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## A titanosaurid sauropod from the Upper Cretaceous of Chihuahua, Mexico

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### RESUMEN

*Restos de un saurópodo titanosáurido fueron descubiertos en la zona de Altares, en el noreste del Estado de Chihuahua, México. El material fósil proviene de rocas que han sido correlacionadas ya sea con la parte continental más superior de la Formación Aguja o la parte continental más inferior de la Formación Javelina. El material incluye los cuerpos de cuatro vértebras caudales posteriores y son identificados como pertenecientes a la familia Titanosauridae con base en la condición fuertemente procélica. Este es el primer registro de la familia para el país.*

*Palabras clave: titanosáurido, saurópodo, Altares, Chihuahua, México.*

### ABSTRACT

*Remains of a titanosaurid sauropod were discovered in the area of Altares, in the northeastern corner of the State of Chihuahua, Mexico. The fossil material was collected from rocks that have been correlated either to the continental upper part of the Aguja Formation or to the lowest part of the continental Javelina Formation. The fossil material includes the centra of four posterior caudal vertebrae. They are identified to belong to the family Titanosauridae on the basis of their strongly procoelus condition. This is the first record of titanosaurids in Mexico.*

*Keywords: titanosaurid, sauropod, Altares, Chihuahua, Mexico.*

### INTRODUCTION

This note reports on titanosaur remains that have been recovered from the area of Altares, in the northeastern corner of the State of Chihuahua (Figure 1). The fossils were collected in strata that have been correlated either to the continental upper part of the Aguja Formation or the lowest part of the continental Javelina Formation (Palomino-Sánchez and Vega-Ramírez, pers. comm., 2001). Other vertebrate remains and petrified wood were also collected with the titanosaurid material (Montellano *et al.*, 2000).

Titanosaurids were first recognized from the Late Cretaceous of India, and the oldest known generally

accepted titanosaurid record is from the Late Jurassic of Africa (Jacobs *et al.*, 1993). Titanosaurid sauropods have been found throughout the world, including South America; Europe, North America, Africa, Madagascar and India (McIntosh, 1997; Curry and Forster, 1999; Forster, 1999). The family Titanosauridae is the most widely distributed as well as the last surviving group of Cretaceous sauropods. The family includes the last recorded sauropod in North America from the Late Cretaceous (Late Maastrichtian) local faunas in Texas, New Mexico, Utah and Wyoming (Jacobs *et al.*, 1993) and recently from the Late Campanian of Arizona (McCord, 1997). This is the first record of titanosaurids in Mexico, south of the Río Bravo.

## SYSTEMATIC PALEONTOLOGY

Family TITANOSAURIDAE Lydekker, 1893  
Genus et species indet.

**Diagnosis.** Salgado *et al.* (1997) proposed that the members of Titanosauridae are united by the following synapomorphies: 1) absence of hyposphene–hypantrum articulation in posterior trunk vertebrae; 2) six sacral vertebrae; 3) anterior caudals strongly procoelus having ball and socket articular faces; 4) mid and posterior caudals strongly procoelus. Wilson and Sereno (1998) recognized as one of the synapomorphies of the Titanosauria the anterior caudal centra with prominent convex posterior face, and the anterior and middle caudal vertebrae with prespinal and postspinal laminae.

**Comments.** Bonaparte *et al.* (2000) questioned the use of the procoelus character of the caudal vertebrae to characterize titanosaurids. They considered that procoelus of the anterior caudal vertebrae represents an adaptation in tail structure which developed after the middle Late Jurassic in several different groups of sauropods, and is thus not restricted to titanosaurids. Nevertheless, several recent authors utilize centrum morphology in generic and species identification of Cretaceous sauropods (*e. g.*, Jain and Bandyopadhyay, 1997; Gomani, 1999).

**Material.** Four partial posterior caudal vertebrae (IGM 6080) were recovered (Figure 2) together at the locality named Cri–Cri. A tentatively identified? dorsal or sacrocaudal vertebra (IGM 6080-5) was also collected in the same locality (Figure 3). In all the specimens, the centra are preserved, but the transverse processes and neural arches are lacking. The material is deposited at the Museo de Paleontología of the Instituto de Geología,

Universidad Nacional Autónoma de México, in Mexico City (IGM). For measurements see Table 1.

**Occurrence.** Late Jurassic of Africa; Early Cretaceous of Africa, Europe, North America and questionably South America; Late Cretaceous of Africa, Madagascar, South America, North America, Europe and Asia.

