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DIMETRODON (AMNIOTA: SYNAPSIDA: SPHENACODONTIDAE) FROM THE LOWER PERMIAN ABO FORMATION, SOCORRO COUNTY, NEW MEXICO

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Abstract—We document dorsal vertebrae and neural spine fragments of a small specimen of *Dimetrodon*, NMMNH P-57872, from the middle part of the Lower Permian Abo Formation in Socorro County, New Mexico. This adds to the relatively few records of *Dimetrodon* outside of Texas and Oklahoma and is the only Early Permian locality that yields the taxon in Socorro County. The locality is approximately 140 km from the nearest Early Permian marine shoreline and near the flanks of the Joyita uplift of the ancestral Rocky Mountain orogeny, so it is consistent with *Dimetrodon* having been a fully terrestrial, inland predator. Nevertheless, its rarity outside of Texas and Oklahoma cannot be readily explained.

INTRODUCTION

The sail-backed basal synapsid ("pelycosaurian"-grade) *Dimetrodon* is one of the most distinctive basal amniotes of the Permian Period. Originally described by Cope (1878) from the Lower Permian of Texas, *Dimetrodon* is well known from Lower Permian strata of the Wichita, Clear Fork and Pearce River groups of Texas and equivalent strata in Oklahoma (e.g., Romer and Price, 1940; Reisz, 1986; Lucas, 2006). Outside of Texas the genus has sparse records in New Mexico, Utah and Arizona (Vaughn, 1966, 1969; Berman, 1977; Madalena et al., 2007) and it has recently been documented from the Lower Permian of Germany (Berman et al., 2001, 2004). Here, we add to the sparse record of *Dimetrodon* from New Mexico a recently discovered specimen from Socorro County, New Mexico, consisting of vertebrae with distinctive elongate neural spines. In this article, NMMNH refers to the New Mexico Museum of Natural History and Science in Albuquerque, New Mexico.

PROVENANCE

The *Dimetrodon* fossil (NMMNH P-57872) documented here was collected by one of us (TM) in 2005 from NMMNH locality 7726 in section 31, T2S, R2E in the Cerros de Amado of central Socorro County. NMMNH locality 7726 is in an intraformational conglomerate at the base of laterally accreted channel sandstone lens of the Lower Permian Abo Formation (Fig. 1). This, plus the broken, disarticulated state of the vertebrae and their encasement in grayish-red, fine-grained sandstone indicates transport as channel lag. The Abo Formation section below the fossil locality is faulted, so that the basal contact with the underlying Bursum Formation is not exposed (Cather and Colpitts, 2005). Locality 7726 is about 106 m below the top of the Abo Formation (contact with base of Cañada de Amarilla Formation of the Yeso Group); locally the Abo Formation is about 200 m thick. Thus, the *Dimetrodon* locality is approximately in the middle of the local Abo Formation section.

DESCRIPTION

The *Dimetrodon* fossil, NMMNH P-57872, consists of four dorsal vertebrae and six incomplete, detached neural spines. We illustrate only the most complete and diagnostic elements here (Fig. 2). The centra are amphicoelous, notochordal and the lateral surfaces are deeply concave, so that the articular ends of the centra flare outward to form a subcircular rim in anteroposterior view, surrounding a deep, conical notochordal funnel. The centra have prominent midventral keels. The neural arch is fused to the centrum, suggesting these vertebrae pertain to an adult. The transverse processes are blunt and extend about 3 mm laterally from the anterior articular rim. The processes narrow slightly along their length and terminate in a dorsoventrally-elongate oval "cup" that faces postero-ventrally. The prezygapophyses are positioned lateral to the neural canal, inclined anteriorly and have slightly concave anterior surfaces. The incomplete postzygopophyses are positioned above the neural canal at the base of the neural spine and can only be described as small, posteriorly-projecting flanges.

