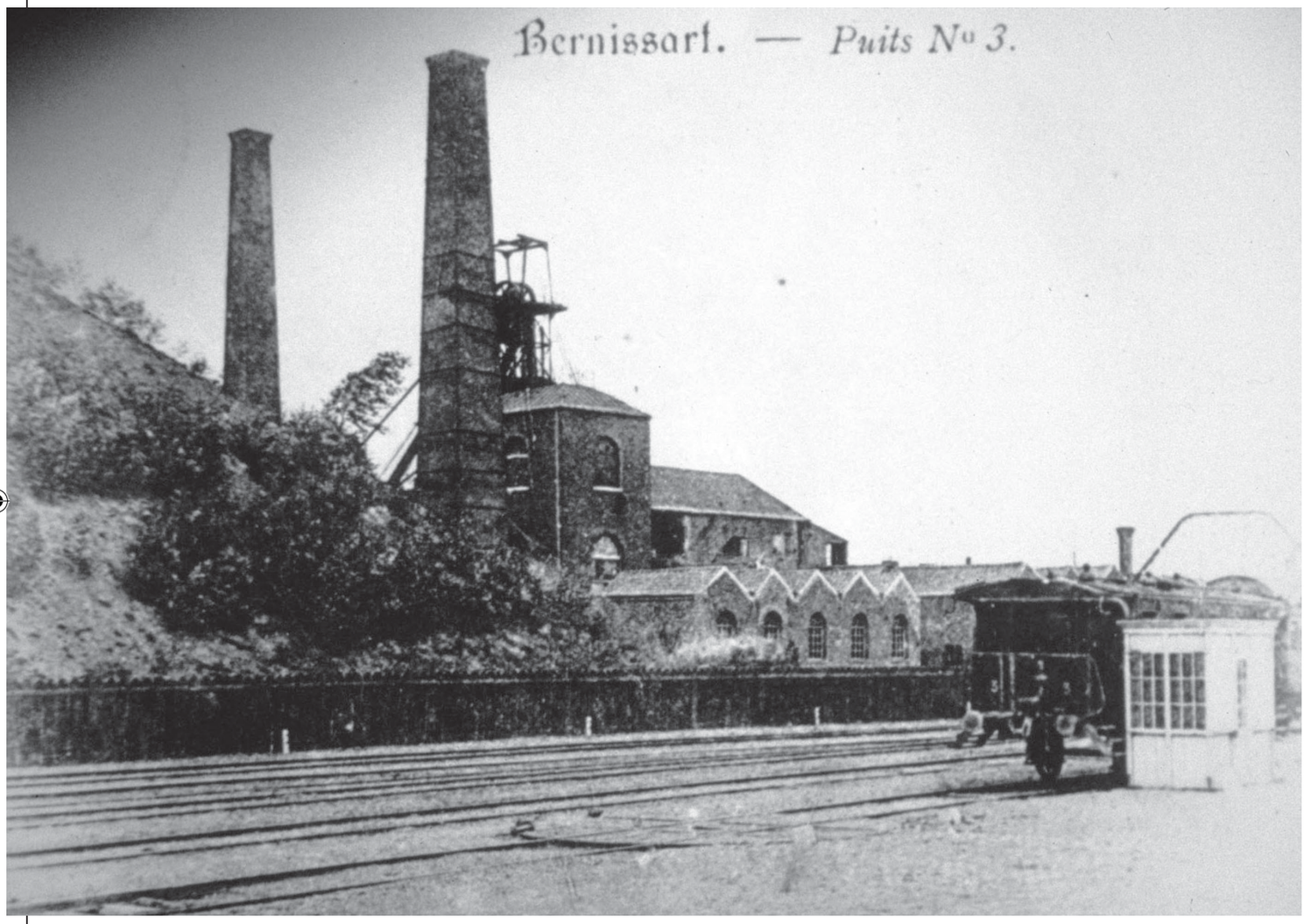

1.1. The Sainte-Barbe pit and mine buildings in 1878, at the time when the iguanodons were discovered.

Bernissart and the Iguanodons: Historical Perspective and New Investigations

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Pascal Godefroit*, Johan Yans, and Pierre Bultynck

The discovery of complete and articulated skeletons of *Iguanodon* at Bernissart in 1878 came at a time when the anatomy of dinosaurs was still poorly understood, and thus considerable advances were made possible. Here we briefly describe, mainly from documents in the archives of the Royal Belgian Institute of Natural Sciences, the circumstances of the discovery of the Bernissart iguanodons. We also provide information about their preparation and mounting in laboratories, for exhibitions, and in early studies. We also summarize the latest results of a multidisciplinary project dedicated to the material collected in the cores drilled in 2002–2003 in and around the Iguanodon Sinkhole at Bernissart.

The Bernissart Iguanodons: A Cornerstone in the History of Paleontology

The discovery of the first *Iguanodon* fossils has become a legend in the small world of paleontology. Around 1822, Mary Ann Mantell accompanied her husband, the physician Dr. Gideon Algernon Mantell, on his medical rounds and by chance discovered large fossilized teeth. Her husband found the teeth intriguing. With advice from Georges Cuvier, William Clift, and William Daniel Conybeare, he described them and named them *Iguanodon*, "iguana tooth," because of their superficial resemblance to those of living iguanas (Mantell, 1825). *Iguanodon* was one the three founding members of the Dinosauria—along with *Megalosaurus* and *Hylaeosaurus*—named by Richard Owen in 1842.

For 56 years, little was known about *Iguanodon* and other dinosaurs. Mantell imagined these antediluvian animals to be some kind of giant lizards with elongated bodies and sprawling limbs (Benton, 1989). In 1854, the sculptor Waterhouse Hawkins, following Owen's advice, realized full-size reconstructions of *Iguanodon* and *Megalosaurus* for the Crystal Palace exhibition in London. *Iguanodon* was reconstructed as a rhinoceros-like heavy quadruped with a large spike on its nose. These impressive monsters invoked the first public sensation over dinosaurs (Norman, 1985).

The first partial dinosaur skeleton, named *Hadrosaurus foulkii* Leidy, 1858, was discovered in 1857 in New Jersey. This skeleton was reconstructed in a bipedal gait at the Academy of Natural Sciences of Philadelphia, but many questions were still left unanswered about the general appearance of dinosaurs.

Then, 20 years later, another *Iguanodon* discovery broke the scientific world—and the dinosaur world—wide open (Forster, 1997). The discovery of complete and articulated skeletons of *Iguanodon* at Bernissart in 1878 revealed for the first time the anatomy of dinosaurs, and thus considerable advances were made possible, in combination with the remarkable

discoveries in the American Midwest described by Marsh and Cope (Norman, 1987).

Many manuscripts and plans relating to the original excavations at Bernissart are preserved in the paleontological archives of the RBINS, which allow us to reconstruct the circumstances of the discovery of these fantastic dinosaurs.

Institutional abbreviations. NHMUK, The Natural History Museum, London (formerly the British Museum [Natural History]), U.K.; RBINS, Royal Belgian Institute of Natural Sciences, Brussels (formerly MRHNB, Musée royal d'Histoire naturelle de Belgique), Belgium.

