Dilophosaurus – less of a frilly, venom-spitting lizard than we thought

October 23 2015, by Robert Gay

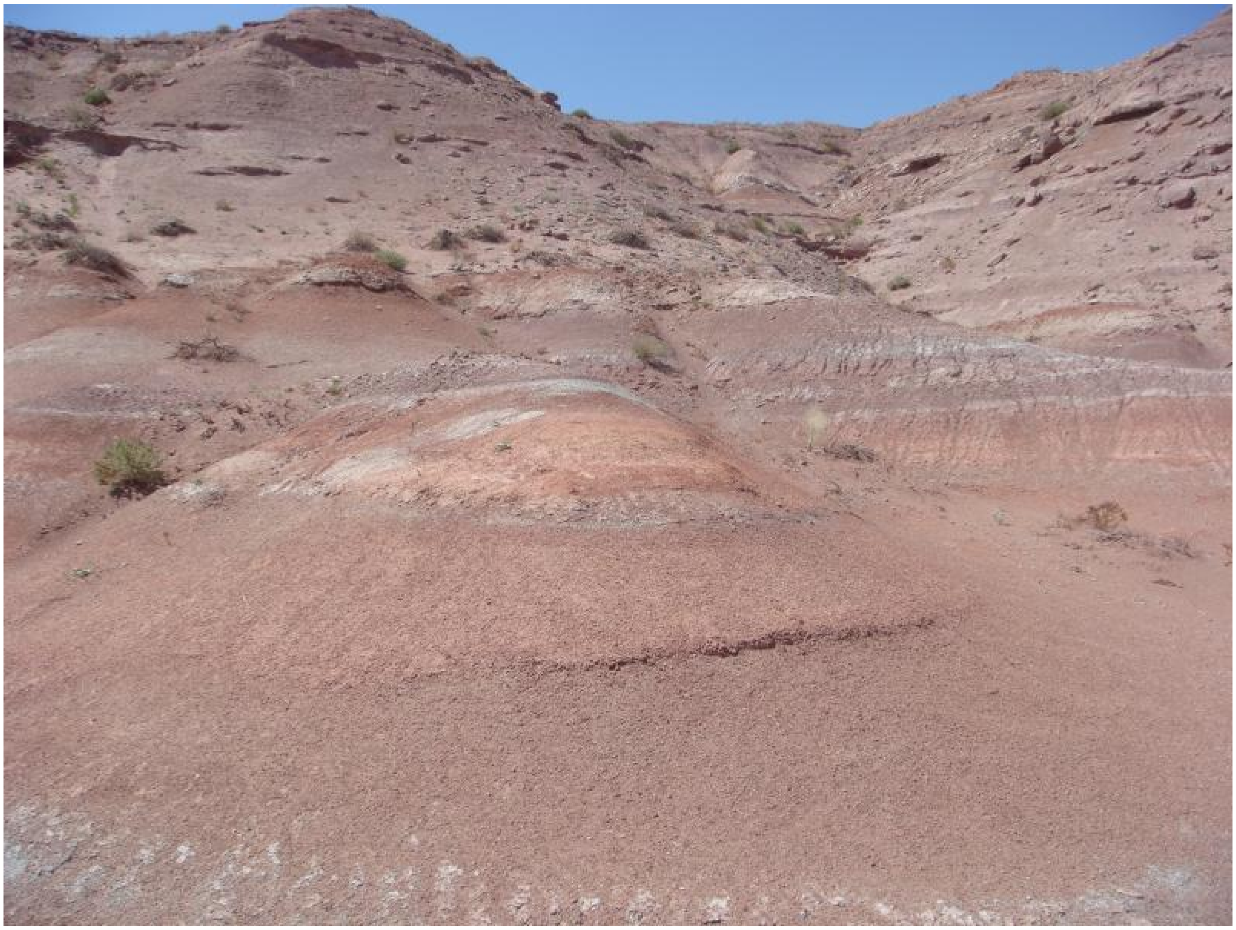
The locality near where the holotype of Dilophosaurus was found

When people think of the Mesozoic, most people think of dinosaurs.

Rightfully so: dinosaurs were major components of terrestrial ecosystems for almost all of the Mesozoic. Dinosaurs are charismatic; people are naturally fascinated by them, especially iconic taxa like Tyrannosaurus, Stegosaurus, and Ankylosaurus. One of the big questions in dinosaur paleontology, however, is what allowed this successful increase in diversity and body size throughout their reign. We know from the global fossil record that the Triassic was a time of odd archosauromorphs living alongside small and relatively rare dinosaurs. We know that by the middle of the Jurassic Period these large diverse, dinosaur-dominated assemblages were in place. What happened in between? How did the small theropod dinosaurs of the Late Triassic become the large dominant predators of the Jurassic? The Early Jurassic terrestrial fossil record is sparse but there is one animal that can help: Dilophosaurus wetherilli. On Friday, 10/16/15, Adam Marsh, a PhD candidate at the University of Texas at Austin, gave a talk about his research on this animal. His research and a history of the animal itself are given here.

