4th Triennial
International Mosasaur Meeting
May 20-25, 2013
Dallas, Texas

PROGRAM and ABSTRACTS

Michael J. Polcyn and Louis L. Jacobs, Editors

SMU | DEDMAN COLLEGE OF HUMANITIES & SCIENCES

ISEM AT SMU

SMU Shuler Museum of Paleontology

Dallas Paleontological Society

DEGOLYER · HIS BOOK · E.

Per[o]t Museum of Nature and Science

Host Committee: Michael J. Polcyn, Louis L. Jacobs, Diana P. Vineyard, Dale A. Winkler

4th Triennial
International Mosasaur Meeting
May 20-25, 2013
Dallas, Texas

Schedule of Meeting Events

Evening of May 19, 7:30 p.m. – Public lecture by Johan Lindgren

MOLECULAR PALEONTOLOGY – NOVEL APPROACHES TO ANCIENT ANIMALS.

Hosted by the Dallas Paleontological Society, held at the Ellison Miles Geotechnology Institute (EMGI) at Brookhaven College

Afternoon of May 20, 3:00 – 5:30 – Registration, Holiday Inn Dallas Central - Park Cities

Evening of May 20, 6:30 – 9:00 p.m. – Welcome reception, Perot Museum of Nature and Science

Morning of May 21, 8:00-9:30 – On-site registration, Room, 153 N.L. Heroy Science Hall, SMU

May 21, 22, and 23 – Presentations, 133 Fondren Science, SMU

May 21, 22, and 23 – Poster Sessions, 153 N.L. Heroy Science Hall, SMU

Evening of May 23 – Banquet, Holiday Inn Dallas Central - Park Cities, 6:30 – 9:00

May 24 and 25 – Field trip through the Upper Cretaceous of North Texas, depart from Holiday Inn Dallas Central - Park Cities, 8:00

Schedule of Talks
Tuesday, May 21

9:30 OPENING REMARKS – Louis L. Jacobs, President, ISEM at SMU

James E. Quick, Associate Vice President for Research and Dean of Graduate Studies, SMU

Session 1
Moderator: Louis L. Jacobs

10:00 TEXAS MOSASAURS — Michael J. Polcyn

10:30 MOSASAURID FAUNAS FROM THE MAASTRICHTIAN PHOSPHATES OF MOROCCO: SYSTEMATICS, PALAEOBIOGEOGRAPHY AND PALAEOECOLOGY — Nathalie Bardet, Alexandra Houssaye, Peggy Vincent, Xabier Pereda Suberbiola, and Mbarek Amaghzaz

11:00 BIOSTRATIGRAPHIC DISTRIBUTIONS OF ALABAMA MOSASAURS HIGHLIGHTING PATTERNS OF THE CRETACEOUS–PALEOGENE EXTINCTION IN THE GULF OF MEXICO —Takehito Ikejiri

11:30 GREENSAND MOSASAURS OF NEW JERSEY AND THE K/T BIOTIC TRANSITION OF MARINE VERTEBRATES — William B. Gallagher

12:00-1:00 Lunch – Heroy 153

PROJECTO PALEOANGOLA: A VIDEO PRESENTATION — Louis L. Jacobs
A short film by Kalunga Lima.

Session 2
Moderator: Mike Polcyn

1:00 CENOMANIAN-TURONIAN MOSASAUROIDS FROM THE BOHEMIAN CRETACEOUS BASIN — Benjamin P. Kear, Sven Sachs, Boris Ekrt, and Jahn J. Hornung

1:30 THE MEXICAN MOSASAUR FOSSIL RECORD: AN OVERVIEW — Valentina Zavaleta-Villarreal, Marisol Montellano-Ballesteros, and Jesús Alvarado-Ortega

2:00 AN UPDATED BIOSTRATIGRAPHY OF KANSAS MOSASAURS — Michael J. Everhart

2:30 Coffee Break – Heroy 153

Session 3
Moderator: Michael J. Everhart

3:00 THE MOSASAUR FAUNA OF ARKANSAS, USA — Kelly J. Irwin and Michael J. Polcyn

3:30 THE MOSASAURS OF ANGOLA: AN UPDATE — Michael J. Polcyn, Louis L. Jacobs, Anne Schulp, and Octavio Mateus

4:00 MOSASAUR DIVERSITY IN THE IZUMI GROUP OF THE SOUTHWEST JAPAN — Masahiro Tanimoto, Tetsuya Shinzyo, and Masahiro Sato

4:30 A LOWER TURONIAN MOSASAUR FROM THE TROPIC SHALE OF UTAH — Barry Albright, Michael J. Polcyn, and Allen Titus

5:00 ADJOURN

Wednesday May 22

Session 4
Moderator: Johan Lindgren

8:30 TOOTH HISTOLOGY OF PISCIVOROUS AND DUROPHAGOUS MOSASAURS: LIMITATIONS AND OPPORTUNITIES OF SQUAMATE TOOTH DEVELOPMENT — Rodrigo Pellegrini and Brian Beatty

9:00 MICROANATOMICAL AND HISTOLOGICAL FEATURES IN THE LONG BONES OF MOSASAURINE MOSASAURS: IMPLICATIONS FOR AQUATIC ADAPTATION AND GROWTH RATES — Alexandra Houssaye and Johan Lindgren

9:30 VERTEBRAL PATHOLOGY IN MOSASAURS — Bruce M. Rothschild & Michael J. Everhart

10:00 Coffee Break – Heroy 153

Session 5

Moderator: Alexandra Houssaye

10:30 MOSASAUR PREDATION ON TURTLES IN THE SMOKY HILL CHALK OF WESTERN KANSAS — Michael J. Everhart, Anthony Maltese, and Jacob Jet

11:00 THE PALEOBIOGEOGRAPHICAL EFFECTS OF THE PARIETAL FORAMEN ON MOSASAURS — Andy Connolly, Larry Martin, and Steven Hasiotis

11:30 EXTRAORDINARY FOSSILS: IMPLICATIONS FOR THE LIFE AND HABITS OF MOSASAURID REPTILES— Johan Lindgren

12:00-1:00 Lunch – Heroy 153

Lunch Speaker

NOTES ON THE HISTORY OF VERTEBRATE PALEONTOLOGY IN TEXAS FROM THE ARCHIVES OF THE DEGOLYER LIBRARY, SOUTHERN METHODIST UNIVERSITY — Louis L. Jacobs

A treasure of letters and art brings SMU close to Edward Drinker Cope, Jacob Boll, Robert T. Hill, and Charles R. Knight

SPECIAL EXHIBIT: DEGOLYER LIBRARY TREASURES OF PALEONTOLOGY — Texana Room, DeGolyer Library

Session 6
Moderator: Nathalie Bardet

1:00 A MOSASAUR FROM THE FOX HILLS FORMATION OF SOUTH DAKOTA, USA AND A REEVALUATION OF THE SYNONYMY OF *MOSASAURUS MAXIMUS* AND *MOSASAURUS HOFFMANNI* — Lynn T. Harrell, Jr.

1:30 THE AFFINITIES AND REASSIGNMENT OF *MOSASAURUS GRACILIS* — Hallie P. Street and Michael W. Caldwell

2:00 A NEW MOSASAURINE (SQUAMATA: MOSASAURIDAE) WITH LARGE FLIPPERS FROM THE LATEST CAMPANIAN HASEGAWA MUDDY SANDSTONE MEMBER OUTCROPPED IN WAKAYAMA PREFECTURE, WESTERN JAPAN: A PRELIMINARY REPORT — Takuya Konishi, Masaaki Ohara, Akihiro Misaki, and Hiroshige Matsuoka

2:30 Coffee Break – Heroy 153

Session 7
Moderator: Christopher Strganac

3:00 RARE EARTH ELEMENT (REE) ANALYSIS OF MOSASAUR FOSSILS FROM THE UPPER CRETACEOUS MARINE CARBONATE FORMATIONS OF WESTERN ALABAMA, USA — T. Lynn Harrell, Jr. and Alberto Perez-Huerta

3:30 δ^{13}C ISOTOPE SIGNAL IN MAASTRICHT MOSASAUR TOOTH ENAMEL — Anne S. Schulp, Hubert B. Vonhof, H. (Jeroen) J.L. van der Lubbe, Renée Janssen, and Remy R. van Baal

4:00 CHRONOSTRATIGRAPHY OF MARINE SEDIMENTS AT BENTIABA, ANGOLA, AND MOSASAUR NICHE PARTITIONING AT THE SOUTH ATLANTIC MARGIN — Christopher Strganac, Louis L. Jacobs, Michael J. Polcyn, Michael J., Kurt M. Ferguson, Octávio Mateus, and Anne S. Schulp

4:30 THE EVOLUTION OF MOSASAUR FEEDING ECOLOGY THROUGH THE LENS OF STABLE CARBON ISOTOPES — John A. Robbins, Michael J. Polcyn, and Johan Lindgren

5:00 ADJOURN

Thursday May 23

Session 8
Moderator: Anne Schulp

8:30 NEW HALISAURINE (MOSASAURIDAE: HALISAURINAE) MATERIAL FROM NORTHERN JAPAN — Takuya Konishi, Michael. W Caldwell, Tomohiro Nishimura, Kazuhiko Sakurai, and Kyo Tanoue,

9:00 THE RELATIONSHIPS OF ALABAMA HALISAURINE MOSASAURS — Michael J. Polcyn, James Lamb, Gorden Bell, Jr., Johan Lindgren, and Benjamin Kear

9:30 A BABY MOSASAUROID FROM THE TURONIAN OF MOROCCO - *TETHYSAURUS* "JUNIOR" DISCOVERED? — Alexandra Houssaye and Nathalie Bardet

10:00 Coffee Break – Heroy 153

Session 9
Moderator: Takuya Konishi

10:30 SOFT TISSUE REPLACEMENT STRUCTURES – A WINDOW TO THE BIOLOGY AND EVOLUTION OF MOSASAURS — Johan Lindgren, Michael J. Polcyn, Hani F. Kaddumi, Takuya Konishi, and Michael W. Caldwell

11:00 OUR EMERGING KNOWLEDGE OF *CARINODENS BELGICUS* — Anne S. Schulp, John W.M. Jagt, Michael J. Polcyn, Eric W.A. Mulder, Peter Formanoy, Hani F. Kaddumi, Johan Lindgren, and Femke Holwerda

11:30 *PROGNATHODON RAPAX* REVISITED — Gorden Bell, Jr., and Michael J. Polcyn

12:00 Lunch – Heroy 153

Lunch Speaker

CHASING GODZILLA, JAPAN'S FAVORITE SEA MONSTER - Dean William M. Tsutsui, Dedman College of Humanities and Sciences, SMU

Dean Tsutsui breathes fire into his examination of postwar Japan using this scaly pop icon.

Session 10
Moderator: Mike Polcyn

1:00 "CARLO", A NEW, *PROGNATHODON*-LIKE MOSASAUR FROM THE TYPE MAASTRICHTIAN — Anne S. Schulp and John W.M. Jagt

1:30 THE MORPHOLOGY AND TAXONOMY OF *CLIDASTES "MOOREVILLENSIS"* AND A CLOSELY RELATED FORM FROM THE CAMPANIAN GULF COAST OF NORTH AMERICA — Gorden Bell, Jr., Samuel W. Shannon, and Michael J. Polcyn

2:00 THE FOSSIL VERTEBRATES ASSOCIATED WITH MOSASAURS FROM SOME MEXICAN LOCALITIES — Héctor Gerardo Porras-Múzquiz and Jesús Alvarado-Ortega

2:30 A LATE CRETACEOUS MARINE REPTILE ON THE TETHYS SEA MARGINS (SOUTHERN NEGEV, ISRAEL), AND ITS PALAEOGEOGRAPHIC RECONSTRUCTION — Rivka Rabinovich, Hanan Ginat, Michael Schudack, Ulla Schudack, Sarit Ashckenazi-Polivoda, and Gideon Rogolsky

2:30 Coffee Break – Heroy 153

3:00-4:00 POSTER PRESENTATION SESSION (Heroy 153)

Session 11

Moderator: Dale Winkler

4:00 THE UPPER CRETACEOUS GEOLOGY OF NORTH TEXAS — Louis L. Jacobs and Michael J. Polcyn

4:15 TERRESTRIAL TETRAPOD FAUNA DURING THE LOWER TO UPPER CRETACEOUS TRANSITION IN NORTH-CENTRAL TEXAS — Dale A. Winkler, Timothy S. Myers, Anthony R. Fiorillo, and Ronald S. Tykoski

4:30 AN OVERVIEW OF FOSSIL TURTLES OF NORTH-CENTRAL TEXAS – Diana P. Vineyard

4:45 THE PLESIOSAURS OF NORTH TEXAS — Ricardo Araújo and Michael J. Polcyn

5:00 CLOSING REMARKS- ADJOURN

Posters
Tuesday May 21- Thursday May 23
Heroy Bldg 153

THE EFFECT OF SPECIMEN QUALITY ON THE EVOLUTION AND BIODIVERSITY OF THE MESOZOIC MARINE REPTILIA: MOSASAUROIDEA — Daniel Driscoll, Tom Stubbs, Alex Dunhill, and Michael Benton

DENTAL HISTOLOGY OF MOSASAURS AND A MARINE CROCODYLIAN FROM THE LOWER CAMPANIAN OF SOUTHERN SWEDEN — Johan A. Gren and Johan Lindgren

PUTATIVE GUT CONTENT OF A *MOSASAURUS* FROM THE CAMPANIAN OF ARKANSAS — Ellen Jönsson, Mats E. Eriksson, Johan Lindgren, Anders Lindskog, Michael J. Polcyn, and Kelly Irwin

OCCURRENCE OF A TYLOSAURINE MOSASAUR (*MOSASAURIDAE; RUSSELLOSAURINAE*) FROM THE TURONIAN OF CHIHUAHUA STATE, MEXICO — Abelaid Loera-Flores

4th Triennial
International Mosasaur Meeting
May 20-25, 2013
Dallas, Texas

ABSTRACTS
(Alphabetical by Surname)

A LOWER TURONIAN MOSASAUR FROM THE TROPIC SHALE OF UTAH

Barry L. Albright[1], Michael J. Polcyn[2], Alan L. Titus[3]

