

A NEW ADDITION TO THE CRETACEOUS SEAWAY OF NORTH DAKOTA

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In July of 2015, 17-year-old Deborah Shepherd from Green Cove Springs, Florida was visiting the Pembina Gorge State Recreation Area in northeastern North Dakota (Cavalier County) with her family. One member of Deborah's family had previously attended the Pembina Gorge public fossil dig, and they had brought the family up to the roadside marker near the fossil site to see the area. The group was exploring the area and had dispersed a bit when they heard Deborah excitedly call out. She came running up to the group holding a fist-sized piece of white bone encased in a crust of black shale (fig. 1). Along one side of the bone four large teeth were present. Deborah had found part of the jaw of an ancient sea monster: a mosasaur.

Mosasaurus were large aquatic reptiles that lived in the oceans during the Mesozoic while dinosaurs were ruling the land. Though they lived at the same time as the dinosaurs, they are actually more closely related to snakes and monitor lizards (like the Komodo dragon) than they are to dinosaurs. They swam using four large flippers and an extremely long, stiff tail, and had to return to the surface to breathe (fig. 2), just like modern whales and dolphins. They were the top predators of the seas

during their time, with some species reaching lengths of close to 50 feet and displaying teeth as large as that of a *Tyrannosaurus rex*.

What happened next in this story was key to facilitating an important discovery about North Dakota's past. Rather than deciding to keep the fossil as a personal keepsake, which would be illegal on state owned lands, they wrapped the fossil in some tissue paper so they wouldn't lose any of the pieces and brought it to the local North Dakota Parks and Recreation Department (NDPRD) office in Walhalla. There the staff recorded information about where the fossil was found and by



Figure 2. Reconstruction of a mosasaur. Painting by Becky Barnes.

whom, and took temporary possession of the fossil. They then reported the discovery to the paleontology program at the North Dakota Geological Survey, who works with the NDPRD to manage paleontological resources on Park land. Since the annual Pembina Gorge fossil dig was taking place in a few weeks, they were told to hold onto the fossil until the paleontology group arrived and they could show them exactly where it came from.

July 20th was the first day of the seventh Pembina Gorge public fossil dig, and NDGS paleontologist Jeff Person set out to find where the jaw piece came from and whether or not more bones may be present in that same spot. Using the information Deborah Shepherd provided, Jeff quickly discovered where the bone was found. The location was higher up the hillside than the main quarry, in an area that had not yet been worked. More white bone was slightly protruding from the soft, black rock and the piece Deborah had turned in fit right back onto the broken surface. There was a good chance that at least the rest of that jaw bone was still in the ground. Jeff carefully followed the jaw bone into the hillside, shaving away the black shale. The rest of the lower jaw was there, with many of the teeth still in place, as were



Figure 1. The partial lower jaw originally discovered by Deborah Shepherd.

