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NOTE

THE FIRST MOSASAUR (SQUAMATA) FROM THE LATE CRETACEOUS OF TURKEY

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Mosasaurids are a group of giant-sized Late Cretaceous marine lizards (Russell, 1967; DeBraga and Carroll, 1993; Bell, 1997). They have been found all over the world but are particularly abundant in Santonian to Maastrichtian marine deposits of North America (Western Interior Sea) and Europe (northern Mediterranean Tethys margin). Though most European and Middle-East countries have yielded mosasaur remains, they were unknown until now in Turkey. Here we report the first mosasaur recovered from this country and from Western Asia, and refer it to the species *Mosasaurus hoffmanni*. This discovery supports the hypothesis of a mosasaur distribution linked to palaeolatitudinal gradients between the northern and southern margins of the Mediterranean Tethys during the Late Cretaceous.

Abbreviations Used—**HU**, Hacettepe University, Department of Geological Engineering, Ankara, Turkey; **IRSNB**, Institut Royal des Sciences Naturelles de Belgique, Bruxelles, Belgium; MNHN, Muséum National d'Histoire Naturelle, Paris, France; **NHMM**, Natuurhistorisch Museum Maastricht, Maastricht, The Netherlands.

GEOLOGICAL SETTING

The specimen was found by the second author near the Beyler dam, located near the town of Devrekani, which is about 250 km north of Ankara, in northern Turkey (Fig. 1). This area is part of the 'Pontid Tectonic Units' of Turkey (Ketin, 1966) and includes stratigraphical units ranging from Pre-Mesozoic up to Holocene.

The mosasaur was found in brown nodulous limestones from the uppermost part of the Davutlar Formation. This formation is latest Maastrichtian to early–mid Paleocene in age (Tunoğlu, 1991, 1992, 1993a, b; Tunodlu and Temel, 1996). The Davutlar formation lies conformably on the Middle–Upper Maastrichtian Tomalar formation and is conformably overlain by the Upper Paleocene–Eocene Gürleyikdere formation.

The Davutlar formation consists of silty to sandy limestones, marls, and sandstones (Fig. 1). It includes a well-exposed K/T boundary (KTB), one of the few in Turkey. Just below the KTB is a fossiliferous level very rich in invertebrate macrofossils (ammonites, inocerams, echinoderms, corals, crabs) and microfossils (calcareous nannoplankton, planktonic and benthic foraminifera, ostracods). The mosasaur specimen comes from this level. According to petrographical analysis, these sandstones correspond to greywacke, subgreywacke and litharenite. The Davutlar formation was deposited in a near-shore environment with sediment coming from a recycled obduction-collision orogenic provenance (Tunoğlu, 1993a, b; Tunoğlu and Temel, 1996).