The Discovery and Excavation of the Bernissart Iguanodons

Bernissart is a former coal-mining village in southwestern Belgium, situated 21 km south of Mons and less than 1 km from the Franco-Belgian frontier. Pre-industrial coal extraction began at Bernissart around 1717 (Delguste, 2003). In 1757, Duke Emmanuel de Croÿ grouped together the different coal companies in northern France into the powerful Anzin Company, which started the industrial exploitation of the coal in the Bernissart area during the second half of the eighteenth century (Delguste, 2006). In the nineteenth century, the Bernissart Coal Board Limited Company dug five coal pits on Bernissart territory. The Négresse pit (no. 1, exploited from 1841) and Sainte-Barbe pit (no. 3, exploited from 1849; Fig. 1.1) were used for coal extraction and coupled with the Moulin pit (no. 2, exploited from 1842) for ventilation. The Sainte-Catherine pit (no. 4, exploited from 1864) was the third extraction pit and was coupled with pit no. 5 (exploited from ?1874) for ventilation. The maximum distance between pits 1 and 5 was about 1,600 m. With a depth of 422 m, the Sainte-Barbe pit was the deepest. In spite of a rather archaic technology, the daily production for the three extraction pits was about 800 tons. However, the flood problems were more important than in other coal mines from the Mons area; steam pumps were used to extract the water.

On February 28, 1878, miners digging a horizontal exploration gallery 322 m below ground level suddenly encountered, 35 m to the south of the Luronne seam, disturbed rocks, indicating that they were penetrating inside a vertical cran—a local term meaning a pit formed by natural collapse through the coal seams that was filled especially with clayey deposits normally located above the coal measures.

On March 1, chief overseer Cyprien Ballez, engineer Léon Latinis, and mine director Gustave Fagès went down into the Sainte-Barbe pit to evaluate the situation. It was decided to traverse this cran and to rejoin the coal seam on the other side. Overseer Motuelle and miners Jules Créteur and Alphonse Blanchard were put in charge of continuing the exploration gallery through the perturbed layers of the cran. On March 9, Ballez noticed that the exploration gallery was still in the perturbed zone of the cran.

In March, the miners had already collected dinosaur remains: fragmentary bones and teeth, which are labeled "remains of the first Iguanodon, March 1878" and are housed in the paleontological collections of the RBINS. But they apparently paid little attention to these discoveries, believing that they were just fossil wood.

On April 1, the exploration team again entered nondisturbed but inclined formations. On April 3, Ballez and Latinis went down again together

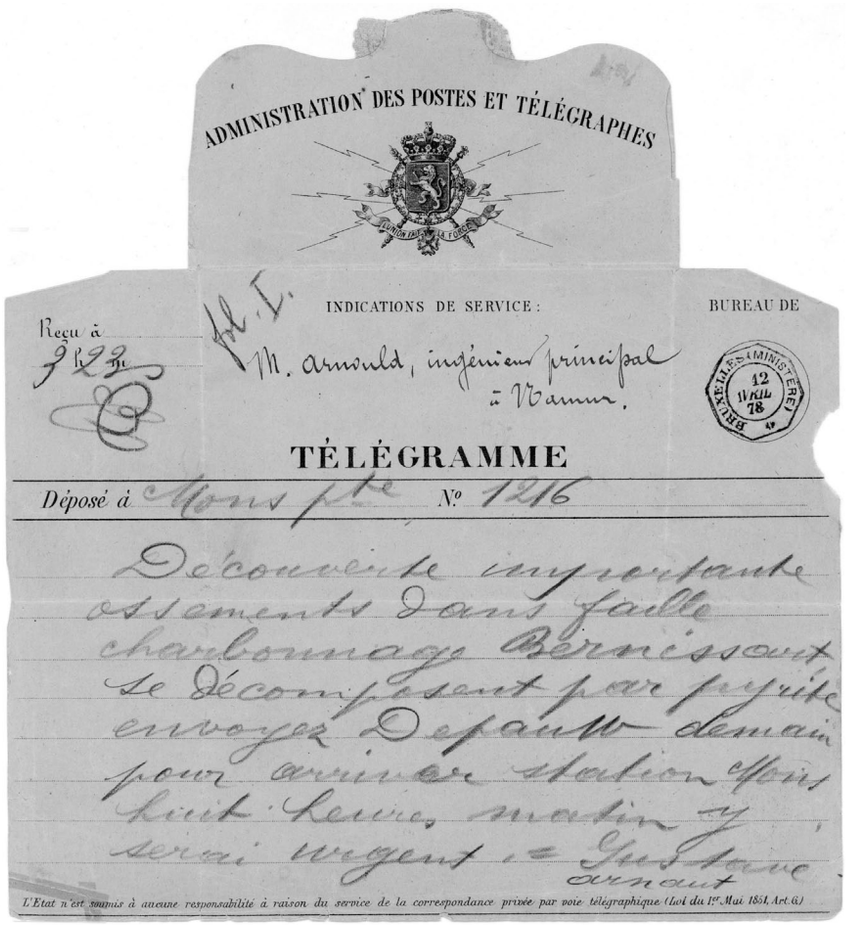
in the exploration gallery. The engineer estimated that they had again reached coal-bearing formations. Latinis's explanations apparently did not satisfy Fagès. Indeed, the mine manager decided to accompany the engineer and the chief overseer in the exploration gallery on April 5. While inspecting the deposits, Fagès found a long object with an oval cross section and a fibrous texture. Latinis believed that it was a fossil oak branch. Conversely, Fagès ironically asserted that it was a rib of Father Adam. Miner Jules Créteur mentioned that he had already found a larger fossil, and the team soon unearthed limb bones in the gallery. In the evening, miners brought several fragments of these fossils to Café Dubruille. There the local doctor, Lhoir, who also worked for the coal mine, burned one of the fragments and confirmed that the fossils collected by the miners were bones, not wood. Many new fossils were discovered by the miners in the night of April 5–6. On April 6, Fagès ordered Ballez to bring all the fragments of bones that the miners had collected to the surface and to lock up the end of the gallery.

On Sunday, April 7, Latinis was commissioned to go to Mons to show the fossils to the well-known geologist François-Léopold Cornet. But Cornet was not home. Latinis thus left the fossils to his young son, Jules (a future renowned geologist), and asked him to tell his father that these bones had been found in the Sainte-Barbe pit at Bernissart.

On April 8, F.-L. Cornet came to Bernissart and briefly discussed the Bernissart discovery with Latinis. He could not meet Fagès, who was with Ballez in the Sainte-Catherine pit. On April 10, Cornet told the zoologist Pierre-Joseph Van Beneden, professor of paleontology at Leuven University, that Latinis, who was a former student of Van Beneden, had discovered fossil bones at Bernissart, and he sent him some of the bones that Latinis had left with his son. Van Beneden quickly identified the teeth as belonging to the dinosaur *Iguanodon*, previously described from Wealden deposits in England.

On April 12, Fagès went to Mons to meet the chief mining engineer, Gustave Arnould, who immediately sent a telegram to Edouard Dupont, director of the Musée royal d'Histoire naturelle de Belgique (MRHNB) at Brussels to inform him of the important discovery at 322m below ground level in the Sainte-Barbe Pit (Fig. 1.2).

On Saturday, April 13, Louis De Pauw, head preparer at the MRHNB and a man who already had extensive experience in the excavation and preparation of fossil vertebrates, met Arnould at Blaton. They went together to Bernissart. Fagès showed them the bones recently found in the gallery; De Pauw recognized two ungual phalanges and one vertebral centrum. It was then decided to go down together into the fossiliferous gallery. De Pauw (1902) reported that the walls of the exploration gallery were completely covered by fossil bones, plants, and fishes. Ballez, Motuelle, Créteur, and Blanchard soon unearthed a complete hind limb that they transported on a plank covered with straw. But after a 300-m walk, the bones began to disintegrate on contact with the fresh air of the mine galleries. De Pauw protected the biggest remaining fragment with his own clothes, and Ballez and Motuelle brought the fossils to the surface. De Pauw realized that the presence of pyrite inside the bones was one of the biggest problems that they had to face if they were to unearth the fossils from the Sainte-Barbe pit.


