The Abo Pass tracksite: a lower permian tetrapod footprint assemblage from central New Mexico

Spencer G. Lucas, Justin A. Spielmann, and Allan J. Lerner

2009, pp. 285-290. https://doi.org/10.56577/FFC-60.285

in:

Geology of the Chupadera Mesa, Lueth, Virgil; Lucas, Spencer G.; Chamberlin, Richard M.; [eds.], New Mexico Geological Society 60th Annual Fall Field Conference Guidebook, 438 p. https://doi.org/10.56577/FFC-60

This page is intentionally left blank to maintain order of facing pages.

THE ABO PASS TRACKSITE: A LOWER PERMIAN TETRAPOD FOOTPRINT ASSEMBLAGE FROM CENTRAL NEW MEXICO

SPENCER G. LUCAS, JUSTIN A. SPIELMANN AND ALLAN J. LERNER
New Mexico Museum of Natural History and Science, 1801 Mountain Rd. NW, Albuquerque, NM 87104

ABSTRACT—The Abo Pass tracksite is in the Cañon de Espinoso Member of the Abo Formation at Abo Pass in Valencia County, New Mexico. The locality is dominated by footprints of *Amphisauropus kablikae*, with far fewer numbers of *Dromopus lacertoides*, *Batrachichnus salamandroides* and *Ichniotherium cottae*. This tracksite exemplifies the concept of a Lower Permian *Amphisauropus* sub-ichnocoenosis of red-bed tetrapod tracksites from inland fluvial settings near uplifts. However, the abundance of *Amphisauropus* at the site could be anomalous, and this possibility highlights the need for additional data with which to fully evaluate proposed ichnofacies models of Early Permian red-bed tetrapod footprints.

INTRODUCTION

Numerous tetrapod (amphibian and reptile) footprint localities have been documented from the Lower Permian Abo Formation and correlative strata in New Mexico (Hunt et al., 2005a). One of the most prolific of these localities is the Abo Pass tracksite, first published by Lucas et al. (2001). This site is located in the Cañon de Espinoso Member of the Abo Formation just east of Abo Pass in Valencia County (Fig. 1). Lucas et al. (2001) drew attention to and documented records of the ichnogenera *Amphisauropus* and *Varanopus* at the Abo Pass tracksite, but did not completely document the tetrapod ichnofossil assemblage. Here, we provide far more thorough documentation and discuss the significance of the Abo Pass tracksite for interpreting Early Permian tetrapod ichnofacies and ichnocoenoses. In this article, NMMNH refers to the New Mexico of Natural History and Science, Albuquerque.

GEOLOGICAL CONTEXT

The Abo Pass tracksite, NMMNH locality 4510 (sec. 9, T02N, R05E), is located in a 0.3- to 1.3-m-thick, thinly-bedded, fine-grained sandstone bed with extensive ripple laminae (Fig. 1). Some of the track-bearing surfaces have mudcracks and raindrop impressions indicative of subaerial exposure. This bed is laterally extensive, with a strike of hundreds of meters. In places the ripples and climbing ripples are within long, shallow trough crossbeds.

The tracksite is located ~140 m above the base of the Abo Formation in the Cañon de Espinoso Member of Lucas et al. (2005a). Indeed, the track-bearing bed is equivalent to bed 23 of the Abo type section of Lucas et al. (2005a, fig. 5). Given that the Abo Formation is ~300 m thick at Abo Pass, the Abo Pass tracksite is approximately in the middle of the formation, not in the lower part of the formation as stated by Lucas et al. (2001). Also note that Lucas et al. (2001) listed the Abo Pass tracksite as NMMNH locality 4394, but it was subsequently reassigned as locality 4510.

The Abo Formation is generally assigned a Wolfcampian age, though the upper part of the formation may be early Leonardian. At Abo Pass, the Bursum Formation, which underlies the Abo Formation, contains early Wolfcampian fusulinids (Myers,

