Lucas, S.G. and Heckert, A.B., eds., 1995, Early Permian footprints and facies. New Mexico Museum of Natural History and Science Bulletin No. 6.

Preliminary Report on Paleontology of the Abo Formation, McLeod Hills, Sierra County, New Mexico

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ABSTRACT: Six fossil localities in the Abo Formation in the McLeod Hills of Sierra County, New Mexico, produce tetrapod body fossils (jaw of a sphenacodont pelycosaur), fossil plants (*Calamites* pith cast, *Walchia* and seed-fern foliar impressions) and tetrapod footprints of the ichnotaxa *Batrachichnus delicatulus* (Lull), cf. *Batrachichnus* sp., *Gilmoreichnus hermitanus* (Gilmore), *Dimetropus* sp. and indeterminate reptilian ichnotaxa. These ichnotaxa occur in Abo red beds that lack intertongued marine facies and indicate persistence of the *Batrachichnus-Dromopus* ichnofacies from marine shorelines to facies well inland.

INTRODUCTION

Early Permian siliciclastic red beds of the Abo, Cutler and Sangre de Cristo Formations produce significant vertebrate fossil assemblages across much of northern New Mexico (Berman, 1993). Until recently, the southernmost vertebrate fossil records in the Abo Formation of New Mexico were those reported by Vaughn (1969) from the southern Caballo Mountains in Sierra County and the Sacramento Mountains of Otero County. Recent collecting, however, has revealed extensive tetrapod-footprint assemblages from strata transitional from the nonmarine Abo Formation to the marine Hueco Formation further south in the Doña Ana and Robledo Mountains of Doña Ana County.

Recent collecting by Jerry MacDonald and David Slagle has also revealed extensive tetrapod footprint assemblages in the Abo Formation of the southern Caballo Mountains. These assemblages and associated tetrapod body fossils and megafossil plans are reported on here. They are from localities in a long, north-south Abo hogback that forms the core of the McLeod Hills (Figs. 1, 2, 3A). Because these outcrops have only been prospected for fossils in reconnaissance, this report can be considered preliminary. Here, NMMNH refers to the New Mexico Museum of Natural History and Science.

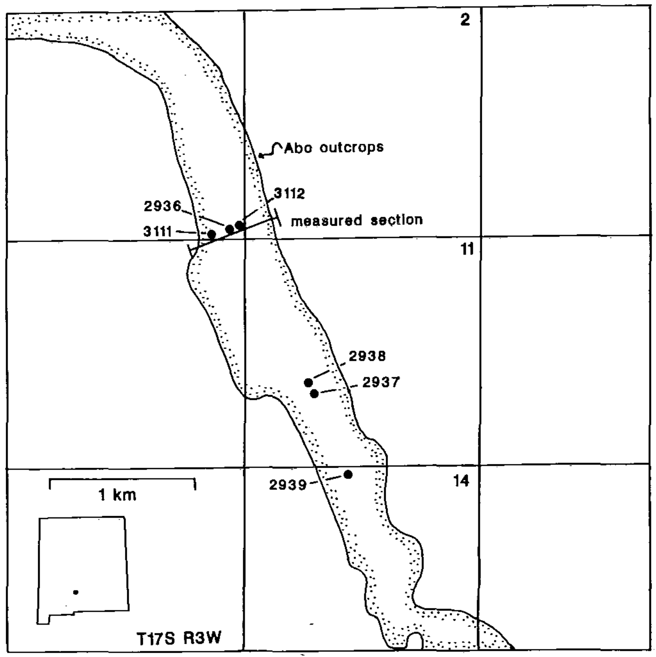

FIGURE 1. Map showing NMMNH fossil localities in the McLeod Hills and location of measured stratigraphic section in Figure 2. Geology adapted from Kelley and Silver (1952).