Using the measurement protocol of Romer and Price (1940) and Berman (1977), the dimensions of the most complete centrum (Fig. 2F-I) are: length = 23 mm, width = 21 mm, height at posterior end = 22 mm. The base of the neural spine on this centrum is a thin, laterally compressed blade that is 10 mm long antero-posteriorly. A second centrum, still embedded in matrix (Fig. 2A), is similar in morphology, but is more complete and its short, blade-like proximal portion abruptly changes distally, a short distance above the postzygapophyses, to a transvere figure-eight (or dumbbell-shape) outline in horizontal cross-section with midline anterior and posterior grooves.

None of the isolated neural spines are complete, and some are represented by molds in sandstone due to postdepositional erosion (Fig. 2B-E). From one of these molds (Fig. 2C-D), a resin cast has been made of the missing spine (Fig. 2E). The incomplete spine (based on the cast) has a figure-eight (or dumbbell-shaped) cross-sectional outline and a maximum dorsoventral

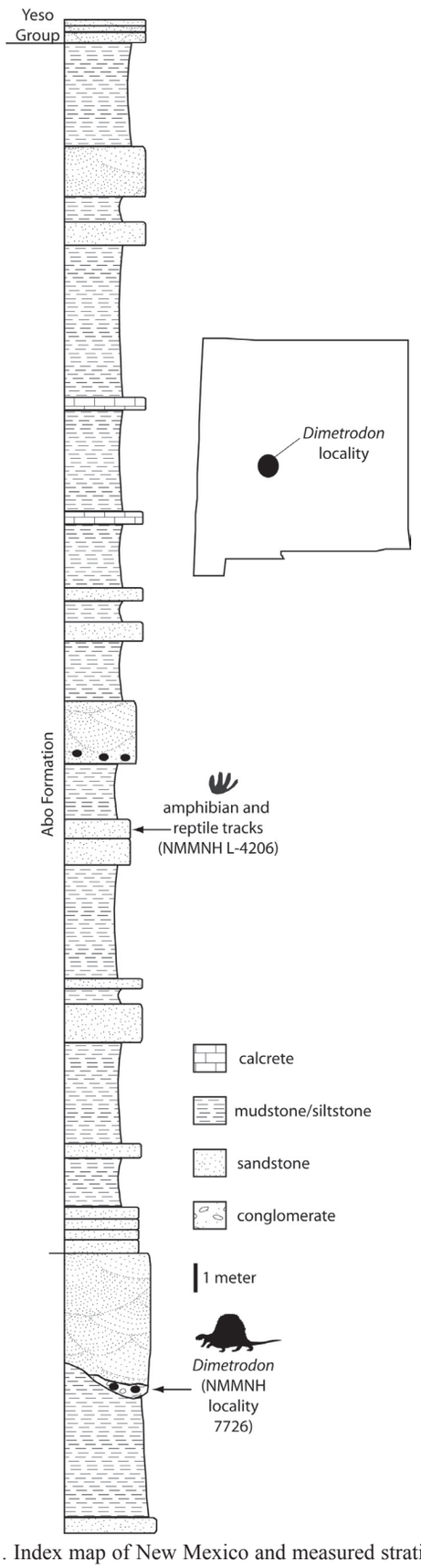

FIGURE 1. Index map of New Mexico and measured stratigraphic section showing *Dimetrodon* locality in the Cerros de Amado, Socorro County, New Mexico.

height of 110 mm, a maximum antero-posterior length of 8 mm, and a maximum transverse width of 12 mm.

IDENTIFICATION

The centra and incomplete neural spines of NMMNH P-57872 closely resemble anterior thoracic vertebrae of *Dimetrodon occidentalis* and *D. teitonis* described by Berman (1977) and Berman et al. (2001), respectively (see also Reisz, 1986). The slender elongate neural spines with anterior and posterior grooves are particularly characteristic of the genus. The height to width ratio of the most complete centrum is 1.0, and the length-to-height ratio is also 1.0. These differ significantly from the values reported by Berman (1977, table 1) for *D. occidentalis*, the only species of *Dimetrodon* previously reported from New Mexico. Instead, they are much closer to other small species of *Dimetrodon,* such as *D. milleri* and *D. limbatus*. However, NMMNH P-57872 is too incomplete to assign to a species of *Dimetrodon*, though it clearly pertains to a small specimen of the genus.

