



Review

# The Cretaceous Dinosaur Record from Normandy (NW France): A Review

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## Abstract

The Cretaceous dinosaur record from Normandy, in NW France, is reviewed. It includes several enigmatic specimens that were briefly mentioned in short notes published during the 19th and 20th centuries that have since then been destroyed in World War II or lost. Since they were neither described in detail nor illustrated, their identification must remain uncertain, but some may have been ankylosaur remains, while another specimen may have belonged to a bird or a non-avian theropod. Specimens that were properly described and are kept in museums in Normandy come from Albian and Cenomanian horizons in the coastal cliffs of Seine-Maritime. The Albian record, from Cape La Hève (Le Havre) includes an incomplete titanosaurian sauropod skeleton, described as *Normanniasaurus genceyi*, and an isolated caudal vertebra from the same provenance, probably belonging to that taxon. The Cenomanian record is limited to a group of bones and a tooth of the furileusaurian abelisaurid theropod *Caletodraco cottardi* from the glauconitic Chalk at Saint-Jouin-Bruneval. All these specimens come from marine sediments and are in all likelihood derived from floating carcasses that drifted over a fairly long distance from an emergent land area corresponding to the Armorican massif in the west. Although scanty, the record from Normandy sheds some light on the poorly known dinosaurs that inhabited north-western Europe during the middle part of the Cretaceous, some of which apparently had Gondwanan affinities.

**Keywords:** Normandy; Cretaceous; Dinosauria; Sauropoda; Theropoda; stratigraphy; palaeogeography

## 1. Introduction

Normandy, a region of north-western France, has a remarkable dinosaur record. The first finds of dinosaur fossils (initially interpreted as crocodile bones) in that area date back to the end of the 18th century [1–3]. Since then, a number of discoveries have taken place, making Normandy one of the regions of France with the best dinosaur record in terms of stratigraphic completeness. The earliest known dinosaurs from Normandy are latest Triassic (Rhaetian) sauropodomorphs [4], but most of the specimens come from rocks ranging in age from Hettangian to Kimmeridgian, with notable finds from Bathonian, Callovian and Oxfordian formations [2]. The Cretaceous record is scantier, but, as shown below, it includes important finds that provide interesting evidence about the rather poorly known “mid-Cretaceous” dinosaurs from north-western Europe.

Institutional abbreviations: MHNH: Muséum d’Histoire Naturelle du Havre.



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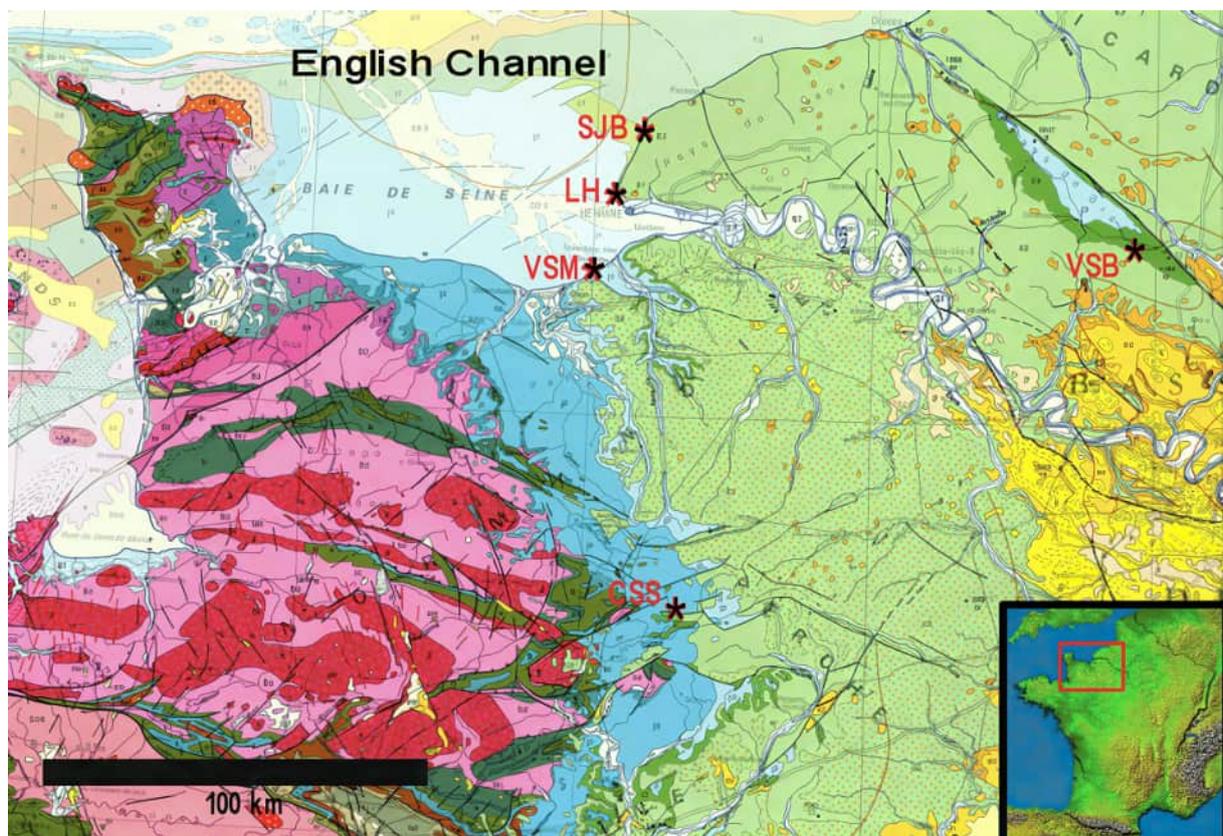
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## 2. Geological and Historical Framework

From a geological point of view, Normandy lies astride two distinct domains: the mainly Palaeozoic Armorican massif in the west and the Mesozoic–Cenozoic Anglo-Paris basin in the east [5]. The Cretaceous rocks of Normandy crop out in spectacular fashion in the Chalk cliffs along the English Channel, north of the estuary of the Seine River, but also occur in many other parts of the region, where they often form vast Chalk plateaus. Except in the Bray anticline in the north-eastern part of the region, where Wealden-type Lower Cretaceous formations occur, the Cretaceous deposits of Normandy are mainly marine in origin. The Cretaceous dinosaur remains hitherto known from Normandy, whether Albian or Cenomanian in age (Figure 1), have all been found in marine formations. The land areas where these dinosaurs lived were apparently emergent parts of the Armorican massif in the west (see discussion below) and the fossil specimens can be interpreted as remains of floating carcasses that eventually sank to the bottom after drifting at the surface of the sea over fairly long distances. This explains the scanty and discontinuous nature of the Cretaceous dinosaur record from Normandy.