STRATIGRAPHY

Kelley and Silver (1952), Sherry (1990) and Mack et al. (this volume) described the Abo Formation in the McLeod Hills. As Kelley and Silver (1952, fig. 2) mapped these strata, the Abo Formation dips to the northeast (locally it is overturned to the northeast), overlies strata of the Bar B Formation to the west and is overlain to the east-northeast by the Yeso Formation (Fig. 1). We measured a complete section of the Abo Formation mostly in the SE1/4 sec. 3, T17S, R3W and located six fossil localities in that section (Figs. 1–2).

In this section, the Abo Formation is 324 m thick and consists mostly of grayish red mudstone (84% of the measured section, assuming covered intervals are underlain by mudstone) (Fig. 3). Sandstone makes up 12% of the measured section, and the remaining lithologies are minor constituents—siltstone (3%), conglomerate (1%) and shale (<1%). Kelley and Silver (1952, p. 100) stated the Abo Formation is 550 to 1100 ft thick in the Caballo Mountains. They placed the top of the underlying Bar B Formation at the same place we do:

> The uppermost beds of the Bar B are intercalated with reddish-brown siltstone, limestone conglomerate, and calcareous sandstone through an uneven stratigraphic interval of about 50 feet. In mapping we have attempted to draw the top of the Bar B and the Magdalena Group at the top of the uppermost marine limestone in the transition zone ... Inasmuch as it is clear that the uppermost fossiliferous limestone is marine, and it is not certain that the intercalated red beds of the zone are not marine, we believe that the top of the transition zone is better chosen as the top of the Magdalena than the bottom of the zone (Kelley and Silver, 1952, p. 94).

Sherry (1990) and Mack et al. (this volume) placed the Bar B-Abo contact somewhat lower than we do, at the base of the stratigraphically lowest red beds (base of our unit 2). These workers also divided the Abo Formation in the McLeod Hills into informal lower and upper members. In our section (Fig. 2), our units 11-43 correspond to their lower member, and units 44-57 to their upper member. However, we do not attempt here subdivision of the Abo Formation in the McLeod Hills.

FOSSIL LOCALITIES

Prospecting by Jerry MacDonald and David Slagle discovered six fossil localities in the Abo Formation in the McLeod Hills:

1. NMMNH locality 2936—at UTM 3638620N, 299859E, zone 13 in grayish red, ripple-laminated micaceous litharenite (unit 28 of the measured section: Fig. 2).
2. NMMNH locality 2937—at UTM 3637926N, 300393E, zone 13 at the same stratigraphic level as locality 2936.
3. NMMNH locality 2938—at UTM 3638153N, 300335E, zone 13 at the same stratigraphic level as localities 2936 and 2937.
4. NMMNH locality 2939—at UTM 3635896N, 301107E, zone 13 at the same stratigraphic level as localities 2936, 2937 and 2938.
5. NMMNH locality 3111—at UTM 3638506N, 299892E, zone 13 in a calcrete-clast conglomerate, (unit 23 of the measured section: Fig. 2).
6. NMMNH locality 3112—at UTM 3638660N, 299425E, zone 13, a lens of green laminated shale, (unit 35 of the measured section: Fig. 2).

