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A skull of *Cyamodus* (Sauropterygia, Placodontia) from the Triassic of Fusea, Province of Udine, northeastern Italy

Abstract - A skull of a cyamodontoid placodont from the Triassic, presumably Upper Triassic (Carnian), of Fusea (Udine Province, northeastern Italy) had previously been referred to *Placochelys placodonta*, a taxon that is otherwise known exclusively from the Upper Triassic of Veszprém, Hungary. The skull from Fusea, that is now accessed in the Collection of the Museo Friulano di Storia Naturale in Udine, is described in detail. The specimen can be referred to the genus *Cyamodus*, with which it shares several characters, including two diagnostic ones. The material is too incomplete and too poorly preserved, however, to serve as the basis for the description of a new species.

Key words: cyamodontoid placodonts, *Cyamodus*, skull, Triassic, Italy.

Riassunto - Un cranio di *Cyamodus* (Sauropterygia, Placodontia) proveniente dal Triassico di Fusea, Provincia di Udine, Italia nordorientale.

Viene descritto il cranio di un placodonte ciamodontoide proveniente dal Triassico, presumibilmente dal Triassico superiore (Carnico), di Fusea (Udine), già pubblicato come appartenente alla specie *Placochelys placodonta*, altrimenti nota esclusivamente nel Triassico superiore di Veszprém (Ungheria). L'esemplare, che era in giacenza senza numero di catalogo presso il Museo Civico di Storia Naturale di Milano, è stato recentemente restituito per competenza territoriale alle Collezioni del Museo Friulano di Storia Naturale (Udine) e provvisto di un numero di catalogo.

Lo studio in dettaglio del cranio ha dimostrato che esso non è riferibile al genere *Placochelys*, bensì al genere *Cyamodus*, con il quale condivide diversi caratteri, due dei quali diagnostici: la presenza di una proiezione ventrale bipartita sul processo palatino dello pterigoideo, precedentemente descritta come una coppia di tubercoli di origine dermica, e la presenza di un tubercolo laterale sull'estremità distale del processo paraoccipitale, che conferisce a quest'ultimo una tipica angolazione distale. Come in tutti i placodonti ciamodontoidi, il cranio di Fusea è caratterizzato dall'esposizione ridotta degli pterigoidei sulla volta palatina e dalla prèsenza di un processo mediale dello giugale che si connette al palatino in corrispondenza del margine anteriore della finestra subtemporale. Le coane sono separate dai vomeri medialmente e delimitate lateralmente da un sottile processo anteriore dei palatini, anteriormente e anterolateralmente dai mascellari. I premascellari sembrano essere esclusi dai margini delle coane. Sono chiaramente identificabili i foramina pterigo-palatini, i foramina pterigo-paraoccipitali e i passaggi per la carotide interna tipici di tutti i placodonti ciamodontoidi, nonché i foramina giugulari. Osteodermi conici sono fusi alla superficie posteriore e posterolaterale dell'arcata temporale. Il condilo basioccipitale è molto sviluppato. La dentatura è costituita da due denti palatini e da tre mascellari, mentre la presenza di una dentatura premascellare non può essere accertata poiché il rostro premascellare non è conservato. I denti palatini posteriori sono molto più grandi degli

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anteriori e particolarmente allungati in senso anteroposteriore. A differenza di quanto si osserva in molte specie di *Cyamodus*, i denti mascellari posteriori sono allineati ai palatini anteriori e sono più grandi di questi. Nessuno dei caratteri descritti è sinapomorfo con caratteri di *Placochelys placodonta*.