[1]Department of Physics, University of North Florida, 1 UNF Dr., Jacksonville, Forida 32224, USA; [2]Roy M. Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA; [3]Grand Staircase-Escalante National Monument, 669 S. Highway 89A, Kanab, Utah 84741, USA

Fieldwork and research conducted since 1999 in the Tropic Shale of southern Utah has greatly expanded our understanding of the vertebrate fauna that existed in the Cretaceous Western Interior Seaway during the early Turonian (≈93 Ma). In addition to several species of fish, there is a significant reptilian fauna that includes five species of short-necked plesiosaurs, three turtles, and the most complete specimen of a Late Cretaceous therizinosaurid dinosaur yet known from North America. Anomalously missing, however, have been the long-necked plesiosaurs (elasmosaurs) and mosasaurs. However, in 2012, a partial fragmentary mosasauroid skeleton was recovered by surface collecting and subsequent sieving of sediments. The specimen was found in the lower part of the Tropic Shale from between the informally named "C" and "D" bentonite horizons. This places the specimen within the lower portion of the *Mytiloides kossmati* biozone, probably within the *Vascoceras birchbyi* Ammonoid Biozone, indicating a middle Early Turonian age. This predates the occurrence of *Dallasaurus turneri* and *Russellosaurus coheni* from the middle Turonian of Texas by as much as a million years. Though badly weathered, the specimen is represented by a relatively large number of vertebrae and some skull fragments. Though somewhat broken, the premaxilla is broadly curved anteriorly, with no rostrum anterior to the base of the teeth as is also the case with the anterior

dentary. The development of the premaxilla appears to be more advanced than seen in *Tethysaurus* from the Lower Turonian of Morocco, in that the branches of the fifth cranial nerve are completely internalized and exit on the dorsal surface as a small number of large foramina, a condition shared with *Russellosaurus*. It shares articulated hemal arches with the slightly older basal mosasaur, *Vallecillosaurus*, from the Lower Turonian *P. flexuosum* Ammonoid Biozone of northeastern Mexico. However, that taxon does not include skull material for comparison. The vertebral morphology suggests russellosaurian affinities, and the cranial material displays characters shared with plioplatecarpine mosasaurs. The occurrence of derived mosasaurs in the Lower Turonian is consistent with previous predictions of the timing of radiations of mosasaur clades and this specimen represents the oldest occurrence of an advanced mosasaur in North America.

THE PLESIOSAURS OF NORTH TEXAS

Ricardo Araújo[1,2] and Michael J. Polcyn[1]

[1]Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas, USA; [2]Museu da Lourinhã, Rua João Luís de Moura, 95, 2530-158 Lourinhã, Portugal

North Texas is among the few places in the world to preserve a rock record that documents the Early to Late Cretaceous transition of marine amniotes. This is a critical period of diversification of plesiosaurs before their demise at the K-Pg boundary. In the mid-Cretaceous, Brachaucheninae, the last representatives of Pliosauridae, become extinct and the Xenopsaria radiates into two speciose clades: Leptocleididia (including Polycotylidae) and Elasmosauridae. The oldest record of a Texas plesiosaur has been ascribed to *Trinacromerum* sp. from the Late Albian, but unreported material now indicates the presence of a medium sized pliosaurid during that time. The most abundant record comes from the Cenomanian and Turonian. The Cenomanian record includes the pliosaurid *Brachauchenius,* and possibly a new species of elasmosaurid, the polycotylid *Trinacromerum,* and a new leptocleidid. From the Turonian of the Eagle Ford Formation comes one of the best elasmosaurid skulls known, that of *Libonectes morgani*, as well as a poorly known brachauchenine *Brachauchenius hudsoni.* The Coniacian through Maastrichtian record is poor, being exclusively composed of relatively fragmentary elasmosaurids and polycotylids.

MOSASAURID FAUNAS FROM THE MAASTRICHTIAN PHOSPHATES OF MOROCCO: SYSTEMATICS, PALAEOBIOGEOGRAPHY AND PALAEOECOLOGY

Nathalie Bardet[1], Alexandra Houssaye[2], Peggy Vincent[3], Xabier Pereda Suberbiola[4], Mbarek Amaghzaz[5]

[1]CNRS UMR 7207, Département Histoire de la Terre, Muséum National d'Histoire Naturelle, Paris, France ; [2]Steinmann Institut für Geologie, Paläontologie und Mineralogie, Universität Bonn, Germany; [3]Staatliches Museum für Naturkunde, Stuttgart, Germany; [4]Departamento Estratigrafía y Paleontología, Facultad de Ciencia y Tecnología, Universidad del País Vasco/EHU, Bilbao, Spain; [5]Office Chérifien des Phosphates, Centre minier de Khouribga, Morocco

The Late Cretaceous-Paleogene phosphates of Morocco are known worldwide for their richness in vertebrate fossil remains (Arambourg, 1952; Bardet et al., 2010). Mosasaurids are represented by at least 11 species and 7 genera. Mosasaurinae (*Mosasaurus*, *Prognathodon*, *Eremiasaurus*, *Globidens*, *Carinodens*) are predominant while halisauromorphs (*Halisaurus*) remain scarce. Russellosaurina remain also scarce (Plioplatecarpinae: "*Platecarpus*" *ptychodon*) or are apparently absent (Tylosaurinae). These mosasaurid faunas are typical of the southern Mediterranean Tethys margin and differ, at least at the specific level, from coeval faunas from the northern margin (Bardet, 2012). Palaeoecologically, these mosasaurid taxa exhibit specific tooth morphologies. Placing them into predator guilds - such as those defined by Massare (1987) - indicates adaptation for piercing, crushing or cutting and thus their prey preferences. The combination of this information with data referring to the gross morphology and to the degree of adaptation to a marine life reveals niche partitioning not only between these mosasaurid faunas, but also with the coeval marine reptiles and selachians in this epicontinental sea.

Arambourg, C. 1952. Les vertébrés fossiles des gisements de phosphates (Maroc-Algérie-Tunisie). Notes et Mémoires du Service Géologique du Maroc, 92: 1-372.

Bardet, N. 2012. Maastrichtian marine reptiles of the Mediterranean Tethys: a palaeobiogeographical approach. Bull. Soc. Geol. France, 183: 573-596.

Bardet, N., Pereda Suberbiola, X., Jouve, S., Bourdon, E., Vincent, P., Houssaye, A., Rage, J.-C., Jalil, N. E., Bouya, B., and Amaghzaz, M. 2010. Reptilian assemblages from the latest Cretaceous-Palaeogene phosphates of Morocco: from Arambourg to present time. Historical Biology, 22: 186-199.

Massare, J.A. 1987. Tooth morphology and prey preference of Mesozoic marine reptiles. Journal of Vertebrate Paleontology, 7: 121-137.

PROGNATHODON RAPAX REVISITED

Gorden Bell, Jr.[1], and Michael J. Polcyn[2]

[1]PO Box 38, Baker, Nevada 89311, USA; [2]Roy M. Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA

The materials assigned by O.P. Hay (1902) as the type of his new species, *Tylosaurus rapax*, consist of two incomplete right quadrates from the New Jersey greensands (AMNH 1490). Subsequently, the species was referred to Williston's (1879) genus *Brachysaurus*, but that name was preoccupied and a new genus, *Ancylocentrum* (Schmidt, 1927), was erected to contain both Williston's (1879) *B. overtoni* and Hay's (1902) *B. rapax*. Later, additional materials, including a good quadrate, were described by Chaffee (1939) as *A. hundgerfordi* and later referred by Russell (1967) to *Prognathodon rapax,* in which he also subsumed *Liodon validus* (Cope, 1869-1870) and *Macrosaurus laevis*, in part (Leidy, 1865). The type materials for *P. rapax* are no less confusing than its taxonomic history. Russell's (1967) diagnosis of *P. rapax* was limited to a "large tuberosity on anteromedian edge of quadrate shaft, suprastapedial process strongly constricted dorsally." We review the distribution of previously recognized quadrate characters for a number of *Prognathodon* species and closely related forms, concluding Russell's diagnosis for *P. rapax* may be applicable at a more inclusive level. Nonetheless, though similar in the diagnostic characters of Russell (1967), other details of the morphology of the two quadrates of Hay's (1902) type suggest it may include two different taxa, the large one sharing characters with *P. overtoni* and the smaller one with *Plesiotylosaurus.*

THE MORPHOLOGY AND TAXONOMY OF CLIDASTES "MOOREVILLENSIS" AND A CLOSELY RELATED FORM FROM THE CAMPANIAN GULF COAST OF NORTH AMERICA

Gorden Bell, Jr.[1], Samual Shannon[2], and Michael J. Polcyn[3]

[1]PO Box 38, Baker, NV 89311 USA; [2]134 Foxhall Road, Pike Road, Alabama 36064-3400, USA; [3]Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA

The first use of the name "*moorevillensis*" in mosasaur taxonomy was as a subspecies of *Clidastes liodontus* in an unpublished master's thesis (Shannon, 1975). Subsequent use of "*moorevillensis*" in various published works (e.g. Bell 1993; 1997; Bell and Polcyn, 2005; Polcyn and Bell, 2005) was at the species level, and used as an expediency to designate an operational taxonomic unit (OTU) for phylogenetic analyses, but without formal assignment of a type specimen, description, or figures, and *Clidastes moorevillensis* is thus currently considered a *nomen nudum* under ICZN rules. However, there are numerous

specimens known from the Mooreville Chalk of the Gulf Coast Cretaceous representing nearly all skeletal elements and supporting designation of a new taxon. It is easily differentiated from *C. liodontus* by its large adult size, distinctive frontal, and ontogenetic development of an infrastapedial process on the quadrate; and from *C. propython* by the lack of a triangular-shaped frontal. *C. propython* and *C.* "*moorevillensis*" commonly co-occur in the Cretaceous Gulf Coast of North America while the latter is rare in the Western Interior Seaway. There are younger specimens of *Clidastes* from the Gulf Coast Cretaceous that are distinct, but share some characters with *Clidastes "moorevillensis"* but appear to be taxonomically distinct.

THE PALEOBIOGEOGRAPHICAL EFFECTS OF THE PARIETAL FORAMEN IN MOSASAURS

A. Connolly[1,2], L.D. Martin[2], and S. Hasiotis[1]

[1]Geology Department, University of Kansas; [2]University of Kansas Natural History Museum and Biodiversity Institute, Lawrence, Kansas 66045, USA

Modern vertebrates living in high-latitude environments require a larger pineal gland or parietal foramen (PF) than vertebrates living in low-latitude environments. This correlation, however, may not apply to ancient PF-bearing vertebrates because the PF has rarely been researched. Mosasaurs (Squamata, Mosasauridae) are a group of extinct marine lizards that have a PF and lived worldwide during the Late Cretaceous. The global distribution of mosasaurs makes them ideal candidates for testing the biogeographical effects of the PF size. In order to test if the size of the PF in mosasaurs follows a latitudinal pattern—the higher the paleolatitude, the greater the diameter of the PF—the ratio of the length of the PF to the length of the parietal bone (PB) is used as a proxy for the diameter of the PF. This ratio can then be used to compare mosasaurs from different paleolatitudes with varying quality of preservation. The hypothesis to be tested is that the PF/PB increases as paleolatitude increases both among genera and within genera. The first test is to compare this ratio in specimens—averaged within the same genus—among different genera. The second test is to compare this ratio in specimens within the same genus of varying latitudinal distribution. Preliminary results based on current data are revealing. The first test did not support the prediction that the ratio of the PF/PB increased with increased paleolatitude. Mosasaurs bearing a large-diameter PF, such as *Platecarpus* and *Plioplatecarpus*, had a similar southern latitudinal distribution as mosasaurs, such as *Tylosaurus*, bearing a small-diameter PF. The second test did not support the prediction as specimens of high-latitude-dwelling mosasaurs (e.g., specimens of *Platecarpus* and *Plioplatecarpus*) had about the same PF/PB as their low-latitude-dwelling relatives. Results of the second test may indicate that individuals of *Platecarpus* and *Plioplatecarpus* lived in a diverse latitudinal habitat (i.e., cosmopolitan) and not in localized areas (i.e.,

endemic). This can be reflective on their modern analogs, the Cetaceans (whales), who also had a cosmopolitan distribution. There may also be a relationship between the size of the PF to the ability to dive deeply in mosasaurs. A large PF may be used in deep diving in mosasaurs to orient themselves at depth. This could be the reason why the supposed shallow dwelling *Clidastes* had a smaller PF compared to the supposed deep diver *Platecarpus*. More specimens need to be analyzed before a robust evaluation can be made for both tests.

THE EFFECT OF SPECIMEN QUALITY ON THE EVOLUTION AND BIODIVERSITY OF THE MESOZOIC MARINE REPTILIA: MOSASAUROIDEA

Daniel Driscoll[1], Tom Stubbs[1], Alex Dunhill[1], Michael Benton[1]

[1]*Department of Palaeobiology, School of Earth Sciences, University of Bristol, Bristol BS8 1RJ, United Kingdom*

Palaeontology has played a major part in the understanding of macroevolution as a driver of biological diversity on this planet. The diversity of marine reptiles through the Mesozoic has recently been a subject of interest and debate, with many dismissing the idea that the fossil record provides any useful record of past biodiversity. In contrast to previous results, this study demonstrates that Lagerstätten effects do not bias the record of marine reptiles in the Mesozoic, including mosasaurs. We also investigate fossil quality in mosasaurs using specimen completeness metric. Fossil quality through evolutionary time is examined, and compared with sea level and palaeobiodiversity.

