



Tetrapod footprints from the lower Permian Abo Formation near Bingham, Socorro County, New Mexico

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TETRAPOD FOOTPRINTS FROM THE LOWER PERMIAN ABO FORMATION NEAR BINGHAM, SOCORRO COUNTY, NEW MEXICO

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ABSTRACT—We document tetrapod footprints from a locality at the base of the Lower Permian Cañon de Espinosa Member of the Abo Formation in the northern Oscura Mountains near Bingham, Socorro County, New Mexico. The footprints are assigned to *Batrachichnus salamandroides*, *Dromopus lacertoides*, *Gilmoreichnus hermitanus*, cf. *Dimetropus* sp. and *Characichnos* sp. The fact that *Batrachichnus* and *Dromopus* dominate the assemblage, and its low diversity, are consistent with the concept that tetrapod footprint ichnodiversity in the Abo depositional system decreased inland from the Hueco seaway shoreline. The tetrapod footprint assemblage from the Abo Formation near Bingham well represents the *Dimetropus* sub-ichnocoenosis and is its northernmost record in the Abo depositional system. However, the precise factors that controlled the distribution of this sub-ichnocoenosis in the Abo depositional system remain unclear.

INTRODUCTION

New Mexico has an extensive and world famous fossil record of Early Permian tetrapod footprints from the Abo Formation and correlative strata across the state. These footprints have had a significant impact on re-evaluating late Paleozoic tetrapod footprint ichnotaxonomy and biostratigraphy, and in the delineation of footprint ichnofacies and ichnocoenoses (see, for example, articles in Lucas and Heckert, 1995, and Lucas et al., 1998, as well as Lucas, 2005, 2007, and Hunt and Lucas, 2006, 2007).

One of the least documented Abo Formation footprint collecting areas is near Bingham in Socorro County (Fig. 1). First mentioned by Hunt et al. (1993), Hunt et al. (1995) presented the only published documentation of Abo tracks from near Bingham. Here, we document the results of footprint collections made by the NMMNH (New Mexico Museum of Natural History and Science) near Bingham during the last 15 years, focusing on documenting footprints from the most prolific locality.

ABO FOOTPRINT LOCALITIES NEAR BINGHAM

New Mexico Museum of Natural History and Science records list seven Abo tracksites near Bingham:

1. NMMNH locality 2771 – Hunt et al. (1995, p. 266, figs. 2G, 5) documented two ichnotaxa from this site – *Dromopus agilis* and *Hyloidichnus bifurcatus*.
2. NMMNH locality 7666 – One of us (SGL) discovered this locality, and it is the most prolific Abo tracksite known near Bingham. Its tetrapod ichnofauna is documented below. It also yields the fossil plants *Walchia* (NMMNH P-57993) and *Supaia* (NMMNH P-57988, P-57992 and P-57994).
3. NMMNH locality 7667 – W. Cotton (written commun., 2004) observed an incomplete footprint, possibly *Dimetropus*, at this site.
4. NMMNH locality 7668 – A slab (NMMNH P-58023) with multiple tracks of *Dromopus lacertoides* in concave epirelief was collected at this site.

5. NMMNH locality 7669 – A slab (NMMNH P-58024) with “swim traces” (*Characichnos*) in convex hyporelief was collected at this site.
6. NMMNH locality 7670 – This site yielded a slab (NMMNH P-58022) with tracks of *Dromopus lacertoides* in concave epirelief and a slab (NMMNH P-58021) with an incomplete track of *Limnopus* sp. in concave epirelief.
7. NMMNH locality 7671 – This site yielded a slab (NMMNH P-58025) with tracks of *Gilmoreichnus hermitanus* in convex hyporelief.