ADMINISTRATION DES POSTES ET TÉLÉGRAPHES

INDICATIONS DE SERVICE :

BUREAU DE

Reçu à 9 h 22 m

M. arnould, ingénieur principal à Namur.

TÉLÉGRAMME

Déposé à Mons pte N° 1216

Découverte importante ossements dans faille charbonnage Bernissart se décomposent par pyrite envoyez Depauw demain pour arriver station Mons huit heures matin y serai urgent = Gustave arnaut

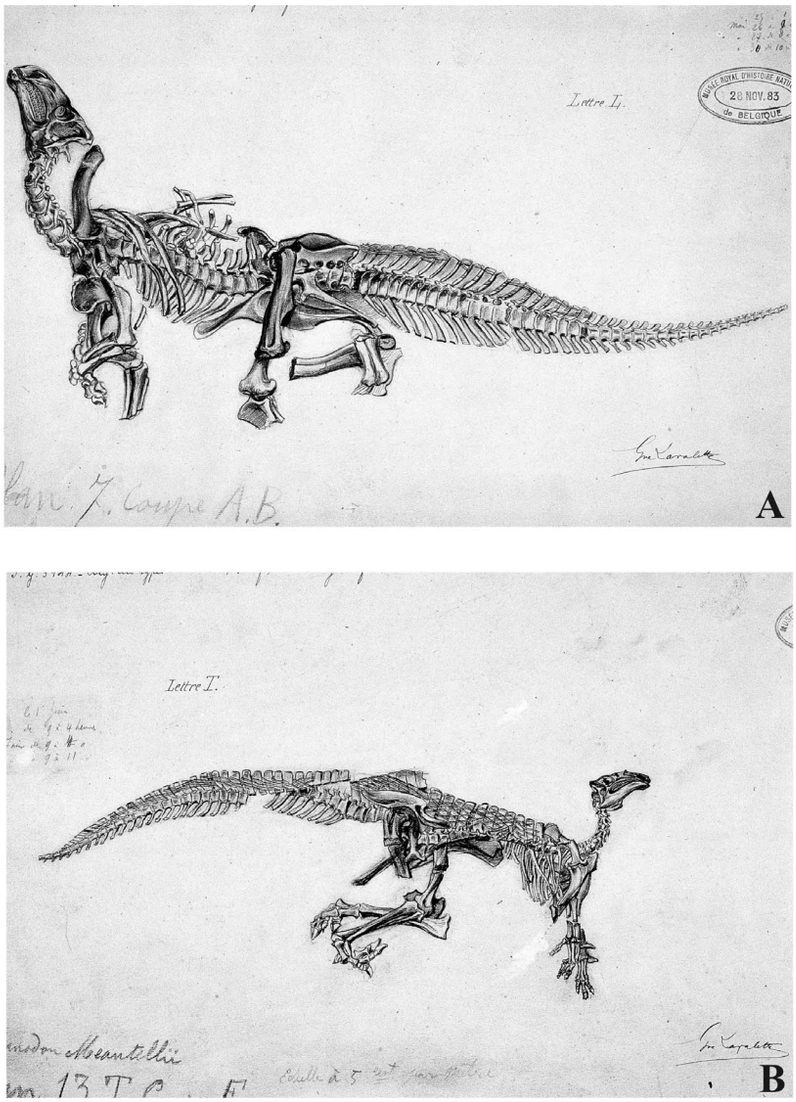
L'Etat n'est soumis à aucune responsabilité à raison du service de la correspondance privée par voie télégraphique (Loi du 1er Mai 1851, Art. 6.)

1.2. Telegram of April 12, 1878. Translation: "Important discovery of bones in coalfield fault Bernissart decomposing due to pyrite. Send De Pauw tomorrow to arrive Mons station 8 a.m. Shall be there. Urgent. Gustave Arnaut."

He packed the collected bones in a box full of sawdust and brought them back to Brussels. In MRHNB workshops, he succeeded in solidifying the limb bones from Bernissart with gelatin. In the meantime, Latinis prepared 11 more boxes full of fossils at Bernissart.

Fagès quickly gathered together the board of directors of the Bernissart Coal Board Limited Company. They decided to donate the fossils discovered in the Sainte-Barbe pit to the Belgian state and to notify Charles Delcour, minister of the interior, and Edouard Dupont, director of the MRHNB, about this decision. But the excavations could not immediately begin because the MRHNB team was busy preparing for the Paris World's Fair.

De Pauw settled in Bernissart on May 10, and the excavations began on Wednesday, May 15. The excavation team included one warder (M. Sonnet) and one molder (A. Vandepoel) from the MRHNB, six miners (J. Créteur, A. Blanchard, J. Gérard, E. Saudemont, D. Lesplingart, and Dieudonné), and the overseers Ballez, Mortuelle, and Pierrard. Every day from 5:30 in the morning until 12:30 in the afternoon, the team went down into the Sainte-Barbe pit. The excavation method De Pauw created proved to be efficient and is still used today during paleontological excavations. Each *Iguanodon* skeleton was split into pieces. The exposed bones were first covered by wet paper or liquid clay and coated by a layer of plaster of Paris. The fossils were then undercut in a bed of matrix and the reverse side plastered. The block was then reinforced with either strips of wood or



1.3. A, Drawing by G. Lavalette in 1883 of specimen "L" (RBINS R56) of *Iguanodon bernissartensis,* as discovered in the Sainte-Barbe pit. B, Drawing by G. Lavalette in 1882 of specimen "T" (RBINS R57) of *Mantellisaurus atherfieldensis,* as discovered in Sainte-Barbe pit. C, Sketch of the assemblage of plaster blocks containing pieces into which specimen "T" (RBINS R57) was divided for raising to the surface. Block "1T" contains the skull and "5T," the end of the tail of this individual.

steel, then coated with a second layer of plaster. After being sketched and cataloged (Fig. 1.3), the blocks were carried to the surface. Every afternoon, from 3:00, the team collected fossils on the coal tip in sediments previously extracted from the pit (De Pauw, 1902).

In August 1878, a big earthquake blocked the excavation team for 2 hours in the gallery 322 m below ground level. This gallery was subsequently flooded, and on Tuesday, October 22, the team was forced to abandon their work for several months. The tools and the last fossiliferous blocks had to be left behind in the flooded galleries. At that time, five skeletons of *Iguanodon* had already been discovered, although only that of "A" (RBINS VERT-5144-1716) had been excavated completely.