L'attribuzione del cranio di Fusea al genere *Placochelys* non appare quindi fondata su una descrizione morfologica sufficientemente dettagliata, bensì basata soprattutto su considerazioni di tipo stratigrafico, cioè sull'assunto che gli strati di Fusea rappresentassero i "Raiblier Schichten", correlabili agli strati del "Keuper inferiore" di Veszprém (Ungheria) da cui proviene il materiale tipico di *Placochelys placodonta*. Allo stato attuale delle conoscenze non è tuttavia possibile accertare con sicurezza se gli strati di Fusea siano effettivamente coevi a quelli di Veszprém. Studi stratigrafici recenti datano questi ultimi al limite Iulico-Tuvalico. Gli strati di Fusea invece non hanno ancora una datazione così precisa: una ipotizzata datazione al Carnico inferiore (Iulico), più probabilmente alla sua parte più bassa, richiede infatti ulteriore verifica. L'appartenenza del cranio di Fusea al genere *Placochelys* venne ulteriormente giustificata dalla formula dentaria: benché l'esemplare non conservasse il rostro, veniva ipotizzato che esso fosse privo di una dentatura premascellare, e che la formula dentaria fosse dunque quella tipica del genere *Placochelys*. Il cranio di Fusea veniva infine associato a un frammento di carapace rinvenuto non lontano da Fusea, nel Carnico di Dogna, e identificato come appartenente alla specie *Placochelys placodonta*: tale frammento non presenta tuttavia i caratteri distintivi del carapace di tale specie, e potrebbe essere invece associato al materiale tipico della specie *Protenodontosaurus italicus*, rinvenuto in una località sempre nei pressi di Dogna.

Il cattivo stato di conservazione del cranio di Fusea ed il confronto con le varie specie di *Cyamodus* dimostrano l'impossibilità di attribuire l'esemplare ad una specie nota. Sulla base di questo singolo esemplare non è neppure consigliabile l'istituzione di una nuova entità specifica di *Cyamodus* nel Triassico di Fusea, anche se i dati in nostro possesso danno una certa consistenza all'ipotesi di una specie tipica del Carnico friulano, non precedentemente descritta, cui potrebbero essere riferiti anche numerosi frammenti di carapace rinvenuti nell'affioramento di Fusea, se pure non in connessione anatomica con il cranio qui descritto, e recentemente in parte pubblicati.

Parole chiave: placodonti ciamodontoidi, *Cyamodus*, cranio, Triassico, Italia.

Introduction

The Triassic marine reptiles from the Tre Venezie Area, northeastern Italy were recently comprehensively reviewed by Rieppel & Dalla Vecchia (2001), and their paleobiogeographic significance was reviewed by Rieppel (1999). Rieppel & Dalla Vecchia (2001) briefly touched upon a cyamodontoid skull from Fusea near Tolmezzo (Fig. 1), Province of Udine, which was first reported by Zucchi Stolfa (1975). After acid preparation of the ventral side of the skull, the specimen was described and figured in greater detail by Pinna & Zucchi Stolfa (1979), and identified as *Placochelys placodonta*. Rieppel & Dalla Vecchia (2001; see also Rieppel, 2000) noted that the description of this specimen by Pinna & Zucchi Stolfa (1979) did not offer enough morphological detail to identify the skull to the genus and species level, but that in its general appearance the specimen resembled *Cyamodus* more than *Placochelys*. The identification of the cyamodontoid from Fusea hence appeared to be based primarily on stratigraphic considerations, as Pinna & Zucchi Stolfa (1979) believed the Fusea deposits to be contemporaneous to the "Veszprém marls", Hungary, which yielded the type material of *Placochelys placodonta*. According to Pinna and Zucchi Stolfa the "Veszprém marls" correspond to the "Raiblier Schichten" of the Julian Alps, and, following Jaekel (1902: 127; 1907: 5), were dated as "lower Keuper". Following that stratigraphic assessment, Pinna & Zucchi Stolfa (1979) concluded that *Placochelys placodonta* was distributed on the carbonate platform that stretched from the eastern Alps to Hungary (the southern Alps - Hungarian carbonate platform: Marcoux *et al.*, 1993; Marcoux & Baud, 1995) located in the southwestern part of the Tethys. While this paleogeographic assessment remains

valid (Rieppel, 2001), it should be noted that the conteporaneity of Fusea and Veszprém outcrops needs further discussion.

The skull described in the present paper was very probably found in the layer E of the stratigraphic column of the Fusea site (Dalla Vecchia, 2000, Fig. 5) (see Fig. 1 for the location of the site), as is indicated by the type of matrix surrounding the fossil, i.e., a dark gray-blackish limestone. This was also confirmed by Mario Cuder, who collected the specimen.