Dinosaur remains from Cretaceous rocks in Normandy were first reported during the 19th century. Unfortunately, some of the major palaeontological collections in Normandy were destroyed by Allied air raids in 1944 [2,6–9], which led to the destruction of potentially important dinosaur specimens that had not been described in detail and can no longer be identified with any accuracy. Interestingly, almost all of the Cretaceous dinosaur fossils from Normandy, including the most recent finds, were found by amateur collectors.



**Figure 1.** Geological map of Normandy and surrounding areas, showing the location of dinosaur localities mentioned in the text. CSS: Coulonges-sur-Sarthe (Orne), Cenomanian; LH: Cape la Hève, Bléville, Le Havre (Seine-Maritime), Albian; SJB: Saint-Jouin-Bruneval (Seine-Maritime), Cenomanian; VSB: Villers-Saint-Bathélémy (Oise), Albian; and VSM: Villers-sur-Mer (Calvados), Cenomanian.

### 3. Lost or Destroyed Specimens

#### 3.1. A Possible Armoured Dinosaur from the Cenomanian of Coulonges-sur-Sarthe (Orne)

The earliest mention of a Cretaceous dinosaur from Normandy is a very brief note published in 1876 by Jules (actually Pierre-Gilles) Morière (1817–1888), who was then a Professor of Botany, Mineralogy and Geology at the University of Caen (for details about Morière, see [10]). This note [11] was part of a report on a meeting of the *Société Linnéenne de Normandie*, at which Morière exhibited a portion of a femur of a dinosaur which he identified as *Iguanodon*, found in the *Craie chloritée* (glauconitic Chalk, Cenomanian) of Coulonges-sur-Sarthe, in the department of Orne, in the south-eastern part of Normandy. He did not describe the specimen, but only mentioned that according to Mantell, this “singular dinosaurian” was 23 to 24 m long, with a body circumference of 5 m. Little was provided about the circumstances of the find, except that the fossils had been presented to the Natural History Museum of the city of Caen by the widow of Mr Olivier, the first president of the Imperial Court of Justice, upon whose property they had been found.

A different interpretation of the specimens from Coulonges-sur-Sarthe was given in 1904 by Alexandre Bigot [12], who was then a Professor of Geology at the University of Caen (see [13] for more details about Bigot). According to him, *Iguanodon* was unknown so late in the Cretaceous, and the remains were probably dermal spines of a dinosaur, analogous to those of the Jurassic *Stegosaurus*. In his list of fossils destroyed by the July 1944 air raid on Caen, Bigot [6] mentioned again the specimens from Coulonges-sur-Sarthe as “bones considered as pieces of the dermal armour of a dinosaur related to the stegosaurs”.

The fossils from Coulonges-sur-Sarthe were destroyed in the British air raid on Caen in July 1944 [6], and since neither a detailed description nor illustrations were published, the affinities of this purported dinosaur must remain uncertain. There is an obvious discrepancy between Morière’s mention of a femur and Bigot’s identification of dermal spines, but it seems that several skeletal elements were present, and they may have included both a femur and dermal scutes, although the fact that Bigot made no mention of the femur is puzzling. If Bigot’s interpretation of some of the fossils as dermal spines was correct, they may have belonged to an ankylosaur. Ankylosaur remains are known from the Cenomanian Chalk of England [14–16].

#### 3.2. A Dinosaurian Dermal Scute (?) from the Cretaceous of Cape la Hève (Seine-Maritime)

In a report on the activities of the *Société géologique de Normandie et des amis du Muséum du Havre* for the years 1924 to 1930, its general secretary, Georges Catherine [17], noted that Mr Jean-Jacques Stiegelmann had displayed a bony dermal plate of a dinosaur from the Cretaceous of la Hève at one of the meetings of the society. No description or illustration was provided.

Jean-Jacques Stiegelmann (1873–1955) was an active amateur palaeontologist who amassed a large collection of fossils from the surroundings of Le Havre, in the department of Seine-Maritime [18]. Little can be said about the purported dinosaur plate from la Hève that was mentioned by Catherine. Cape la Hève, just west of the city of Le Havre, is well-known for its cliffs, where Kimmeridgian and Cretaceous rocks are exposed. The Cretaceous succession at la Hève begins with upper Aptian sands, followed by Albian conglomerates, clays and marls, overlain by Cenomanian Chalk [19,20]. The specimen may have come from any one of these formations.

Stiegelmann’s collection was destroyed in the Allied air raid of September 1944, in which his wife was killed [18]. This bombing raid also caused the destruction of the palaeontological collections of the Le Havre Natural History Museum [2,9]. The purported

dinosaur dermal plate may have belonged to an ankylosaur, but this interpretation is highly tentative.

### 3.3. *A Putative Bird Bone from the Cenomanian of Villers-sur-Mer (Calvados)*

In 1933, in a very brief note [21], the fossil collector Charles Hupier (1858–1937) mentioned the discovery of a “thin, partitioned bone” in a block of Cenomanian rock that had fallen from the cliff at Villers-sur-Mer (department of Calvados). Lower Cenomanian Chalk tops the mainly Jurassic Vaches Noires cliffs along the coast west of Villers-sur-Mer [22]. The bone was examined by Marcellin Boule (1861–1942), then Head of the Palaeontology department of the Muséum National d’Histoire Naturelle in Paris [23], who identified it as belonging to a fairly large bird and encouraged Hupier to prepare a thin section. The section showed osteoblasts and Haversian canals. The latter were numerous, small, and branching at right angles. These characters were considered as fairly characteristic of birds. Hupier considered that this was the first record of birds from the Cenomanian of France. A brief mention of this discovery appeared in a semi-popular natural history journal [24], but no detailed study was ever published, despite the potential interest of the find, at a time when relatively few Cretaceous birds were known.

Unfortunately, the present whereabouts of the specimen are unknown. Charles Hupier (1858–1937) was a pharmacist with a keen interest in photography [25], geology and prehistory, who had amassed a fine collection of fossils and prehistoric artefacts [26]. It has so far not been possible to locate the Hupier collection, which may have been dispersed after his death. The bone from Villers-sur-Mer may have indeed belonged to a bird. However, Haversian bone is common among non-avian dinosaurs [27] and it cannot be excluded that the specimen found by Hupier actually was non-avian. Since no figure or detailed description of the bone and its osteohistological characters was published, the exact affinities of the specimen remain uncertain, but it seems likely that it belonged either to a small non-avian dinosaur or to a bird. A third option would be a pterosaur, with the partitions noted by Hupier possibly being the trabeculae commonly found inside pterosaur bones. However, as noted by Steel [28], pterosaurs generally lack dense Haversian tissue, and this is not consistent with the numerous Haversian canals reported by Hupier.