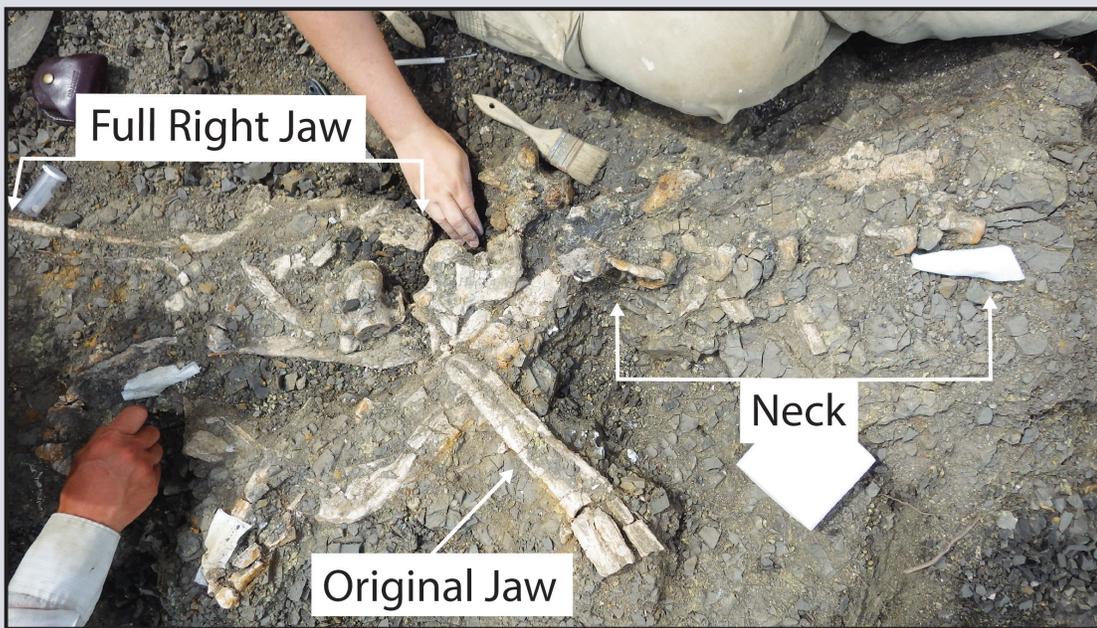


Figure 3. The Pembina Gorge mosasaur being excavated. The neck is to the right and the skull is to the left. Major body sections labeled.

many other bones from the same animal. Deborah had found not just a bone, but a partial skeleton.

Over the course of the next week the NDGS paleontology crew, with the assistance of dozens of public dig participants, uncovered a good portion of a skull of a mosasaur, as well as the front portion of the neck (fig. 3). The individual bones in the skull of a mosasaur do not usually fuse together during life. As a result, when these animals died and the flesh surrounding the bones rotted away, all of the individual bones would collapse into a pile and would often be scattered around by ocean currents and scavengers. That is what had happened to this specimen, resulting in a jumbled pile of skull bones rather than a three-dimensionally preserved skull. The crew carefully worked around the bones, finding thin gaps between groups of bones where they could be separated into

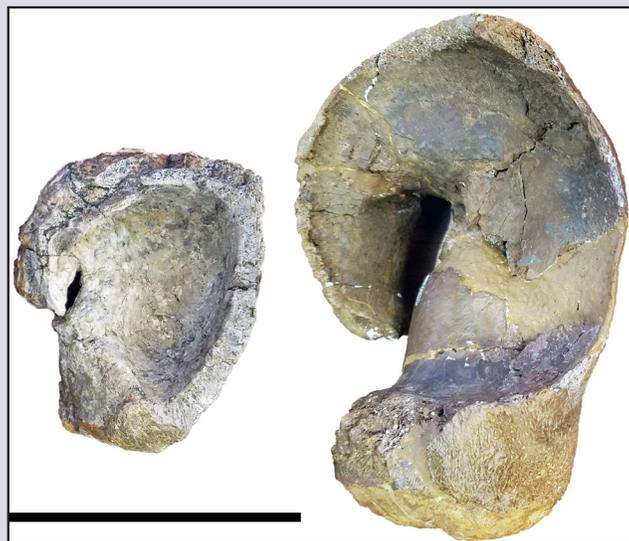


Figure 4. The right quadrate from the Pembina Gorge mosasaur (left) compared to the right quadrate from a specimen of *Plioplatecarpus* previously collected near Cooperstown, North Dakota (right). Scale bar is 10 cm.

smaller blocks for removal. By the end of the 2015 public dig, twelve plaster-encased blocks were removed from the site, each containing portions of the mosasaur skull and neck.

The 8th Pembina Gorge public fossil dig took place in August of 2016, and the paleontology crew immediately set to work reopening the small quarry where the skull was collected the prior year to see if any additional bones could be found. Loose rock had been piled into the quarry to protect any bones that may still be in the rock and limit the

amount of natural erosion in the quarry. Once the bulk of that loose rock was removed, the back wall was brushed clean with paint brushes to expose the wall of fresh rock. As I was brushing clean one section of the back wall, the outer surface of the rock crumbled away and a well-preserved bone literally tumbled into my lap. I picked it up and quickly realized it was the quadrate

