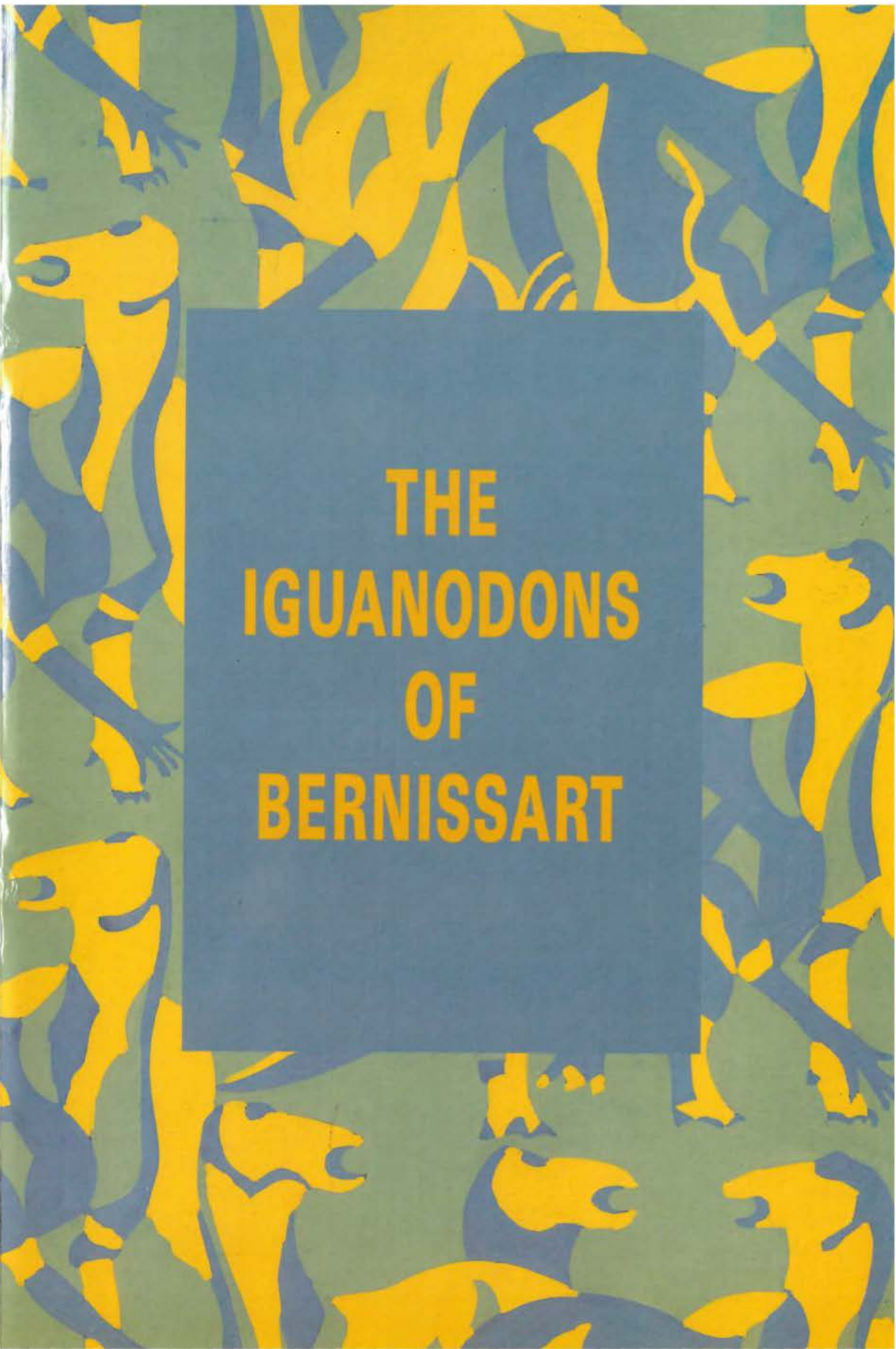

THE IGUANODONS OF BERNISSART

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THE IGUANODONS OF BERNISSART

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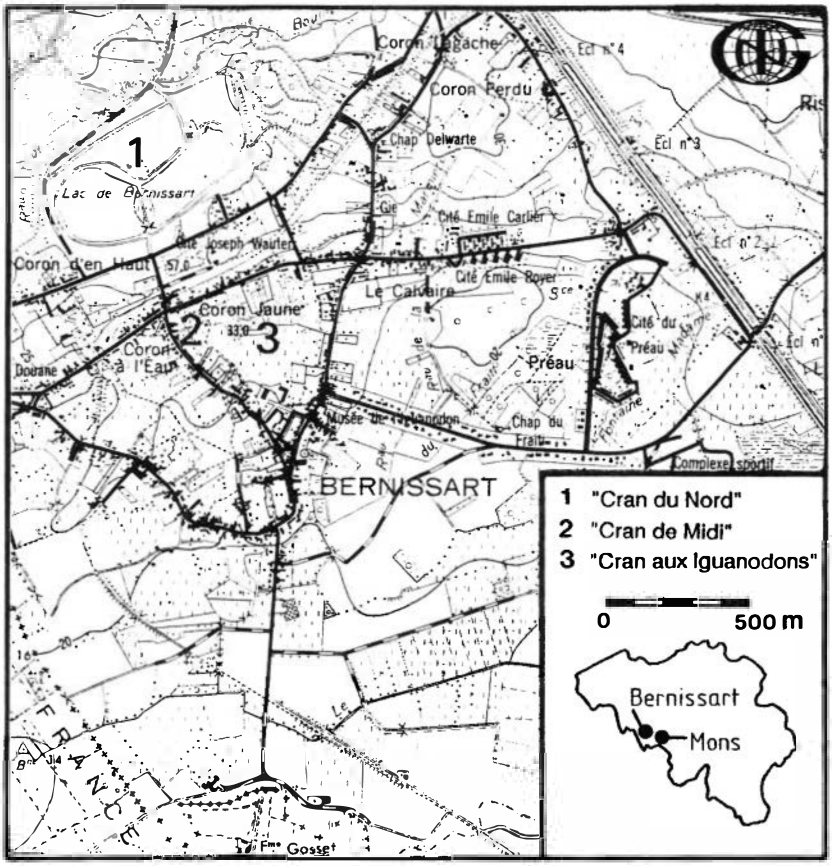


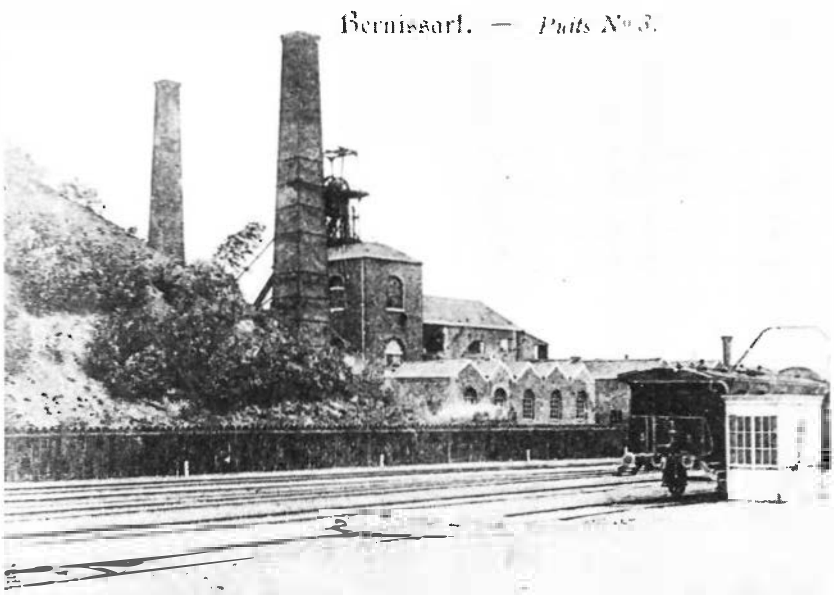
Location and plan of the Bernissart area. Part of Sheet 45/1-2, Beloeil-Baudour, enlarged from the 1:25 000 topographic map. By permission (A1060) of the 'Nationaal Geografisch Instituut'.

'Cran' is a term peculiar to Hainaut Province, where Bernissart is located, and means a pit formed by natural collapse.

'Coron', printed five times in the upper part of the map, is a term used in Wallonia for a district occupied by miners' cottages.

FROM BERNISSART TO THE MUSEUM

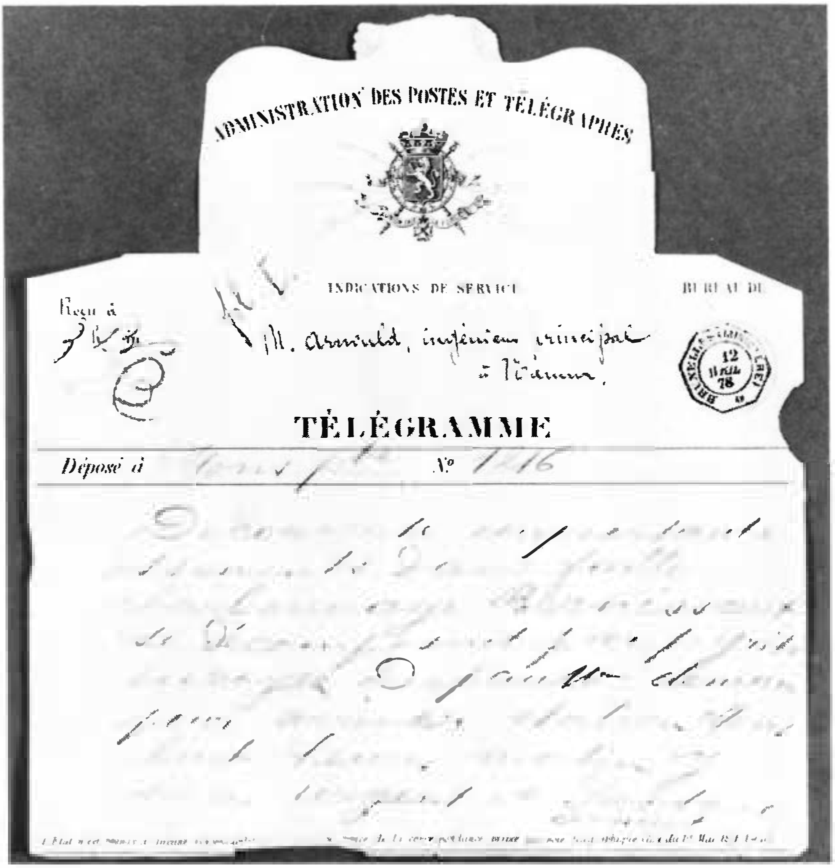
Bernissart is a former coal-mining village in southwestern Belgium, situated 21 km west of Mons and less than 1 km from the Franco-Belgian frontier. Since 1878 its name has become known worldwide thanks to a palaeontological discovery, as important as it was fortuitous. On February 28 that year, two miners, J. CRETEUR and A. BLANCHARD, found what they supposed to be a tree trunk filled with gold, 322 m below ground level in a gallery of the Sainte-Barbe Pit. A few days later the mine manager, G. FAGES, and the local doctor, L'HOIR, concluded that the specimen was, in fact, a fossil bone filled with pyrite, a bright golden-yellow mineral sometimes called 'fool's gold' as it is often confused with real gold by non-specialists. A little later P.J. VAN BENEDEN, zoologist from Leuven University, was the first to recognise among these fragmentary fossils some teeth of Iguanodons, large herbi-



