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A NEW CRETACEOUS DINOSAUR TRACKSITE IN SOUTHERN NEW MEXICO

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ABSTRACT

Several large tridactyl undertracks made by between four and six dinosaurs are preserved on a single bedding plane in the Anapra Sandstone (Late Albian, Cretaceous) at Cerro de Cristo Rey, Doña Ana County, New Mexico. Because the Anapra Sandstone is herein correlated lithostratigraphically and ichnotaxonomically with the Dakota Sandstone, it is proposed that these tracks extend the southern geographic range of the Dakota Megatracksite Complex approximately 500 km. We assign the tracks described here to the ichnogenus *Magnoavipes* based on morphology and age (latest Albian), although several of the tracks are larger than any published data on this ichnotaxon. Also, the presence of *Caririchnium* along with *Magnoavipes* has biostratigraphic significance and confirms the value of the ichnofacies concept.

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KEY WORDS: dinosaur, Mid-Cretaceous, New Mexico Tracksite, Dakota Megatracksite, *Magnoavipes*, *Caririchnium* ichnofacies, ichnofacies

INTRODUCTION

A previously undescribed series of tridactyl dinosaur footprints are described from the Mid-Cretaceous Anapra Sandstone (Strain 1976) also known as the Sarten Member of the Mojado Formation (Lucas and Estep 1998; Kappus et al. in press). The presence of these tracks may expand the southern geographic boundary of the Albian-Cenomanian “Dinosaur Freeway” (Lockley et al. 1992) or the “Dakota Megatracksite Complex” (Lockley and Hunt 1995) by approximately 500 km. The site described here includes eight moderately well-preserved undertracks and other additional poorly preserved tracks in a shale quarry on the northern flank of Cerro de Cristo Rey in southernmost Doña Ana County, New Mexico (Figure 1). Cristo Rey is a hypabyssal andesite pluton of Eocene age (Lovejoy 1976).

Size and pace length differences among the tracks suggest that at least five individual dino-

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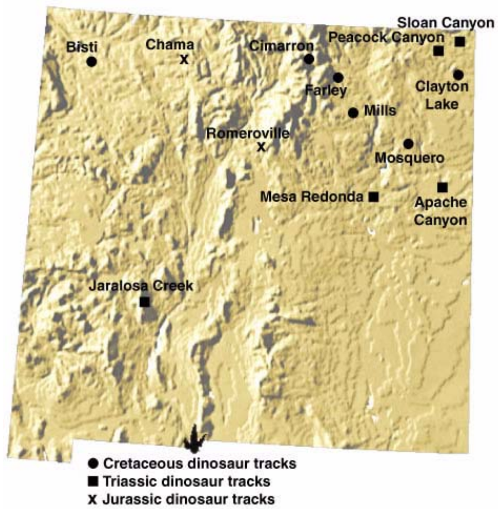

FIGURE 1. Map of New Mexico showing dinosaur tracksites. The tracksite described here is indicated by the tridactyl footprint symbol.

saurs were present. The direction of progression (parallel to footlength, see Lockley et al. 1999) of all of the tracks except one is a westerly (present-day) direction. An east-progressing track is the same size as two of the others. It could have been made by one of the five individuals, or it could be the track of a sixth dinosaur.

STRATIGRAPHY AND AGE

Stratigraphy

Strain (1976) divided the Anapra Sandstone into three sandstone members and one silty shale member (see Figure 2.1). Total thickness of the Anapra varies from 52.5 m to 64 m due to tectonic thinning of the shales around the pluton, Cerro de Cristo Rey. Footprints are preserved at the top of the second sandstone member (Figure 2.1), a tidal and littoral unit (LeMone and Kotlowski 1996) which consists of thin to massive beds of fine- to medium-grained, ferruginous sandstone and interbedded dark grey shales. Underlying cross beds are truncated by the track-bearing bed described here.

Marine shales (Mesilla Valley Formation below and Del Rio Clay above) bracket the Anapra (Strain 1976; figure 2b). Fossil oysters (*Exogyra whitneyi*) occur in the top-most 1–2 m of the Anapra; worm castings and poorly preserved twig/stem-like land plant material occur on some sandstone bed tops. Lignite laminae occur (LeMone and Kotlowski 1996) in the siltstone that overlies the tracks. Sedimentary structures within the Anapra sandstones include extensive cross-beds, ripple marks, and channel-fill sequences indicating that deposition of the Anapra took place on a tidal shoal to fluvial-paludal delta complex along the