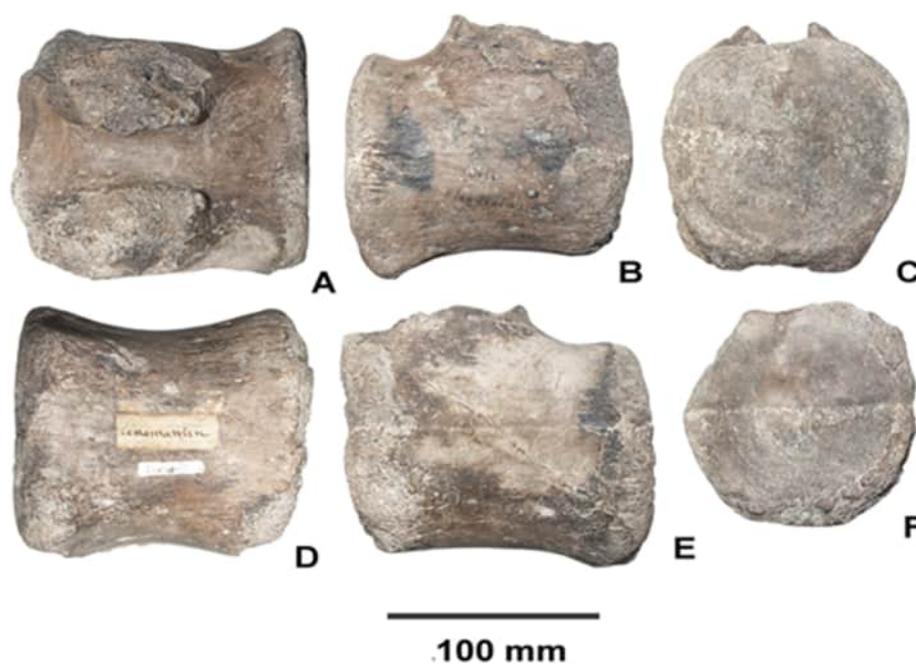
## 4. Currently Available Specimens

### 4.1. *The Sauropod Vertebra from the Albian of Bléville (Seine-Maritime)*

A vertebra (Figure 2) in the collections of the Rouen Natural History Museum (PAL.2010.0.1980.MHN) was identified as a sauropod caudal vertebra by Buffetaut [29]. The specimen was part of the large collection amassed by the merchant Ernest-Lucien Bucaille (1835–1892), a keen amateur palaeontologist who published a number of papers on fossils from Normandy, especially echinoids [30], and was also interested in prehistoric archaeology. His collection was acquired by the city of Rouen after his death. The specimen was apparently first mentioned, as a “vertebra of a saurian (genus and species unknown”, in the catalogue of the geological exhibition held in Le Havre in 1877 [31]—where, according to Fortin [30], Bucaille exhibited a selection of his most remarkable fossils. The label on the specimen identifies it as a saurian vertebra and gives Bléville as its locality of origin. Bléville, now part of the city of Le Havre, was until 1953 a separate village, which included part of the coast north of Cape la Hève.

The stratigraphical origin of the specimen is slightly ambiguous. The label on the specimen indicates a Cenomanian age, and another label found in the cardboard box containing the specimen bears the mention “Cenomanian?”. However, in the catalogue of the 1877 exhibition, it is listed among the Albian fossils [31]. Savalle [32], in a paper on the Neocomian micaceous sands of la Hève, mentioned a “saurian vertebra”, which was

probably that in Bucaille's collection, from these sands, but what he meant by "Neocomian" is unclear, although he apparently placed them between the Kimmeridgian and Aptian beds. However, it is now accepted that the Cretaceous succession at la Hève begins with the upper Aptian [19,20]. The presence of glauconite in the very small patches of matrix on the vertebra suggests that it may have come either from the glauconite-bearing beds of the upper Albian ("Gaize") or from the lower Cenomanian glauconitic Chalk (Figure 3). The boundary between the Albian and the Cenomanian at la Hève was the subject of much discussion [33,34]. Bucaille himself [35,36] placed the Gaize in the Cenomanian, while Lennier [37] placed it in the Albian, as accepted today [19,20,34,38]. It therefore seems likely that the vertebra in the Bucaille collection came from marine upper Albian rocks, which have yielded various other vertebrate remains belonging to turtles and ichthyosaurs [29].