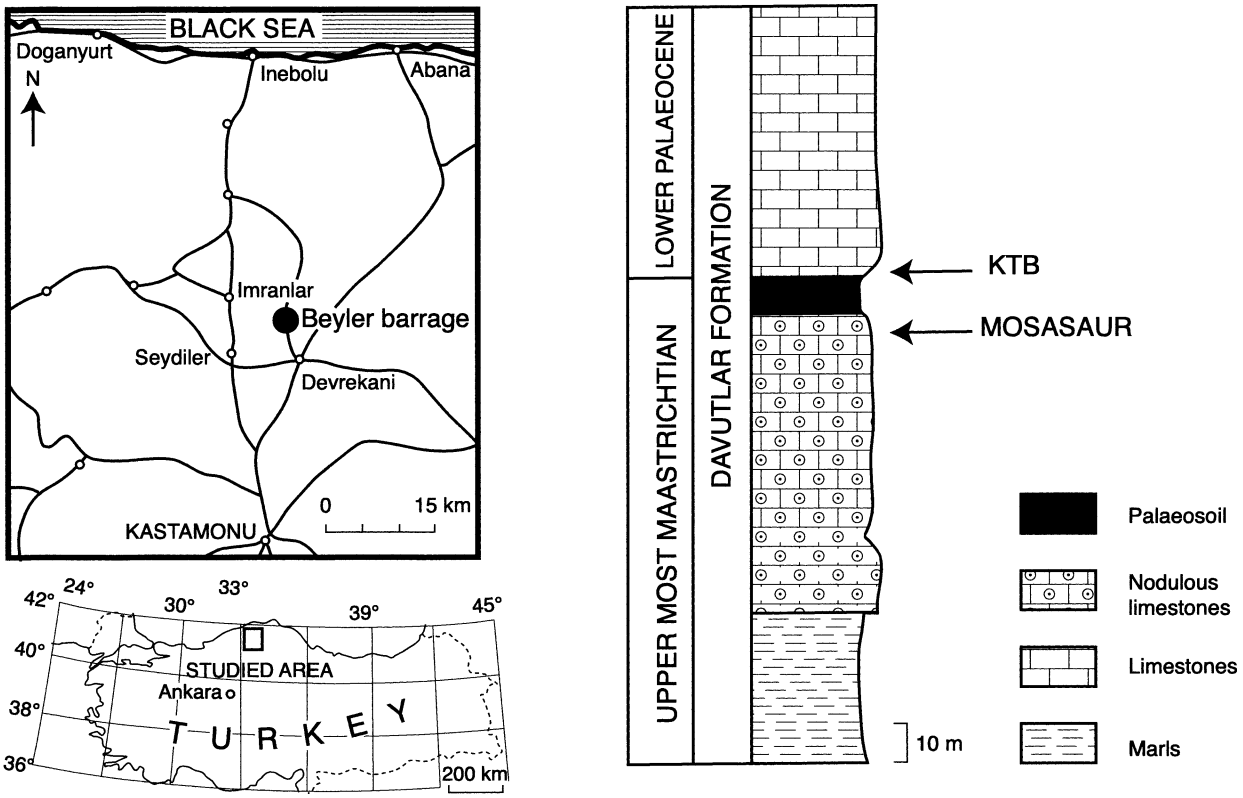

FIGURE 1. Geographical and stratigraphical settings of the mosasaur specimen.