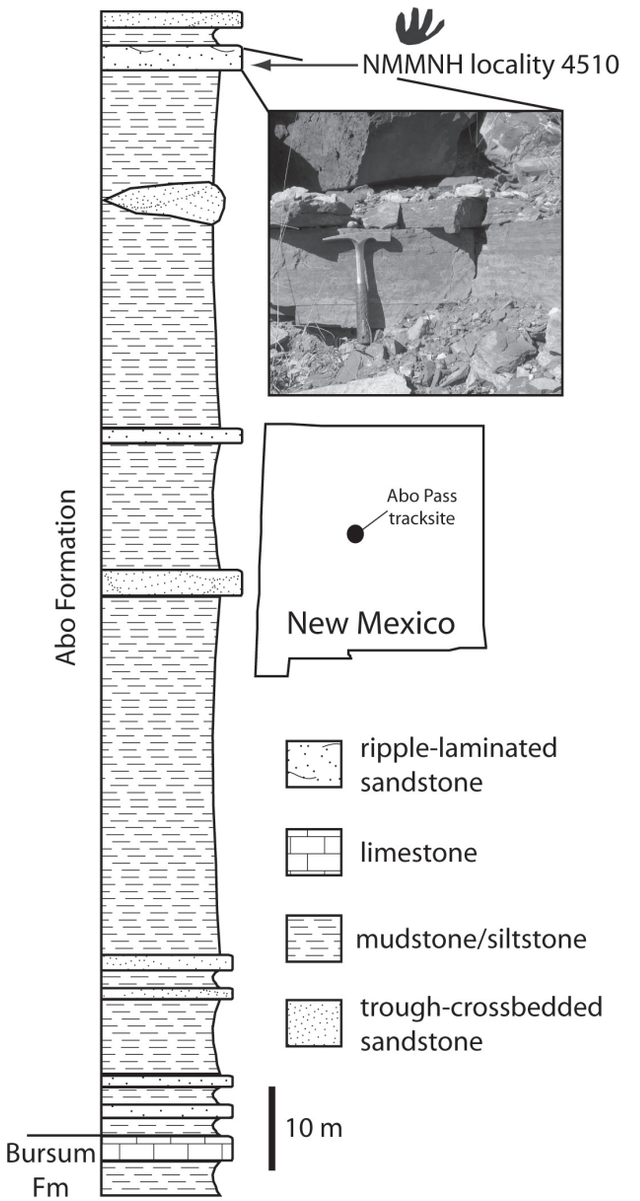

FIGURE 1. Stratigraphic section and index map showing the location and stratigraphic level of NMMNH locality 4510, with an inset picture of the track-bearing bed at the locality.

1977). Therefore, it seems likely that the Abo Pass tracksite is of middle or late Wolfcampian age.

SYSTEMATIC ICHNOLOGY

Ichnogenus *Batrachichnus* Woodworth, 1900
Batrachichnus salamandroides (Geinitz, 1861)
Fig. 2A-B

Referred specimens: Three slabs with multiple tracks from NMMNH locality 4510, one in concave epirelief (NMMNH P-31344) and two in convex hyporelief (NMMNH P-31325, 31335a).

Description: The tracks from Abo Pass that we assign to *Batrachichnus* are the tracks of a small quadruped in which pes length is less than 20 mm. The pentadactyl pes track is plantigrade to semiplantigrade, digit imprints I-III are closely grouped, and they increase in length from I to IV. Digit imprint IV is longest, and digit imprint V is posterior to the other digit imprints. The manus track is tetradactyl, semiplantigrade and smaller than that of the pes. The digit imprints on the manus track increase in length from I to III, and digit imprint IV diverges laterally. No body or tail drag impressions are evident.

Comments: *Batrachichnus* is not abundant at the Abo Pass tracksite. Most are poorly preserved undertracks that are plantigrade, with short, thin digit imprints and/or are tetradactyl manus tracks, all justifiably assigned to *B. salamandroides* (cf. Hunt et al., 1995; Haubold et al., 1995; Voigt, 2004; Lucas et al., 2005b, c). *Batrachichnus* is the trackway of a small temnospondyl amphibian.

Ichnogenus *Amphisauropus* Haubold, 1970
Amphisauropus kablikae (Geinitz and Deichmüller, 1882)
Figs. 3-4

Referred specimens: Thirty-seven slabs with multiple tracks from NMMNH locality 4510, 25 in concave epirelief: NMMNH P-31309, P-31316, P-31317, P-31322, P-31323, P-31326, P-31330, P-31331, P-31336–P-31339, P-31342, P-31343, P-31345, P-31349, P-31445, P-31446, P-31663, P-31665, P-31672, P-31673, P-33299, P-33306, P-33307; and 12 in convex hyporelief: NMMNH P-31310, 31312, P-31313, P-31333, P-31318, P-31319, P-31335b, P-31340, P-31443, P-31667 and P-31674.

