Northern New Mexico was a hothouse 212 million years ago, with just a few carnivorous dinosaurs (like the one in the background) and lots of early crocodile relatives (*foreground*). VICTOR LESHYK

Raging fires, high temps kept big dinosaurs out of North America for millions of years

By Michael Balter | Jun. 15, 2015 , 3:15 PM

GHOST RANCH, NEW MEXICO—The flaming red cliffs of this sprawling estate in northern New Mexico present a major mystery to the dozens of paleontologists who come here every summer to dig up some of the oldest dinosaurs known in North America: The earliest definitive dinosaurs arose sometime between **245** million and **230** million years ago at high latitudes in the Southern Hemisphere, yet none appeared in North America and other then-tropical regions for another 30 million years. What kept them out?

Now, an interdisciplinary team of paleontologists, geologists, and other scientists suggests a dramatic answer: During the Late Triassic period between about 215 million and 205 million years ago, Ghost Ranch and other dinosaur-rich locations in North America were subject to carbon dioxide levels many times higher than today's. These regions, which were much closer to the equator back then, at about the latitude of today's southern India, were subject to raging wildfires and extreme fluctuations in temperature and vegetation growth. All of this made life inhospitable for larger, energy-hungry dinosaurs, the team argues online today in the *Proceedings of the National Academy of Sciences.* The researchers say their work is the **first large-scale study** to correlate multiple indicators of prehistoric climate with an extensive fossil record of both early dinosaurs and related species.

Ghost Ranch, a favorite of filmmakers as well artist Georgia O'Keeffe, who painted its dramatic landscape hundreds of times, has been a fossil haven since the 1940s. That's when paleontologists began finding a number of small meat-eating dinosaurs at various locations within the 8500-hectare site, including specimens of a slender, 3-meter-long carnivore called *Coelophysis*, which is on proud display at the ranch's paleontology museum. In 2005, a new team of paleontologists, including Randall Irmis, now at the Natural History Museum of Utah in Salt Lake City, began digging at an outcrop known as Hayden Quarry, unearthing thousands of fossil bones that quickly turned into **one of the most important collections of dinosaurs and related vertebrates in the world**, dated to between 205 million and 215 million years ago. During a recent visit, little dinosaurs and related critters seemed to be practically oozing out of the sandy red soil.

Nevertheless, only about 15% of the vertebrates found at Ghost Ranch are actually dinosaurs; most of the rest belong to the lineage that would later give rise to crocodiles and alligators. And although larger, long-necked plant eaters—the ancestors of great beasts such as *Brontosaurus* and *Diplodocus*—were already thriving farther

north and south of the equator at this time, none have been found at Ghost Ranch or any other site closer to the equator dated to that time period.

Paleontologists “haven’t found a single [plant-eating] dinosaur” near the equator during the Triassic,” Irmis says, whereas in areas much farther south and north of the equator in South America, southern Africa, and Germany, thousands of such fossils have been uncovered.

To figure out why, the team sampled rock from Hayden Quarry and other locations at Ghost Ranch and analyzed their isotopes to figure out the levels of carbon and oxygen in the atmosphere at the time the sediments had been deposited by flowing rivers and streams during the Late Triassic. The researchers also isolated charcoal and fossil pollen and spores from the rocks, giving them a profile of the vegetation in the area between 215 million and 205 million years ago.

They found that Ghost Ranch was a hothouse during the Late Triassic, with mean annual temperatures as high as about 28°C. Carbon dioxide levels ranged between about 1200 and 2400 parts per million (ppm), many times higher than the already alarming 400 ppm Earth is experiencing today and the estimated 280 ppm just before the Industrial Revolution. Plants fluctuated widely, with ferns sprouting during wetter conditions and conifers such as pines thriving during drier periods. Microscopic measurement of the amount of reflected light the charcoal gives off, which can be used to determine the temperature at which the wood burned, indicated that forest fires burned at up to 680°C.

“Our findings demonstrate that the tropical climate swung wildly with extremes of drought and intense heat,” says lead author Jessica Whiteside, a geochemist at the University of Southampton in the United Kingdom. The intense wildfires, she adds, “swept the landscape” during dry periods and constantly “reshaped the vegetation available” for large, fast-growing, plant-eating dinosaurs—although the much slower growing crocodile relatives were able to survive it. That kept dinos from getting a foothold in North America and other low latitude regions until the Triassic had ended and the more climatically stable Jurassic period had begun, about 200 million years ago, the team argues. That so-called Triassic–Jurassic boundary also marked the beginning of the dinosaurs’ dominance of the entire world, and the extinction of most of the early crocodile relatives and other nondinosaur reptiles that had thrived up until then.

The team’s interpretation of climatic conditions at Ghost Ranch “are certainly convincing,” says Michael Benton, a paleobiologist at the University of Bristol in the United Kingdom. Nevertheless, he says, the researchers’ conclusion that plant-eating dinos were at an early disadvantage because they were particularly energy hungry depends on the assumption that they were warm-blooded whereas other reptiles were cold-blooded, “a **pervasive idea** that has not been entirely established.”

And Hans-Dieter Sues, a paleobiologist at the Smithsonian Institution’s National Museum of Natural History in Washington, D.C., cautions that although the new study is a “very important contribution,” it focuses on “a single restricted area. We need comparable information from a wider range of sites to test their generality.”

Nick Fraser, a paleontologist at National Museums of Scotland in Edinburgh, agrees: “No one locality or region can be regarded as the Holy Grail, but this is an excellent starting point.”

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