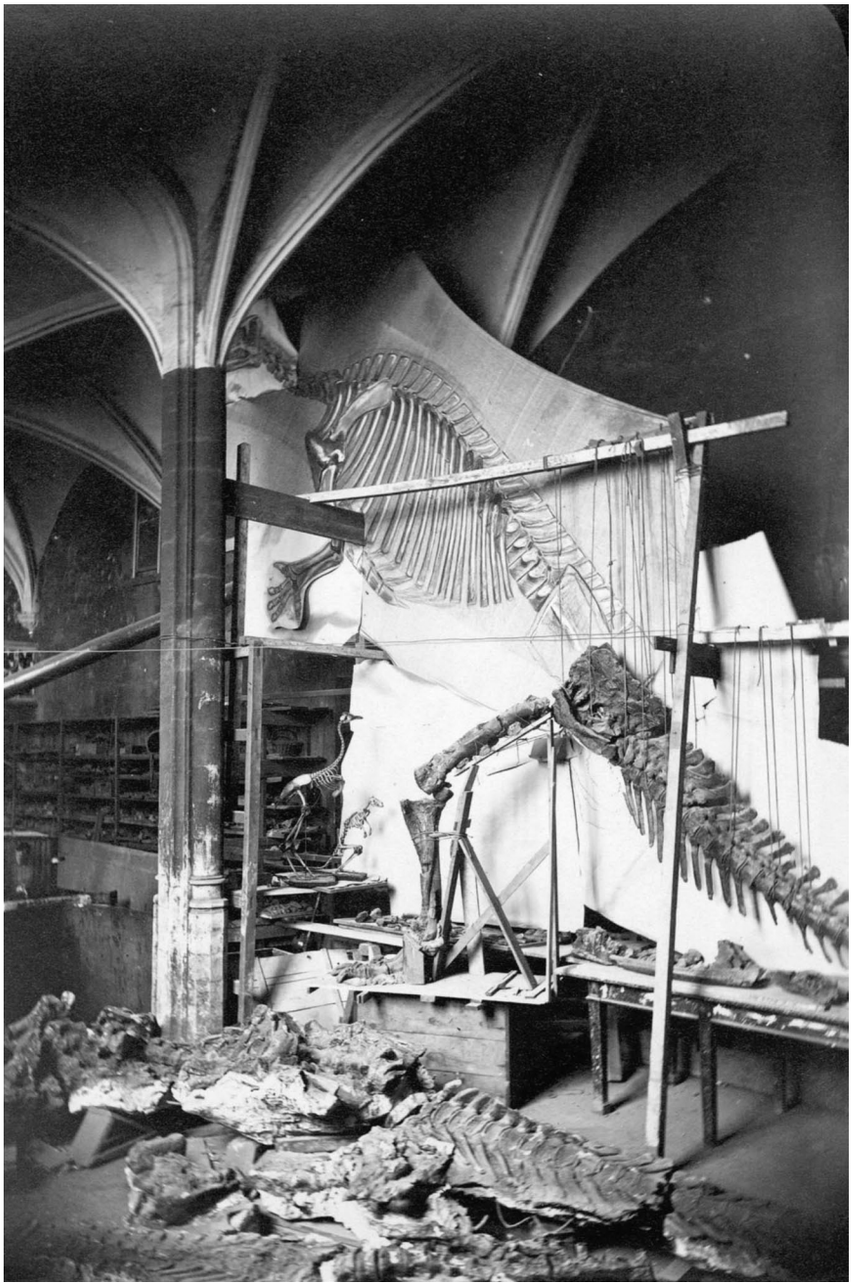
Between October 1878 and April 1879, individual "A" was prepared and mounted in the museum workshop at the St. Georges Chapel of Nassau Palace. The front part of this specimen had been destroyed during the original gallery excavations. This was one of the earliest mounted skeletons of associated dinosaur remains (Norman, 1986; Fig. 1.4).

In the meantime, Antoine Sohier replaced Latinis as engineer in the Bernissart Coal Board Limited Company and received the task of repairing the damaged galleries and replacing the old wooden shaft lining of the Sainte-Barbe pit with a cast iron one (see Sohier, 1880). Since the discovery of the first fossils in the Sainte-Barbe pit, the relations between Fagès and Latinis were characterized by conflict. Latinis was regularly dressed down because he did not regularly inspect the galleries. Latinis was apparently absent without leave when the gallery collapsed after the earthquake, and Fagès held him responsible for the collapse.

The excavations restarted on May 12, 1879. De Pauw was accompanied by four members of the MRHNB team (M. Sonnet, A. Collard, and A. and L. Vandepoel) and by the same miners as in 1878. J. Créteur was the first to find the abandoned tools and blocks in the gallery at −322 m (Fig. 1.5A). The excavations proceeded with great success, resulting in the removal of 14 more or less complete and four partial skeletons of iguanodontids, two *Bernissartia* (a dwarf crocodile) skeletons, one "*Goniopholis*" (larger crocodile) skeleton, two turtles, and innumerable fishes and plant remains. From this first concentration of fossils, the gallery at the 322-m level was extended horizontally for about 50 m in an east–southeast direction across the cran, passing through an area where the stratified sediments were almost horizontal but apparently devoid of large vertebrate remains. On October 22, 1879, another *Goniopholis* specimen was discovered at about 38 m from the entrance of the cran. A further eight well-preserved *Iguanodon* skeletons were discovered between 38 and 60 m from the entrance before reaching its opposite side (Fig. 1.5B).

In 1881, a new horizontal gallery was dug at a depth of −356 m. The miners also encountered fossiliferous clays, but the diameter of the cran was extremely restricted (approximately 8 m) at this level. Three more articulated skeletons were recovered from this third series of excavations (Fig. 1.5C). The clayey layers had completely disappeared 3 m below.

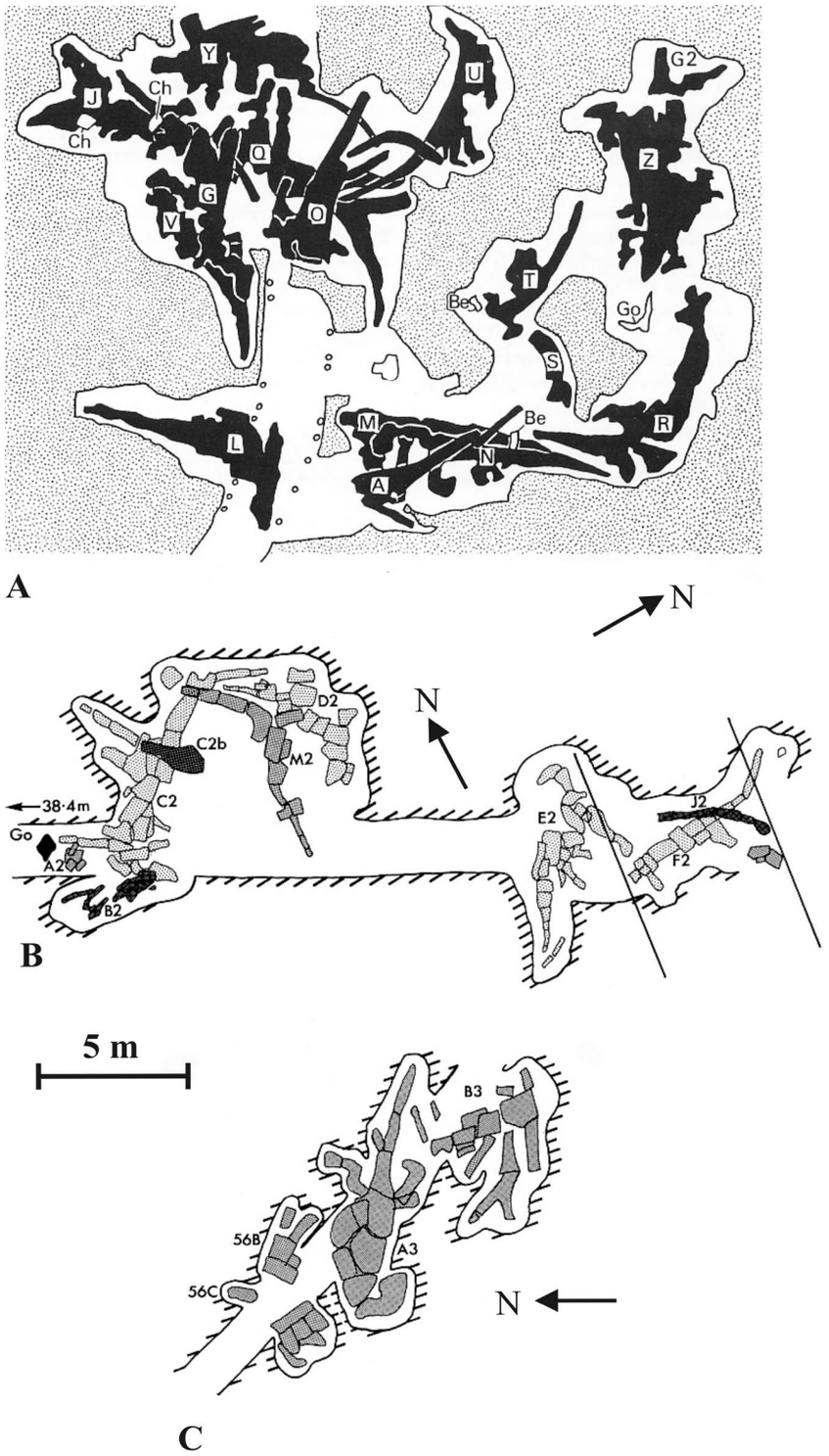
After three years of excavations at Bernissart, about 600 blocks, weighing a total of more than 130 tonnes, were transported to Brussels in furniture removal vans, each of 3 tonnes' capacity.