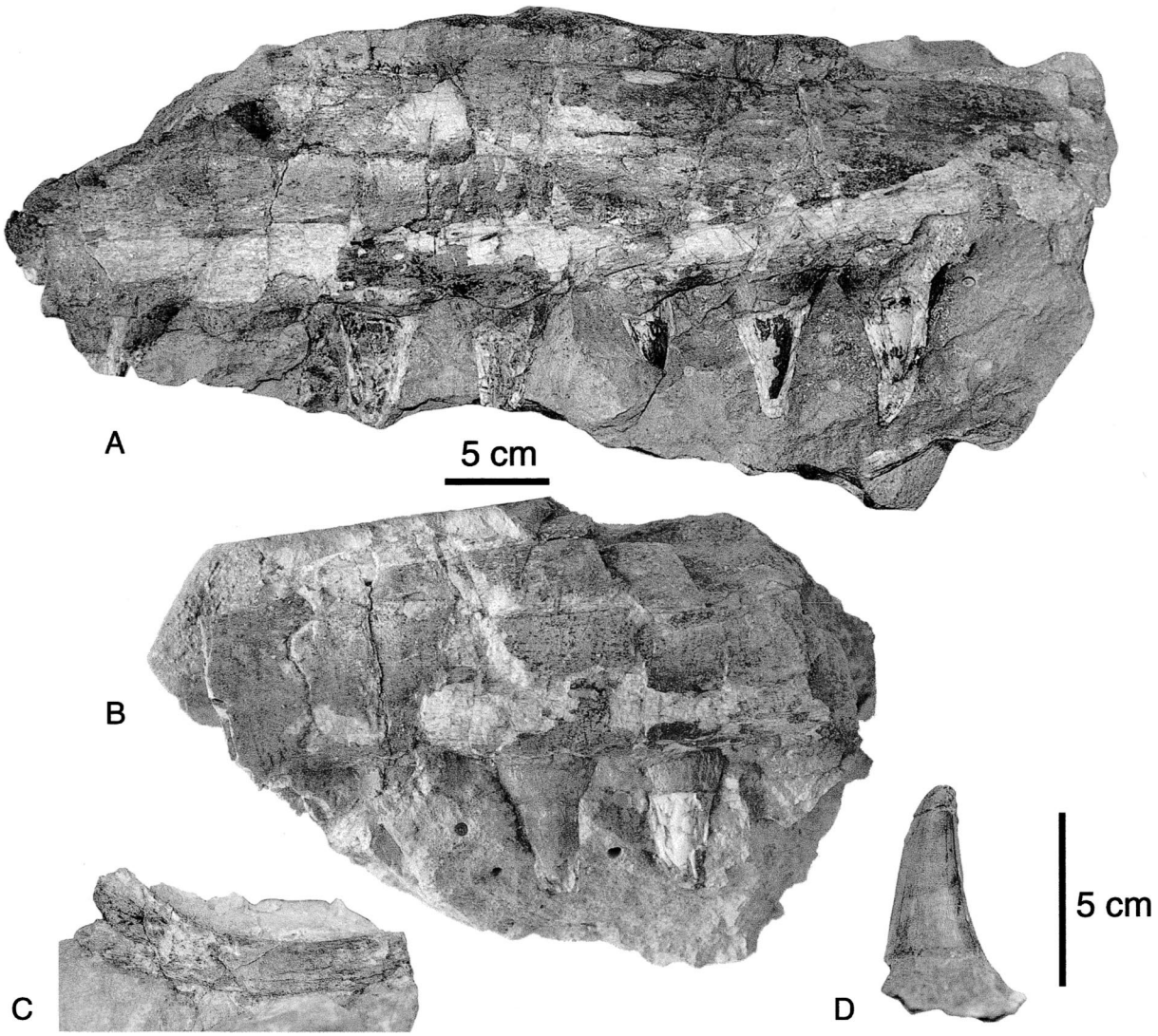

FIGURE 2. *Mosasaurus hoffmanni*, referred specimen, HU. JMB-0057-99 (Department of Geological Engineering, Hacettepe University, Ankara), Beyler dam, Devrekani Town/Kastamonu City area (northern Turkey), Davutlar Formation, latest Maastrichtian. **A**, right maxilla fragment in lateral view. **B**, left maxilla fragment in lateral view. **C**, left jugal fragment in medial view. **D**, dentary? marginal tooth in labial view (corresponds to print ''tp1'' in Fig. 3A).

SYSTEMATIC PALAEONTOLOGY

SQUAMATA Oppel, 1811
MOSASAUROIDEA Camp, 1923
MOSASAURIDAE Gervais, 1853
MOSASAURINAE Williston, 1897
MOSASAURUS Conybeare, 1822
MOSASAURUS HOFFMANNI Mantell, 1829

Referred Material—HU. JMB-0057-99, remains of a large skull, including two maxillary fragments (right and left) with teeth, a partial left jugal, several isolated teeth and indeterminate bones, probably from the palate, preserved in several blocks as part and counterpart. The specimen will be curated at the Museum of Natural History of the General Directorate of Mineral Research and Exploration of Ankara (Turkey).

Horizon and Locality—Beyler dam, Devrekani Town/Kastamonu City area, northern Turkey; Davutlar formation, latest Maastrichtian (Fig. 1).

Preservation—The remains are most probably part of a single individual because all the elements were found very close together and have comparable size. The very hard, fine-grained sandstone matrix does not show acid reaction. It has not been possible to extract the bones from the rock but some details have been prepared using an air scribe. Most of the surface of both the bones and teeth (enamel) have been damaged by fracturing of the blocks. However, it was possible to take Plaster of Paris casts of the labial tooth ornamentation from the counterpart slab.

Description—The largest and most complete jaw fragment is a 52 cm-long portion of the right maxilla (Figs. 2A, 3A). It bears nine large teeth or alveoli. The dorsal margin is emarginated for the nares; this emargination is slightly sinusoidal and was at least 25 cm long. Anterior to the naris, the maxilla strongly tapers to 5.8 cm high at its broken anterior end, indicating that only a small portion (about 10 cm and probably two teeth) is missing. Posteriorly, the bone widens progressively to reach a maximum height of about 13 cm. The surface of the bone is damaged so that the foraminal row, normally present in mosasaurs, and prefrontal contact are missing.