AN UPDATED BIOSTRATIGRAPHY OF KANSAS MOSASAURS

Michael J. Everhart[1]

[1]*Sternberg Museum of Natural History, Fort Hays State University, Hays, Kansas 67601, USA*

Mosasaurs have been described from Kansas since Cope's brief oral description and naming of *Tylosaurus* (*Macrosaurus*) *proriger* at the June 1,1869, meeting of the Academy of Natural Sciences of Philadelphia. Cope's report was based on a specimen at Harvard obtained by Louis Agassiz in 1868 from near Monument Rocks in Gove County, Kansas. Cope's report also included the first stratigraphic reference to the occurrence of mosasaurs in Kansas; "…probably from the No. 3 of the Upper Cretaceous of Hayden." Since that time, thousands of mosasaur specimens have been collected from Kansas, most notably by Marsh's Yale Scientific Expeditions of the early 1870s, by collectors working for E.D. Cope, by

Charles H. and George F. Sternberg, and by S.W. Williston's field crews at the University of Kansas. These specimens were collected predominately from the Smoky Hill Chalk Member of the Niobrara Formation. Early records of locality and stratigraphic occurrence are suspect due to the lack of maps and limited knowledge of the geology of the Upper Cretaceous in Kansas, but the accuracy of this data has improved significantly over the years, especially since the early 1990s. Williston (1898) synonymized many of the early mosasaur names and was the first to discuss the stratigraphic occurrence of mosasaurs in the Smoky Hill Chalk, placing them in either the upper (*Hesperornis*) or lower (*Rudistes*) beds. Russell (1967) further refined the identification of species, but only described their occurrence in the upper and lower zones of the chalk. These beds or zones were generally undefined until a detailed description of stratigraphic marker units in the Smoky Hill Chalk was published by Hattin (1982). Stewart (1990) discussed the biostratigraphy of the chalk, including mosasaurs, by dividing it into six biostratigraphic zones, and utilizing Hattin's (1982) marker units. Schumacher (1993) and Sheldon (1996) further discussed the occurrence of Kansas mosasaurs within the Niobrara Formation. Everhart (2001) subsequently provided the first comprehensive report on mosasaur biostratigraphy in the Smoky Hill Chalk. Significant changes have occurred since 2001 in regard to the stratigraphic occurrence of mosasaurs in Kansas, including the description of two new species, the redescription of genera and species of *Platecarpus* dating back to the 1870s, and the collection of additional specimens, especially from below the Smoky Hill Chalk. A third, earlier occurring species of *Tylosaurus* from Kansas (*T. kansasensis*) was described by Everhart (2005); a second species of *Selmasaurus* (*S. johnsoni*) was reported by Polcyn and Everhart (2008); plioplatecarpines were redescribed by Konishi and Caldwell in a series of papers, including placing of *Platecarpus planifrons* into a new genus (*Plesioplatecarpus*; 2011), occurring only in the lower chalk; the earliest occurrence of *Tylosaurus* reported by Everhart (2005) from the underlying Fort Hays Member (early Coniacian) of the Niobrara Formation; and Polcyn et al. (2008) reported on Turonian mosasaurs from the Western Interior Seaway based on specimens from Kansas and Texas. In addition, two species previously unreported from Kansas, *Plioplatecarpus primaevus* (Everhart, pers. obs.) and *Globidens dakotensis* (Everhart, 2008) have been discovered in the overlying Sharon Springs Formation (Middle Campanian).

MOSASAUR PREDATION ON TURTLES IN THE SMOKY HILL CHALK OF WESTERN KANSAS

Michael J. Everhart[1], Anthony Maltese[2], Jacobs Jett[2]

[1]Sternberg Museum of Natural History, Fort Hays State University, Hays, Kansas 67601, USA; [2]Rocky Mountain Dinosaur Resource Center, Woodland Park, Colorado 80863, USA

Although Dollo (1887) wrote that "*Hainosaurus* undoubtedly fed upon marine turtles, because their remains have been found in its carcass," the specimens on which he based this comment have not been relocated. Few examples of this predatory behavior have been documented in the fossil record. Here we report on four turtle specimens which provide evidence of attacks by mosasaurs on turtles during the deposition of the Smoky Hill Chalk in western Kansas.

A new, mostly articulated specimen of *Protostega* cf. *P. gigas* (FHSM VP-17979) was collected from the middle Santonian Smoky Hill Chalk of eastern Gove County, Kansas in 2011. The turtle measured about 0.8 m across the carapace and would have been about 1.5 m long when alive. Preparation of the specimen at the Rocky Mountain Dinosaur Resource Center revealed damage consistent with an attack by a large mosasaur, most likely *Tylosaurus proriger*. Most of the left side of the turtle's skull is missing, the left humerus is severed at mid-shaft and the right front paddle missing at the elbow. In addition, the turtle exhibits nearly a hundred unhealed puncture wounds on the plastron and additional bite marks on the carapace. The large number bite marks, the damaged skull, and missing limbs indicate that the turtle was bitten several times during the attack and suggest that the mosasaur rotated the turtle in a attempt to swallow it. Failing that, the carcass was released and sank to where it settled right side up on the sea floor. There was no indication of further scavenging by sharks or other marine organisms. Coincidentally, remains of a 9 m *Tylosaurus proriger* (1.2 m skull) were discovered near the turtle locality in 1996. Although no connection is inferred between the two specimens, the mosasaur provides a contemporaneous example of the size of the largest marine predator living in the Western Interior Sea at the time. The collection of the Sternberg Museum of Natural History also contains the remains of a *Toxochelys latiremis* turtle (FHSM VP-700; carapace length about 50 cm) with multiple, circular bite marks consistent with an attack by a mosasaur (Konuki 2008). The turtle was badly damaged, but not consumed. Two additional *Toxochelys* specimens, one of which was discovered lodged in the throat of an adult mosasaur were discovered by field crews from Triebold Paleontology, Inc. The larger *Toxochelys* (RMDRC 08-003) displays partially healed circular puncture wounds across the carapace and the plastron, indicating a bite made with an elongate jaw and ruling out the predatory fish *Xiphactinus* as a suspect. Subsequent bone re-growth around these wounds indicates the turtle survived the initial attack for a period of weeks or months. The second specimen was a relatively complete but disarticulated juvenile *Toxochelys* with an estimated carapace length of 26 cm, discovered during preparation in the throat

region of a reasonably complete *Platecarpus planifrons* (RMDRC 10-015). The completeness and local concentration of the turtle remains, as well as the lack acid etching on the bones suggest that although the mosasaur had swallowed the turtle, it died before digesting it. The location of the remains within the carcass may indicate the turtle lodged in the mosasaur's throat, causing death by suffocation.

GREENSAND MOSASAURS OF NEW JERSEY AND THE K/T BIOTIC TRANSITION OF MARINE VERTEBRATES

William B. Gallagher [1]

[1]*Department of Geological, Environmental, and Marine Sciences, Rider University, Lawrenceville, New Jersey 08648, USA*

Comparative taphonomy of Late Cretaceous and Early Paleogene fossil deposits in the Atlantic Coastal Plain of New Jersey reveals patterns of preservation for vertebrate specimens (Gallagher, 2012). Campanian glauconitic marls yield isolated elements of mosasaurs and only the occasional multi-element specimen. The Maastrichtian Navesink and New Egypt Formations have yielded more of the mosasaur type specimens and multi-element remains known from these deposits (Gallagher et al., 2012). A widespread Ir excursion plus dinoflagellate biostratigraphy places the K/T boundary at the base of the Hornerstown Formation, in conjunction with a concentration of marine fossils. Stratigraphically, the highest mosasaurs known from the New Jersey Maastrichtian-Danian sequence come from the basal Hornerstown Formation, a nearly pure glauconite sand deposit that was mined extensively for fertilizer and water conditioner from the mid-nineteenth century until the present day. During the acme of marl mining in the late 19th century, the marl pits produced numerous vertebrate fossils including mosasaurs. Stratigraphic terminology for these specimens is often in the old miners' terms for the economically productive beds, and when this information is available for 19th century specimens it can be used to determine stratigraphic provenance. Most of the mosasaur specimens from this greensand deposit consist of single elements, such as vertebrae or teeth, but there are some multi-element specimens and at least one near complete skull from the Hornerstown Formation. This is YPM 773, consisting of some 32 skull bones and teeth. Associated with the specimen is a vial of greensand matrix that is unique to the Hornerstown Formation. The stratigraphic provenance of the specimen is given on its label as Middle Greensand, an old 19th century term for the Hornerstown Formation. The specimen is a large skull of *Mosasaurus hoffmanni* assigned to *M. maximus* on its label. The quadrate is 1/3 to ¼ larger than the holotype specimen of *M. hoffmanni*, and larger than the quadrates of NJSM 11052 and 11053 from the Inversand Pit. More recent discoveries of mosasaur material from the basal Hornerstown Formation greensand include ANSP 15679, a string of four caudal vertebrae, plus newly discovered brain

cases, and a jaw section with teeth. These are the highest and hence youngest mosasaur fossils from the Cretaceous sequence of New Jersey. Here, extinction of mosasaurs led to a trophic cascade in which smaller predators radiated and proliferated in shallow marine waters, including crocodylians (5 species in the Hornerstown Formation), and basal forms of modern selachians (*Paleocarcharodon*, *Otodus*). Sea turtles also proliferated in the wake of the mass extinction event. By the Eocene Epoch an Elvis taxon, *Basilosaurus*, appeared, an ecological analogue for large predaceous mosasaurs. In the modern Southern Ocean, whaling has reduced populations of large cetaceans and led to the proliferation of smaller predators in Antarctic waters. This localized event suggests how the paleoecological dynamics of larger mass extinctions may have functioned in world oceans.

DENTAL HISTOLOGY OF MOSASAURS AND A MARINE CROCODYLIAN FROM THE LOWER CAMPANIAN OF SOUTHERN SWEDEN

Johan A. Gren[1] and Johan Lindgren[1]

[1]*Department of Geology, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden*

Based on incremental line width measurements and growth line counts, we assessed dentine formation rates in three mosasaur taxa (*Dollosaurus* sp., cf. *Platecarpus* and *Tylosaurus ivoensis*) and one taxon of marine crocodylian (*Aigialosuchus* sp.), from the lower Campanian of southernmost Sweden. Two sets of periodic dentinal markings characterized by concentric, alternating opaque and transparent laminae were recognized: one set comprising thin striations situated 6–34 µm apart (depending on taxon) which is superimposed onto a second set of coarser bands where spaces vary between 102 and 275 µm. Because the size and morphology of the finer striations correspond to daily increments found in extant crocodylian dentine, we conclude that they are homologous structures (i.e., lines of von Ebner). Likewise, the coarser bands could correspond to Andresen lines of mammalian dentine. It is estimated that the deposition of dentine at the sectioned level of the tooth-crowns took 342 (cf. *Platecarpus*), 426 (*Dollosaurus* sp.), 487 (*T. ivoensis*), and 259 (*Aigialosuchus* sp.) days, respectively.

A MOSASAUR FROM THE FOX HILLS FORMATION OF SOUTH DAKOTA, USA AND A REEVALUATION OF THE SYNONYMY OF *MOSASAURUS MAXIMUS* AND *MOSASAURUS HOFFMANNI*

Lynn T. Harrell[1]

[1]*Department of Geological Sciences, University of Alabama, Tuscaloosa, Alabama 35487, USA*

In 1993 a mosasaur skull in concretion was recovered by Ms. Helen Ross from the channel of the Moreau River in Ziebach County, South Dakota. The skull was analyzed by the author using analog and digital instruments to determine its morphological characteristics. The specimen was concluded to be a mature individual of *Mosasaurus hoffmanni* based on this analysis and comparison with known material in museums across the Northern Hemisphere. In addition to being the first semi-articulated mosasaur fossil from the Trail City Member of the Fox Hills Formation, this specimen represents the first definitive occurrence of *M. hoffmanni* from the northern portion of the Western Interior Seaway and greatly extends its paleobiogeographic range. Diagnostic features of the new skull include: a tightly united palatal region, anterior marginal dentition with a D-shaped horizontal cross-section, finely serrated anterior and posterior carina of teeth, two to five facets on the labial surface of marginal dentition, fourteen maxillary teeth, narial opening originating dorsal to a point between the fifth and sixth maxillary teeth, two long posteriorly directed tongues from the frontal extending well beyond the pineal opening of the parietal, frontal excluded from the orbital margin, ascending process of jugal possessing a broad base, a C-shaped emargination on the anterolateral wing of the coronoid, and the surangular forming a buttress on the posterior margin of the ascending process of the coronoid. In Mulder (1999) the North American taxon *Mosasaurus maximus* was synonymized with the European *Mosasaurus hoffmanni* because of the similarity of their morphology. This synonymy was reevaluated and determined to be valid based on the examination of specimens from Western Europe and the United States. Morphological similarities include: premaxilla with prominent mid-dorsal ridge, form and number of the marginal dentition, maxilla with pronounced lateral bulge, external nares begin between 5th and 6th maxillary teeth, anterolateral and posteromedial projections of the frontal, jugal with broad base, quadrate shape, tightly united palatal unit, large anterolateral flange of coronoid and C-shaped notch. Minor differences noted were considered too insignificant to separate the species, or were deemed to be ontogenetic. Differences include: slender dentaries in some individuals, range of development of the C-shaped notch of the coronoid, and differences in the shape of the supratemporal fenestra.

Mulder, E. 1999. Transatlantic latest Cretaceous mosasaurs (Reptilia, Lacertilia) from the Maastrichtian type area and New Jersey. Netherlands Journal of Geosciences/Geologie en Mijnbouw, 78: 281-300.

RARE EARTH ELEMENT (REE) ANALYSIS OF MOSASAUR FOSSILS FROM THE UPPER CRETACEOUS MARINE CARBONATE FORMATIONS OF WESTERN ALABAMA, USA

Lynn T. Harrell, Jr.[1] and Alberto Pérez-Huerta[1]

[1]*Department of Geological Sciences, University of Alabama, Tuscaloosa, Alabama 35487, USA*

Previous research on habitat segregation of mosasaurs has been based on either lithology or faunal assemblages associated with fossil remains of mosasaurs. This approach has provided equivocal information and therefore, the preference of habitat by different mosasaur taxa is insufficiently constrained. The rare earth element (REE) content of vertebrate fossils has been used by previous researchers to determine taphonomic conditions, stratigraphic correlation, and paleoecology of the geologic formations in which the fossils are found. In the Upper Cretaceous marine formations of North America, these studies have focused on the primarily siliciclastic deposits of the northern Western Interior Seaway (WIS) of South Dakota and the Atlantic Coastal Plain (ACP) of New Jersey. Patrick *et al*. (2007) demonstrated that the REE profiles of mosasaur fossils from the Pierre Shale Group of South Dakota could be used to infer relative bathymetry at the time of deposition based on ratios of light to medium to heavy REE. The current study is focused on the analysis of the rare earth element content of mosasaur fossils from the Upper Cretaceous Selma Group and Eutaw Formation of western Alabama. Results of the REE analysis are used to infer the relative paleobathymetry associated with the mosasaur specimens to determine if certain taxonomic groups showed a preference for a particular water depth. Comparisons are made with mosasaur specimens reported in the literature from other regions of North America with different depositional environments to corroborate or refute the findings.