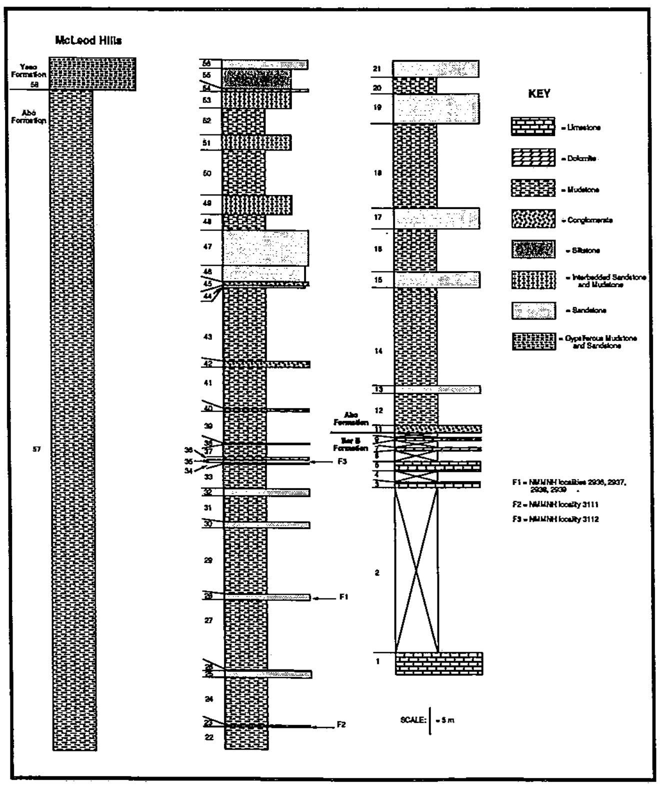

FIGURE 2. Measured stratigraphic section of the Abo Formation in the McLeod Hills. See Figure 1 for location of the section and the Appendix for description of the numbered lithologic units.

PALEONTOLOGY

The following discussion surveys all the main morphotypes of trackway, but does not list all the collected materials as referred specimens. This will be presented in a subsequent, complete study of this ichnofauna.

Batrachichnus delicatulus (Lull, 1918)

Batrachichnus is represented by numerous specimens, some of which preserve tail drags, including the following: NMMNH locality 2937: NMMNH P-24608, 7 convex track pairs (Fig. 4A); NMMNH locality 2938: NMMNH P-24612, about 15 convex tracks with tail drag.

cf. *Batrachichnus* sp.

Several of the *Batrachichnus* specimens are not specifically determinate, although they demonstrate the presence of this ichnogenus, including from NMMNH locality 2937: NMMNH P-24607, more than 20 concave tracks.

Limnopus sp.

Limnopus is represented by several specimens (but no long trackway segments have been collected) including from NMMNH locality 2937: NMMNH P-24606, 2 concave tracks.

Hyloidichnus bifurcatus Gilmore, 1927

This rare ichnospecies is represented by one long trackway segment from NMMNH locality 2938: NMMNH P-24610, 12 concave track pairs (Fig. 4B).

Dromopus sp.

Dromopus specimens are common at the McLeod localities. Following Haubold et al. (this volume), we do not attempt to place these specimens in an ichnospecies, pending taxonomic revision of this ichnotaxon. The specimens include: NMMNH locality 2936: NMMNH P-24604: 1 concave track, NMMNH P-24609, numerous concave tracks.

Gilmoreichnus hermitanus (Gilmore, 1927)

This ichnospecies is not common at the McLeod localities: NMMNH locality 2938: NMMNH P-24611, 5 convex tracks with tail drag (Fig. 4D).

Dimetropus sp.

Dimetropus is represented in the collection by one poorly preserved specimen which is specifically indeterminate: NMMNH locality 2938: NMMNH P-24613, 2 convex tracks (Fig. 4E).

Reptilian ichnotaxa indeterminate

NMMNH P-24605, three concave tracks from locality 2936, represents a large, *Ichniotherium*-sized reptile track and shows that there is potential to find more large ichnotaxa.

PALEOECOLOGY

The collection of vertebrate tracks from the McLeod localities is relatively small, so all paleoecological conclusions must be considered tentative. In general, most tracks are relatively small (foot length < 3 cm), and larger types, such as *Dimetropus* and unidentified forms (Fig. 4), are rare. *Batrachichnus* is the most common ichnogenus, with lesser numbers of *Dromopus* and rare *Hyloidichnus*, *Gilmoreichnus* and *Limnopus*. *Limnopus* and *Batrachichnus* are tracks of large- and

