The age and provenance of the *Globidens timorensis* holotype

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ABSTRACT

Three fossil teeth reported from the Upper Cretaceous of West Timor are the only known fossils of Mosasaurus-type marine reptiles in the eastern Tethys region. However, there is some uncertainty about the exact locality of origin of these fossils.

INTRODUCTION

During the last few million years of the Cretaceous, large marine reptiles of the globidensine mosasaurs group (Squamata: Mosasauridae) diversified to successfully exploit a wide range of niches in the marine ecosystem (e.g., Schulp, 2006; Polcyn et al., 2013). Although by Maastrichtian times the Globidensini reached a global distribution, the durophagous taxa within Globidensini (i.e. *Globidens* and *Carinodens*) so far have only been reported from the Tethyan-Atlantic realm and the Western Interior Seaway of North America (Polcyn et al., 2010; Mulder et al., 2013), with one single exception: the holotype lot of *Globidens timorensis* von Huene 1935, two tooth crowns reported from Timor, the easternmost Sunda Islands.

Since the description in 1935, no other occurrences of durophagous mosasaurs have been reported from outside the greater Atlantic-Tethyan realm (Figure 1). This renders this isolated occurrence at Timor somewhat puzzling. To make matters more complicated, the available details on the exact provenance and age of the *Globidens timorensis* holotype are rather ambiguous.

The recent publication of two new species of *Globidens* from Morocco and the United States (Bardet et al., 2005; Martin, 2007) and new material