Patrick, D., Martin, J., Parris, D., Grandstaff, B. 2007b. Rare earth element (REE) analysis of fossil vertebrates from the Upper Cretaceous Pierre Shale Group for the purpose of paleobathymetric interpretations of the Western Interior Seaway, in Martin, J. and Parris, D. (eds.), The Geology and Paleontology of the Late Cretaceous Marine Deposits of the Dakotas. Geological Society of America Special Paper 427: 71-83.

A BABY MOSASAUROID FROM THE TURONIAN OF MOROCCO - *TETHYSAURUS* "JUNIOR" DISCOVERED?

Alexandra Houssaye[1] and Nathalie Bardet[2]

[1]Steinmann Institut für Geologie, Paläontologie und Mineralogie, Universität Bonn, Nussallee 8, 53115 Bonn, Germany. [2]UMR 7207 du CNRS, Département Histoire de la Terre, Muséum National d'Histoire Naturelle, C.P. 38, 8 rue Buffon, 75005 Paris, France

New mosasauroid remains were discovered all together in the same large sedimentary nodule that contained MNHN GOU3, a referred specimen of *Tethysaurus nopcsai* Bardet et al., 2003 (Bardet et al., 2003). This new material is from the Goulmima region, southern Morocco and dated from the Middle Turonian (Bardet et al., 2008). The bones consist of isolated and fragmentary cranial elements (skull and mandible) and some vertebrae. All have comparable size and there are no duplicates so that they could all belong to the same individual. Their tiny size highly suggest a juvenile condition, which is also supported by the histological analysis of two vertebrae. Indeed, cartilage occurs in the core of bone trabeculae deep into the centrum, unlike the adult condition where it is restricted to the condylar and cotylar surfaces. Although the cranial bones do not exhibit any diagnostic character within mosasauroids, the juvenile condition combined to the fact that they were all found associated with MNHN GOU 3, considered an adult individual, could indicate that they belong to a juvenile specimen of *Tethysaurus*. This inference is supported by the strong anterior projection of the zygosphene, a peculiar feature of *Tethysaurus*.

Bardet, N., Houssaye, A., Pereda Suberbiola, X., and Rage, J.C. 2008. The Cenomanian-Turonian (Late Cretaceous) radiation of marine squamates (Reptilia): The role of the Mediterranean Tethys. Bulletin de la Société Géologique de France, 179: 605-622.

Bardet, N., Pereda Suberbiola, X., and Jalil, N.-E. 2003. A new mosasauroid (Squamata) from the Late Cretaceous (Turonian) of Morocco. Comptes Rendus Palevol, 2: 607-616.

MICROANATOMICAL AND HISTOLOGICAL FEATURES IN THE LONG BONES OF MOSASAURINE MOSASAURS – IMPLICATIONS FOR AQUATIC ADAPTATION AND GROWTH RATES

Alexandra Houssaye[1] and Johan Lindgren[2]

[1]Steinmann Institut für Geologie, Paläontologie und Mineralogie, Universität Bonn, Nussallee 8, 53115 Bonn, Germany; [2]Department of Geology, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden

During their evolution in the Late Cretaceous, mosasauroids attained a worldwide distribution, notably via increase in body size and open ocean adaptations. This transition from landlubbing animals to fully-fledged leviathans is manifested not only at the gross anatomic level but is also readily apparent in their inner bone structure, which undergoes profound modifications. This contribution describes, both qualitatively and quantitatively, the microanatomical (i.e., inner organization) and histological (i.e., tissue) characteristics of pro- and epipodial bones in one lineage of mosasauroids; i.e., the subfamily Mosasaurinae. By using data from limb bones in combination with recent knowledge on the inner structure of ribs and vertebrae, and by making comparisons with extant squamates and semi-aquatic to fully marine amniotes, we discuss possible implications on mosasaurine evolution, aquatic adaptation, growth rates, and basic metabolic rates. Notably, the dominance of an unusual type of parallel-fibered bone, with large and randomly shaped cells (otherwise typical of fibrous bone) suggests growth rates and, by extension, basic metabolic rates intermediate between that of the extant leatherback turtle *Dermochelys* and those suggested for plesiosaurs and ichthyosaurs. Moreover, microanatomical features of the basal genus *Dallasaurus* differ from those of other, more derived mosasaurines, thereby illustrating the progressive adaptations of this lineage of mosasauroids to an open-marine life. The more complete image of the various microanatomical trends observed within mosasaurine mosasauroids supports the convergence between this lineage and cetaceans in the ecological transition from coastal to pelagic lifestyles.

BIOSTRATIGRAPHIC DISTRIBUTION OF ALABAMA MOSASAURS HIGHLIGHTING PATTERNS OF THE CRETACEOUS–PALEOGENE EXTINCTION IN THE GULF OF MEXICO

Takehito Ikejiri[1]

[1]*Department of Geological Sciences and Alabama Museum of Natural History, University of Alabama, Tuscaloosa, AL 35487*

Since the syntype of *Holcodus acutidens* (=*Platecarpus*?) was collected in 1851, a tremendous amount of mosasaur remains have been recovered from Alabama. A total of 1,543 specimens including nearly complete, articulated skeletons are currently housed at nine institutions. Of the specimens, at least 10 genera and 14 species are confirmed from Alabama (Ikejiri et al., in press): *Clidastes liodontus*, *Clidastes "moorevillensis"*, *Clidastes propython*, *Eonatator sternbergi*, *Globidens alabamaensis*, *Halisaurus*(?) sp., *Mosasaurus conodon*, *Mosasaurus maximus*, *Mosasaurus missouriensis*(?), *Platecarpus ictericus*(?), *Platecarpus somenensis*, *Platecarpus tympaniticus*, *Plioplatecarpus* sp., *Prognathodon* sp., *Selmasaurus russelli*, *Tylosaurus nepaeolicus*(?), and *Tylosaurus proriger*. Based on numbers of both taxa (genera and species) and specimens, the 1,543 mosasaur specimens allow investigating detailed stratigraphic occurrences in Alabama. Five Upper Cretaceous (the Early Santonian to the Late Maastrichtian) stratigraphic units are established: Unit 1 (the Eutaw Formation); Unit 2 (the Mooreville Chalk and the Blufftown formations); Unit 3 (the Demopolis Chalk Formation); Unit 4 (the Ripley Formation); and Unit 5 (the Prairie Bluff and the Providence Sand formations) (Ikejiri et al., in press). Among the five stratigraphic units, Unit 2 has the largest 'number of identified specimens' (NISP=1,211). Unit 1 has the second largest NISP (=131), and less than 100 NISPs recorded from Unit 3, Unit 5, and Unit 4. Ratios of NISP-to-area of surface geology of each unit (km^2) allow direct comparisons of relative mosasaur richness among the stratigraphic units. The highest concentration of mosasaur remains occurs in Unit 2 (the Mooreville Formation in particular). The least mosasaur abundant strata are those of Unit 4. Based on an NISP-based analysis, I interpret patterns of the mosasaur extinction by the end of the Cretaceous. Paleogeographically, Alabama was located in the northern margin of the Gulf of Mexico along the coastline of the southern Appalachia Landmass during the Late Cretaceous. If the Chicxulub asteroid impact is the main cause of mosasaur extinctions in the Cretaceous Gulf of Mexico, high values of NISP, indicating a relatively abundant fossil record, must be found in Unit 5 (Upper Maastrichtian). Those data, however, show no strong evidence of a sharp decline in the very upper Maastrichtian strata, but indicate a much earlier decline event(s) of mosasaur populations, which possibly started as early as the Middle Campanian (Unit 3 or 4). Therefore, the impact scenario can be rejected for the main cause, but other cause(s) likely played a main role for the mosasaur extinction in the Cretaceous Gulf of Mexico, such as plate tectonics and/or global sea-level changes.

Ikejiri, T., J. A. Ebersole, H. L. Blewitt, and S. M. Ebersole. In press. An overview of Late Cretaceous vertebrates from Alabama. Alabama Museum of Natural History Bulletin 31.

UPPER CRETACEOUS MARINE AMNIOTE-BEARING ROCKS OF THE EAST TEXAS BASIN

Louis L. Jacobs[1]

[1]Roy M. Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA

The East Texas Basin contains a remarkable record of marine life representing the last 30 million years of the Cretaceous. Structurally, the basin falls between two highs, the San Marcos Arch to the west and the Sabine Uplift to the east. These structural highs reflect older Appalachian trends incorporated in the Jurassic opening of the Gulf of Mexico. Additional subsidence was due to sediment loading and displacement of the underlying Luann Salt, which was deposited during the initial phases of formation of the Gulf of Mexico. Mobilization of the salt led to activation of faults forming the western margin of the East Texas Basin. High sea stands of the mid-Cretaceous caused by rapid sea floor spreading, including the opening of the South Atlantic Ocean, inundated the Gulf Coast region and led to completion of the North American Western Interior Seaway. The stratigraphic section, for purposes of this conference, begins in the Dallas-Fort Worth International Airport area with the mid-Cenomanian Woodbine Formation, unconformably overlain by the Cenomanian to Turonian Eagle Ford, separated by a hardground from the overlying Austin Chalk, which extends through the Santonian into lower Campanian. There is an 86 Ma radiometric date on a bentonite from the lower Austin and some generally imprecise $\delta^{13}C$ chemostratigraphic data, but otherwise time control currently derives from fossils. This section comprises the Gulf Series, the basal unit being the regressive Woodbine Formation composed of near shore partially emergent deltaic rocks with angiosperms and dinosaurs, including footprints, among other terrestrial indicators. The Eagle Ford initiates a classic marine transgression, followed by the Austin, and continued to the east by the superposed Campanian and Maastrichtian Taylor and Navarro marls and clays. These units, separated by unconformities, are 3rd order sequences ranging in duration from 2 my (Woodbine) to 12 my (Taylor). The section beginning with the Eagle Ford and continuing through the Navarro provides an excellent record of mosasaur evolution from about 92 Ma until the end of the Cretaceous.

CENOMANIAN-TURONIAN MOSASAUROIDS FROM THE BOHEMIAN CRETACEOUS BASIN

[1]Benjamin P. Kear, [2]Sven Sachs, [3] Boris Ekrt,
and [4]Jahn J. Hornung

[1]Palaeobiology Programme, Department of Earth Sciences, Uppsala University, Villavägen 16, SE-752 36 Uppsala, Sweden; [2]Im Hof 9, 51766 Engelskirchen, Germany; [3]Department of Paleontology, National Museum Prague, Václavské námestí 68, 115 79 Prague, Czech Republic; [4]Geowissenschaftliches Zentrum, Abteilung Geobiologie, Georg-August-Universität, Goldschmidtstraße 1-3, 37077 Göttingen, Germany

The Bohemian Cretaceous Basin (BCB) is an intracontinental depositional depression that extends from Brno in eastern Moravia, through Bohemia to the north and west of Prague, and across the Czech-German border into southern Saxony around Dresden. During the early Late Cretaceous, the BCB formed part of the continuous peri-Tethyan shelf of central and southern Europe, which was inundated by a northwesterly trending marine transgression extending between the Tethys Ocean and the Boreal North Sea Basin. Fossils of marine amniotes that inhabited this shallow epicontinental seaway have been documented for over 155 years, but have attracted little recent research attention in comparison to other more famous localities elsewhere. Despite this, a comprehensive reassessment of existing museum collections, together with new excavations, has identified a succession of diverse assemblages spanning the late Cenomanian through to Turonian-Coniacian boundary. Conspicuous amongst the remains are the isolated bones and teeth of primitive mosasauroids. The stratigraphically oldest of these specimens derive from the late Cenomanian Dölzschen Formation around Dresden in eastern Germany, and include small teeth and a bone fragment possibly representing the posterior condyle of a procoelous centrum. Unfortunately, only the indeterminate vertebral component is compatible with Mosasauroidea, the teeth probably being attributable to enchodontid teleosts. More clearly diagnostic are a partial dorsal vertebra, a well-preserved maxilla, and some isolated tooth crowns from early-late Turonian strata of the Bílá Hora, Jizera, and Teplice formations in the Bohemian region of the Czech Republic. The maxilla in particular displays a premaxillary contact that is situated anterior to the midline of the fourth maxillary tooth position, a characteristic trait of Tethysaurinae. The dorsal vertebra likewise manifests a tethysaurine-like dorsoventrally compressed, reniform condylar outline, but the articular face is sub-vertical thus resembling *Dallasaurus* and derived mosasaurines. The identification of potential tethysaurines in the BCB is consistent with the hypothesized distributional restriction of early mosasauroids to a mid-low palaeolatitude, warm-water belt during the Turonian. Moreover, their sympatric occurrence with some of the last plesiosaurian megacarnivores warrants further investigation, especially in the light of possible ecomorph replacement by advanced mosasauroids later in the Cretaceous.

