

CHAPTER ONE

**GADOUFAOUA: IN THE SANDS OF THE TÉNÉRÉ**

THERE IS A PLACE on this Earth where, simply by hopping out of your car, you risk suddenly finding yourself nose to nose with a dinosaur: a dinosaur embedded in the desert, whose spinal column, disengaged by the gritty winds from the friable sandstones that have encased it for 110 million years, is separating cleanly from the horizon between earth and sky.

At Gadoufaoua, spread over three hundred square kilometers (about 116 sq. mi.) in the south of the desert of Ténéré in Niger, there are millions of bones, dozens of dinosaur skeletons. Their diversity and quality of preservation constitute an exceptional paleontological locale, the greatest exposure of dinosaurs in Africa. It was at Gadoufaoua, in the field, that as a young beginner I learned how to study and collect dinosaurs. It was there that I experienced the dune and the *reg* for the first time.

A fortunate convergence of circumstances made me a dinosaur hunter. In December of 1964, Professor Jean-Paul Lehman, Chair of Paleontology in the National Museum of Natural History (MNHN) at Paris, invited me to pay him a visit in his office. "Invited" is the word, because no professor, no lab director, among all the talented professionals that I have ever known, was more thoughtful, more gentlemanly, more likable than he. No one else had more moral and scientific authority over the researchers in his charge. He had studied paleontology in Sweden under Eric Stensiö, the great specialist in some of the very oldest vertebrates, and was internationally renowned and revered for his learning. He also wielded a dry sense of humor with style and finesse. During his weekly lectures in his courses at the Jardin des Plantes, his excellent and

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often esoteric jokes made the second-year students burst out laughing, while the rest of the audience, comprising casual auditors and first-year students, sat stone-still, missing the keys to his puns and allusions.

Professor Lehman informed me with a smile that the geologists of the French Atomic Energy Commission (CEA), prospecting Niger in search of uranium, had just discovered some fossil bones. The CEA wanted a paleontologist to visit them in the field to identify these fossils, to ascertain (if possible) the age of the beds in which they were deposited, and eventually to determine the conditions of deposition and the environment that prevailed when these animals roamed that part of Africa.

My director, whose smile was becoming slightly malicious, suggested that I go to Niger. The CEA would pick up the airfare and costs. At 24, having just left the benches of the university, I was filled with the accounts of traveling naturalists, including the *Méharées* of the *parpailot*¹ Theodore Monod, professor of ichthyology at MNHN (“the Museum,” as I often call it) – whom I met frequently since we both lived on Port-Royal Square – and the *Lettres de voyage* of the Jesuit Pierre Teilhard de Chardin. I dreamed of the wide open spaces, of wonderful discoveries, and I wanted to put into practice an encyclopedic morass of theoretical knowledge that I had ingested at the Sorbonne over hundreds of hours of authoritative courses.

My immediate response to Monsieur Lehman’s proposal was obviously enthusiastic. But as it turned out, I was answering yes to the following question: “Do you take paleontology as your spouse and promise to serve her faithfully for the rest of your days?” The minister of this religion, Professor Lehman, with one more malicious smile, opened his drawer, took out a plane ticket, handed it to me, and said, “Here you are. You leave in a week. Don’t forget your quinine.”

A week later, an Air Niger DC-6 landed in Agadès, Niger, as horsemen dressed all in white and blue pranced around the runway, preventing the livestock from crossing the stony plain that served as an airfield. At the foot of the gangway, a welcoming committee composed of geo-

¹ A *parpailot* is a name ironically given to Huguenots (Protestants) in France; this word comes from Old French, and it originally denoted people who went through the streets dressed in *chemises*, or long shirts. Monod, a truly remarkable and revered man (now over 95, as this is written), has explored much of the world, mostly on foot, in a quest for understanding of the natural world as well as for peace among its inhabitants. *Méharées*, the title of one of his famous books, is an Arabic word meaning a trip through the desert.

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Figure 1. The Gadoufaoua locality, in the desert of the Ténéré in Niger, where dinosaur skeletons are exposed by the constant sandy winds. (Photo by P. De Latil)

logic engineers and the heads of the mission awaited the envoy from the Museum – doubtless some old professor with bifocals and white hair. They were stupefied to encounter, coming down the gangway, a student still wet behind the ears.