1.4. Mounting, in 1878, of the first *Iguanodon* specimen (specimen "A," RBINS VERT-5144-1716) in the St. Georges Chapel, or Nassau Chapel, assembly workshop of the MRHNB. This room is now an exhibition hall in the Albert I Royal Library, Brussels. To the left of the iguanodon's hind limb can be seen the skeletons of a kangaroo and a cassowary, used as models in assembling the skeleton.

The excavations at Bernissart were particularly expensive for the Belgian state (about 70,000 francs in modern currency), and the government had already allocated two extraordinary grants. In 1881, the expenses involved by this enterprise were considered too high by the Belgian government, and the excavations were stopped. Members of parliament suggested that an *Iguanodon* skeleton should be sold abroad to defray expenses, but public outcry prevented this transaction.

During World War I, the German occupation authorities decided to start new excavations at Bernissart (see Roolf, Chapter 2 in this book). The plans, revealed in documents captured after the liberation of Belgium, indicated that a new gallery was to be excavated at −340 m. The exploration gallery was stopped on October 11, 1918, 30 m in front of the border of



1.5. Plan views of the excavations at Bernissart, with the skeletons restored in their original locations (adapted by Norman 1986 from original archived documents in RBINS). Not all the letter/number-coded individuals are now identifiable in the collections. A, First series at –322 m; B, second series at –322 m on the east–southeast side of the cran; C, third series at –356 m. *Abbreviations:* Be, the small crocodile *Bernissartia;* Go, the larger crocodile "*Goniopholis*"; ch, turtles.

the cran. Unfortunately, the newly excavated tunnel collapsed when the occupying forces withdrew.

On January 20, 1919, Albert Anciaux, then the director general of the colliery at Bernissart, sent a letter to Gustave Gilson (the director of the MRHNB after Edouard Dupont), complaining that the costs of the aborted excavation in Bernissart between 1916 and 1918, which were entirely borne by the colliery owners, amounted to 36,604 francs. The Belgian government reimbursed these expenses in May 1923 (Gosselin, 1998).

After the war, the extraction pits were put again into exploitation at Bernissart. But coal extraction at Bernissart was no longer financially viable, even as the mining activities at the neighboring Harchies colliery became highly profitable.

On September 1921, Anciaux informed Gilson that for reasons of economy, the water pumps and ventilators at the Sainte-Barbe pit would had to be removed and the pit abandoned, unless funds could be found elsewhere. The director of the Bernissart colliery proposed two solutions to maintain the paleontological research activities in Sainte-Barbe pit and estimated the annual maintenance costs: 1,242,700 or 755,310 francs, depending on the solution that was chosen. G. Gilson approached the Belgian government and private sponsors to find financial support. Despite national and international appeals, the Sainte-Barbe pit was definitively closed at the end of October 1921.

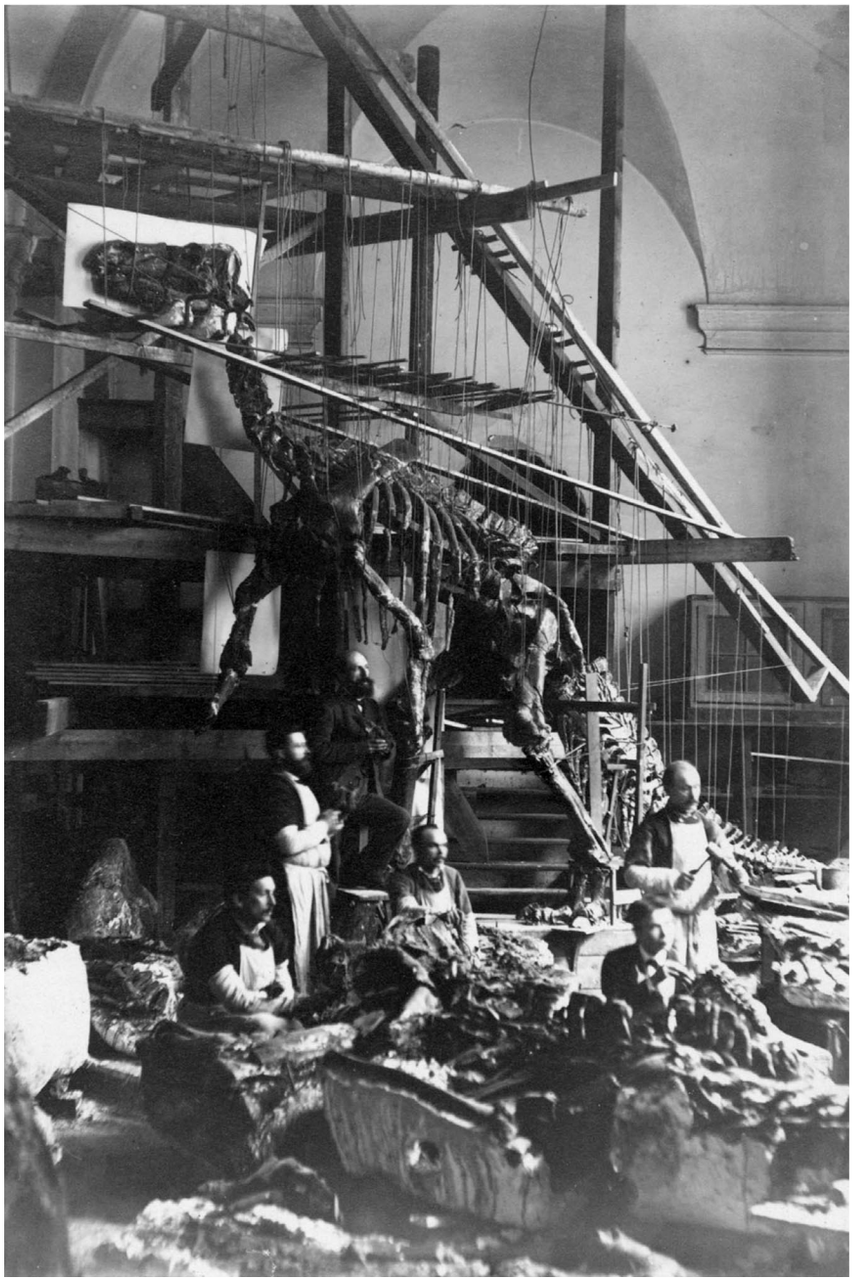
At the beginning of the 1930s, Jules Destrée, then minister without portfolio and senator, again requested that the Belgian government release 1 million francs to restart excavations at Bernissart. The moment was badly chosen, thanks to the dramatic consequences of the 1929 stock market crash on the Belgian economy, particularly on the collieries.

