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EVOLUTION

Chilean and Antarctic Fossils Reveal the Last "Geologic Minutes" of the Age of Dinosaurs [Slide Show]

The analysis of large outcrops and beds with the remains of dinosaurs, marine reptiles and plant life suggests there were connections between Antarctica and South America long before the current Cenozoic era, as it is commonly accepted

By Ángela Posada-Swafford on April 11, 2016

Researchers must drive several hours from Puerto Natales to Estancia Cerro Guido, then drive a jeep on a dirt road to Las Chinas post. From then on, it is a six-hour walk to the El Puesto excavation site, crossing hilly tussocks and small streams.
Pablo Ruiz, INACH

The geometric shapes of plateaus, peaks and outcrops of bare brown rock look over endless valleys of olive-yellow grasslands. Their austerity and majesty—along with the herds of guanacos and wild horses—announce that this is a decidedly Patagonian landscape. At the top of one of the hills Marcelo Leppe contemplates the slope of loose soil at his feet. It is covered with clear stones arranged haphazardly. The sunset's oblique light illuminates the pieces protruding from the sands, suddenly revealing their true identities.

Many of them are disarticulated fragments of fossils—hundreds and hundreds of them. Rib cage tips, rounded femur heads, slivers of vertebrae ranging from a few centimeters to a meter long. Beneath the surface, one imagines larger, more complete pieces. It is a bed of hadrosaurs, herbivorous dinosaurs belonging to the duck-billed family, extending for seven kilometers. "Something big happened here," says Leppe, a paleobotanist and chief scientist at the Chilean Antarctic Institute (INACH), who since 2012 has been excavating and analyzing Chile's most important dinosaur and plant fossil repository—and in some respects South America's—with an international, interdisciplinary team. "There were thousands of animals whose bones are partially burned; perhaps they were victims of a paleo-wildfire. It's somewhat strange."

The hadrosaurs are the southernmost dinosaurs yet discovered on the continent, and are only the beginning of the story. Indeed, the excavation sites of El Puesto, Las Chinas and Cerro Guido, part of the Dorotea and Cerro Fortaleza formations near the border with Argentina, are a kind of "Rosetta stone" to the end of the Cretaceous period: They are providing an unprecedented resolution view to the Campanian and Maastrichtian stages, between 72 million and 66 million years ago, geologic minutes before the fatal impact of the Chicxulub meteorite. "This here is a very extensive marine and terrestrial record of what until now was a missing part of the story, and it speaks of a very active time of new species, competition and distribution of organisms," Leppe says.

The large number of fossils includes the remains of titanosaurid sauropods (the largest in Chile), marine reptiles, wood, pollen, rarely seen flowers in perfect shape as well as the oldest fossil leaves in South America of the *Nothofagus* tree (a genus belonging along with oak, coihue and lenga to the Fagaceae family) among 40 other plant species. Thanks to these sequences, Leppe's group is rebuilding the biogeography, along with the environmental and geologic conditions not only of the tip of South America but of the Antarctic Peninsula in an era of climate change, when both continents were forming their modern geography.

One of the most dramatic effects of the changing climate at the end of the Cretaceous was the fluctuation in sea level, which fell at least 25 meters within just a million years. On several occasions, when the ocean receded it left land bridges between the continents, acting as stepping stones over the ancient rocks of the ancient supercontinent Gondwana.

The fossils Leppe and his team are finding in Patagonia and in Antarctica's James Ross Basin and the South Shetland Islands support theories that the sea level fell at least three times, following three consecutive cold pulses 73 million, 70 million and 68 million years ago. And they establish connections between Antarctica and South America much before the Cenozoic, the era of the ascendency of mammals, as it is commonly accepted. "These cooling events are of interest to us specifically because they help explain that land bridges were not just corridors allowing the exchange of fauna and flora but places where perhaps species evolved," explains Leppe one icy afternoon, sitting before a wood-burning stove at a shelter that has seen better days. "So, here comes to play the new paradigm that climate change, and not only plate tectonics, is one of the mechanisms governing evolution in terms of new niches and species."

The richness of what has been discovered is keeping the 25 experts (and counting) from Chile, Brazil, Germany, Argentina and Japan busy; they have

about three weeks each summer to comb these mountains for snapshots of the past. The dig sites are in the middle of the 100,000 hectares belonging to the private enterprise of the Estancia Cerro Guido.

The team, funded largely by Chile's National Commission for Scientific and Technological Research, includes experts in paleomagnetism, pollen, plants, geology, dinosaurs and marine reptiles. The study will extend for several years, and it is already working on biostratigraphy, paleodiversity, past climate using plant fossils as well as isotopic analysis of strontium, carbon and oxygen. It will also look at microglendonites (hydrated crystals forming in marine environments) among other lines of investigation taking place at research centers in those five countries, and soon in the U.K.