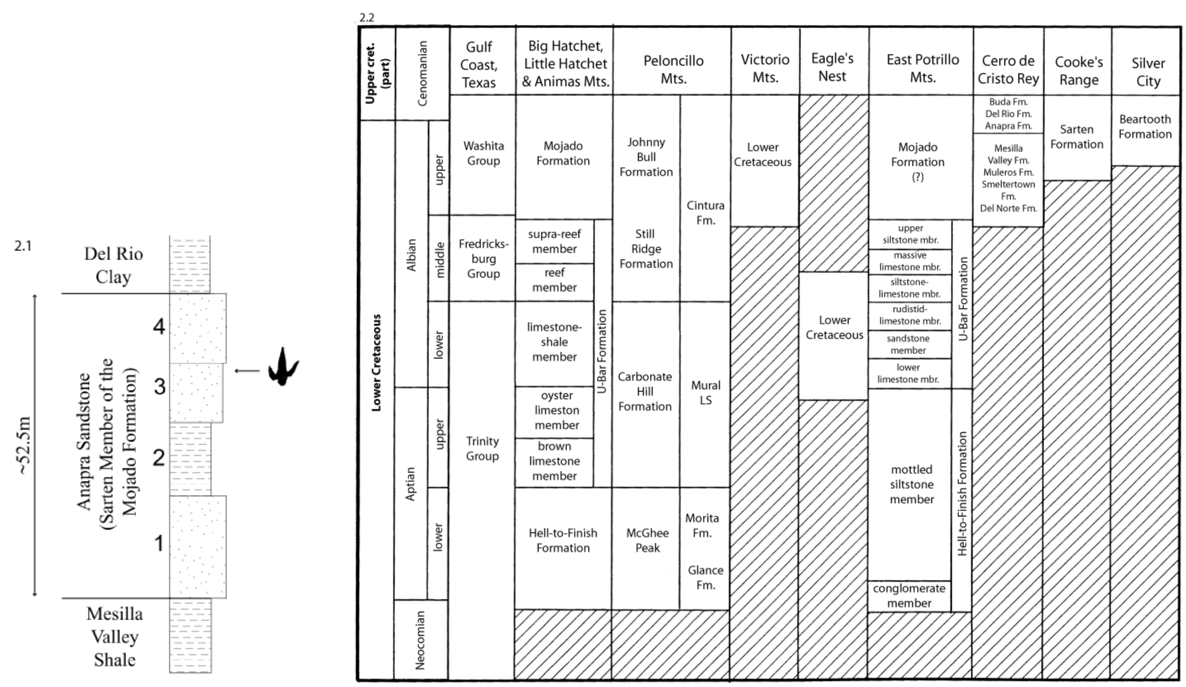

FIGURE 2. 2.1. Simplified stratigraphic section of the Anapra Sandstone (numbers refer to units from Strain 1976) showing the stratigraphic location of the tracksite described. Study horizons indicated by the tridactyl footprint symbol. **2.2.** Nomenclature and correlation of Lower Cretaceous rocks in New Mexicofrom Lucas and Estep 1998.

northern margin of the Chihuahuan embayment (LeMone and Kotlowski 1996). For general stratigraphy of the Cerro de Cristo Rey uplift, see Lovejoy (1976).

Lithologically, the Anapra Sandstone resembles coeval clastic rocks in the region and has been renamed as the Sarten Member of the Mojado Formation by Lucas and Estep (1998). We support this correlation but will refer to the Sarten Member as the Anapra Sandstone here for clarity and simplicity. The Anapra is assigned to the *Plesioturrilites brazoensis* ammonite zone of latest Albian age (Lucas and Estep 1998) based on stratigraphic correlation with the Sarten Member of the Mojado Formation (Figure 2.2). The Anapra correlates lithostratigraphically with part of the Dakota Sandstone, and so broadly correlates stratigraphically to the Dinosaur Freeway of Lockley et al. (1992). In the San Andres Mountains (60 miles to the north), east of Las Cruces, New Mexico, outcrops of the Fryingpan Spring Member of the Mojado Formation (Lucas and Estep 1998) and the overlying Dakota Sandstone are present (Lucas and Estep 1998). Historically there has been some disagreement about which unit of the Mojado Formation is present beneath the Dakota at this locality, and what the thickness is. We concur with Lucas and Estep (1998) as stated above, due to the petrologic similarity of the Fryingpan Spring Member to the Mesilla Valley Shale (Strain 1976), which underlies the Anapra Sandstone (Sarten Member) locally, and due to the petrologic similarity of the Dakota Sandstone to the Anapra.