According to Gosselin (1998), the German occupation authorities again tried to start excavations at Bernissart between 1940 and 1945. They took maps and documents necessary for a new exploitation of the fossiliferous site away from André Capart (then a section director at the MRHNB) and De Pauw's son. However, we did not find any document in the archives of the RBINS that could corroborate this hypothesis.

Preparation, Mounting, and Exhibition of the Bernissart Iguanodons

From 1882 onward, once the excavations at Bernissart had ceased, museum preparation proceeded rapidly. Once the *Iguanodon* blocks arrived in Brussels, they were stored in the museum workshop, housed in the St. Georges Chapel of Nassau Palace, now preserved as an exhibition hall in the Albert I Royal Library. De Pauw (1902) described in detail the preparation of the *Iguanodon* skeletons. The plastered blocks were exposed on their upper surface (the surface containing the bones exposed in the gallery) by removing the protective casing of plaster of Paris. Then a wall of plaster was constructed around the block and a hot glue mixture, diluted with alcohol and saturated with arsenic, was poured on top. De Pauw believed that the arsenic was able to "kill" the pyrite. Excess glue mixture was cleaned off and the block hardened in a drying room. The reverse side of the block was then prepared with a cold chisel to remove the plaster and the matrix, and the glue mixture was applied on this side. The pyrite was systematically curetted from the bones. Some vertebrae contained more than 1 kg of pyrite. The remaining cavities were filled with *carton-pierre*, a stable mixture of paper, glue, and talc.

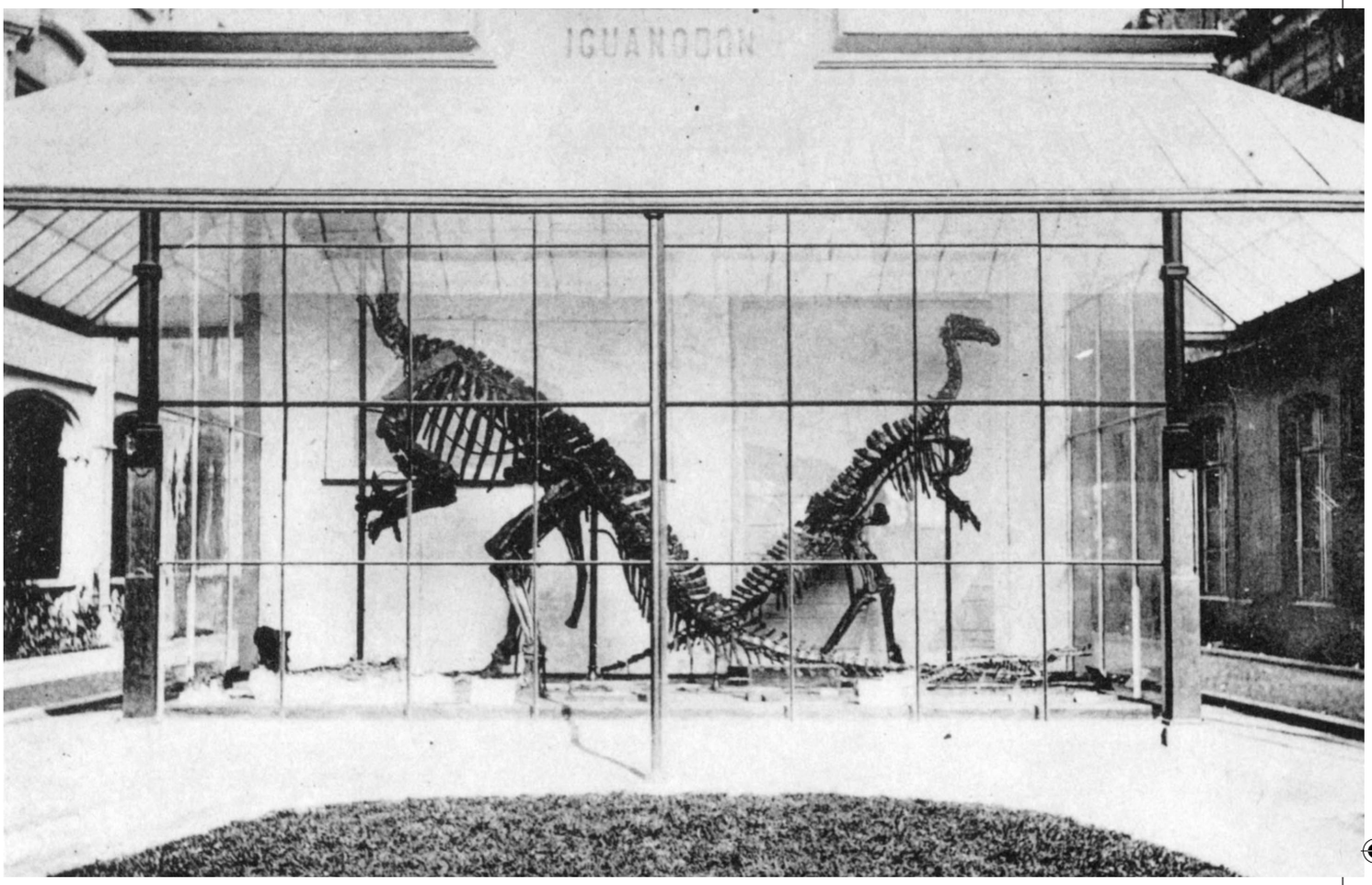
It was decided to mount the best preserved *Iguanodon* specimens in a lifelike gait. In 1882, the first complete specimen (individual "Q," RBINS R51, the holotype of *Iguanodon bernissartensis*) was assembled and mounted by L. De Pauw and his team in the St. Georges Chapel. The bones were suspended from scaffolding by ropes that could be adjusted so as to obtain the most lifelike position for the complete skeleton, which



1.6. Mounting in 1882 of the first complete *Iguanodon* specimen (specimen "Q," RBINSR51, the holotype of *I. bernissartensis*) in the St. Georges Chapel. The bearded figure closest to the specimen is L. De Pauw.

was then supported by an iron framework (Fig. 1.6). This first mounted specimen was publicly exhibited in 1883 in a glass cage constructed in the interior court of Nassau Palace. In 1884, the cage was lengthened to accommodate a second specimen (individual "T," RBINS R57, the only complete specimen of *Mantellisaurus atherfieldensis*) and a selection of fossils of the Bernissart flora and fauna (Fig. 1.7).

But the Nassau Palace chapel quickly became too small for the storage, preparation, mounting, and exhibition of these numerous and bulky skeletons. In 1891, the iguanodons were transported to a new location: the Royal Museum of Natural History in Leopold Park. In 1899, five specimens were mounted in a glass cage close to the entrance of the museum. From 1902 onward, the whole Bernissart exhibition was permanently installed in the newly constructed Janlet Wing of the MRHNB. Eleven complete specimens



1.7. First two complete specimens of Bernissart iguanodons exhibited in the interior court of the Nassau Palace, Brussels, in 1884. Left, holotype specimen of *Iguanodon bernissartensis* (individual "Q," RBINS R51); right, complete specimen of *Mantellisaurus atherfieldensis* (individual "T," RBINS R57).

were exhibited in a lifelike gait, while 12 more or less complete and eight fragmentary individuals were presented as an *en gisement* display (Fig. 1.8).

