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THE FIRST PTEROSAUR FROM THE LATE JURASSIC OF SWITZERLAND : EVIDENCE FOR THE LARGEST JURASSIC FLYING ANIMAL

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Abstract : An enigmatic bone from the Solothurn Turtle Limestone (Late Jurassic; Kimmeridgian) from an old quarry near St. Niklaus (Solothurn, Switzerland) is reexamined. This specimen, previously identified as coelurosaurian fibula by Huene (1926) is now interpreted as the wing phalanx II of a pterodactyloid pterosaur with a wingspan between 3.5 m and 5 m. Pterosaurs with wingspans of over 2.5 m had previously not been found in rocks older than Early Cretaecous.

Key words : Pterosaur – Late Jurassic – Northern Switzerland.

Le premier ptérosaure du Jurassique supérieur de Suisse : le plus grand animal volant du Jurassique

Résumé : Un os énigmatique des Calcaires à tortues de Soleure (Jurassique supérieur; Kimmeridgien) provenant d'une carrière abandonnée de St. Niklaus (Soleure, Suisse) est réexaminé. Ce spécimen, identifié par Huene (1926) comme une fibula de coelurosaure est réinterprété comme la second phalange alaire d'un ptérodactyle dont l'envergure est estimée entre 3.5 m et 5 m. Des ptérosaures avec une envergure dépassant 2.5 m n'avaient jamais été signalés dans des sédiments antérieurs au Crétacé inférieur.

Mots clés : Ptérosaure - Jurassique supérieur - Nord de la Suisse.

INTRODUCTION

The Solothurn Turtle Limestone is an important lagerstätten in the Late Jurassic of northwestern Switzerland (e.g., Hugi, 1825; Rütimeyer, 1873). The vertebrate body-fossil fauna includes marine turtles, fish, crocodiles as well as a sauropod-dominated terrestrial vertebrate ichnofauna (Meyer, 1993; 1994a, b).

Among those vertebrate specimens from the Solothurn Turtle Limestone is an enigmatic bone that is elongated and straight (Huene, 1926; pl. 26, fig. 61). This was one of three enigmatic bones of which Huene sent sketches to Baron F. Nopsca in Vienna for help with identification. Huene (1926) concluded that the specimen was too straight for a rib end, and that it probably represented the distal part of a fibula of a coelurosaurian dinosaur.

As part of a project to evaluate the Late Jurassic dinosaurs of Switzerland (see also Meyer & Hunt 1998), we have reexamined this putative theropod specimen. All specimens discussed in this paper are stored in the Naturmuseum Solothurn (NMS), Switzerland or in the British Museum of Natural History, London (BMNHR).

GEOLOGIC SETTING AND DEPOSITIONAL ENVIRONMENT

In his first description Huene (1926) provided only a very rough locality information, stating that the enigmatic bone came from a quarry in St. Verena, near Solothurn (Northern Switzerland). Recent observations and additional information from the Museum catalogue now reveal that the specimen which is the principal subject of this paper derives from one of the nineteenth century quarries that operated around the small village of St. Niklaus near Solothurn (e.g. Meyer 1994a).