NMMNH LOCALITY 7666

Geological Context

NMMNH locality 7666 is in a 2.2-m-thick ripple-laminated sandstone ledge approximately 76 m above the base of the Abo Formation (Fig. 1). We interpret this ledge to be the local base of the Cañon de Espinosa Member of the Abo Formation of Lucas et al. (2005a). As in the type section of the Abo Formation and other Abo outcrops in central New Mexico, the lower part of the formation in the northern Oscura Mountains is composed of red mudstone intercalated with trough-crossbedded, channelform arkosic sandstone and conglomerate beds. This is the Scholle Member of Lucas et al. (2005a) and is ~76 m thick in the northern Oscura Mountains. Above it, the Abo Formation is mudstone/siltstone beds intercalated with laterally extensive sheets of fine-grained sandstone that display ripple laminations and climbing ripples, sometimes arranged in long, shallow trough forms (DiMichele et al., 2007). This is the Cañon de Espinosa Member of the Abo Formation of Lucas et al. (2005a), and it is 41 m thick in the northern Oscura Mountains.

At NMMNH locality 7666, tracks occur throughout the sandstone bed at the base of the Cañon de Espinosa Member. Also present is a *Supaia*-dominated paleoflora, with rare *Walchia* (cf. DiMichele et al., 2007). Although numerous track slabs were observed at NMMNH locality 7666, only 15 were collected to voucher the locality.

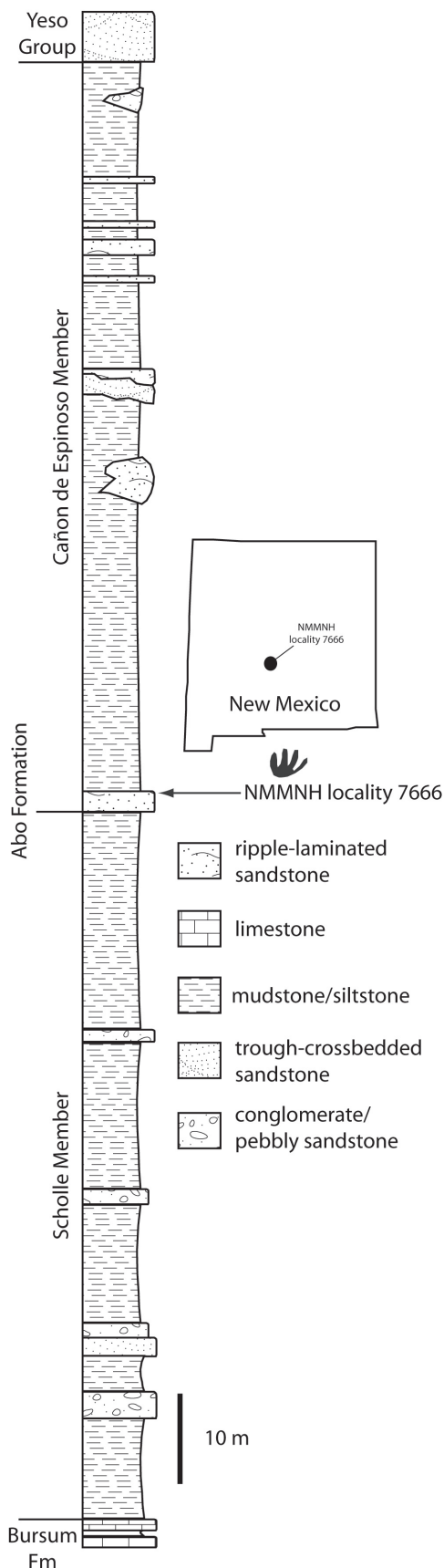


FIGURE 1. Stratigraphic section and index map showing the location and stratigraphic level of NMMNH locality 7666.

SYSTEMATIC ICINOLOGY

Ichnogenus Batrachichnus Woodworth, 1900 *Batrachichnus salamandroides* (Geinitz, 1861)

Fig. 2A-C

Referred specimens: Five slabs with multiple tracks from NMMNH locality 7666, two preserved in concave epirelief (NMMNH P-57977 [Fig. 2A] and P-57979), and three preserved in convex hyporelief (NMMNH P-57978, P-57984 [Fig. 2C] and P-57989 [Fig. 2B]).