A little history will help here. The discovery of traces of uranium in the region of Agadès was a by-product of the study of the copper deposits that were associated with it. From 1957 to 1961, the French overseas Bureau of Mines, then the Bureau of Geological and Mineral Research (BRGM), carried out a series of prospecting expeditions west of the granite mountain range of the Aïr, located northeast of the city of Agadès.

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It had been known for a very long time that there was copper in the area. In 1354 the great Arabian explorer Ibn Battûta had noted the copper mines at Takedda, a place perhaps two hundred kilometers (200 km \approx 125 mi.) from Agadès, in the region of Azelik. Today it's an archaeological site near a mine.

In 1957, the French geologist Imreh studied this region and noticed some blocks among the sediments that had been colored yellow and green by the oxidized salts of copper and uranium. Another geologist from the BRGM, Hughes Faure, had been drawing up a geologic map of the sedimentary formations of eastern Niger since 1954. His fieldwork brought him to the southeast of the Aïr range, where he discovered numerous remains of dinosaurs; he sent several fragments to the geologist Albert-Félix de Lapparent, an exceptional and legendary man whom we shall encounter again. In a memoir on the dinosaurs of the Sahara, he noted the potential interest that this region of Niger held for paleontologists.

Since 1958, the mining prospectors' results had led the CEA to develop an important research initiative, searching for uranium all through the south and west of Aïr. Why this uranium fever? Because France, under General de Gaulle's leadership, wanted to become a great nuclear power. For that, it needed to procure the basic, indispensable ingredient of natural uranium. Now, the sources of uranium in France are mostly concentrated as veins encased in granite, principally in France's great mountain range, the Massif Central, but it was too difficult to get enough uranium out of them to form sufficient stocks. The Americans made it so that France couldn't stock up through existing producers like Canada, and this highly strategic element could not be bought legally beyond the Iron Curtain. So the French were left to fend for themselves. There were, however, important reserves of uranium outside France, in geologic contexts that were very different from the Massif Central. It was known that the great sedimentary basins of North America were very rich in uranium, but the prospecting techniques that they used there were ultrasecret and obviously not for publication. So the French geologists had to leave the Hexagon (a nickname for our roughly six-sided country), and work out for themselves the methods of prospecting, collecting, exploiting, and concentrating uranium from sedimentary rock formations. Niger satisfied all the requirements for this undertaking. So began a great technological adventure that would be crowned with success. A small team of geologists, all from the famous school of geology

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at Nancy, were going to have to cut corners and gain the knowledge and the necessary techniques. They had to learn in record time how to exploit one of the greatest deposits of uranium in Africa. Today Arlit, north of Agadès, is the name of a mining city and of an immense open-air quarry. The research that led to the establishment of this mine, and the construction of a town in the middle of the desert more than 6,000 km (3,729 mi.) from France, was a great technological and human adventure still largely unknown to the French people, and its story should really be written some day.

After the first moment of surprise passed, the welcome from my geological colleagues from Nancy was very warm – as was the temperature, 38 °C in the shade (100 °F). They told me that we would leave for the field at dawn the next day. A French prospector and three Niger technicians were assigned to accompany me in a Land Rover and a 4 × 4 Renault truck. Visiting the little town of Agadès – its beautiful mosque, whose adobe minaret is the tallest in West Africa, its tortuous streets and its picturesque market – would be for another day.

The next day at sunrise, we took the eastern road that led to the desert of Ténéré. Within the first kilometers, the change of scenery was complete and disorienting: the granitic relief of the mountains, the shrubby bush with its acacias, the bustards, the gazelles and ostriches, the Tuaregs and their caravans of dromedaries stretching out in long strings – everything was new to me, everything enchanted me, and I plunged ecstatically into a world whose light, contrasts, and scents I had been completely ignorant of just hours before. I had been out of Paris scarcely two days.