A NEW HALISAURINE (MOSASAURIDAE: HALISAURINAE) MATERIAL FROM NORTHERN JAPAN

[1]Takuya Konishi, [1]Michael W. Caldwell, [1]Tomohiro Nishimura, [2]Kazuhiko Sakurai and [3]Kyo Tanoue

[1]Department of Biological Sciences, Biological Sciences Building, University of Alberta, Edmonton, Alberta, Canada T6G 2E9; [2]Hobetsu Museum, 80-6 Hobetsu, Mukawa-cho, Yufutsu-gun, Hokkaido 054-0211, Japan; [3]Fukuoka University, 8-19-1 Nanakuma, Jonan-ku, Fukuoka 814-0180, Japan

Until recently, remains of halisaurines had only been collected in North and South America, Europe, and Africa. We report here on the first occurrence of a halisaurine mosasaur from lowest Maastrichtian sediments outcropping near Hobetsu, Hokkaido, northern Japan. The new specimen is exquisitely preserved inside a calcareous concretion and consists of a large number of cranial elements, six of them in pairs, and several anterior vertebrae. The significance of the new material is at least threefold as follows: (1) it fills in an extensive paleobiogeographic gap for the Halisauruinae by extending the spatial range of the group to include the northwestern Pacific, a midway point latitude-wise within the gap, and establishes the global distribution during Maastrichtian within the Northern Hemisphere; (2) it presents a wealth of information on the cranial anatomy of halisaurines in exquisite detail, shedding new light on sub-familial interrelationships; and (3) the high paleo-latitude occurrence of the group in the Pacific, not unexpected based on discoveries in Europe, hints at the group's adaptability to a wide temperature tolerance. Qualitative character evaluation strongly suggests that the new Japanese specimen exhibits a mixture of characters between those displayed by *Halisaurus platyspondylus* and *Phosphorosaurus ortliebi*, casting some doubt on the generic distinction between the two as has been recently suggested. The Japanese material also confirms many cranial features that were previously unknown or known incompletely among members of the subfamily, which will no doubt help determine halisaurine synapomorphies with more accuracy in future phylogenetic analyses. One such character is an unusually elongate and stalk-like jugal process of the postorbitofrontal, where it projects more laterally than it does ventrally at about 30^{o} from the horizontal. When articulated with the jugal, the process comprises approximately 50% of the postorbital margin length, and the laterally directed projection of this process makes the orbit, which is enormous in the new specimen, face more dorsally, a character that is so far only equivocally suggested in the partially restored skull of the *Eonatator sternbergii* holotype.

Holmes, R. B., and Sues, H.-D. 2000. A partial skeleton of the basal mosasaur Halisaurus platyspondylus from the Severn Formation (Upper Cretaceous: Maastrichtian) of Maryland. Journal of Paleontology 74:309–316.

Lindgren, J., and Siverson, M. 2005. Halisaurus sternbergi, a small mosasaur with an intercontinental distribution. Journal of Paleontology 79:763–773.

Polcyn, M. J., Lindgren, J., Bardet, N., Cornelissen, D., Verding, L. and Schulp, A. S. 2012. Description of new specimens of Halisaurus arambourgi *Bardet and Pereda Suberbiola, 2005 and the relationships of Halisaurinae. Bulletin de la Société Géologique de France 183:123–136.*

A NEW MOSASAURINE (SQUAMATA: MOSASAURIDAE) WITH LARGE FLIPPERS FROM THE LATEST CAMPANIAN HASEGAWA MUDDY SANDSTONE MEMBER, WAKAYAMA PREFECTURE, WESTERN JAPAN: A PRELIMINARY REPORT

Takuya Konishi[1], Masaaki Ohara[2], Akihiro Misaki[3], and Hiroshige Matsuoka[4]

[1]Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada T6G 2E9; [2]Wakayama Prefectural Museum of Natural History, 370-1 Funo, Kainan-shi, Wakayama 642-0001, Japan; [3]Kitakyushu Museum of Natural History & Human History, 2-4-1 Higashida, Yahatahigashi-ku, Kitakyushu, Fukuoka 805-0071, Japan; [4]Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, Oiwake-cho, Kitashirakawa, Sakyo-ku, Kyoto 606-8502, Japan

Reported here is the first mosasaur specimen from Japan with both the front and hind flippers preserved as well as the skull. The specimen was discovered in 2006 from the upper Campanian portion of the Toyajo Formation, the Hasegawa Muddy Sandstone Member, exposed in Wakayama Prefecture, Western Japan. Due to the hard nature of the fossil-containing matrix and the large number of recovered elements, the preparation of the specimen is still ongoing but has so far revealed the following elements at least: mandibles, the posterior part of the skull including a partial braincase, several cervical and about 20 articulated dorsal vertebrae with ribs, shoulder girdle elements including a right scapula, and front and hind flippers. The co-occurrence of an ammonite *Pachydiscus awajiensis* assigns the latest Campanian age to the mosasaur with confidence. A high degree of ossification in appendicular bones and caudal centra with fused haemal arch-spine complexes identify the specimen as pertaining to the subfamily Mosasaurinae, which is congruent with the mosasaurine-dominant time period in which the specimen was found. Unexpectedly, most elements that comprise front and hind flippers are recovered in articulation, providing us with useful osteological information that helps us understand systematic placement of the new specimen. No known mosasaurine flippers are identical to those of the new specimen, but the closest resemblance is seen in front flippers of the Wakayama specimen and the holotype of *Mosasaurus hobetsuensis*, a mosasaurine from lowest Maastrichtian strata in Hokkaido, northern Japan. The two specimens share a robust pectoral crest and a reduced postglenoid process, a strong olecranon, an antero-posteriorly expanded antebrachial foramen, and

short, hourglass-shaped phalanges. Surprisingly, both the front and hind flippers of the new specimen, measuring at least 80 cm long, exceed the head length based on the gracile mandible with an estimated length of 80 cm. Marginal teeth are slender, posteromedially curved, smooth to weakly faceted or striated, circular in cross-section in general, and the crown height does not exceed 4 cm. Thus, it seems that the new mosasaurine exhibits disproportionately gracile jaws and teeth relative to its well-developed flippers. Interestingly, the only known marginal tooth for the holotype *M. hobetsuensis* is also slender in proportion.

Misaki, A., and H. Maeda. 2009. Lithostratigraphy and biostratigraphy of the Campanian-Maastrichtian Toyajo Formation in Wakayama, southwestern Japan. Cretaceous Research 30: 1398–1414.

Suzuki, S. 1985. Upper Cretaceous mosasaur remains from southern part of Central Hokkaido, Japan: A preliminary report. Bulletin of Hobetsu Museum 2: 31–42.

PUTATIVE GUT CONTENT OF A *MOSASAURUS* FROM THE CAMPANIAN OF ARKANSAS

Ellen Jönsson[1], Mats E. Eriksson[1], Johan Lindgren[1], Anders Lindskog[1], Michael J. Polcyn, and Kelly Irwin[3]

[1]Department of Geology, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden; [2]Roy M. Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA; [3]Arkansas Game and Fish Commission, 915 East Sevier Street, Benton, Arkansas 72015, USA

Ancient food webs and trophic structures are difficult to reconstruct but can provide intriguing insights into predator-prey relationships. Useful evidence of diet of extinct animals derives primarily from two sources of information; i.e., *in situ* gut contents (cololites) and fossil faeces (coprolites). Clearly, only the former can directly link fossil dietary matter to a specific host organism, whereas it is generally difficult to unambiguously associate coprolites with a specific producer. Putative gut content was discovered in association with a newly excavated specimen of *Mosasaurus* from the Upper Campanian part of the Marlbrook Marl in Arkansas. Underneath the ribcage were bone fragments that clearly do not belong to the animal itself. Their position and appearance suggest that they represent gut content. In addition to the pieces of bones, nodular specimens that might also belong to the gut content were found. Our knowledge of mosasaur diet and their digestive efficiency is still in its infancy, although the database is continuously growing.

A REVIEW OF THE MOSASAUR FAUNA OF ARKANSAS, USA

Kelly J. Irwin[1] and Michael J. Polcyn[2]

[1]Arkansas Game and Fish Commission, 915 East Sevier Street, Benton, Arkansas 72015, USA; [2]Roy M. Huffington Department of Earth Sciences, Southern Methodist University, 3225 Daniel Avenue, Dallas, Texas 75275, USA

Previous reports of mosasaurs from Arkansas include *Mosasaurus conodon* (Russell, 1967), *Prognathodon sp.* (Irwin, 2008)*, Platecarpus sp.* (Russell, 1967) and *Plioplatecarpus primaevus* (Irwin, 2008). Renewed prospecting and collection efforts in the Upper Cretaceous (Campanian – Maastrichtian) formations of southwestern Arkansas, USA, and searches of museum and university holdings, has produced several new taxonomic and stratigraphic records for the state. We confirm the identification of a mounted specimen at Southern Arkansas University as *Platecarpus* sp. (Russell, 1967), from the lower Campanian Brownstown Marl Formation. Additionally, two posterior trunk vertebrae recovered from the Brownstown Marl are identified as cf. *Clidastes* sp. The middle Campanian Ozan Formation has yielded a partial skull and vertebrae of *Clidastes propython,* the first occurrence of this taxon in Arkansas. A poorly preserved, large vertebral centrum from the basal Ozan Formation is most likely referable to *Tylosaurus*, a common taxon in the Ozan of Texas, where it is represented by *Tylosaurus proriger*. A new specimen of *Mosasaurus conodon* consisting of a large portion of the skull and postcranial skeleton, including limb and girdle material, from the upper Campanian Marlbrook Marl Formation confirms Russell's (1967) report of this taxon.. Prior reports (Irwin, 2008) of *Plioplatecarpus primaevus* from the upper Campanian Marlbrook Marl warrants reassessment of the species assignment due to newly recognized characters. We also report the first known Maastrichtian mosasaurs from Arkansas, from the Arkadelphia Marl and Saratoga Chalk, including cranial elements of *Mosasaurus* cf. *hoffmanni* and a single plioplatecarpine vertebra. The mosasaur fauna of Arkansas exhibits greater species diversity than previously recognized, and is beginning to yield specimens that promise to increase our knowledge of the morphology, systematics, temporal and biogeographic distribution of these magnificent Upper Cretaceous marine lizards.

EXTRAORDINARY FOSSILS – IMPLICATIONS FOR THE LIFE AND HABITS OF MOSASAUR REPTILES

Johan Lindgren[1]

[1]Department of Geology, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden

The fossil record is capable of exceptional preservation and occasionally labile and decay-prone tissues, such as skin and scales, are preserved as organic residues or phosphatized remains with a high degree of morphological fidelity. These rare findings yield information on features that are generally not available to the scientific community, and are thus important for our understanding of evolutionary patterns, modes of locomotion, the degree of adaptation, and the biology of extinct animals. In addition to soft-tissue replacement structures, the methodological advances and new tools of molecular biology and analytical biochemistry have provided access to another source of geobiologically relevant information; i.e., primary organic compounds associated with exceptionally preserved fossils. Examination of ancient biomolecules provides, among other things, an independent means of testing current phylogenetic hypotheses, thereby strengthening the objectivity of the field of paleontology. Here, I review current knowledge on soft tissue structures and primary biomolecules obtained from mosasaur fossils, and show how this novel information can be used to elucidate traits that contributed to an outstanding radiation of giant marine squamates during the Late Cretaceous.

SOFT TISSUE REPLACEMENT STRUCTURES: A WINDOW TO THE BIOLOGY AND EVOLUTION OF MOSASAURS

Johan Lindgren[1], Michael J. Polcyn[2], Hani F. Kaddumi[3], Takuya Konishi[4], and Michael W. Caldwell[4]

[1]Department of Geology, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden; [2]Roy M. Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA; [3]Eternal River Museum of Natural History, Amman, Jordan 11123; [4]Department of Biological Sciences, and Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada

Paleontology investigates the origin and evolution of the biosphere, and in order to do so, paleontologists rely on anatomical information from the fossilized hard-parts and soft-tissue replacement structures of extinct organisms. For instance, the recognition of phosphatized and calcified scales and partial body outlines in a group of extinct, secondarily aquatically adapted lizards, i.e., mosasaurs, has

provided unique insights into anatomical traits that presumably facilitated streamlining and energy-efficient swimming. These discoveries challenge the traditional view of these marine reptiles as serpentine creatures with slender bodies and elongate, dorsoventrally narrow tails that were capable only of generating short burst of speed during brief ambush pursuits. Furthermore, from this astonishing convergence in body form and caudal fluke morphology with other secondarily aquatic tetrapods, such as ichthyosaur reptiles and cetaceans, it is concluded that similar physiological and morphological responses have occurred in distantly related tetrapod clades to cope with comparable evolutionary constraints and selection pressures.

OCCURRENCE OF A TYLOSAURINE MOSASAUR (*MOSASAURIDAE; RUSSELLOSAURINA*) FROM THE TURONIAN OF CHIHUAHUA STATE, MEXICO

Abelaid Loera-Flores[1]

[1]*Dirección de Minerales Energéticos, Gerencia de Evaluación, Servicio Geológico Mexicano*

A new tylosaurine mosasaur specimen was discovered at San Antonio El Bravo, Ojinaga municipality, central east Chihuahua, Mexico. It was collected from the middle member of the Ojinaga Formation (Turonian), during field studies regarding natural gas generation in coal shales of the Late Cretaceous by the Dirección de Evaluación de MineralesEnergéticos del Servicio Geológico Mexicano. Comparative analysis of the specimen (SGM-M1) reveals features of the parafamily Russellosaurina; more specifically it shares a number of features with *Tylosaurus.* It has an elongate, conical, longirostrine “V” shape skull , a shield-like, broad frontal, 12 to 13 dentary and maxillary teeth, a similar premaxilla-maxilla suture, similar proportions of mandible and quadrate bone, and an elongate, rounded predental rostrum. The new material differs in proportion of the predental rostrum and appears to be shorter than either *T. proriger* or *T. nepaeolicus*. Additionally, the external nares begin at approximately the 4th maxillary tooth in *T. proriger* and *T. nepaeolicus*, but are more anterior in our specimen. Having poorly developed infrastapedial process of the quadrate, the eroded tympanic rim and suprastapedial processes, and internarial bar triangular in cross-section places the specimen close to *T. kansasensis.* A significant difference is the absence of a central ridge on the frontal; however, that may be due to erosion and preservation. Thus, anatomical features of SGM-M1 in comparison with other specimens shows it belongs to the taxon *Tylosaurus* Marsh 1872, with significant affinities with *Tylosaurus kansasensis* Everhart 2005.

Loera-Flores, A., 2013.Occurrence of a tylosaurine mosasaur (Mosasauridae; Russellosaurina) from the Turonian of Chihuahua State, Mexico. Boletín de la Sociedad Geológica Mexicana, Vol. 65, No. 1. (Online).