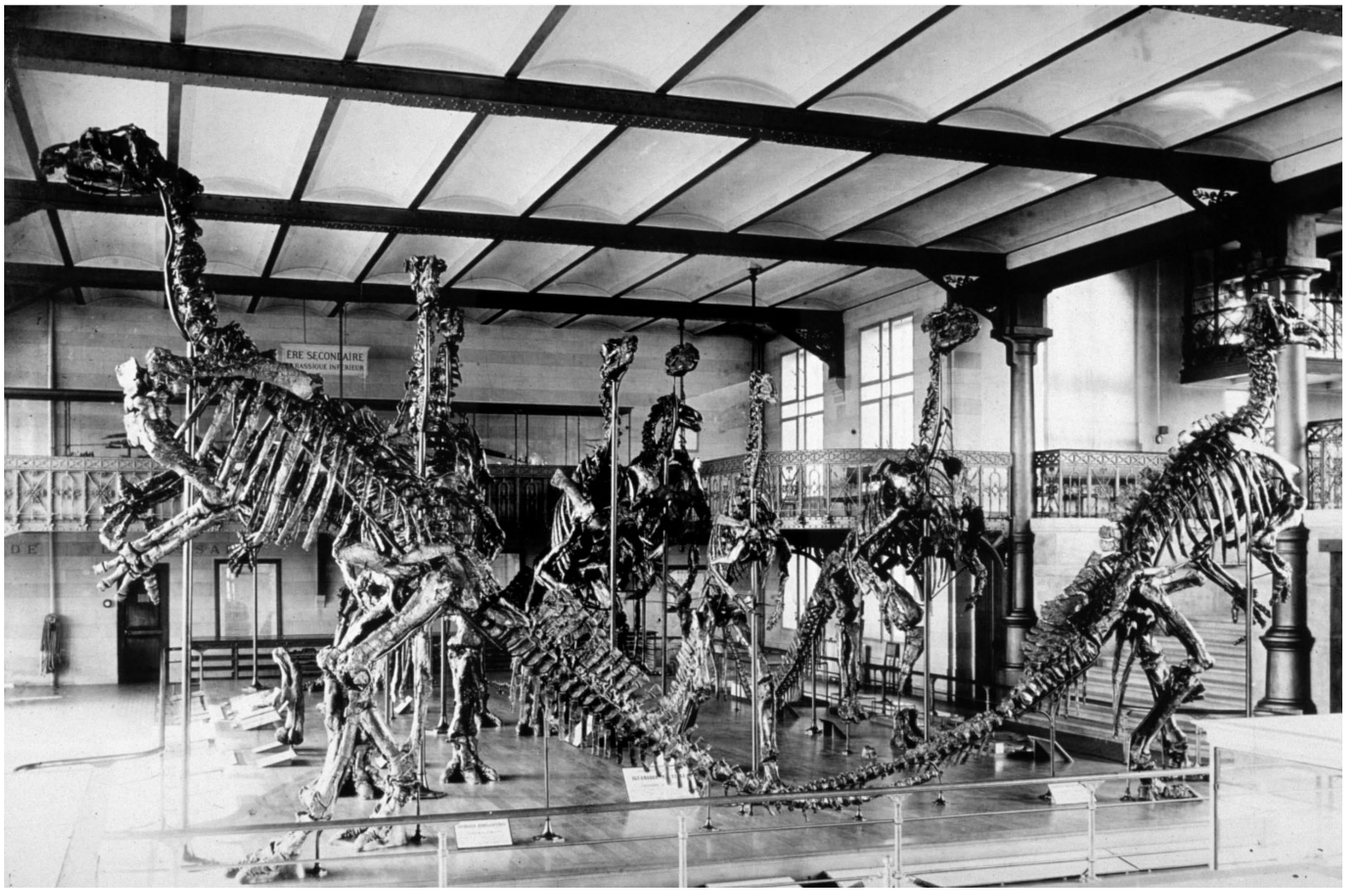
Between 1933 and 1937, the *Iguanodon* skeletons were dismantled and treated because 30 years of changes in temperature and humidity had damaged them. The bones were soaked in a mixture of alcohol and shellac, a natural lacquer secreted by coccid insects. The specimens were installed into two large glass cages to stabilize the temperature and humidity of their environment (Fig. 1.9).

During World War II, all the specimens were again dismantled and stocked in the cellars of the museum, for fear of aerial bombings. But the humidity was too much for these fragile fossils, which were again mounted in the exhibition hall before the end of the war (Bultynck, 1989).

From 2004 to 2007, the MRHNB's Janlet Wing was renovated. On this occasion, the iguanodon skeletons were again completely restored. All the bones were reinforced by a solution of synthetic polyvinyl acetate in acetone and alcohol (known by the trade name Mowilith). New glass cages were constructed to protect the skeletons (Fig. 1.10).

The Study of the Bernissart Iguanodons

From the beginning, E. Dupont and G. Fagès had friendly relations. Dupont expressed his gratitude to Fagès, who had accepted the care of the Bernissart fossils for the MRHNB, and Dupont did everything in his power to



1.8. The Bernissart iguanodons, mounted in life-like gait, in the Janlet Wing of the MRHNB in the early 1930s.

flatter Fagès. In 1883, he suggested to the minister of the interior that Fagès be decorated with the Order of Leopold, the highest distinction in Belgium. Dupont even invited Fagès and his wife to celebrate Christmas 1878 in his home! (They politely refused.) The explanatory label at the feet of the first mounted specimen in the interior court of Nassau Palace mentioned that it was "discovered in 1878 in Bernissart colliery by M. Fagès, director of the society." This label irritated P.-J. Van Beneden, who thought that he ought to be credited with first discovering the iguanodons because it was he who had first identified the fossils as belonging to the genus *Iguanodon* and who had published the first scientific note about these dinosaurs (Van Beneden, 1878). It was the start of an epic, although completely futile, dispute between Van Beneden and Dupont over the authorship of the Bernissart iguanodons during noisy sessions of the Academy of Sciences in 1883. As a consequence of these disputes, Dupont insisted that Van Beneden give the handful of bones that Cornet had sent to him in April 1878 back to the MRHNB. Of course, Van Beneden refused, and the relations between the director of the MRHNB and the professor at Leuven University continued to deteriorate.

A third contentious point, again involving P. J. Van Beneden, concerned the species that had been discovered at Bernissart: did it belong to a new species or to *Iguanodon mantelli*, already described from disarticulated specimens discovered in England? Just after the discovery of the Bernissart iguanodons, Dupont had asked the young naturalist Georges Albert Boulenger to study these specimens. In 1881, Boulenger presented his first

1.9. The Bernissart iguanodons, presented in an *en gisement* display in the Janlet Wing of the RBINS in the early 2000s.

results to the Belgian Academy of Sciences, Letters, and Fine Arts. He described the anatomy of the pelvis of these dinosaurs and proposed that the greater number of sacral vertebrae (six) in the Bernissart form, as opposed to the five sacral vertebrae in *I. mantelli*, merited the establishment of a new species that he named *Iguanodon bernissartensis*. Unfortunately, this paper was refused publication, although a brief, highly critical review of Boulenger's paper was published by Van Beneden (1881), then president of the science section of the academy, who claimed that observed anatomical differences were most probably attributable to sexual dimorphism and that the Bernissart iguanodons belonged to *Iguanodon mantelli*. Shortly afterward, in 1881, Boulenger accepted a post at the British Museum (Natural History), and in 1882, study of the Bernissart iguanodons was entrusted to Louis Dollo, a mining engineer of French origin who eventually became a Belgian citizen and who entirely devoted his career to vertebrate paleontology at the MRHNB.