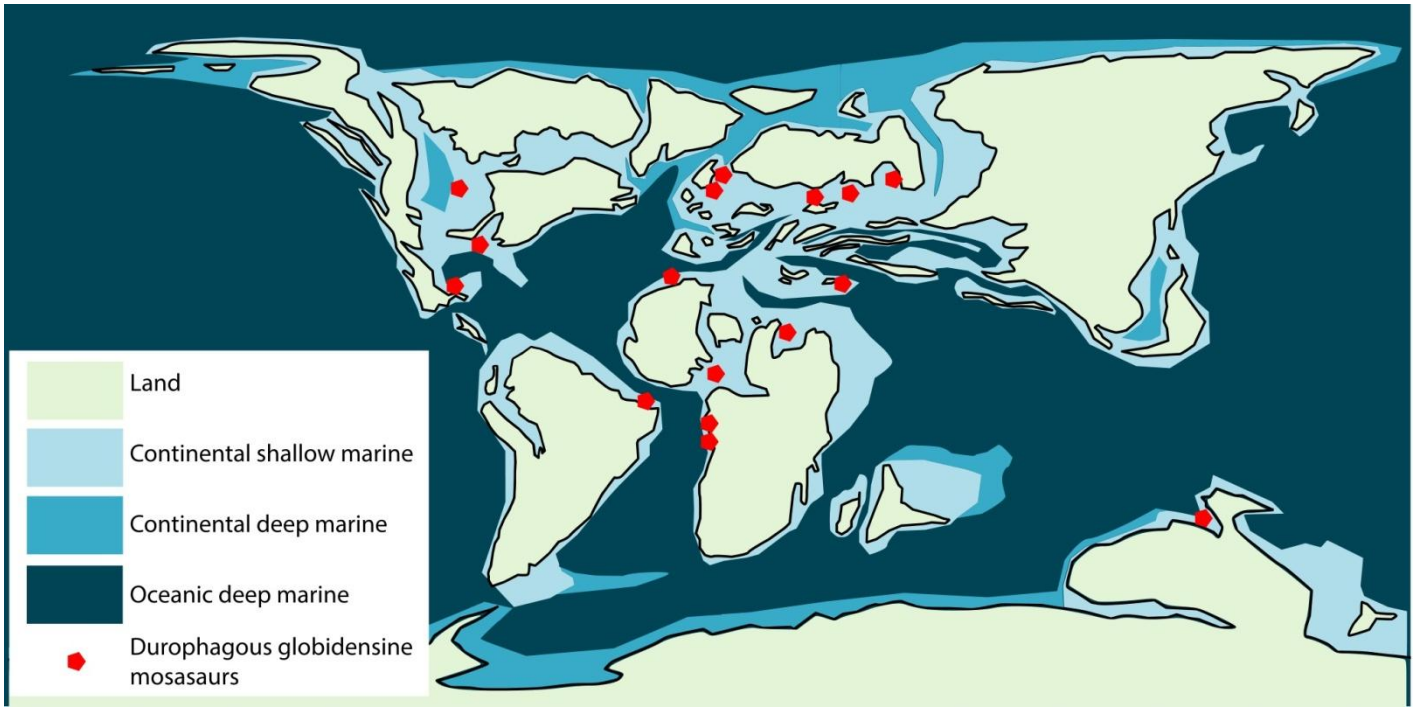


Figure 1 *.Generalized Late Cretaceous palaeogeographical map of worldwide durophagous globidensine mosasaur occurrences. Modified from Polcyn et al. (2010) and Mulder et al. (2013).*

from Angola (Polcyn et al., 2010) has greatly improved our understanding of the morphology, evolution and paleobiogeography of these durophagous mosasaurs. Considering the biogeographic importance of the occurrence in Timor, we here present a brief investigation into the collection history of the specimen, and a discussion of its age assignment.

HISTORICAL OVERVIEW

The holotype lot of *Globidens timorensis* von Huene (1935) is presently stored in the collections of Naturalis Biodiversity Center in Leiden, the Netherlands. Initially, the fossils were part of a larger collection which was split in two parts. One part went to the Technical University, Delft and the other to the Geological Institute, later Zoological Museum, of the University of Amsterdam. It remains unclear which part contained the *Globidens timorensis* fossils, but presumably it was the first, as the teeth were sent from Delft to Friedrich Von Huene.

The two holotype teeth are registered in the Naturalis collections as NBC-RGM 14690 and NBC-RGM 14691 (Figures 2A and 2B). The first author also noticed a third tooth in the same collection, resembling affinities to the holotype lot. Interestingly, this third tooth does *not* correspond to the additional tooth illustrated as Fig. 3 in Von Huene (1935) and also briefly mentioned in De Beaufort (1926). The third tooth is registered as NBC-RGM T6296 and illustrated here in Figure 2C.

Confusion exists as to the provenance of the holotype material. Two localities were mentioned by Von Huene (1935): "Oë Batok II" and "near Niki-Niki" (see Figure 3). Erika von Huene did not visit the sites herself; she received the two teeth (14690 and 14691) from her father, Friedrich von Huene, who in turn had received them from J.H.F. Umbgrove, who at the time was in charge of the fossil collection of the Technical University Delft . According to Umbgrove, the teeth were found in the vicinity of Baoen (also spelled Baung; it is near Oë Batok). Von Huene doubted this, as the Oë Batok locality is known as a locality with blocks of Late Triassic cephalopod limestones (Von Huene, 1935; p. 414): *"Es handelt sich dabei um einen Block von Karn. Nor. Trias mit Ammoniten,* Aulacoceras, Heterastridium, *die Ammoniten sind von Diener-Arthaber-Pachukas beschrieben und bestimmt. Von einem Vorkommen von Ober-kreide oder gar* Mosasaurus *an dieser Lokalität wird kein Wort gesagt. Dies ist auffallend und läßt an eine nachträgliche Fundortsverwachslung denken. Andererseits ist nach meiner Meinung nicht ausgeschlossen, daß in der Umgebung von Baung.. (Baoen)... ein gleiches Kreidevorkommen existiert, wie an der ca. 90. km NO gelegenen Lokalität Noil [sic!] Tobe."*

Nonetheless, the two teeth in the Dutch collection are described from "Baung", but a mix-up of localities could be involved. We believe that there is a distinct possibility that the two teeth came from the Noil Tobe site near Niki-Niki, 90 km North-East of Baoen, just like the third tooth in the initial description, which was at the time in the collection of Prof. Wanner in Bonn. At the Noil Tobe site, Lamnid sharks were found, suggesting a Cretaceous instead of Triassic age (Burck, 1923, p. 44 and De Beaufort, 1923). As circumstantial evidence, shark material as described by De Beaufort (1923) accompanies the *Globidens timorensis* holotype in the same drawer.