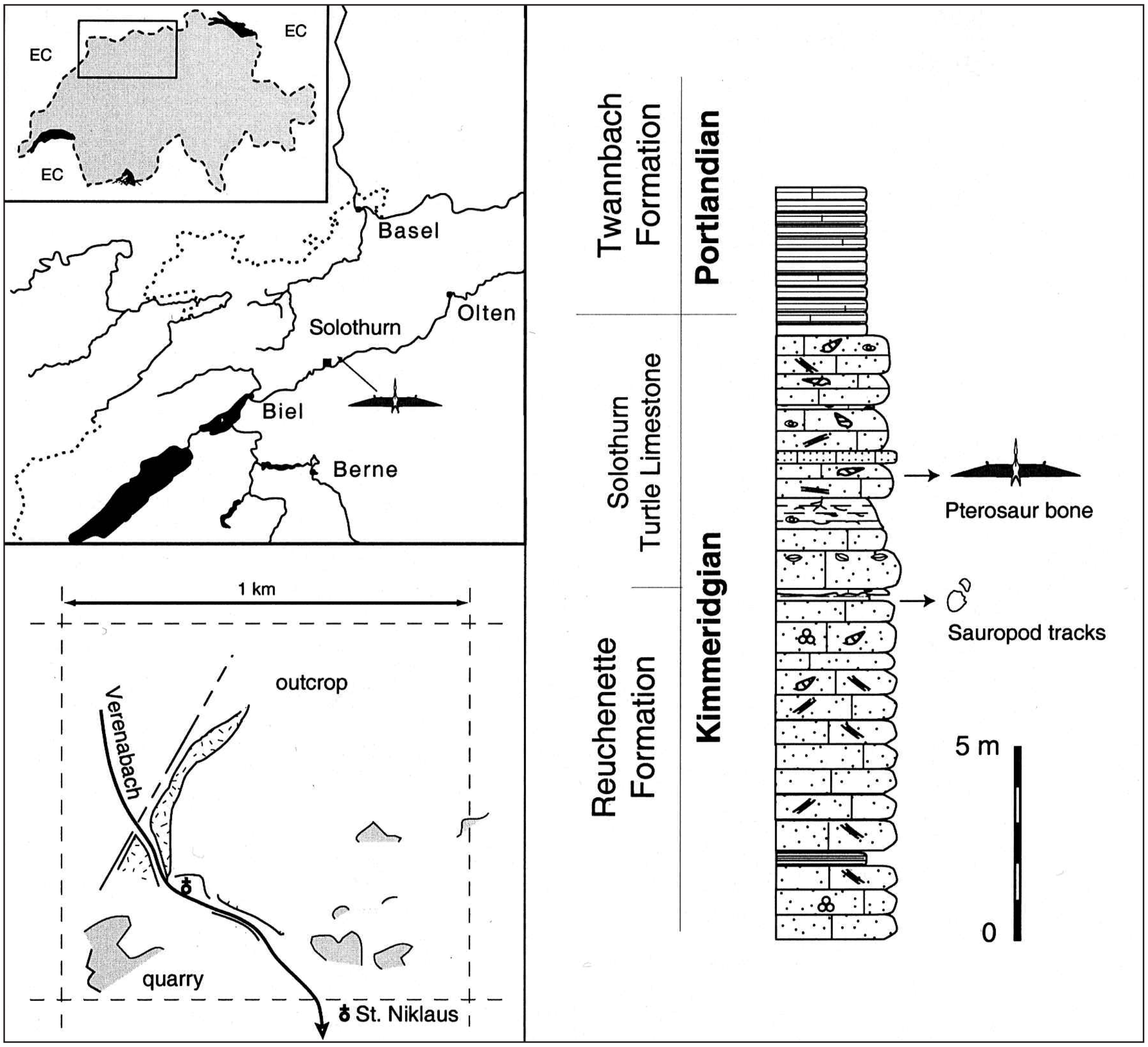

Fig. 1 General map of Switzerland, quarry location and geological section of St. Niklaus quarry (Kimmeridgian; Solothurn, Northern Switzerland) indicating pterosaur bone locality
Fig.1: Carte générale de la Suisse, localisation de la carrière et profil géologique de St. Niklaus (Kimmeridgien, Soleure, Suisse) avec indication du gisement.

In the 19th century most of the quarries around the small village of St. Niklaus (Verena anticline) yielded fossil vertebrates, whereas today all of the then existing quarries are no longer operational.

At the time of the original description, Huene (1926) still believed that the Solothurn Turtle Limestone (Kanton Solothurn, Switzerland) was of Portlandian age. New biostratigraphic data confirm that the fossil yielding member is of Late Kimmeridgian age (*sensu gallico*) on the basis of index ammonites (fig. 1; Meyer & Pittman 1994; Gygi, 1995). The main fossil producing limestones are bioturbated micrites and grainstones, deposited in a subtidal setting. The fauna indicates a highly diverse lagoon community similar to the coeval lagerstätten of Solnhofen in Germany and Cerin in France.

DESCRIPTION

The putative theropod bone from Solothurn (NMS 20'870) has been slightly damaged since Huene examined it. The matrix core used to extend beyond the end of the bone giving it a length of 420 mm (Huene, 1926, pl. 27, fig. 61), whereas this dimension is now 415 mm. The surface is smooth and has a silky appearance (fig. 2).