The second jaw fragment preserved is 29 cm long, 11.5 cm high at its widest point, and bears the remains of five teeth (Figs. 2B, 3B). Based on comparisons with the right maxilla, it appears to represent the posterior part of the left maxilla. The lateral surface bears five foramina (Fig. 3B).

A 14 cm section of the ventral horizontal ramus of the left jugal is preserved in medial view (Figs. 2C, 3C). It is located not far from its

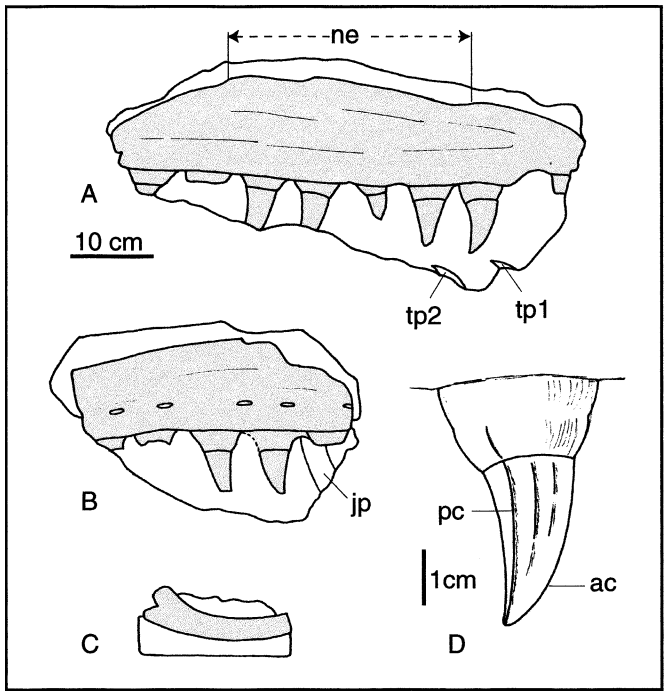

FIGURE 3. *Mosasaurus hoffmanni*, referred specimen, HU. JMB-0057-99 (Department of Geological Engineering, Hacettepe University, Ankara), Beyler dam, Devrekani Town/Kastamonu City area (northern Turkey), Davutlar Formation, latest Maastrichtian; **A**, right maxilla fragment in lateral view. **B**, left maxilla fragment in lateral view. **C**, left jugal fragment in medial view. **D**, labial ornamentation of the maxillary marginal tooth of the right maxilla just dorsal to tp1 in **A** obtained from counterslab. **Abbreviations**: **ac**, anterior carina; **ne**, narial emargination; **jg**, jugal print; **pc**, posterior carina; **tp1-2**, dentary? tooth prints (''tp1'' corresponds to the tooth of Fig. 2D).

natural anatomical position relative to the left maxilla. It is very robust and about 2.5–3 cm high. It possesses a very flat ventral margin and a slightly concave dorsal one. Neither the ascending ramus nor the posteroventral process is preserved.

The teeth are uniformly large (enamel crown about 5–6 cm high), tall, relatively slender, and slightly posteriorly recurved (Figs. 2D, 3D). They bear two carinae with minute serrations. The posterior carina moves from an antero-lateral position to a posterior one along the series, whereas the anterior carina is anteriorly located on the crown. The labial surface is only slightly convex whereas the most extensive lingual surface is very highly convex, producing in the tooth a 'U'-shaped cross-section. The labial surface of each tooth bears two or three prisms, according to the tooth. There are more prisms on the lingual surface but they are less distinct. The enamel exhibits minute striae giving it a silky aspect. Tooth bases are large and inflated.

Systematic Attribution—The great size and robustness of the specimens indicate that the animal was a very large mosasaur. Mosasaurid teeth are very informative and often permit assignment of isolated specimens to genera or even species (Russell, 1967; Debraga and Carroll, 1993). The 'U'-shaped cross-section of HU. JMB-0057-99 is characteristic of the genus *Mosasaurus* (Russell, 1967). The occurrence of a few (2–3) large prisms on the labial surface of the crown is a synapomorphy of *Mosasaurus hoffmanni* (Russell, 1967; Lingham-Soliar, 1995). Moreover, the silky aspect of the enamel of HU. JMB-0057-99 looks much like that preserved on the type specimen of *M. hoffmanni* (MNHN—AC 9648, Paris) and several referred specimens (i.e., IRSNB R 12, IRSNB R 25, IRSNB R 26).