An attempt to reconstruct the provenance and collecting history of the *Globidens timorensis* holotype, requires retracing the footsteps of the expeditions in the area in Dutch colonial times. In the early 20th century three geological expeditions took place in West-Timor. The first two were partly simultaneous expeditions, a German-funded one led by J. Wanner (1911) and a Dutch-funded one led by G.A.F. Molengraaff (1910-1911). The focus of these expeditions was on the general geology of Timor (Molengraaff, 1918), but abundant fossil material was collected by both expeditions, all of which was then made available for studies to Wanner and co-workers, and results were published in 30 monographs in the voluminous series 'Palaeontologie von Timor' (1914-1928). No Cretaceous age fossils or sediments were mentioned in



Figure 2. *A-B Holotypes of Globidens timorensis teeth (A: NBC-RGM 14690; B: NBC-RGM 14691). C: Additional fragmentary tooth in holotype collection (NBC-RGM T6296).*

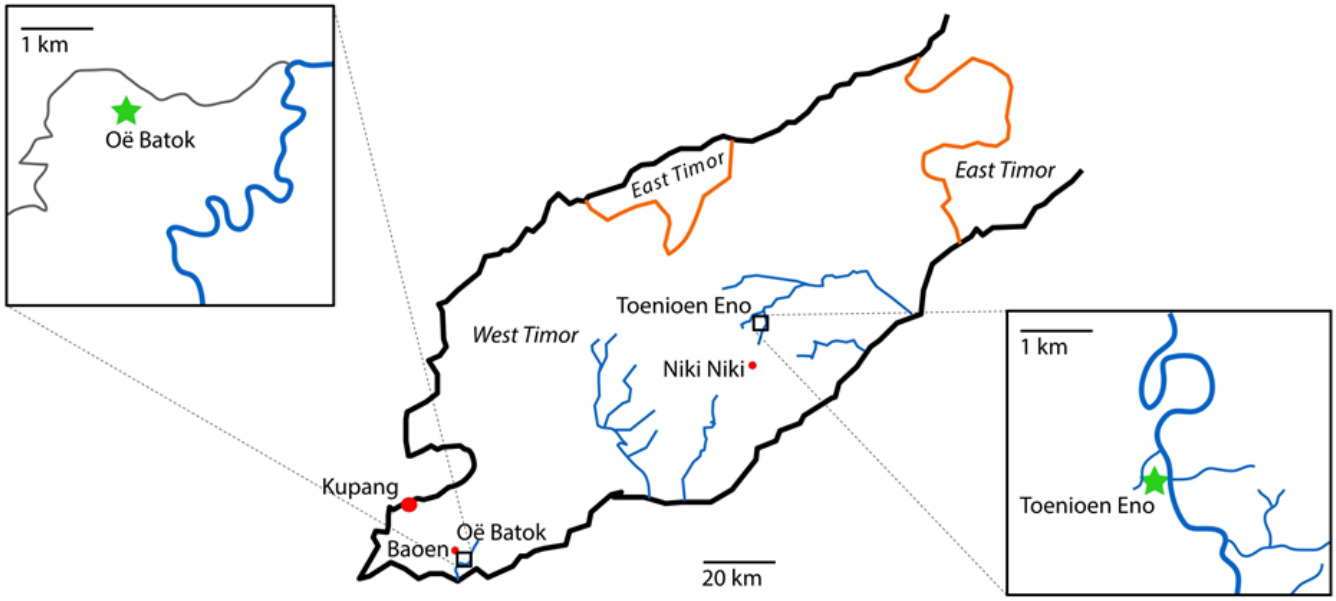


Figure 3. *Simplified map of west Timor, with the locations Oë Batok and Toenioen Eno. The Oë Batok area is-at the scale of the available geological maps- entirely mapped as Quarternary, but small blocks within the Quaternary could be of Mesozoic age. Toenioen Eno is part of the Miocene or Pliocene Bobonaro mélange complex, which contains blocks of older age.*

the Molengraaff (1918) journal.