## DISCUSSION

The caudal vertebrae (IGM 6080) are referred to the family Titanosauridae on the basis of their strongly procoelus condition and their morphological similarity to the proximal caudal vertebrae described for *Alamosaurus* by Gilmore (1946). Gilmore indicated that the posterior end of the second caudal vertebrae is higher than wide and that this proportion persists back to twelfth caudal vertebra. After the fifteenth caudal, the posterior faces are wider than high. Following this line of reasoning, two of the vertebrae (IGM 6080-2 and 3) fit the proportions of more proximal vertebrae, while the other two (IGM 6080-1 and 4) are from a more distal position in the tail. Compared with the vertebrae of the tail of *Alamosaurus sanjuanensis* described and illustrated by Gilmore (1946), the vertebrae from Chihuahua are half of the size. They also are smaller than those described from Arizona (McCord, 1997) and from Texas (Lawson, 1972). Chevron facets are preserved on the ventral side of the posterior rim of the centra of two vertebrae (IGM 6080-1 and 2).

The centrum of the vertebra (IGM 6080-5) is almost amphiplatyan. The anterior and posterior articular faces are elliptical, and although the transverse processes are missing, the scars are directed laterally as described by MacIntosh (1990) for dorsal vertebra. In his

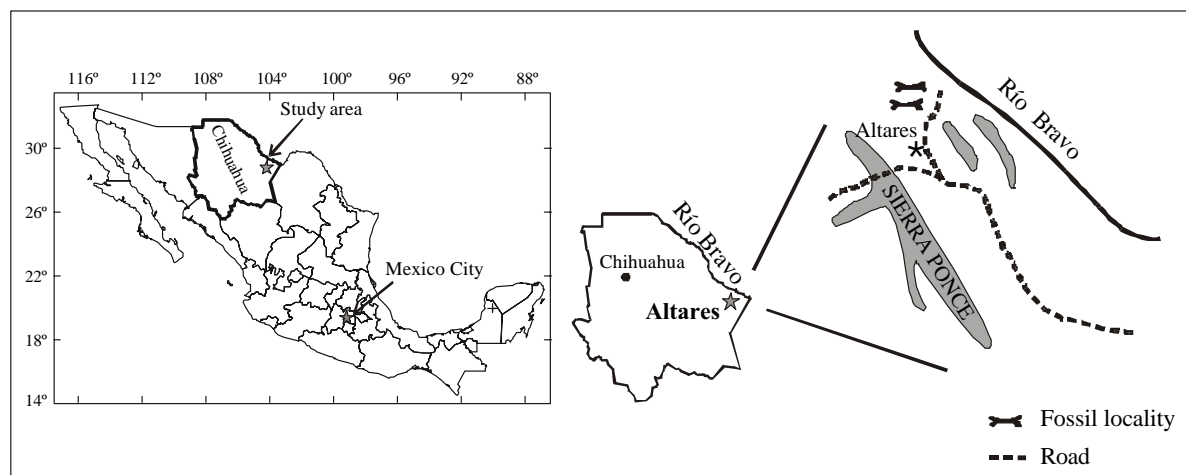


Figure 1. Map showing the location of Altares, in the northeastern corner of the State of Chihuahua, Mexico.



Figure 2. Titanosaurid caudal vertebrae (IGM 6080-2), from Chihuahua, Mexico. Right, lateral view; left, dorsal view. Scale x 0.91.