The maxilla of the mosasaur from Turkey is estimated to have been about 70 cm long, indicating a total skull length of about 130 cm. This size enters the range expected for *M. hoffmanni*, being larger than MNHN-AC9648 (holotype) and IRSNB R12 (both with skulls about 100 cm long), comparable to IRSNB R26 (skull about 130 cm long) and smaller than NHMM 009002 (skull about 160 cm long). *M. hoffmanni*, with a maximum total body length estimated at more than 17 m (based on NHMM 009002), is currently regarded as the largest mosasaurid and one of the largest marine creatures of all times (Lingham-Soliar, 1995).

DISCUSSION

Paleobiogeographical Distribution—Until now, *M. hoffmanni* has been found predominantly in the Maastrichtian of The Netherlands (see Lingham-Soliar, 1995), but is also known from Belgium (Lingham-Soliar, 1995), Bulgaria (Tzankov, 1939), and Poland (Sulimski, 1968). Isolated teeth from the Maastrichtian of Niger and the Congo have been attributed tentatively to cf. *M. hoffmanni* (Lingham-Soliar, 1991, 1994) but their very poor preservation precludes specific identification.

Recently, Mulder (1999) suggested that *Mosasaurus maximus* Cope, 1869, from the Maastrichtian of New Jersey (USA), is a junior synonym of *Mosasaurus hoffmanni*. This has been previously suggested by Russell (1967) but rejected by Lingham-Soliar (1995). It implies that *M. hoffmanni* should be known from the Maastrichtian of Europe and North America. The discovery of *M. hoffmanni* in Turkey extends its paleobiogeographical occurrence to Western Asia.

New Jersey, North-Central Europe and Northern Turkey all lie on a paleolatitudinal belt about 30° N (see Camoin et al., 1993), suggesting that *M. hoffmanni* is restricted to this paleolatitudinal zone. Nicholls and Russell (1990) have shown that the distribution of Late Cretaceous vertebrate faunas of the Western Interior Sea is linked to paleolatitudinal gradients. A Northern Interior Subprovince is characterised by low faunal diversity and is dominated by plesiosaurs, hesperornithiform birds and the mosasaur *Platecarpus*. A Southern Interior Subprovince is defined by high faunal diversity and is dominated by sharks, turtles and the mosasaur *Clidastes*. An analogous faunal distribution pattern seems to apply to mosasaurid faunas from the Mediterranean Tethys. Indeed, mosasaur faunas from the northern margin (around 30° N) are different from their contemporaries in the southern margin (around 20° N–20° S), the former being dominated by *Mosasaurus*, *Hainosaurus*, *Plioplatecarpus* and *Carinodens*, the latter by *Prognathodon*, *Platecarpus* and *Globidens* (Bardet and Pereda Suberbiola, 1996; Bardet et al., 2000). In contrast, the faunas from the northern margin of the Mediterranean Tethys and those from New Jersey, located in the same paleolatitudinal belt, show close affinities (Mulder, 1999). The discovery of the first mosasaur from the Maastrichtian of Turkey supports the hypothesis of a distribution of Late Cretaceous mosasaurs linked to paleolatitudes (Bardet and Pereda Suberbiola, 1998).

Stratigraphical Distribution—With the exception of a specimen (IRSNB IG 8697) found in the Lower Maastrichtian Ciply Phosphatic Chalk of Belgium (Robaszynski and Christiansen, 1989), *M. hoffmanni* has been recovered exclusively from Upper Maastrichtian levels: the Navesink to basal Hornerstown formation of New Jersey (Gallagher, 1993), the Upper Gulpen and Maastricht formations of The Netherlands (Jagt et al., 1995), the Kayiaka formation of Bulgaria (Tzankov, 1939; Nikolov, pers. comm.), an unnamed formation in Poland (Sulimski, 1968), and now the Davutlar formation of Turkey. *M. hoffmanni* is thus one of the youngest mosasaurs found in the fossil record. Moreover, in Turkey, it has been recovered about 10–15 m below the KTB (cf. Fig. 1), so that the Turkish specimen is one of the youngest referred to this species.

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