The fossiliferous layers of Fusea have been dated by Rieppel & Dalla Vecchia (2001: 9) as uppermost Julian or middle Carnian (according to the local partition of the Carnian into the Julian, or lower Carnian, and the Tuvalian, or upper Carnian). After completion of the manuscript of Rieppel & Dalla Vecchia (2001; accepted for publication in March 1999), Dalla Vecchia (2000) again reviewed the stratigraphic position and the details of the stratigraphical column of the sedimentary layers yielding fossil vertebrates near Fusea. Dalla Vecchia (2000) confirmed that the fossil bearing strata of Fusea belong to the upper part of the

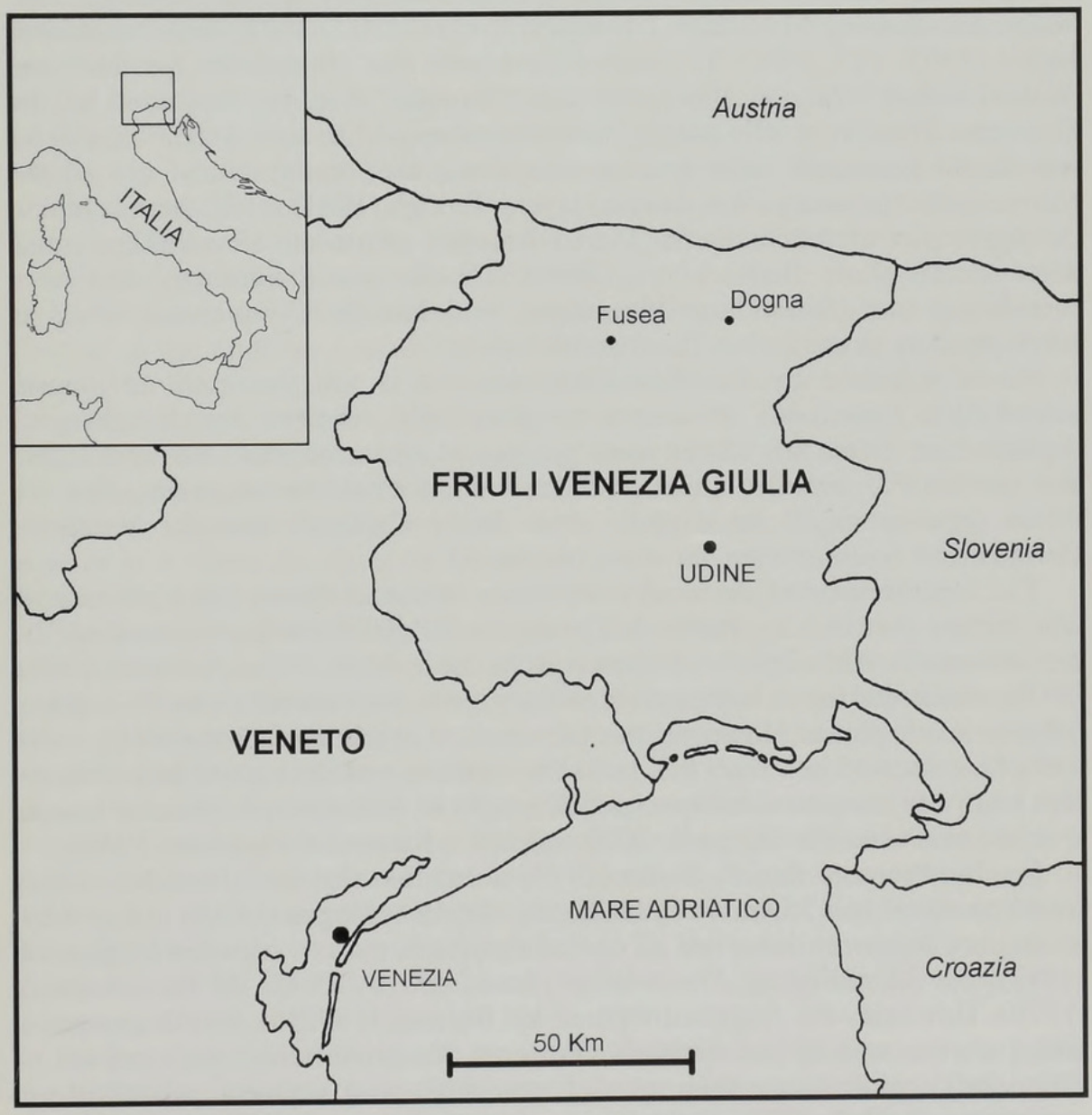

Fig. 1 - Location of the fossiliferous sites of Fusea and Dogna.
Fig. 1 - Localizzazione geografica dei siti fossiliferi di Fusea e Dogna.

lower Carnian. A position of these layers of the Fusea site "high" within the lower Carnian was assumed on the basis of a comparison with the well known stratigraphy of the Dolomites, located at a considerable distance west of Fusea. However, recent research by Jadoul *et al.* (2000) demonstrated that in the area of Dogna (Fig. 1), not far from Fusea, the last carbonate platform preceding the deposition of Dolomia Principale is entirely of Ladinian age, its upper limit approximately corresponding to the Ladinian-Carnian boundary. If it were assumed that the last carbonate platform above which the Fusea fossiliferous layers are located is of the same age as that in the area of Dogna, the dating of the Fusea site would have to be older (i.e. basal Carnian). However, Dalla Vecchia (pers. comm.) points out that the Fusea area, even if not very far from Dogna, is rather different from a stratigraphic point of view, and thinks that on the basis of present knowledge it may be more prudent to consider the Fusea layers as early Carnian in age, without further specification.

The only known material of *Placochelys placodonta* was found in the *Physocardia* beds (= *Cornucardia hornigi* beds) of Jeruzsálemhegy near Veszprém, Bakony Mountains, Hungary (Jaekel, 1902, 1907; Arthaber 1906). Jaekel (1902: 127; 1907: 5) referred the layers that yielded the fossils to the "lower Keuper" (at the time, the term "Keuper" was not restricted to the Germanic Triassic as it is today). Recent studies of the area were *Placochelys* was found generated more precise data about the stratigraphical age of the *Cornucardia* (formerly *Physocardia*) layers. Balogh (1981) refers these layers to the upper part of the Veszprém Marl Formation sensu lato (Sandorhegy unit), dated as Tuvalian. Budai *et al.