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

View in 1985 of the waste-tip and mine buildings at the Sainte-Barbe pit, closed in 1921.

vorous reptiles living about 135 million years ago. On April 12, 1878, the management of the colliery sent a telegram to E. DUPONT, director of the Royal Museum of Natural History (as the present Institute was then called) in Brussels, asking for the services of L. DE PAUW, a technician highly experienced in the restoration of fossils. Assisted by one museum warder, one moulder and nine miners, L. DE PAUW was to spend the next three years actively directing excavations and restoring bones which, when brought to the surface, began to decompose owing to oxidation of the pyrite they contained. The find of fossils in the mine proved to be unique; almost thirty, more or less complete skeletons of Iguanodons were found lying as they had fallen, little disturbed, if at all, by their burial. Hundreds of fragments of plants, fishes, some tortoises and crocodiles, one salamander and a fragment of an insect were also discovered. Each Iguanodon skeleton was split into pieces that were coated with plaster of Paris; after being sketched and catalogued the blocks were carried to the surface. In this way the fragments could be assembled later like a jigsaw puzzle. The researches were not untertaken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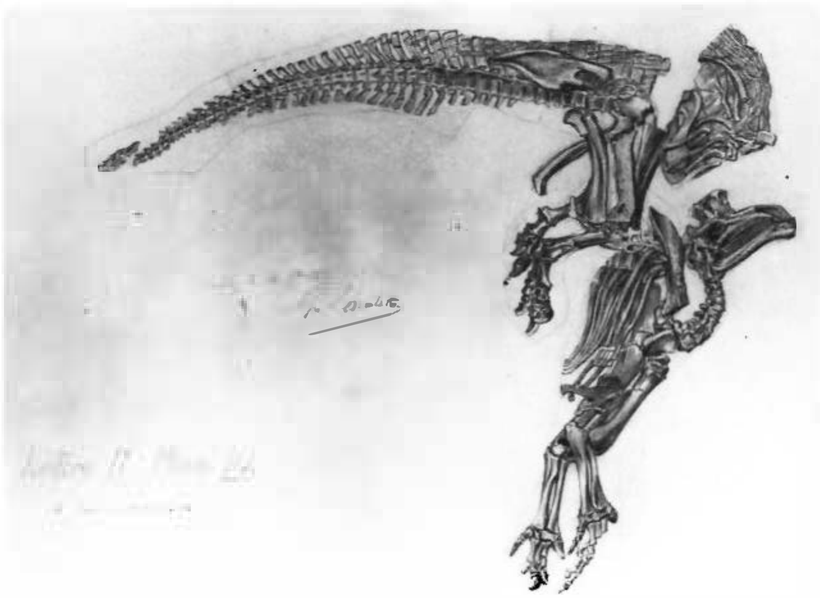
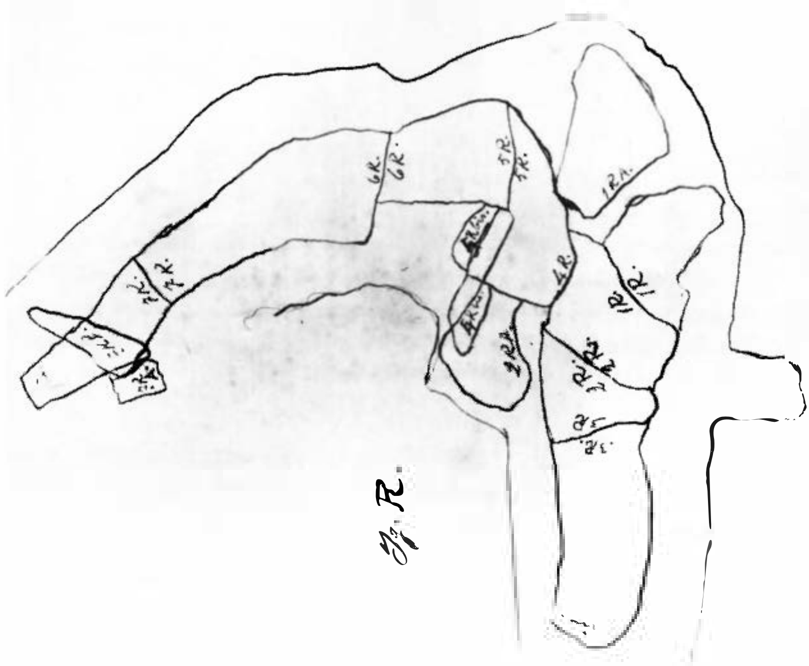
Telegram of April 12th, 1872 (translation).
Important find of bones in coalfield fault Bernissart decomposing due to pyrite send Depauw tomorrow to arrive Mons station 8 a.m. shall be there urgent.
Gustave Arnaut.

without danger. In August, 1878, an earthquake accompanied by collapse occurred in the mine; in autumn the same year, flooding of the gallery 322 m below ground level forced the team to abandon their excavations hurriedly. The latter were restarted from 1879 onwards; they were extended horizontally for 50 m at the same level, and a new gallery was cut at a depth of 356 m.

In all, six hundred blocks totalling 130 tonnes were moved. Transported to Brussels in furniture removal vans, each of 3 tonnes capacity, they were stored in the Museum workshop, the St. George chapel or Nassau



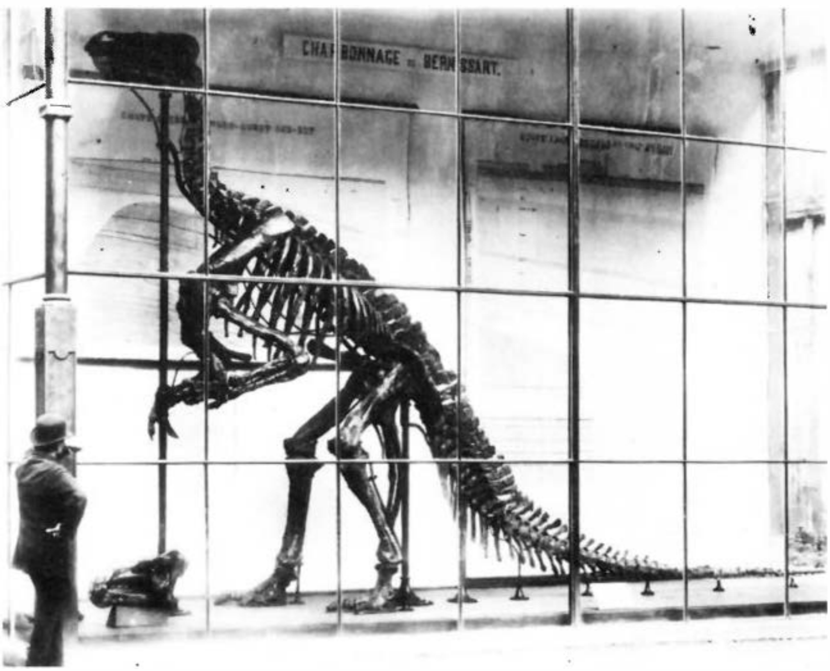


Upper: drawing by G. LAVALETTE in 1883 of a specimen of *Iguanodon bernissartensis* as discovered in the Sainte-Barbe pit.
Lower: sketch of the assemblage of blocks of plaster containing pieces into which the above specimen was divided for raising to the surface.

Palace chapel, dating from 1520 and now preserved as an exhibition hall in the Albert I Royal Library.

In 1881 the excavations were stopped. The whole enterprise, begun thanks to the generosity of the 'Société Anonyme des Charbonnages de Bernissart', involved much expense for the Belgian government. Because of the need for supplementary subsidies, certain members of Parliament suggested that an Iguanodon should be sold abroad, but subsequent public outcry prevented the transaction.

In 1883 the first specimen was exhibited publicly in a glass cage specially constructed in the interior court of the Nassau Palace. In 1892, when the museum in the Nassau Palace chapel had become too small, the Iguanodons were transported to a new home in the Leopold Park, where some examples were first exhibited in the former convent. From 1902 onwards the whole collection was permanently installed in the newly constructed Janlet Wing where, just before 1940, it was enclosed in large glass cages. On two occasions, in 1985 and 1988, two specimens, each insured for 100 million Belgian Francs, left the Institute for a few months to be exhibited in Japan, notably in Tokyo and Nagoya.



The first example of *Iguanodon bernissartensis* exhibited publicly, in 1883, in the interior court of the Nassau Palace.

The Bernissart Iguanodons for everyone.

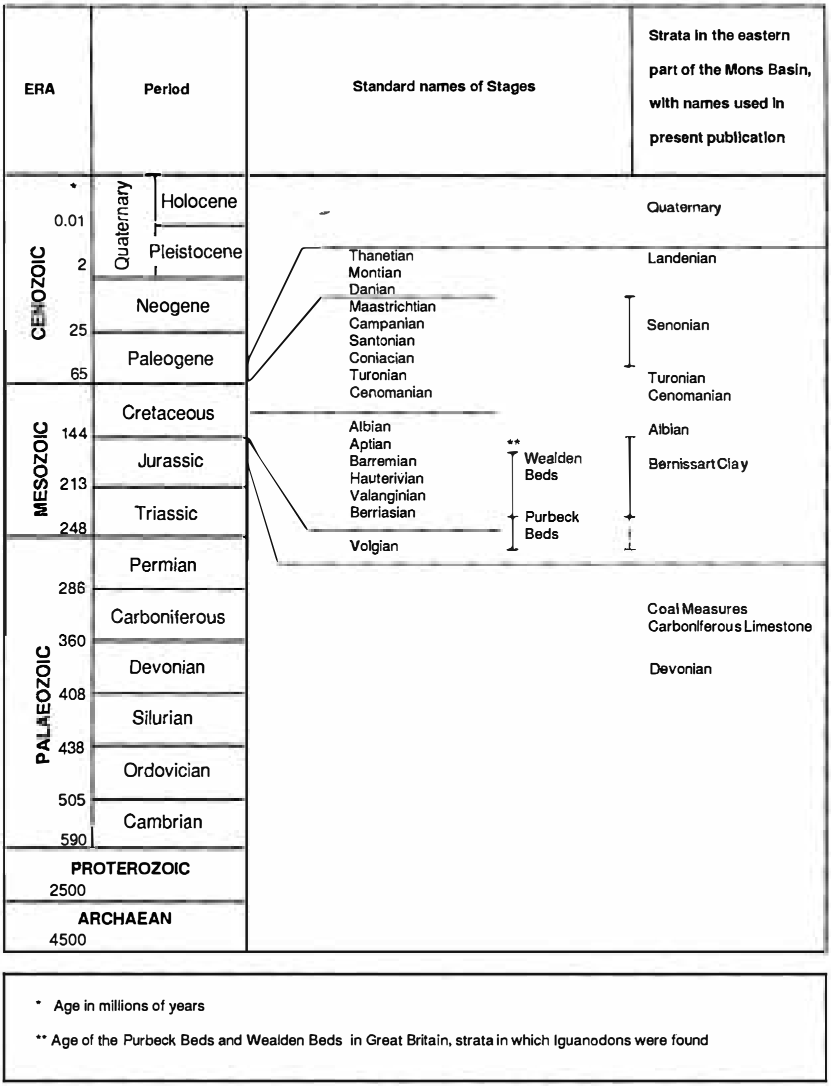
IGUANODONS IN THE ROCKS

Bernissart is situated on the southern edge of a basin-shaped structure, known to geologists as the Mons Basin, in which mostly Cretaceous and Tertiary strata are exposed. Nearly all the Cretaceous beds were deposited in a marine environment, but the lowest strata, mainly in the southern part of the basin, consist of clayey, sandy and lignitic continental deposits, formed probably in ponds and swamps. These continental strata are known by local names such as: Bernissart Clay, Baudour Clay, and Thieu Sands and Gravels. The clays were at one time exploited, for example at Baudour, for the production of ceramics and refractory bricks, and a few businesses still remain.