Description: Both manus and pes tracks are pentadactyl. Pes digit imprint IV is the longest, and digit tip imprints are generally rounded. Both manus and pes tracks are wider than long (average length x width = 55 mm x 35 mm). Manus tracks slightly smaller than pes tracks, and divarication between pes digit imprints I and V ~ 130°. Trackways (Fig. 4) are those of a quadruped in which manus tracks are rotated medially and pes tracks are parallel to the direction of travel.

Comments: These tracks are readily referred to *Amphisauropus* (Lucas et al., 2001). Lucas et al. (2001) referred these tracks to *A. latus*, but we assign them to *A. kablikae*, following Voigt (2004), who considered *A. latus* Haubold, 1970 to be a junior subjective synonym of *A. kablikae* (Geinitz and Deichmüller, 1882). *Amphisauropus* is interpreted as the footprint of a seymouriamorph.

There is a wide range of extramorphological variation in the footprints assigned to *Amphisauropus* from NMMNH locality 4510 (Figs. 3-4). This range of variation encompasses specimens from the site assigned (without description) to *Gilmoreichnus hermitanus* and *Hyloidichnus* sp. by Lucas et al. (2001), and the single specimen (NMMNH P-31333) illustrated and assigned to *Ichniotherium cottae* by Hunt et al. (2005b, fig. 2D). This specimen is small (52 mm long), has a very short digit imprint V, straight digit imprints (not curved toward the midline) and lacks expanded digit tip imprints, characteristics that distinguish it from *Ichniotherium* (e.g., Voigt and Haubold, 2000; Voigt, 2004; Voigt et al., 2007). Instead, we identify this footprint as *Amphisauropus*.

Footprints assigned to *Limnopus* by Lucas et al. (2001) were not explicitly listed by specimen number, but the ichnogeneric identification was based on undertracks with rounded digit tip imprints, some of which are tetradactyl, that we identify as *Amphisauropus* (e.g., Fig. 3C). We infer that the single trackway of *Amphisauropus* mapped here (Fig. 4) has such undertracks, and also has footprints with pointed digit tip imprints (Fig. 3B, D). These were the basis for identifying *Gilmoreichnus* (Lucas et al., 2001). We abandon this identification as well as the identification of *Hyloidichnus* by Lucas et al. (2001) based on specimens such as NMMNH P-31324 (Fig. 3F), which we re-interpret as lengthy digit drags associated with an *Amphisauropus* track (cf. Lucas et al., 2001, fig. 5). Thus, the Abo Pass sample of *Amphisauropus* shows a wide range of extramorphological variation (also see Lucas et al., 2001, figs. 2-5), well demonstrated by NMMNH P-31343, the trackway mapped here (Fig. 4).

This trackway (Fig. 4) preserves eight somewhat incomplete manus-pes track pairs, with a trackway width of 230 mm, strides that range from 180 to 230 mm, pace range of 90 to 130 mm and an average pace angulation of ~40° (measuring protocol according to Leonardi, 1987, pl. 1). Pes and manus tracks are all plantigrade, but digit imprint counts range from three to five, and digit tip imprints range from rounded and slightly expanded distally to distally pointed. Digit imprint shapes are either straight or variously curved. Manus tracks are usually rotated medially towards the trackway midline, but there is some variation in this, and in the degree of overstepping of pes and manus tracks. All of these variants in manus and pes track shape and orientation are part of a single individual's trackway, and thus are indicative of considerable extramorphological variation in *Amphisauropus* from the Abo Pass tracksite (also see Lucas et al., 2001).

Ichnogenus *Dromopus* Marsh, 1894
Dromopus lacertoides (Geinitz, 1861)
Fig. 2D

Referred specimens: Eight slabs with multiple tracks from NMMNH locality 4510, two slabs in concave epirelief: NMMNH P-31315 and 31350; and six slabs in convex hyporelief: NMMNH P-31304, 31306, 31311, 31320, 31328 and 31444.

