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**New material of Peirosaurids from Neuquén, Patagonia:
its age**

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ABSTRACT

The first evidence of a crocodyform on the Futalognko quarry (Neuquén, Argentina) is presented. The Portezuelo Formation has given in this site an extraordinary fossil record. The more impressive materials correspond to sauropod, theropod and ornithopod dinosaurs. However; it is also important the evidence of turtles, pterosaur, crocodiles, fish and plants. In this paper we describe a crocodyliform tooth that is assigned to the Peirosauridae family, probably to *Lomasuchus palpebrosus*. The tooth comes from the Portezuelo Formation. Two more crocodyliforms are known from the area: *Lomasuchus palpebrosus* herein referred to the Portezuelo Formation (upper Turonian – lower Coniacian) and *Peirosaurus tormini* assigned to the Bajo de la Carpa Formation (upper Coniacian).

PALABRAS CLAVES:

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ABSTRACT - NUEVO MATERIAL DE PEIROSAURIDO DE NEUQUÉN, PATAGONIA: SU EDAD. Presentamos la primer evidencia de un crocodylifome del yacimiento Futalognko (Neuquén, Argentina). La Formación Portezuelo ha dado un extraordinario registro fósil. Los más impresionantes corresponden a dinosaurios saurópodos, terópodos y ornitópodos. También es importante la evidencia de tortugas, pterosaurios, cocodrilos, peces y plantas. En este

trabajo describimos un diente de crocodyliforme asignado a la familia Peirosauridae, probablemente a *Lomasuchus palpebrosus*. El diente proviene de la Formación Portezuelo. Dos Crocodyliformes más son conocido en este área: *Lomasuchus palpebrosus* referido a la Formación Portezuelo (Turoniano Tardío – Coniaciano Inferior) y *Peirosaurus tormini* asignado a la Formación Bajo de la Carpa (Coniaciano Tardío).

1. Introduction

Cretaceous crocodyliforms from South America have been described by many authors, Woodward (1991); Price (1945; 1955; 1959); Bonaparte (1991); Gasparini; Buffetaut (1980); Kellner (1987); Chiappe (1988); Carvalho; Campos (1988); Gasparini; Spalletti (1990); Gasparini; Chiappe; Fernandez (1991) Ortega; Gasparini; Buscalioni; Calvo (2000); Carvalho, Ribeiro, Avilla (2004); Buffetaut; Taquet (1977), Turner; Calvo (2005), Nobre; Carvalho (2006); Carvalho; Vasconcellos; Aparecida; Tavares (2007); Leardi; Pol, (2009) etc. The Futalogno quarry, on the north coast of Barreales lake (Fig. 1), is actually the Barreales Lake Paleontological Center. This quarry has given in one year an extraordinary record of Upper Cretaceous vertebrate fauna and flora. Up to know, this record includes sauropod, theropod and ornithopod dinosaurs, turtles, pterosaurs, crocodiles, fish, angiosperm and gymnosperm plants (CALVO; PORFIRI; VERALLI; POBLETE 2001; CALVO; PORFIRI; VERALLI; POBLETE; KELLNER 2002a; CALVO; PORFIRI; VERALLI; NOVAS 2002b; PORFIRI; CALVO, 2002; GALLO; CALVO; KELLNER 2003). On the long field excavation of 2002, more than 80 vertebrate teeth were recovered from this site. One of them, collected by a paleontological team of the National University of Comahue is described here as a crocodyliform tooth. Our identification of this tooth as a crocodyliform is based on the

presence of smooth carinae crenulated by enamel wrinkles and a constricted waist between the crown and root. The morphology resembles that present in the peirosaurid, *Lomasuchus palpebrosus*. This genus, originally described as belonging to the Rio Colorado Formation, is now assigned to the Portezuelo Formation (see below) (Upper Turonian – Lower Coniacian; LEANZA; HUGO 2001). The Patagonian specimen of *Peirosaurus tormini* (GASPARINI 1982) referred to Rio Colorado Formation (GASPARINI; CHIAPPE; FERNÁNDEZ 1991) is assigned to the Bajo de la Carpa formation of the Rio Neuquén Subgroup (Santonian; RAMOS, 1981, HUGO; LEANZA 2001).