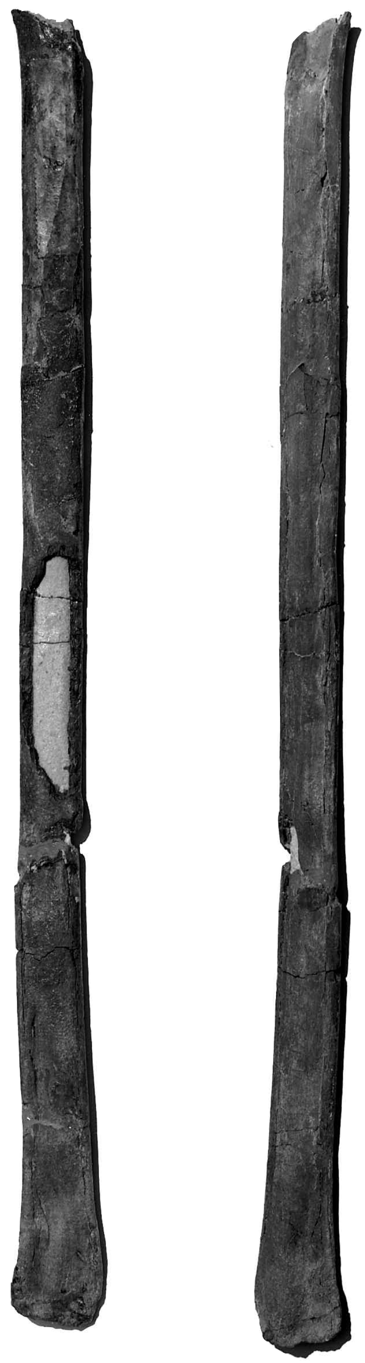

Fig. 2 : Wing phalanx 2 of Pterodactyloidea indet. (length: 415 mm; NMS 20'870) from the Late Jurassic (Kimmeridgian) of St. Niklaus, Solothurn (Switzerland).

Fig. 2 : Phalange alaire 2 de Pterodactyloidea indet. (longueur : 415 mm ; NMS 20'870), Jurassique supérieur (Kimmeridgien) de St. Niklaus, Soleure (Suisse).

The majority of the bone consists of a narrow, straight, flattened shaft. In lateral view, one edge is straight, and the other is gently concave, principally as a result of flaring of the ends of the bone. The thicker end of the bone is broken (maximum width 21.8 mm), while the other is flatter and preserves an almost complete termination (maximum width 29 mm). The tip of the more complete end is flared with the majority of curvature on one side. The broken end also exhibits flexure in the same direction. The majority of the shaft of the bone is sub- parallel sided, with a width of about 20 mm, and a thickness of about 9 mm.

In cross section the shaft is almost flat on one side. The other side is gently rounded and has a median ridge that extends for three quarters of the length resulting in a rounded triangular cross section. Bordering one edge of the median ridge is a narrow furrow that is less than 2 mm deep. Beyond the median ridge at the thinner, more complete end, is a rounded compression fracture. On this side there is a broken section in the middle of the shaft that provides a window into the matrix-filled interior. The bone is hollow with the thickness of the cortex ranging from 1.4 to 3.2 mm.

SYSTEMATICS

The hollowness of the bone indicates that it represents a member of the Theropoda (including Aves) or Pterosauria (Gauthier, 1986; Sereno *et al.*, 1993; Novas, 1993). Even a cursory examination of the literature for these groups reveals a striking similarity of the Swiss bone to the wing phalanges of pterosaurs. Indeed, in all details of morphology including elongation of the shaft, rounded triangular cross section, asymmetrical flaring of both ends and the thinness of bone, NMS 20'870 is nearly identical in morphology to a right wing phalanx 2 of a pterosaur (e.g. compare Wellnhofer: 1985; fig. 24). The proximal end of NMS 20'870 differs from the wing phalanx 1 of pterosaurs in lacking any indication of thickening or of a concave articulation (e. g., Wellnhofer: 1985, fig. 24a-d, Wellnhofer: 1977, fig. 15a-b). However, the proximal end of NMS 20'870 does flare as in wing phalanx 2 as opposed to wing phalanges 4 and 5 (e. g., Wellnhofer: 1977, fig. 15c-h).

