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TETRAPOD FOOTPRINTS FROM THE MIDDLE TRIASSIC (PEROVKAN-EARLY ANISIAN) MOENKOPI FORMATION, WEST-CENTRAL NEW MEXICO

SPENCER G. LUCAS, ANDREW B. HECKERT AND ADRIAN P. HUNT
New Mexico Museum of Natural History, 1801 Mountain Rd NW,
Albuquerque, NM 87104

ABSTRACT.—Tetrapod footprints from a locality near Prewitt, Cibola County, New Mexico, are in the lower part of the Anton Chico Member of the Moenkopi Formation. These Perovkan age (early Anisian) footprints represent three tetrapod ichnotaxa: swimming traces, *Chirotherium* and *Therapsipus*. These New Mexican Moenkopi tracks are part of a Euaramerican *Chirotherium* ichnofauna of Early-Middle Triassic age. They also reaffirm that the tetrapod ichnofauna of the Moenkopi Formation, which is archosaur and dicynodont dominated, is sampling a different vertebrate fauna than the temnospondyl-dominated body fossil assemblages of the unit.

INTRODUCTION

Tetrapod footprints have long been known from the Triassic Moenkopi Formation in Arizona, and Peabody (1948) described them in a now classic monograph. In 1988, one of us (SGL) discovered tetrapod footprints in the Moenkopi Formation of west-central New Mexico. Lucas and Hayden (1989, p. 194, fig. 4d) mentioned this occurrence, illustrated "reptile swimming traces," and noted that the ichnofauna is dominated by a "large-manus *Chirotherium*." Hunt and Lucas (1993) briefly described and illustrated some tracks from the locality, attributing them to a new ichnotaxon similar to *Therapsipus* (named elsewhere in the same volume by Hunt et al., 1993) and to swimming traces. In this paper, we provide detailed documentation of the Moenkopi tetrapod footprints from west-central New Mexico. NMMNH refers to the New Mexico Museum of Natural History, Albuquerque.

LOCALITY

The Moenkopi track locality is NMMNH locality 356, in the NE1/4 NW1/4 SE1/4, sec. 36, T13N, R12W, Cibola County, about 6 km south of Prewitt (Fig. 1). Stratigraphically, the track-bearing bed is a ripple-laminated to massive, fine-grained sandstone in the lower 0.5 m of the Anton Chico Member of the Moenkopi Formation. The principal track-bearing layer preserves most tetrapod tracks in convex epirelief together with nondescript invertebrate feeding traces and abundant desiccation cracks. The Anton Chico Member is of Perovkan (early Anisian) age, and a correlative of the Holbrook Member of the Moenkopi Formation in Arizona (Morales, 1987; Lucas, 1998; Lucas and Schoch, 2002).

ICHNOTAXA

The NMMNH collection includes 13 catalogued specimens of Moenkopi tracks from NMMNH locality 356. Three discrete tetrapod ichnotaxa are present: tetrapod swimming traces, *Chirotherium* and *Therapsipus* (Figs. 2-3).

Swimming Traces

Tetrapod swimming traces are the most abundant tetrapod ichnofossils at NMMNH locality 356, and have been illustrated by Lucas and Hayden (1989, fig. 4) and by Hunt and Lucas (1993, fig. 23c-d). NMMNH specimens 14147, 14148, 14150, 14155 and 14157 (Fig. 3A) are characteristic. Other swim traces were not collected. The NMMNH specimens consist of straight grooves (parallel scratch marks) up to 100 mm long and 15 mm wide. There are as many as five parallel grooves on some traces.