* (1999) consider the Sandorhegy unit as a formational unit (Sandorhegy Formation), and date the *Cornucardia* levels as corresponding to the Julian-Tuvalian boundary.

As is indicated by the discussion above it is, on the basis of present knowledge, impossible to assess unequivocally whether the fossiliferous deposits near Fusea are of the same geological age as are the Veszprém layers that yielded *Placochelys*, although there is some evidence suggesting that the Fusea deposits might be slightly older (early Carnian) than the Veszprém *Cornucardia* layers (Julian-Tuvalian boundary).

The identification of the skull from Fusea as that of *Placochelys placodonta* was further justified by Pinna & Zucchi Stolfa (1979) with reference to the dental formula. Although the specimen lacks the rostrum, Pinna & Zucchi Stolfa (1979) concluded that it had no premaxillary teeth, three maxillary teeth, and two palatine tooth plates. However, the presence or absence of premaxillary teeth cannot be assessed in a skull that lacks the rostrum, and three maxillary teeth are also known to occur in some species (that might be different specimens of a same species) of *Cyamodus* (Rieppel, 2000 and 2001; Rieppel & Hagdorn, 1999).

Finally, Pinna & Zucchi Stolfa (1979) noted that the skull from Fusea was found no more than 25 km away from a locality near Dogna (Friuli) that yielded a carapace fragment described as one of *Psephoderma* cfr. *alpinum* by Bassani (1892), but identified as *Placochelys placodonta* by Pinna & Zucchi Stolfa (1979). However, the fragment figured by Bassani (1892) is very incomplete, and it shows none of the distinctive features that characterize the carapace of *Placochelys placodonta* such as the very high and pointed, tuberculiform osteoderms (Jaekel, 1907). Furthermore, other localities near Dogna have since yielded two skulls that have been identified as those of a new genus and species,

Protenodontosaurus italicus Pinna, 1990 (see also Nosotti & Pinna, 1999), to which the respective carapace fragment might have to be referred.