TOOTH HISTOLOGY OF PISCIVOROUS AND DUROPHAGOUS MOSASAURS: LIMITATIONS AND OPPORTUNITIES OF SQUAMATE TOOTH DEVELOPMENT

Rodrigo Pellegrini[1] and Brian Beatty[2]

[1]Bureau of Natural History, New Jersey State Museum, PO Box 530, Trenton, New Jersey 08625-0530, USA; [2]Dept. of Anatomy, New York College of Osteopathic Medicine, Northern Boulevard, P.O. Box 8000, Old Westbury, New York 11568, USA

In the 2011 ISPH symposium, we presented thin-sections of a pterygoid tooth of *Mosasaurus maximus* from the Cretaceous of New Jersey, along with thin-sections of a maxillary/dentary tooth of the same taxon and locality. The enamel-dentine junction (EDJ) was smooth in both teeth and enamel thickness varied only slightly. We also reported the presence of growth lines in the dentine of the pterygoid tooth, which we misidentified as Lines of von Ebner, and herein re-interpret as Andresen lines. Lines of von Ebner are present in the maxillary/dentary tooth. We now present sections of teeth of *Globidens cf. phosphaticus* from Morroco, which do not show Andresen lines, but show unmistakable lines of von Ebner in the dentine, as well as a puzzling funnel-shaped structure that we hypothesize to be related to the globular morphology of the tooth and its development. We use the von Ebner lines in the sectioned *Globidens* teeth to estimate the rate of replacement for this species, and compare it to those obtained by other authors (Gren, 2011; Chinsamy et. al, 2012) for different, non-durophagous mosasaur genera. Enamel thickness variation is more extreme in *G. cf. phosphaticus* than in *M. maximus*, most likely due to durophagy. Unlike in many archosauriforms, squamates appear to have tooth surface morphology (in this case, better described as texture) primarily due to enamel development rather than dentine development.

Chinsamy, A., Tunoglu, C., and Thomas, D.B. 2012. Dental microstructure and geochemistry of Mosasaurus hoffmanni (Squamata: Mosasauridae) from the Late Cretaceous of Turkey. Bulletin de la Société Géologique de France 2012 183 (2): 85-92.

Gren, J. 2011. Dental histology of Cretaceous mosasaurs (Reptilia, Squamata): incremental growth lines in dentine and implications for tooth replacement. Dissertations in Geology at Lund University, Master's thesis, no 288 (45 hp/ECTS credits). Department of Earth and Ecosystem Sciences, Division of Geology, Lund University. Available online at:

http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=2277896&fileOId=2277901

Pellegrini, R. and Beatty, B. 2011. Enamel and dentine histology of a mosasaur pterygoid tooth: Implications for development. In Köhler, M., Jordana, X., and Marín, N. (editors), First International Symposium on Paleohistology, 1: 79.

TEXAS MOSASAURS

Michael J. Polcyn[1]

[1]*Roy M. Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA*

The record of Texas mosasaurs and related forms is reviewed and along with new occurrences are reported in a chronostratigraphic framework. The last summary of Texas mosasaurs was that of Thurmond in 1969 and since that time, a number of new reports have corrected and expanded the record, which includes some of the oldest mosasaurs in North America. I report here new specimens of the dolichichosaurid taxon *Coniasaurus,* ranging in age from the middle Cenomanian to the upper part of the Middle Turonian. The new material includes partial skeletons and numerous isolated cranial and vertebral elements. From the lower Middle Turonian, we report a new specimen of *Dallasaurus,* which includes portions of the skull, confirming its mosasaurine affinities, but also demonstrating the relatively primitive nature of the taxon. Other Turonian taxa, represented by partial skulls, demonstrate plioplatecarpine and tylosaurine affinities. Material from the Coniacian though Lower Campanian Austin Chalk contains an assemblage comparable to that of the Western Interior Seaway. Of particular note is an exceptionally well-preserved skull of a relatively derived *Platecarpus* from the basal Coniacian. In addition to *Tylosaurus proriger* and *Platecarpus willistoni,* which are relatively common in the Middle Campanian Ozan Formation, I report new material of *Globidens alabamaensis* and a relatively derived species of *Clidastes* and *Mosasaurus conodon* is reported from the contemporaneous Wolf City Sand. A new specimen of *Prognathodon overtoni* is reported from Upper Campanian Marlbrook Marl, which also contains fragmentary specimens of *Plioplatecarpus* and *Tylosaurus. Mosasaurs conodon* is found in the Lower Maastrichtian Neylandville Marl. The Texas record is unique in its long temporal range and geographical setting between the southern Gulf Coast and the Western Interior Seaway.

THE MOSASAURS OF ANGOLA: AN UPDATE

Michael J.Polcyn[1], Louis L. Jacobs[1], Anne S.Schulp[2], Octávio Mateus[3]

[1]Roy M Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA; [2]CICEGe, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal; [3]Natuurhistorisch Museum Maastricht, De Bosquetplein 6/7, NL-6211KJ Maastricht, The Netherlands

Active fieldwork by Projecto PaleoAngola has greatly expanded the fossil marine amniote record for the South Atlantic coast of West Africa. We review the published mosasaur record and present new data on a number of recent discoveries. Three mosasaur taxa are known from Iembe: *Angolasaurus bocagei*, *Tylosaurus iembeensis*, and a new small mosasaur with affinities to Halisaurinae. The former two species are considered to be Turonian in age, but the latter is likely Santonian in age. Previously reported taxa from the Campanian-Maastrichtian sediments near Bentiaba includes *Mosasaurus cf. hoffmanni*, *Prognathodon kianda*, *Prognathodon cf. saturator, Globidens phosphaticus, Carinodens sp., Halisaurus sp. Phosphorosaurus sp., and Platecarpus ptychodon.* We report here new data on a remarkably complete, semi-articulated skeleton of *Prognathodon kianda,* which contains gut contents including portions of three other mosasaurs. One of the three is readily identifiable as *"Platecarpus" ptychodon* and another may represent a new species or possibly a juvenile of the genus *Mosasaurus*. In addition, a mass of bones found isolated contains portions of at least three individuals of a new species of *Halisaurus* and a subadult *Prognathodon kianda*. Taphonomic modification of the bone and teeth indicates this too is gut content, but its isolated nature suggests it may have been disgorged. New specimens of *"Platecarpus" ptychodon* elucidate the morphology of this taxon. Although we previously reported *P. cf. saturator* from Angola, recently discovered material indicates it in fact represents a new species of *Prognathodon*. The rich marine amniote fauna of coastal Angola is the result of upwelling-driven productivity. Taphonomic evidence suggests current driven concentrations of carcasses, as is seen today along the Skeleton Coast, and in some cases such as the Bentiaba locality, occur in a relatively restricted environment. This unique setting provides a temporally restricted and taxonomically diverse sample, giving us an emerging picture of prey-predator and prey-scavenger interactions in the Late Cretaceous of the South Atlantic.

THE RELATIONSHIPS OF ALABAMA HALISAURINE MOSASAURS

Michael J. Polcyn[1], James Lamb[2], Gorden Bell, Jr.[3], Johan Lindgren[4], Benjamin Kear[5]

[1]Roy M. Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA; [2]Black Belt Museum, West Alabama University, Station 45 Livingston, AL 35470, USA; [3] P.O. Box 38, Baker, NV 89311, U S A; [4]Department of Geology, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden; [5]Palaeobiology Programme, Department of Earth Sciences, Uppsala University, Villavägen 16, SE-752 36 Uppsala, Sweden

New and previously undescribed specimens of *Eonatator* from Alabama are reported. Other fossils initially referred to *Eonatator sternbergii* (Wiman, 1921) by Russell (1967, 1970), are also reviewed. Digital X-radiographs of the holotype skeleton of *Eonatator sternbergii*, housed in the Museum of Evolution at Uppsala University, Sweden, are presented to assess the extent of restoration and reveal obscured morphology. New remains from Alabama include an immature individual that includes a significant portion of the skull, especially a well preserved parietal and quadrate, which complement specimens previously assessed by Bell (1993, 1997). Taken together, this revised data set permits a more complete understanding of the morphology of *Eonatator* and elucidates relationships within Halisaurinae. The Alabama *Eonatator* material is found to be the sister taxon of *Eonatator sternbergi??*, but differs in the relative development of the posteromedial process of the parietal, position of the pineal foramen, and path of the articular-surangular suture in lateral aspect. The type material of *Tylosaurus zangerli* (Russell, 1970), also from Alabama, consists of only a humerus and femur that compare closely to those elements in the type of *E. sternbergi* and should be referred to that genus. Geographic and temporal sympatry suggest that *E. zangerli* and the other Alabama specimens of *Eonatator* are probably conspecific. However, we prefer not to assign the remaining Alabama *Eonatator* material to that species without clear evidence from specimens possessing both limb and cranial elements. The specimen USNM 3777 from Kansas, previously referred to *Eonatator sternbergii* (Russell, 1967), although clearly a halisaurine, does not support referral to the genus *Eonatator.*

THE FOSSIL VERTEBRATES ASSOCIATED WITH MOSASAURS FROM SOME MEXICAN LOCALITIES

Héctor Gerardo Porras-Múzquiz[1] and Jesús Alvarado-Ortega[2]

[1]Museo Histórico de Múzquiz, Ayuntamiento de Múzquiz, Hidalgo Norte 205, Múzquiz, Coahuila, 26340, México; [2]Departamento de Paleonotlogía, Instituto de Geología, Universidad Nacional Autónoma de México, Circuito de la investigación s/n, Ciudad Universitaria, Delegación Coyoacán, D.F. 04510, México.

The fossil record of mosasaurs in Mexico is scarce and has been little studied. The aim of present contribution is to provide a better picture of macro-faunal communities of which these marine reptiles were a part, mainly from unpublished localities within the Muzquiz area, Coahuila State, and San José de Gracia, Puebla State, northern and central Mexico respectively. In Coahuila, around Muzquiz Municipality, mosasaurs have been collected commercial quarries, specifically Los Temporales, Piedritas, El Pilote, El Rosario, and La Mula, where flat and fossiliferous marl of Cenomanian-Santonian age are extracted. These sites bear remains of a rich and diverse marine fauna including ammonites, bivalves, crabs, as well as chondrichthyes (*Squalicorax*, *Cretoxyrhina*, *Cretolamna*, *Ptychodus*, among others), Osteichthyes (Pycnodontiformes, Asidorynchiformes, Ichthyodectiformes, Pachyrhizodontidae, Tselfatiiformes, Enchodontidae, Aspidopleuridae, Acanthomorpha, Clupeiformes, among others), and other vertebrates (turtles, plesiosaurs, and birds). San José de Gracia quarry is a recently discovered locality, near to the town of Molcaxac, Puebla. In this site are flat marls that bear scarce but interesting Turonian marine fossils. Ammonites and oysters are best represented, along with *Squalicorax*, Enchodontidae, Salmoniformes, Aulopifromes and Ichthyodectiformes.

LATE CRETACEOUS MARINE REPTILE ON THE TETHYS SEA MARGINS (SOUTHERN NEGEV, ISRAEL), AND ITS PALAEOGEOGRAPHIC RECONSTRUCTION

Rivka Rabinovich[1], Hanan Ginat[2], Mjchael Schudack[3], Ulla Schudack[3], Sarit Ashckenazi-Polivoda[2], Gideon Rogolsky[2]

[1]National Natural History Collections, Institute of Earth Sciences, Institute of Archaeology, The Hebrew University of Jerusalem, Berman Building, Edmond J. Safra campus, Givat Ram, Jerusalem 91904, Israel; [2]The Dead Sea and Arava Science Center, Tamar regional council, Dead-Sea mobile post 86910, Israel; [3]Fachrichtung Palaeontologie, Institut fuer Geologische Wissenschaften, Freie Universitaet Berlin, Malteserstrasse 74-100, Haus D, D-12249 Berlin, Germany

Recent research into the Late Cretaceous of the southern Negev (Israel, Santonian, Menuha formation) reveals several unconformities in the formation, spatial changes in lithofacies, agglomeration of carbonate concretions and other nodules, in localities of various settings. In addition, localities rich in microfossils and with few marine reptiles were identified. A multidisciplinary approach is crucial in order to reconstruct the regional palaeogeography along the ancient shoreline of the Tethys Sea, and explain the environmental conditions under which the various sedimentological formations and fauna existed. Parts of a plesiosaur skeleton were found in a locality (site 20) where the rock included laminated bio-micritic limestone, rich in mud and some marl. Several layers are made of carbonate mud of fine silt size particles. The laminae are very thin, and mostly continuous. The sediments are rich with microfossils – foraminifera and ostracods – that were preserved in the carbonate mud. Indicative planktic foraminifera species (e.g., *Dicarinella asymetrica*, *D. concavata*, *Sigalia decoratissima carpatica*) are present, as well as species indicative of opportunistic life strategy typical of the upwelling system in the region (Ashckenazi-Polivoda et al., 2011). Marine ostracods (e.g., *Brachycythere angulata*, *Cythereis rosenfeldi evoluta*), and many echinoid spines suggest open marine environment.The *in situ* distribution of the plesiosaur will be examined in light of the above and compared with evidence from the adjacent area (Bardet and Suberbiola, 2002).

Ashckenazi-Polivoda, S., Abramovich, S., Almogi-Labin, A., Schneider-Mor, A., Feinstein, S., Püttman, W., and Berner, Z. 2011, Paleoenvironments of the latest Cretaceous oil shale sequence, southern Tethys, Israel, as an integral part of the prevailing upwelling system. Paleogeography, Palaeoclimatology, Palaeoecology 305, 93-108.

Bardet, N., and Suberbiola, X. P., 2002. Marine reptiles from the Late Cretaceous phosphates of Jordan: Palaeobiogeographical implications. Geodiversitas 24(4), 831-839.