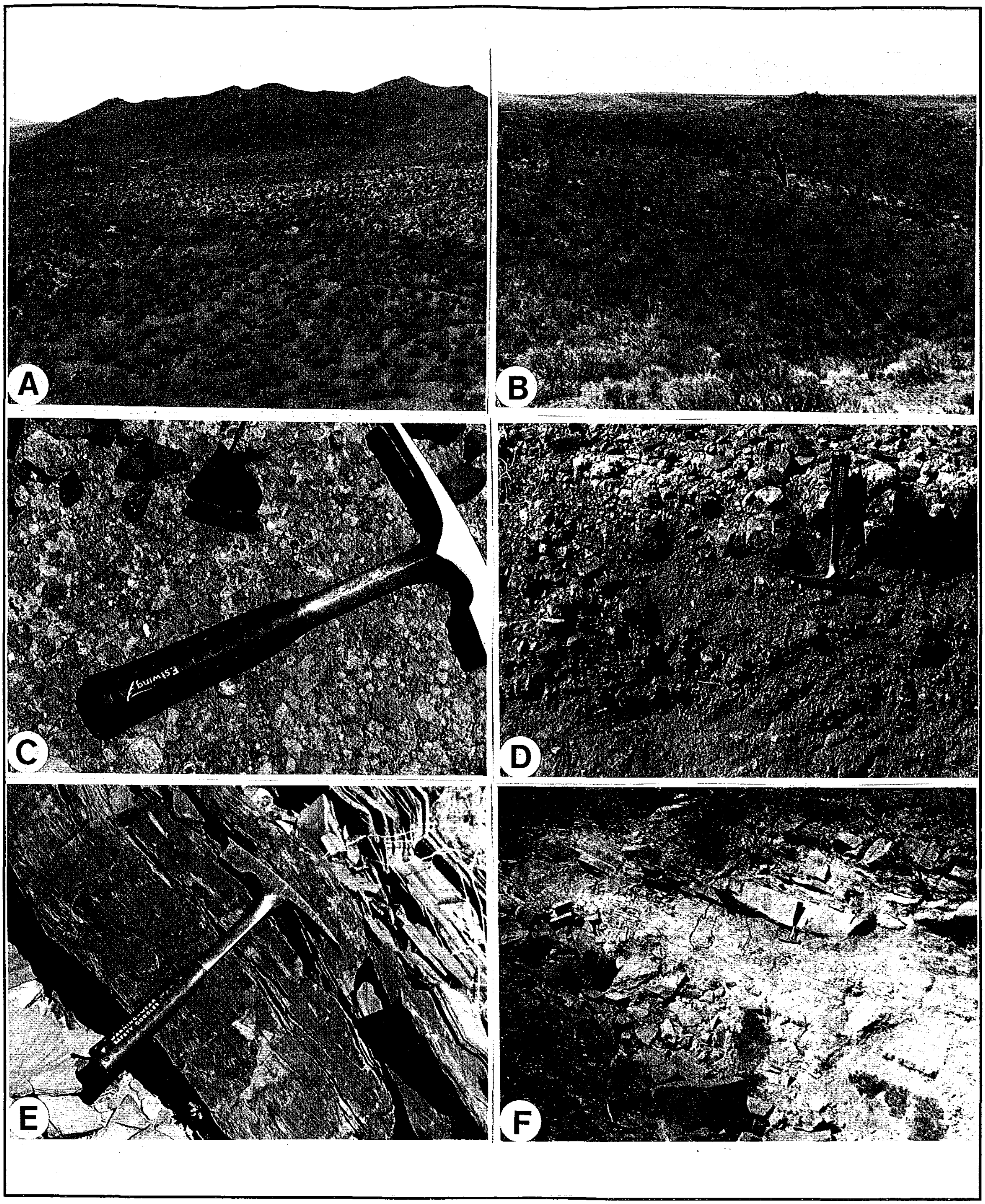

FIGURE 3. Selected outcrops of the Abo Formation in the McLeod Hills. A, Overview of Abo Formation hogbacks looking south to the SW1/4 sec. 11, T17S, R3W. B, Overview of upper part of measured section with locality 3112 indicated by arrow. C, Bone-bearing calcrete-clast conglomerate at NMMNH locality 3111 (unit 23 of measured section in Figure 2). D, Mudstone with calcrete nodules, unit 27 of the measured section in Figure 2. E, Track-bearing sandstone at NMMNH locality 2938 (unit 28 of measured section in Figure 2). F, Lens of lacustrine shale at NMMNH locality 3111 (unit 35 of measured section in Figure 2).