In northern New Mexico, westernmost Oklahoma, and southern Colorado, dinosaur tracksites in the Dakota Sandstone constitute the “Dakota Megatracksite Complex” (Lockley and Hunt 1995). These tracksites occur in numerous outcrops of the Dakota, spread over the Colorado Front Range and southeastern Colorado, westernmost Oklahoma, and northeastern New Mexico. Age of the sites varies but most are thought to be Late Albian-Early Cenomanian. Others (Lucas et al. 2000) have argued that age disparities between individual tracksites render the “megatracksite” concept problematic. Nonetheless, the Cristo Rey site on the New Mexico/Republic of Mexico border stratigraphically extends the geographic distribution of Dakota Megatracksite 500–600 km to the south from northeastern New Mexico.

In Texas, approximately 400 km to the east, slightly older (Early Albian) strata contain the westernmost dinosaur tracks yet reported in the state.

Age

The Albian/Cenomanian boundary was placed (Strain 1976) at the contact between the underlying Mesilla Valley Shale and the Anapra, and Strain (1976) correlated the Anapra with the Main Street Formation (Cenomanian) of the Washita Group in central Texas. We have found that lens-like accumulations (<5 cm thick) of foraminiferal (*Cribratina texana* packstone occur sporadically throughout the Mesilla Valley Shale, but are not found in overlying strata. These foraminifera indicate that the Mesilla Valley is Albian in age (Loeblich and Tappan 1964). The presence of *Exogyra whitneyi* in the upper 1–2 m of the Anapra, and in the overlying Del Rio clay indicates that the Albian/Cenomanian boundary falls somewhere within the Anapra. Lucas and Estep (1998) placed the Albian/Cenomanian boundary at the top of the Anapra, at the Anapra/Del Rio contact. In this interpretation, the Anapra is chronologically equivalent to the Mesa Rica Sandstone, a dinosaur footprint-bearing unit in northeastern New Mexico. Scott (1970) correlated the Mesa Rica of New Mexico with the Dakota of southeastern Colorado.

TRACKSITE DESCRIPTION

The undertracks described here lie on a tectonically tilted bedding surface that strikes 120º and dips 65º to the northeast, and occur in an area approximately 2 m wide by 5 m long (Figure 3.1) in an inactive quarry 0.3 km east and 0.25 km north of the southwest corner of Section 9, R4E, T29S, in the Smeltertown TX-NM 7.5 minute quadrangle, on posted private property.

The prints are preserved in convex epirelief (1–5 cm) above the sandstone bed because they are actually sub-surface “undertracks” (Lockley and Hunt 1995) or subsurface “compression shapes” (Brown 1999) preserved on a bioturbated, hematized sandstone bedding plane that was once covered by a veneer of silty mud. Prints were likely produced by theropod dinosaurs (see Taxonomy section below), who walked on the mud surface, compressing the sand below and leaving undertracks matching the size and depth of each track. The bio-compacted sand was more strongly lithified, and thus today stands out in relief from the bedding plane.

Table 1 shows foot and pace lengths of the track-makers, as well as digit divarication angles, measured on the outcrop. Lettered tracks in Figure 3.1 indicate individual dinosaurs, correlated to the track data in Table 1. Also, some of the sub-surface compression shapes (“undertracks”) include features called “pressure releases” (Brown 1999)

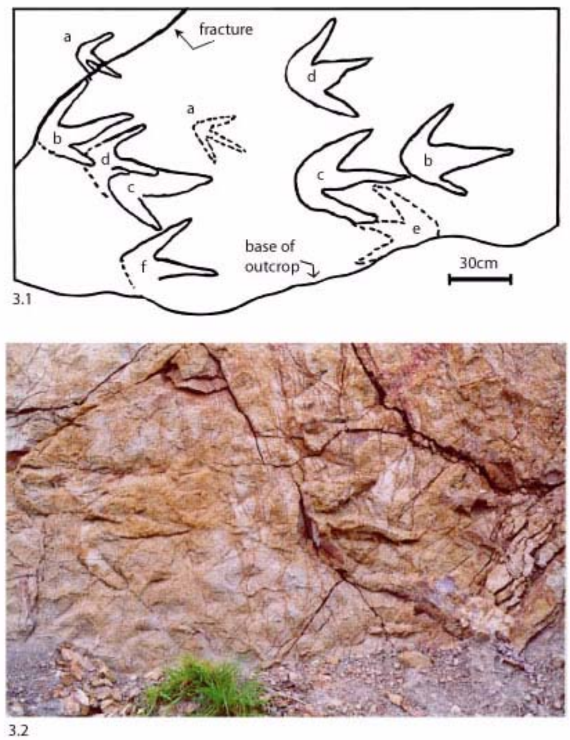

FIGURE 3. 3.1. Map of the track-bearing outcrop looking south-southwest with individual tracks and track pairs (Table 1) labeled. **3.2.** Photo looking south-southwest of the track-bearing outcrop. Fracture illustrated in 3.1 extends from left-center margin to top-center margin of photo.