The Iguanodons, together with other fossil animals and plants, come from the Bernissart Clay. But how old are these continental deposits? In the past they were considered to be of 'Wealdian' age for the simple reason that they contain many fossils, both plants and animals, known also from the Weald Clay, named after a region in southeastern England. The term 'Wealdian' is no longer in general use, and in practice the relative age of strata is best expressed with reference to rocks deposited under marine conditions during a particuler interval of time. The Bernissart Clay is generally attributed to the Lower Cretaceous, in particular from the Berriasian Stage to the Aptian Stage, and its age is approximately 140 to 115 million years.

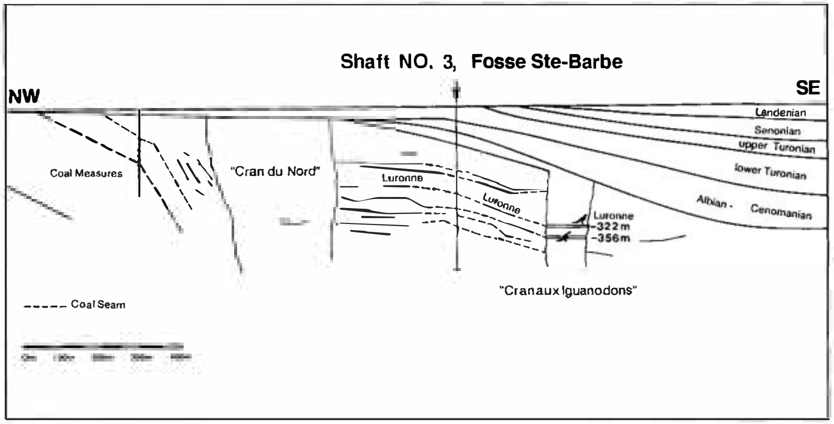
These Mesozoic and Tertiary deposits cover older rocks of the Palaeozoic, notably of the Carboniferous, represented by Dinantian limestones and the Coal Measures, which are present at a depth of some 10's of metres to 350 m. Each of the different coal seams exploited in the mines had an individual name: Luronne, Présidente, Daubresse, Glorieuse, etc. In 1878 some miners reported that the Luronne seam was cut out, at 322 m depth, by what they called a '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. The principal worry for the miners was to traverse or circumvent such 'crans' as quickly as possible and rejoin the coal seam.

The Hainaut coalfield is riddled with such 'crans', natural pits filled with younger deposits. These pits have a circular or elliptical outline,



Geological time scale showing probable age of the Bernissart Clay.

with diameter varying between some 10's of metres and 250 m, and a maximum depth of 343 m. In 1870 two famous Belgian geologists, J. CORNET and R. BRIART, discovered that the pits correspond to natural collapses caused by the presence of large solution cavities in the subjacent Carboniferous Limestone. The roofs of the cavities were



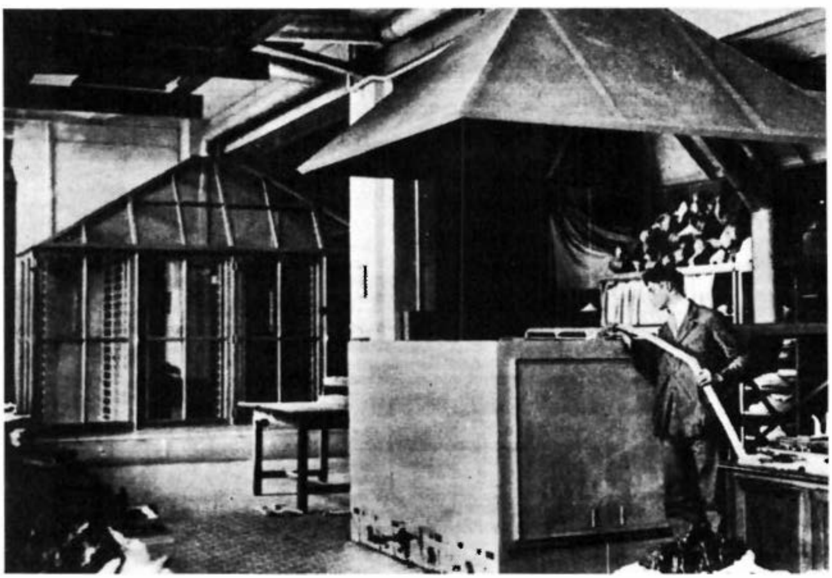
Cross-section through the Coal Measures and younger strata at Bernissart (after a figure by A. DELMER and P. VAN WICHELEN, 1980). The three levels with Iguanodons are shown; two at a depth of 322 m, and one at 356 m.

Recent natural pit in the neighbourhood of Tournai, in the Escaut valley (negative by W. LOY). These zones of collapse, with breadth and depth of about 10 m, are produced by the foundering of solution cavities in the Carboniferous Limestone under the weight of Tertiary and Quaternary deposits.

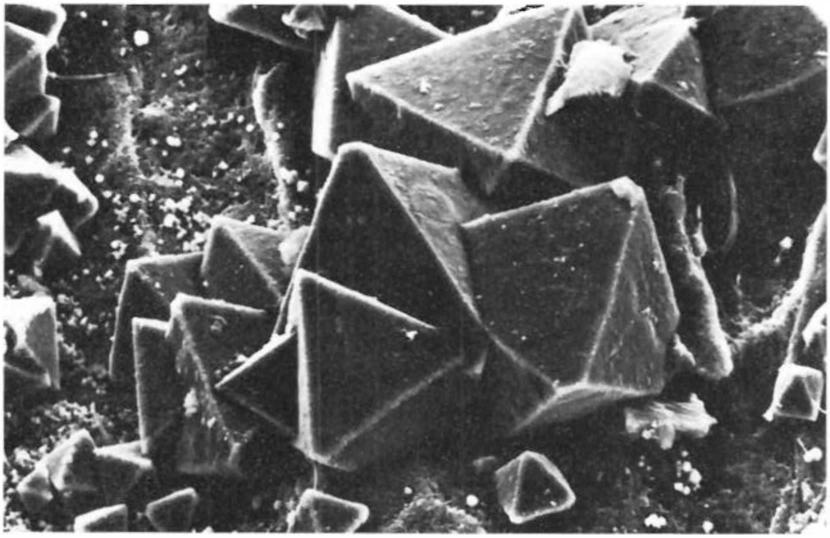
eventually unable to support the weight of overlying rocks; they collapsed and an almost vertical pit, filled with younger, overlying deposits, was formed in the Coal Measures. The material filling the pits consists mainly of Coal Measures débris and Cretaceous deposits; the absence of Tertiary beds indicates that the pits were formed before that period. In 1980 A. DELMER and P. VAN WICHELEN produced an inventory of one hundred and seventeen 'crans' in the Hainaut Basin. At Bernissart, three 'crans' were discovered: the 'Cran du Nord', the 'Cran du Midi', and the 'Cran aux Iguanodons'. The 'Cran du Midi' has been generally, though incorrectly, indicated as the place where the Iguanodons were discovered.

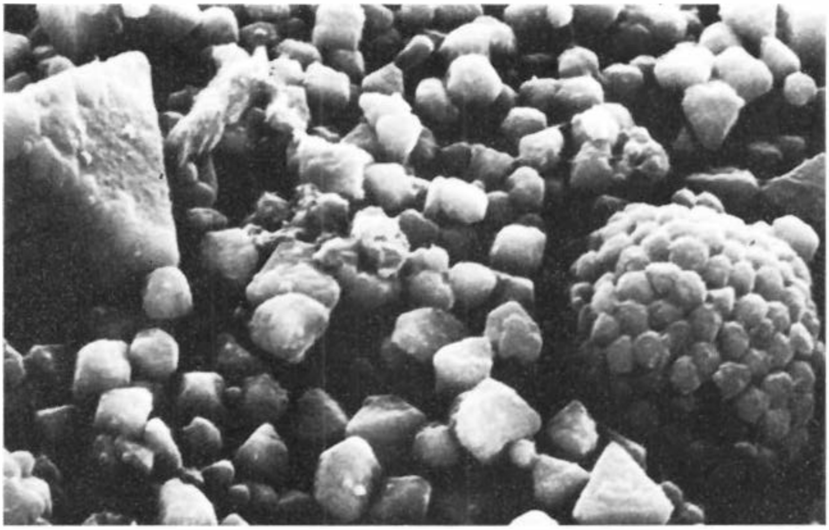
IGUANODONS IN THE LABORATORY

After death the Iguanodons were covered by clayey deposits that completely isolated them from the air. This absence of air during decomposition of the tissues is responsible for the dark colour of the bones. Under such conditions dead bodies putrefy due to the activity of sulphurous bacteria; the acid consequently produced reacts with iron in the sediment to form pyrite, which is deposited in cavities within the bones. In contact with damp air the pyrite oxidises to form either a salt, iron sulphate, or an iron oxide, limonite; decomposition of both leads to the disintegration of bone containing them. To prevent such deterioration, between 1878 and 1905 the bones were impregnated with carpenter's glue, after elimination of the often very abundant pyrite (some vertebrae contained more than 1 kg of it!). Existing cavities were first filled with a sort of 'carton-pierre' (a mixture of pulped paper, carpen-



Laboratory used for treatment of the fossil bones at the Royal Museum of Natural History, Brussels, about 1930.





Pyrite from a bone of *Iguanodon bernissartensis*, viewed under the scanning electron microscope.

Upper: × 500; lower: × 5000. The pyrite may be crystalline, of regular appearance, in small cubes or octahedra; or microcrystalline, forming small clusters with a raspberry-like shape (negatives by R. VAN TASSEL and K. WOUTERS).

ter's glue, talc and plaster) reinforced with iron wire. Before being applied the carpenter's glue was soaked in water saturated with arsenious acid, used at that time as a disinfectant. To ensure its better penetration into the bones, it was rendered more liquid by the addition of alcohol.

Until 1932 the specimens were exposed to the air in the exhibition hall, and thirty years of changes in temperature and humidity, due to contact with the atmosphere, had produced clear evidence of damage. A new form of treatment was urgently needed.

Between 1933 and 1937 all the specimens were dismantled and soaked in a mixture of alcohol and shellac, a natural laquer secreted by Coccidae, insects that lived originally on fig-trees but have since adapted to other habitats; this treatment is responsible for the brownish appearance of the bones. At the same time two glass cages were constructed in order to maintain the specimens at more constant temperature and humidity. In 1984, the year just before the specimens were first sent on loan to Japan, the bones of two skeletons were reinforced by the application of a solution in alcohol of Mowilith, a synthetic product used in the manufacture of glues.