2. Locality and Geology

The Futalognko quarry, on the North coast of Barreales lake, (Fig.1) is placed 90 km northwest of Neuquén city. Because of the fossil richness of these outcrops, we have built a new Paleontological site for the National University of Comahue. Today, this place is named Barreales Lake Paleontological Center, and it is the first permanent Educational Paleontological site in South America dedicated to the field researching.

The Neuquén basin of western Argentina has deposits ranging from Upper Triassic to Tertiary. These deposits include a sequence of marine and continental deposits. The Neuquén Group is composed of sediments deposited in a continental, fluvial environment (ULIANA; DELLAPE 1989) that range from Albian to Campanian age (ULIANA; DELLAPE 1981; LEGARRETA; GULISANO 1989; CALVO 1991; CALVO; SALGADO 1995).

The crocodilian tooth comes from continental deposits from the top of Portezuelo Formation (Fig. 2), Río Neuquén Subgroup, Neuquén Group (CAZAU; ULIANA 1973; LEANZA 1999). The age of these deposits has been interpreted as Turonian (HUGO; LEANZA 2001). The Río Neuquén Subgroup is composed of two formations, the lower one named Portezuelo and the upper one named Plottier. The Portezuelo Formation is characterized by yellowish sandstones, red and green claystones, and few conglomerates. The Bajo de la Carpa Formation is composed of coarse-grained, light violet and pink sandstones of fluvial origin. Rain drops, chemical nodules, palaeosols and siliceous geodes are very abundant throughout the unit. Reddish siltstones and claystones form thin beds between the hard sandstone layers. The tooth comes from a fine conglomerate. Portezuelo Formation represents a fluvial environment characterized by a meandering river. The temperate and humid climate allowed exuberant vegetation.