I couldn't help thinking of Dr. Pierre Noël, a family friend whom I had visited before leaving and who had been a doctor in the colonies in 1911. He was posted to Niger and boarded ship at Bordeaux as a young man to take up his duties at Bilma, a tiny township located on the border of Niger, beyond the sands of the Ténéré, toward Chad and Libya. It had taken him seven months to reach his post and start work, after an impressive journey: Bordeaux to Dakar by ocean liner, Dakar to Kayes (Mali) by train, Bamako to Niamey (Niger) by riverboat, Niamey to Agadès on horseback over trails. The last lap of the journey, Agadès to Bilma, was made possible by the Azalaï, the great caravan of thousands of dromedaries that traveled as far as the oasis of Djado once a year to collect dates and to bring the salt that is so necessary to man and beast from Bilma to the sedentary stockbreeders of the south. During

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the journey of seven months this man – who later taught a course of study for future naturalists at the Jardin des Plantes and the Musée de l'Homme in Paris – had collected sharpened flints, neolithic pottery, and insects, cared for the wounds of men and women who had suffered the attacks and pillages of rebel tribes, and drawn up a French–Kanouri grammar, all the time protecting his precious notebooks as much as possible from the ravages of termites. Seven months of traveling for him, but only 48 hours for me, while I read the paper on a couple of planes! Yet, in those earlier days the immersion into the sands of Niger was less sudden and brutal, and certainly had its own advantages.

After some hours on a trail, we left the road to Ténéré to head east-southeast, progressively navigating the strings of dunes, *regs*, and strips of very fluid sand called *fech-fech*, where our Land Rovers sank up to their wheels. With great difficulty, we crossed immense areas covered with clods of sand 50 centimeters (cm) high, crowned with tufts of tough-stalked herbaceous plants. Progress was slow and difficult; the heat and the jolts tremendously irritated my prospector guide, who favored me with his vast vocabulary of oaths.

We rolled on for 10 hours. The cars were stuck in the sand five or six times, and I quickly learned how to haul out heavy sheets of corrugated steel, place them under the wheels, and, stretching out on the ground, use a shovel or my arms to remove the burning sand – a substance that seemed more liquid than solid, because the temperature was so high. Proceeding along, we crossed many strings of dunes and rosaries of *barkhanes*, V-shaped dunes whose lee sides fell off steeply. One false move in driving meant certain disaster. Our vehicles threaded their way among these tire traps; no trail was visible. However, I learned to decipher the alignments of dromedary droppings, which occurred in great numbers on the sands. They showed the traces of camel tracks; merely by following these rather strange road signs, somewhat different from the red-and-white-painted markers of our wide European nature trails, we were able to navigate southward. This route, taken by camel-drivers for so long, wended its way astutely through piles of sand, avoiding slopes and traps. To rely on these droppings was to cross the dunes in a good mood; to deviate a few meters to the left or right meant misery, getting stuck, aggravation, and the risk of transmission damage.

Progress was very slow; our vehicles went only 10 or 20 km in an hour (6–13 mi.). And suddenly, at the bend of a long and high dune, there appeared a small mound with a wooden fork at its top. At the

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summit were some Tuaregs. We were at the well of Éméchédouï. It was very difficult to spot in this sea of sand; a few dozen meters to the east or west and we would have passed right by it. The few nomads present were occupied in watering their dromedaries from the well, drawing a brackish water whose purity left much to be desired. Around the well, the many skeletons bleached by the sun attested to the dryness of the region. This well had been in use for a very long time: The mound on which we found ourselves was no more than an accumulation of cow dung and dromedary droppings. This hardly encouraged us as to the quality of the well water.

We can only imagine the hypotheses and interpretations that archaeologists will form when they excavate this site 10,000 years from now. Small artificial mounds made entirely of shells, called *Kjokkenmøding*, are found in northern Europe; the Danish prehistorians who have studied them think they had something to do with kitchen debris. The site of Éméchédouï has certainly been occupied since ancient times. A few dozen meters from the well, the ground is strewn with sharpened arrowheads, potsherds, small pieces of polished stone, and even bone harpoons. Fragments of silurid fish skeletons and crocodile bones showed that we were walking on the bottom of a neolithic lake: Four or five thousand years earlier, the Sahara had been green and littered with lakes and streams. Humans and herds had been plentiful. Then the climate became dry. The presence of people, intensive deforestation, and overgrazing accelerated the process; the desert grew relentlessly, and still continues to encroach southward. An often violent seasonal wind blows during the dry season from December to March, from the northeast to the southwest. This northern wind, the *harmattan*, desiccates crops and brings enormous quantities of sand that sterilize the ground little by little. The bottoms of these neolithic lakes, lost in the middle of a field of dunes in what is a desert region today, contain the evidence of climatic changes that have come upon this part of Africa.