In the last sentence of their paper, Pinna & Zucchi Stolfa (1979: 312) emphasize that "the only characteristic feature of the specimen [from Fusea] appears to be the presence – of which we remain doubtful – of two small osseous tubercles on the ventral flange of the pterygoid." This observation is important, because a double ventral projection of the pterygoid flange is a feature diagnostic of the genus *Cyamodus* (Rieppel, 2000). The skull, that was previously deposited at the Museo Civico di Storia Naturale di Milano without a catalogue number, has recently served as a basis for its redescription in an attempt to assess its generic identity. The specimen is now accessed in the Collection of the Museo Friulano di Storia Naturale (MFSN) in Udine under the collection number 26830.

Morphological description of the specimen MFSN 26830 (Fig. 2)

The skull

The skull is strongly dorsoventrally compressed, and lacks the rostrum. It is prepared in ventral view. Its maximal length is 144.5 mm, its maximal width is 146.7 mm (as preserved).

The skull is broken at the anterior end of the maxilla, at a level well in front of the internal nares. Indeed, it appears that the right maxilla is preserved up to its anterior tip, which hence seems to have separated from the premaxilla at the sutural contact. The internal nares are well preserved, at least around their posterior margins. They are separated by paired vomers. Each internal naris is drop-shaped, wider anteriorly than posteriorly. Fine breakage of the bone along their anterior margins renders the identification of sutures difficult, but it seems possible to identify, at the midline, a transversely oriented and interdigitating contact of the vomer with the premaxilla. If correctly identified, this suture would indicate that the premaxilla remains excluded from the internal naris. The contact of the vomer with the maxilla along the anterior margin of the internal naris cannot be identified, nor is the suture between maxilla and palatine clearly delineated. However, it is possible to vaguely identify, on both sides of the skull, the anterior tip of the palatine as it tapers out along the lateral margin of the internal naris. This restricts the maxilla to the anterolateral and anterior margin of the internal naris.

The anterior and anteromedial margin of the subtemporal fossa is particularly well preserved on the right side of the skull. As in all cyamodontoids, the pterygoid forms a slender, tapering process that extends anteriorly lateral to the posterior palatine tooth plate. In front of the pterygoid, the palatine forms the anteromedial margin of the subtemporal fossa. The latter can be seen to slightly expand laterally as it appears to meet a distinct medial process of the jugal that seems to form most of the anterior margin of the subtemporal fossa. This putative medial process of the jugal is not clearly demarcated from the posterior end of the maxilla, as what appears to be an irregular suture might also be the result of breakage. However, as here interpreted (Fig. 2), the palatine - jugal contact in specimen MFSN 26830 is identical to that of *Cyamodus kuhnschnyderi* (holotype, SMNS 15855: Nosotti & Pinna, 1996).

On the right side of the skull, the suture between the palatine and pterygoid can be followed around the posterolateral corner of the posterior palatine tooth plate. In spite of severe dorsoventral compression of the skull, the posterior dental lamina foramina remain distinct, albeit filled with matrix. The right