Description: The tracks from near Bingham that we assign to *Batrachichnus* are those of a small quadruped in which pes track length is less than 20 mm. The pentadactyl pes track is plantigrade to semiplantigrade, digit imprint lengths increase from I to IV, and digit imprint V is posterior to and laterally diverges from the other digit imprints. The manus track is tetradactyl, semiplantigrade and smaller than the pes track. The digit imprints on the manus track increase in length from I to III, and digit imprint IV diverges outward (Fig. 2A-C). No body or tail drags/impressions are evident.

Comments: The size and morphology of these tracks supports their identification as *Batrachichnus salamandroides* (cf. Haubold et al., 1995; Melchor and Sarjeant, 2004; Lucas, 2005; Lucas et al., 2005a, b), as discussed above. *Batrachichnus* is the track/trackway of a small temnospondyl amphibian.

Ichnogenus Dromopus Marsh, 1894 *Dromopus lacertoides* (Geinitz, 1861)

Fig. 2D-E

Referred specimens: Four slabs with multiple tracks from NMMNH locality 7666, one preserved in concave epirelief (NMMNH P-57981) and three preserved in convex hyporelief (NMMNH P-57978 [Fig. 2D], P-57980 and P-57990 [Fig. 2E]).

Description: Pes tracks are 10-30 mm long, pentadactyl and are plantigrade but 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. NMMNH P-57978 (Fig. 2D) has two crooked digit imprints and a digit imprint with a bifurcated digit tip, extramorphological variants seen in some specimens of *Dromopus*.

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), as discussed above. *Dromopus* is widely considered to be the track/trackway of an araeoscelid reptile.

Ichnogenus Gilmoreichnus Haubold, 1971 *Gilmoreichnus hermitanus* (Gilmore, 1927)

Fig. 2G

Referred specimens: Three slabs from NMMNH locality 7666, two in concave epirelief (NMMNH P-57982 and P-57983 [Fig. 2G]) and one in convex hyporelief (NMMNH P-57986).

