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Therizinosaur—Mystery of the Sickle-Claw Dinosaur

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Figure. 1 How did this dinosaur get buried in mud at the bottom of the Cretaceous Western Interior Seaway? One hypothesis: Lost at sea, perhaps swept away by winds or change in currents, flailing about to protect itself from plesiosaurs and sharks until it could no longer stay afloat. An alternate hypothesis: Bloat and float. Illustration by Victor Leshyk.

Mission

To inform and advise the public about the geologic character of Arizona in order to increase understanding and encourage prudent development of the State's land, water, mineral, and energy resources.

Activities

Public Information

Inform the public by answering inquiries, preparing and selling maps and reports, maintaining a library, databases, and a website, giving talks, and leading fieldtrips.

Geologic Mapping

Map and describe the origin and character of rock units and their weathering products.

Hazards and Limitations

Investigate geologic hazards and limitations such as earthquakes, land subsidence, flooding, and rock solution that may affect the health and welfare of the public or impact land and resource management.

Energy and Mineral Resources

Describe the origin, distribution, and character of metallic, nonmetallic, and energy resources and identify areas that have potential for future discoveries.

Oil and Gas Conservation Commission

Assist in carrying out the rules, orders, and policies established by the Commission, which regulates the drilling for and production of oil, gas, helium, carbon dioxide, and geothermal resources.

Figure 2: The western shore of the Cretaceous Western Interior Seaway 93 million years ago, roughly the Cenomanian-Turonian boundary. Illustration by Ron Blakey (Dept. of Geology, Northern Arizona University).

Plesiosaurs, mosasaurs, huge predatory fish, and a variety of sharks patrolled the seas 93 million years ago in modern northern Arizona and surrounding states. Ammonoids and nautiloids drifted with the currents, sinking to the depths by day and rising to shallower water at night under the protective cover of darkness.

The Late Cretaceous seas had submerged the interior of the North American continent from the modern Gulf of Mexico to the arctic, its western shoreline fluctuating with rise and fall of sea level in western New Mexico, eastern Arizona, and eastern Utah. Biodiversity in these warm marine waters was high and our knowledge of this fauna is extensive, but knowledge of terrestrial faunas during this time is meager worldwide. Active tectonism produced several structural basins in the Early Cretaceous, setting the stage for the accumulation of thick wedges of sediments shed from the uplands in the Cenomanian and Turonian. The Zuni Basin in eastern Arizona and western New Mexico, and the Kaiparowits Basin in southern Utah promise to yield a continuing wealth of new fossils from the Lower and Upper Cretaceous of the American West.