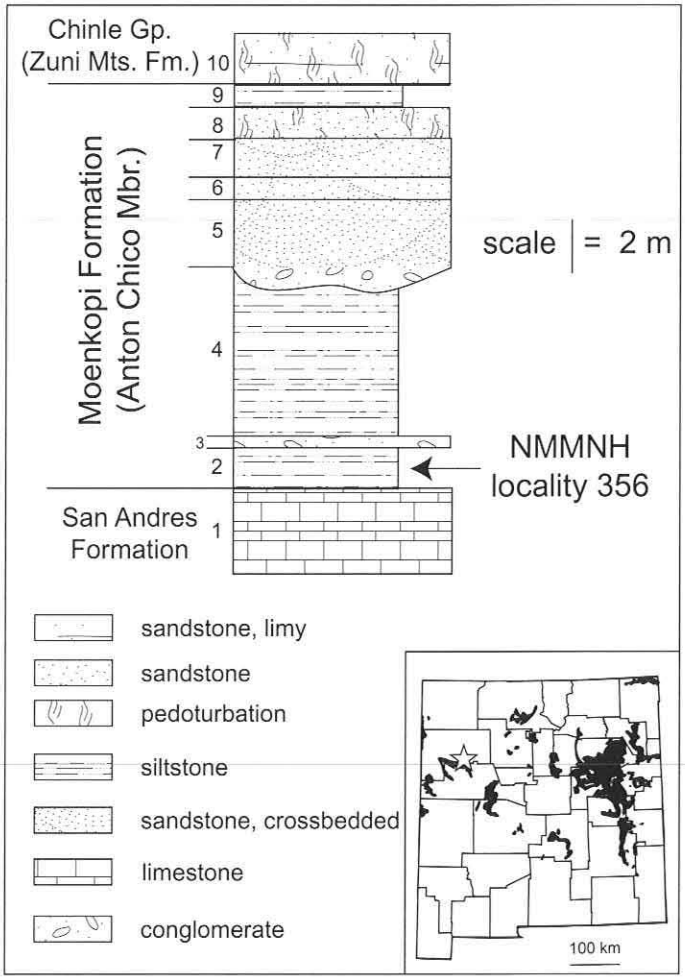

FIGURE 1. Index map and stratigraphic section showing the distribution of Triassic strata in New Mexico and the location of NMMNH locality 356 (star on inset map).

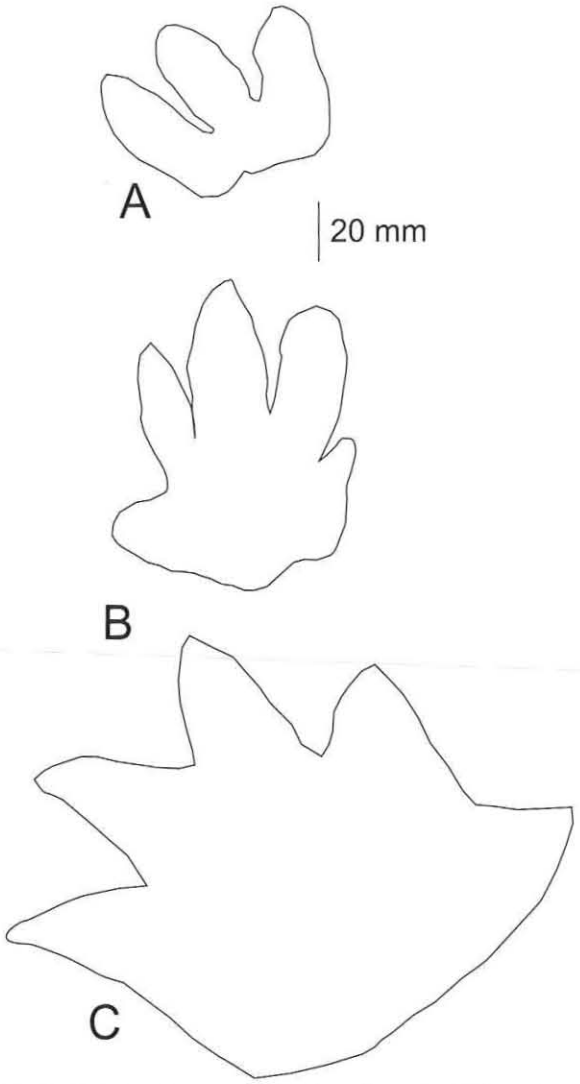

FIGURE 2. Outline drawings of selected tetrapod footprints from NMMNH locality 356. A. NMMNH P-26037, incomplete manus? impression of *Chirotherium* sp. B. NMMNH P-14146, right pes impression of *Chirotherium* sp. C. NMMNH P-14161, right pes impression of *Therapsipus* sp.

Similar traces from the Moenkopi Formation in Wyoming and Utah have been interpreted as tetrapod swimming traces, and we follow this interpretation (Boyd and Loope, 1984). Clearly, they indicate subaqueous conditions at the time the traces were made.