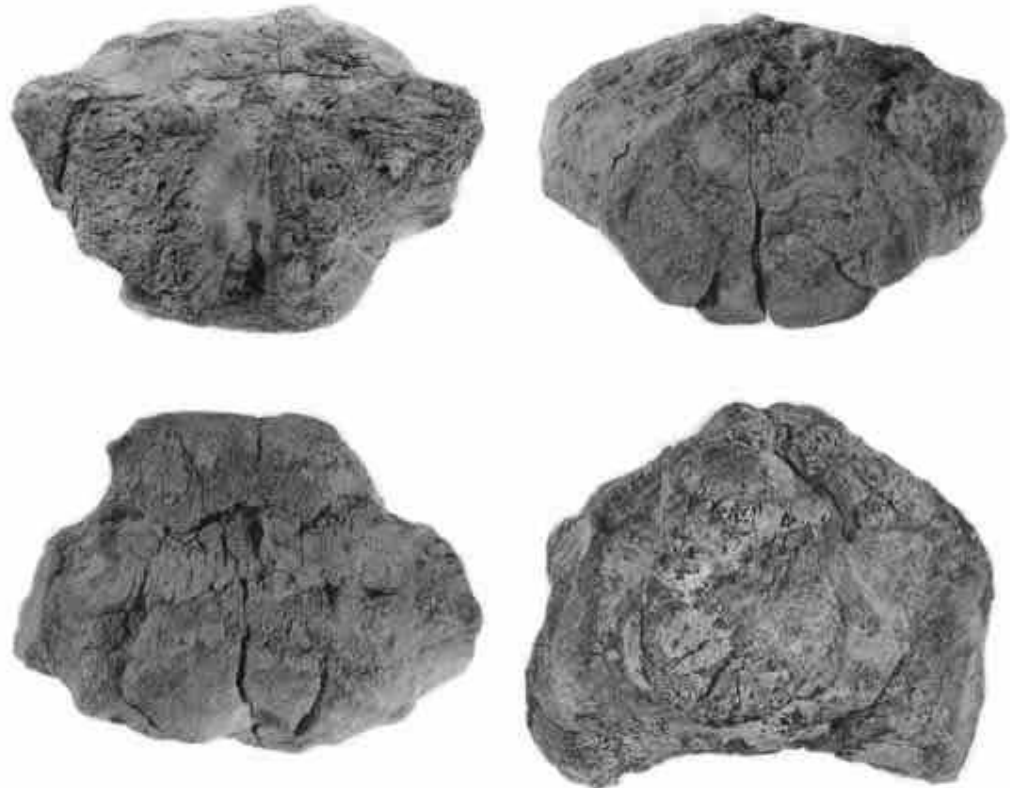


Figure 3. Titanosaurid vertebra (IGM 6080-5), from Chihuahua, Mexico. Upper left, dorsal view; upper right, posterior view. Lower left, ventral view. Scale x 0.60. Lower right, lateral view, scale x 0.82.

Table 1. Measurements of the titanosaurid caudal vertebrae recovered from Chihuahua, Mexico

	IGM 6080-1	IGM 6080-2	IGM 6080-3	IGM 6080-4
Greatest horizontal diameter of centrum at the distal end	69.4	64.6	66.4	57.2
Greatest vertical diameter of centrum at the distal end	72.4	67.9	71.5	48.5

review, Dr. Lehman pointed out that the sauropod dorsal vertebrae have prominent pleurocoels and do not have transverse processes, and he suggested it belongs more likely to a sacrocaudal centrum. Unfortunately, the vertebra is poorly preserved and it is difficult to place it in a certain position. Measurements: greatest length of centrum: 92.7 mm; greatest horizontal diameter of centrum distal end 91.6 mm., greatest horizontal diameter of centrum cranial end 68 mm.

The only genus of titanosaur described thus far from North America is *Alamosaurus* (Lucas and Hunt, 1989), known only from partial specimens. Recently, Lehman and Coulson (2002) described a juvenile specimen of *Alamosaurus sanjuanensis*, which includes skeletal elements that have not been previously described for the species and thus provides significant osteological information. Complete titanosaurid skulls and articulated skeletons have yet to be described (McIntosh, 1990). Curry and Forster (2001) described the single most complete titanosaur yet discovered. It was recovered in Madagascar. Without more complete information, it is difficult to distinguish which differences are due to age, sex, or interspecific variation. Because of this situation, I prefer to refer the material only to family level.

Titanosaurids were by far the predominant sauropods in the Late Cretaceous. It was proposed (Lucas and Hunt, 1989; Kirkland *et al.*, 1997; Cifelli *et al.*, 1997; Maxwell and Cifelli, 2000) that sauropods were extirpated from North America by the end of the Albian, and recolonized the continent from South America during the Maastrichtian, perhaps as late as 70 Ma (Lucas, 1994).

Titanosaurid remains in the Late Cretaceous Adobe Canyon Formation described by McCord (1997) suggest that the time of reinvasion of sauropods was probably late Campanian, as was earlier suggested by Bonaparte (1984). However, remains of primitive titanosaurids have been found in the Lower Cretaceous Cedar Mountain Formation in Utah (Britt *et al.*, 1996, 1998); their presence confirms that this kind of sauropod was present in North America during Early Cretaceous time. The authors argued that this find contradicts the hypothesis that titanosaurs did not invade North America from South America until Late Cretaceous.

Wilson and Sereno (1998) questioned the mid-Cretaceous sauropod hiatus in North America, and

suggested that this may be due to poor sampling. The cladistic analysis undertaken by Salgado and Calvo (1997) suggests that *Alamosaurus* is the sister taxon of Saltasaurinae, a South American endemic titanosaur group from the latest Cretaceous, which is consistent with previous biogeographical interpretation that *Alamosaurus* is a Late Cretaceous immigrant from South America. Lehman and Coulson (2002) considered that the species *A. sanjuanensis* is most closely related to an unnamed titanosaur from Brazil and *Neuquensaurus australis* from Argentina.

The presence of titanosaurids in northern Mexico is not surprising if dispersal did indeed occur from South America toward North America. Unfortunately, the geology of this part of the country is poorly known, there is only one unpublished geological study of the area made by F. Palomino and M. Vega, staff members of the INEGI (Instituto Nacional de Estadística, Geografía e Informática). The spotty outcrops of these formations are small. Their report suggests that it is not possible to distinguish the continental Aguja Formation from the lower part of the Javelina Formation. The age of these formations is considered to range from late Campanian–late Maastrichtian (Lehman, 1985). Titanosaurids have been collected in the Maastrichtian beds of the Big Bend National Park (Lawson, 1972). Lehman and Coulson (2002) reported *Alamosaurus sanjuanensis* from Black Peaks Formation, also in the Big Bend National Park, just below the Cretaceous–Tertiary boundary horizon. The presence of this dinosaur in Chihuahua represents the first record of a titanosaurid in Mexico.

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