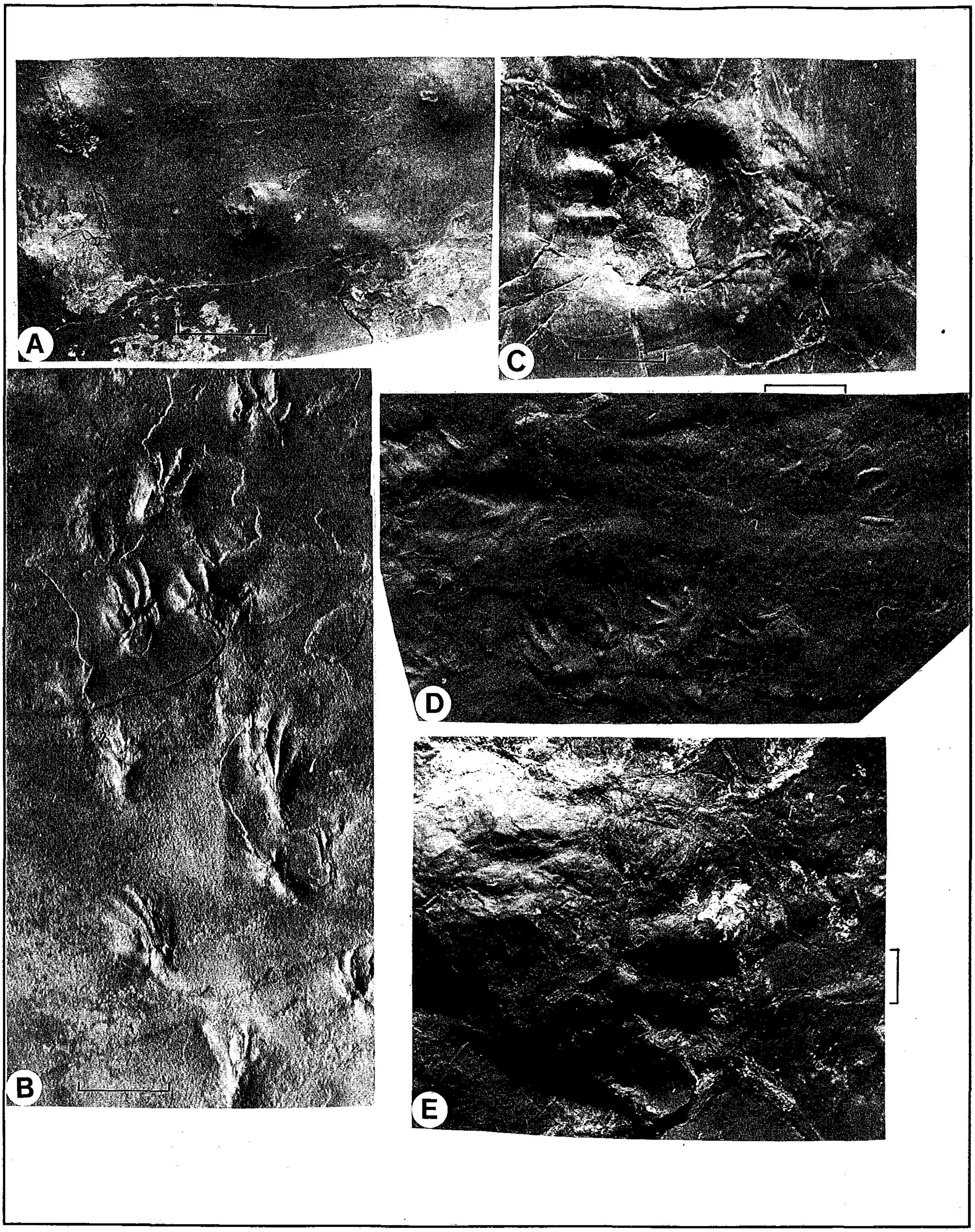

FIGURE 4. Selected tetrapod footprints from the Abo Formation in the McLeod Hills. A, *Batrachichnus delicatulus*, NMMNH P-24608 from locality 2937. B, *Hyloidichnus bifurcatus*, NMMNH P-24610 from locality 2938. C, *Limnopus* sp., NMMNH P-24606 from locality 2937. D, *Gilmoreichnus hermitanus*, NMMNH P-24611 from locality 2938. E, *Dimetropus* sp., NMMNH P-24613 from locality 2938. Bar scales = 2 cm.

medium-sized temnospondyls, respectively, and *Dimetropus* and *Gilmoreichnus* represent sphenacodont pelycosaurs. *Dromopus* is probably the track of an araeoscelid, and *Hyloidichnus* is that of a primitive reptile (seymouriamorph, diadectid or captorhinomorph). Therefore, the dominant trackmakers in the McLeod ichnofaunas are small temnospondyls and araeoscelids. This association is common in the ichnofaunas of the Hueco Formation in the Robledo Mountains of southern New Mexico (Hunt et al., this volume), and in the Earp Formation in the Big Hatchet Mountains (Lucas and Hunt, this volume).

One factor that biases the initial collections is that they are largely comprised of small slabs, which partly explains the paucity of large footprints. However, we believe that the ichnofauna is dominated by small tracks, though this must be demonstrated with certainty by further collecting. Abo facies in the McLeod Hills lack directly intertongued marine rocks of Hueco lithology. Although there is some tidal influence evident in some of the sandstone complexes of the Abo Formation in the McLeod Hills (Mack et al., this volume), the Abo facies clearly are very different from the facies exposed in the Doña Ana, Robledo and Big Hatchet Mountains to the south. Despite this facies change, the tetrapod ichnofacies—dominated by *Batrachichnus* and *Dromopus*—does not change from the McLeod Hills to the more southerly mountain ranges. The preliminary data from the McLeod Hills thus suggest a persistence of this ichnofacies from the marine shoreline to immediately inland.

ACKNOWLEDGMENTS

Jerry MacDonald and David Slagle discovered and collected tetrapod footprints in the McLeod Hills and spent time with us in the field showing us their localities.