TRAVELERS IN TIME

Walking along the endless hillsides, valleys and Patagonian summits, paleontologists are moving in geologic time: By advancing or retracing just a few dozens of meters, they go from the Campanian to the Maastrichtian stage, and by crossing over to the next hill they land in the Cenozoic. They also move between the land and the sea, because marine and terrestrial sediment sequences overlap in some places, the result visible in light- and dark-brown veins. "These clearly are marine transgressions and regressions because this area was sensitive to the tides—the ebbs and flows of the ocean obeying climate change," says Gerson Fauth, a geologist at the University of Vale do Rio dos Sinos (Unisinos) in Brazil, pointing at the outcrop. "We look for chunks of soil containing foraminifera and other microfossils because those are excellent indicators of the marine conditions in which they lived, so we do thorough characterization and dating studies," he explains.

His colleague at Unisinos and compatriot, paleobotanist Thiérs Wilberger, on the other hand, cannot contain his emotion while recalling his discovery, three

days earlier, of a small flower in strikingly perfect condition which could be 72 million years old and belong to the Solanaceae family. “This is something quite rare because flower petals are delicate, and to find one as old and as well preserved, it is a gift,” he says. “I was gently opening thin layers of sediment with my rock pick, as though they were the leaves of a book. And when I saw it, I had to take a breath, get away momentarily and allow my heart to slow down and my eyes to dry out,” he recalls.

Why the fossil record of the planet does not show flowers prior to 120 million years ago is something that Darwin himself called “the abominable mystery of angiosperms”; flowering plants suddenly exploded in the Cretaceous period and went on to dominate the world until today. Under the original flower, Wilberger found another layer filled with many others, “as if they had fallen yesterday from the tree,” he notes.

“The flower is wonderful, and we are describing it, but one of the key evidences in the theory of the land bridges between Antarctica and South America are the *Nothofagus* leaves, which we found on both continents,” Leppe adds. Paleobiological analysis of this ancient plant reveals that its seeds are intolerant to seawater and the wind will not disperse them over long distances. In other words, *Nothofagus* needs solid ground in order to move forward. “Not far from here, in the area known as El Puesto, we found the first fossilized leaf of this genus, and the oldest one in South America so far,” he adds, gesturing toward the horizon. “It is 68 million years old and looks quite modern in its features. It belongs to the same family of lengas, ruiles and coihue trees that now inhabit Patagonia and New Zealand. At the same time, Tania Lindner Dutra, also at Unisinos, found in Antarctica the oldest *Nothofagus* leaves so far. Their exact age is being analyzed with radiometric methods in Germany but they fall somewhere around 83 million to 81 million years.”

The *Nothofagus* dispersion all the way to New Zealand, however, still requires a satisfactory explanation because of the lack of land bridges between New

Zealand and Australia that can justify the presence of fossils in both places. “Not everything is inside the bag,” says Leppe, laughing. “On the other hand, last year in Nelson Island, Antarctica, we found a bed of the largest and best preserved *Nothofagus* leaves yet; they are close in age those of those of Tania Dutra’s. The leaves are 15 centimeters long, adapted to warm conditions, therefore high sea level, so they probably lived in a moment of disconnection [between] South America–Antarctica. The following *Nothofagus* in our history are the ones here in Cerro Guido. Those leaves are not very large, therefore there is correlation with colder weather.”

Forensic work has revealed one more surprise: at the end of the Cretaceous, the Antarctic forest and that at the tip of South America were quite similar to the modern forests of Valdivia, Chile, and those in southern Brazil. In addition to the *Nothofagus,* the past and the present share the families Araucarias, Podocarpaceae (conifers), Proteaceae (angiosperm), Licopodiaceae (vascular plants) and Equisetaceae (horse tails). It is easy to imagine a titanosaur slowly navigating among them, perhaps chewing on a mouthful of flowers. “Antarctica is alive today in the forests of Chile,” Leppe says. “I need Chileans to understand that this is something very special.”

At some point we are being watched by eight Andean condors, circling lazily above our heads, their white collars shining in the afternoon light. Occasionally one of them drops from the sky toward those researchers who have spent some time lying face-down as they rest on the hillside. “They come to see if we are dead,” Leppe points out. "Sometimes they approach so [close] that we can see their eyes.”

Lurking condors, hours-long hikes under sacks loaded with shovels and rocks, and nights where the only thing that separates the sleeper from the cold winds of the austral spring is the delicate fabric of a tent. This is the currency that negotiates the extreme paleontology in South America’s deep south.

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