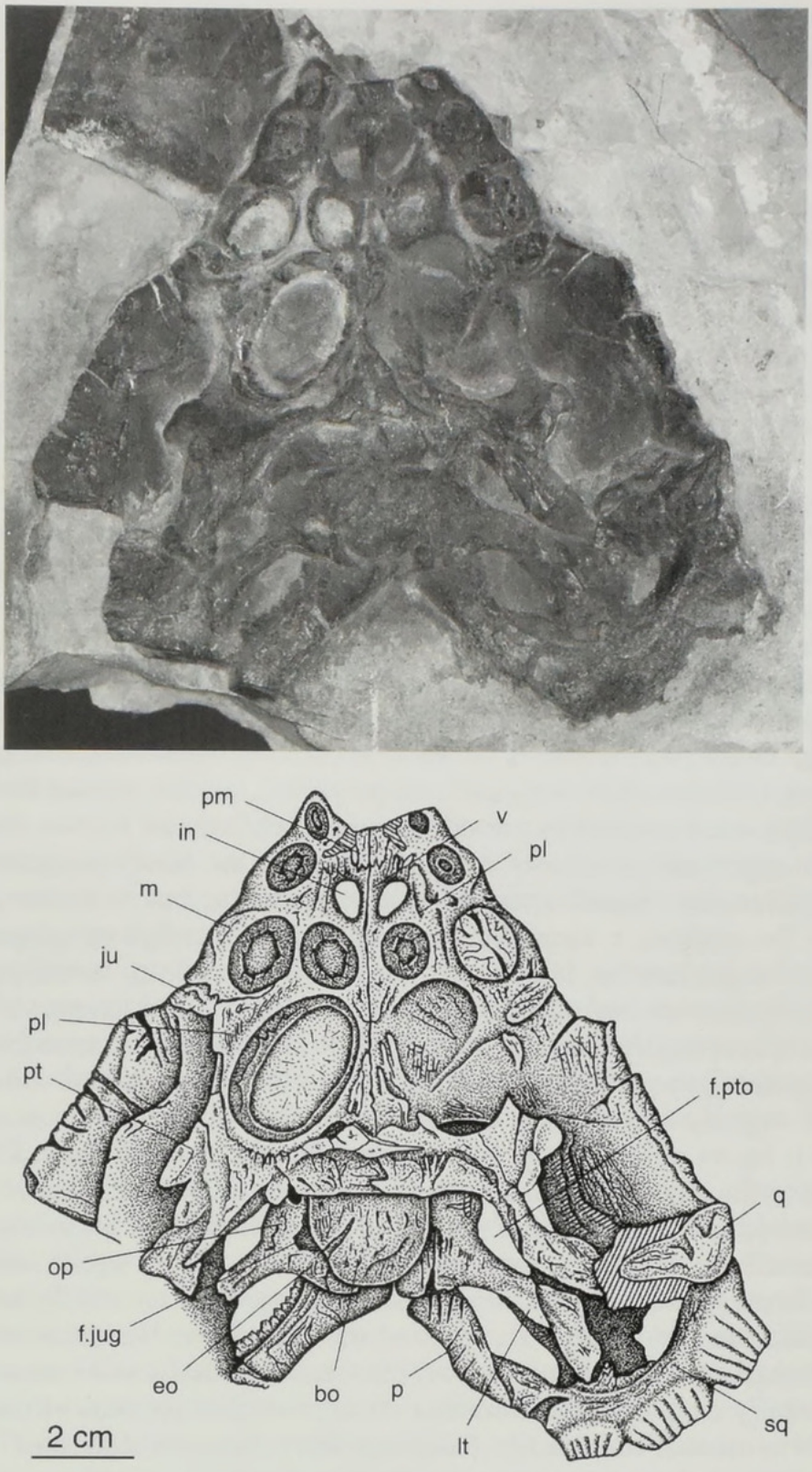

Fig. 2 - The skull of *Cyamodus* sp. (MFSN 26830) from the Triassic of Fusea (Province Udine, northeastern Italy). Abbreviations: bo, basioccipital; eo, exoccipital; f.jug, jugular foramen; f.pto, pterygo-paroccipital foramen; in, internal naris; ju, jugal; lt, lateral tubercle on angulated paroccipital process; m, maxilla; op, opisthotic; p, parietal; pl, palatine; pm, premaxilla; pt, pterygoid; q, quadrate; sq, squamosal; v, vomer.

Fig. 2 - Il cranio di *Cyamodus* sp. (MFSN 26830) del Triassico di Fusea (Udine). Abbreviazioni: bo, basioccipitale; eo, esoccipitale; f.jug, foramen giugulare; f.pto, foramen pterygo-paraoccipitale; in, narice interna; ju, giugale; lt, tubercolo laterale del processo paraoccipitale; m, mascellare; op, opistotico; p, parietale; pl, palatino; pm, premascellare; pt, pterigoideo; q, quadrato; sq, squamoso; v, vomere.