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APPENDIX: MEASURED STRATIGRAPHIC SECTION

Section begins at 13249646E, 3638239N and ends at 13300173E, 3638943N. Strata dip 25° to due north at base of section.

unit	lithology	thickness (m)
Yeso Formation:		
58	Nodular gypsum and sandstone; gypsum is light greenish gray (5G8/1) to white (N9); sandstone is similarly colored but stained to grayish pink (5R8/2); very fine-grained, subangular, well-sorted quartzarenite; not calcareous; unit crops out just east of road on east side of McLeod Hills.	not measured
Abo Formation:		
57	Mudstone; red; interval is much covered from slopes of McLeod hills out onto flats past dirt road. Thickness assumes constant dip of 58°.	124.5
56	Sandstone; pale red (5R6/2) fresh, weathers to blackish red (5R2/2); very fine- to fine-grained, subangular to angular, moderately well-sorted sublitharenite; very slightly micaceous; ripple laminated and herringbone crossbedded; not calcareous; forms a ledge.	1.5
55	Siltstone; dark reddish brown (10R3/4) fresh, weathers pale reddish brown (10R5/4) and moderate reddish brown (10R4/6); well indurated; laminar to massive; not calcareous.	4.7
54	Conglomerate; grayish red (5R4/2); clasts are calcrete nodules up to 25 mm in diameter; calcareous; matrix is silty mudstone; not calcareous; forms a ledge.	0.5
53	Sandstone and mudstone interbedded; sandstones are ledgy and wavy; same colors and lithologies as unit 49.	3.0
52	Mudstone; much covered.	6.0
51	Sandstone; same colors and lithology as unit 49 but actually 3 ledges with thin mudstone partings.	2.7
50	Mudstone; red; much covered.	8.7
49	Silty sandstone and sandy siltstone; grayish red (10R4/2); very fine-grained quartzarenite; well indurated; laminar to ripple laminated; not calcareous; forms a ledge.	3.4
	Above this unit dip changes to 58°.	
48	Covered slope; most likely red mudstone.	3.0
47	Silty sandstone; pale reddish brown (10R5/4) to pale red (10R6/2); very fine-grained, subangular, moderately well-sorted micaceous sublitharenite; small scale trough crossbeds and ripples; some muddy laminae are calcareous; uppermost unit of prominent hogback that crests the hills locally.	6.5

