



Early Permian trace fossils from the Abo formation near Jemez Springs, Sandoval County, New Mexico

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EARLY PERMIAN TRACE FOSSILS FROM THE ABO FORMATION NEAR JEMEZ SPRINGS, SANDOVAL COUNTY, NEW MEXICO

SPENCER G. LUCAS

New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, NM 87104; spencer.lucas@dca.nm.gov

ABSTRACT—The first known tetrapod footprint assemblage from the Abo Formation in the Jemez Mountains is from New Mexico Museum of Natural History locality 10325, in a 1.3-m-thick bed of ripple-laminated sandstone about 44 m below the upper contact of the Abo Formation with the overlying De Chelly Sandstone of the Yeso Group. The footprints are associated with walchian conifer impressions, *Supaia*, and a low-diversity invertebrate ichnoassemblage dominated by *Scoyenia* but including *Diplopodichnus*, *Palaeophycus*, *Planolites* and cf. *Sphaerapus*. Most of the footprints are of temnospondyls (*Limnopus*). Rare footprints at the locality can be assigned to cf. *Varanopus* (captorhinomorph reptile), cf. *Amphisauropus* (seymouriamorph) and *Ichniotherium* (diadectomorph). The occurrences of *Amphisauropus* and *Ichniotherium* are significant, as these ichnotaxa are only present in relatively inland localities of the Abo depositional system. The Jemez Springs footprint locality fits that, as it was far from the Abo-Hueco shoreline in southern New Mexico.

INTRODUCTION

New Mexico has the most extensive record of early Permian vertebrate footprints (Lucas and Heckert, 1995; Lucas et al., 1998; Minter and Braddy, 2009; Hunt and Lucas, 2015; Lucas and DiMichele, 2015). These footprints come from tracksites in the lower Permian Abo Formation and lower Yeso Group and correlative strata and are best known from the Villanueva area in San Miguel County (Voigt and Lucas, 2015a), northeastern Socorro County (Voigt and Lucas, 2017), and Prehistoric Trackways National Monument in the Robledo Mountains of Doña Ana County (Lucas et al., 2011; Voigt and Lucas, 2015b). In New Mexico, early Permian vertebrate footprints are also known from Bernalillo, Valencia, Sierra, Otero, and Hidalgo Counties (Hunt and Lucas, 2015).

LOCALITY 10325 NEAR JEMEZ SPRINGS

In the canyon of the Jemez River in Sandoval County, fossil bones of vertebrates from the early Permian Abo Formation are common and have been known since the 1930s (Lucas et al., 2012), but footprints have proven to be uncommon. An exception is New Mexico Museum of Natural History and Science (NMMNH) locality 10325, not far south of the village of Jemez Springs. Here, a 1.3-m-thick bed of ripple-laminated sandstone of the Cañon de Espinosa Member of the Abo Formation, about 44 m below the upper contact of the Abo Formation with the overlying De Chelly Sandstone of the Yeso Group, contains numerous fossil footprints. These footprints are associated with impressions of plant foliage (walchian conifers and *Supaia*) and an invertebrate ichnoassemblage dominated by *Scoyenia* but including *Diplopodichnus*, *Palaeophycus*, and *Planolites*, common arthropod trace fossils at many lower Permian outcrops in New Mexico (e.g., Minter and Braddy, 2009). One unusual invertebrate trace fossil from locality 10325 is NMMNH P-78358 (Fig. 1E), which bears

strong similarity to *Sphaerapus*, a compaction burrow made by a hexapod (Lucas et al., 2013). This trace is a horizontal, unbranched burrow with an ellipsoidal cross section made of rows of noncoprolitic, lenticular sediment pellets, some of which are imbricated. However, the unpacked central tunnel characteristic of *Sphaerapus* burrows is not well preserved, so I identify P-78358 as cf. *Sphaerapus* isp. It is possible that this specimen may be in large part a microbially induced sedimentary structure.

The most common footprints at locality 10325 are assigned to *Limnopus heterodactylus* (Fig. 1A, C, F). These are footprints of a quadruped with a tetradactyl manus and pentadactyl pes in which the digits are short with blunt tips, and the palm/sole impressions are relatively large and rounded. Two size groups are present: one with pes tracks ~30 mm long and a larger group with pes tracks ~40 mm long. *Limnopus* is the tracks of temnospondyl amphibians, and these are relatively small footprints of *Limnopus* (Voigt and Lucas, 2018).

Other footprint ichnotaxa at locality 10325 are much less common, and most are represented by single specimens. A single manus track is assigned to cf. *Amphisauropus kablikae* (Fig. 1D). It is pentadactyl and has short digits with blunt tips and a very short palm impression (length x width = 62 x 27 mm). *Amphisauropus* is the footprint of a reptiliomorph, most likely a seymouriamorph (Voigt and Lucas, 2018).

Several footprints can be identified as cf. *Varanopus* isp. (Fig. 1B). These are lacertoid tracks up to 40 mm long in which digit length increases from digit I through IV, and the sole imprint is short. Early captorhinomorphs are considered to be the trackmaker (Voigt and Lucas, 2018).

A single, very large and incomplete footprint (length = 175 mm) has a large, circular sole impression and three thick digits preserved, one of which has a distally expanded end (Fig. 1F). This footprint belongs to *Ichniotherium*, well established as the footprint of a diadectomorph (Voigt et al., 2007).