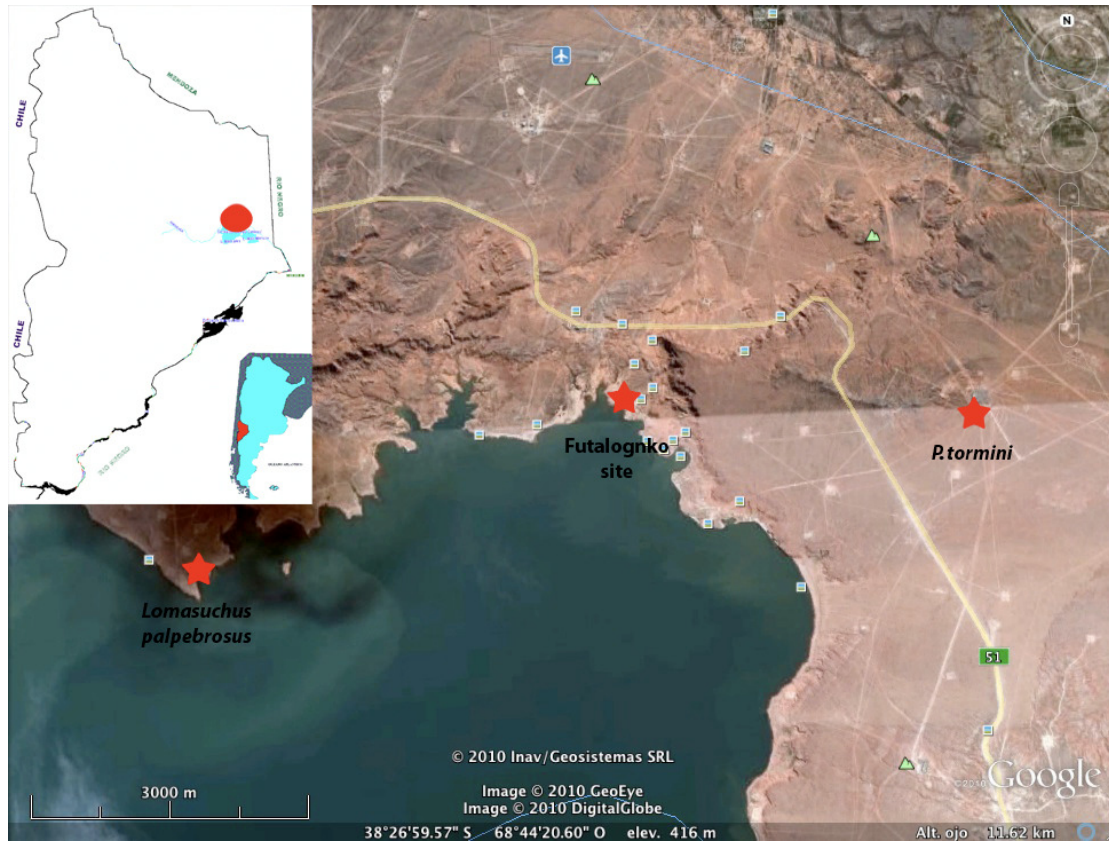


Fig. 1. Locality map of Crocodile tooth in the North Coast of Barreales lake.



| | | | | |
|-------------------------|----------------------|---------------------|-------------------------|--|
| UPPER CRETACEOUS | Neuquén Group | Sub-group | Formations | |
| | | Río Colorado | Anacleto |  <i>Peirosaurus tormini</i> |
| | | | Bajo de la Carpa | |
| | | Río Neuquén | Plottier |  <i>Lomasuchus palpebrosus</i> |
| | | | Portezuelo | |
| | | Río Limay | Lisandro | |
| | | | Huincul | |
| | | | Candeleros | |

Fig. 2. Generalized stratigraphic section of the study area, North coast of Barreales lake.

3. Material

The material consists in one tooth belonging to the collection of the Museum of the National University of Comahue. MUCPv-411. It is housed at the Barreales Lake Paleontological Center. The tooth preserves its crown complete and the beginning of the root. (Fig.3).

4. Tooth Description

The tooth is strongly compressed labiolingually with the anteroposterior diameter almost twice that of the transverse diameter (3.8 and 6.7 mm respectively). The height of the tooth is 6.00 mm. The crown is separated

from the root by a fairly well marked constriction. The crown is straight. The lingual face is slightly convex, and a shallow sulcus runs close to the carinae; this sulcus is more developed on the anterior border than on the posterior ones. The labial face is strongly convex. Based on the shape and morphology, this tooth was probably placed on the middle portion of the tooth row. In labial and lingual views, crowns are lanceolate in shape, with finely serrated smooth carinae. There are 4 to 5 serrations (denticles) per millimeter.

On the base of the tooth, the carinae have 5 denticles per millimeter. Denticles are slightly worn, showing a pronounced semi-transparent enamel layer at the tip. Denticles are formed just by enamel; so that, they are called false zipodont (PRASAD; DE BROIN 2002) Carinae placed on the middle and on the apical portion of the tooth has 4 denticles per millimeter. Denticles are straight and perpendicular to the margin. They are worn, and show a rounded shape. Toward the apical portion, denticles are too much worn, showing just the base of it. All denticles have a semi-transparent enamel layer developed at the tip.