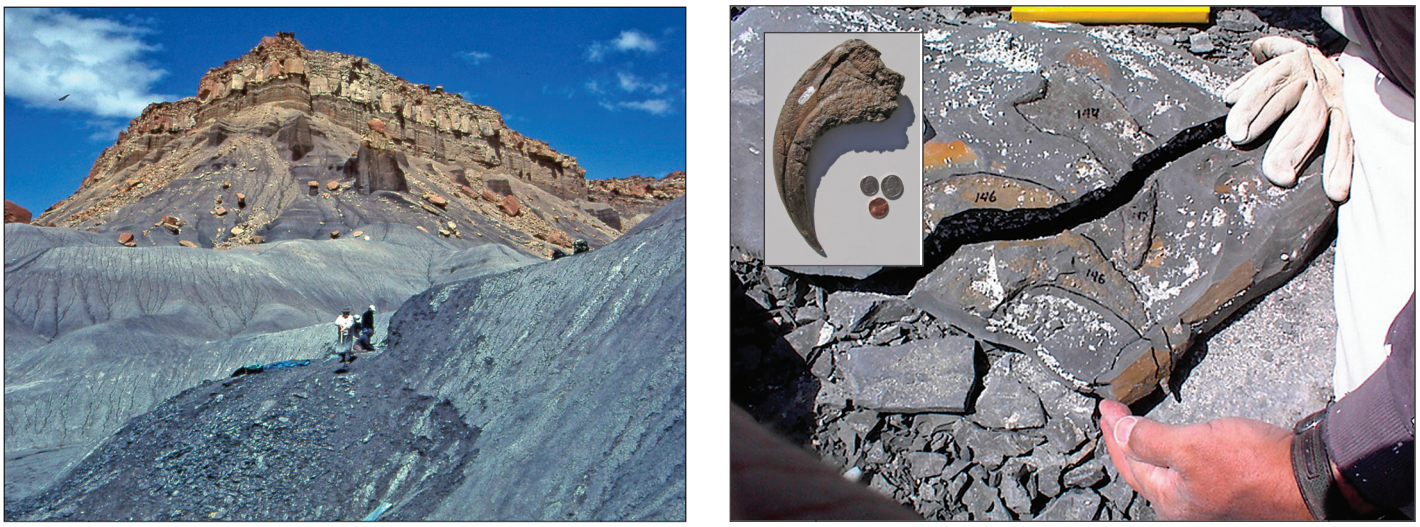

Figure 3. Left, the therizinosaur site in southern Utah, early in the excavation. The notch in the hillside extended considerably farther to the right by the time the excavation was completed. The base of the notch marks the horizon that contained the bones, in the lower part of the Tropic Shale. Cliff-forming sandstones above the Tropic Shale are the lower part of the Straight Cliffs Formation. These two formations as shown here represent maximum transgression and subsequent regression of the sea. Right, two claws from the hand in the shale matrix, outlined with marking pen, and one claw after laboratory processing (inset). Both photos by Dave Gillette.

The Mancos Shale and correlative formations of the Colorado Plateau hold the secrets to this watery history of the North American heartland. An arm of the Cretaceous Western Interior Seaway extended across northeastern Arizona and southern Utah, its shoreline reaching as far west as modern Cedar City, Utah. Sediments deposited in the Kaiparowits Basin accumulated as marine mud deposited in quiet water. Its rich invertebrate fauna includes abundant mollusks that permit remarkable precision in dating individual beds of the Tropic Shale (Late Cenomanian-Early Turonian). In addition, water-laid ash beds interrupt the stratigraphic succession of these beds, in turn permitting independent correlation of one site to another.

Museum of Northern Arizona paleontologists began excavating early Turonian plesiosaurs from the Tropic Shale in southern Utah in 1999. None were complete, but some were partial skeletons with remarkable preservation. During the next six years, our field crews recovered more than a dozen partial skeletons of plesiosaurs and a variety of sea turtles, fish, and sharks in the area just north of the Arizona border in southern Utah immediately west and north of Lake Powell. Near the small community of Big Water, Utah, local residents call the landscape "The Moon" for its spectacular cliffs and dry, barren washes carved by erosion in the Dakota Formation, Tropic Shale, and Straight Cliffs Formation.

A lucky discovery by Big Water resident Merle Graffam stunned the MNA crew in the year 2000, following the successful excavation of the skeleton of a large plesiosaur in The Moon of Big Water. It was a toe bone, too large to be from a plesiosaur. It was clearly a dinosaur toe bone, but its location was far from the western shoreline of the Cretaceous Western Interior Seaway a hundred kilometers to the west. Dinosaurs only lived on land. Here was a bone in the midst of a rich marine fauna, entirely out of place.

Well into the excavation that followed, we were astonished with the realization we had uncovered the skeleton of a sickle-claw dinosaur, till then known only in Asia, and only from partial skeletons. The iconic dinosaur, *Therizinosaurus cheloniformis*, a giant sickle-claw dinosaur from Mongolia, epitomizes the group and their enigma: A misnamed giant among giants, a bizarre member of a misunderstood and misplaced family, bearing claws on the hand recalling Edward Scissorhands, the central character in a modern movie. When it was discovered by Mongolian paleontologists in the 1950s, its claws were so unusual they concluded uneasily it was a giant turtle. Their name for these bones of the forelimb bears testimony to that conclusion (*Therizinosaurus* = "sickle-claw reptile"; cheloniformis = "turtle-form"). Later discoveries revealed their understandable mistake: This animal was a dinosaur, not a turtle. Now the name can be loosely translated as "sickle-claw dinosaur."

For three decades paleontologists debated the ancestry of the therizinosaurs. As new discoveries added to the body of knowledge of these strange dinosaurs, classifications explored a variety of possibilities. For a long time the therizinosaurs were tentative members of the group of dinosaurs called the "Prosauropoda," long-necked and largely bipedal dinosaurs that bear a faint resemblance to the Sauropoda (also known as the "long-neck dinosaurs" in the media). With new discoveries in Asia in the 1980s and 1990s assignment to the Prosauropoda became less and less acceptable. Only recently therizinosaurs were recognized as members of the Theropoda, the name given to the entire group of predatory (carnivorous) dinosaurs.