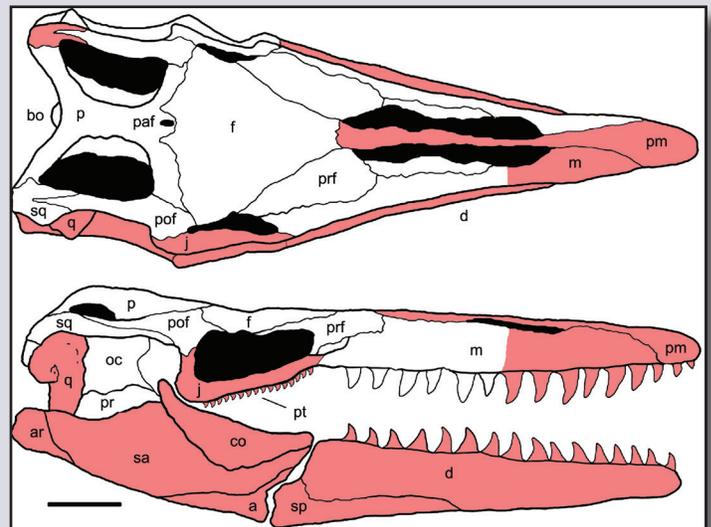


Figure 5. Reconstruction of the skull of *Mosasaurus* highlighting (in red) which bones from the skull have been cleaned and identified so far from the Pembina Gorge mosasaur. Modified from Ikejiri and Lucas (2015: fig. 4). Scale bar is 10 cm.

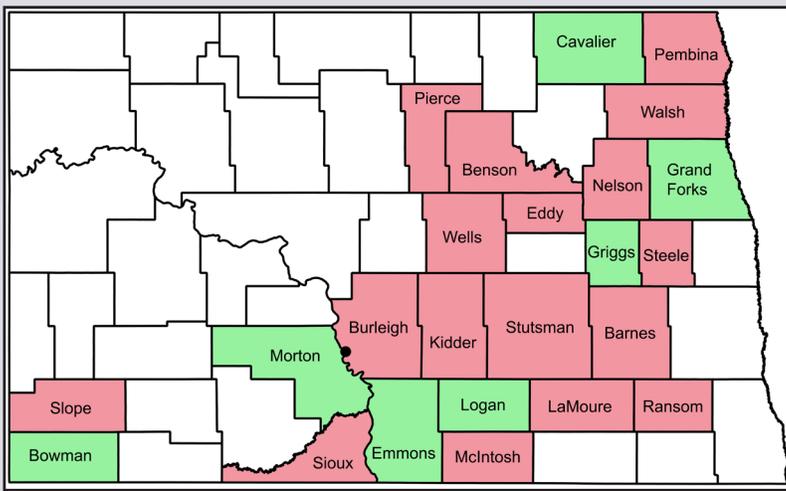


Figure 6. Map of North Dakota showing where mosasaur fossils have been found (green counties) and those counties that have the right type of rocks to preserve mosasaur fossils, but no specimens have yet been recovered (red counties). The Pembina Gorge mosasaur was discovered in Cavalier County.

(part of the jaw joint), which is one of the most important bones for identifying different species of mosasaurs. As we all huddled around we quickly realized that this bone was very different from any other specimen we had seen from North Dakota, suggesting it belonged to a species never before discovered in the state (fig. 4). Over the course of the dig we found two additional skull bones from the mosasaur that were removed in a small jacket and transported back to Bismarck.

This discovery is exciting because only a few mosasaur skulls are known from North Dakota, and none from the Pembina Gorge fossil site. So far three of the 13 plaster jackets that were collected over the past two years have been opened and cleaned, and the results are exciting (fig. 5). The entire right side of the lower jaw was recovered intact, including many of the teeth, to go along with the partial left lower jaw that was first discovered at the site. Also of note is a section of the neck that is still all connected together in original position that includes six vertebrae from the base of the neck along with some intact ribs and a possible bite mark. As more plaster jackets are opened and cleaned we will gain a more complete understanding of how much of the skull we have found so far, and how much more may still be out in the rock waiting to be uncovered.