In 1942 a local Navajo man named Jessie Williams discovered several large theropod dinosaur skeletons near the small town of Tuba City, Arizona. Williams reported his find to paleontologist Charles Camp who in turn relayed the information to paleontologist Sam Welles. Recognizing that no dinosaurs had ever been published from the Kayenta Formation, he named it Megalosaurus wetherilli, after trader John Wetherill. It wasn't until 1964 that a larger, more complete specimen was found. The skull of this newer, larger specimen preserved the famous crests for which Welles eventually named the genus: two-crested reptile. Dilophosaurus.

Despite the abundance of material (at least three individuals) the animal remained something of an enigma to paleontologists for decades. This is partially due to the fragmentary and often frustrating preservation found in the Kayenta Formation. Specimens tend to be crusted with hard mineral coatings and are often severely crushed by diagenetic processes. The bones of theropod dinosaurs, noted for their hollow nature, suffer under these preservational conditions. In addition, Welles' 1984 seminal monograph on the taxon relied heavily on line drawings of specimens. In some cases Welles' illustrations either oversimplified elements or showed portions of the anatomy that were actually not preserved. Welles also used composite information from the holotype, paratype, and the 1964 specimen to inform his descriptions, conclusions, and reconstructions. It was often not clear from what specimen he was drawing his data. In addition Welles believed, as of 1984, that the larger specimen may have represented a new taxon. While Welles changed his mind on this topic (based on his personal communication saved at the UCMP) after publication of his monograph, the idea limited what information was presented in this tome.



One of the quarries near Gold Spring

So where does this leave the state of early theropod evolution? Pretty unsettled. Welles did not use modern phylogenetic techniques to analyze the relationships of Dilophosaurus with respect to other taxa but subsequent authors have. Most have found it to lie outside of Averostra (a group of dinosaurs including Allosaurus, Ceratosaurus, Tyrannosaurus, and modern birds), with some placing it back within the Coelophysoidea, a group of predominately Late Triassic dinosaurs that also have Early Jurassic relatives. The biggest issue with these analyses is that they coded Dilophosaurus as a composite of all the specimens, just as Welles had described them. So what to do? As with most questions in paleontology, the answer is to find more fossils. This is exactly what happened at the University of Texas at Austin in the field seasons during the late 1990s and early 2000s. As Adam said to me, "Tim Rowe wanted a Dilophosaurus, so they went looking for Dilophosaurus." They came back successful! At least two new specimens have been discovered by crews from the University of Texas at Austin. Together with Adam's reanalysis of the specimens at the University of California Museum of Paleontology at Berkeley, California, we now have a better picture of what Dilophosaurus looked like and its relationships to other early theropods.

First of all: the crests. Everyone always falls in love with the crests, even in the horrid-looking Dilophosaurus from Jurassic Park. For some time, at least since the mid-1990s, there has been some question as to whether all specimens of Dilophosaurus possessed paired cranial crests. Although the new specimens housed in Texas don't preserve that portion of the cranium, all other specimens do show a pair of crests on the top of the skull. Previously thought to be made of bony extensions of the nasal and lacrimal bones, reanalysis of the UCMP specimens also shows a contribution to the crest by the premaxilla! The bony protrusion seen on the posterior lacrimal portion of the crest also appears to be real and not a preservational artifact. There's also apparently a large preorbital boss on the lacrimal, though exactly what that looked like in the specimen or in life was not discussed. Still – paleoartists take note! The limbs are also apparently highly derived; a poster at SVP by Phil Senter talked about the grappling capabilities of the arms of Dilophosaurus being well-suited for restraining large, struggling prey but I did not get a chance to see it since it was during one of my posters. Adam told me that in general he agrees with the idea that Dilophosaurus was using its forelimbs for prey manipulation but distortion of the limbs is likely due to postmortem processes.

