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NEW DATA ON THE LATE PERMIAN VERTEBRATE FAUNA OF POSTO QUEIMADO, RIO DO RASTO FORMATION, SOUTHERN BRAZIL

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ABSTRACT - New vertebrate fossils are reported from the Late Permian continental Rio do Rasto Formation in the Paraná Basin, southern Brazil. The remains were collected at the locality of Posto Queimado, in the central region of Rio Grande do Sul State, corresponding to levels of the Morro Pelado Member. Newly-recorded hybodontiform sharks, temnospondyl amphibians, and pareasaurian reptiles, as well as the previously reported paleonisciform and dipnoan fishes, and dinocephalian therapsids, comprise the fauna at this locality. The association between pareiasaurids and dinocephalians is documented for the first time in the Brazilian Permian. Based on these records, a contemporaneity between Posto Queimado and Bagé-Aceguá local faunas and their correlation to the *Tapinocephalus* Assemblage Zone of the South African Karoo are suggested.

Key words: Late Permian, southern Brazil, pareiasaurid, temnospondyl, sharks, Rio do Rasto Formation.

RESUMO - Novos fósseis de vertebrados são registrados para o Permiano Superior continental da Formação Rio do Rasto na Bacia do Paraná, sul do Brasil. Os materiais foram coletados na localidade de Posto Queimado, na região central do Estado do Rio Grande do Sul, correspondente aos níveis do Membro Morro Pelado. Tubarões hibodontiformes registrados anteriormente, anfíbios temnospôndilos e répteis pareiasaurídeos, além dos previamente citados peixes paleonisciformes e dipnóicos, e dentes de dinocefálios constituem a fauna nesta localidade. A associação entre pareiasaurídeos e dinocéfalos é registrada pela primeira vez no Permiano brasileiro. Baseado nestes registros, é sugerida a contemporaneidade entre as faunas locais de Posto Queimado e Bagé-Aceguá e sua correlação com a Zona de Associação de *Tapinocephalus* da Bacia do Karoo na Árica do Sul.

Palavras chave: Permiano Superior, sul do Brasil, pareiasaurídeo, temnospôndilo, tubarões, Formação Rio do Rasto.

INTRODUCTION

The Paraná Basin in southern Brazil is well known for its exceptional record of fossil vertebrates. Upper Paleozoic and lower Mesozoic beds in that basin represent an important source of evidence about ancient life in South America (Barberena *et al.*, 1985a, b). Particularly significant are the Late Permian faunas of the Paraná Basin which, together with the fauna of the Pedra do Fogo Formation in the northern of Brazil, provide the only knowledge of continental vertebrates of that age for South America (Barberena *et al.*, 1985a,b; Cox & Hutchinson, 1991; Langer, 2000). The vertebrate-bearing continental deposits of the Upper Permian Rio do Rasto Formation are exposed in three localities in the Paraná Basin (Figure 1). Two of these, considered as classical localities, are the Serra do Cadeado in the Paraná state and the Bagé-Aceguá road, in the Rio Grande do Sul State, close to the border with Uruguay (Barberena *et al.*, 1985a,b). The third locality, known as Posto Queimado, was discovered more recently in the north of São Gabriel municipality, in the central region of the Rio Grande do Sul State. Vertebrate remains previously reported for this locality are fragmentary and isolated elements, including a spine fragment tentatively attributed to a hybodontiform shark, dipnoan tooth plates, paleonisciform scales, and isolated teeth assigned to different families of dinocephalian therapsids (Richter & Langer, 1998; Langer, 2000). Recent expeditions to this area resulted in the discovery of more complete fossil remains, including articulated elements. The most diagnostic fossils recovered include a complete shark fin spine, a large mandible of a temnospondyl amphibian and a pareiasaur partial skull with teeth, and humerus.

The aim of this contribution is to report these new findings and provide an update of the vertebrate fossil occurrences at the Posto Queimado locality. We also briefly discuss the implications of these new fossils for the biostratigraphical correlation of the Brazilian Late Permian vertebrate faunas.

Figure 1. Upper Permian areas (in gray) of the Paraná Basin in Southern Brazil showing the tetrapod bearing sites (black squares): **1**. Bagé-Acegua Highway, **2**. Posto Queimado; **3**. Serra do Cadeado. (Modified from Barberena *et al.* 1985)

MATERIAL AND METHODS

Collecting site. The fossils were collected in the Timbaúva region, 20 km NW of São Gabriel municipality (Figure 1), Rio Grande do Sul State, at the outcrop known as Posto Queimado (30° 01' S, 54° 09' W).