NAMING AND DESCRIBING THE BERNISSART IGUANODONS

It is difficult to decide who should be credited with first discovering the Iguanodons in 1878. Was it G. FAGES, the mine engineer who first recognised the presence of fossil bones; or was it P.J. VAN BENEDEN, the zoologist from Leuven University, who first recognised Iguanodon teeth among the fossils? At that time disputes over authorship were often heated, most notably in the course of a noisy session of the Academy of Sciences in 1883. A second contentious point concerned the species that had been discovered: did it belong to a new species or to the already known *Iguanodon mantelli*? * G.A. BOULENGER, a young naturalist from the Brussels Museum, was asked by his director to examine the material, and in 1881 he presented his first results to the Belgian Royal Academy of Sciences, Letters and Fine Arts. According to him the species was new and he named it *Iguanodon bernissartensis*. P.J. VAN BENEDEN, then president of the Science section of the Academy, was once more involved; he thought otherwise and claimed that the species present was *Iguanodon mantelli*. As a result of his adverse opinion, G.A. BOULENGER's complete study was never published, and this has led to arguments concerning authorship of the species *Iguanodon bernissartensis*. Later, in 1881, G.A. BOULENGER left Belgium for London, where he pursued a distinguished career in zoology at the British Museum (Natural History) and Belgium's loss was ultimately Britain's gain. In 1882 study of the Iguanodons was entrusted to L. DOLLO, a mining engineer of French origin who eventually became a Belgian citizen and devoted himself entirely to vertebrate palaeontology at the Brussels Museum. His best known studies are those on the Iguanodons and mosasaurs (a group of marine reptiles).

* The first known fragment of *Iguanodon*, a tooth more than 5 cm long, had been found fortuitously in 1822, in Sussex, England, by Mrs. A. MANTELL-WOODHOUSE. The species name, *Iguanodon mantelli*, was dedicated to her husband G. MANTELL, a country doctor and a well-known fossil collector.

Under L. DOLLO's direction, L. DE PAUW assembled and mounted the first complete Iguanodon skeleton in the St. George Chapel of the Nassau Palace. The bones were suspended from a scaffolding by ropes that could be adjusted so as to obtain the most lifelike position for the complete skeleton, which was then supported by an iron framework.

L. DOLLO (born Lille 1857 - died Uccle 1931).
Curator at the Royal Museum of Natural History from 1882 to 1925 and considered the 'scientific father' of the Bernissart Iguanodons.

Between 1882 and 1923 L. DOLLO published a score of contributions on the Iguanodons, in which he distinguished two species at Bernissart. One, a previously described species *Iguanodon mantelli*, was represented by a single complete, smaller specimen; the other, larger form was *Iguanodon bernissartensis*, the new species proposed by G.A. BOULENGER. L. DOLLO described in detail both the various parts of the skeleton

The St. George Chapel, or Nassau Chapel, assembly workshop of the Royal Museum of Natural History, in 1878; the room is now an exhibition hall in the Albert I Royal Library, Brussels. To the left of the Iguanodon's hindleg can be seen the skeletons of a kangaroo and an ostrich, used as models in assembling the bones.

Picture, painted by L. BECKER in 1884, of the mounting, in 1882, of the first complete skeleton of a Bernissart Iguanodon in the St. George Chapel. The bearded figure with bent knee is L. DE PAUW.

and the foot-prints, as well as the mode of life and relationships with other dinosaurians. The high quality of his work gave the impression that there was nothing left to add, and a long silence ensued.

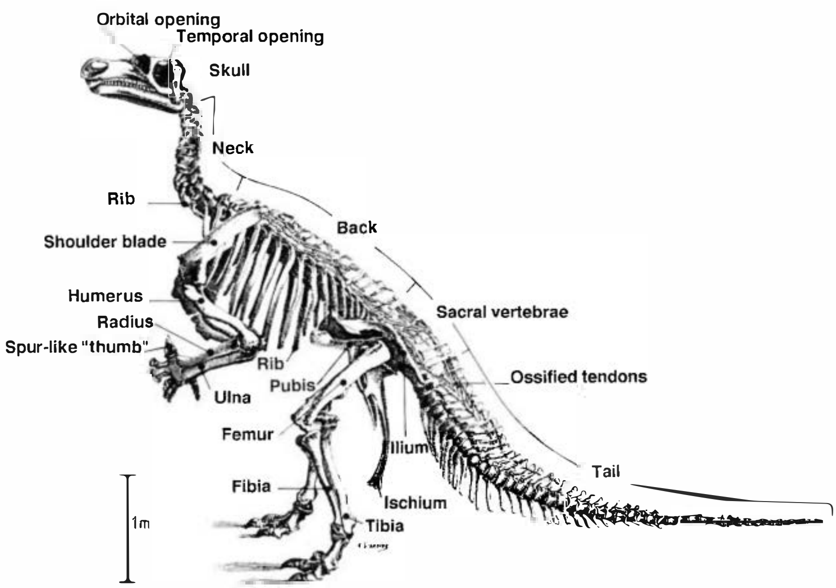
In 1960 E. CASIER, curator of fossil vertebrates at the Institute, wrote a review of the Iguanodons and the other fossils, including plants, insects, fishes, tortoises and crocodiles, found at Bernissart.

In 1980 the British palaeontologist D. NORMAN published a new study of *Iguanodon bernissartensis*. He described the skeleton with the precision necessary nowadays for distinguishing it from the ten or so other species discovered since 1878; he also confirmed the presence of two species of Iguanodon at Bernissart. A later study, in 1986, by the same author concluded that the small Iguanodon from Bernissart belongs to *Iguanodon atherfieldensis*, a species known from the Wealden Beds of the Isle of Wight, in southern England, and described first by another British palaeontologist R.V. HOOLEY in 1925. Nevertheless the name *Iguanodon mantelli* is retained here for the smaller specimen from Bernissart. In addition to the above, a large number of foreign specialists undertook the study of the other fossils found at Bernissart.

A LOOK AT THE SKELETON OF *IGUANODON BERNISSARTENSIS*

The skeleton, almost 5 m tall and measuring about 10 m from the muzzle to the tip of the tail, is mounted in the Museum like that of a kangaroo. The skull, about 85 cm long, recalls that of a horse, with its flat-sided appearance and the large eye sockets located on the sides. The name Iguanodon, meaning 'Iguana tooth' (*odon*= Greek for tooth), refers to the characteristic form of the long teeth, which number about a hundred and were replaced continuously. The front of the jaws lacks teeth and carries two bony projections.

The vertebral column is composed of eighty-six vertebrae, the first eleven forming the neck, which resembles that of a giraffe in its length and that of a swan in its S-shape. The fifty last vertebrae support the very massive tail. Most of the vertebrae carry a network of strips, a few



Skeleton of *Iguanodon bernissartensis*, after a drawing, dated 1885, by R. VIANDIER.

cm wide and up to 50 cm long. The latter are particularly well developed in the middle and posterior parts of the column, and correspond probably to ossified tendons that functioned in the lateral balance of the tail. The shoulder blades, situated laterally, are the most striking bones of the shoulder, which supported the solidly constructed forelegs (or arms). The joints at the base of the hand were apparently only slightly movable. The most curious feature of the hand is the second phalange of the thumb, which forms a pronounced spur, directed laterally towards the exterior and movable with reference to the palm. The pelvic girdle resembles that of the birds, particularly running birds such as the ostrich.

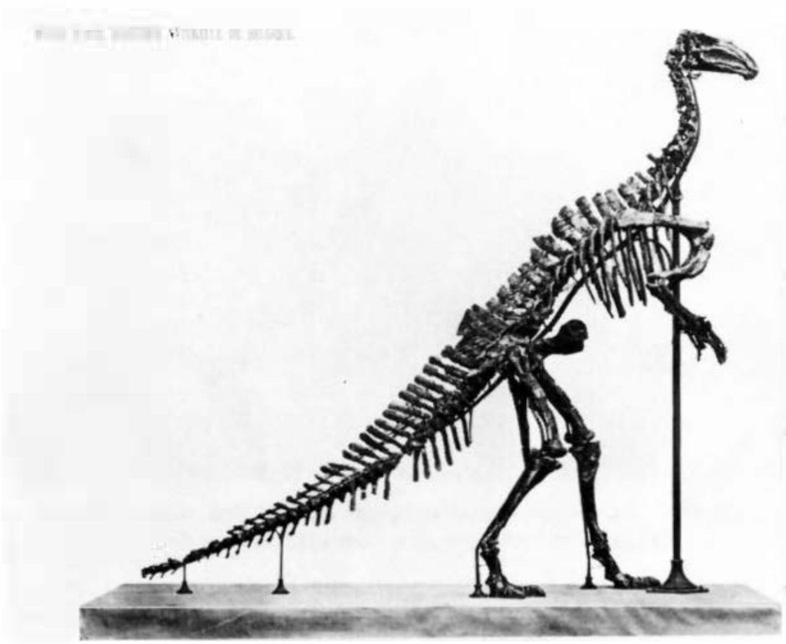
The hindlegs are clearly longer and more solid than the forelegs. They carry three toes, splayed like those of birds, and the name Ornithopoda (*ornis* = Latin for bird; *podos* = Greek for leg), the group of reptiles to which Iguanodon belongs, underlines this resemblance. The foot ends in strong phalanges, the distal ones of which are wider and hoof-like in shape.

Ossified tendons on the last dorsal vertebrae and the first sacral vertebrae of *Iguanodon bernissartensis*. One fifth natural size.

◀ Skull and cervical vertebrae of *Iguanodon bernissartensis*. The teeth of the lower jaw show the wide, oblique grinding surfaces characteristic of a herbivore.

DIFFERENCES BETWEEN *IGUANODON BERNISSARTENSIS* AND *IGUANODON MANTELLI*

Among about thirty large specimens of *Iguanodon bernissartensis* found at Bernissart was a single, complete skeleton of a small Iguanodon about 6 m long and 4 m tall. L. DOLLO was convinced that the differences were unrelated to either the growth stage or sex of the animal, and since then it has been almost universally agreed that the specimen belongs to another species, assigned here to *Iguanodon mantelli*. The latter was a more slender form, as is clearly demonstrated by the skull and forelegs. Other differences include the structure of the pelvic girdle, the relative size of the forelegs and hindlegs, and the number of phalanges in certain digits of the hand.



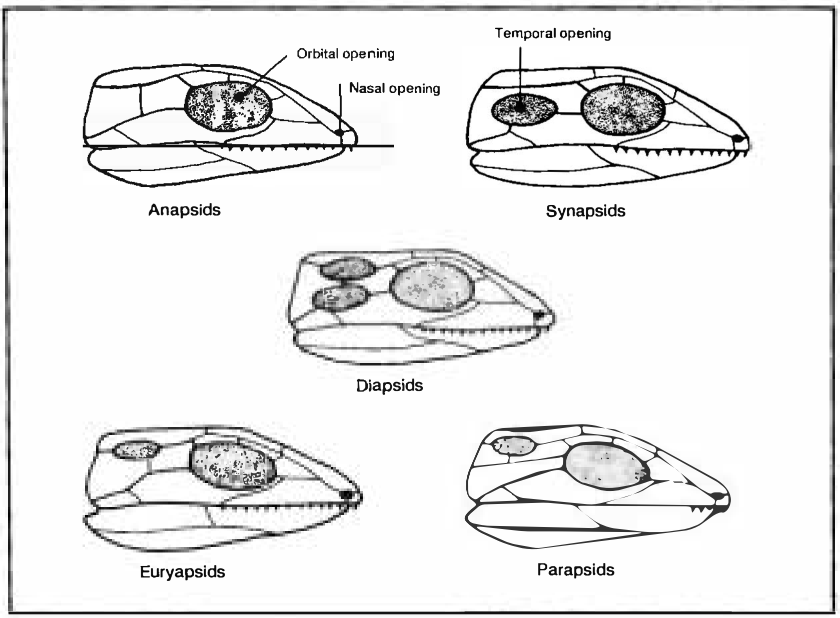
Iguanodon mantelli.