To muddy the waters even further, we now know these terrestrial dinosaurs had but meager defense on land or in water, with decidedly weak skull and jaws, pitifully small teeth, a huge pot-belly, broad hips, powerful but cumbersome legs, and a short tail. These

relatives of the mighty *Tyrannosaurus rex* and the media favorite *Velociraptor* bore a seemingly singular distinction among all predatory dinosaurs: they preyed on plants.

In a remarkable coincidence that could not have been scripted for a Hollywood movie, another team of paleontologists had discovered therizinosaur bones in the Zuni Basin of westernmost New Mexico, associated with the newly described skeleton of an early ceratopsian (horned dinosaur) they appropriately named *Zuniceratops*. Leaders of that field crew Jim Kirkland and Doug Wolfe puzzled over their discovery, too, and accumulated sufficient information about their therizinosaur to publish the name *Nothronychus mckinleyi* (loosely, "McKinley's sloth claw dinosaur"). Their publication in 2001 was the first to describe a sickle-claw dinosaur from North America. Amazingly, the therizinosaur skeleton that our MNA crew excavated in 2000 and 2001 belongs in the same genus. Their partial skeleton included the ischium, one of the bones of the hip, a bone so unusual there could be no doubt about its identification as a therizinosaur.

Merle Graffam's discovery led to the excavation of a much more complete skeleton that would further elucidate the anatomy of this odd dinosaur. The skeleton from The Moon of Big Water lacks the skull and jaws, but nearly all other bones of the skeleton are represented. Some are fragmentary, a few elements are missing (for example, some of the toe bones and ribs), and many of the bones were badly crushed due to compression from burial. Laboratory processing of the bones took an additional four years. Now the skeleton has been fully prepared, and it is the central figure of a new exhibit at MNA, "THERIZINOSAUR—Mystery of the Sickle-Claw Dinosaur" that opens September 16, 2007 in Flagstaff.

This new species from The Moon of Big Water is closely related to *Nothronychus mckinleyi*, its new name not yet published. It is a little older (by about a half million years) and a little heavier than its close relative from the Zuni Basin. This sickle-claw dinosaur measures about 4 meters (roughly 14 feet) from tip of snout to the tip of the tail in a standing posture, and more than three meters tall (ten feet) when standing erect. Its heavy body surely weighed close to a metric ton (2400 pounds), at least with its pot-belly full of food. How did this ungainly relative of the otherwisesleek and agile carnivorous dinosaurs make a living? How did they use their sharp, sickle-shaped claws, three on each hand? What did they eat? How did one skeleton come to rest 100 kilometers from shore in the muddy bottom waters of the interior seaway? Bloat and float? Marooned at sea? Does this genus have close relatives in Asia? Did therizinosaurs originate in Asia and expand across the northland to North America, or originate in North America and expand and diversify in Asia?

The exhibit explores these mysteries, with a mounted skeleton constructed of casts of the real bones of the dinosaur from The Moon of Big Water, and the real bones themselves in a re-creation of the excavation as they were recovered as an in situ display. Large pterosaurs like *Pteranodon* and toothed birds such as *Ichthyornis* ruled the skies over the Cretaceous Western

Figure 4. Mounted skeleton of *Nothronychus*, the sickle-claw dinosaur from the Tropic Shale of southern Utah. The small head, tiny teeth, massive claws on the hands, expansive belly, broad hips, and short tail distinguish this dinosaur from all of its carnivorous relatives. Height as mounted is about 8 ½ feet, but would be 13 feet tall in a more erect posture.

— continued on page 5

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Interior Seaway, and plesiosaurs and sharks ruled the seas. The exhibit features the spectacular artwork of Victor Leshyk, Brian and Eric Gold, and Ron Blakey who with several others bring life to this window in our remote and largely forgotten past.

To add mystery to the puzzle, a team of paleontologists from the University of Utah and the Utah Geological Survey recently described still another therizinosaur (*Falcarius utahensis*), this one much older and much smaller than *Nothronychus*, from the Lower Cretaceous Cedar Mountain Formation of eastern Utah. At this rate of discovery, we can predict (tongue-in-cheek) that by the end of the decade North America will rival Asia in therizinosaur diversity if not abundance!