The sediments outcropping at Posto Queimado are assigned to the Morro Pelado Member of the Rio do Rasto Formation (Lavina, 1991). The area is covered by several ravines which exposed a sequence composed of red mudstones intercalated with conglomerates representing lacustrine and channel deposits (Lavina, 1991; Langer, 2000).

Preparation techniques. Thin sections of scales and teeth were prepared using standard techniques. The fossils were embedded in resin before being cut by a low speed ISOMET (Buheler) electric saw. These sections were ground thinner, first in the same device and then manually polished.

Material. Most of the materials recovered are fragmentary, hampering a precise taxonomic identification. The most complete and diagnosable elements are described here. All the specimens are housed in the collection of the Museu de Ciências e Tecnologia-PUCRS, Porto Alegre, Rio Grande do Sul State (MCP-PV).

SYSTEMATIC PALEONTOLOGY

ELASMOBRANCHII Bonaparte, 1838
HYBODONTOIDEA Zangerl, 1981
(Figure 2)

Material. MCP 4274-PV, a complete finspine.

Description. The finspine measures 50 mm in length. It is slightly compressed laterally with convex anterior and posterior walls, giving an oval outline in cross section. Parallel longitudinal ribs are present on the external surface, narrowing and anastomosing toward the apex. The posterior border bears small, hook-shaped denticles arranged in a pair of longitudinal rows. Thin sections evidenced a thick trabecular dentine contouring the spine cavity. There is no enamel layer.

Discussion. The presence of hybodontoid sharks at Posto Queimado was first reported by Richter & Langer (1998) based on a spine fragment. Due to similarities between acanthodian and hybodontoid spines, these authors discussed a possible acanthodian affinity for the spine fragment. However, the combination of a pair of denticle rows in the posterior border of the spine and the histological structure of the trunk (Maisey, 1975), supports a hybodontoidea assignment for the new specimen.

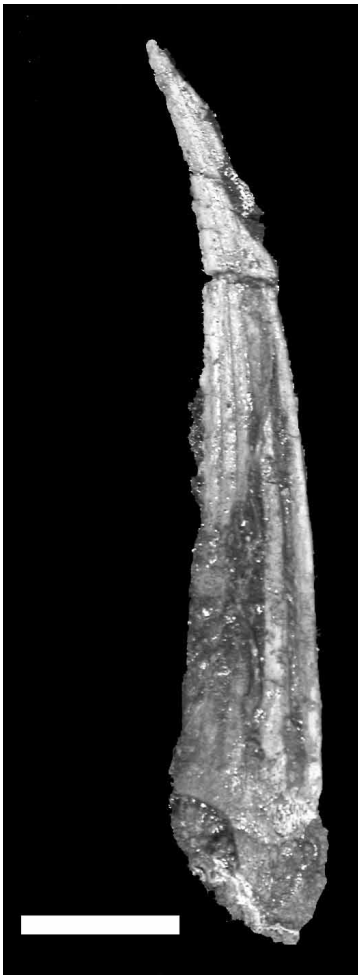

Figure 2. Hybodontoidea finspine, MCP 4274-PV, in lateral view. Scale bar = 1 cm.

AMPHIBIA Linnaeus, 1758
TEMNOSPONDYLI Zittel, 1888 (sensu Milner, 1993)
(Figure 3)

