having a more tapered anterior in dorsal view and being less symmetric in lateral view.

Gastropods

***Gyraulus veternus* (Meek and Hayden, 1864)** (Fig. 4A–B)

The most common fossils from locality 2573 are specimens of a planispiral gastropod represented by more than 50 shells. These appear to have been misidentified by Girty and Reeside as juvenile Triassic ammonoids, possibly *Meekoceras*. However, these shells lack any sutures or septa dividing chambers. They clearly are gastropod, not cephalopod. They closely resemble specimens of *Gyraulus veternus* from the Morrison Formation (Yen and Reeside, 1946, figs. 6a–b; Yen, 1952, pl. 6, figs. 20a–l) and *Gyraulus* cf. *G. veternus* from the Kootenai Formation of Montana (Yen, 1951, pl. 1, figs. 15a–c).

***Reesidella* sp. (Yen and Reeside)** (Fig. 4E)

The second most common gastropod at locality 2573 is assigned to *Reesidella* (= *Amnicola*) sp. About 20 shells are obvately oblong with a

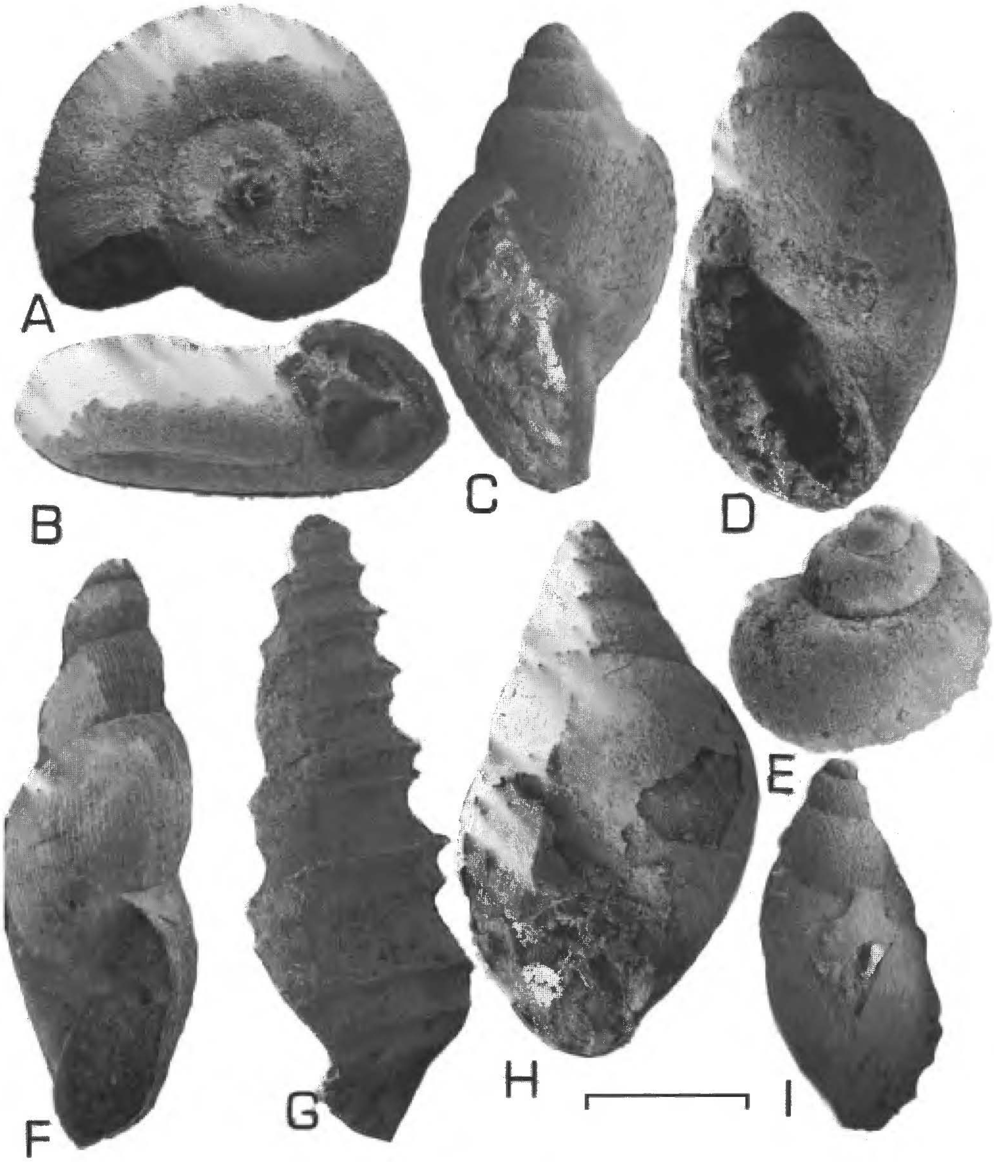

FIGURE 4. Selected gastropods from NMMNH locality 2573. A–B, *Gyraulus veternus* (Meek and Hayden), NMMNH P-20834. C, *Physa* sp., NMMNH P-20837. D, *Physa* sp., NMMNH P-20838. E, *Reesidella* sp. (Yen and Reeside), NMMNH P-20839. F, *Zaptychius*? sp., NMMNH P-20815. G, *Mesopyrgium pendilabium*, NMMNH P-20803. H, *Physa* sp., NMMNH P-20807. I, *Physa* sp., NMMNH P-20836. Scale bar = 1000 μm.

spire and body whorl of nearly equal height. The apex is small, the whorls expand rapidly and are slightly shouldered with deeply impressed sutures, and the aperture is pyriform (Yen and Reeside, 1946, fig. 2A). The specimens apparently are *Reesidella* but are too low spired to be assigned to *R. gilloides* (Yen and Reeside).