which support measurements of pace length and therefore relative speed of movement of the animals. For example, the pace length of dinosaur "b" is much longer than dinosaur "c," even though "c" has a longer foot length (Table 1, Figure 3.1), indicating that animal "b" was moving more rapidly than was "c." This interpretation is supported by the presence of pressure releases of greater intensity, showing greater effort in maintaining forward motion (Brown 1999). Thulborn (1990) noted structures within tracks that are distortions caused by nodes on the digits of the foot. However at this time, it appears that the pressure releases are not simply distortion by the digital nodes.

In addition to the prints described herein, additional tracks of other dinosaurs and other reptiles have been found at several other locations in the area (Kappus et al. in press).

TAXONOMY

Comparison of the Anapra prints with illustrated prints (Lockley and Hunt 1995; Lucas et al. 2000; Lockley et al. 2001; Thulborn 1990) from middle-Cretaceous strata, as well as other Dakota-age (early Cenomanian) rocks in New Mexico suggests that the Anapra track-makers were theropods, and that the undertracks are attributable to the ichnogenus *Magnoavipes*. This ichnogenus was first described by Lee (1997) who described the tracks as large bird tracks, and hence the name, which means "big bird track." Our assignment of the tracks described here to this particular ichnogenus is based on morphological similarity with the systematic ichnology of *Magnoavipes* in Lockley et al. (2001), as well as similarity in age to *Magnoavipes* tracks described by Lee (1997) and Lockley et al. (2001). The tracks described here, like all tracks attributable to the ichnogenus *Magnoavipes*, have long, slender toes, which gently taper to a sharp point or claw impression. The total angles of digit divarication are wide (60º–85º), with observable angles between digits II and III being commonly smaller than between digits III and IV. The average footprint length to width ratio is 1.07 (range of 0.87–1.43), which is also characteristic of tracks attributed *Magnoavipes* (Lockley et al. 2001).

TABLE 1. Measurements of individual tracks shown in Figure 3.1. Tracks are paired by measurements and position, and pace length and digit divarication were measured on the outcrop.

Individual	Foot length, east to west	Length of pace	Digit (II-IV) divarication
Pair a	29 cm, 30 cm	68 cm	80º, 80º
Pair b	44 cm, ~48 cm	190 cm	70º, 70º
Pair c	53 cm, 53 cm	96 cm	n/a, 60º
Pair d	32 cm, 34 cm	120 cm	85º, 85º
Single e	~40 cm	n/a	60º
Single f	~44 cm	n/a	80º

The *Magnoavipes* undertracks described herein differ in several details from published data. For example, several of the tracks are much larger than previously described *Magnoavipes* tracks of the Dinosaur Freeway. Previously studied tracks are up to 38 cm in length (Lockley et al. 2001), whereas the tracks at Cristo Rey reach lengths of 53 cm. Also, at the outcrop mapped in this study, undertracks of *Magnoavipes* are the only ichnogenus present.

Tracks of the ichnogenus *Caririchnium* (and possibly *Amblydactylus*) are also found in great abundance at several other sites around Cristo Rey in association with additional tracks attributed to the ichnogenus *Magnoavipes* (Kappus et al. in press). *Caririchnium* tracks have bilobate heels, whereas similar *Amblydactylus* tracks have rounded heels. This is presently the principal characteristic used to distinguish them from each other, although shape and orientation of the pads of the foot (Brown 1999) may prove to be valuable in the future. The presence of crescent-shaped manus prints is also associated with *Caririchnium*, but not *Amblydactylus* (Lockley and Hunt 1995).

Caririchnium is distinguishable from *Magnoavipes* by the presence of wider, blunt-ended toes with smaller digit divarication angles (Thulborn 1990). Digit III of the *Caririchnium* tracks is also shorter in comparison to digits II and IV, whereas in *Magnoavipes* digit III is longer (Thulborn 1990). Also, *Magnoavipes* tracks are elevated digitigrade (see Figure 3.1), while *Caririchnium* is plantigrade, showing the bilobate heel impressions mentioned above.

The presence of *Caririchnium* along with *Magnoavipes* has biostratigraphic significance and supports the value of the ichnofacies concept described by Lockley et al. (1994). More research on the Cristo Rey tracksite is needed to assess whether or not this tracksite can be included in the "Caririchnium ichnofacies" of Lockley et al. (1994).

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