RELATIONSHIPS BETWEEN IGUANODONS AND OTHER REPTILES

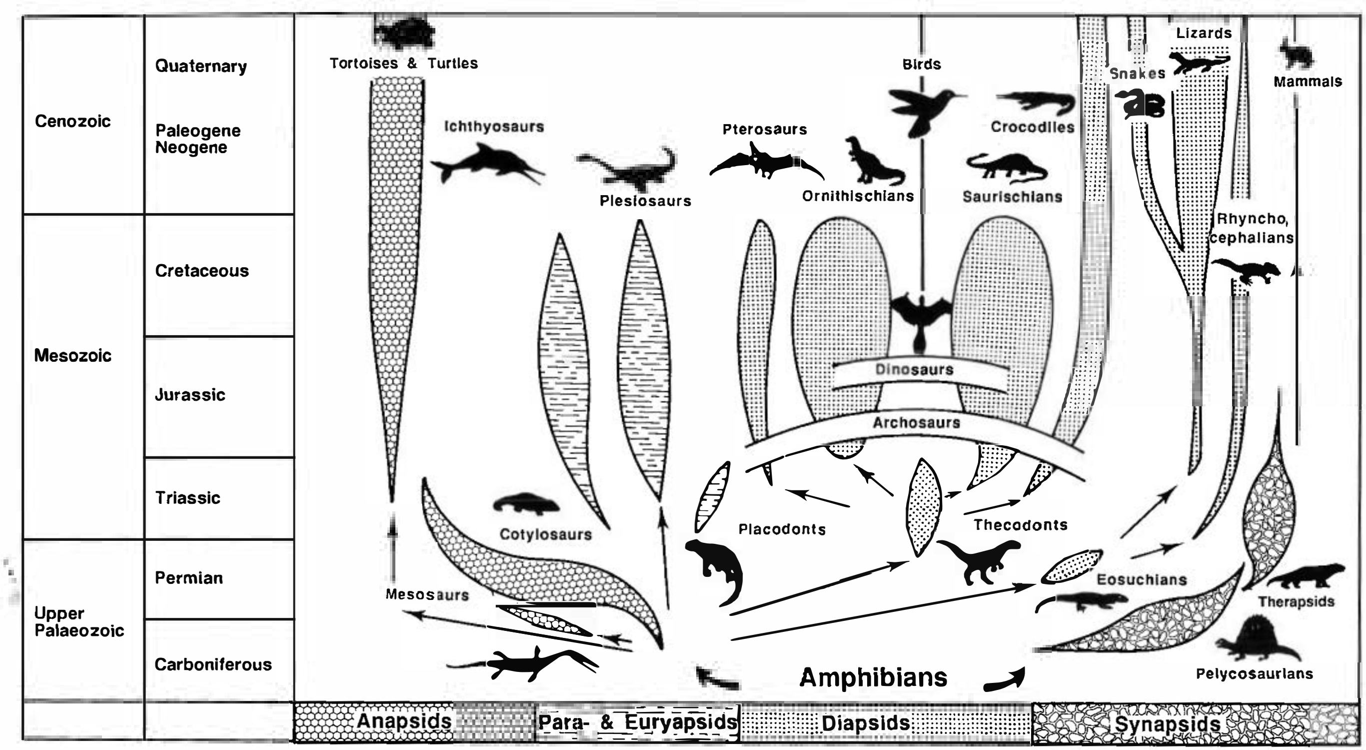
The reptiles, the class of vertebrates to which the Iguanodons amongst others belong, may be classified particularly on the basis of the number and position of temporal openings situated in the lateral and posterior parts of the skull. This means of classification is still often used and forms the basis of the table, which shows the principal groups of reptiles, together with their ancestors and descendants.

The Iguanodons form part of the ornithischians which, together with the saurischians, make up the dinosaurs or 'terrible lizards', a group dominant between about 250 and 65 million years ago.

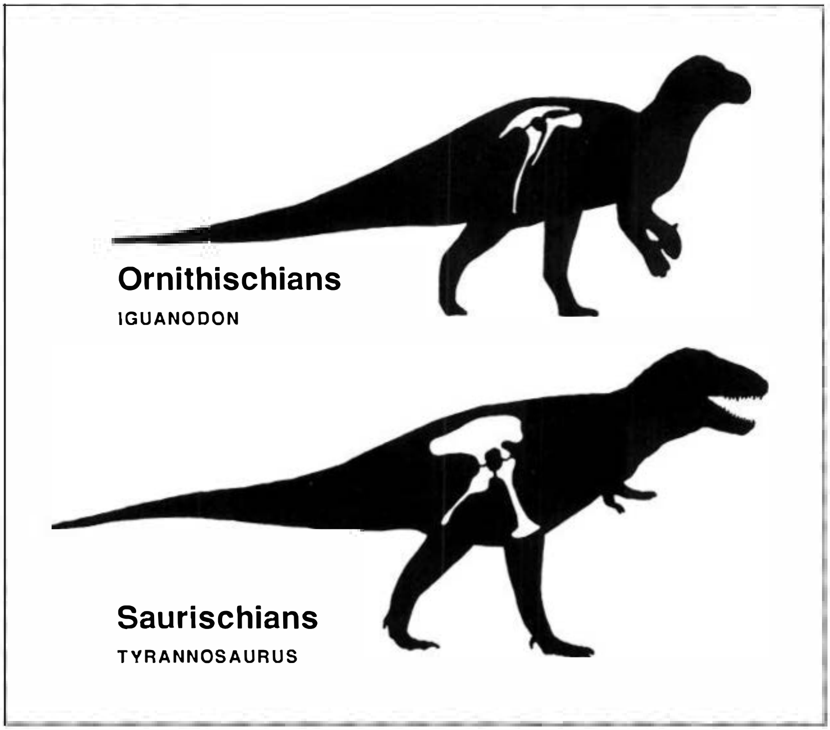
The diagram, which shows the direct ancestors and descendants of the Iguanodons, is based on data and comments published by P. TAQUET



Classification of the reptiles, based on the temporal openings (after E.H. COLBERT, 1969).

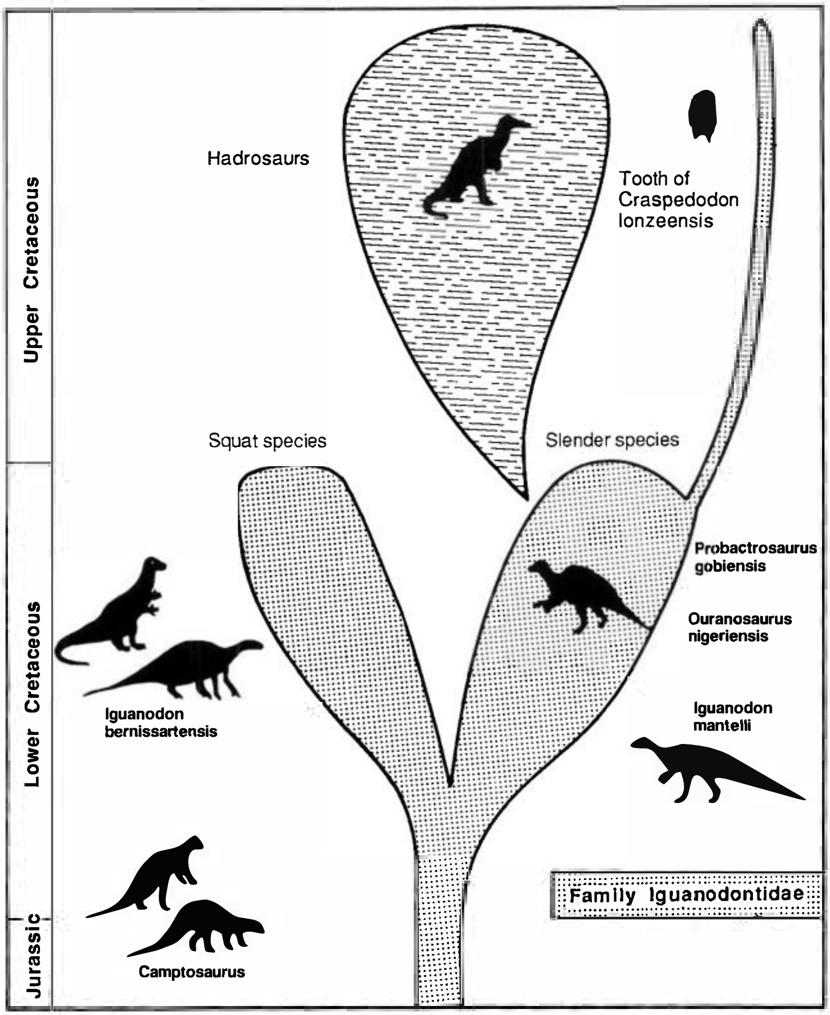


Relationships between the reptiles (after A.S. ROMER, 1966, and A.J. CHARIG, 1983).



The pelvic girdle in ornithischians and saurischians (after drawings in 'Dinosaurs and their living relatives' British Museum (Natural History) 1979). Ornithischians and saurischians differ principally in the structure of the pelvic girdle, as their names in Greek indicate: *ischion* = hip joint of the pelvic girdle; *ornis* = bird; and *sauros* = lizard.

in 1975. The direct ancestor of the Iguanodons, *Camptosaurus*, is unknown in Belgium; its skeleton has been found in the Upper Jurassic rocks of Wyoming, U.S.A., and England. During the Lower Cretaceous the Iguanodons evolved in two directions. One evolutionary line, to which *Iguanodon bernissartensis* belongs, is characterised by massive, bipedal or quadripedal species and appears not to have left any descendants. The second line, which includes, notably, *Iguanodon mantelli*, comprises species that were more slender and moved exclusively on their hindlegs; in the Upper Cretaceous it evolved towards the hadrosaurians or 'duck-billed dinosaurs', found particularly in North America and Mongolia. The decline of the iguanodontids and the development of the hadrosaurians may have been related to their feeding habits and changes in vegetation. It is supposed that the dentition of the first group was particularly adapted to the mastication of tender plants such as ferns; on the other hand the hadrosaurians could feed on harder plants such as the branches and needles of conifers. In the Upper Cretaceous one of the few representatives of the iguanodontid line is *Craspedodon*, from northwestern Europe. This dinosaur is known only from its teeth, some of which were discovered at Lonzée, about 40 km southeast of Brussels.



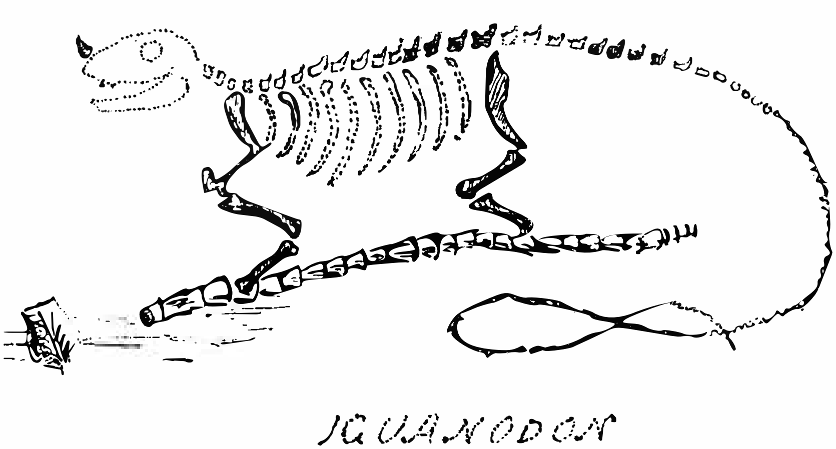
Ancestors and descendants of the Iguanodons (based on data and comments by P. TAQUET, 1975).

LIFE STYLE OF THE BERNISSART IGUANODONS

Did they walk on two or on four legs?