Chirotherium

Two collected specimens appear to belong to the characteristic Early-Middle Triassic tetrapod ichnogenus *Chirotherium*. These are the tracks of pentadactyl quadrupeds with clawed digits in which the pes is much larger than the manus. NMMNH P-14146 (Figs. 2B, 3B) is a five-toed track that is 98 mm wide and 106 mm long. We identify it as a right pes impression with digit 5 well displaced postero-laterally from the row of digits 1-4. Digit 3 is longest and slightly longer than digit 4, which is longer than digit 2.

NMMNH P-26037 (Figs. 2A, 3C) is a tridactyl print that is 65 mm wide and 72 mm long. We identify it as a partial manus imprint preserving digits 2, 3 and 4, which are subequal in length.

These specimens show diagnostic features of *Chirotherium*, to which they are assigned (cf. Peabody, 1948; Haubold, 1971, 1984). With a pes length of almost 11 cm, the *Chirotherium* specimens from NMMNH locality 356 are medium sized, about the size of *C. minus*, *C. barthi* or *C. coltoni* (Peabody, 1948). However, given their poor preservation and the oversplit ichnospecies-level taxonomy of *Chirotherium*, we only identify the locality 356 specimens as *Chirotherium* sp.

Therapsipus

Several specimens (NMMNH P-14153, 14154, 14156 and 14161) from locality 356 are assignable to *Therapsipus*, a tetrapod ichnogenus described by Hunt et al. (1993) from the Holbrook Member of the Moenkopi Formation in eastern Arizona. These specimens (e.g., Figs. 2C, 3D) have pes prints that are 120-140 mm wide, 130-150 mm long and have five digits, each about 50 mm long. They are the tracks of a quadruped with a pentadactyl manus and pes of nearly equal size, with a low pace angulation and without a divergent digit 5. The digit tips are acute.

NMMNH P-14153 (Fig. 3E) is a trackway of about 10 prints, and indicates a trackway width of about 380 mm, a feature that also distinguishes them from the much narrower trackways of *Chirotherium*. These tracks most closely resemble *Therapsipus*, to which they are assigned (Hunt et al., 1993). However, given their poor preservation, we only assign them to *Therapsipus* sp.

DISCUSSION

The presence of tetrapod tracks in the Anton Chico Member of the Moenkopi Formation is not surprising and further supports correlation of the Anton Chico Member to the Holbrook Member in Arizona, which also yields *Chirotherium* tracks. Indeed, there appears to be a global tetrapod ichnoassemblage characterized by tracks of *Chirotherium* in red beds of late Early (Olenekian = Nonesian) and early Middle (Anisian = Perovkan) Triassic age. Key localities are:

1. German Buntsandstein, where most *Chirotherium* tracksites are of Nonesian age, but some are of Perovkan age (e.g., Haubold, 1971, 1984; Haderer et al., 1995).

2. Buntsandstein of France, correlative to the Buntsandstein records in Germany.

3. Middle Triassic of the Italian Dolomites (Avanzini et al., 2001).

4. Early and Middle Triassic Moenkopi Formation, Arizona and Utah (Peabody, 1948).

5. The New Mexican Moenkopi record documented here.

The *Chirotherium* ichnofauna can thus be considered a Euramerican ichnofauna of Nonesian-Perovkan age.

The tetrapod ichnofauna previously reported from the Moenkopi Formation is dominated by tracks of archosaurs (*Chirotherium*) and of therapsids (*Therapsipus*) (Peabody, 1948; Hunt et al., 1993). The locality reported here is consistent with this conclu-