***Mesopyrgium pendilabium* (Yen and Reeside, 1946)** (Fig. 4G)

About 12 specimens are present. The highly turreted spire and the two spiral carinae on the periphery of later whorls are diagnostic characteristics (Yen and Reeside, 1946, p. 56, fig. 4). This species is well known from the Morrison Formation (Yen and Reeside, 1946; Yen, 1952), but this is the first record from Lower Cretaceous strata.

***Physa* spp.** (Fig. 4C–D, H–I)

Physa also is a common gastropod in the assemblage, being represented by 20 specimens. These shells are sinistral and relatively narrowly to broadly fusiform in outline. They have a relatively short, conical spire, well impressed sutures so that the whorls are slightly shouldered, and whorls that rapidly increase in size. These specimens clearly belong to *Physa* (MacNeil, 1939, pl. 37, fig. 15; Yen and Reeside, 1946, figs. 8–9; Yen, 1951, pl. 2, figs. 14–16), and the sample from locality 2573 encompasses a range of variation that includes more than one species. We avoid a species-level assignment pending further study.

***Zaptychius?* sp.** (Fig. 4F)

This distinctive snail is represented by 12 shells that are dextral and slender with a high spire. They have compressed whorls that are barely convex with a surface of fine transverse ribs; the aperture is narrow and elongate. These specimens somewhat resemble *Zaptychius haldemani* (White, 1895, pl. 5, figs. 8–9; Yen and Reeside, 1946, fig. 5), but they are not as narrow nor as loosely coiled, they have more convex whorls and their whorls are not higher than wide. Therefore, the specimens from NMMNH locality 2573 are not *Z. haldemani* and may not even be *Zaptychius*. However, they are tentatively referred to that genus for lack of an obvious alternative. These specimens probably are a new taxon.

Bivalves

***Unio?* sp.**

Three small bivalves are tentatively assigned to *Unio*.

CORRELATION AND PALEOGEOGRAPHIC SIGNIFICANCE

We are certain that NMMNH locality 2573 is the same site reported by Dane (1935) and Shoemaker and Newman (1959) because:

1. The location of the site is in the Salt Valley near the corner of T22–23S, R19–20E, and this matches the locality data of Dane and Shoemaker and Newman, and locality data on file with the U.S. Geological Survey.
2. The light yellowish brown color of the fossiliferous beds matches the description of Shoemaker and Newman.
3. The abundance of the gastropod *Gyraulus*, which we believe was mistaken for juvenile *Meekoceras*, also matches the descriptions of earlier workers.
4. A search by us and by R. Paull (oral commun., 1996) throughout this area failed to locate any other fossiliferous stratum that could match the original descriptions.

The micro- and macrofossils from locality 2573 indicate that the original identification of the Lower Triassic Sinbad Formation in the Salt Valley is incorrect. The strata assigned to the Sinbad belong to the Lower Cretaceous Cedar Mountain Formation, which has a well established age of Barremian to Albian (e.g., Lucas, 1992; Aubrey, 1996; Kirkland et al., 1997a, b). As Lucas (1995) concluded, the eastern extent of the Sinbad Formation is in the Canyonlands in the Holeman Spring Basin (T28S, R18E), as McKnight (1941) documented (Fig. 1).

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APPENDIX—MEASURED STRATIGRAPHIC SECTION

Section measured at NMMNH locality 2573. Strata dip 20° to N60°E. Strata here are exposed on a rounded hill in the center of a breached anticline.

unit	lithology	thickness
4	Mudstone; sand, bentonitic; pale olive (10 Y 6/2); contains limestone nodules that are pale yellowish orange (10 YR 8/6); forms a slope.	12+
3	Limestone; micritic wackestone to packstone; moderate yellowish brown (10 YR 5/4); forms a ledge; NMMNH locality 2573.	2.8
2	Mudstone and silty sandstone; mudstone same color and lithology as unit 4; sandstone is very pale orange (10 YR 8/2), very fine grained, subangular, well sorted and quartzose; it forms lenses and is ripple laminated and bioturbated; mudstone contains numerous light olive gray (5 Y 6/1) limestone nodules up to 25 cm in diameter; unit forms a slope.	21.0
1	Sandstone and conglomeratic sandstone; sandstone is white (N9) and moderate yellowish brown (10 YR 5/4), fine- to medium-grained, moderately sorted, subrounded litharenite; conglomerate clasts are mostly black and gray chert and quartzite up to 1.5 cm diameter; trough crossbedded and ripple laminated; forms a bench.	4.5

These steinkerns (natural casts) of freshwater unionid bivalves are in a bed of the Upper Jurassic Salt Wash Member of the Morrison Formation at Recapture Creek, near Bluff, Utah.