The identity of the Pembina Gorge Mosasaur

Over the years, several mosasaur specimens have been collected from the Pierre Formation in North Dakota from Cavalier and Griggs counties in the east all the way down to Bowman County in the southwest (fig. 6). Those specimens represent several different kinds of mosasaurs, including *Plioplatecarpus* from Griggs and Bowman counties (Schaefer et al., 1995; Hoganson et al., 1999), a likely specimen of the very large-bodied (over 30 feet long) *Tylosaurus* from Grand Forks County (Hoganson, 2014), and some possible material of *Platecarpus* from Cavalier and Bowman counties (Hoganson, 2014). The mosasaur tree of life is divided roughly in half into two broad groups. All of the mosasaurs

previously reported from the Pierre Formation of North Dakota fall on one side of that tree. Examination of the bones that are cleaned up thus far from the Pembina Gorge mosasaur indicate that it belongs on the other side of the tree within the genus *Mosasaurus*. Among those species, it most closely resembles *Mosasaurus conodon*, which is smaller than other species of *Mosasaurus* and has an elongate, narrow skull. However, there are some differences between the Pembina Gorge mosasaur and *M. conodon*. Mosasaurs have a bone in the back of the roof of their mouth called the pterygoid that has teeth used to hold its prey in place while feeding, just like closely related snakes and monitor lizards. In *M. conodon*, eight medium-sized teeth are present in the pterygoid, but in the Pembina Gorge mosasaur 16 small teeth are present. No other species of *Mosasaurus* has near that many teeth in the pterygoid. There are also some differences in the shape of the quadrate, which forms part of the jaw joint. At this time it remains unclear if these differences indicate that the Pembina Gorge mosasaur is unique enough to be considered a new species, or if they are minor enough to still consider it a specimen of *M. conodon* that has a few atypical features. For now, the Pembina Gorge mosasaur is identified as *Mosasaurus* sp., which indicates that it belongs to the genus *Mosasaurus*, but we are uncertain at this time exactly which species it represents. Regardless, this is the first time *Mosasaurus* has been discovered in the Pierre Formation of North Dakota, providing us with important information for reconstructing the fauna and environment of the Cretaceous seaway of North Dakota.

Past Discoveries at the Pembina Gorge Site

The first public fossil digs were held at the Pembina Gorge fossil site from 2000-2002, resulting in the collection of fossils from fish, diving birds, and isolated bones from mosasaurs. For the next nine years no public digs took place in the Pembina Gorge, although members of the NDGS paleontology program did stop through occasionally to examine the area and conduct scientific research. In 2012, public digs began again in the Pembina Gorge and were immediately successful. From 2012 to 2014 a very complete mosasaur skeleton was collected a few feet to the south of the previous quarry at the site (fig. 7). Unfortunately, no part of the skull was found from that specimen, though over 110 vertebrae from the spine were recovered, spanning from the neck to the tip of the tail. That specimen is now on display in the Geologic Time Gallery at the North Dakota Heritage Center & State Museum. As luck would have it, Deborah's discovery was situated immediately above that quarry, about six feet higher up in the rock (fig. 7). When Deborah reported finding the partial jaw bone at the site, our first hope was that she had found the missing skull that went with the previously collected skeleton. However, once we figured out how much higher up in the rock this skull was positioned we realized that this skull was from a different individual. The question remains as to whether these two skeletons collected at the Pembina Gorge fossil site are from the same species, or if they each represent different species. Hopefully, continued work at the site will produce more of the skeleton to go along with the

partial skull already collected so that there are more bones to compare between the two specimens. Either way, these discoveries highlight how productive the rocks are in the Pembina Gorge and the importance of continued work in this area to ensure the protection and preservation of these important fossils.

Working Together to Protect the Past

The Pembina Gorge public fossil dig is an excellent example of how staff at the NDPRD and the NDGS continue to work together to protect paleontological resources on lands managed by the NDPRD. This partnership includes cooperatively developing educational information and programming for those sites, the most prominent of which are the public fossil digs. Those efforts provide unique opportunities for the people of North Dakota to learn about our prehistoric heritage and to assist in efforts to preserve this information for future generations.

They also provide exciting activities that bring tourists into North Dakota from across the country (Person, 2016). In addition to cooperative activities at the Pembina Gorge State Recreation Area, these two departments recently finalized an agreement to cooperatively manage the paleontological resources on an NDPRD-administered parcel of land south of Mandan along the Missouri River bluffs that preserves fossils of some of the last dinosaurs that lived in North Dakota.

