SCIENCE

Utah's 'Grand Staircase' Leads Back in Time to Dinosaur Shangri-La

By JENNIFER PINKOWSKI JULY 20, 2015

A segment of a duck-billed dinosaur's tail, embedded in sandstone, found in an extraordinary part of Utah's Grand Staircase monument called the Kaiparowits Plateau. Cory Richards/National Geographic

KANAB, Utah — On a stormy day in southern Utah last summer, the paleontologist Alan Titus wandered from the roadside, hot, wet and annoyed. A team from California was supposed to assist him in a ground survey of the craggy, buggy badlands of Utah's Grand Staircase-Escalante National Monument. But his colleagues had bailed because of the lousy weather.

His eyes scanned the flat ground near Wahweap Creek, about 200 yards from one of the few roads that wind through the Grand Staircase's remote and rugged 1.9 million acres. Dr. Titus had walked this area before and found nothing.

This time, however, the skull of an adult tyrannosaur peered up at him. Nearby, Dr. Titus spotted something else: a tyrannosaur toe bone.

From their terrifying seven-inch teeth to their comically disproportionate arms, tyrannosaurs loom large in the public imagination. But these ancient predators are quite rare in the fossil record.

By December, the bones of the excavated tyrannosaur lay encased in plaster in a lab here, awaiting closer analysis. "It was the find of my lifetime," said Dr. Titus, a paleontologist with the Bureau of Land Management.

Ian Miller, a paleobotanist at the Denver Museum of Nature & Science looking for fossilized plants in the Kaiparowits Plateau. Cory Richards/National Geographic

But it is just one of the many extraordinary discoveries made here. In the past 15 years, Dr. Titus and his colleagues at the bureau — along with the Natural History Museum of Utah, the Denver Museum of Nature & Science and hundreds of volunteers, interns and researchers — have excavated tens of thousands of fossils from an extraordinary part of the Grand Staircase monument called the Kaiparowits Plateau, a 50-mile-long, high-elevation ridge.

One of the richest troves of fossils from the Late Cretaceous Period, the Kaiparowits is providing a window into the hothouse world that was home to the dinosaurs in their twilight, about 10 million years before their sudden extinction.

There are a number of well-preserved Late Cretaceous sites in the western United States, including New Mexico's San Juan Basin; the Judith River, the Two Medicine region and the Hell Creek formation in Montana; and Dinosaur Provincial Park in Alberta, Canada. But the Kaiparowits stands out for the sheer number of well-preserved, unique fossils. Finds from this ancient ecosystem are challenging long-held assumptions about dinosaur physiology, evolution and environment.

Most fossils have been excavated from a part of the plateau called the Kaiparowits formation, a multilayered band of sandstone and mudstone dating from 76.6 million to 74.5 million years ago. Quickly deposited layers of sand and mud buried the fossils in a pristine state.

Their preservation is spectacular: articulated skeletons, fossilized skin, plants so shockingly fresh that their delicate leaves can be peeled right off the rocks. When they are illuminated beneath an epifluorescence microscope, their cuticles, or waxy leaf coverings, fluoresce bright green, revealing their cellular structures.

A turtle fossil, about 76 million years old, found at the site. Bureau of Land Management

Among the animals discovered here are 21 never-before-seen dinosaurs. Many are ceratopsids, or horned-face dinosaurs, including the ornately frilled Kosmoceratops richardsoni (named after Scott Richardson, a paleontologist with the Bureau of Land Management) and Nasutoceratops titusi (named after Dr. Titus), a herbivore with a skull seven feet long, an oversize nose and forward-facing horns.

As many as four species of horned dinosaurs lived here 77 million years ago — twice as many as have been discovered at contemporaneous sites in North America, said Scott Sampson, a paleontologist at the Denver museum, whose team has excavated in the Kaiparowits since 2004.

Hadrosaurs, or duck-billed dinosaurs, are also common in the Kaiparowits, and two new species of tyrannosaurs have been found on the plateau: the 12-foot-tall Teratophoneus curriei ("monstrous murderer"), which died 75 million years ago; and Lythronax argestes ("king of gore"), at 81 million years old the oldest true tyrannosaurid known to science.

The Kaiparowits also has yielded some of the greatest crocodile and turtle diversity in the ancient world: six crocodile species and 17 turtle species. One three-foot-long turtle discovered last summer died pregnant, her body full of eggs.

Once a Steamy, Swampy Forest

Today the Kaiparowits is a craggy expanse of shrub-covered rock and sheer cliffs with little moisture; plants hungrily shoot their roots 30 feet down to suck calcium phosphate from still-buried fossils, sometimes destroying them in the process.

By The New York Times

"We're in a constant battle with the roots," Dr. Titus said. "They find the bones hundreds of years before we do."

But 75 million years ago, the region was a steamy, swampy, coastal forest in southern Laramidia, a narrow continent stretching from Alaska to Mexico that formed about 96 million years ago when the Western Interior Seaway bisected North America, separating the land mass into two continents — Laramidia in the west and Appalachia in the east — for more than 20 million years.