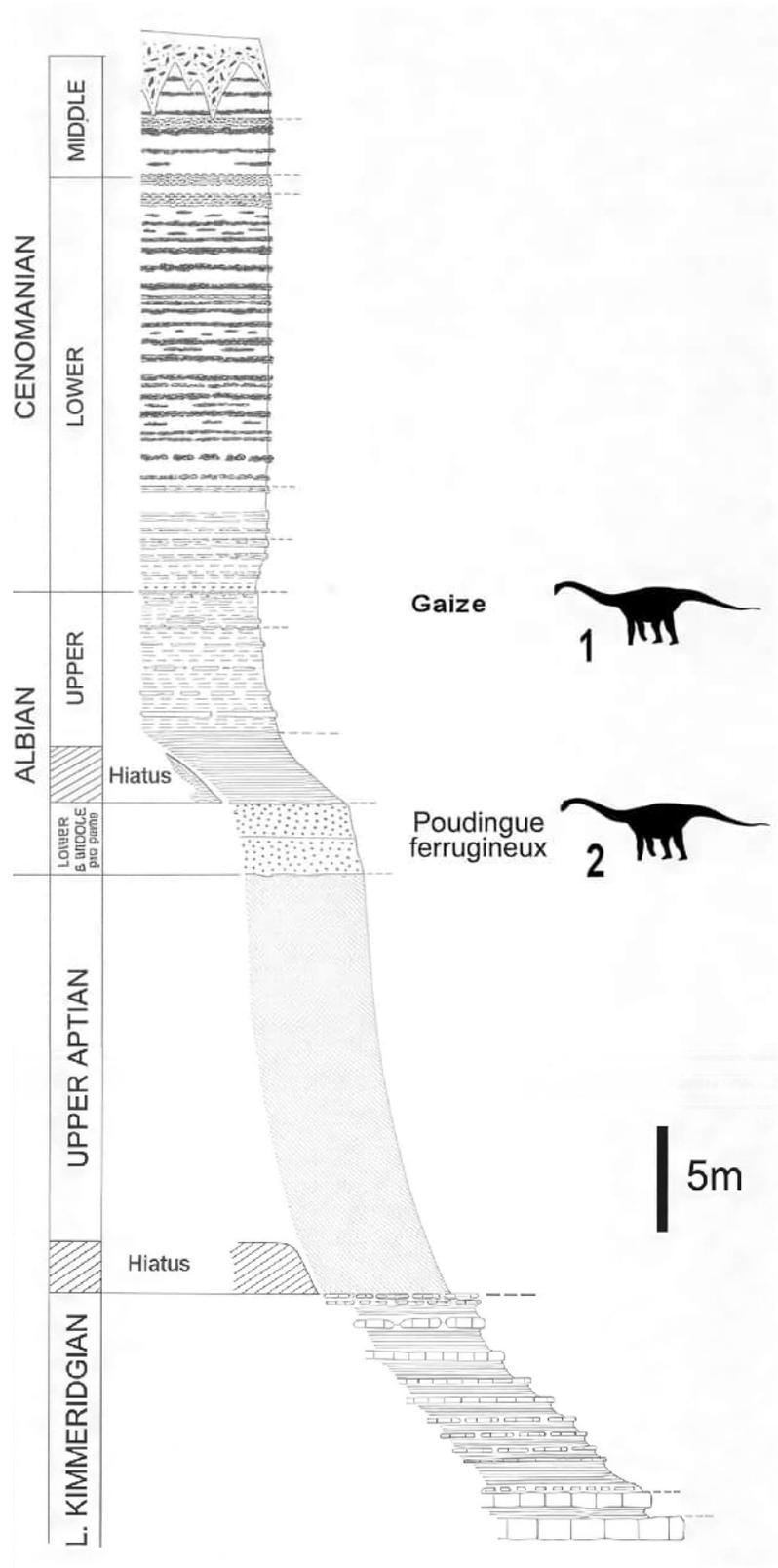


**Figure 2.** Isolated caudal vertebra of a sauropod dinosaur, probably *Normanniasaurus genceyi*, from the Albian of Bléville (Le Havre), in the Bucaille collection, Natural History Museum, Rouen: (A) dorsal view; (B) right lateral view; (C) caudal view; (D) ventral view; (E) right lateral view; and (F) cranial view.

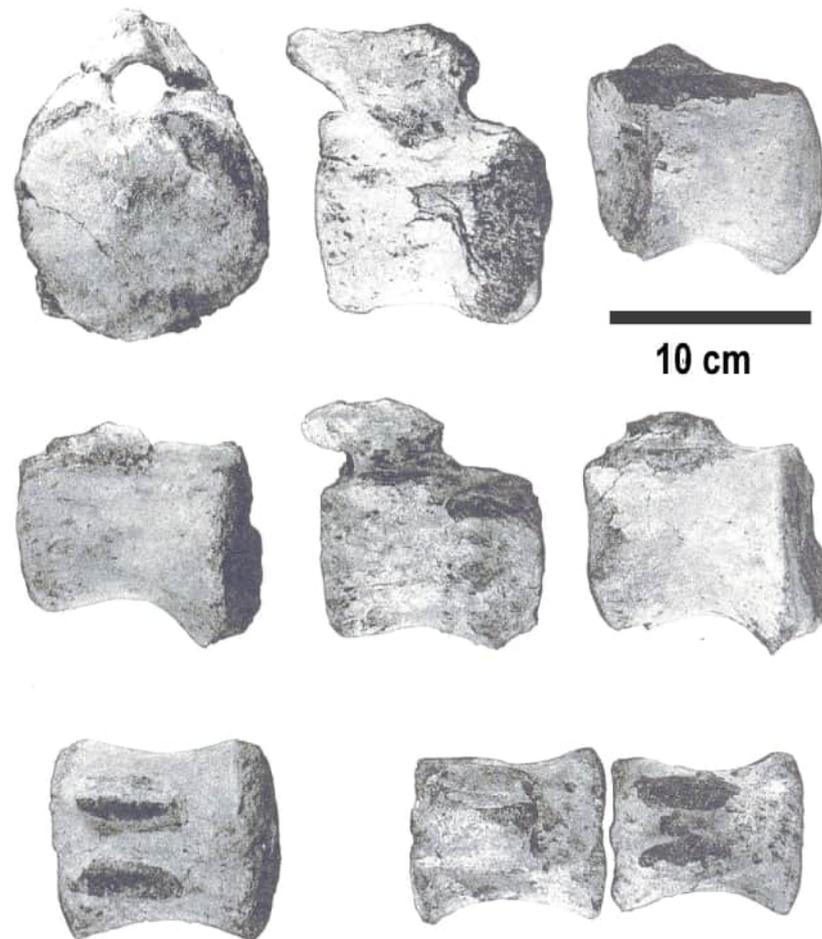
#### Description and Identification

The specimen was described in detail by Buffetaut [29]. It is an isolated caudal vertebra, missing most of the neural arch (only the base of its pedicels is preserved). The centrum is nearly cylindrical, with only a moderate constriction and weakly concave anterior and posterior articular surfaces. Chevron facets are visible at the posteroventral end of the centrum.

The specimen was identified as a mid-caudal vertebra of an indeterminate sauropod. Close similarities were pointed out with a mid-caudal vertebra from a group of 10 vertebrae from a single individual of a sauropod dinosaur (Figure 4), described by Lapparent [39], from a sandy lens at the base of the Albian Gault Clay in the Moru quarry at Villers-Saint-Barthélémy (Oise), in the south-eastern part of the Pays de Bray (outside Normandy), about 133 km east of Bléville. Le Loeuff et al. [40] referred the vertebra from Bléville to *Normanniasaurus genceyi*, a titanosaurian sauropod known from several skeletal elements found in lower Albian rocks at Bléville (see below).



**Figure 3.** Section of the Cape la Hève cliff at Bléville (Le Havre, Seine-Maritime), showing the stratigraphical position of Albian sauropod remains. 1: Isolated caudal vertebra in the Bucaille collection, probably from the Gaize, Natural History Museum, Rouen. 2: Incomplete skeleton, holotype of *Normanniasaurus genceyi*, Natural History Museum, Le Havre. Modified after [40].



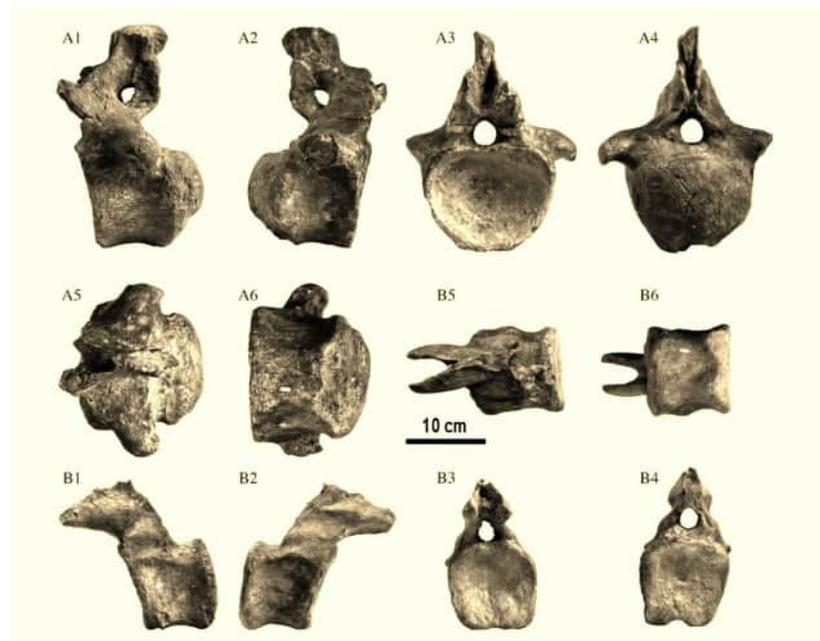
**Figure 4.** Caudal vertebrae from a sauropod dinosaur, probably *Normanniasaurus genceyi*, from the Albian of the Moru quarry, Villers-Saint-Barthélemy (Oise) in various views, for comparison with the vertebrae from the Albian of Bléville illustrated on Figures 3 and 5. Modified after [39].

