

FIRST RECORD OF EUCRYPTODIRAN TURTLES FROM THE EARLY CRETACEOUS (VALANGINIAN), AT THE NORTHERNMOST PART OF SOUTH AMERICA

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ABSTRACT. New fossil turtle material from the Early Cretaceous of (Valanginian) of Colombia is described here. The material consists of carapace bones discovered in shallow marine sequences of the Rosablanca Formation, Eastern Cordillera, Zapatoca, Department of Santander. These fossils represent the oldest record of eucryptodiran turtles for the northernmost part of South America. Although detailed taxonomic resolution cannot be defined within Eucryptodira, the material resembles marine turtles in morphology and histology particularly to Protostegidae clade. Eucryptodires are the new element in the reptilian fauna of the Rosablanca Formation, which also has panpleurodires turtles, undescribed fish, plesiosaurs, and ichthyosaurs.

KEYWORDS. Turtles; Eucryptodira; Valanginian; South America; Colombia.

INTRODUCTION

Eucryptodira represent one of the largest clade of fossil and extant turtles, including the crown group cryptodira or hidden-necked turtles (see Joyce 2007 for details about their phylogenetic relationships). The fossil record of eucryptodires shows that they have been a widely distributed and important reptile clade, very well adapted to almost all environmental conditions since the late Jurassic (Mateus *et al.*, 2009). In South America, the earliest report of a eucryptodire so far known is *Neusticemys neuquina* from the Late Jurassic (Tithonian) of Argentina (Fernandez and de la Fuente, 1993). *Neusticemys neuquina* was considered the oldest known marine turtle (“proto-Protostegidae” *vide* Lapparent de Broin, 2001); however, its relationship has been questioned and its affinity with other eucryptodires is uncertain (de la Fuente, 2007). The early Cretaceous record of South American eucryptodires is also represented by *Santanachelys gaffneyi* from the Late Aptian or Early Albian (~110 Ma), Ceará State, Brazil (Hirayama, 1998), *Desmatochelys* sp. from the Barremian-Aptian (125 Ma) of Colombia (Elliot *et al.*, 1997), *Chubutemys copelloi* from the Aptian (125 Ma) of Argentina (Gaffney *et al.*, 2007), and a recent discovery of a nearly complete undescribed skeleton from the Barremian-Aptian of Colombia (Paramo, 2008).

Here I describe new fossils from the Early Cretaceous in the eastern Cordillera of Colombia that represent the oldest known record of eucryptodiran turtles from the northernmost part of South America. The fossils, three costal bones and one peripheral, were collected from a small square (50 cm x 50 cm)

belonging to a grid of 5 m x 8 m, which was displayed at the top of a limestone layer, exposed three meters above the layer where the stem pleurodiran turtle *Notemys zapatocaensis* was found (Cadena and Gaffney, 2005). The strata belong to the upper segment of the shallow marine deposits of the Rosablanca Formation, widely exposed in Zapatoca town area (Fig. 1A). I assume all bones described here belong to a single individual, based on their proximity between each other inside the grid, as well as the relative size between them.

Together with the eucryptodiran remains described here, fragmentary fossils of plesiosaurs and ichthyosaurs, as well as fish teeth and many ammonites, bivalves, oysters, and gastropods were collected within the grid previously defined. One of the ammonite species has been identified as *Saynoceras verrucosum* (Etayo, pers. comm. 2009) (Fig. 1B), a



FIGURE 1. A, Location of Zapatoca town, Department of Santander, Colombia 06°50'35"N, 73°13'50"W. B, *Saynoceras verrucosum*, ammonite indicator of the base of the Late Valanginian, collected together with the eucryptodiran described here.

chronostratigraphic marker for the base of the Late Valanginian (approximately 138 Ma) following Ogg *et al.*, (2008).

SYSTEMATIC PALEONTOLOGY

Testudines Linneaus, 1758 or Batsch, 1788

Cryptodira Cope, 1868

Eucryptodira Gaffney, 1975

Gen. et sp. indet.

Fig. 2A-N

Referred specimens: IPN 15 EAC-14012003-4A, left partial second costal bone (Fig. 2A-B, G-J); IPN 15 EAC-14012003-4B, left nearly complete sixth costal bone (Fig. 2C-D); IPN 15 EAC-14012003-4C, left nearly complete eighth costal bone (Fig. 2E-F); IPN 15 EAC-14012003 4D, left partial ninth peripheral bone (Fig. 2K-N). IPN-EAC, Museo Geológico José Royo y Gómez – Instituto Colombiano de Geología y Minería-Ingeominas, Bogotá, Colombia.