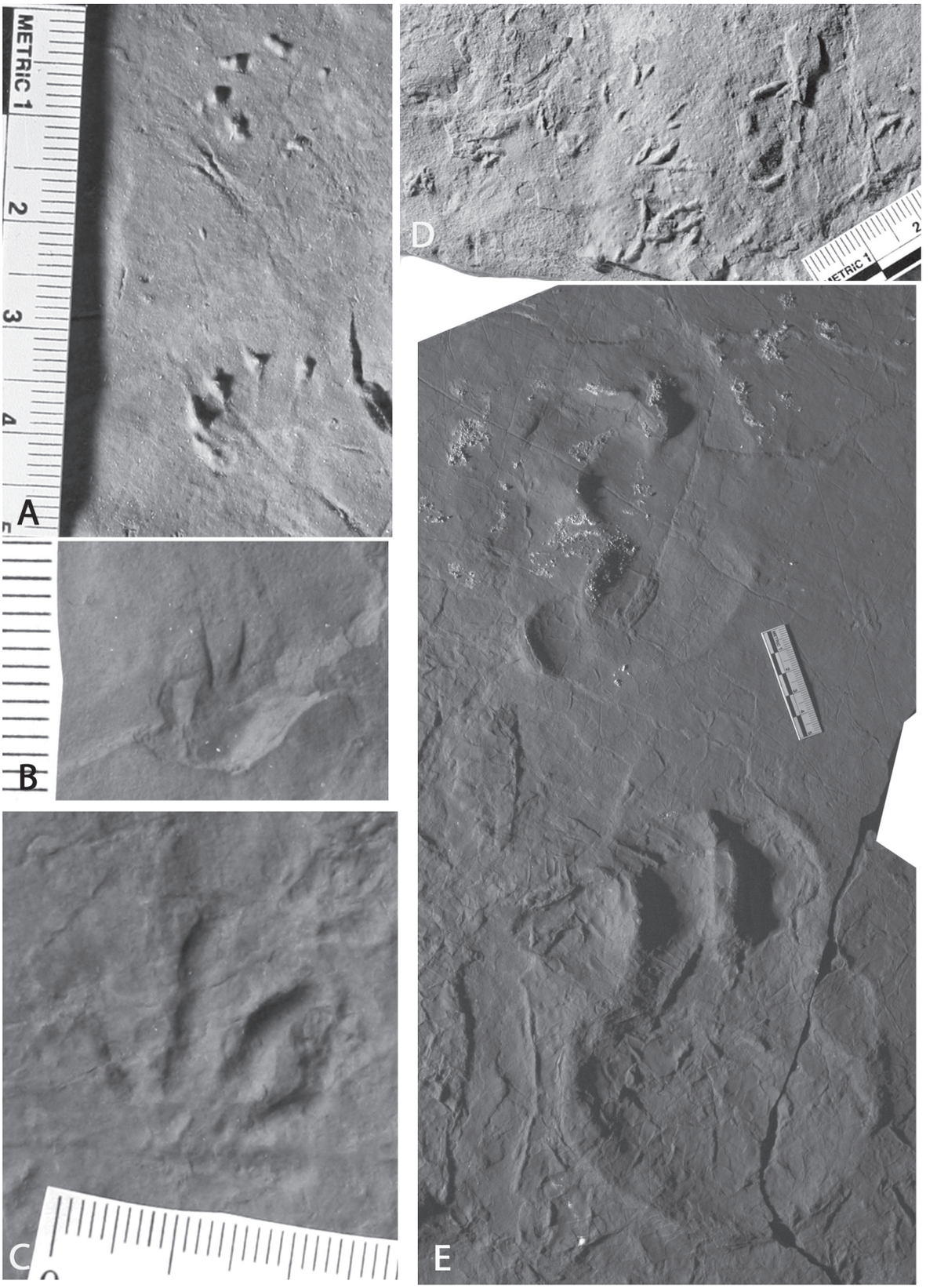

FIGURE 2. Selected tetrapod footprints from NMMNH L-4510. **A-B**, *Batrachichnus salamandroides*, **A**, NMMNH P-31325, digit tip impressions in convex hyporelief, **B**, NMMNH P-31335, small isolated track in convex hyporelief. **C**, *Varanopus curvidactylus*, NMMNH P-31347, isolated track in concave epirelief. **D**, *Dromopus lacertoides*, NMMNH P-31320, trampled surface in convex hyporelief. **E**, *Ichniotherium cottae***,** NMMNH P-51593, large manus-pes pair in concave epirelief.