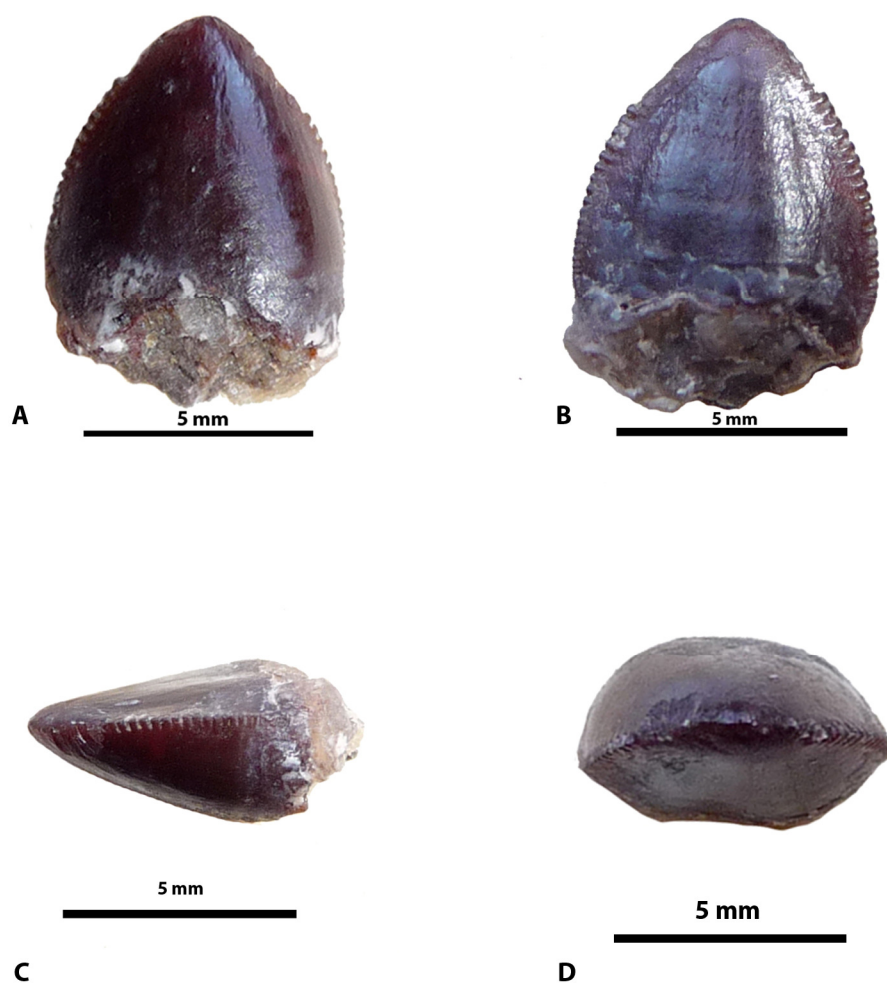


Fig. 3. Crocodilian tooth. MUCPv. 411. A. labial; B. lingual; C. Mesial; D. oclusal. Scale bar: 5 mm.

5. Comparisons and conclusions

The known Peirosaurid crocodyliform from South America are based on material belonging to *Uberabasuchus terrificus* CARVALHO; RIBEIRO; AVILLA (2004). *Montealtosuchus arrudacamposi* CARVALHO; VASCONCELLOS; APARECIDA; TAVARES (2007); *Barcinosuchus gradilis* LEARDI; POL, 2009; *Peirosaurus tormini* (PRICE 1955) *Lomasuchus papebrosus* (GASPARINI; CHIAPPE; FERNANDEZ 1991) Despite there is no

general consensus on mesoeucrocodylian relationships, there is some agreement about the monophyly of some clades; Ortega; Gasparini; Buscalioni; Calvo (2000); Turner (2006); Larson; Sues (2007). Peirosauridae has been recently placed in a new clade named Sebecia, Larson; Sues (2007) which include the african form *Hamadasuchus* as a sister group of all the rest of Peirosaurids.

Among metasuchian crocodiles, this tooth has a morphology that resemble those of Peirosaurids based on the presence of serrations; among other features. For instance it is clearly not a Notosuchians because members of this group lack denticles in teeth; *Notosuchus terrestris*, and *Comahuesuchus brachybuccalis* have oval section teeth with striations, but no serrated margins as in MUCPv 411. *Malawisuchus* and *Candidodon*, others notosuchian crocodiles have a complete different morphology and they are characterized by multicuspidate teeth. *Araripesuchus* (PRICE 1959) lacks denticles on teeth (*sensu* ORTEGA; GASPARINI; BUSCALIONI; CALVO 2000) so that, it is not the case of the Barreales lake tooth. *Baurusuchus* has anterior teeth flattened, slightly curved but with a morphology similar to those theropod dinosaurs (RIFF; KELLNER, 2001); posterior teeth are elliptical but in all cases the anteroposterior/labiolingual ratio is more than 60%. We exclude this tooth form Neosuchia (*sensu* LARSSON; SUES 2007) by having smooth borders on teeth.

Two Sebecia (LARSSON; SUES 2007) crocodyliforms were found in the area where this tooth was found. They belong to the Peirosauridae (GASPARINI 1982); *Peirosaurus tormini* (PRICE 1955) found 3km South east of Futalongko site and *Lomasuchus palpebrosus* (GASPARINI; CHIAPPE;

FERNÁNDEZ 1991) excavated 5 km west of this site. The subcircular maxillary and dentary teeth of *P. tormini* are different to the tooth described here. On the other hand, the maxilar tooth description of *L. palpebrosus* is very similar.