Description: IPN 15 EAC-14012003-4A preserves the most medial portion of the left second costal bone, exhibiting 1.8 cm of average thickness in cross section (Fig. 2G, I) and a relatively smooth dorsal surface with an irregular pattern of shallow circular pits (Fig. 2A). The medial edge is slightly straight with a short central protuberance, indicating a sutural contact with a long and almost rectangular second neural bone. On the ventral surface, the rib head is strongly marked, projecting toward the vertebral body in an approximately 45° angle with respect to the ventral surface of the costal, and considerably separated from the sutural contact between the costal and the neural (Fig. 2B). In lateral cross section the bone exhibits a marked high vascularisation with cancellous bone, which is the dominant tissue from the external to the internal edge of the bone, osteons with a wide range of sizes, and a poorly identifiable internal cortex and highly reduced and slightly vascularized external cortex (Fig. 2G, H). In longitudinal cross section, due to a naturally broken posterodorsal edge of the costal, it is possible to see the bone configuration, exhibiting a much more marked vascularisation of the internal cortex that remains totally undifferentiated from the cancellous bone (Fig. 2I, J).

IPN 15 EAC-14012003-4B preserves a nearly complete left sixth costal bone broken into two pieces, only lacking the most lateral portion. As for the third costal, the dorsal surface of the sixth costal is

relatively smooth, with two considerably deep, circular, pits, one at the most anteromedial region and the other at the posterocentral region (Fig. 2C). Additionally, on the dorsal surface no scale sulcus is discernable. In dorsal view, the outline of the medial edge is slightly concave at the most anterior and central portion of the costal, with a oblique posterior end, indicating a contact with the second neural, and possibly the sixth and the seventh neurals. Based on these contacts, the seventh neural may have been pentagonal in shape. Two especially notable features are present on the ventral surface: a strongly marked scar of the rib head on the medial region, and a marked outline that projects ventrally to the rib, principally on the lateral region (Fig. 2D). The thickness of the bone is 1.4 cm on average and follows the same bone histological pattern described for the third costal.

IPN 15 EAC-14012003-4C preserves a fairly complete eighth costal bone, only lacking the most lateral posterior portion, and a small piece of the anterior central left region. The dorsal surface is smooth, with shallow circular pits similar to that of the third and the sixth costals, but differs from these two in having an incipient and irregular sulcus marking the boundary between pleural scales at the anterolateral region of the costal (Fig. 2E). In dorsal view, the medial edge is almost straight and without a central sutural scar, indicating that it lacked a contact with a neural bone, and consequently meeting the right eighth costal on the medial side. On the ventral surface a scar of the rib head is present, but slightly eroded and more medially positioned than in the third and the sixth costals, close to the medial sutural contact with the right costal (Fig. 2F). Laterally the costal decreases considerably in thickness, being only 6 mm thick at the edge.

The last of the four carapaceal elements described here is preserved in IPN 15 EAC-14012003-4D a partial left ninth peripheral bone with its posteromedial region missing. On the dorsal surface, this peripheral bone has a greater abundance of shallow and slightly deep pits than the costal bones, and while the sulcus between the marginal scales is poorly preserved, it is clearly indicated on the lateral margin by the presence of a shallow notch (Fig. 2K). The medial edge is broken revealing the histological pattern (Fig. 2M), which is similar to that described for the third and sixth costals. On the ventral surface, the sulcus between the marginal scales is clearly distinct as well as a shallow embayment on the medial portion, indicating the contact with the most lateral projection of a costal bone.