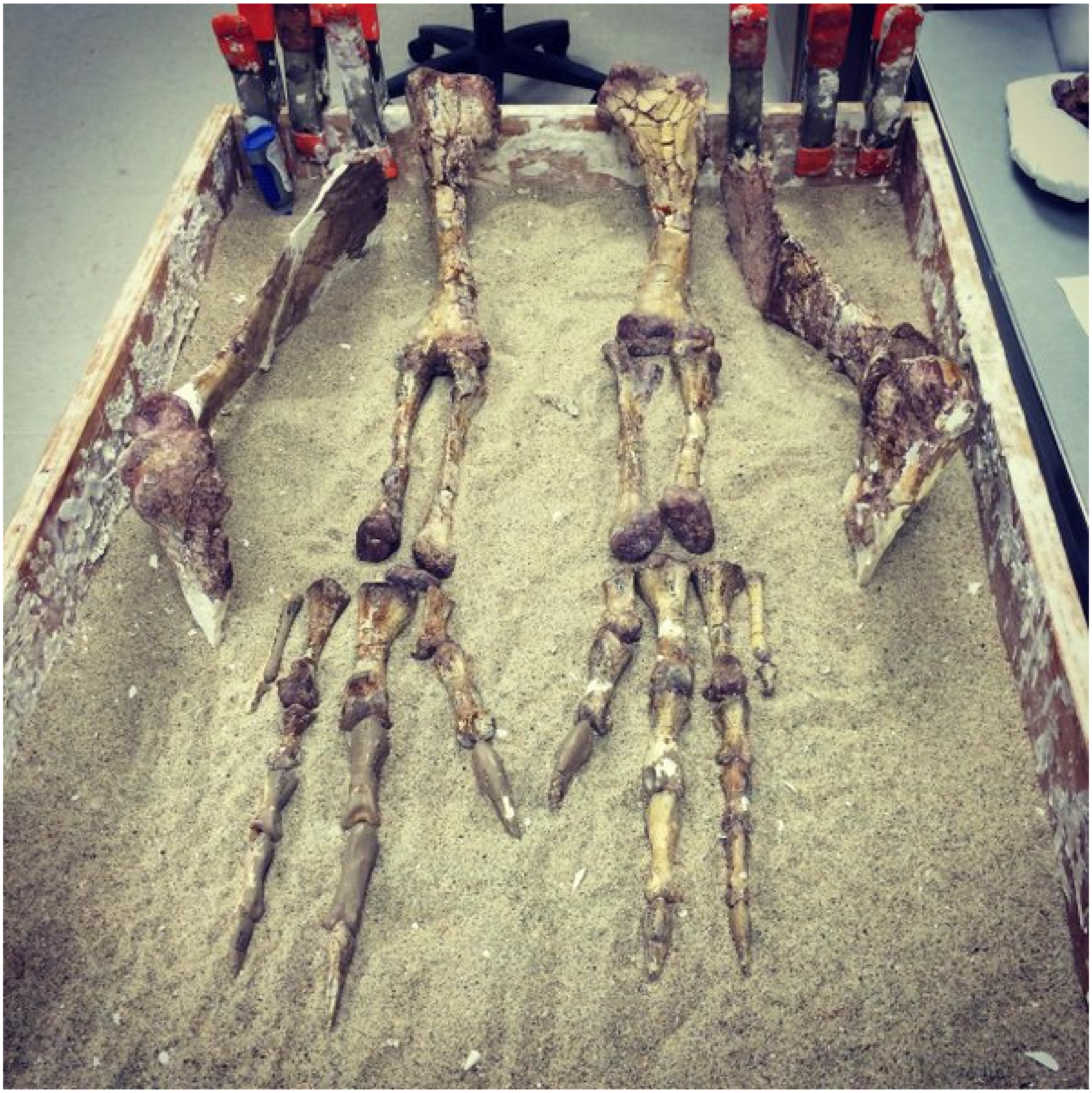
With these new data, Adam performed a phylogenetic analysis using each specimen as an OTU, or operational taxonomic unit. He did this sequentially by starting with just the holotype specimen, then the paratype, and so forth, adding each additional specimen until all UCMP and TMM specimens were included in his matrix. What he found was that all specimens show up as more derived than Cryolophosaurus and just outside of Averostra. Even more significantly, they end up forming a monophyletic group by themselves. What we have been calling Dilophosaurus since the latter half of the 20th century appears to represent a valid fossil taxon. Suggestions of systematic or sexual differences, Adam said, are better explained as ontogeny and individual variation within a single taxon. This is a point that I agree with; I said the same thing in 2005 but I was approaching the problem in a different way than Adam has tackled the issue.

Hindlimb of Dilophosaurus

Another interesting point that Adam raised is that Dilophosaurus is now known from a much larger portion of the Kayenta Formation. Welles' specimens were found very low in the section while the TMM material was recovered fairly high up. At least one of the TMM specimens was recovered from the Sarahsaurus type quarry near Gold Spring, in what is called the "middle third" of the formation. Some of the work that Adam is doing focuses specifically on figuring how much time this stratigraphic interval represents. By measuring stratigraphic sections and tying in the specimens that have been found, Adam hopes to see how these animals are related in time and space.

The tail bones of Dilophosaurus

What lies in store for our friend Dilophosaurus in the near future? Adam wants to do some more laser ablation ICP-MS detrital zircon dating. His preliminary results suggest an age significantly younger than previous reports. He also wishes to study fossils that have previously been closely related to Dilophosaurus in past phylogenetic analyses. This will be especially useful for testing how theropod traits were acquired and modified in the early history of the clade, as well as for understanding how theropod dinosaurs acquired their large body sizes after the end-Triassic mass extinction. Outside of just Dilophosaurus, Adam is working on revising anatomical descriptions and systematic placements of some important but poorly understood Early Mesozoic taxa, such as Chindesaurus (a herrerasaurid from the Late Triassic of Arizona and New Mexico) and Sarahsaurus (an early sauropodomorph also known from the Kayenta Formation). By looking at his revised phylogenies and updated U-Pb dates for the Kayenta Formation, Adam hopes to be able to test ideas on vicariance and dispersal for the various North American saurischian clades as they recovered from the Triassic/Jurassic extinction.



The forelimbs of Dilophosaurus

Rob hoping that Jurassic Park was wrong in the venom-spitting reconstruction of Dilophosaurus

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