But at present, the purpose of our trip was to discover and study vanished worlds that were far, far older than the presence of humans on Earth. We got back in our all-terrain vehicles and set our caps eastward.

We were navigating by compass in a landscape that from far away seems absolutely flat and featureless. But up close it's a patchwork of clods of sand, *barkhanes*, sheets of gravel, and stretches of grass, without any trails and with no point of reference. Finally, toward the middle of the afternoon, a small cliff emerged on the eastern horizon. It is

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called Gadoufaoua, which means in Tamachek, the language of the Tuaregs, “the place where the dromedaries are afraid to descend among the bumpy rocks.”

An hour later, we entered the camp of the prospecting geologists from the Atomic Energy Commission. It consisted of about a dozen tents and could be recognized only by two metallic masts visible from far away, connected by a radio antenna. Our welcome was immediate and cordial. The long day was nearly over; the sun plunged suddenly under the horizon, and night descended quickly. But I had a lot of trouble sleeping in my tent, because the impressions and images of the day’s journey were tumbling around so much in my head.

Early the next morning, at dawn, my geological colleagues did me the honor of showing me the locality that they had discovered. We went out by car several kilometers from there and suddenly, around a small sandstone promontory, appeared one, then two vertebral columns. But this time, they were not the bleached bones of dromedaries. The vertebrae were of a somber color, bluish and stony. Some of them were still encased in the sandstones that had protected them from destruction for millions of years. The spectacle was striking. Imagine . . . no. It’s unimaginable, because there is no equivalent in nature. Over many hundreds of square meters, huge skeletons were embedded in the sand, lounging or lying on their flanks like dromedaries at night. The undulations of the sand reminded me of a beach where a herd of elephant seals were stretched. But these were not dromedaries, nor elephant seals: They were dinosaurs.

Leaping from the car, my heart pounding, I headed toward the best preserved among them. I had the exhilarating feeling of being in the skin of Professor Challenger in Conan Doyle’s famous novel *The Lost World* as he discovered a herd of living iguanodons in the heart of the Amazonian forest.

A first glance told me that the the bones were superbly fossilized; they were solid and well mineralized, and the structure of the bony tissues was perfectly preserved. These skeletons had not been disturbed by erosion or by movements of the Earth. The gritty wind had worked like sandpaper or any other abrasive, naturally disengaging the fossil bones bit by bit. The result was striking and unique: The vertebral columns of these dinosaurs crowned the summits of little mounds and were separating themselves along the horizon between sand and sky. The two best skeletons were seven or eight meters long (23–26 ft.). It was easy