posterior dental lamina foramen is somewhat dislocated medially due to distortion of the skull. More medial parts of the dermal palate are again subject to severe breakage. Nevertheless, it is possible to identify parts of the suture between the pterygoid and palatine in the area between and behind the posterior palatine tooth plates, which indicates a very narrow ventral (palatal) exposure of the pterygoids. The length of the pterygoid exposure (between the posterior margin of the dermal palate and the posterior margin of the palatine) is a maximum of 11.2 mm, which compares to a minimum length of the palatine (between the posterior palatine - pterygoid contact and the posterior margin of the internal naris) of 49 mm. There remains the possibility, however, that the palatal exposure of the pterygoid is even more limited, if it is assumed that dorsoventral compression of the skull resulted in some ventral exposure of the posteriormost part of the para-basisphenoid between the very narrow yet crushed pterygoid and the basioccipital (occipital condyle).

The longitudinally oriented ventrally projecting pterygoid flange (both sides) and the quadrate ramus of the pterygoid (left side) are well preserved. As observed by Pinna & Zucchi Stolfa (1979), the pterygoid flange bears a double ventral projection (rather than separate tubercles). The pterygo-paroccipital foramen is exposed in ventral view between the paroccipital process (ventral view) and the quadrate ramus of the pterygoid. Details of the contact of the quadrate ramus of the pterygoid with the quadrate are obscured by breakage. The mandibular condyle of the quadrate is biconvex, and it is broader laterally than medially.

The temporal arch is preserved in ventral view, with its posterolateral and posterior parts preserved on the left side only. Incompletely preserved, tuberculiform osteoderms are fused to the posterolateral and posterior surface of the left temporal arch. A posteriorly trending, sigmoidally curved suture indicates the contact of the squamosal with the parietal on the posteromedial surface of the temporal arch.

The basioccipital projects from above the pterygoids to form a large occipital condyle, with a length of 19.5 mm and a width of 23.7 mm. These dimensions may be exaggerated due to dorsoventral compression of the skull and the ventral exposure of more anterior parts of the basioccipital. On the other hand, a large occipital condyle is also characteristic of *Cyamodus kuhnschnyderi* (Nosotti & Pinna, 1996). A notochordal pit is exposed on the posterior surface of the occipital condyle. Crushed remains of the braincase are preserved on either side of the occipital condyle. Whereas the right paroccipital process is incomplete, the left one is well preserved, and shows a distinct angulation in its distal part. A similar angulation of the paroccipital process is observed in *Cyamodus kuhnschnyderi*, where it is correlated with the development of a lateral tubercle projecting downward and posteriorly from the posterior margin of the distal part of the paroccipital process (Nosotti & Pinna, 1996: 19). A similar tubercle, although now abraded, can be identified in specimen MFSN 26830.

From behind and above the occipital condyle project the dorsomedial spurs of the exoccipital that in the undistorted skull formed the dorsal margin of the foramen magnum. The crushed jugular foramen can be identified in the distorted braincase wall on both sides of the occipital condyle. The contact of the braincase with the dermal palate (pterygoids), which involves the basioccipital tuber, the ventrally projecting flange of the opisthotic, and the passage for the internal carotid

between the two, is identifiable yet poorly preserved on either side of the skull.

The dentition

The premaxillae are not preserved, thus nothing can be said about the shape of the premaxillary rostrum and its dentition. It might be argued that the skull of specimen MFSN 26830 is too narrow at the anterior end of the maxilla to allow for a short and broad rostrum as is characteristic of *Cyamodus*. Comparison with *Cyamodus kuhnschnyderi* (Nosotti & Pinna, 1996) indicates similar proportions, however. Dividing the distance from the anterior margin of the internal naris to the posterior margin of the dermal palate (measured along the midline of the skull) by the width of the skull at the level of the premaxillary - maxillary suture yields a quotient of 2.35 for *Cyamodus kuhnschnyderi* (holotype, SMNS 15855), 2.39 for specimen MFSN 26830.

The maxillae bear three teeth each that increase in size from front to back. As discussed before, three maxillary teeth are also known for some species (that might be different specimens of a same species) of the genus *Cyamodus* (Rieppel & Hagdorn, 1999).