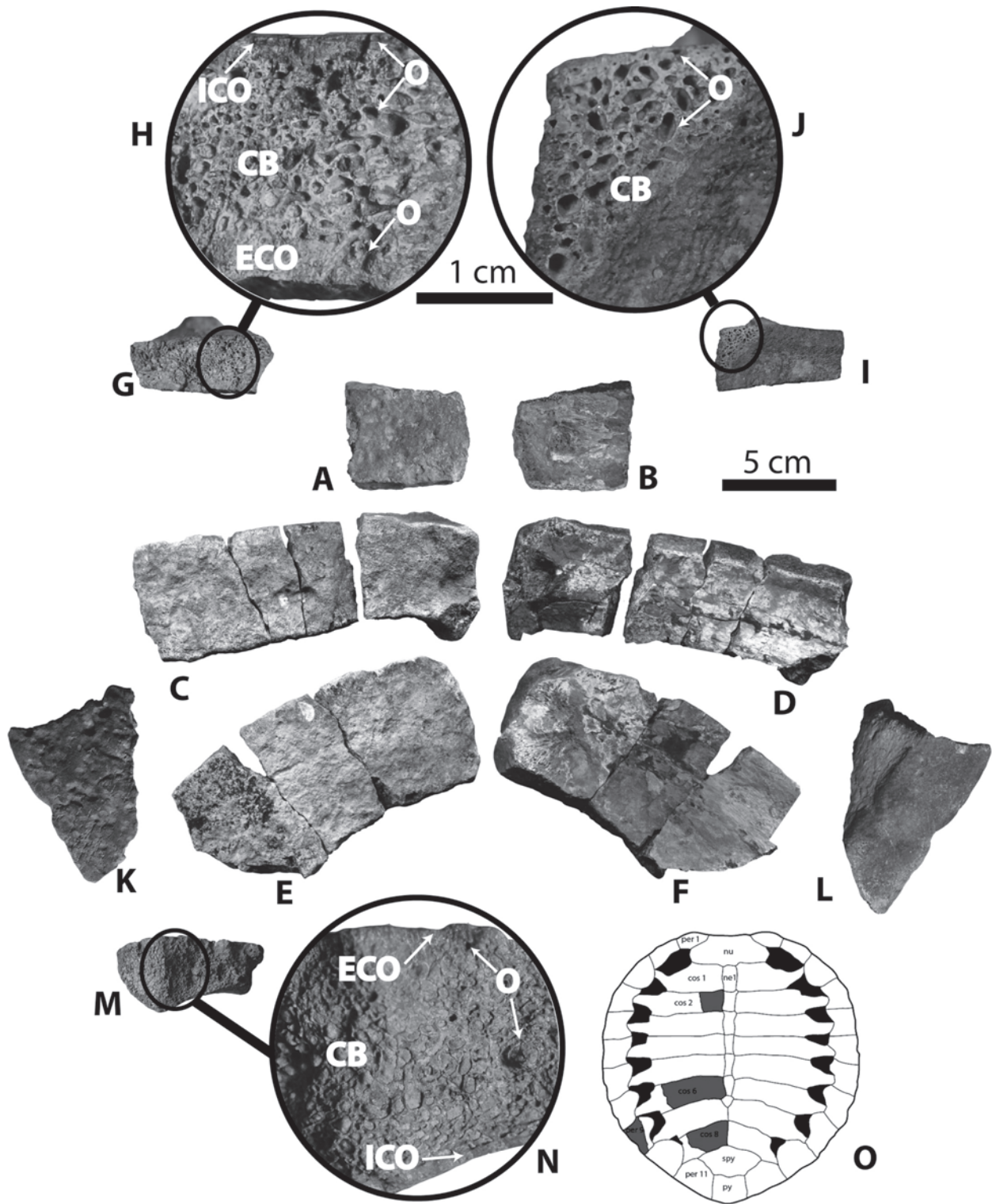


FIGURE 2. Eucryptodiran costal bones described in this paper. A B, IPN 15 EAC-14012003-4A, left partial second costal, in dorsal (A) and ventral (B) views. C, D, IPN 15 EAC-14012003-4B, left sixth costal, in dorsal (C) and ventral (D) views. E, F, IPN 15 EAC-14012003-4C, left eighth costal, in dorsal (E) and ventral (F) views. G, H, IPN 15 EAC-14012003-4A, in lateral view, ventral surface up (G) and close up for the area rounded by the black circle (H). I, J, IPN 15 EAC-14012003-4A, in posterodorsal view, ventral surface up (I) and close up for the area rounded by the black circle (J). K, L, IPN 15 EAC-14012003-4D, left ninth peripheral, in dorsal (K) and ventral (L) views. M, N, IPN 15 EAC-14012003-4A, in posterior view, dorsal face up (M) and close up for the area rounded by the black circle (N). O. Composite reconstruction of *Mesodermochelys undulatus*, from the Maastrichtian of Japan, modified from Hirayama and Chitoku, (1996 Fig. 17), the correspondence with the three costals and the peripheral bone described here is shown in grey. 5 cm scale bar applies for A-F, G, I, K-M. 1 cm scale bar applies for H, J and N. **Abbreviations:** CB, cancellous bone; cos, costal bone; ECO, external cortex; ICO, internal cortex; ne, neural bone, nu, nuchal bone; O, osteon; per, peripheral bone; py, pygal bone; sp, suprapygal bone.