It is not yet established whether the Iguanodons were bipedal or quadripedal, in spite of the availability of some complete skeletons. How does one try to answer this apparently simple question? It can be done by comparing the length of the forelegs and hindlegs, and by studying the structure of the pelvic girdle, hands and feet, the form of the articulations, etc. But let us begin at the beginning.

The first reconstruction of an Iguanodon skeleton was carried out with the aid of a small number of isolated bones found in 1835 by G. MANTELL at Maidstone, southeast England. The animal was represented as a quadruped, a sort of giant lizard at least 30 m long. One of the first bones to be found was the pointed 'spur', thought at first to be a horn on the nose but in fact the first digit of the hand, as was shown later at Bernissart.

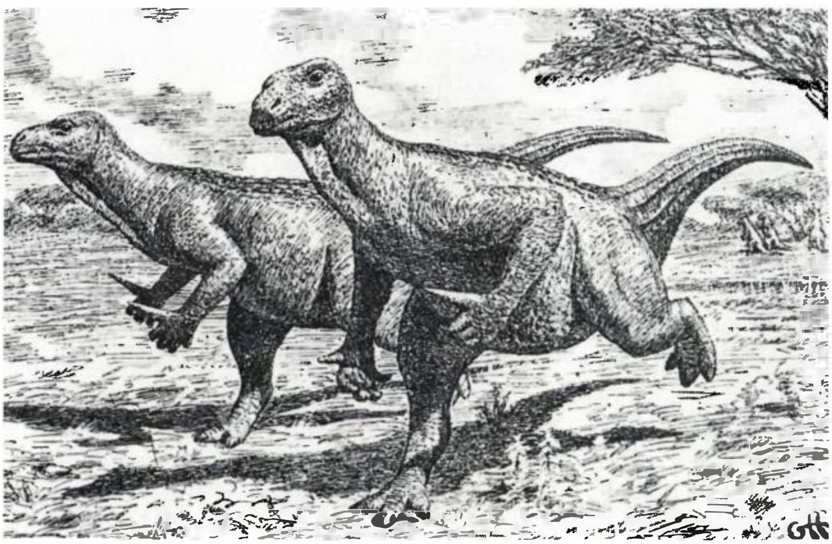


The first reconstruction of an Iguanodon skeleton by G. MANTELL, around 1835. By permission of the British Museum (Natural History).

In 1854 R. OWEN, a British palaeontologist, produced a reconstruction of the whole body, and a model, natural size, was exhibited at the Crystal Palace, in Sydenham Park, London. The animal was represented as a heavy quadruped with a thick, scaly skin and, once again, a horn on the nose.

A more realistic representation of animals related to the Iguanodons was produced in 1858, thanks to the discovery of a *Hadrosaurus*, or 'duck-billed dinosaur', in the Upper Cretaceous of the U.S.A. The fairly complete skeleton, with the forelegs much shorter than the hindlegs, led J. LEIDY to conclude that the animal resembled a kangaroo rather than a pachyderm quadruped.

L. DOLLO firmly believed that the Iguanodons were bipedal and compared the life position of the body with that of a kangaroo or an ostrich. Footprints of Iguanodons found in England and Germany during the nineteenth century strongly influenced this interpretation as they appeared always to correspond to impressions of the hind feet, easy



Reconstruction of Iguanodons running, by G. HEILMANN in 1916.

◀ Views of Iguanodons in the two glass cages.
Upper: the cage with eleven specimens mounted in life position according to L. DOLLO in 1882.
Lower: the cage with twenty specimens, complete and incomplete, each lying as found in the natural pit.

to recognise on account of their three toes. The arrangement of the pelvic girdle and hindlegs, comparable with that found in birds, seemed to lend weight to this hypothesis. In addition it was supposed that the tail offered solid support to the upright body when the animal was at rest. When running, the tail would have been in a more or less horizontal position, acting as a counterbalance to the heavy anterior part of the body. L. DOLLO considered that the digits of the hands and feet of Iguanodons were those of a terrestrial animal, adapted to running on firm ground, as suggested by the reduced number of functional toes supporting the weight of the body.

The hypothesis of an upright, bipedal position, defended by L. DOLLO, has not found universal support. In 1916 G. HEILMANN showed the animal in running position, leaning forward with the back and tail almost horizontal. In 1970 P.M. GALTON, an American dinosaur specialist, also believed that, for running, the ornithopods adopted an almost horizontal position, using only the hind feet. D. NORMAN considers that not only was the body horizontal, but that certain species of Iguanodons such as *Iguanodon bernissartensis* were essentially quadripedal, adopting a bipedal position only for feeding or defence. What arguments support this last interpretation?

In the first place the curvature of the tail has been artificially exaggerated in mounted specimens, the vertebrae of which are badly articulated. This anomaly disappears if the body and the tail are more horizontal, as demonstrated by some of the specimens now lying, as discovered, in the glass cage. The same examples show also in striking fashion that the difference in length between the hindlegs and forelegs (an argument in favour of a bipedal stance) is amplified by the upright position. In addition, the present mounting shows the neck in the form of a letter S, like that of a swan. This looks artificial because, in such a position, the articulating head of the first cervical vertebra and the posterior face of the skull are completely out of joint. In a more horizontal mounting, this joint becomes more natural. If the back and the tail are horizontal, the latter, which was very heavy, formed a counterbalance to the rest of

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Iguanodon bernissartensis, weighing 2 to 5 tonnes, in normal walking position. This reconstruction, based on the quadripedal position proposed by D. NORMAN in 1980, is taken from the catalogue 'The superstar of ancient times Iguanodon exhibition in Japan', © NTV 1985. ▶

the body, with the sacral bone functioning like the point of equilibrium between the two arms of a balance. The sacral vertebrae would be submitted to opposing tractional forces, as a result of which they were well developed and reinforced by ossified tendons.

A more or less horizontal position would naturally draw the forelegs much closer to the ground. D. NORMAN believes also that the animal rested on its forelegs, because the strongly fused carpal bones of *Iguanodon bernissartensis* must have functioned mainly in supporting the weight of the body. According to him the fossil footprints show an alternation of impressions of hindlegs and forelegs. This quadripedal position would have been normal during walking and running, with the animal sitting upright on its hind legs in a defensive posture or while browsing. On the other hand the smaller species *Iguanodon mantelli*, with its lighter, shorter forelegs, must have been bipedal.

Skin

L. DE PAUW, who supervised the excavations at Bernissart, noted several times that scraps of skin were found near the bones and, sometimes, still attached to the vertebrae; he added that the skin was comparable to that of a toad. In 1987 D. NORMAN mentioned that impressions of the skin had been found rarely on parts of the skeleton of *Iguanodon mantelli*. It is now generally believed that the skin of the Iguanodons was finely granulate with small mosaic-like elements, the size and arrangement of which varied according to their position on the body. These changes may have corresponded to a colour pattern, with pigmentation darker on the back and lighter on the belly, as in modern Reptiles. In most reconstructions the colour of the Iguanodons is shown as brownish-green.

Sexual dimorphism and reproduction

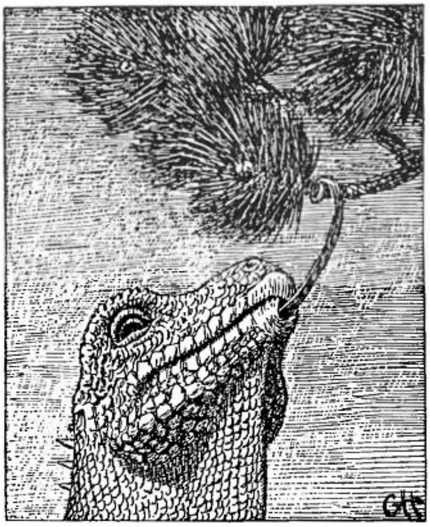
Certain researchers interpreted the small *Iguanodon mantelli* and the large *Iguanodon bernissartensis* as, respectively, the female and male of one and the same species. However, the majority of palaeontologists, including most recently D. NORMAN, no longer accept this point of view.

Most modern reptiles reproduce by means of eggs with a hard shell, implying internal fertilisation. The eggs are laid on firm ground and, after a time, hatch without brooding. That the dinosaurs reproduced in the same manner is confirmed by finds of eggs about 80 million years old in the Gobi Desert of Mongolia and in Montana, U.S.A.

Feeding habits

The dentition of Iguanodons is characteristic of herbivores. The anterior part of the mouth contains no teeth and is formed by two distinctive bones. The latter, covered perhaps by a horny layer with cutting edges, formed an apparatus that permitted browsing on plants. A series of spatula-shaped teeth is situated farther back in the mouth. During chewing, the teeth of the upper jaw slid, towards the outer side, on those of the lower jaw; the chewing surfaces were thus bevelled and continually sharpened in use. This type of dentition is well adapted to the cutting and chewing of plant food.

In the neighbourhood of Bernissart several fossil plants were found that must originally have formed the principal food source of the Iguanodons. They are primarily ferns and secondarily conifers. The best known fern, *Weichselia*, is sometimes represented as a sort of liana, twined around the trunks of trees. For this reason the Iguanodon is often shown upright, standing on its hind legs, browsing on the trees like a giraffe, with the spur-like thumb serving as support when leaning against a tree.



L. DOLLO, like G. MANTELL, who discovered the first Iguanodon, and certain other authors at the beginning of the century thought these animals, like the giraffe, were equipped with a prehensile tongue for grasping and tearing leaves from trees. This view is no longer accepted. Drawing by G. HEILMANN in 1928.

It may also have been capable of taking branches and foliage in its hands since, according to L. DOLLO, the little finger might have been recurved towards the inside of the palm.

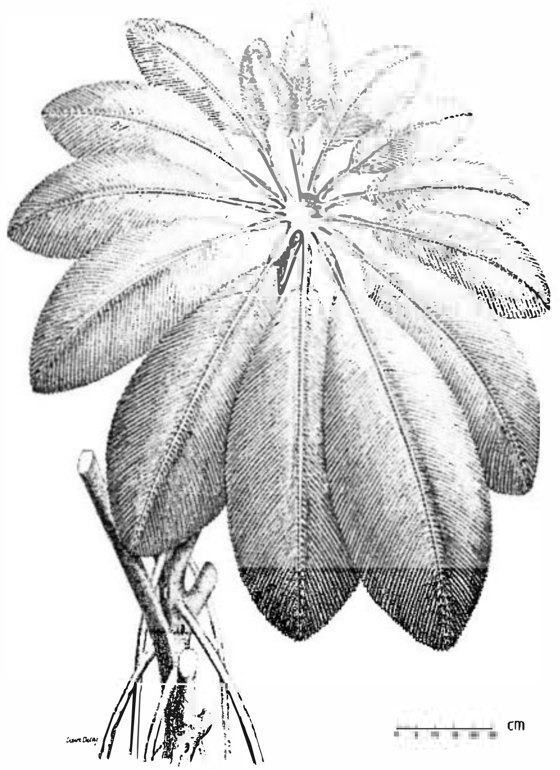
Conversely, other workers believe that *Weichselia* was not a climbing plant with aerial roots, the presence of which has not been demonstrated with certainty. If these ferns formed a low ground cover it is logical to accept that the Iguanodons moved on four legs in order to graze.

Defence

The upright position, resting on the hind legs, the sharp spur on the hand, and the powerful muscular tail suggest that the Iguanodons were well able to defend themselves when attacked.