#### 4.2. The Titanosaurian Sauropod from the Albian of Bléville (Seine-Maritime)

A group of bones belonging to a single individual was collected from a coastal outcrop at Bléville (now part of the city of Le Havre, see above) by Pierre Gencey in 1990. The specimen was reported by Buffetaut [41] and described in detail by Le Loeuff et al. [40] as *Normanniasaurus genceyi*. The stratigraphic origin of the bones is well-ascertained (Figure 3): they come from the Poudingue ferrugineux formation, which in the past was referred to the Aptian but is now known to be of early to middle Albian age [19,20,42]. The coarse detritic deposits of the Poudingue ferrugineux were derived from the Armorican massif to the west and it is likely that the dinosaur carcass drifted from a land area located in that region. Although it contains marine fossils, including ammonites, the Poudingue ferrugineux has also yielded fairly abundant plant remains [19,20]. Crocodile remains, including a partial skull, were also reported from the Poudingue ferrugineux [37,43], but the specimen was kept at the Natural History Museum in Le Havre and was destroyed by the British air raid of September 1944.

#### Description and Identification

The sauropod material (Figure 5) from the Poudingue ferrugineux found by Pierre Gencey consists of fragments of presacral vertebrae, an incomplete sacrum, an anterior caudal vertebra, a middle caudal vertebra, a right scapula, parts of both ilia and ischia, the proximal end of a femur and the proximal end of a fibula (collection numbers MHNH 2013.2.1 to 2013.2.12).



**Figure 5.** Caudal vertebrae of the holotype of the titanosaurian sauropod *Normanniasaurus genceyi*, from the Albian of Bléville (Le Havre). A: Anterior caudal vertebra (MHNH-2013.2.1.1) in left lateral (A1), right lateral (A2), cranial (A3), caudal (A4), dorsal (A5) and ventral (A6) views. B: Middle caudal vertebra (MHNH-2013.2.1.2) in left lateral (B1), right lateral (B2), cranial (B3), caudal (B4), dorsal (B5) and ventral (B6) views. Modified after [40].

Le Loeuff et al. [40] identified the partial sauropod skeleton from Bléville as a new genus and species of Titanosauria, *Normanniasaurus genceyi*, and gave the following diagnosis [40] (p. 25): “presacral vertebrae with hyposphene–hypantrum articulation; internal texture of presacral vertebrae cancellous; anterior caudal vertebrae deeply procoelous, with antepostzygapophysial foramen, deep postspinal and prespinal fossae and axially elongated neural spine; middle caudal vertebrae amphicoelous with cranially inserted neural arch; dorsal projection of the spinoprezygapophysial lamina in mid-caudals; ilium with a craniolaterally expanded blade”.

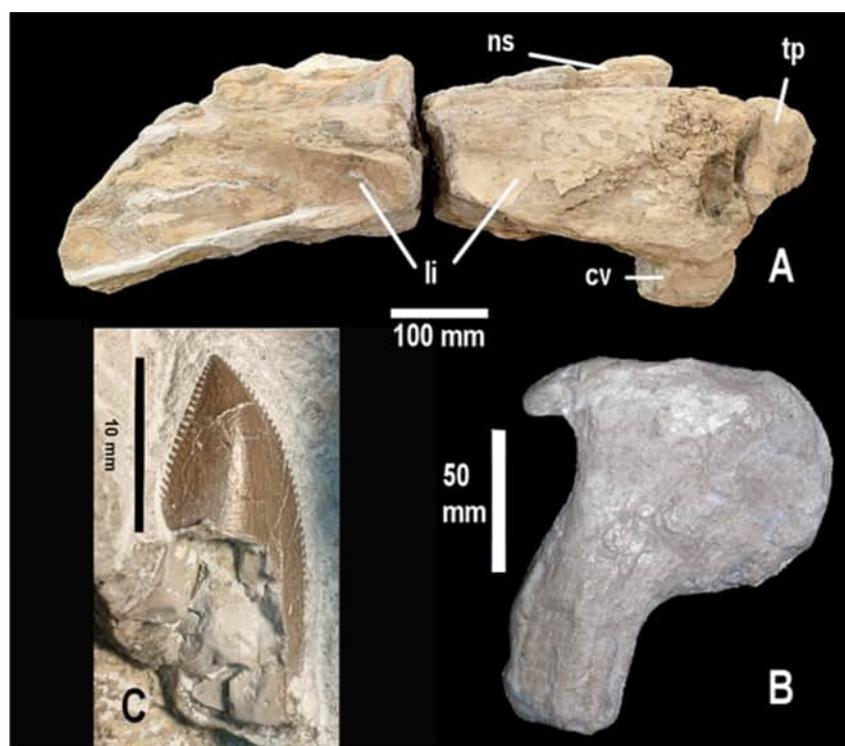
Le Loeuff et al. [40] considered that the above-mentioned isolated caudal vertebra in the Bucaille collection very probably belonged to *Normanniasaurus genceyi*, although it presumably comes from a higher level of the Albian succession at Bléville. They also compared the material from Bléville with various sauropod remains of similar age from other parts of the Anglo-Paris basin and found close similarities with the above-mentioned sauropod caudal vertebrae from the Moru quarry described by Lapparent [39], which they tentatively referred to *Normanniasaurus genceyi*. Similarities were also found with sauropod caudal vertebrae from the lower Albian Sables verts of the Argonne area of eastern France, described by Buffetaut and Nori [44]. The sauropod vertebrae from the middle Albian of Pargny-sur-Saulx (eastern France) described by Martin et al. [45] were found to be very different from those of *Normanniasaurus genceyi*. As to the sauropod vertebrae from the Cambridge Greensand of England, probably of Albian age although reworked in a Cenomanian deposit [16,46], described as *Macrurosaurus semnus* by Seeley [47], they apparently belong to two distinct sauropod taxa [48] and show no special similarities with the specimen from Bléville.

Although Le Loeuff et al. [40] interpreted *Normanniasaurus genceyi* as a ‘basal’ titanosaur, Mannion et al. [49] considered it as a ‘derived’ titanosaur clustering with Gondwanan taxa. Díez Díaz et al. [50] placed it in the clade Rinconsauria, which otherwise comprises South American and African titanosaurs, with the African *Rukwasaurus* as a sister group.