Between 1882 and 1923, Dollo (1882a, 1882b, 1883a, 1883b, 1883c, 1884, 1885a, 1885b, 1888, 1906, 1923) published many preliminary notes on the Bernissart fauna, especially on *Iguanodon*. While studying in detail several parts of the *Iguanodon* skeleton, Dollo began to adopt a forensic approach to understanding these fossils. He developed a new style of paleontology that became known as paleobiology—paleontology expanded to investigate

1.10. A new cage for the Bernissart iguanodons in 2007.

the biology, and by implication the ecology and behavior, of extinct creatures. The first paper (Dollo, 1882a) examined the basis for the creation of the new species, *I. bernissartensis*, as distinct from *I. mantelli*. Dollo established an overall similarity in anatomy between the smaller and more gracile species from Bernissart (RBINS R57) and the remains of the "Mantelpiece" (NHMUK 3741), and therefore by convention identified RBINS R57 as *Iguanodon mantelli* (Norman, 1993). With respect to the larger species, Dollo (1882a) circumvented the problems of sexual dimorphism in the sacral count by demonstrating a wider range of additional anatomic differences: skull proportions, size of narial openings, shape of the orbit, size and shape of the infratemporal openings, shape of scapular blade, completeness of external coracoid foramen and overall shape of the coracoid, size of the humerus, proportions of the manus and pollex, and shape of the anterior pubic blade. Dollo finally concluded that they merited being considered a separate species.

Dollo's final contribution to the *Iguanodon* story was published in 1923 as a synthetic study to honor the centenary of Mantell's original paper. He identified *Iguanodon* as an ecological equivalent of the giraffe. Its kangaroo-like posture enabled it to reach high into the trees to gather its fodder, which it was able to draw into its mouth with its long, muscular tongue. The sharp beak was used to nip off tough stems, while the teeth served to pulp the food before it was swallowed. This image of *Iguanodon* as a gigantic kangaroo-style creature, as depicted by Dollo, has become

iconic during more than 60 years and was reinforced by the distribution of full-size replicas of mounted skeletons of *Iguanodon* from Brussels to many of the great museums around the world (Norman, 2005).

In 1980, British paleontologist D. Norman published a monograph on *Iguanodon bernissartensis*. He described the skeleton with the precision required nowadays. Functional analysis of the skeleton revealed that the vertebral column, stiffened by a network of ossified tendons, was held more or less horizontal while the animal was walking or running. Norman also believed that *I. bernissartensis* was mainly quadrupedal. The structure of the pectoral girdle, the ratios of the forelimb and hind limb lengths, the strongly fused carpal bones, and the presence of hooflike unguals on the middle three digits of the hand suggested that the adult of *I. bernissartensis* spent most of its time in a quadrupedal posture, although juveniles had a predominantly bipedal mode of life.

In 1986, Norman described the small *Iguanodon* species from Bernissart and concluded that it belonged to *Iguanodon atherfieldensis* Hooley, 1925, a species previously described from the Wealden Beds of the Isle of Wight. Moreover, he stressed that the former name for it, *Iguanodon mantelli*, is a nomen dubium as a result of the fragmentary preservation of the type material of that species.

On the occasion of the mounting of an *Iguanodon bernissartensis* cast in a quadrupedal position at the RBINS in 1992, Bultynck discussed in a short paper the posture and gait of this species.

It is also worth mentioning that many specialists undertook the study of the other fossils found at Bernissart: C. E. Bertrand (1903) and G. Poinar Jr. and A. J. Boucot (2006) for coprolites, A. Lameere and G. Severin (1897) for insects, R. H. Traquair (1911) and L. Taverne (1981, 1982, 1999) for fishes, Buffetaut (1975) and M. A. Norell and J. M. Clark (1990) for the crocodile *Bernissartia fagesii*, and A. C. Seward (1900), K. L. Alvin (1953, 1957, 1960, 1971), and F. Stockmans (1960) for plants.

New Boreholes within the Iguanodon Sinkhole

In 2002–2003, three new boreholes were drilled within and around the Iguanodon Sinkhole at Bernissart. Initially, the aim of this drilling program was to evaluate the chances of finding more fossils, to understand the genesis of the Iguanodon Sinkhole, and to test a seismic geophysical technique for ground imaging (Tshibangu et al., 2004a, 2004b). In October 2002, the drilling program started with a completely cored well (named BER 3) using the PQ wireline technique. BER 3 reached 349.95 m of Thanetian, Late Cretaceous, Early Cretaceous, and Westphalian sediments (Yans et al., 2005b; Yans, 2007). During these operations, various parameters were recorded: rate of penetration, core recovery, and brief core descriptions (Tshibangu et al., 2004a, 2004b). BER 3 provided exceptional material to improve our knowledge of the iguanodon-bearing Wealden facies, with multidisciplinary research funded by FRS-FNRS (FRFC no. 2.4.568.04.F). Another borehole (BER 2) was also cut into the Wealden facies (Spagna and Van Itterbeeck, 2006).

The formation processes of the Iguanodon Sinkhole were documented by sedimentological studies of the lacustrine Wealden facies (including clay mineralogy, granulometry, and magnetic susceptibility; Spagna et al.,

2008; Spagna et al., Chapter 9 in this book) and by characterization of the organic matter with Rock-eval, palynofacies, soluble alkane content, and carbon isotope and structural analyses (Schnyder et al., 2009). Schnyder et al. (2009) suggested two steps in the life of the lacustrine Wealden facies of Bernissart: a first step with a large supply of plant debris, and a second step with active algal/bacterial activity with amorphous organic matter, which followed the lake's level variations. The paleontological content was studied using paleohistology (de Ricqlès and Yans, 2003; de Ricqlès et al., Chapter 12 in this book) and diagenesis of the bone fragments (Leduc, Chapter 11 in this book), characterization of amber, and preparations for diatom and ostracod analyses, which were unfortunately barren (C. Cornet, pers. comm.; B. Andreu, pers. comm.). A late Late Barremian to earliest Aptian age was estimated for the iguanodon-bearing sediments by both palynology and chemostratigraphy (Yans et al., 2005a, 2006, 2010; Dejax et al., 2007a; Yans et al., Chapter 8 in this book), which permitted a better knowledge of the initial steps of the subsidence in the Mons Basin (Spagna et al., 2007). Moreover, Wealden facies samples from the RBINS collection (historical searches of 1878–1881) and other localities in the Mons Basin (Hautrage, Thieu, Baudour) were also investigated. Rare dinosaur fossils are described from the Baudour Clays Formation (Godefroit et al., Chapter 13 in this book). Palynology and determination of wood and plant mesofossil fragments provide further information about the paleoenvironment of the Mons Basin during the Early Cretaceous (Gerards et al., 2007, 2008; Dejax et al., 2007b, 2008; Gomez et al., 2008; Gomez et al., Chapter 10 in this book). In Thieu, the occurrence of dinoflagellate cysts suggests marine influences in the Wealden facies of the Eastern part of the Mons Basin (Yans et al., 2007). These data were integrated into the Early Cretaceous geological context of Northwest Europe (Thiry et al., 2006; Quinif et al., 2006). Studies are still in progress . . .

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