As all cyamodontoids with the exception of *Cyamodus rostratus* (Rieppel, 2000 and 2001), specimen MFSN 26830 shows two palatine tooth plates of which the anterior one is much smaller than the posterior one. However, specimen MFSN 26830 appears to have posterior palatine tooth plates which are more distinctly elongated than are those of *Cyamodus*. Precise measurements are difficult to obtain on specimen MFSN 26830, because only the replacement tooth of the right posterior palatine tooth plate is preserved, and incompletely exposed at the depth of the vacated functional alveolus. Nevertheless, it should be noted that *Cyamodus hildegardis* shows posterior palatine tooth plates that are somewhat elongated, but not quite as much as are those of specimen MFSN 26830 (Rieppel, 2001).

Cyamodus muensteri (including *Cyamodus laticeps*: Rieppel, 2000), *Cyamodus hildegardis*, and *Cyamodus kuhnschnyderi* differ from *Cyamodus rostratus* in that the posteriormost maxillary teeth are aligned with the anterior palatine tooth plates on a line which describes an anteriorly weakly concave curve. By comparison, the posteriormost maxillary teeth of specimen MFSN 26830 are positioned slightly more posterior, i.e., directly lateral to the palatine tooth plates such that the teeth line up on a straight line. Specimen MFSN 26830 also differs from other species (or different specimens of a same species) of *Cyamodus* in that the posterior maxillary teeth are larger than the anterior palatine tooth plates. In other species (or different specimens of a same species) of *Cyamodus*, the posterior maxillary tooth is smaller, or at best of equal size, compared to the anterior palatine tooth plate. It should be noted, however, that the slight difference of the relative position of the posterior maxillary tooth plate in specimen MFSN 26830 might well be due to distortion of this badly compressed skull, while their relative size may be subject to individual variation.

Discussion and Conclusions

The cyamodontoid skull from the Triassic of Fusea (Udine Province) does not share any uniquely derived characters with *Placochelys placodonta*. The rostrum is not preserved in specimen MFSN 26830, and three maxillary teeth are not exclusively characteristic of *Placochelys*, but also occur within the genus *Cyamodus*.

By contrast, the skull from Fusea shares two characters diagnostic of the

genus *Cyamodus*, viz. the double ventral projection of the pterygoid flange, and a distally angulated paroccipital process correlated with the development of a lateral tubercle. A similar tubercle is developed in *Protenodontosaurus italicus*, an occurrence that optimizes as convergence (Rieppel, 2001). Other characters which specimen MFSN 26830 shares with *Cyamodus*, but not exclusively, are the relatively narrow palatal exposure of the pterygoid, and the presence of a medial process on the jugal which meets the palatine at the anterior margin of the subtemporal fossa. The conclusion therefore is that specimen MFSN 26830 must be referred to the genus *Cyamodus*.

Within the genus *Cyamodus*, specimen MFSN 26830 resembles *Cyamodus kuhnschnyderi* (Nosotti & Pinna, 1996) in many morphological details as was discussed above, but it shares with *Cyamodus hildegardis* the elongated posterior palatine tooth plates, and the large tuberculiform osteoderms fused to the posterolateral and posterior surface of the temporal arch. Given its poor preservation, the cranial anatomy of *Cyamodus hildegardis* remains largely unknown otherwise.

The skull of the cyamodontoid from Fusea is relatively poorly preserved as well, for which reason it would seem premature to name a new taxon for that locality. It should be noted, however, that the Fusea locality also yielded several carapace fragments (partly published in Rieppel & Dalla Vecchia, 2001), which were not articulated with the skull here described, but which might in part have been associated with that skull, as some of them were found on the surface of the same bed that yielded the skull. These carapace fragments do not compare to the well-known carapace of *Cyamodus hildegardis* (Peyer, 1931), nor to the rare fragments of dermal armor that have been referred to *Cyamodus kuhnschnyderi* (Nosotti & Pinna, 1996). It cannot, therefore, be ruled out that an as yet undiagnosed new species of *Cyamodus* occurred in the Carnian of Fusea (Province Udine, Italy). Its formal description, and diagnosis, must await the preparation and description of collected, but yet unpublished material, apparently including more complete and better preserved specimens, however.

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