A third Timor expedition ('2e Nederlandsche Timor-Expeditie') in 1916, led by geologists H.G. Jonker, H.D.M. Burck and L.J.C. Van Es, focused on collecting additional Permian and Triassic fossil material from sites already identified by the Molengraaff and Wanner expeditions (Burck, 1923). Numerous fossils were documented and collected from different locations, and it seems likely that the *Globidens* material was collected during this expedition, but there is no reference to the material in the journal of this expedition, even though the location Oë Batok was mentioned (Burck, 1923, p. 31-32): *"In this river, which, like Bihati, is a tributary of Noil Kasimoeti, three cephalopod blocks were found in close proximity of each other. Two of these blocks, Oë Batok I and II, were situated across one and another, leaving only a narrow passage to the water flowing in between them. Both blocks were cubic and have a similar content. The third block, Oë Batok III, was located not far downstream and from its appearance suggested a different fossil content (No samples were taken from this block). The first two blocks were unusually rich in fossils. Although only two blocks were sampled, the amount of fossils collected makes Oë Batok one of the richest localities".*

Although the characteristics of the two first blocks are not described, the fossil content is summarized: ammonites, Aulacoceratidae, belemnites and *Heterastridium,* an Upper Triassic hydrozoan (Burck, 1923, p. 32). The third block located slightly downstream had a different appearance; a limestone containing ammonites, Aviculidae molluscs (*Halobia* or *Daonella*), brachiopods and few crinoids and Aulacoceratidae (Burck, 1923, p. 32). However, there is no mention of fossil reptile teeth. All fossils present in the Oë Batok rocks are characteristically Triassic (e.g. McRoberts, 1997).

As the *Globidens* teeth in the holotype lot lack adhering sediment, there is no chance of obtaining an age determination through micropaleontological means. An age assignment therefore, has to be based on collection records or additional field work. An attempt to reconstruct or narrow down the provenance (and age) based on available maps proved difficult: Timor has a complex geological history with sediments ranging in age from Permian to Quaternary. These sediments were deformed during the collision between Australia and South East Asia (Audley-Charles, 1968 and many other papers).

According to the early-20th-century expedition journals, the fossil sites visited during the 1916 expedition are all located in Triassic (Oë Batok) or Permian sediments (Toenioen En(n)o). Van Es (1925) published a geological map of western Timor, most likely based on the information gathered by the three expeditions. Oë Batok is situated in the south-west of the island of Timor (Figure 2). According to the 1925 map, Upper Pliocene- Lower Pleistocene and Upper Triassic sediments are present at these locations. A more recent map compiled by the Indonesian Geological Survey (Suwitodirdjo et al., 1979) shows the same pattern. Oë Batok is within the Upper Pliocene - Lower Pleistocene Noelle Formation outcrops; Toenioen Eno within the Bobonaro mélange complex (Miocene- Pliocene; Charlton, 2009), the latter formation being a tectonic mélange of scaly clay containing large and small blocks of sediments of various age. The composition of these blocks ranges from metamorphic basement rocks to Mesozoic deep ocean sediments (Charlton, 2009).

DISCUSSION AND CONCLUSION

No other occurrences of durophagous globidensine mosasaurs have been reported from the region. Limited sampling in the area might partially account for this absence (e.g. Sato et al., 2012). Nonetheless, the absence of *Globidens* and closely related taxa in the Asian realm remains puzzling, for reasons outlined in Mulder et al. (2013). Even though the provenance of *G. timorensis* remains unclear, and -confusingly- accompanying Triassic fauna has been mentioned in association with this occurrence, the geological maps from 1925 and 1979 are not sufficiently detailed to rule out a Cretaceous age entirely. Jonker, based on the concordance of the layers, concluded the age of the Noil Tobé area to be Triassic, whereas Burck et al (1926) reported fossils of (Cretaceous) lamnid sharks from the same location, suggesting a more complex geological structure than previously assumed by Jonker. Although the holotype lot of *G. timorensis* is now retraced, and morphological comparison with the other species of *Globidens* is currently ongoing, no further historical records on the provenance of the fossils could be retraced at this time. Given the interesting paleobiogeographical as well as geological consequences of this potential occurrence of a durophagous mosasaur in Timor, a new research visit to the sites would be called for.

ACKNOWLEDGEMENTS

Dr. J. de Vos and Dr. H.J.M. Meijer retraced the *Globidens timorensis* holotype lot in the collections at Naturalis Biodiversity Center, Leiden, the Netherlands.

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