PLANTS AND ANIMALS LIVING ALONGSIDE THE BERNISSART IGUANODONS

In addition to the Iguanodons, numerous other fossils were found in the clayey deposits of Bernissart. They include: plant remains, fishes, a

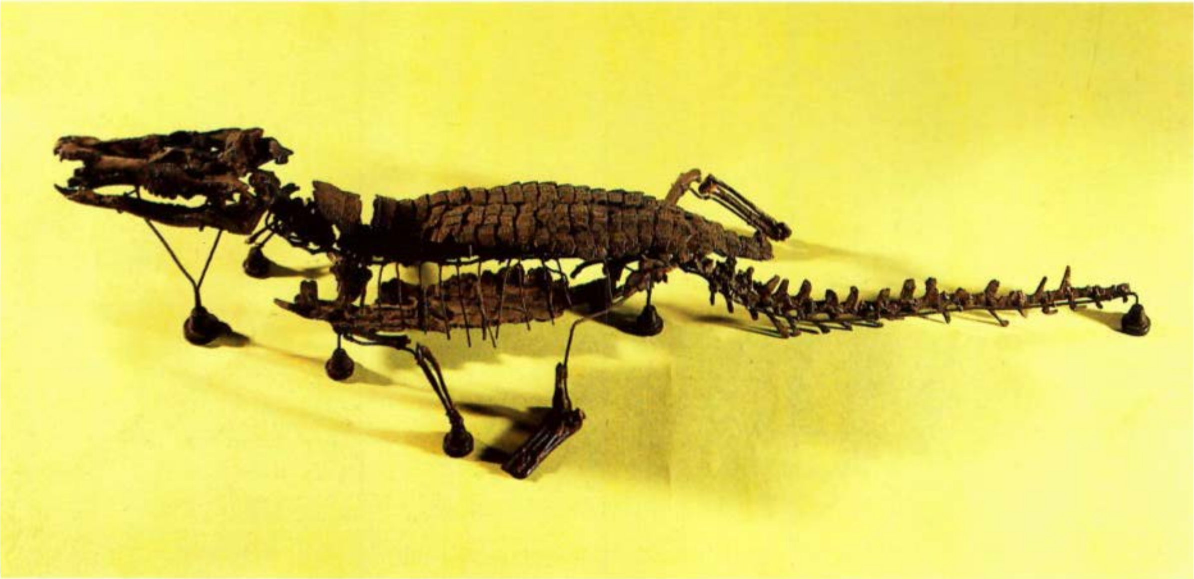


The excavations at Bernissart yielded hundreds of plant remains. These consisted almost entirely of small fragments of a fern, *Weichselia reticulata*, a reconstruction of which by K.L. ALVIN in 1971, based on data published by C. BOMMER in 1911, shows that it was some metres tall. The presence of aerial roots in the lower part of the drawing has sometimes been questioned. Also found at Bernissart were rare fragments of fossil wood, fruits of conifers, and some drops of fossil resin, known as amber.

salamander, some tortoises and crocodiles, a phalange of a carnivorous dinosaur, an insect, and coprolites, or fossil excrement. All these elements are important in reconstructing the setting in which the Iguanodons lived, and together they suggest a swampy environment in a warm, subtropical to tropical region.

Among some thousands of fossil fishes, from 10 to 60 cm long, found at Bernissart, the most distinctive species is *Macromesodon bernissartensis*, with disc-like, flattened shape and a very short snout.

Two fishes, *Amiopsis dolloi* (figured here) and *Amiopsis lata*, are important in reconstructing the environment in which the Iguanodons lived. They belong to the family Amiidae, of which only a single species, *Amia calva* or mudfish, survives at the present day. This freshwater fish lives in stagnant, lacustrine and swampy waters, poor in oxygen, in southeastern U.S.A., including the Everglades of southern Florida. The Everglades are a swampy region developed above a calcareous subsoil, and their geological and ecological characters show points of resemblance to those of the Iguanodon-bearing deposits.



Bernissartia fagesii, 66 cm long, is the smaller and more distinctive of the two species of crocodile found at Bernissart.

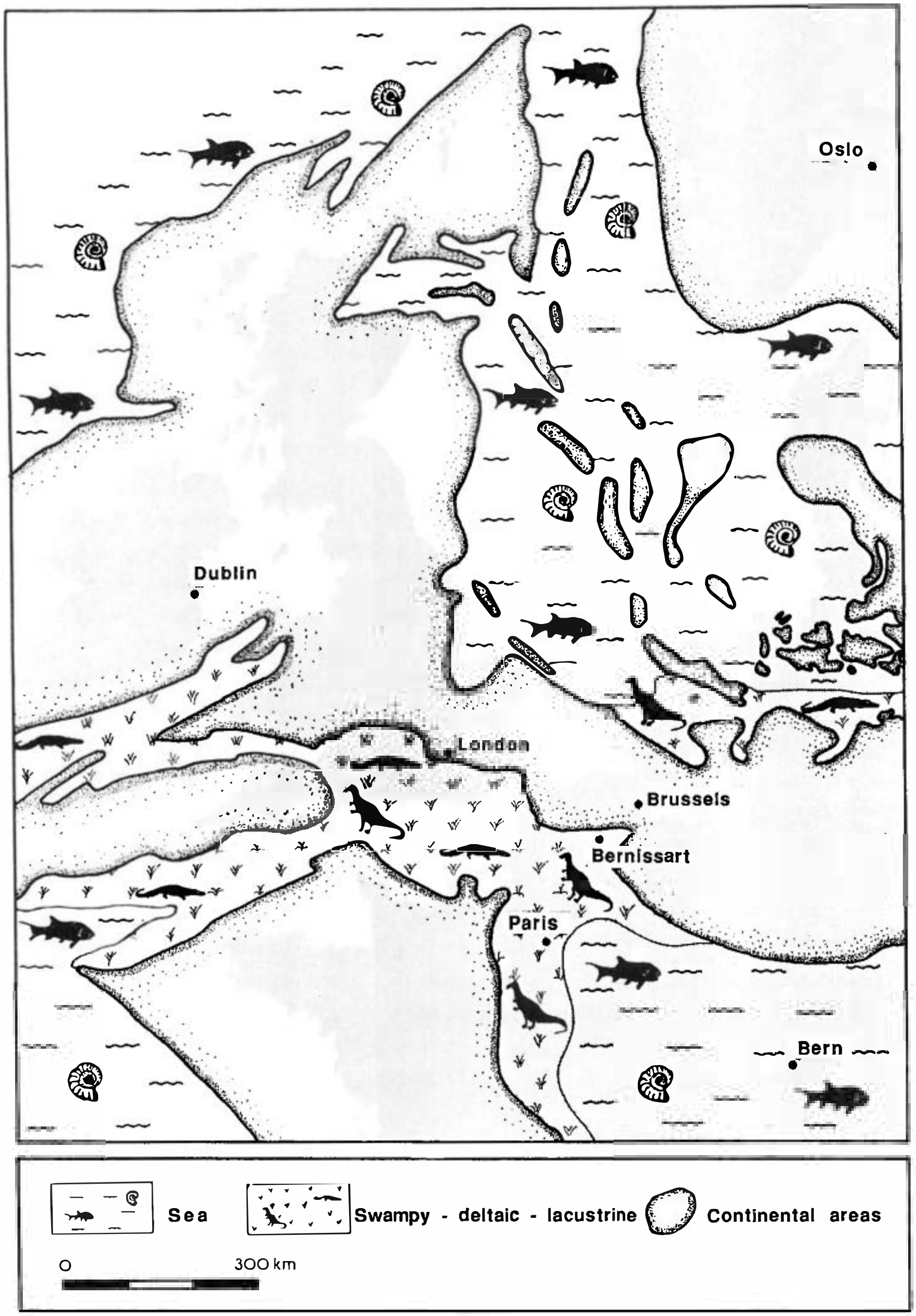
Chitracephalus dumonii, as drawn by R. VIANDIER in 1885, is the larger of the two new species of tortoise found at Bernissart. Its total length is 25 cm and the head and relatively long neck could be retracted within the dorsal carapace.

Some hundreds of coprolites, or fossil excrement, were found at Bernissart. From 3 to 13 cm long, they contain muscular fibres but no plant remains. For this raison they are probably attributable to the carnivorous dinosaur *Megalosaurus dunkeri*, only a single phalange of which is known from the site.

BERNISSART ABOUT 135 MILLION YEARS AGO

In the Cretaceous, the distribution and extent of continents and seas were different from those we know today. Maps showing ancient oceans and continents can be produced by means of measuring the original magnetism of rocks deposited during a particular period in the region investigated. Once the magnetic field has been established for a certain interval of time, we can deduce the previous latitude of the region. The territory that now forms Belgium is situated at a latitude of 50° North. During the Lower Cretaceous its position was much farther south, at a latitude of about 35° North, and the climate was consequently subtropical. This agrees perfectly with the picture of the environmental setting based on the fossil animals and plants from Bernissart. Modern representatives of the fishes, crocodiles and tortoises live in hot subtropical or tropical regions. In addition, the growth-rings of the fossil wood provide evidence of a climate with alternating dry and rainy seasons.

The map shows the seas and continents of northwestern Europe during the Lower Cretaceous. Bernissart was clearly outside the marine domain and formed part of a lowland region, with swamps and small lakes, that extended northwestwards into southern England and Ireland, and opened southwards into a great Cretaceous sea, the Tethys. Corresponding 'Wealden' strata in southeast England were traditionally interpreted as deltaic deposits but are now thought to have been deposited on muddy, alluvial, coastal plains. The Mons Basin may have been located within the same large lowland region and must have appeared like a valley, about 40 km long and oriented east-west, with marshes, ponds, and hillocks that were a little drier and covered with ferns. To the north and east the large valley was surrounded by conifer-covered hills. It was in this valley that the Iguanodons both lived and died.

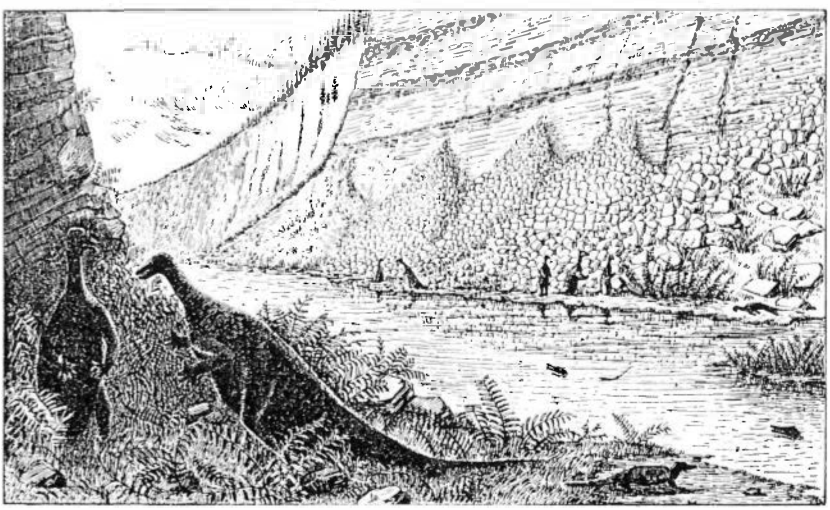


Seas and continents of northwestern Europe some 135 million years ago.