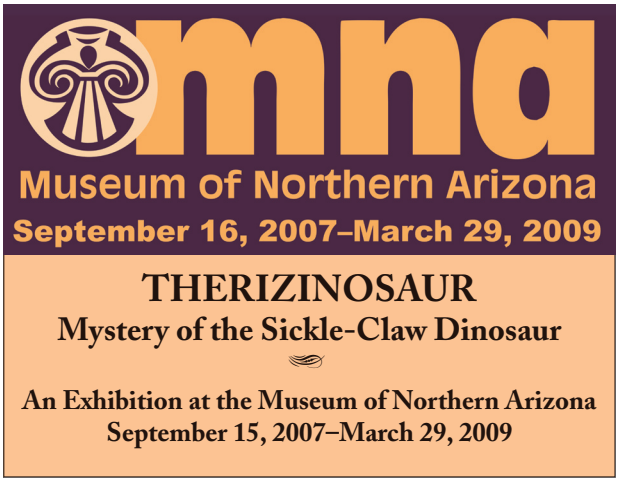


Figure 5. Reconstruction of Nothronychus on land. Although volcanoes are a cliché in dinosaur art, volcanic ash in the Tropic Shale indicates proximity of tectonic activity on land where these dinosaurs lived. Several Pteranodon soar safely overhead. Illustration by Victor Leshyk.

New Publications

Brown, D.E., 2007, Clifton Hot Springs, Arizona: GRED III Final Report. CR-07-A, 37 p.

Lindsey, D.A. and Van Gosen, B.S., 2007, Surficial Geologic Map of the Mount Hopkins and northern part of the San Cayetano Mountains 7.5' Quadrangles, Santa Cruz and Pima Counties, Arizona. CM-06-A, 1:24,000 scale.

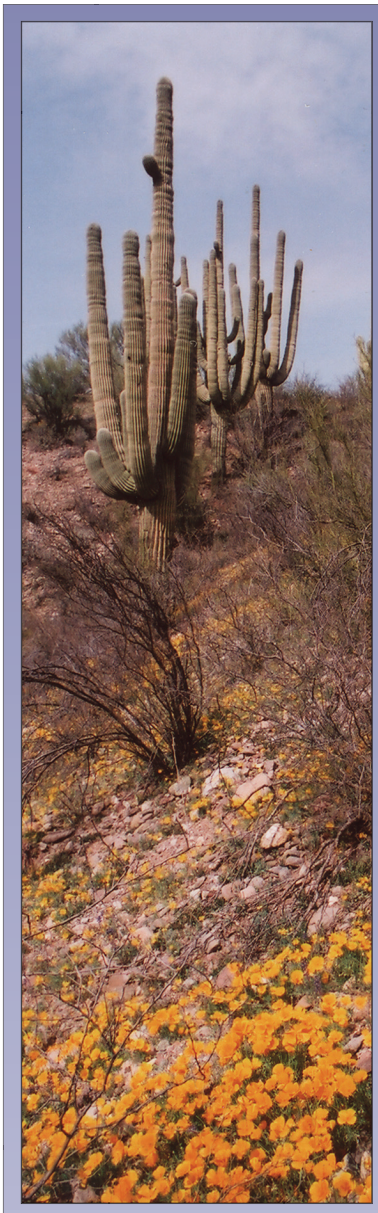
Rhys-Evans, G., 2007, Geology of the Bloody Basin: Central Arizona's Transition Zone. CR-07-B, 1:24,000 scale, 121 p.

Richard, S.M, Shipman T.C., Greene, L.C. and Harris R.C., 2007, Estimated Depth to Bedrock in Arizona, DGM-52 v.1. 1:1,000,000 scale, 6 p.

Spencer, J.E., Ferguson, C.A., Pearthree, P.A. and Richard S.M., 2007, Geologic Map of the Boundary Cone 7.5' Quadrangle, Mohave County, Arizona. DGM-54, 1:24,000 scale.

Youberg, A. and Spencer J.E., 2007, Geochemical fingerprint of a Plio-Pleistocene tephra in California Wash in the Benson area, San Pedro River Valley, southeastern Arizona. OFR-07-02, 13 p.

For pricing see Publications & Maps @ www.azgs.az.gov



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