The large size of the specimen and the absence of a deep phalangeal groove (e.g. Wellnhofer, 1977) suggests that this bone does not represent a rhamphorynchoid. However, it is conceivable that the small, 2 mm, deep groove on the Swiss specimen is a remnant of the large feature found in some rhamphorhynchoids, and that the development of this character is a size-related feature. However, some rhamphorhynchoids lack these grooves (Unwin, 1988).

The large size of the Swiss specimen suggests an affinity with pterodactyloids. NMS 20'870 is about twice the size of the largest rhamphorhynchoids such as *Rhamphorhynchus longiceps*. Comparison with published descriptions of pterodactyloids (e.g. *Santanadactylus*, Wellnhofer, 1985), and direct comparison with specimens (e.g. *Pteranodon*, BMNHR 2959), indicates a very close similarity to NMS 20'870. However, with only a wing phalanx and a tooth (see below), it is not possible to assign the Solothurn pterosaur to a particular subclade within Pterosauria.

The rounded compression fractures on the phalanx are consistent with damage caused be tooth impacts. It is possible that these tooth marks were made during scavenging of the pterosaur carcass. Potential scavengers in the Solothurn lagoon include, the large mesosuchian aquatic crocodile *Machimosaurus,* an animal that is known to have to fed on marine turtles (Meyer 1994a).

Two other specimens from the same locality, housed in the Naturmuseum, might also pertain to a pterosaur. The first is a laterally compressed tooth (NMS 20'537), in which the pyramidal root cavity is partially filled in by matrix. The enamel is smooth, and the tooth is not serrated. The tooth is slightly incurved, and the lateral flattening increases toward the tip which is slightly rounded. The cross section of the base of the tooth is ovoid (5.3 x 4.1 mm), and the height is 12.7 mm. This tooth is morphologically similar to teeth assigned by Wellnhofer (1985) to *Araripesaurus santanae* (Wellnhofer: 1985, fig. 7f) and *Santanadactylus araripensis* (Wellnhofer: 1985, figs. 7a-e), and pterosaur teeth from the Lower Cretaceous of England (BMNH specimens). Teeth of pterosaurs usually display a distally recurved part of the enamel margin on the lingual and buccal side. However, this feature is not preserved in the specimen, and therefore the attribution to a pterosaur must remain doubtful.

The other specimen is an elongated, faintly curved, hollow bone that is broken into two pieces and preserved on a slab of matrix (NMS 7124). The longest fragment is 56 mm long, and 7.4 mm wide and has a rounded cross section. The smaller piece is 11.5 mm long and 6.8 mm wide. Give the shape, size, and hollowness of these bones, they potentially represent fragments of pterosaur ribs.

DISCUSSION

Given the virtually complete preservation, it is possible to estimate the wingspan of the Solothurn pterosaur by comparison with pterosaurs of similar size, and for which complete wings and skeletons are known.

The wing phalanx II of *Santanadactylus pricei* has a length of 324 mm (compared with about 420 mm for the Solothurn specimen). Reconstructions of *Santanadactylus pricei,* provided by Wellnhofer (1991a: fig. 35), suggest that the Swiss pterosaur would have had a wingspan of about 4.24 m. If compared to *Santanadactylus araripensis* (cf. Wellnhofer 1985: fig. 48), whose phalanx II measures 395 mm, the Swiss specimen would have reached a wingspan of 5 m. Similar calculations based on the famous restoration of *Pteranodon cf. longiceps* (7 m wingspan) at the Yale Peabody Museum, indicate a wingspan of about 4.06 m for the Solothurn animal.

Given allometric changes during growth in wing bones, it is likely that the calculations based on the Brazilian pterosaur give closer approximation of the wingspan of the Solothurn specimen. It seems likely that the Swiss pterosaur had a wingspan in excess of 4 m. However, the relative length of wing phalanx II varies considerably in pterosaurs, and it is possible that the wingspan could have been as short as 3.5 m, or as long as 5.0 m. No other Jurassic pterosaurs are known to have had such large wingspans with *Pterodactylus grandis* only reaching 2.5 m (Wellnhofer, 1991). Pterosaurs of comparable size to the Solothurn creature have not previously been found in rocks older than Lower Cretaceous in age.