THE EVOLUTION OF MOSASAUR FEEDING ECOLOGY THROUGH THE LENS OF STABLE CARBION ISOTOPES

John A. Robbins[1], Michael J. Polcyn[2], Johan Lindgren[3]

[1]Department of Geology and Geophysics, Texas A&M University, MS 3115, College Station, Texas 77843, USA; [2]Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA; [3]Department of Geology, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden

In this contribution we explore the evolution of the feeding ecology of mosasaurs using stable carbon isotope ($\delta^{13}C$) measurements from tooth enamel. We build on the preliminary study of Robbins et al. (2008), which in turn was modeled on the work of Clementz and Koch (2001) in their study of the effect of foraging area on the $\delta^{13}C$ values of tooth enamel in extant marine mammals. We sample from a variety of localities in North America, Europe and Africa, spanning nearly 30 million years of mosasaur evolution, and representing 53 individuals across four subfamilies. In spite of the relatively small sample size, some large scale patterns emerge. $\delta^{13}C$ values generally decrease through time, suggesting a trend of increasing offshore range extension, with near shore foraging increasingly under represented over time. Segregation of foraging area at the subfamily level is established early in the fossil record based on disparate $\delta^{13}C$ ranges between taxa with different modes of life. Based on the expansion of $\delta^{13}C$ range, mosasaurines exhibit rapid niche differentiation in the Campanian and thereafter occupy the widest range of foraging areas of all subfamilies. *Mosasaurus* replaces large tylosaurines in the late Campanian or early Maastrichtian in the farthest offshore range, although it is unclear whether this was due to competition or merely exploitation of a vacated niche. Comparison of $\delta^{13}C$ values with tooth form and body size shows a relatively strong correlation; however, some exceptions exist. *Progathodon* and *Globidens* exhibit significantly depleted values (~ -8 to 16‰), suggesting that respiratory effects may play an important role in fractionation as hypothesized by Biasatti (2004) for turtles. *Tethysaurus* exhibits more negative values (~ -7‰) than predicted for a small bodied, near-shore marine form, opening the possibility of a dominantly estuarine habit for that taxon, as reported from the Santonian of Hungary (Makádi et al., 2012). The isotope values of specific taxa were remarkably consistent across geographically disparate localities; however, high latitude localities in Sweden show depleted values for specific genera when compared to those from Africa and North America, while retaining the segregation pattern amongst taxa. This consistent bias may be related to paleogeography and depositional setting.

Biasatti, D. M. 2004. Stable carbon isotopic profiles of sea turtle humeri: implications for ecology and physiology. Palaeogeography, Palaeoclimatology, Palaeoecology, 206(3), 203-216.

Clementz, M. T., and Koch, P. L. 2001. Differentiating aquatic mammal habitat and foraging ecology with stable isotopes in tooth enamel. Oecologia, 129(3), 461-472.

Makádi, L., Caldwell, M. W., & Ősi, A. 2012. The first freshwater mosasauroid (Upper Cretaceous, Hungary) and a new clade of basal mosasauroids. PloS one, 7(12), e51781.

Robbins, J. A., Ferguson, K. M., Polcyn, M. J., and Jacobs, L. L. 2008. Application of stable carbon isotope analysis to mosasaur ecology. In: Everhart, M. (editor), Proceedings of the Second Mosasaur Meeting, Fort Hays Studies, Special Issue 3: 123–130.

VERTEBRAL PATHOLOGY IN MOSASAURS

Bruce M. Rothschild[1], Michael J. Everhart[2]

[1]University of Kansas, Lawrence, Kansas 66045, USA; [21]Sternberg Museum of Natural History, Fort Hays State University, Hays, Kansas 67601, USA

Three forms of pathology are routinely noted in the vertebrae of mosasaurs: shark bites, avascular necrosis and fusion, in addition to isolated reports of 'tumors.' Grooves on vertebrae evidence shark bites, while associated new bone formation allows recognition of predation. The former is common; the latter, relatively rare but provides insights to behavior of both the mosasaur and its attacker. Recognition of diving disease in mosasaurs was based upon identification of a specific associated pathology, avascular necrosis. The devitalized bone typically becomes necrotic (and lucent to x-rays), secondary to loss of vascular supply. The resultant loss of mechanical integrity makes the surface susceptible to compression stresses across the shoulder and hip joint. The resultant damaged bone can no longer resist the normal stresses across the joint and partly collapses, producing a visible subsidence zone. Avascular necrosis was invariably present in *Platecarpus, Tylosaur, Mosasaurus, Plioplatecarpus, Prognathodon, Hainosaurus* and an Antarctic mosasaur, and invariably absent from *Clidastes, Ectenosaurus, Globidens, Halisaurus* and *Kolposaurus*. Fused mosasaur vertebrae are attributable to reactive bone from trauma and infection (e.g., related to trauma of shark bites) and perhaps to splinting or a disease documented in contemporary varanids. It would appear that fusion through vertebral centra occurs whenever motion is lost at that segment. However, there is another form of fusion through the outer layers of what is presumed to have been an intervertebral disk, as has been documented in contemporary *Varanus*. Isolated suggestion of tumors is a more complex subject. Moodie's suggestion of osteoma must be rejected on the basis of apparent lesion size and location. The only other recognized 'tumor' has been called an osteoma, but its size complicates histologic examination to assure it is not simply a hamartoma, as human skull so-called osteoma have been now reclassified.

OUR EMERGING KNOWLEDGE OF *CARINODENS BELGICUS*

Anne S. Schulp[1,2,3], John W.M. Jagt[1], Mike J. Polcyn[4], Eric W.A. Mulder[1,5], Peter Formanoy[5], Hani F. Kaddumi[6], Johan Lindgren[7], Femke Holwerda[8]

[1]Natuurhistorisch Museum Maastricht, De Bosquetplein 6-7, NL6211KJ Maastricht, The Netherlands; [2]Faculty of Earth and Life Sciences, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands; [3]Naturalis Biodiversity Center, Leiden, The Netherlands; [4]Roy M. Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA; [5]Museum Natura Docet / Wonderryck Twente, Denekamp, The Netherlands; [6]Eternal River Museum, Amman, Jordan; [7]Lund University, Lund, Sweden; [8]Bayerische Staatssammlung für Paläontologie und Geologie, Munich, Germany

The diminutive durophagous mosasaur *Carinodens* has been considered "enigmatic" and "rare". However, in recent years, new material has become available allowing a more complete picture of this taxon. A large number HOW MANY?of isolated tooth crowns have been recognized in the collections of the Africa Museum at Tervuren (Belgium) originating from West Africa and a single tooth from the Maastrichtian of Maryland, USA, has now come to light. In 2011 an isolated tooth crown was recovered from the Maastrichtian in southern Angola. These and previous reports indicate a broad geographic distribution of this taxon, ranging the north and south Atlantic margins of Europe, North America, South America and West Africa and also the margins of the Mesogean and Neotethys of North Africa and the Middle East. Nonetheless, most of what we know about this taxon was based on isolated teeth and jaw fragments, and mostly limited to the posterior portion of the tooth row. Recently, the morphology of the anterior dentition was illuminated by new material from Morocco. As is the case with most historical reports of *Carinodens*, only a few dozen relatively large posterior tooth crowns were known after many years of collecting in the Maastrichtian type area, suggesting a historical collecting bias towards the distinctive posterior teeth. This has recently been mitigated by recognition of the more conservative anterior dentition of this taxon, and recently two anterior teeth have been identified from the Maastrichtian type area. A new species of *Carinodens* was recently described on the basis of partially prepared cranial material, cervical vertebrae and a partial flipper from Jordan. CT scanning of that specimen provides new data, elucidating skull roof morphology and confirming its mosasaurine affinities, but presenting a mosaic of derived and plesiomorphic characters suggesting a relatively basal position with globidensine mosasaurs. The skull of *Carinodens* is relatively lightly built and narrow with elongate gracile jaws. Analysis of microwear patterns on tooth crowns of *Carinodens belgicus* confirm a durophagous habit, but given the configuration of the skull, prey preference, prey acquisition, and feeding style likely differed significantly from *Globidens.*

$\delta^{13}C$ ISOTOPE SIGNAL IN MAASTRICHT MOSASAUR TOOTH ENAMEL

Anne S. Schulp[1,2,3], Hubert B. Vonhof [2], H. (Jeroen) J.L. van der Lubbe[4], Renée Janssen[2], and Remy R. van Baal[2]

[1]Natuurhistorisch Museum Maastricht, De Bosquetplein 6-7, NL-6211KJ Maastricht, The Netherlands; [2]Faculty of Earth and Life Sciences, VU University Amsterdam, De Boelelaan 1085, NL-1081HV Amsterdam, The Netherlands; [3]Naturalis Biodiversity Center, Leiden, The Netherlands; [4]Marine Climate Research, Institute of Geosciences, Christian-Albrechts-Universität zu Kiel, Ludewig-Meyn-Str. 10, D-24118, Kiel, Germany

We analyzed the carbon isotope signal ($\delta^{13}C$) in tooth enamel from all five mosasaur taxa from the type Maastrichtian. As this represents a dataset from a *single* site and a *narrow* time slice, the spatiotemporal bias in the signal is much reduced, allowing to focus with more confidence on the ecological and physiological factors involved. The five mosasaur taxa known from the type Maastrichtian seas (*Carinodens belgicus*, *Prognathodon sectorius*, *Prognathodon saturator*, *Mosasaurus hoffmanni* and *Plioplatecarpus marshi*) show distinct partitioning in tooth enamel $\delta^{13}C$ value, with larger taxa preserving more negative values. This pattern compares favorably with previously published mosasaur $\delta^{13}C$ data, which showed a similar correlation between $\delta^{13}C$ and body size (Robbins et al., 2008). Interestingly, the carbon isotope composition of mosasaur tooth enamel of the type Maastrichtian has remarkably low $\delta^{13}C$ low values compared to those of sharks from the same ecosystem. By analysing a relatively large sample of mosasaur teeth from different taxa but from the same age and area, we have been able to significantly reduce the impact of spatiotemporal $\delta^{13}C$ variation in the dataset, and can now pinpoint resource partitioning, reflected through (1) Bohr effect (e.g., Biasatti, 2004) (and therefore diving/foraging behavior) and (2) dietary specialization, as important determinants in the $\delta^{13}C$ signal as preserved in mosasaur tooth enamel

Biasatti, D.M., 2004. Stable carbon isotopic profiles of sea turtle humeri: Implications for ecology and physiology. Palaeogeography, Palaeoclimatology, Palaeoecology 206: 203–216.

Robbins, J.A., Ferguson, K.M., Polcyn, M.J., and Jacobs, L.L., 2008. Application of stable carbon isotope analysis to mosasaur ecology. In: Everhart, M. (editor), Proceedings of the Second Mosasaur Meeting, Fort Hays Studies, Special Issue 3: 123–130.

"CARLO", A NEW, *PROGNATHODON*-LIKE MOSASAUR FROM THE TYPE MAASTRICHTIAN

Anne S. Schulp[1,2,3] and John W.M. Jagt[1]

[1]Natuurhistorisch Museum Maastricht, De Bosquetplein 6-7, NL6211KJ Maastricht, The Netherlands; [2]Faculty of Earth and Life Sciences, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands; [3]Naturalis Biodiversity Center, Leiden, The Netherlands

In September 2012, quarry operator Carlo Brauer recognized the remains of a large mosasaur in the flint-rich Lixhe 3 Member (Gulpen Formation) within the Maastrichtian type section at the ENCI Quarry, near Maastricht, the Netherlands. Natuurhistorisch Museum Maastricht (NHMM) staff, with help from its crew of volunteers, managed to recover the specimen in a few weeks' time. Preparation work is ongoing at this moment [April 2013]. Material exposed thus far includes partial jaw sections, a (distorted) premaxilla, a pterygoid, an angular, and multiple elements of the axial skeleton. Haemal arches are fused. The morphology of the heterodont dentition is similar to that of *Prognathodon sectorius* (previously known as *L[e]iodon sectorius*, but recently reassigned to *Prognathodon*); features include a swollen base in the tooth outline, labiolingually flattened crown and sharp carinae. With eight of the twelve plaster jackets still awaiting preparation, we feel confident that sufficient material will ultimately be available to permit specific attribution. The specimen, nicknamed "Carlo" after its discoverer, is now in the NHMM collections under registration number NHMM2012072. The taphonomic setting of the fossil is dissimilar to the pattern generally observed higher in the section: here, individual bones are scattered over a wide area; bones are often distorted, and the surface is heavily abraded. Work on $\delta^{13}C$ and $\delta^{13}C$ values from the tooth enamel is under way; preliminary results show $\delta^{13}C$ values to be considerably less negative than those obtained from material higher up in the section. Dental microwear is currently being analyzed; the first SEM images suggest that this individual experienced relatively limited wear. The discovery of the fossil coincided with the last preparations of a special temporary exhibition at the NHMM focusing on "high-tech" and innovative mosasaur research. The preparation work on the fossil is performed in a special "open laboratory" which now, as a last-minute addition, features prominently in the new exhibition. This contribution will include a short "virtual tour" through the exhibition, which features quite a few research topics presented at earlier Mosasaur Meetings.

THE AFFINITIES AND REASSIGNMENT OF *MOSASAURUS GRACILIS*

Hallie P. Street[1] and Michael W. Caldwell[1,2]

[1]Department of Biological Sciences, University of Alberta, Edmonton, Alberta T6G 2E9, Canada; [2]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta T6G 2E9, Canada

Mosasaurus gracilis is an example of one of the multitude of species that was assigned to the genus *Mosasaurus* early in the nineteenth century. At this time, the process of naming new species had not been established, and the characters that diagnose the genus *Mosasaurus* remained poorly defined. When fragmentary mosasaur fossils were recognized from the Middle Chalk of Great Britain, they were assigned to *Mosasaurus* based on the known extent of the taxonomy of the time. The Middle Chalk fossils were significantly smaller than the famous type species, *M. hoffmannii*, and were dubbed *M. gracilis*. However, the fossil specimens assigned to this species are fragmentary and display very few diagnostic characters. From what can be observed from these specimens, it appears that *M. gracilis* does not agree with the morphology of mosasaurine mosasaurs but rather shares more characters, such as a short rostrum on the dentary anterior to the first teeth, with recently characterized russellosaurine mosasaurs. In addition, *M. gracilis* is known from Turonian-aged deposits, while other species belonging to *Mosasaurus* are Upper Campanian to Masstrichtian in age. Based on the evidence of shared characters and contemporaneity, we suggest that *M. gracilis* be removed from *Mosasaurus* because it shares more affinities with the russellosaur-like mosasaurs.

CHRONOSTRATIGRAPHY OF MARINE SEDIMENTS AT BENTIABA, ANGOLA, AND MOSASAUR NICHE PARTITIONING AT THE SOUTH ATLANTIC MARGIN

Christopher Strganac[1], Louis L. Jacobs[1], Michael J. Polcyn[1], Kurt M. Ferguson[1], Octavio Mateus[2], Anne S. Schulp[3]

[1]Roy M Huffington Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA; [2]CICEGe, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal; [3]Natuurhistorisch Museum Maastricht, De Bosquetplein 6/7, NL-6211KJ Maastricht, The Netherland.