A similar tooth was described from the Albian-Cenomanian of Morocco, the Trematochampsid *Hamadasuchus rebouli* (BUFFETAUT 1994). A more detailed description of these teeth was made by Larsson; Sidor (1999) and Larson; Sues (2007) and it shows a more closely relationships to our material. The oldest record of a crocodyliform from Neuquén is *Amargasuchus minor* (CHIAPPE 1988). It was assigned to Trematochampsidae; but unfortunately, there is no tooth preserved. Therefore, we cannot compare it with the material from Barreales Lake.

Peirosaurids where placed in the Trematochampsidae (BUFFETAUT 1988, 1989), but Other authors have either questioned or even rejected the monophyly of Trematochampsidae (GASPARINI; CHIAPPE; FERNANDEZ, 1991; ORTEGA; BUSCALIONI; GASPARINI, 1996; BUCKLEY; BROCHU, 1999); therefore these forms were reassigned to a separate family Peirosauridae (GASPARINI, 1982; GASPARINI; CHIAPPE; FERNÁNDEZ 1991)

In sum, the tooth from Futalognko quarry probably belongs to a member of the Peirosauridae, We cannot assign the certainty this specimen to *Lomasuchus palpebrosus* because the suite of characters that characterize this tooth are also found in other forms (e.g. *Hamadasuchus* from Morocco; *Eremosuchus* from Argel; *Doratodon* from Europe, etc.). However, *L.*

palpebrosus is the only known form with these characters from the same stratigraphic levels, found in very close to the Futalongko quarry.

The Crocodylian fauna of Barreales Lake

The first discovering of a crocodylian from the Barreales Lake area was made by J. Garate Zubillaga, and was described by GASPARINI (1982). The material MOZ 1750 Pv was assigned to *Peirosaurus tormini* and consists of an incomplete skull, jaw, a few centra and postcranial remains. The crocodile was found 600 meters northeast of Pozo LLL-18 (*sensu* GASPARINI; CHIAPPE; FERNÁNDEZ 1991), just 3 km west of Futalognko site. *P. tormini* was assigned to the Río Colorado Formation (GASPARINI 1982; GASPARINI; CHIAPPE; FERNÁNDEZ 1991; BONAPARTE 1996). Actually, the Río Colorado Formation of the Neuquen Group (CAZAU; ULIANA, 1973) has been reevaluated and it is recognized as Río Colorado Subgroup that includes the Bajo de la Carpa Formation on the bottom and Anacleto Formation on the top (RAMOS, 1981, LEANZA, H.A.; S. APESTEGUÍA; F.E NOVAS; M.S. DE LA FUENTE, 2004). Recent studies studies of the Futalognko site (CALVO; PORFIRI; VERALLI; POBLETE; KELLNER 2002a) shows that the strata on the hill where *P. tormini* was found belong to the Bajo de la Carpa Formation. Therefore, the collected stratigraphic horizon of *P. tormini* occurs within the Bajo de la Carpa Formation and the age is Santonian (*sensu* HUGO; LEANZA 2001).

The second discovering of a crocodylian comes from the Pozo LLL-153 (*sensu* GASPARINI; CHIAPPE; FERNÁNDEZ 1991), on the north coast of Barreales Lake. The discovery was also made by G. Zubillaga and was

described by Gasparini; Chiappe; Fernández (1991). The material MOZ 4084 Pv is the holotype of *Lomasuchus palpebrosus*. The species is represented by an almost complete skull and fragment of the left lower jaw. This material comes, 5 km East of Futalognko site, and equal to *P. tormini*, it was assigned to the Río Colorado Formation. However, stratigraphic studies in the area of Barreales lake shows that this taxa comes from Portezuelo Formation, Rio Neuquen subgroup (SÁNCHEZ, M.L.; S. HEREDIA; J.O. CALVO, 2006.). The age is also upper Turonian – lower Coniacian (*sensu* LEANZA; HUGO, 2001). The tooth described in this paper comes from Portezuelo Formation on the coast of the Barreales Lake and its morphology is more similar to *Lomasuchus palpebrosus* than *Peirosaurus tormini*, which is in according with stratigraphic level.

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