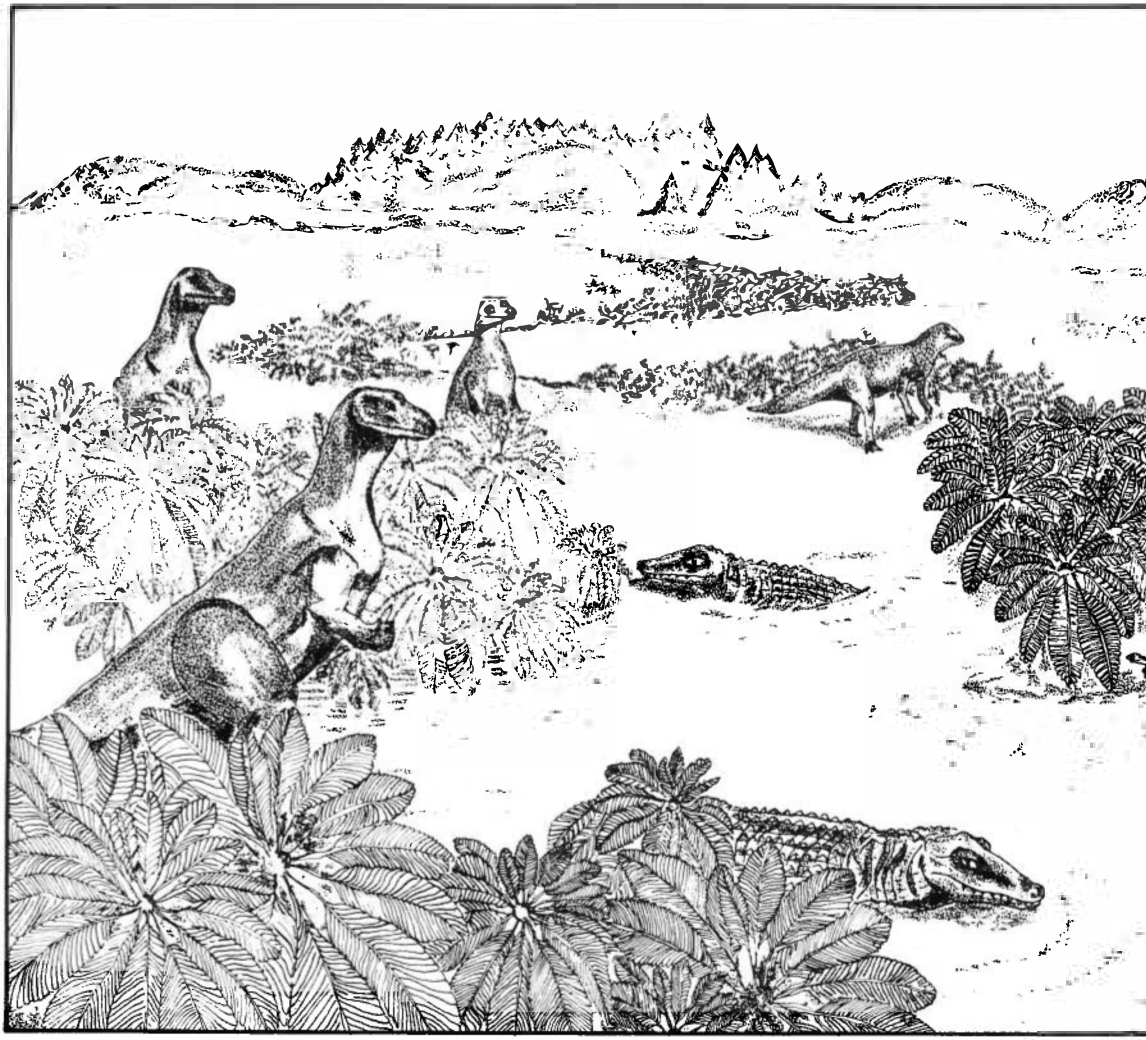
DEAD AND BURIED AT BERNISSART

The discovery of such a large number of almost complete skeletons of Iguanodons at Bernissart is exceptional in the history of palaeontology and unique in the region. Of the one hundred and seventeen natural pits known from the coalfields in the Mons Basin, only one yielded Iguanodons. Furthermore, no trace of these animals has been found in the Cretaceous continental strata cropping out in the basin. It is not surprising, therefore, that since the original find in 1878 several investigators have tried to explain the unique character of the occurrence.

From the very beginning, the scientists were divided into two camps. One group considered the deposit to be the result of sudden burial provoked by a catastrophic cause. The other group thought the large number of skeletons was unrelated to any exceptional causes of death but was due to their fortuitous, special preservation in the natural pit at Bernissart. For this reason they preferred to seek a geological explanation.

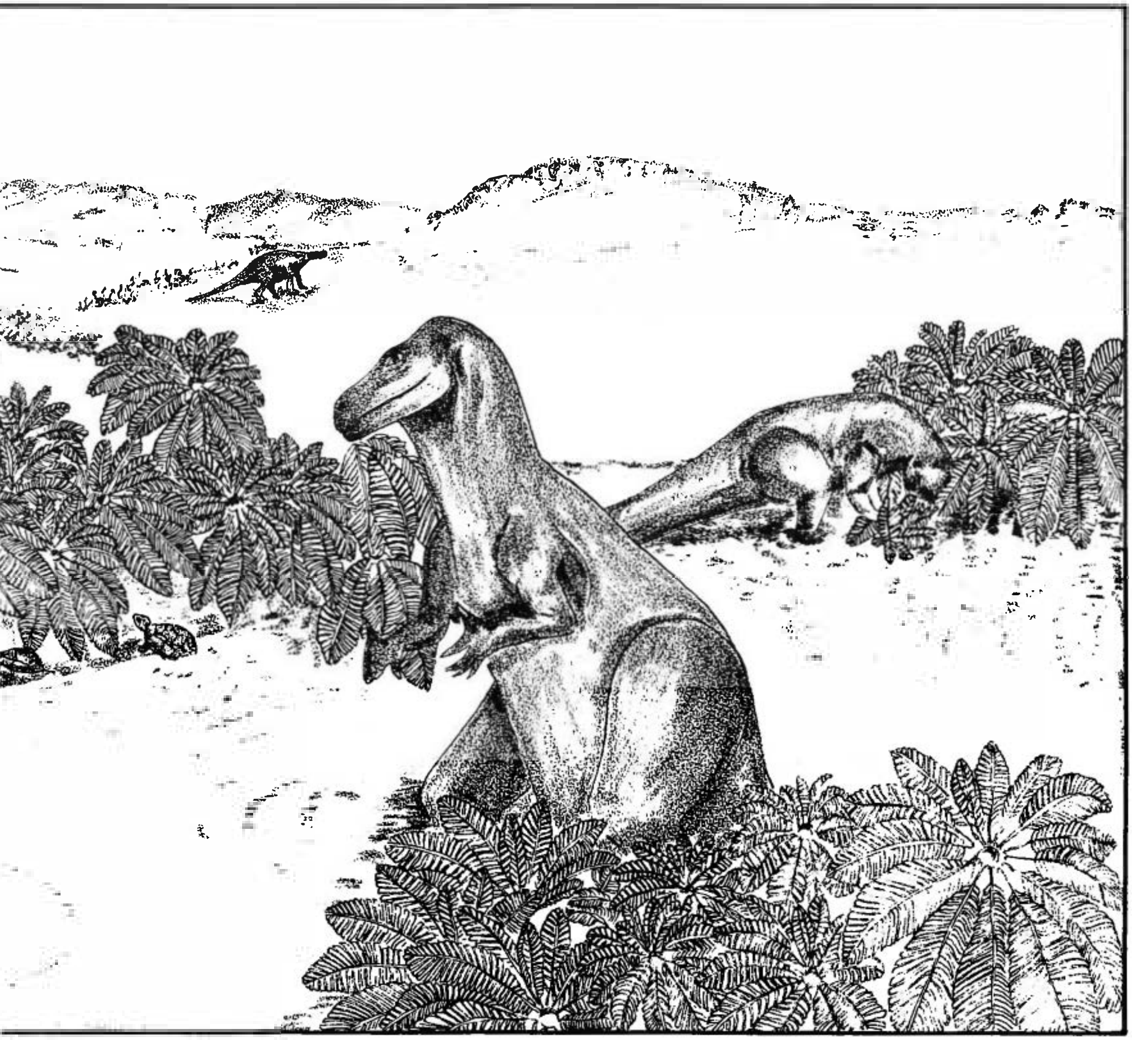


The Bernissart Valley as visualised by E. DUPONT in 1872, an interpretation no longer accepted.



Reconstruction of the Bernissart area during the Early Cretaceous, with swamps and small lakes.

Several catastrophic causes of death were proposed, some of which originate from the reconstruction of the Bernissart environment at the beginning of the Cretaceous by E. DUPONT, director of the Museum at the time of the discovery. According to him the Bernissart deposit formed within a short, deep, transverse valley with very steep sides from 130 to 200 m high. This depression, excavated in rocks of the Coal



Measures, opened to the south into the principal valley, directed east-west, of the Mons Basin. E. DUPONT gave the name 'Bernissart Valley' to the transverse depression, on the banks and in the low-lying, wet, swampy areas of which the Iguanodons lived.

Several authors found convincing the suggestion that a sudden flood had drowned the Iguanodons in the narrow valley during an exceptionally rainy season. Although E. DUPONT accepted the idea that the valley was filled with material eroded and transported during similar rises of water level, he never established a link between the latter and the death of the Iguanodons. It is still more surprising that this concept of a Bernissart Valley, categorically abandoned after the end of last century by Belgian geologists and palaeontologists, has survived in the foreign literature. According to another unconvincing hypothesis, the Iguanodons did not live at the bottom of the valley but on top of the adjacent plateau, from which, pursued by carnivores, they fell into the ravine. Others have suggested that the Iguanodons, put to flight by animals, fire or earthquake, ventured too far into the swamp and became bogged down.

L. DOLLO proposed yet another explanation, making a comparison with a situation known at the present day, whereby old animals leave their herd in order to die at a specific place.

In 1960 E. CASIER sought the cause of extinction in a hot climate, with alternations of dry and rainy seasons, that characterised the region at the beginning of the Cretaceous. On this hypothesis the animals would have died either from lack of water during a period of exceptional drought, or from becoming bogged down in the swamps while in search of water. For us, each of these explanations ignores the observations noted in the excavation records. Certain of the latter, partially published by L. DE PAUW in 1898, show that the skeletons were found at three separate places in the natural pit of the 'Cran aux Iguanodons': two were at, respectively, the western and eastern extremities of a gallery at a depth of 322 m; the third was at a depth of 356 m. The thirty or so skeletons were found in different beds of clay at these three locations, and their presence in the pit does not mean that all the animals died at the same time; the hypothesis by which a large herd was suddenly wiped out can therefore be abandoned. J. CORNET had already shown, in 1927, that the natural pit was formed and filled at the beginning of the Cretaceous, more or less at the time when the Iguanodons lived, and that consequently the skeletons escaped the erosion that caused the disappearance of Iguanodon-bearing strata elsewhere in the Mons Basin. The site was probably at one of the lowest levels in the region and coincided with the position of the future natural pit. The corpses of the Iguanodons slid towards the depression and accumulated there. The beds containing the bodies were preserved out of contact with the air and must have fallen quickly into the pit. The clayey deposits were still more or less plastic when they collapsed into the depression, and consequently the skeletons were not dislocated or broken into many pieces.

At the beginning of the Cretaceous there were no doubt numerous

Iguanodons living in the Mons Basin; nevertheless it is likely that they have been preserved only in the 'Cran aux Iguanodons' at Bernissart.

In reply to a final, often-asked question, it is clear that the disappearance of the Iguanodons at Bernissart has no connection with the world-wide extinction of the dinosaurs at, or towards, the end of the Cretaceous, some 65 million years ago.

If you want to read more about Bernissart and Dinosaurs:

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