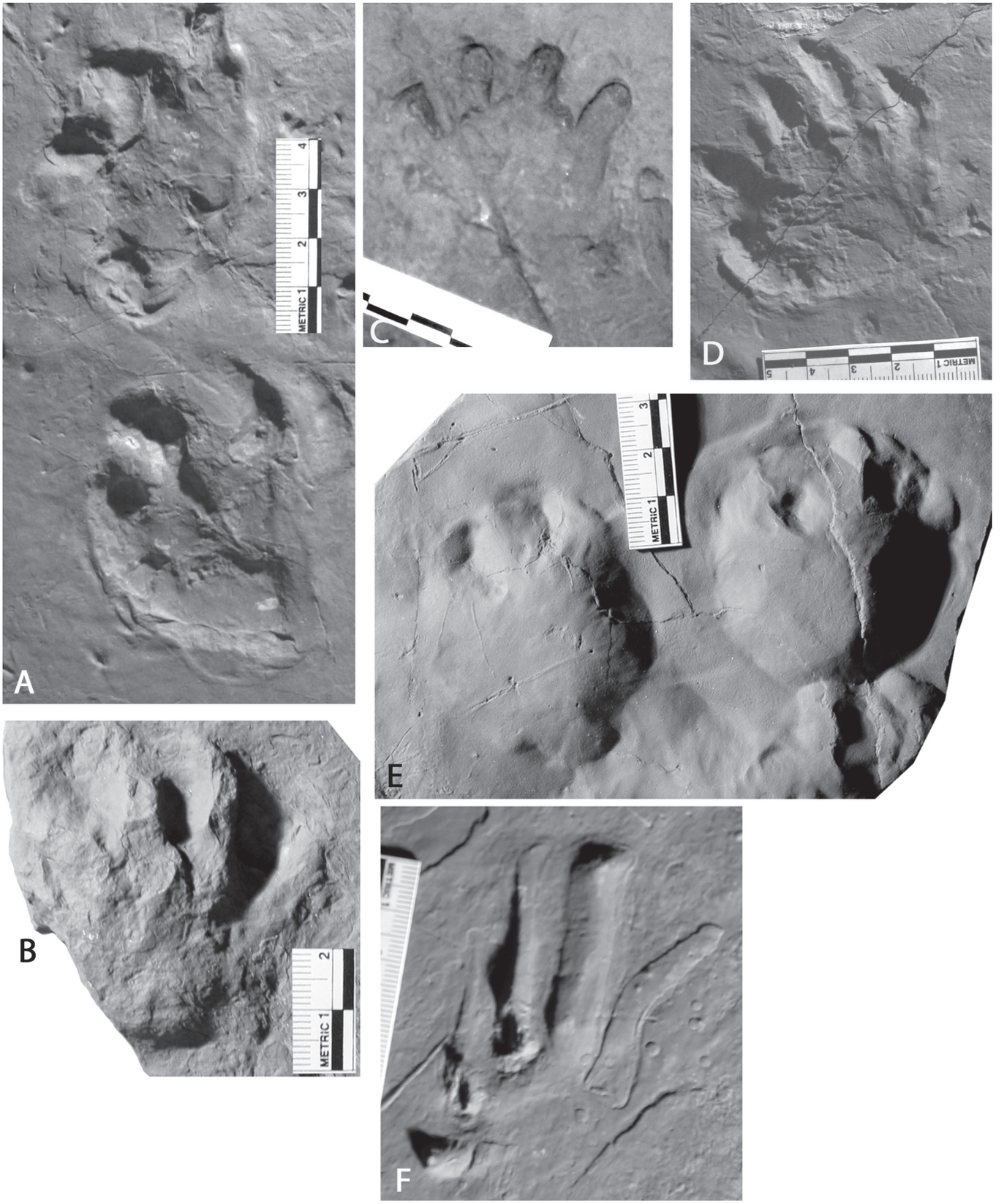

FIGURE 3. Selected tetrapod footprints of *Amphisauropus kablikae* from NMMNH L-4510 demonstrating the wide range of extramorphological variation. **A-B**, NMMNH P-31343, **A**, paired tracks in concave epirelief (Fig. 4, rp2 and rm2) and **B**, isolated track in convex hyporelief (Fig. 4, rp1). **C**, NMMNH P-31345, isolated track in concave epirelief. **D**, NMMNH P-31343, isolated track in concave epirelief (Fig. 4, rp4). **E**, NMMNH P-31313, paired tracks with large "sole" imprint in convex hyporelief. **F**, NMMNH P-31324, tracks with extended digit marks ("scratches") in convex hyporelief.

Description: Pes tracks are 10-20 mm long, pentadactyl and are plantigrade but generally lack a "heel" imprint. Pes digit imprints are curved and increase in length greatly from I to IV. Digit imprint V is laterally or postero-laterally directed. The manus track is smaller than the pes track but similar. Most of the *Dromopus* tracks from locality 4510 are didactyl or tridactyl undertracks.

Comments: These tracks are readily assigned to *Dromopus lacertoides* based on size and morphology (cf. Haubold et al., 1995; Hunt et al., 1995; Voigt, 2004; Lucas et al., 2005b). *Dromopus* is widely considered to be the footprint of an araeoscelid reptile.