#### 4.3. The Abelisaurid Theropod *Caletodraco cottardi* from the Cenomanian Cliffs of Saint-Jouin-Bruneval

Buffetaut et al. [51] described as *Caletodraco cottardi* a group of bones and a tooth (Figure 6) belonging to a theropod dinosaur from the lower Cenomanian glauconitic Chalk at Saint-Jouin-Bruneval (Seine-Maritime) on the Channel coast NE of Le Havre. The fossils were found on two separate occasions by Nicolas Cottard in chalk blocks that had fallen from the cliff (Figure 7) and were found to fit together. The stratigraphic provenance of the specimen is known with some precision, thanks to the detailed study of the Saint-Jouin-Bruneval cliff carried out by Hoyez et al. [38]: lithological evidence strongly suggests that it comes from the *Mantelliceras dixoni* zone of the lower Cenomanian glauconitic Chalk, probably from the C3 zone of Hoyez et al. [38] (Figure 8).

The theropod bones from Saint-Jouin-Bruneval are in all likelihood remains of a carcass that drifted for some time before sinking to the bottom of the Chalk Sea. It apparently went through a rather complex taphonomic history, since two isolated teeth were found in the matrix close to the bones. One is a theropod tooth, showing abelisaurid characters that may belong to the same individual as the bones, and was displaced at some stage during fossilisation, or to a distinct individual, in which case it may indicate either cannibalistic predation or scavenging. The second tooth is a shark tooth that indicates scavenging on the carcass, either when it was floating at the surface of the sea or once it had sunk to the bottom. As for other dinosaur specimens from marine Cretaceous rocks in Normandy, the Saint-Jouin-Bruneval theropod probably lived on an emergent land area that was part of the Armorican massif, west of the place where it eventually came to rest on the sea bottom after somehow being carried out to sea and drifting over a fairly long distance (roughly 100 km).



**Figure 6.** Elements of the holotype of the abelisaurid theropod *Caletodraco cottardi* (Natural History Museum, Le Havre, MHNH 2024.1.1.1). (A) General view of the specimen in left lateral view (cv: centrum of first caudal vertebra; li: left ilium; ns: fused neural spines of the sacral vertebrae; and tp: transverse process of first caudal vertebra). (B) Close-up of the transverse process of the first caudal vertebra in ventrolateral view, showing the hatchet shape typical for furileusaurian abelisaurids. (C) abelisaurid tooth embedded in the matrix of the specimen.

### Description and Identification

The dinosaur specimen from Saint-Jouin-Bruneval consists of an isolated tooth, a sacrum, the first caudal vertebra and parts of both ilia (MHNH 2024.1.1.1). The bones are preserved within two blocks of glauconitic chalk and could not be completely freed from the hard matrix.

Buffetaut et al. [51] identified the specimen from Saint-Jouin-Bruneval as a new genus and species of abelisaurid theropod, *Caletodraco cottardi*, and gave the following diagnosis: “a large abelisaurid theropod showing furileusaurian characteristics, including a straight dorsal margin of the ilium and a distally expanded and crescent shaped tip of the dorsally orientated transverse process of the first caudal vertebra, with a convex distal margin, differing from previously known furileusaurians by the following autapomorphy: the distinctive shape of the transverse process, with a short anterior spine and a rounded and expanded fan-shaped semicircular posterodistal margin”.



**Figure 7.** Rockfall in the cliffs of Cenomanian Chalk at Saint-Jouin-Bruneval (Seine-Maritime), where the elements of the holotype of the abelisaurid theropod *Caletodraco cottardi* were found by Nicolas Cottard in 2021 and 2023. Photo: E. Buffetaut.

Although abelisaurid theropods are widespread in the Late Cretaceous of Europe [51–55], the occurrence in Europe of a representative of the clade Furileusauria, which until then had been reported only in South America, was unexpected. Buffetaut [56] showed that *Genusaurus sisteronis*, from the Albian of south-eastern France, exhibits various furileusaurian characters and should also be placed within that clade. It therefore appears that furileusaurian abelisaurids were present in Europe during the Albian–Cenomanian time interval. Whether they also occurred there at later stages of the Cretaceous is uncertain, since the tibia from the Campanian of La Boucharde, in south-

eastern France, which was regarded by Buffetaut et al. [51] as possibly belonging to a furileusaurian, in fact probably belongs to the majungasaurine abelisaurid *Arcovenator* or to a related form [56]. What is currently known of the abelisaurid record from Europe indicates that several lineages were present there during the Cretaceous [51,54–56]. Some appear to have affinities with South American forms (Furileusauria), while others apparently belong to a less derived clade known mainly from India, Madagascar and Africa (Majungasaurinae). The palaeobiogeographical implications of the apparently rather complex evolutionary history of European abelisaurids, as exemplified by the furileusaurian *Caletodraco cottardi* from Normandy, remain to be investigated in detail.

	<i>W. devonense</i>	Turonian
HG Antifer 3	<i>N. juddii</i>	Ce6
	<i>M. geslinianum</i>	
Surface er. sub plenus	<i>C. naviculare</i>	Ce5A b
Marne Antifer		Ce5A a
Marne Beaurepaire		Ce5 b
Marne Fourquet	<i>A. jukesbrownel</i>	Ce5 a
Marne à <i>H. subglobosus</i>		
HG Rouen 3	<i>A. rhotomagense</i>	<i>T. acutus</i>
Marne Gonnevillle		<i>T. costatus</i>
HG Rouen 2		
Horizon de Rouen		
HG Rouen 1	<i>Cn. Inerme</i>	Ce4 a
HG Bruneval 3	<i>M. dixoni</i>	Ce3 b
HG Bruneval 2		Ce3 a
HG Bruneval 1	<i>M. mantelli</i>	<i>M. saxbii</i>
Marne Poterie		
HG Bléville 1		<i>S. schlueteri</i>
		<i>N. carollanense</i>
Surface rav. Octeville	<i>S. dispar</i>	Albian
<b>Stratigraphic markers</b>	<b>Ammonite zones</b>	<b>Sequences</b>



Figure 8. Stratigraphical position of the holotype specimen of *Caletodraco cottardi* in the Cenomanian section at Saint-Jouin-Bruneval (after [51]).

### 5. Discussion

#### 5.1. Stratigraphical and Geographical Origin of the Specimens

The Cretaceous dinosaur record from Normandy is scanty, even taking into account the rather enigmatic specimens that were only briefly mentioned before they were destroyed or lost. It can be summarised as follows:

Stratigraphical Origin	Geographical Location	Taxon
Cretaceous, unspecified stage	Cape la Hève	Ankylosaur (?)
Albian	Bléville	<i>Normanniasaurus genceyi</i>
Cenomanian	Coulonges-sur-Sarthe	Ankylosaur (?)
Cenomanian	Villers-sur-Mer	Theropod (avian?)
Cenomanian	Saint-Jouin-Bruneval	<i>Caletodraco cottardi</i>

It should be noted that the occurrence of ankylosaurs is highly tentative, being based only on the mention of undescribed bony plates or spines. The specimens from la Hève and Coulonges-sur-Sarthe may not even have belonged to dinosaurs. The presence of a bird or a small non-avian theropod in the Cenomanian of Villers-sur-Mer seems to be slightly better ascertained on the basis of Hupier's brief description of the bone and its histology, but unless the specimen is rediscovered, it will be difficult to provide a well-founded identification.