unit	lithology	thickness (m)
46	Sandstone; pale reddish brown (10R5/4) to moderate reddish orange (10R6/6); very fine- to fine-grained, subangular, micaceous, sublitharenite; laminated; thinly bedded; platey; not calcareous.	2.5
45	Conglomerate; pale red (5R6/2) to moderate red (5R5/4); clasts are calcrete nodules and mudstone rip-ups up to 20 mm across; only nodules are calcareous; sandy matrix weathers high.	0.4
44	Silty sandstone; pale reddish brown (10R5/4) to pale red (10R6/2); silty to very fine-grained, subangular to subrounded, micaceous, sublitharenite; ripple laminated; very slightly calcareous.	0.6
43	Mudstone; moderate reddish orange (10R6/6) to pale red (10R6/2); clean to slightly silty; not calcareous.	13.7
42	Conglomerate and sandstone; same color and lithology as unit 40; conglomerate clasts are calcrete rip-ups.	1.0
41	Mudstone; same colors and lithology as unit 37; much covered.	7.8
40	Sandstone and conglomerate; grayish red (10R4/2); conglomerate is moderate orange pink (10R7/4) fresh; sandstone is very fine- to fine-grained, micaceous, sublitharenite; conglomerate clasts are small (2–4 mm) calcrete nodules; conglomerate is calcareous; trough crossbedded; unit fines upward; forms a ledge.	0.6
39	Mudstone; red; much covered slope.	5.7
38	Sandstone; same colors and lithology as unit 32.	0.2
37	Mudstone; same colors and lithology as unit 33.	2.5
36	Conglomerate; yellowish gray (5Y7/2) to light olive gray (5Y6/1), rare bands of moderate red (5R4/6) plants debris; clasts are calcrete and mudstone rip-ups up to 8 cm in length; unit fines upward into sandstone and siltstone; trough crossbedded; some plant material; not calcareous except calcrete clasts; forms a ledge.	0.6
35	Shale; light greenish gray (5G8/1); calcareous; unit produces plants and some conchostracans.	0.4
34	Conglomerate; olive gray (5Y4/1) to light brownish gray (5YR4/1) fresh, weathers yellowish gray (5Y8/1) to pinkish gray (5R8/1); clasts are calcrete and mudstone rip-ups up to 8 cm in length; unit fines upward into sandstone and siltstone; unit forms a lens; locally fossiliferous.	0.2
33	Mudstone; pale reddish brown (10R5/4) to moderate reddish brown (10R4/6); calcareous.	4.3
32	Sandstone; same colors and lithology as unit 30; ledge.	1.2
31	Mudstone; same colors and lithology as unit 29.	5.1
30	Sandstone; grayish red (10R4/2) to dark reddish brown (10R3/4); only dark reddish brown where weathered; very fine-grained, subangular, well-sorted, micaceous sublitharenite; well-indurated; ripple laminated to small-scale trough crossbedded; not calcareous; forms a ledge.	1.2
29	Mudstone; same color and lithology as unit 27 but few, if any, calcretes; much covered; forms a slope.	12.3
	Above this unit change dip to 25° to N35° E.	
28	Sandstone; grayish red (10R4/2); very fine-grained, subrounded, well sorted micaceous litharenite; NMMNH localities 2936, 2937, 2938, and 2939 produce plants and tetrapod footprints in this bed; ripple laminated; forms a very persistent ledge.	1.2
27	Mudstone; grayish red (5R4/2) with some mottles of yellowish gray (5Y8/1) associated with calcrete nodules; calcrete nodules up to 60 mm in diameter in ledgy horizons every couple of meters in fresh outcrop.	13.6
26	Conglomerate; light bluish gray (5B7/1) fresh, weathered and stained pale reddish brown (10R5/4) and pale red (10R6/2); calcrete pebbles up to 15 mm in diameter.	0.2
25	Silty sandstone; greenish black (5GY2/1) fresh, weathers to grayish red (5R4/2); very fine-grained, subangular, moderately well-sorted, micaceous sublitharenite; small trough crossbeds; not calcareous; forms a ledge.	1.4
24	Mudstone?; much covered slope.	9.3
23	Conglomerate; speckled pale yellowish brown (10YR6/2) and moderate yellowish brown (10YR5/4); clast-supported with moderate reddish orange matrix; clasts 2–5 mm in diameter; no bed forms; lenticular unit; sphenacodont locality.	0,4
22	Mudstone?; much covered slope.	4.1
21	Sandstone; same colors and lithology as unit 19; ledge.	3.0
20	Mudstone?; covered slope.	3.0
	Offset 100 yards to northeast at top of this bed and change dip to 11° to N60° E.	
19	Sandstone; pale reddish brown (10R5/4); very fine- to medium-grained, subangular, moderately poorly sorted, micaceous sublitharenite; flaser bedded and ripple laminated.	5.4
18	Mudstone?; covered slope.	15.8
17	Sandstone; pale red (5R6/2) to grayish red (5R4/2), only grayish red weathered; very fine-grained, subangular, moderately well-sorted micaceous sublitharenite; some horizontal bioturbation with feeding traces on bedding planes; calcareous; forms a ledge.	4.2