In this context it is interesting to note that Wright *et al.* (1996) identified *Purbeckopus* from the

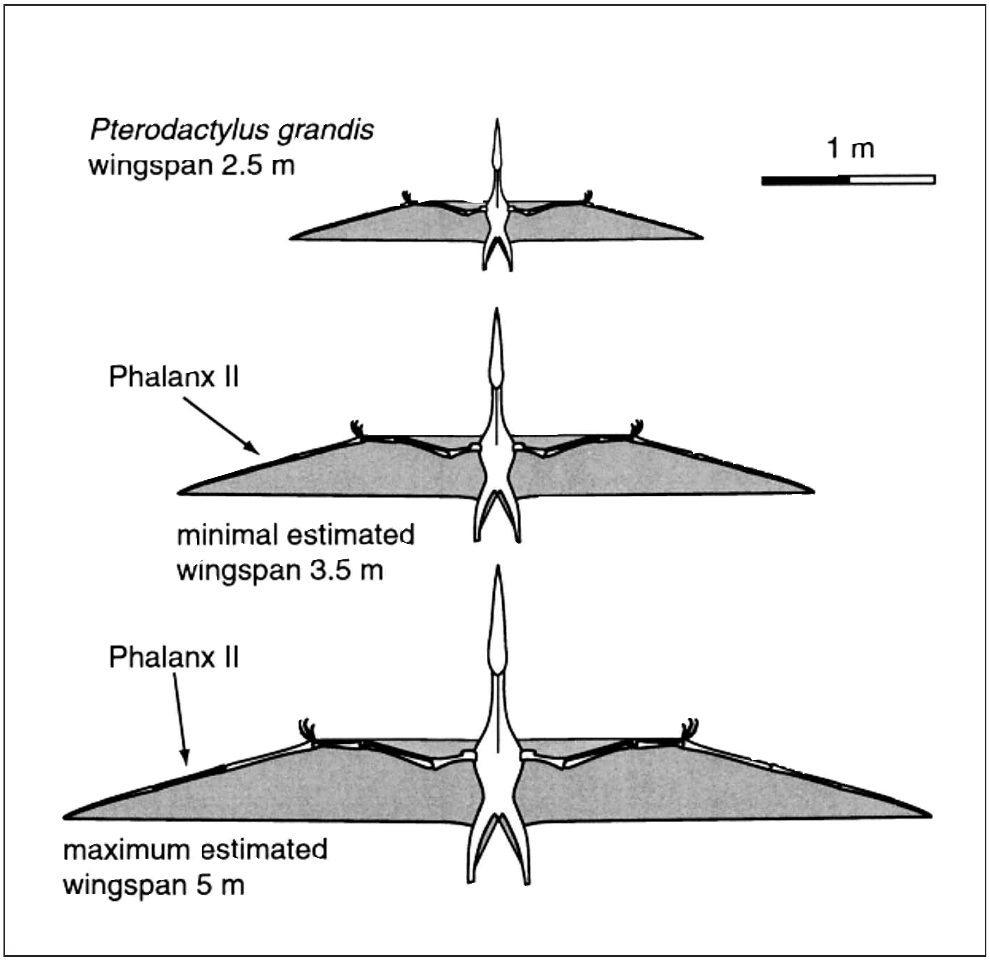

Fig. 3
Comparative sketch of *Pterodactylus grandis*, minmal and maximal wingspan of specimen discussed in this paper.

Fig. 3
Dessin comparatif de *Pterodactylus grandis*, envergure minimale et maximale du spécimen discuté dans cet article.

Purbeck Group as a pterosaur track, and estimated that the animal responsible for these ichnites had a wingspan of about 6 m. On the basis of their observations they postulated the existence of large pterosaurs by the end of the Jurassic.

CONCLUSIONS

An elongate bone from the Kimmeridgian Solothurn Turtle Limestone is reinterpreted as a wing finger bone (phalanx II) of a ?pterodactyloid pterosaur with a wingspan between 3.5 m and 5 m (fig. 3). In addition, other specimens tentatively assigned to Pterosauria from this locality include a tooth and fragmented ribs. Pterosaurs with wingspans of over 2.5 m have previously not been found in rocks older than Early Cretaceous. The described material confirms the presence of large to very large pterosaurs already in the Late Jurassic.

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