Material. MCP 4275-PV, an incomplete right mandibular ramus.
Description. The total length of jaw preserved is 450 mm, despite lacking the anterior and posterior ends, which suggests that the complete length may have been in excess of 500 mm. Depth of the mandible increases from 45 mm at anterior end to 80 mm in the posterior end, and it measures about 25 mm in width, presenting an oval cross shape (Figure 3B). Laterally, the mandible is very long and straight, featuring anastomosing and branching ridges on its surface, while in dorsal view, it is straight showing no curvature along its length. The preservation does not allow the recognition of sutures in the lingual surface. The position of the marginal teeth, slightly mesial, makes them visible mostly from the lingual side. Twenty-two teeth are present in the dorsal margin of the dentary. They are conical, straight and uniformly shaped and sized (height=15 mm, width= 5 mm). Thin section of some broken teeth showed the labyrinthodont condition of the dentine (plicidentine). Following these anterior teeth, on the most posterior border of the mandible, there are about 20 smaller teeth (height = 9 mm, width= 2.5 mm), which are also straight and uniform in shape.
Discussion. Four amphibians are known in the Brazilian Permian. Only one species *Prionosuchus plummeri* Price, 1948, is known from the Pedra do Fogo Formation, Parnaiba Basin, Northern Brazil (Cox & Hutchinson, 1991). The remaining three amphibians were discovered in the Rio do Rasto Formation: an unnamed *Rhinesuchus*-like amphibian (Barberena & Dias, 1998) and the rhinesuchid *Australerpeton cosgriffi* Barberena, 1998 from the Serra do Cadeado fauna, and the archegosaurid *Bageherpeton longignathus* Dias & Barberena, 2001 from the Bagé-Aceguá fauna. Comparisons between the Posto Queimado material and the mandibular fragment of the *B. longignathus*, reveals strong differences in the shape and proportions of the mandible and in the morphology and arrangement of the teeth. More detailed comparative studies are required to determine the relationships of the Posto Queimado amphibian.

REPTILIA Laurenti, 1768 (sensu Benton, 1993)
PARAREPTILIA Olson, 1947 (sensu Laurin & Reisz, 1995)
PAREIASAURIA Seeley, 1888 (sensu Lee, 1997)
Provelosaurus americanus (Araújo, 1985)
(Figure 4)

Material. MCP 4263-PV, partial skull and postcranial fragments.
Description. The two skull fragments measure 155 mm in total length (Figure 4). They represent the left lateral and part of the ventral regions of the skull. Most of the maxilla, a complete quadratojugal, and parts of the lachrymal, squamosal and quadrate are preserved. The middle and posterior portion of the maxilla displays eight marginal teeth, which are pedunculated and feature an expanded crown with 5 to 7 cusps. The ornamentation of the skull consists of low, rounded bosses with wide and low ridges. The quadratojugal displays two, rounded, marginal bosses that are restricted to the posteroventral margin of the bone.
Discussion. This constitutes the second record of pareiasaurids for South America. The previous one at the Bagé-Aceguá region, south of Rio Grande do Sul is represented by several materials, including a complete albeit badly distorted skull, belonging to at least two individuals