unit	lithology	thickness (m)
16	Mudstone?; covered slope.	8.0
15	Sandstone; medium gray (N5) to pale red (5R4/2); very fine- to fine-grained, subangular, moderately well-sorted sublitharenite; laminar to ripple laminated; calcareous.	2.8
14	Mudstone?; covered slope.	17.7
13	Sandstone; pale red (10R6/2) to grayish red (10R4/2); very fine- to fine-grained, subangular, moderately well-sorted sublitharenite; ripple to wavy laminated; calcareous; this is the lowest red sandstone ledge.	1.3
12	Covered slopes like unit 2.	6.1
11	Conglomerate; pale olive (10Y6/2) fresh with red staining from above units; clast-supported; clasts are calcrete nodule rip-ups from the very coarse sand fraction to 5 mm; no bed forms; calcareous; forms a ledge.	1.3
	Total thickness of Abo Formation:	320.1 m

unit	lithology	thickness (m)
Bar B Formation:		
10	Covered slope.	1.1
9	Dolomite; same color and lithology as unit 7.	0.5
8	Covered slopes like unit 2.	1.5
7	Dolomite; pale olive (10Y6/2) to yellowish gray (5Y7/2) fresh, weathers to pale greenish yellow (10Y8/2) with pale reddish brown (10R5/4) staining; forms a ledge.	0.5
6	Covered slope like unit 2.	2.5
5	Limestone; medium dark gray (N4) fresh, light olive gray (5Y6/1) weathered; micritic; locally a packstone.	1.7
4	Covered slope like unit 2.	2.5
3	Limestone; medium gray (N5) and dark gray (N5); micritic; some intraclastic fusulinids?; forms a ledge.	1.0
2	Covered red slopes; possibly red shales?	30.6
1	Limestone; medium gray (N5) to medium dark gray (N4); vuggy red siltstone karstic infillings; micritic.	not measured