DISCUSSION

When Romer and Price (1940) published their classic revision of the pelycosaurs, *Dimetrodon* fossils were confined to the Lower Permian of Texas and Oklahoma. Lower Permian strata of the Cutler Group and Abo Formation in New Mexico yielded abundant remains of another large pelycosaur, *Sphenacodon*, so the idea was advanced that *Sphenacodon* and *Dimetrodon* were ecological vicars living west (*Sphenacodon* in New Mexico) and east (*Dimetrodon* in Texas and Oklahoma) of an Early Permian seaway (e.g., Langston, 1953; Romer, 1960).

Discoveries of *Dimetrodon* in New Mexico, Utah and Arizona by Vaughn (1966, 1969), Berman (1977) and Madalena et al. (2007), as well as the record documented here, establish the presence of *Dimetrodon* west of the Early Permian seaway that existed between north-central Texas/central Oklahoma, where *Dimetrodon* is common, and the Four Corners states of Arizona, Utah, Colorado and New Mexico. The recent discovery of *Dimetrodon* in the Lower Permian of Germany (Berman et al., 2001, 2004) extends its geographic range, suggesting that this large predatory pelycosaur may have inhabited much of the Euramerican tropics of Early Permian Pangea.

The rarity of *Dimetrodon* occurrences outside of Texas-Oklahoma merits explanation, and fits with Olson's (1961, 1966, 1971, 1984) idea that large pelycosaurs were tied to aquatic environments because aquatic and semi-aquatic vertebrates were their food sources. However, like Berman et al. (2001), we are skeptical of this explanation because anatomy and facies associations of *Dimetrodon* fossils found outside of Texas and Oklahoma are consistent with it having been a fully terrestrial, inland and upland predator. The Socorro County record of *Dimetrodon* reported here is the third record of *Dimetrodon* from New Mexico. The other two are from Abo Formation red beds in the Jemez Mountains area of northern New Mexico (Berman, 1977; Madalena et al., 2007). During the time of Abo deposition (middle Wolfcampian – early Leondardian), the Jemez Mountains localities were