Ichnogenus *Varanopus* Moodie, 1929
***Varanopus curvidactylus* Moodie, 1929**
Fig. 2C

Referred specimens: Two slabs with multiple tracks from NMMNH locality 4510: one in concave epirelief, NMMNH P-33301, and the other in convex hyporelief, NMMNH P-31347.

Description: Manus and pes tracks pentadactyl and in close sets. Length and width of both manus and pes tracks approximately 20 mm. Divarication of pes digit imprints I-V is ~155°. The digit imprint lengths increase moderately from I to IV, and pes digit imprint V is as short as digit imprint I and directed outward.

Comments: The proportions and positions of the pes digit imprints, especially the relative length and laterally directed position of digit imprint V, justify assigning these tracks to *Varanopus* (Lucas et al., 2001). Lucas et al. (2001) only assigned these specimens to *Varanopus* sp., but subsequent studies of *Varanopus* have improved understanding of its ichnospecies, thus justifying assigning these specimens to the ichnospecies *V. curvidactylus* (cf. Haubold and Lucas, 2001, 2003; Voigt, 2004).

Ichnogenus *Ichniotherium* Pohlig, 1892
***Ichniotherium cottae* (Pohlig, 1885)**
Fig. 2E

Referred specimens: Four slabs with single tracks in concave epirelief from NMMNH locality 4510: NMMNH P-31309, 31310, P-31314, P-31341 and P-51593.

Description: Very large tracks (up to 210 mm long) of a quadruped with pentadactyl and plantigrade manus and pes. Digit impressions are broad and rounded with blunt and broadened tips. Digit lengths increase from I to IV, and digit V is as long as digit II. The pes imprint is longer than wide, whereas the manus imprint is wider than long, and the manus imprint is rotated medially. The pes has a very large and rounded heel (sole) impression.

Comments: These large tracks correspond well to tracks assigned to *Ichniotherium cottae* by Voigt and Haubold (2000), Voigt (2004) and Voigt et al. (2007). The inferred trackmaker of *Ichniotherium* is a diadectomorph.