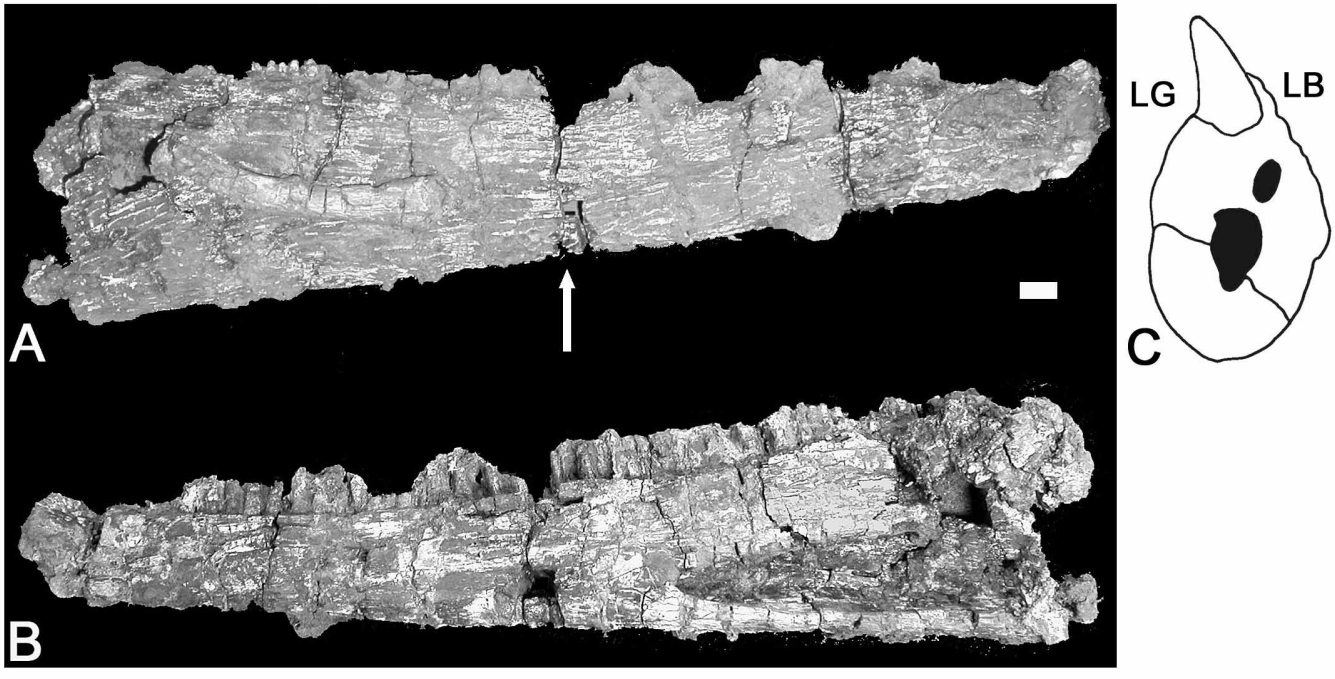

Figure 3. Temnospondyl amphibian, MCP 4275-PV. **A**. Lateral view of the mandible, anterior to the right; **B**. lingual view of the mandible, anterior to left; **C**. cross section of the anterior part (arrow) of the mandible. **LB**. labial surface, **LG**. lingual surface. Scale bar = 1 cm.

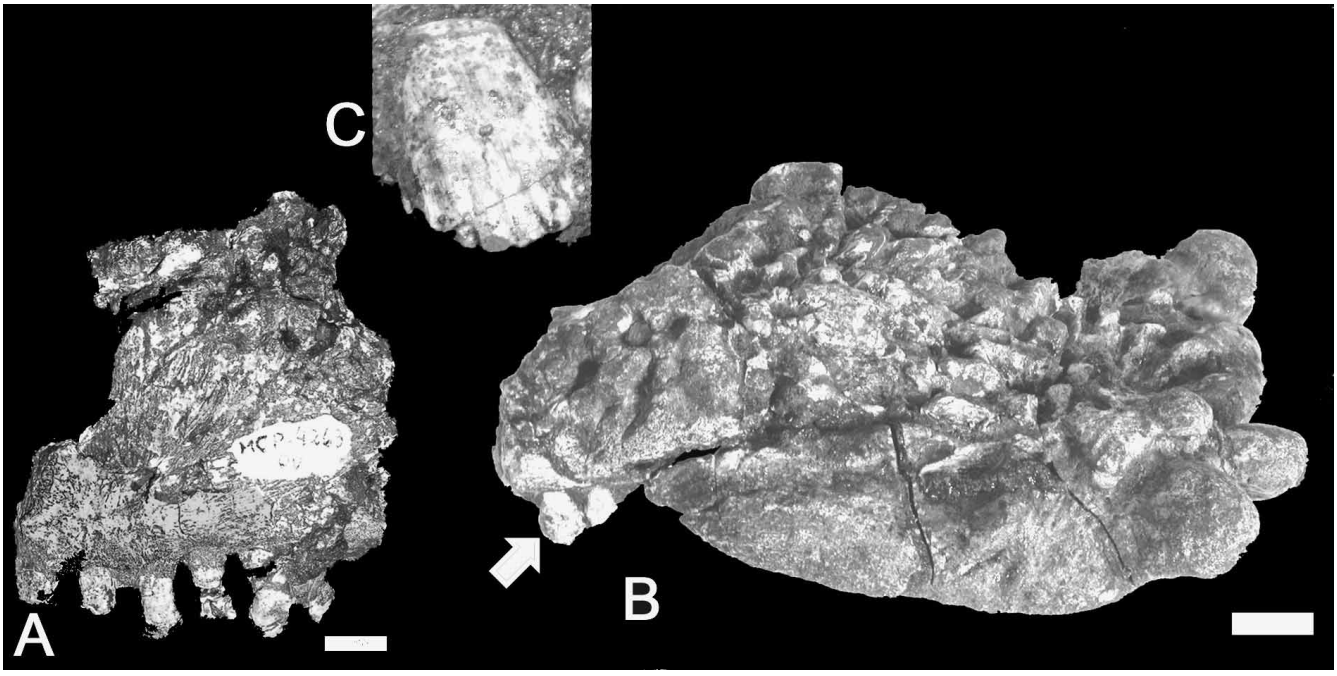

Figure 4. *Provelosaurus americanus* (Araújo, 1985), MCP 4263-PV. **A**. snout in lateral view; **B**. posterior portion of the skull, including the quadratojugal marginal bosses, in lateral view. Arrow indicates the maxillary tooth, enlarged in **C**. **A** and **B** anterior to the left. Scale bar = 1 cm