The carbon isotopic composition of tooth enamel from mosasaurs recovered from a single horizon are analyzed to determine niche partitioning within a geological moment in the Cretaceous South Atlantic Ocean. $\delta^{13}C$ chemostratigraphy and a whole rock $^{40}Ar/^{39}Ar$ radiometric date of 84.6 ± 1.5 Ma constrain the age of a diverse assemblage of marine amniotes at Bentiaba, Angola. One vertebrate fossil-bearing horizon, Bench 19, lies sixty meters above

the dated basalt, which falls within the Santonian interval of widespread volcanism and tectonic activity around the South Atlantic Ocean. A positive ~3‰ $\delta^{13}C$ excursion below the basalt and a negative ~4‰ excursion at the top of the section are identified as the Cenomanian-Turonian Boundary Event during Oceanic Anoxic Event 2,and the Campanian-Maastrichtian Boundary Events, respectively, indicating a Late Cenomanian to Early Maastrichtian age for the strata. Bench 19 is latest Campanian in age, and implies strata that produced a similar mosasaur fauna in Morocco are older than the Maastrichtian age assigned by shark biostratigraphy. $\delta^{13}C$ values derived from 40 isolated teeth assigned to seven mosasaur taxa range from -5.2‰ to -16.1‰ and indicate a negative trend of carbon isotope values with increasing body size. This pattern is comparable to that observed in modern marine mammals along the Pacific coast of North America, where more negative $\delta^{13}C$ values correspond to foraging habitats farther and deeper from shore. $\delta^{13}C$ values of *Globidens* and plesiosaurs are the most negative, and are not significantly different from each other (*P*=1.0). *Globidens* values cannot be explained by body size alone and are interpreted as reflecting deep diving behavior suggested by their durophagus dental morphology. Average $\delta^{13}C$ values of *Mosasaurus*, *Prognathodon*, and *Plioplatecarpus* are consistent with nearshore feeding behavior. *Carinodens*, "*Plioplatecarpus*" *ptychodon*, and *Halisaurus* teeth produced the most positive $\delta^{13}C$ values, interpreted as reflecting shallow marine foraging habitats. *Prognathodon* produced the largest range in $\delta^{13}C$ values, from -5.2‰ to -13.8‰, and are not significantly different from nearshore marine (*P*=.179) or shallow marine taxa (*P*=.081). These results confirm mosasaurs utilized a range of foraging habitats and their $\delta^{13}C$ values do not simply reflect the shallow marine paleoenvironment in which the organisms were buried.

MOSASAUR DIVERSITY IN THE IZUMI GROUP OF THE SOUTHWEST JAPAN

Masahiro Tanimoto[1], Tetsuya Shinzyo[2], and Masahiro Sato[3]

[1]Natural History Museum, Kishiwada City, 6-5 Sakaimachi, Kishiwada, Osaka, 596-0027, Japan; [2]Hamakoshien 4-6-9, Nishinomiya, Hyogo, 663-8154, Japan; [3] 1-14-17 Tenjinbashi, Kita-ku, Osaka, Osaka, 530-0041, Japan

Fossils from Takinoike, Izumisano City, Osaka Prefecture, help reveal mosasaur diversity in the Izumi Group. One of us (Shinzyo) found more than one hundred shark teeth from Takinoike, a. famous Maastrichtian fossil locality in the Izumi Group. With this collection, he also recovered five mosasaur teeth, which are thought to be different individuals. In Izumi Group, in each locality, mosasaur individuals are rare., Two of the five small mosasaur teeth are "*Kourisodon*"-like. They do not preserve the lateral aspect, but if they are laterally compressed, such small and laterally compressed teeth may be juvenile (e.g.,Tanimoto,2005). Two other teeth are medium-sized and faceted. These four teeth together are

tentatively regarded as mosasaurine. The final tooth is very slender, and it is similar to *Halisaursus* teeth in shape and size (Lindgren and Siverson 2005). Alternatively, it is regarded as a plioplatecarpine-like animal (Konishi 2007, personal communication). Additional material is necessary, and will give more information on this unique tooth. Most of mosasaur fossils from the Izumi Group belong to Mosasaurinae. A possible member of Plioplatecarpinae is based only on one tooth (Nunoya specimen in Tanimoto, 2005) and needs further study. In the Izumi Group mosasaurs having small and laterally flattened teeth may not represent a distinct species, and may indicate early ontogenetic stages of a preexisting taxon. Such an interpretation will decrease the diversity of the Izumi Group mosasaurs. On the other hand, the recent find and study of a *Prognathodon*-like jaw fragment from Sennan City, Osaka Prefecture, (Konishi et al., 2012) enriches diversity of mosasaurs of the Izumi Group. Lastly, *Mosasaurus* sp. of Kaizuka City (KSNHM-F6-10-23) exhibits distinct heterodont teeth, and needs comparison with *Eremiasaurus heterodontus* of Morocco (LeBlanc et al., 2012).

Konishi, T., Tanimoto, M., Utsunomiya ,S., Sato, M., and Watanabe, K. 2012. A large mosasaurine (Squamata: Mosasauridae) from the Latest Cretaceous of Osaka Prefecture (SW Japan). Paleontological Research, 16: 79-87.

LeBlanc, A.R.H, Caldwell, M.W., and Bardet, N. 2012. A new mosasaurine from the Maastrichtian (Upper Cretaceous) phosphates of Morocco and its implications for mosasaurine systematics. Journal of Vertebrate Paleontology, 32: 82-104.

Lindgren, J. and Siverson, M. 2005. Halisaurus sternbergi, a small mosasaur with an intercontinental distribution. Journal of Paleontology, 79: 763-773.

Tanimoto, M. 2005. Mosasaur remains from the Upper Cretaceous Izumi Group of southwest Japan. Netherlands Journal of Geosciences, 84: 373-378.

AN OVERVIEW OF FOSSIL TURTLES OF NORTH-CENTRAL TEXAS

Diana P. Vineyard[1]

[1]*Shuler Museum of Paleontology and ISEM at Southern Methodist University, Dallas, Texas 75275, USA*

This study documents the diversity and stratigraphy of Cretaceous marine and freshwater turtles from north-central Texas. Significant specimens are described from the Woodbine Formation through the Taylor Group. Four families of turtles are represented: Protostegidae, Toxochelyidae, Cheloniidae, and Trionychidae. The Woodbine Formation, the lowest unit of the Upper Cretaceous Gulfian Series in north-central Texas, represents fluvial, deltaic, coastal plain, and shelf environments that developed as part of a regressive sequence along the southwestern margin of the Cretaceous Interior Seaway. Along with a diversity of terrestrial fossils found in the Woodbine, freshwater soft-shelled turtles

(Trionychidae) are found. Depositional environments represented in the Eagle Ford Group range from sandy near-shore environments of the Tarrant Formation to muddy shelf environments of the Britton Formation. Turtle material recovered from the Eagle Ford Group represent two families of marine turtles, Cheloniidae and Protostegidae. Overlying the Eagle Ford Group is the Austin Group. The Austin Chalk was deposited during the maximum extent of the Cretaceous Interior Seaway. Numerous marine fossils representing the family Protostegidae are reported from the Austin Group. The Taylor Group, the youngest unit of the Gulfian Series in north-central Texas, represents of shallow shelf environments. Two families of marine turtles are present in the Taylor: Protostegidae and Toxochelyidae. Four articulated and stacked toxocheylids were found in the Ozan Formation of the Taylor Group at the North Sulphur River.

TERRESTRIAL TETRAPOD FAUNA DURING THE LOWER TO UPPER CRETACEOUS TRANSITION IN NORTH-CENTRAL TEXAS

Dale A. Winkler[1], Timothy S. Myers[1], Anthony R. Fiorillo[2], Ronald S. Tykoski[2]

[1]Roy M. Huffington Department of Earth Sciences, Southern Methodist University, Dallas, TX 75275, USA; [2]Perot Museum of Nature and Science, 2201 N. Field Street, Dallas, TX 75202, USA

Terrestrial vertebrate communities in north-central Texas show a dramatic change in composition from the Early Cretaceous into the Cenomanian, a time when some squamates began adapting to a fully marine habitat. Flowering plants first began to dominate floras during the Cenomanian, perhaps driving the faunal changes on land. Seas largely covered the area from the late Early Albian on, but Late Albian and Middle Cenomanian regressive incursions in the region provided environments capable of preserving terrestrial faunas and floras including dinosaurs, mammals, and angiosperms. Small tetrapods from the Woodbine Formation (Middle Cenomanian) include amphibians, birds, lizards and snakes. An extensive coeval marine vertebrate fauna contains marine crocodyliforms, but no aquatic squamates. Diverse terrestrial faunas are gone by the Late Cenomanian with continued inundation by the Western Interior Seaway. Dolichosaurids appear abruptly in the section above the Woodbine Formation, in the overlying Upper Cenomanian Tarrant Formation. Mosasauroids are abundant in Texas beginning in the Turonian, but terrestrial tetrapods are rare and mainly restricted to those types that utilized marine resources, such as pterosaurs and aquatic birds.

THE MEXICAN MOSASAUR FOSSIL RECORD: AN OVERVIEW

Valentina Zavaleta-Villarreal[1], Marisol Montellano-Ballesteros[2], Jesús Alvarado-Ortega[2]

[1]Posgrado en Ciencias Biológicas, Universidad Nacional Autónoma de México, Ciudad Universitaria, Del. Coyoacán, C.P. 04510, D.F., México; [2]Instituto de Geología, Universidad Nacional Autónoma de México, Ciudad Universitaria, Del. Coyoacán, C.P. 04510, D.F., México

Mosasaurs are large marine reptiles that were abundant and diverse in the shallow seas during the Late Cretaceous (Turonian-Maastrichtian). In 1930, Mehl described the first Mexican mosasaur, *Amphekepubis johnsoni* from the Coniacian San Felipe Fm., Nuevo León. The type specimen is housed at the University of Missouri; it includes the pelvic girdle, portion of hind limb, and nine postsacral vertebrae. Camp (1942) synonymized it with *Mosasaurus*; Lingham-Soliar (1995) and Buchy et al. (2005) support this identification. Since then, a few more records have been added. Most remains were collected in the northeastern states of Coahuila, Nuevo León, Tamaulipas and Chihuahua, and were assigned to the subfamily Mosasaurinae (Mehl, 1930; Eberth et al., 2003). Recently, a skull and lower jaw collected from the Turonian Ojinaga Fm. in Chihuahua has being identified as belonging to the subfamily Tylosaurinae (Loera-Flores, 2013). A new species of aigialosaurid, basal mosasaurs otherwise found exclusively in Europe, has been described from Nuevo León as *Vallecillosaurus donrobertoi* (Smith and Buchy, 2008). The type specimen consists of the posterior half of the axial skeleton with much of the tail and the left pelvic appendage, and two partial sections of the tail, with soft tissue preservation. Other specimens have been found at the same locality, but have not yet been described. In recent years, new mosasaur specimens have been collected from different parts of the country. We add three new occurrences in the state of Coahuila: a series of vertebrae from the Campanian Cerro del Pueblo Fm.; a maxilla found in Piedras Negras, in the Eagle Ford Fm., of Turonian age; and the remains of a mosasaurine collected from the Campanian-Maastricthian Aguja Fm. that includes several skull fragments, teeth and postcranial material. We also add the first record from the state of Puebla in central Mexico, where we found a maxilla and premaxilla in the Turonian Mexcala Fm. Interestingly, we also found a slab with the anterior part of a skeleton, including the skull and anterior part of the forelimbs, broken at the level of the sacral vertebra, that appears to be an aigialosaurid, very similar to those found in the northern state of Nuevo León. Based on the morphology of the teeth and the vertebrae, at least five different forms of mosasaur are recognized within this newly collected fossil material. Unfortunately, most of the mexican mosasaur record is scarce; the remains are fragmented, disarticulated, and poorly documented. The specimen from Puebla represents the southernmost record of mosasaurs in North America, extending the geographic distribution of the family Mosasauridae. Due to the geographical position of Mexico during the Late Cretaceous and the diversity showed by this group in the country, the

ongoing study provides useful information to understand the role that Mexico played in the diversification of the mosasauroids.

Buchy, M.-C., Smith, K.T., Frey, E., Stinnesbeck, W., González González, A.H., Ifrim, C., López-Oliva, J.G., and Porras-Muzquiz, H. 2005. Annotated catalogue of marine squamates (Reptilia) from the Upper Cretaceous of northeastern Mexico. Netherlands Journal of Geosciences, 84: 195-205.

Camp, C.L. 1942. California mosasaurs. University of California Memoir, 13: 1-68.

Eberth, D., Sampson, S.D., Rodriguez-De La Rosa, R.A., Aguillon-Martinez, M., Brinkman, D.B., and Lopez-Espinoza, J.. 2003. Las Aguilas: An unusually rich Campanian-age vertebrate locale in southern Coahuila, Mexico. Journal of Vertebrate Paleontology, 23: 47A.

Lingham-Soliar, T. 1995. Anatomy and functional morphology of the largest marine reptile known, Mosasaurus hoffmanni (Mosasauridae, Reptilia) from the Upper Cretaceous, Upper Maastrichtian of the Netherlands. Philosophical Transactions: Biological Sciences, 347: 155-180.

Loera-Flores, A. 2013. Occurrence of a tylosaurine mosasaur (Mosasauridae; Russellosaurina) from the Turonian of Chihuahua State, Mexico. Boletín de la Sociedad Geológica Mexicana, 65(1): 99-107.

Mehl, M.G. 1930. A new genus of Mosasaurs from Mexico, and notes on the pelvic girdle of Platecarpus. Denison University Bulletin, Journal of the Scientific Laboratories, 29: 383-400.

Smith, K.T., and Buchy, M.-C. 2008. A new aigialosaur (Squamata: Anguimorpha) with soft tissue remains from the Upper Cretaceous of Nuevo León, Mexico. Journal of Vertebrate Paleontology, 28: 85-94.