Located about 60 miles from the sea in a flat basin crisscrossed by rivers, lakes and ponds, the Kaiparowits was a water-saturated, multistory forest. Giant pine trees draped with moonseed vines towered over an Everglades-wet forest floor blanketed with gingers, ferns, duckweed, water lettuce and floating, flowering plants.

"It was an extremely diverse, high biomass forest," said Ian Miller, curator of paleobotany at the Denver museum, which has collected more than 12,000 plant specimens from 75 sites in the area.

Paleontologists airlift tons of materials out of the Kaiparowits every year for further analysis. (A single N. titusi skull discovered last year by the paleontologist Joe Sertich of the Denver museum weighed 2,800 pounds.) Last summer alone, the Denver team took 10 tons of ancient plants, woods, vines and dirt from the site by helicopter to sift and screen-wash back in the lab.

Thousands of plant specimens have been collected in the Kaiparowits Plateau, some of which can be peeled right off the rocks. Denver Museum of Nature & Science

All this material supported the site's showiest residents: the dinosaurs. The Kaiparowits is "the Shangri-La of dinosaurs," Dr. Sertich said. "It gives you the opportunity to answer pretty much any question you can come up with about how dinosaurs lived and how they evolved."

One of the most intriguing questions: How did the ecosystem support so many large-bodied dinosaurs?

Giants on a Small Piece of Land

In the Late Cretaceous, southern Utah was home to nine species of animals that weighed well over 2,000 pounds as adults. Compare that with present-day Africa, which supports only a handful of animals that big: elephants, giraffes, hippopotamuses, buffaloes and rhinoceroses.

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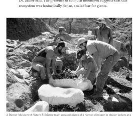
"It's a tiny land mass," Dr. Sampson said of the plateau. "How did you get so many giants in such a small piece of real estate?"

The answer may lie in the leaves, specifically those from the moonseed family. Found in abundance in the Kaiparowits, the heart-shaped moonseed leaves indicate the presence of a dense vine system in the Late Cretaceous.

Today, forests with the highest biomass have "tons and tons" of vines, Dr. Miller said. The presence of so much moonseed suggests that this ecosystem was fantastically dense, a salad bar for giants.



A Denver Museum of Nature & Science team encased pieces of a horned dinosaur in plaster jackets at a new site on the Kaiparowits last year. Denver Museum of Nature & Science

"To get that many bigger-than-hippo-sized herbivores living in a small space, you need an incredible plant ecosystem to support them," he said. "This is unprecedented in the Cretaceous. We've never seen a forest that was so heavily dominated by vines in the fossil record really anywhere on the planet."

The scientists say their finds back the somewhat contentious theory of dinosaur provincialism, which proposes that the animals lived in latitudinal provinces or regional bands where they diversified into distinct species finely attuned to their local environments.

There is little evidence in the geological record of a physical barrier that would have prevented north-south dinosaur migration in Laramidia, further confirmation, some experts say, that the inhabitants were adapted to a narrow ecological niche.

The large number of ancient species discovered in the Kaiparowits "is providing really strong evidence that dinosaur communities and species were very provincial about 75 million years ago," said David Evans, a paleontologist with the Royal Ontario Museum who studies dinosaur diversity in the Late Cretaceous Period at Dinosaur Provincial Park.

"It looks like the differences in the dinosaur fauna between Montana, Alberta and Utah are driven by relatively small-scale ecological differences and fine-scale habitat preferences."

Utahceratops gettyi, top, and Kosmoceratops richardsoni, bottom, were two of nine large dinosaurs discovered in the region. Lukas Panzarin

Specialized adaptation might have eventually posed a problem for these locavores, who might not have easily weathered changing environmental conditions, fluctuating temperatures and changes in sea level common in the last 10 million years of the Cretaceous.

This could explain why fewer big dinosaurs are found in the fossil record as it approaches the mass extinction around 66 million years ago, after which mammals diversified and thrived.

But not everyone is convinced these dinosaurs were so deeply rooted in particular habitats. "That's a good story," said Spencer Lucas, a paleontologist at the New Mexico Museum of Natural History & Science who has excavated Late Cretaceous sites in the San Juan Basin. "But do I believe it? The jury is still out."

Dinosaur provincialism, he said, often reflects the approach of "splitter" paleontologists too eager to separate dinosaurs into different species.

Paleontologists working the Kaiparowits hope their finds also may shed light on the greatest dinosaur mystery: their sudden disappearance.

"What was going on before that major extinction, and what happened in its aftermath?" Dr. Titus said. "How did it lead to our modern world?"

The area, Dr. Evans said, is adding to our knowledge of ancient western North America, which "is really our only high resolution window into the time period leading up to and through the extinction of the dinosaurs and into the age of mammals."

He added, "This is really the only place we can study the causes of dinosaur extinction in any detail."

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