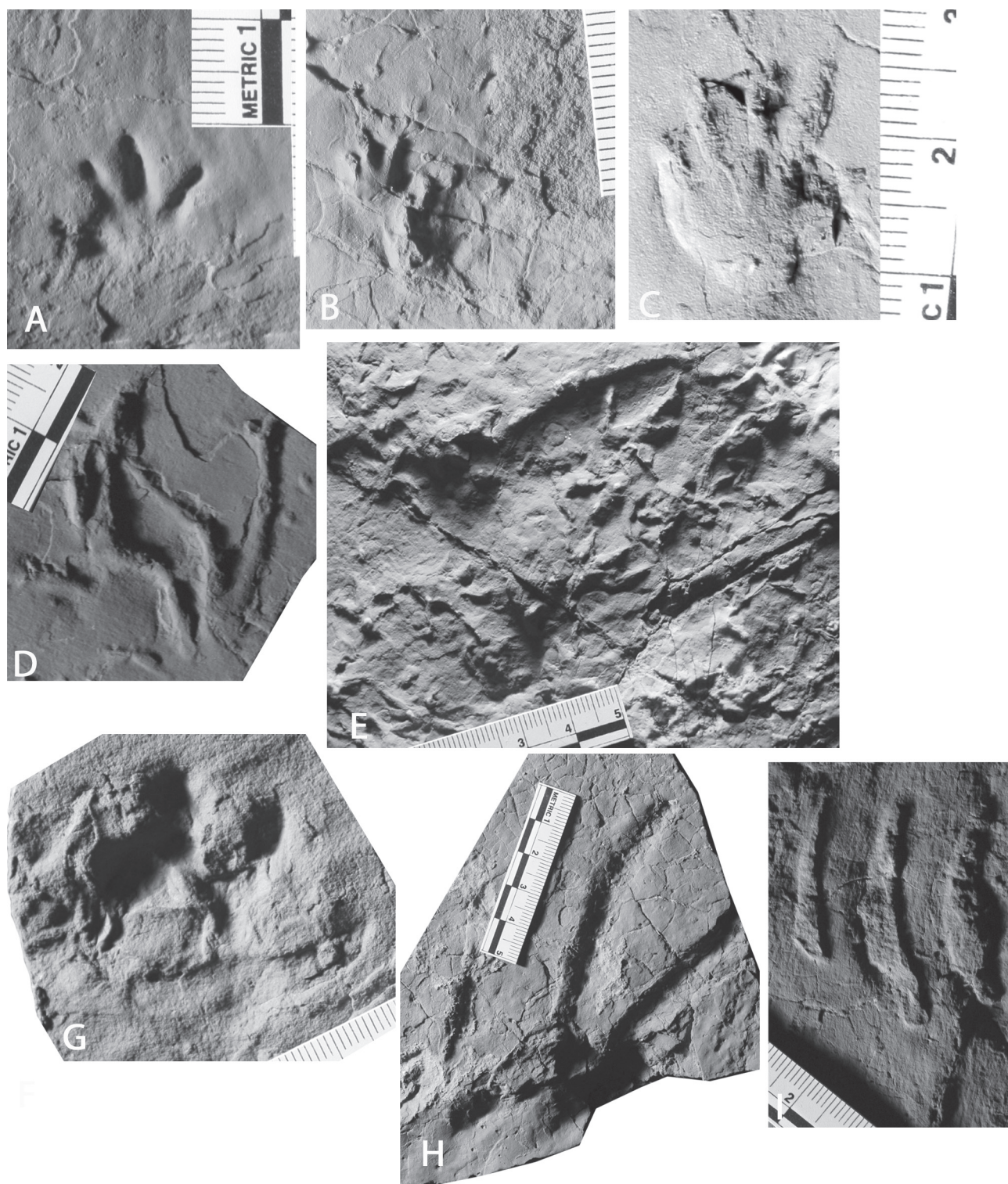


FIGURE 2. Representative tetrapod tracks from NMMNH locality 7666. **A-C**, *Batrachichnus salamandroides*, **A**, NMMNH P-57977, track in concave epirelief; **B**, NMMNH P-57989, track in convex hyporelief; **C**, NMMNH P-57984, track in concave epirelief; **D-E**, *Dromopus lacertoides*, **D**, NMMNH P-57978, track in convex hyporelief; **E**, NMMNH P-57990, numerous tracks in convex hyporelief. **G**, *Gilmoreichnus hermitanus*, NMMNH P-57983, track in concave epirelief. **H**, cf. *Dimetropus* sp., NMMNH P-57987, incomplete track in concave epirelief. **I**, *Characichnos* sp., NMMNH P-57976, track in convex epirelief.

Description: These tracks are pentadactyl and semiplantigrade to plantigrade with a small heel imprint. The digit imprints are thin, pointed and increase in length from I to IV, with II and V subequal in length. Pes track length is approximately 32 mm, and width is approximately 53 mm.

Comments: These tracks closely resemble specimens assigned to *Gilmoreichnus hermitnaus* by Haubold et al. (1995) and Hunt et al. (1995). *Gilmoreichnus* is considered to be the track/trackway of a small pelycosaur.

Ichnogenus *Dimetropus* Romer and Price, 1940

cf. *Dimetropus* sp.

Fig. 2H

Referred specimens: NMMNH P-57987, one slab with part of a footprint in concave epirelief (Fig. 2H).

Description: This incomplete track consists of three long (the longest is at least 90 mm long), narrow, pointed and slightly curved digit imprints. They appear to originate from what may be a “sole” imprint. The two longer digit imprints converge toward that imprint and are well separated from the third, shorter digit imprint.

Comments: This is the largest track in the assemblage and could be part of a *Dimetropus* track (cf. Haubold et al., 1995; Hunt et al., 1995; Voigt, 2004). However, given its incompleteness, any identification of this track must be considered tentative.