CONCLUSION

The occurrences of *Amphisauropus* and *Ichniotherium* are significant, as these ichnotaxa are only present in relatively in-

land localities of the Abo depositional system (Hunt and Lucas, 2006; Minter and Braddy, 2009). The Jemez Springs footprint locality fits that concept, as it was well inland, far from the Abo-Hueco shoreline in southern New Mexico.

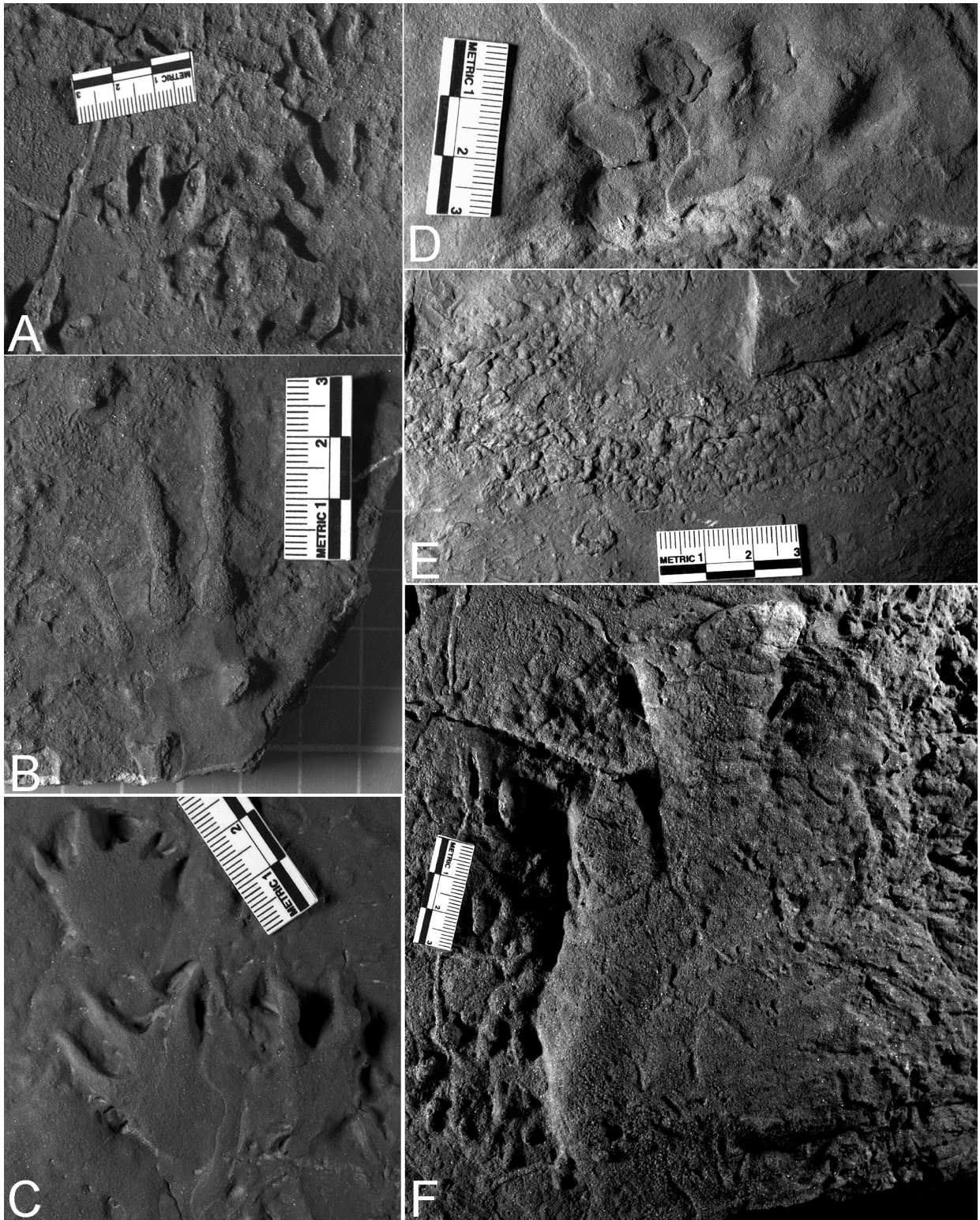


FIGURE 1. Vertebrate footprints (A–D, F) and possible hexapod compaction burrows (E) from the Cañon de Espinoso Member of the Abo Formation at NMMNH locality 10325 near Jemez Springs. (A) *Limnopus heterodactylus*, NMMNH P-78361, multiple footprints in convex hyporelief. (B) cf. *Varanopus* isp., P-78353, incomplete footprint in convex hyporelief. (C) *Limnopus heterodactylus*, P-78352, multiple footprints in convex hyporelief. (D) cf. *Amphisauropus kablikae*, P-78359, in concave epirelief. (E) cf. *Sphaerapus* isp., P-78358, burrows? in convex hyporelief. (F) *Ichniotherium* isp., P-78361, incomplete footprint in convex hyporelief.

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View across San Diego Canyon south of Jemez Springs of red beds of lower Permian Abo Formation (in the foreground and forming most of the slopes across the valley). A subtle color change to more orange, sandstone-dominated strata above the Abo in the distance identifies the lower Permian Yeso Group section underneath the Bandelier Tuff that caps the uplands across the valley. *Photo by Spencer G. Lucas*