DISCUSSION

While fragmentary, the fossils described here are clearly eucryptodires, marine adapted turtles potentially related to Protostegidae (*sensu* Kear and Lee, 2006) based on morphology and bone histology. Until more complete fossils are found, the specimens are referred to “genus and species indeterminate,” but are considered to be the oldest record for eucryptodiran turtles at the northernmost part of South America, being approximately 28 million years older than *Santanachelys gaffneyi* from the Late Aptian or Early Albian (~110 Ma), Ceará State, Brazil (Hirayama, 1998).

Morphological evidence includes: (1) lacking or rudimentary scales sulci on the dorsal surface of costals, a characteristic seen in *Desmatochelys*, *Archeolon*, and *Protostega* (Hirayama, 1997), however, not exclusive of protostegids and also seen in chelonoids, particularly Pandermochelyids (Hirayama, 1998; Joyce, 2007). This seems to be true for all three costals and the peripheral described here. Additionally, they exhibit great similarity in shape and size, with the costals of other protostegids such as *Santanachelys gaffneyi* and *Desmatochelys lowi* figured in Hirayama, (1997), although slightly less advanced in the loss of lateral ossification; (2) ninth peripheral bone with a shallow notch on its lateral edge indicating a contact between the marginal scales, and additionally on the ventral surface a shallow embayment for the contact with the most lateral portion of the costal exists. The same pattern is also present in most of the posterior series of peripherals (seventh or eighth to tenth) of *Santanachelys gaffneyi* and *Desmatochelys*, and also present in some modern chelonoids, for example *Caretta caretta*, as well as fossil forms of pandermochelyids such as *Mesodermochelys undulates* Hirayama and Chitoku, (1996) and the dermochelyid *Toxochelys latiremys* (Nicholls, 1998); (3) the strong development of the ventral rib head of the costal, as well as the prominent exhibition of the rib on ventral surface of the costal, are present on the costal bones described here and are characteristics of most of the protostegids and chelonoids throughout ontogeny. It should be noted that these characters are not exclusive of marine turtles, and they can be present in other turtles, principally during their infancy or juvenile development due to initial poor ossification of the shell; (4) neural bones, long and narrow, almost rectangular or square shaped, are very characteristics in protostegids, for instance in *Santanachelys gaffneyi*, and *Desmatochelys lowi* figured in Hirayama (1997). Although no neural bone was found together

with the costals described here, its possible shape can be interpreted from the outline of the medial edge of the costals, for example the third costal (IPN 15 EAC-14012003-4A) indicates a contact with a single long second neural bone.

Bone histological evidence supports attribution of the three costals and the peripheral bone described here as a well adapted marine turtle. Specifically, in lateral cross-section, the second (IPN 15 EAC-14012003-4A) and sixth (IPN 15 EAC-14012003-4C) costals, and the ninth peripheral (IPN 15 EAC-14012003-4D), exhibit a high degree of vascularisation and a homogeneous spongy appearance, with a very thin external cortex, in contrast to the internal cortex which is almost completely replaced by cancellous bone (Fig. 2H, M). This pattern is exhibited not only transversally, but also longitudinally as seen in the broken posterodorsal edge of the second costal (Fig. 2J). This histological arrangement is found in turtles that are specifically adapted to aquatic/marine environments (Category IV; Scheyer, 2007). Additionally, the second costal (IPN 15 EAC-14012003-4A) and ninth peripheral (IPN 15 EAC-14012003-4D) resemble dermochelyids in that they preserve the external cortex, a characteristic of fully aquatic turtles (Category III; Scheyer, 2007).

The occurrence of Valanginian eucryptodires together with stem pleurodires, as well as the undescribed plesiosaurs and ichthyosaurs from Rosablanca Formation, indicates a marine ecosystem with an important reptilian diversity never before documented for the northernmost part of South America. More fieldwork is needed to find additional and more complete material that can support a most precise systematic and phylogenetic attribution, as well as to reconstruct the paleobiogeographical scenario for South American eucryptodires during the Early Cretaceous.

RESUMEN

Un nuevo material correspondiente a tortugas fósiles del Cretácico temprano (Valanginiano) de Colombia es descrito aquí. Este material consiste de placas del caparazón descubiertas en secuencias marinas someras de la Formación Rosablanca, Cordillera Oriental, Zapatoca, Departamento de Santander. Estos fósiles representan el más antiguo registro de tortugas eucryptodiras en la parte más norte de Sur America. Aunque detallada resolución taxonomica no puede ser definida dentro del clado Eucryptodira, el material descrito asemeja tortugas marinas en morfología

e histología, particularmente al clado Protostegidae. Eucryptodiras son el nuevo elemento en la fauna reptiliana de la Formación Rosablanca, la cual también incluye tortugas panpleurodiras, y material aun sin describir de peces, plesiosaurios, e ichiosaurios.

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