Ichnogenus *Characichnos* Whyte and Romano, 2001

***Characichnos* sp.**

Fig. 2I

Referred specimens: Two slabs with multiple traces in convex hyporelief from NMMNH locality 7666: NMMNH P-57976 (Fig. 2I) and P-57985.

Description: These are “swim tracks” characterized by three parallel, slightly curved digit imprints. The digit imprints are narrow and have pointed tips and vary in length from 25 to 45 mm.

Comments: Similar “swim tracks” are common at many Abo footprint localities, but they have never been assigned to an ichnotaxon. Lockley and Foster (2006) ably reviewed the ichnogenetic nomenclature proposed for tetrapod swim tracks. Based on their review, we refer these three-toed swim tracks from the Abo Formation to *Characichnos*. Whyte and Romano (2001) named the ichnogenus for swim traces from the Jurassic of England that they believed were made by a theropod dinosaur. The size of the Abo swim traces suggest a pelycosaur made them. However, we favor using the same ichnogenetic name for the Jurassic and Permian swim traces based on morphological similarity, regardless of the inferred identity of the tracemakers.

DISCUSSION

The Abo tetrapod track assemblage from locality 7666 is characteristic of many Abo track assemblages from southern New

Mexico in being dominated by footprints of *Batrachichnus* and *Dromopus* and in being of relatively low ichnodiversity. In the Abo depositional system, it is landward of more diverse ichnofossil assemblages such as those from the Robledo Mountains of Doña Ana County that also consist of abundant and diverse arthropod trackways and other invertebrate traces. This supports the idea that vertebrate ichnodiversity may have decreased landward in the Abo depositional system (Lucas et al., 2005c), but total ichnodiversity trends cannot be judged because of the absence of invertebrate ichnofossils at locality 7666. However, the absence of invertebrate trace fossils at locality 7666 is probably a taphonomic artifact of the sediment being too coarse to record small arthropod trails and other invertebrate traces. If this is so, then the low ichnodiversity of locality 7666 may not be a true reflection of biotic diversity (Davis et al., 2007).

The locality 7666 track assemblage fits well into the *Batrachichnus* ichnofacies (ichnocoenosis) of Hunt and Lucas (2006, 2007) in being of medium diversity and dominated by the tracks of quadrupedal carnivores. The assemblage is very similar to *Batrachichnus* ichnofacies sites in the Abo Formation in the Caballo and Fra Cristobal Mountains (e.g., Lucas et al., 2005c). Hunt and Lucas (2006) attempted to divide this ichnofacies into three “sub-ichnocoenoses” along an approximately north-south transect of much of New Mexico (Fig. 3). The locality 7666 assemblage fits into their “*Dimetropus* sub-ichnocoenosis” because of the relative abundance of *Batrachichnus* and the presence of *Dimetropus*. However, Hunt and Lucas (2006) saw this sub-ichnocoenosis as characteristic of “coastal/tidal flat settings,” but the Bingham tracksite is clearly in a relatively inland, alluvial plain setting (DiMichele et al., 2007). This means that the *Dimetropus* sub-ichnocoenosis of Hunt and Lucas (2006) needs to be extended farther inland, with Bingham as its northernmost locality in New Mexico.

The next Abo outcrop belt to the north, in the Joyita Hills uplift, yields track assemblages of the *Amphisauropus* sub-ichnocoenosis of Hunt and Lucas (2006), so apparently the boundary between the two sub-ichnocoenoses (assuming adequate sampling) is within Socorro County. Nevertheless, what factors are controlling the distribution of these sub-ichnocoenoses remain poorly understood. The *Dimetropus* sub-ichnocoenosis remains a less inland/upland association than the *Amphisauropus* sub-ichnocoenosis, but the distance between the two is now a few tens of kilometers. What is needed now is a more detailed study of Abo sedimentology at the Abo tracksites to attempt to more finely discriminate depositional environments and their relationship to the different kinds of tetrapod footprint assemblages.