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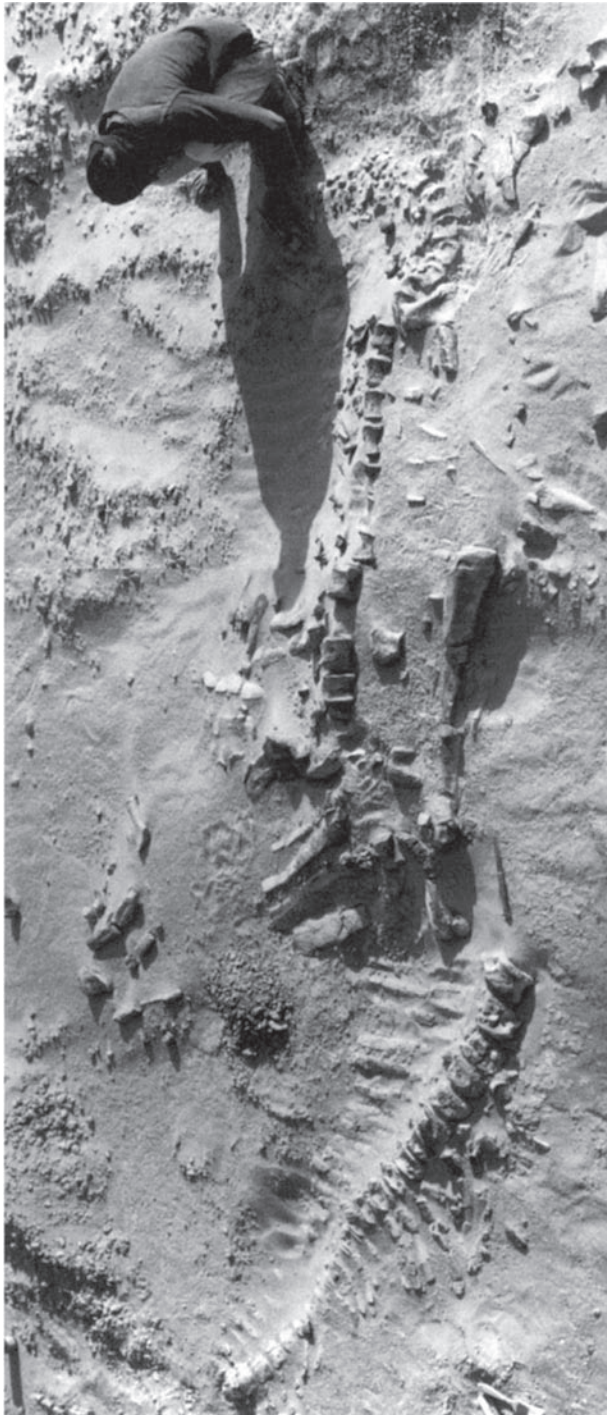


Figure 2. The complete skeleton of an *Ouranosaurus*, a herbivorous bipedal dinosaur, lying on its side like that for 110 million years. (Photo by P. Taquet)

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enough to recognize the front ends of these great reptiles: The neck vertebrae were broad disks, convex in front and concave behind; those of the tail were quadrangular and their size decreased progressively toward the end of the tail, which was still recognizable. Between the neck and tail vertebrae, the dorsals were perfectly visible: They were more massive, and flanked by two sets of flattened ribs. The death-poses of the skeletons could be seen easily on the ground. These nearly complete dinosaurs, separated from their rock matrix in natural pose and stretched out on the sand in a place so deserted and quiet, made such an impression that every one of the assembled scientists fell off talking. The dinosaurs of Gadoufaoua, more than a hundred million years after their death, had the right to a minute of silence.

We regretfully left this unique spot, which the CEA geologists had christened the Cemetery of the Innocents.² All through the day we went from place to place finding more bones. From the abundance of fossilized remains on the ground, their diversity, and the quality of their preservation, I could see right away that the Gadoufaoua area was exceptional. The following days' explorations reinforced that impression and made me realize that this was one of the most important dinosaur-bearing sites in Africa. As it turned out, the strip of land that yielded all these bony remains is about 2 km × 150 km – about a mile wide and a hundred miles long! This was almost unbelievable: it required a 110 million (plus 1,964) years for this discovery and a favorable confluence of circumstances before this January day, when I found myself, a lone fledgling paleontologist, in the middle of an immense dinosaur cemetery. Armed with my geologist's hammer, my notebook, and my pencil, I shouldered a tough new burden of responsibility, as a wave of elation swept over me from my toes to my scalp.

The geologists looking for uranium needed to know the age of these fossil beds. The study of these bones and the paleontologist's determination of what they were would answer their questions; that's why I was invited. But before I could see this part of the research through to its conclusion, I needed their fieldwork to allow me to understand the lay

² The "Cemetery of the Innocents" is where Parisians buried their dead until 1786, when a flood of the River Seine hydraulically exhumed the ageless corpses and floated their putrid remains through the Paris streets. When the waters receded the dead were reburied in the Catacombs, which had been Roman quarries, at what were then the city limits; the remains can still be seen, but the spectacle is not for the faint-hearted. The French Resistance was headquartered there during World War II.