When the doubtful specimens are dismissed, the record boils down to the Albian titanosaurian sauropod *Normanniasaurus genceyi* and the Cenomanian abelisaurid theropod *Caletodraco cottardi*.

### 5.2. Pre-Burial History of the Specimens

The scantiness of this record is probably linked to the fact that all these dinosaur remains are from marine deposits, viz. the Albian Conglomérat ferrugineux and Gaize and the Cenomanian glauconitic Chalk. This implies that the carcasses must have floated from a relatively remote land area before they eventually sank to the sea bottom. Even though dinosaur remains in marine rocks are by no means an unusual occurrence (see [57] about the French record), obviously the events involved between the death of an individual animal and its burial in sediments at the bottom of the sea must have influenced the quality of the fossil record, which can hardly be expected to be as complete as that from continental deposits. In the case of the Cretaceous dinosaurs from Normandy, palaeogeographical and sedimentological evidence helps to reconstruct the processes through which the remains reached their burial location.

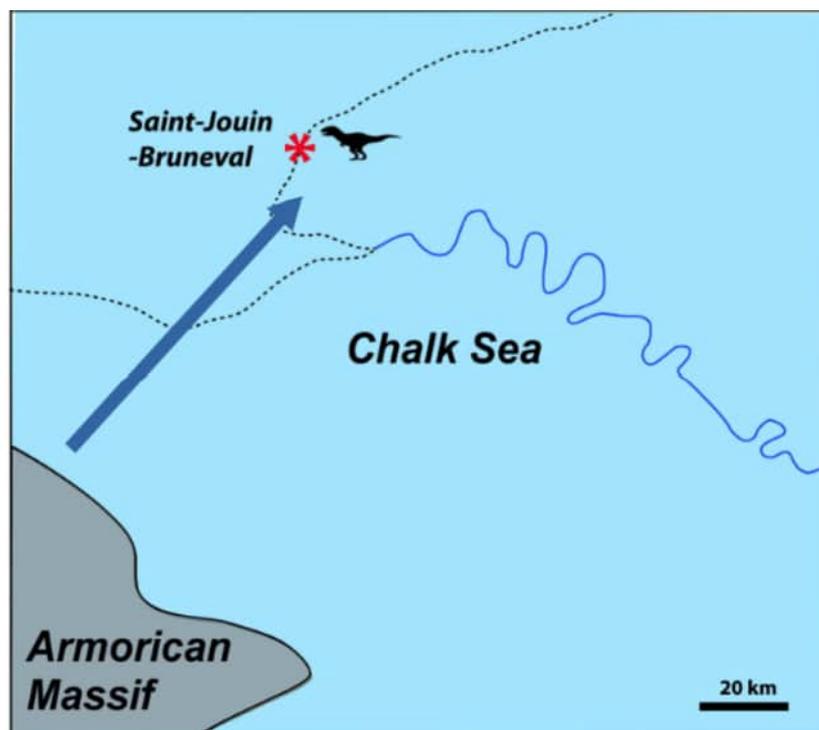
**Poudingue ferrugineux:** as noted above, the type specimen of the sauropod *Normanniasaurus genceyi* was found in the lower to middle Albian Poudingue ferrugineux. Juignet [42] noted that this coarse detritic formation was deposited by violent and discontinuous currents, which carried material issuing from the Armorican basement and its Jurassic cover in the western part of present-day Normandy. The depositional environment was shallow marine. It can therefore be supposed that the partial skeleton from Bléville corresponds to elements of the carcass of a dinosaur that lived on an emergent land area located to the west of the shallow basin where the Poudingue ferrugineux was deposited, possibly in the region of the present Cotentin peninsula (see [58], for a palaeogeographical reconstruction of the Paris basin in the Albian). The strong currents mentioned by Juignet may help to explain how it could be carried over a distance of nearly 100 km.

**Gaize:** although its exact stratigraphical origin remains slightly uncertain [29], the isolated sauropod vertebra from Bléville in the Bucaille collection, referred to *Normanniasaurus genceyi* by Le Loeuff et al. [40], probably comes from the upper Albian Gaize: a grey silty marl containing glauconite. According to Juignet [59], it indicates open marine sedimentation. Juignet [34] noted that the heavy minerals from the upper Albian of the Pays de Caux probably originated from the north-eastern part of the Armorican massif. This is in agreement with the conclusions drawn by Lapparent [39] from the heavy minerals found in the Albian sands of the Pays de Bray, which suggested that the sauropod vertebrae from Villers-Saint-Barthélémy came from the Armorican massif, rather than from the Ardenne region of eastern France (then part of the London–Brabant massif).

**Glauconitic Chalk:** the lower Cenomanian glauconitic Chalk, which has yielded the type specimen of *Caletodraco cottardi* as well as the enigmatic remains from Coulonges-sur-Sarthe and Villers-sur-Mer, is described by Juignet [60] as being transitional between the terrigenous Albian deposits and the pelagic late Cenomanian sediments. Because of the expansion of the infralittoral zone, continental influences decreased by comparison with the situation in the Albian. Not unexpectedly, remains of continental vertebrates such as dinosaurs are uncommon in the glauconitic Chalk of Normandy, but they nevertheless occur. The enigmatic records from Coulonges-sur-Sarthe and

Villers-sur-Mer are from localities that were closer than Saint-Jouin-Bruneval to the nearest emergent land mass in the eastern part of the Armorican massif. Juignet [60] noted that currents were weak during the deposition of the glauconitic Chalk, which may have made the transport of floating carcasses from the Armorican massif less likely. However, Lasseur et al. [61] (p. 13) concluded that “most of the Normandy Chalk facies were deposited under the action of storms” and that the winds blew predominantly from the SW, with a wave fetch (the distance over which waves, under the action of the wind, can travel without obstruction) of at least 200 km. This may help to explain how floating carcasses could be transported from the Armorican massif to the area in present-day Pays de Caux where the remains of *Caletodraco cottardi* were discovered (Figure 9).

The scarcity of dinosaur remains in the Cretaceous of Normandy can be at least partly explained by the fact that they come from marine deposits that were deposited at some distance from the nearest land area, even in the case of the shallow marine Poudingue ferrugineux. By contrast, more abundant dinosaur remains are known from the lower Cenomanian deposits of the Charentes region of the northern Aquitaine basin, in south-western France, which have yielded teeth of troodontid, dromaeosaurid and carcharodontosaurid theropods, brachiosaurid sauropods, iguanodontoid ornithomimid and nodosaurid ankylosaurs [62]. These dinosaur remains are supposed to have originated from land areas corresponding to the emergent Central and Armorican massifs. The Cenomanian dinosaur-bearing beds of the Charentes were deposited in paralic environments and the dinosaurs in question are supposed to have lived in coastal habitats. These conditions are quite different from the marine environments in which the Cretaceous dinosaurs from Normandy were buried after long periods of drifting on the open sea, and they largely explain the higher diversity of the Charentes assemblage. An additional factor is that large-scale screen-washing of sandy sediment was possible at the Charentes localities: a technique that cannot be used in the marine formations of Normandy, where dinosaur remains occur as occasional finds in usually highly consolidated rocks.