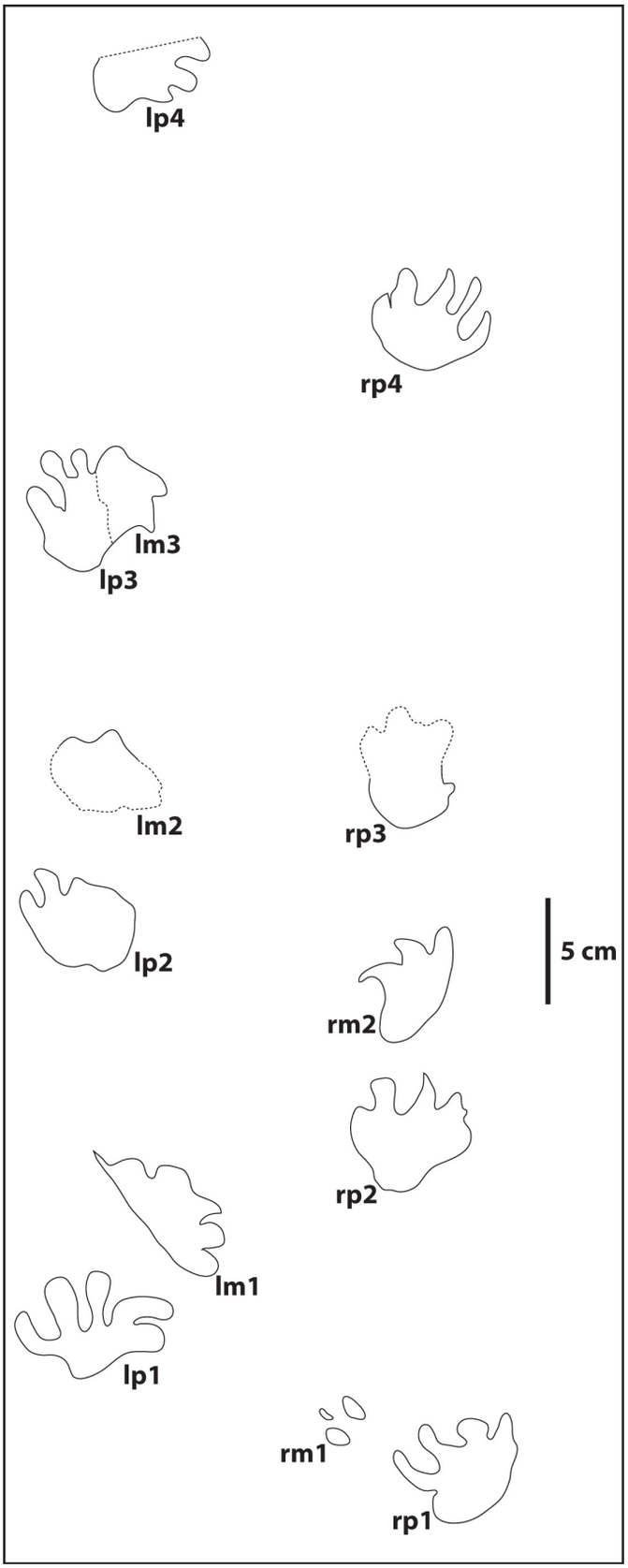

FIGURE 4. Drawing of *Amphisauropus* trackway, NMMNH P-31343, with manus and pes tracks labeled. **Abbreviations:** l = left, m = manus, p = pes, r = right.

DISCUSSION

The Abo Pass tracksite provided the first records of *Amiphisauropus* and *Varanopus* from the Lower Permian red beds of New Mexico (Lucas et al., 2001). Subsequent work in the Cerros de Amado of Socorro County has uncovered more records of *Amphisauropus* in the Abo Formation (Lerner et al., 2003), but no additional records of *Varanopus* are known. One striking feature of the Abo Pass tracksite is its near total domination by footprints of *Amphisauropus*, a feature that distinguishes it from all other Abo Formation tracksites.

When Hunt et al. (2005a) and Hunt and Lucas (2006) drew attention to the Abo Formation records of *Amphisauropus*, they used the data to identify an *Amphisauropus* sub-ichnocoenosis within their *Batrachichnus* ichnocoenosis. They identified this sub-ichnocoenosis from Abo Pass to the Joyita Hills (including the Cerros de Amado) based on the presence of *Amphisauropus* and rare *Ichniotherium*. They attributed this sub-ichnocoenosis to inland fluvial settings close to mountain fronts. The Abo Pass tracksite is undoubtedly from an inland fluvial setting, approximately 200 km from the shoreline of the Hueco seaway to the south and very close to the Joyita and Pedernal uplifts (Kues and Giles, 2004, fig. 11). The Cerros de Amado *Amphisauropus* localities in the Abo Formation are only a few tens of kilometers to the south and were much closer to the Joyita uplift during the Early Permian. However, Abo tracksites to the southeast, in the northern Oscura Mountains of Socorro County, lack *Amphisauropus*. If sampling of these sites is considered adequate, then the geographic division between the two sub-ichnocoenoses – *Amphisauropus* and *Batrachichnus* – is in southern Socorro County.

Nevertheless, we are struck by how abundant *Amphisauropus* is at the Abo Pass tracksite – it is much more abundant (dominant) than at the other *Amphisauropus*-producing tracksites in Socorro County. This dominance may be anomalous, or simply the result of more seymouriamorphs (the inferred trackmaker of *Amphisauropus*) having been present in the Abo Pass area than at other sites in the Abo Formation in Socorro County. Such apparent anomalies in track assemblage composition are a factor that can potentially undermine ichnofacies interpretations like those of Hunt and Lucas (2006), especially if the assumption is that ichnofaunal composition is relatively consistent within an ichnocoenosis or ichnofacies in a given unit. Such anomalies may be explained as patchy paleoecological distribution of the trackmaking fauna or they may potentially be understood by further sampling of a large number of Abo tracksites in as many facies settings as possible. Only with such sampling can the ichnofacies models of Early Permian tracksites advocated by Hunt and Lucas (2006) be fully evaluated.

ACKNOWLEDGMENTS

Lynn Shilton permitted access to land. Numerous NMMNH volunteers and staff assisted in the field. Martin Lockley and Nick Minter provided helpful reviews of the manuscript.

REFERENCES

Geinitz, H.B. and Deichmüller, J.V., 1882, Die Saurier der unteren Dyas von Sachsen: Palaeontographica, v. 29, p. 1-46.

Haubold, H. and Lucas, S.G., 2001, Die Tetrapoden Fährten der Choza Formation (Texas) und das Artinsk-Alterder Redbed Ichnofaunen des unteren Perm: Hallesches Jahrbuch für Geowissenschaften, v. B23, p. 79-108.