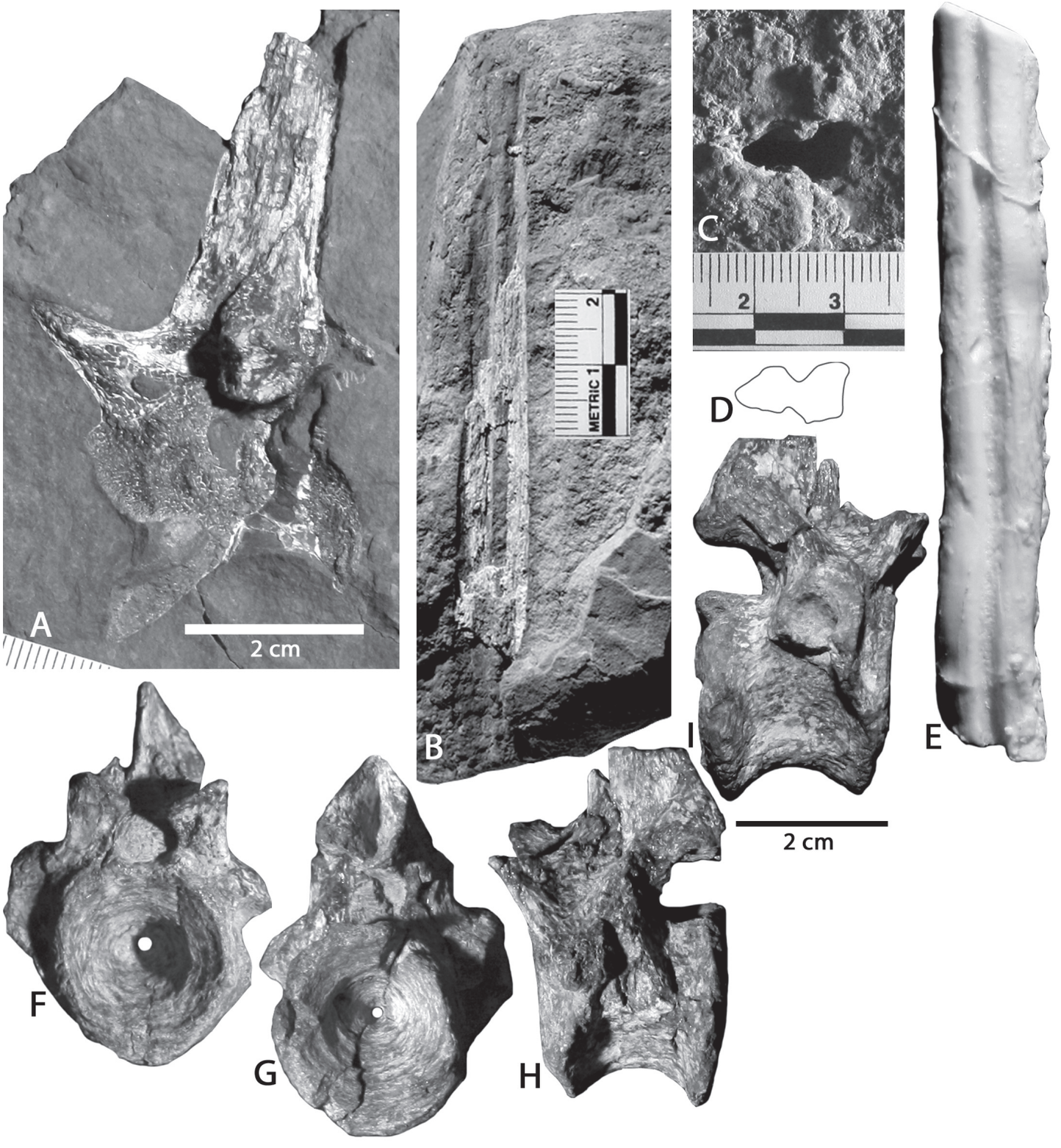

FIGURE 2. *Dimetrodon* sp. vertebrae, NMMNH P-57872, from NMMNH locality 7726, Abo Formation, Socorro County, New Mexico. **A**, Dorsal vertebra in matrix block in left lateral view. **B**, Isolated neural spine in matrix block in lateral view. **C-E**, Neural spine fragment, **C**, natural mold in matrix block, **D**, cross section outline of neural spine based on natural mold and **E**, resin cast of neural spine from natural mold. **F-I**, Dorsal vertebra in **F**, anterior, **G**, posterior, **H**, left lateral and **I**, right lateral views. Upper scale bar for **A**, lower scale bar for **F-I** and scale in **C** applies to **D-E**.

on the flanks of the Peñasco uplift, one of the basement-cored highlands of the ancestral Rocky Mountain orogeny (cf. Kues and Giles, 2004, fig. 11) and at least 350 km north of the Early Permian shoreline (near Las Cruces). The Socorro County locality reported here was about 140 km from the seashore and near the flanks of the Joyita uplift of the ancestral Rocky Mountain orogeny. These New Mexican records of *Dimetrodon* thus were in inland habitats.

The *Dimetrodon* fossils, of course, occur in fluvial facies, so they still are consistent with Olson's concept that this pelycosaur fed on semi-aquatic and/or aquatic vertebrates. But, the distribution of *Dimetrodon* fossils in the Abo Formation in New Mexico is also consistent with it having been a fully terrestrial inland and upland predator. Nevertheless, its rarity outside of Texas and Oklahoma still cannot be readily explained. Additional discoveries of *Dimetrodon*, like that reported here, are needed to fully establish its paleogeographic and paleoenvironmental range, though we expect that full explanation of its varied abundance will remain elusive for some time to come.

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