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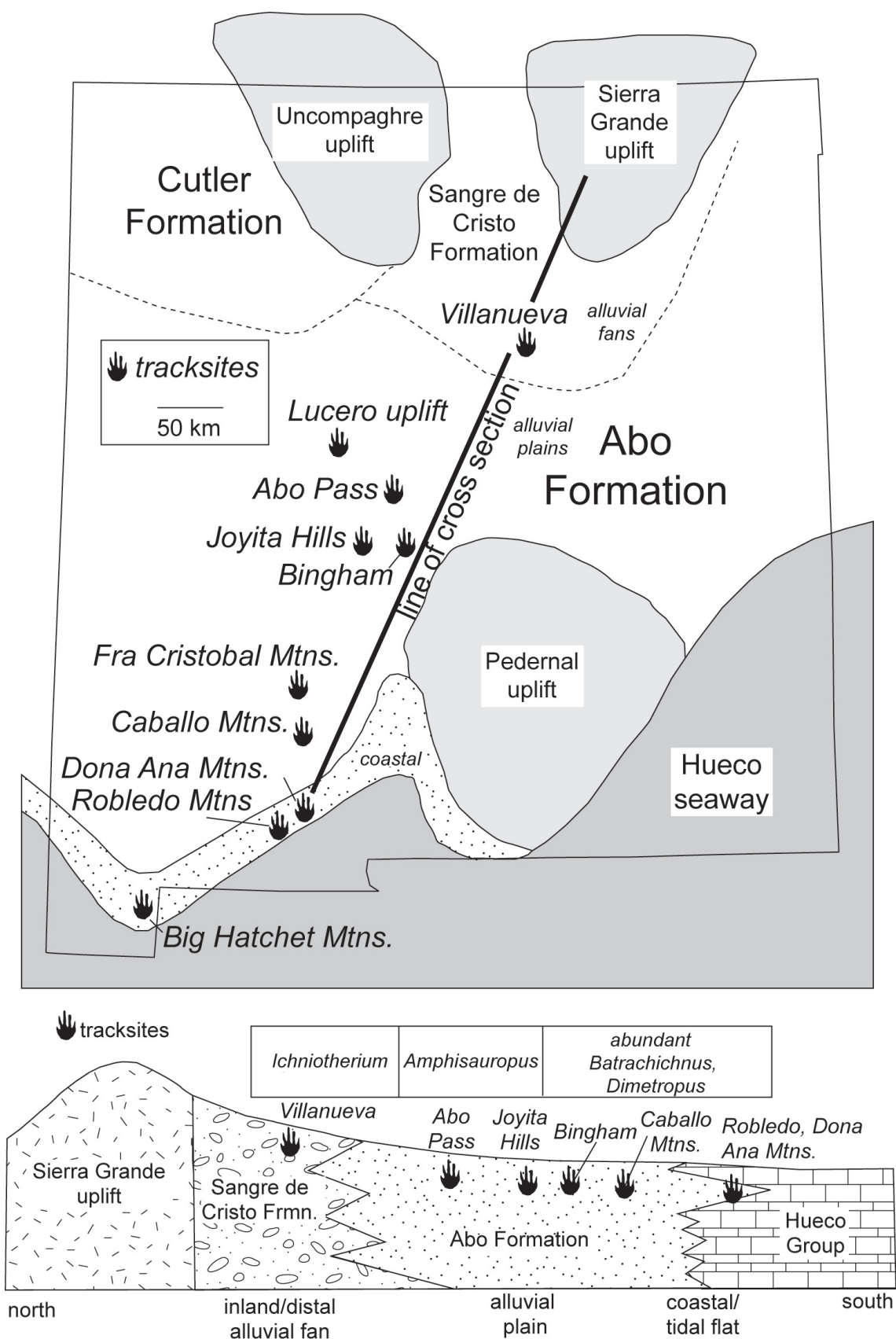


FIGURE 3. Index map showing lower Permian tracksites in New Mexico with contemporaneous depositional features and cross-section showing ichnofacies/ichnocoenosis zonation (modified from Hunt and Lucas, 2006).

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