Haubold, H. and Lucas, S.G., 2003, Tetrapod footprints of the Lower Permian Choza Formation at Castle Peak, Texas: Paläontologische Zeitschrift, v. 77, p. 247-261.

Haubold, H., Hunt, A. P., Lucas, S. G. and Lockley, M. G., 1995, Wolfcampian (Early Permian) vertebrate tracks from Arizona and New Mexico: New Mexico Museum of Natural History and Science, Bulletin 6, p. 135-165.

Hunt, A.P. and Lucas, S.G., 2006, Permian tetrapod ichnofacies; *in* Lucas, S.G., Cassinis, G. and Schneider, J.W., eds., Non-marine Permian biostratigraphy and biochronology: Geological Society of London, Special Publication, v. 265, p. 137-156.

Hunt, A. P., Lucas, S. G., Haubold, H. and Lockley, M. G., 1995, Early Permian (late Wolfcampian) tetrapod tracks from the Robledo Mountains, south-central New Mexico: New Mexico Museum of Natural History and Science, Bulletin 6, p. 167-180.

Hunt, A.P., Lucas, S.G. and Spielmann, J.A., 2005a, Early Permian tetrapod tracksites in New Mexico: New Mexico Museum of Natural History and Science, Bulletin 31, p. 46-48.

Hunt, A.P., Lucas, S.G. and Spielmann, J.A., 2005b, The Permian tetrapod ichnogenus *Ichniotherium cottae* from central New Mexico: New Mexico Museum of Natural History and Science, Bulletin 31, p. 56-58.

Kues, B.S. and Giles, K.A., 2004, The late Paleozoic ancestral Rocky Mountains system in New Mexico; *in* Mack, G.H. and Giles, K.A., eds., The geology of New Mexico: a geologic history: New Mexico Geological Society, Special Publication 11, p. 95-136.

Leonardi, G., 1987, Glossary and manual of tetrapod footprint palaeichnology: Brasilia, Department Nacional da Prudução Mineral, 75 p.

Lerner, A.J., Lucas, S.G. and Voigt, S., 2003, *Amphisauropus* from the Lower Permian Abo Formation, Cerros de Amado, Socorro County, central New Mexico: New Mexico Geology, v. 25, p. 44.

Lucas, S.G., Lerner, A.J. and Haubold, H., 2001, First record of *Amphisauropus* and *Varanopus* in the Lower Permian Abo Formation, central New Mexico: Hallesches Jahrbuch für Geowissenschaften, v. B23, p. 69-78.

Lucas, S.G., Krainer, K. and Colpitts, R.M., Jr., 2005a, Abo-Yeso (Lower Permian) stratigraphy in central New Mexico: New Mexico Museum of Natural History and Science, Bulletin 31, p. 101-117.

Lucas, S.G., Minter, N.J., Spielmann, J.A., Hunt, A.P. and Braddy, S.J., 2005b, Early Permian ichnofossil assemblage from the Fra Cristobal Mountains, southern New Mexico: New Mexico Museum of Natural History and Science, Bulletin 31, p. 140-150.

Lucas, S.G., Minter, N.J., Spielmann, J.A., Smith, J.A. and Braddy, S.J., 2005c, Early Permian ichnofossils from the northern Caballo Mountains, Sierra County, New Mexico: New Mexico Museum of Natural History and Science, Bulletin 31, p. 151-162.

Myers, D.A., 1977, Geologic map of the Scholle quadrangle, Socorro, Valencia, and Torrance counties, New Mexico: U.S. Geological Survey, Geologic Quadrangle Map GQ-1412, scale 1:24,000.

Voigt, S., 2004, Die Tetrapodichnofauna des kontinentalen Oberkarbon und Perm im Thüringer Wald-Ichnotaxonomie, Paläoökologie und Biostratigraphie: Göttigen, Cuvillier Verlag, 179 p.

Voigt, S. and Haubold, H., 2000, Analyse zur Variabilität der Tetrapodenfährte *Ichniotherium cottae* aus dem Tambacher Sandstein (Rotliegend, unter-Perm, Thüringen): Hallesches Jahrbuch für Geowissenschaften, v. B22, p. 17-58.

Voigt, S., Berman, D.S. and Henrici, A.C., 2007, First well-established track-trackmaker association of Paleozoic tetrapods based on *Ichniotherium* trackways and diadectid skeletons from the Lower Permian of Germany: Journal of Vertebrate Paleontology, v. 27, p. 553-570.