

DINOSAUR FAUNAL REPLACEMENT DURING CENOMANIAN TIMES IN PATAGONIA, ARGENTINA

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INTRODUCTION

IN RECENT years, the Neuquén Basin (west-central Argentina) has yielded rich dinosaur faunas ranging from Albian-Cenomanian to lower Campanian in age (Leanza *et al.* 2004). The Neuquén Group (Digregorio 1972; Cazau and Uliana 1973) of the Neuquén Basin has continental deposits of alternating conglomerates, sandstones and claystones (Legarreta and Gulisano 1989).

The Neuquén Group includes the Río Limay, Río Neuquén and Río Colorado subgroups (Ramos 1981; Figure 1). The lowermost of these subgroups (Río Limay) has provided one of the most impressive dinosaur fossil records in terms of yielding the remains of many gigantic forms. This subgroup includes three formations, the Candeleros, Huincul and Lisandro (in ascending stratigraphical order). The richest deposits from the Río Limay subgroup are found in three distinct areas of the Neuquén Basin (Figure 1). New discoveries of dinosaur remains from the Aguada Pichana locality in the Bajo del Añelo area (Figure 1A) have provided new information on faunal replacements during the periods before and after the loss of the land bridge between Africa and South America. In this paper, we review the dinosaur record of the Río Limay Subgroup (Albian-early Turonian) in light of these new discoveries.

THE DINOSAUR FAUNA FROM THE RÍO LIMAY SUBGROUP, NEUQUÉN BASIN

The Candeleros Formation is characterized by a predominance of red sandstones and brown claystones and has yielded a diverse dinosaur fauna of either Albian-early Cenomanian (Calvo 1991) or early Cenomanian age (Leanza and Hugo 2001) (Figure 1). The dinosaur fauna includes the giant carcharodontosaurid theropod *Giganotosaurus carolinii* (Coria and Salgado 1995), the small Dromaeosauridae *Buitreraptor gonzalezorum* (Mac-

ovicky *et al.* 2005), and dinosaur tracks from the El Chocon area that probably belong to coelurosaurian and carcharodontosaurid theropods (Calvo 1991, 1999; Calvo and Mazzeta 2004). Sauropods include: the diplodocimorph *Rebbachisaurus tessonei* (Calvo and Salgado 1995); the primitive titanosaurian *Andesaurus delgadoi* (Calvo and Bonaparte 1991) and several titanosaurian sauropod tracks (Calvo 1991, 1999), also from the El Chocón area; and an unnamed titanosaurid from Bajo del Añelo (Calvo and Salgado 1998).

At the top of the Candeleros Formation, very close its contact with the Huincul Formation, we have found a transitional fauna composed of: the abelisaurid *Ekrixinatosaurus novasi* (Calvo *et al.* 2004) from the Bajo del Añelo area; an unnamed titanosaurid sauropod characterized by having caudal vertebrae that are all procoelous with flattened neural spines (Calvo 1999); and a partial articulated skeleton of *Rebbachisaurus tessonei* (Calvo and Salgado 1995) from the El Chocón area (Figure 1).

The Huincul Formation is characterized mainly by yellow and gray coarse sandstones and conglomerates (Wichmann 1929) and has been dated as late Cenomanian. The theropod fauna includes: the basal abelisaur *Ilokelesia aguadagrandensis* (Coria and Salgado 1998) from the Plaza Huincul area; an undescribed articulated abelisaur (Canale pers. comm., 2005) from the El Chocon area; and a tibia of an undetermined abelisauroid from the Bajo del Añelo area at Aguada Pichanas (Porfiri *et al.* in manuscript). The sauropod fauna includes: the giant titanosaurid *Argentinosaurus huinculensis* (Bonaparte and Coria 1993) from Plaza Huincul; a giant indeterminate titanosaurid (Simon 2001) from El Chocón; a giant unnamed titanosaurid tail (Gandossi *et al.* unpublished data); and remains of *Rebbachisaurus tessonei* from Bajo del Añelo at the Aguada Pichana locality (Calvo *et al.* 2005) (Figure 1). The uppermost unit in the subgroup, the Lisandro Formation, has only yielded the remains of the ornithomimid *Anabisetia saldiviai* (Coria and Calvo 2002).

	Sub-group	Formations
Neuquén Group	Río Colorado	Anacleto
		Bajo de la Carpa
	Río Neuquén	Plottier
		Portezuelo
	Río Limay	Lisandro
		Huincul
Candeleros		
Rayoso/Lohan Cura Fm.		