The protection of paleontological resources on state administered lands also depends on assistance from members of the general public, who spend the greatest amount of time out exploring these lands and often make important discoveries. For example, in the spring of 2016 a student from the University of North Dakota was biking the extensive network of trails in the Pembina Gorge when he noticed some bones poking out of a hillside and reported the find. With his assistance, NDPRD and NDGS staff visited the site in the summer of 2016. Those fossils are from another mosasaur, this time preserved in the Niobrara Formation, which is situated below the Pierre Formation. Very few fossils have been found from the Niobrara Formation in North Dakota, so this find is an important discovery. Additionally, the main Pembina Gorge fossil site was also first discovered by a member of the public who reported their discovery. By working together we can all help to

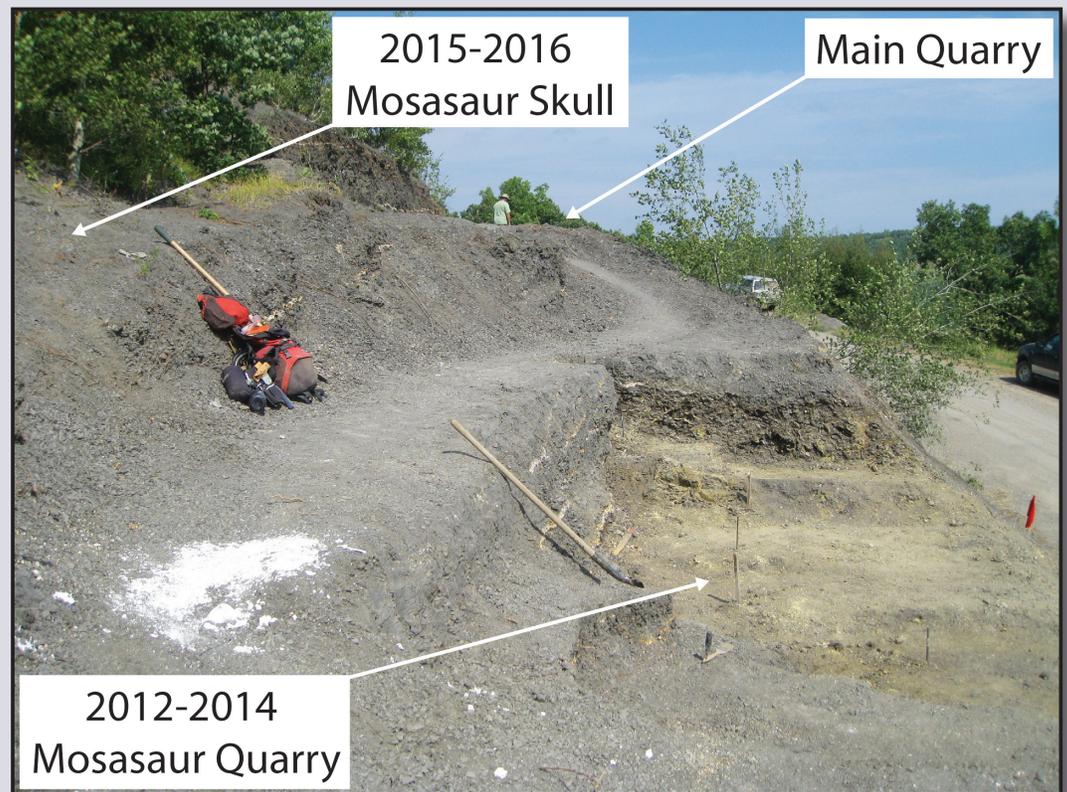


Figure 7. Photograph from 2013 showing the Pembina Gorge fossil site. The main quarry at the site is to the north where public dig volunteer James Daly (green shirt) is standing. The quarry where the postcranial skeleton of a mosasaur was collected can be seen actively being worked in the bottom right. In the top left an arrow points to the spot where the new Pembina Gorge mosasaur skull was found in 2015, right above the old mosasaur quarry.

expand our knowledge of North Dakota’s prehistory and ensure these important resources are preserved for future generations to enjoy.

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