**Figure 9.** Palaeogeographical map of part of Normandy in the early Cenomanian, superimposed on present-day landmarks: coastline (dotted) and Seine river valley (blue). The arrow shows the SW-NE direction of the predominant winds according to Lasseur et al. [61], which may have facilitated the drift of the floating dinosaur carcass from the emergent Armorican massif to the place where it was buried in sediment. Modified after [51].

### 5.3. Affinities of the Cretaceous Dinosaurs from Normandy

The rather meagre Cretaceous dinosaur record from Normandy is restricted to marine Albian and Cenomanian deposits, and it is worth noting that in Normandy, the earlier formations showing a Wealden facies, which are known in the Pays de Bray, have yielded no vertebrate remains, contrary to the Wealden of England, which is well-known for its remarkable dinosaur record [16,63]. The Albian and Cenomanian dinosaur record from other parts of the Anglo-Paris basin is generally scanty [64]. Apart from the above mentioned sauropod vertebrae (which possibly belong to *Normanniasaurus*) from Villers-Saint-Barthélemy in the south-eastern part of the Pays de Bray and those from Pargny-sur-Saulx in eastern France [45], it consists mainly of the theropod, sauropod and ankylosaur remains from the green sands of the Argonne region of north-eastern France ([44] and references therein), and of the dinosaur assemblage from the Cambridge Greensand of England, a Cenomanian formation in which Albian fossils, including dinosaur bones, are reworked [16,46]. This assemblage includes ankylosaurs, ornithopods, sauropods and birds (review in [16]). In addition, ankylosaur remains are known from the Albian of several localities in Kent [15,16].

The Cenomanian record is hardly better, with a handful of sauropod and ornithopod bones from the Cenomanian type area around Le Mans in the south-western part of the Paris basin [65,66], an ankylosaur tooth [67] and theropod tooth fragments from the Loire valley [68] in the southern part of the basin. From the English part of the Anglo-Paris basin, only a few ankylosaur remains from Folkestone in Kent [14] and a hadrosauroid tooth from the middle Cenomanian Totternhoe Stone of Hitchin in Hertfordshire [15,16,69] can be mentioned. Nevertheless, both the Albian sauropod *Normanniasaurus genceyi* and the Cenomanian theropod *Caletodraco cottardi* are known from specimens that have warranted the erection of new taxa and their affinities with other dinosaur records are worth considering.

The Albian record consists of the titanosaurian sauropod *Normanniasaurus genceyi* and the referred isolated vertebra from the Bucaille collection. As noted above, the Albian vertebrae from Villers-Saint-Barthélemy, in the south-eastern part of the Pays de Bray (slightly outside the boundaries of Normandy) seem to belong to a sauropod that is closely related to *Normanniasaurus*. Farther away, vertebrae from the Albian of the Argonne area of eastern France apparently also show similarities, but they were probably derived from the London–Brabant massif, rather than the Armorican massif [44]. As remarked above, there are few similarities between *Normanniasaurus* and *Macrurosaurus semnus* from the Cambridge Greensand of England, or between *Normanniasaurus* and the Albian sauropod from Pargny-sur-Saulx in eastern France. *Normanniasaurus genceyi* thus appears as the best-known element of a sauropod assemblage which inhabited north-western European land masses (Armorican massif and probably London–Brabant massif) at the end of the Early Cretaceous and included other, poorly known forms represented by the Cambridge Greensand and Pargny-sur-Saulx sauropods. As noted above, Mannion et al. [49] considered *Normanniasaurus genceyi* as a derived titanosaur clustering with Gondwanan forms, a conclusion shared by Díez Díaz et al. [50]. This is interesting in terms of the palaeobiogeographical relations of the Cretaceous European archipelago, the fauna of which doubtless included elements with Gondwanan affinities.

As to the abelisaurid *Caletodraco cottardi*, no similar forms have been described from the Cenomanian of the Anglo-Paris basin, which has previously yielded no theropod remains, with the exception of tooth fragments from the Loire valley [68]. The European abelisaurid record begins with *Genusaurus sisteronis*, from the Albian of south-eastern France ([56] and references therein), which, like *Caletodraco*, appears to belong to the furileusaurian clade, unlike some abelisaurids from later geological formations in Europe, such as the majungasaurine *Arcovenator*. It now seems clear that abelisaurids were the dominant Late Cretaceous large theropods in Europe [51–55], but their evolutionary history remains to be worked out. *Caletodraco cottardi* is currently the only abelisaurid to be known from the Cenomanian of north-western Europe. It should be noted, however, that according to Malafaia et al. [54], some of the teeth from the Cenomanian of the Charentes in south-western France described by Vullo et al. [62] as carcharodontosaurid teeth may in fact belong to abelisaurids. As mentioned above, some of the dinosaur remains from the Charentes may have originated from the Armorican massif, like the holotype of *Caletodraco cottardi*.

Apart from their wide distribution in the Cretaceous of Europe, abelisaurids are a mainly Gondwanan theropod family, with numerous representatives in South America, Africa, Madagascar and India. Like the titanosaur *Normanniasaurus*, which, according to Mannion et al. [49] and Díez

Díaz [50], shows affinities with Gondwanan forms, *Caletodraco* can possibly be considered as a Gondwanan element in the Cretaceous dinosaur fauna of Europe.

## 6. Conclusions

The Cretaceous dinosaur record from Normandy is scanty, which is at least partly because it comes exclusively from marine deposits consisting of remains of carcasses which must have drifted over fairly long distances from an emergent land area that in all likelihood was the Armorican massif. Moreover, several potentially interesting specimens were destroyed in World War II (the potential ankylosaur remains from the Cenomanian of Coulonges-sur-Sarthe and the bony scute from an indeterminate Cretaceous horizon at Cape La Hève) or have been lost (the putative bird bone from the Cenomanian of Villers-sur-Mer), without having been properly described. Despite this, some of the material, although far from complete, has proved sufficient to erect new taxa, viz. the Albian sauropod *Normanniasaurus genceyi* and the Cenomanian theropod *Caletodraco cottardi*. Both apparently show Gondwanan affinities and may signal the inception of the Late Cretaceous western European dinosaur fauna, which is known to consist of a mixture of Laurasian and Gondwanan elements [62,70,71].

Although limited, taken together with a few finds from other parts of the Anglo-Paris basin, the record from Normandy gives us a tantalising glimpse of the Cretaceous dinosaur assemblages that inhabited the north-western part of the European archipelago during the Albian–Cenomanian interval. It can only be hoped that a continued search, notably by amateur palaeontologists who are especially active in Normandy, will result in future discoveries that will shed more light on the still very incompletely known Cretaceous dinosaurs from that part of the world.

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