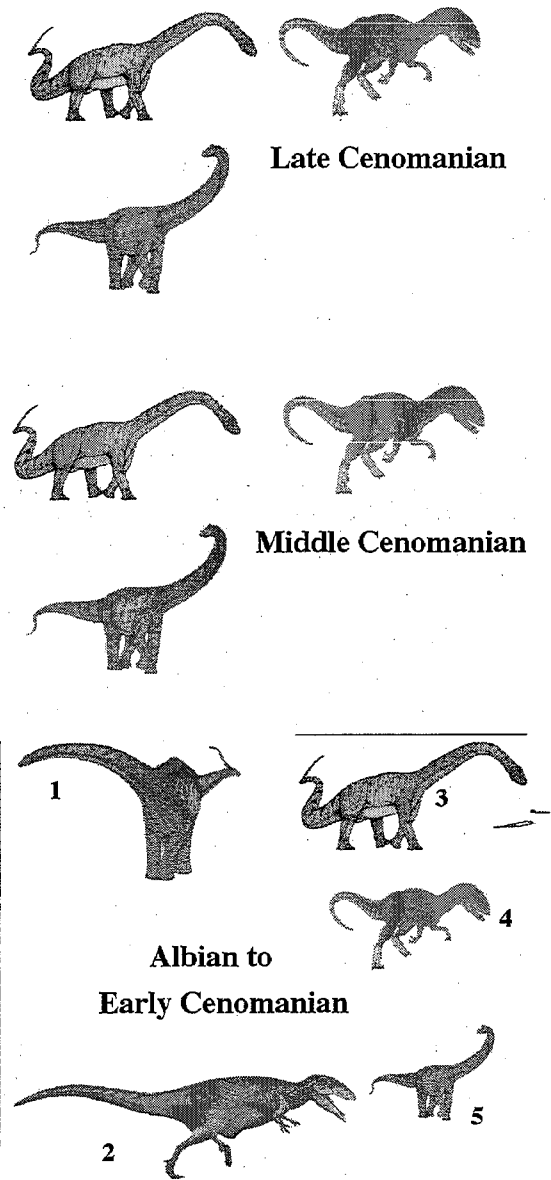
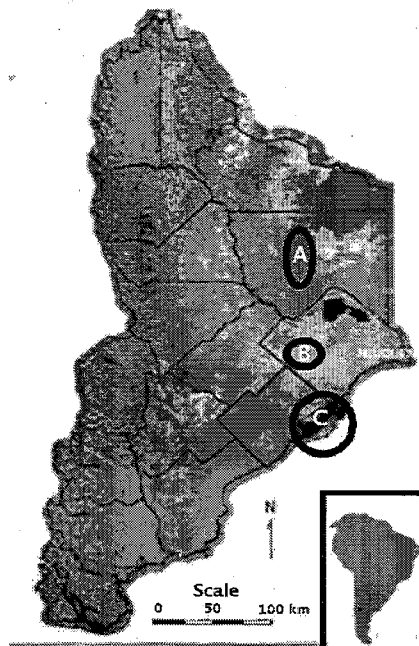


Figure 1. Location map of three palaeontological areas in the Neuquén Basin. A, Bajo del Añelo. B, Plaza Huincul. C, El Chocón. A Cretaceous stratigraphical chart of the Neuquén Group with the fauna recorded is also provided: 1, Titanosauria (primitive); 2, carcharodontosaurids; 3, rebbachisaurids; 4, abelisaurids; and 5, titanosaurids (derived Titanosauridae).

DISCUSSION

Tyrannotitan chubutensis represents the oldest record of a carcharodontosaurid, from the Aptian of Chubut Province (Novas *et al.* 2005). It is probable that carcharodontosaurids spread through Gondwana during Albian-late Cenomanian times with records appearing in North Africa (*Carcharodontosaurus*) and Neuquén Province (*Giganotosaurus*). Based on current evidence, it appears that carcharodontosaurids did not extend beyond the middle Cenomanian, with the abelisaurids becoming the dominant theropods after that time. The oldest known record of an abelisaurid is currently *Ligabueino andesi* from the Barremian-early Aptian of Neuquén (Bonaparte 1996). Therefore, Abelisauria probably originated in South America and then dispersed through the rest of Gondwana.

In the case of sauropods, rebbachisaurids were the most important herbivorous dinosaurs during the Aptian in the Neuquén Basin; the oldest records (Leanza *et al.* 2004) are *Rebbachisaurus* sp. from the Rayoso Formation (Bonaparte 1996; Calvo and Salgado 1996) and *Agustinia ligabuei* from the Lohan Cura Formation (Bonaparte 1999). They could also have dispersed from Patagonia to the rest of Gondwana.

During Albian-early Cenomanian times, North Africa was connected to South America by a land bridge that allowed continuous faunal interchange (Taquet 1977; Calvo and Salgado 1996; Calvo 1999); therefore, carcharodontosaurids (*Carcharodontosaurus saharicus*; Sereno *et al.* 1996), rebbachisaurids (*Rebbachisaurus garasbae*) and Abelisauria dispersed through the rest of Gondwana. This time is recorded in different localities and formations in Patagonia, but the Candeleros Formation is the most prolific. In this formation, we have collected abundant sauropods belonging to Titanosauria (primitive titanosaurids) and Rebbachisauridae and these coexisted with a few derived titanosaurids. In addition, we have recovered carcharodontosaurid and abelisauroid theropods that coexisted with a few abelisaurids.

This contrasts with the fauna present in the Huincul Formation (late Cenomanian), following the separation of South America and Africa. At this time, abelisaurid theropods are abundant but carcharodontosaurids are absent; rebbachisaurids continue to be important, but primitive titanosaurians are replaced by abundant derived titanosaurids.

CONCLUSIONS

The new discoveries in the Bajo del Añelo area at the Aguada Pichanas locality have increased the known distribution of the dinosaur fauna in Patagonia. Moreover, it has allowed extension of the *Rebbachisaurus tessonei* biocron up into the late Cenomanian. In addition, it has allowed us to recognize a faunal association that includes Abelisauroidae, Titanosauridae and Diplodocimorpha in the same sites and stratigraphical levels, extending the area of these discoveries to the north of the Neuquén Basin. New discoveries in the Huincul Formation allow us to propose the occurrence of a slow faunal replacement during Albian-early Cenomanian to late Cenomanian times with the decline of carcharodontosaurids and basal Titanosauria and the radiation of Abelisauria and Titanosauridae.

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