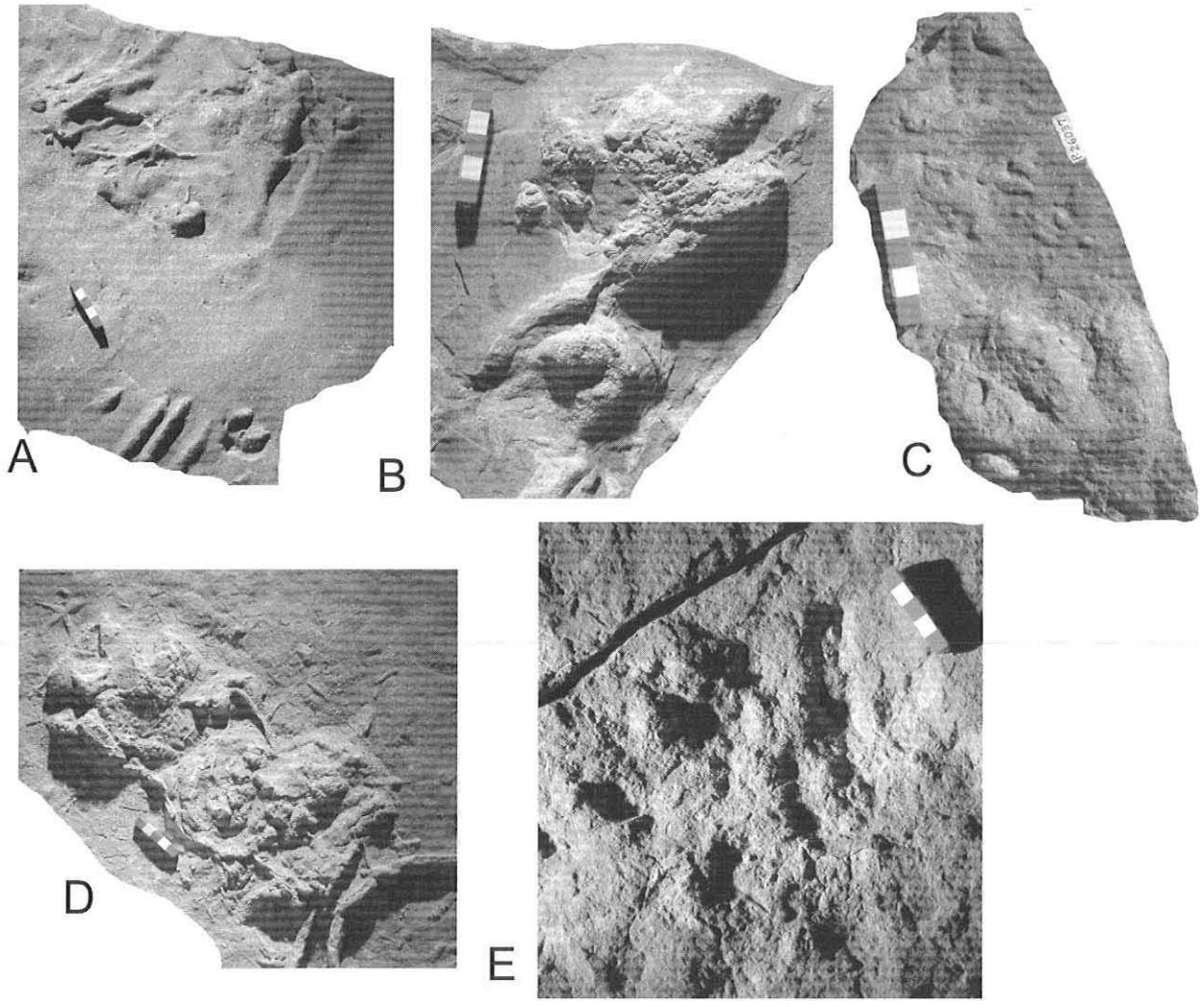

FIGURE 3. Selected tetrapod footprints from NMMNH locality 356. A. NMMNH P-14157, reptile swimming traces. B. NMMNH P-14146, right pes impression of *Chirotherium* sp. C. NMMNH P-26037, incomplete manus? impression of *Chirotherium* sp. D. NMMNH P-14161, right manus and pes impressions of *Therapsipus* sp. E. NMMNH P-14153, left pes impression of *Therapsipus* sp. Scale bars on the photographs are in cm.

sion. However, the body fossil fauna of the Moenkopi Formation is temnospondyl dominated, with much less common archosaurs and no documented therapsids (Morales, 1987; Boy et al., 2001; Lucas and Schoch, 2002). This indicates that different parts of the vertebrate fauna during Moenkopi time are being sampled by the body fossil and ichnofossil records. It also suggests that dicynodont body fossils should be discovered in the Moenkopi Formation.

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