found in ouctcrops separated by 600 m (Araújo, 1985a, b, 1986a, b, 1987, 1989a, b). This record was originally described as *Pareiasaurus americanus* by Araújo (1985a), but Lee (1997) transferred it to the monotypic *Provelosaurus americanus*. Some traits of the new specimen from Posto Queimado, including the general pattern of skull ornamentation, shape of the quadratojugal marginal bosses, weak ornamentation on the maxilla, and tooth shape, are similar to those present in *Provelosaurus americanus* from the Bagé-Aceguá region. These similarities allow a preliminary assignation of the Posto Queimado specimen to *Provelosaurus americanus*. Size differences between these specimens are, however, remarkable. The skull length of the pareiasaur from Posto Queimado is estimated at 210 mm, compared to 350 mm for the *P. americanus* from the Bagé-Aceguá region.

BIOSTRATIGRAPHIC REMARKS

Three tetrapod-based faunas have been recognized in the Upper Permian Rio do Rasto Formation. The Serra do Cadeado fauna in the Paraná State, and the Bagé-Aceguá fauna in the south of Rio Grande do Sul State, were originally proposed as Tatarian in age by Barberena *et al.* (1985a,b). The first fauna was correlated with the *Cistecephalus* zone of Kitching (1977; =*Tropidostoma* and *Cistecephalus* assemblage zones of Rubidge *et al*., 1995) in the South African Karoo, based on the record of the dicynodont *Endothiodon*. The presence of *Pareiasaurus* and the absence of *Endothiodon* in the Bagé-Aceguá fauna led Barberena *et al.* (1985b) to suggest a correlation of this fauna with the *Daptocephalus* zone of Kitching (1977; =*Dicynodon* assemblage zone of Rubidge *et al*., 1995) in the Karoo, being consequently younger (late Tatarian) than the Serra do Cadeado fauna. More recently, Langer (2000) identified a third Late Permian faunal association at the Posto Queimado locality and discussed the chrono-correlation of the three faunas from the Rio do Rasto Formation. Of these, the Posto Queimado fauna was considered to be the oldest (late Kazanian to early Tatarian), based on the presence of dinocephalian teeth. Langer (2000) suggested a possible correlation of the Posto Queimado fauna with the *Eodicynodon* and *Tapinocephalus* assemblage zones of the South African Karoo (Rubidge *et al.*, 1995). The record of *Provelosaurus americanus* was used as evidence of a late Tatarian age for the fauna of the Bagé-Aceguá region. Langer's (2000) proposal of the younger age for this fauna was based on the close phylogenetic relationship between *P. americanus* and the South African "dwarf-pareiasaurs" (Lee, 1997).

The presence of dinocephalians in the Posto Queimado fauna represents a temporal constraint in that, besides the dubious record in the early Kazanian of Russia (Modesto & Rybczynski, 2000), this group is mostly restricted to the late Kazanian-early Tatarian faunas from South Africa and Russia (Rubidge *et al.*, 1995; Battail & Surkov, 2000; Modesto & Rybczynski; 2000; Golubev, 2000). The only Late Permian fauna where dinocephalians and pareiasaurids are known to coexist is in the South African *Tapinocephalus* Assemblage Zone (Smith & Keyser, 1995). This fact suggests a possible correlation of the Posto Queimado fauna with the *Tapinocephalus* Assemblage Zone, implying an early Tatarian

age (Smith & Keyser, 1995; Battail, 2000).

In addition, the similarities exhibited by the pareiasaurids from Posto Queimado and Bagé-Aceguá seems to indicate a contemporaneity of these faunal assemblages, and consequently that the Bagé-Aceguá fauna is probably older than previously proposed by Barberena *et al*. (1985a,b) and Langer (2000). This would be consistent with the presence of the archegosaurid temnospondyl *Bageherpeton longignathus* in the Bagé-Aceguá fauna (Dias & Barberena, 2001), given that the last record of archegosaurid amphibians is in the early Tatarian of Russia (Langer, 2000). Based on above data, the Posto Queimado and Bagé-Aceguá vertebrate faunas are correlated with *Tapinocephalus* Assemblage Zone of the South African Karoo and aged as early Tatarian being consequently older than the Serra do Cadeado fauna. A comprehensive description of the new pareiasaurid from Posto Queimado, currently in progress, will provide a further basis for refining the biostratigraphic correlation between these Late Permian Brazilian faunas.

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