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From Louis XIII (1620) to the Inhigeo Symposium (2022): four centuries of Miocene palaeontology and stratigraphy at Sainte-Croix-du-Mont (Aquitaine, France)

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Abstract. In September 2022, 402 years after the visit of Louis XIII, the participants of the INHIGEO Symposium visited the amazing site of Sainte-Croix-du-Mont (Guyenne, Western France), first described in 1622 by Pierre de L'Ancre. Known for his condemnation of alleged witches to the stake, de L'Ancre included one of the earliest memoirs on the geology of Aquitaine in his book on demonology, *L'incrédulité et mescreance du sortilege* (1622). In this discourse, of which large extracts translated into English are included in the appendix, he described the Miocene shelly sediments of Sainte-Croix-du-Mont and reminded his readers of Louis XIII's visit to this site in 1620. Regarding the origin of these shells, he hesitated between an in-situ generation of the fossils (*i.e.*, *lusus naturae*), their deposition in an ancient sea and their transport by the biblical Flood. He described the layers (called « stages ») from the bottom to the top, thus probably understanding their chronological succession and the principle of superposition, before Steno formally stated it (Steensen, 1669). In 1718, Jules Bellet and Isaac Sarrau de Boynet, of the Academy of Bordeaux, studied the same outcrop; they suggested an organic origin because of the scar left by the adductor muscle on the shells and the effervescence of the latter in vinegar. Sarrau de Boynet, however, refused to admit that the sea had reached this place and adopted the surprising thesis of an anthropic accumulation of oysters, which Montesquieu was reluctant to accept. In his famous manuscript *Telliamed*, Benoît de Maillet assumed a marine origin for these fossils, as did other scientists in the second half of the 18th century, such as Nicolas Desmarest. The systematic study of the shelly sediments of this region began in the 1830s, with the detailed work of Jean-Pierre Sylvestre de Grateloup. These studies, carried out mainly in the Saucats area, about 25 km from Sainte-Croix-du-Mont, led to the definition of two Miocene stratotypes, the Aquitanian by Karl Mayer in 1858 and the Burdigalian by Charles Depéret in 1892.

Keywords: Miocene – Burdigalian – Aquitanian – origin of fossils – Pierre de L'Ancre – Louis XIII – Steno – Telliamed

1. Introduction

The small village of Sainte-Croix-du-Mont dominates the right bank of the Garonne River, 40 km upstream from Bordeaux (Fig. 1). Renowned for its sweet white wine, it is also famous for its spectacular deposit of fossil oysters of the Burdigalian (Lower Miocene). This fossiliferous deposit was visited by the King of France, Louis XIII, on 2 October 1620, and described in 1622 by Pierre de L'Ancre who noted the sequence of superimposed layers which he called « estages » (*i.e.*, « stages »), many years before Steno's

Prodromus (Steensen, 1669) was written. The site was further described in the 18th century by the *Académie de Bordeaux*, mentioned by Benoît de Maillet in his famous *Telliamed*, and finally studied in detail in the 19th and 20th centuries. The site thus allows us to trace the evolution of ideas about the origin of fossils over four centuries, from the *lusus naturae* (game or sport of nature) and transport by the biblical Flood to a deposit by the Atlantic Ocean during the Burdigalian transgression.

On 24 September 2022, 402 years after Louis XIII, the participants in the 47th Annual Symposium

of the International Commission on the History of Geological Sciences (INHIGEO) had the opportunity to visit this site. This article is a modified

version of the unpublished excursion guidebook, to which we have added in Appendix the English translation of Pierre de L'Ancre's text (1622).

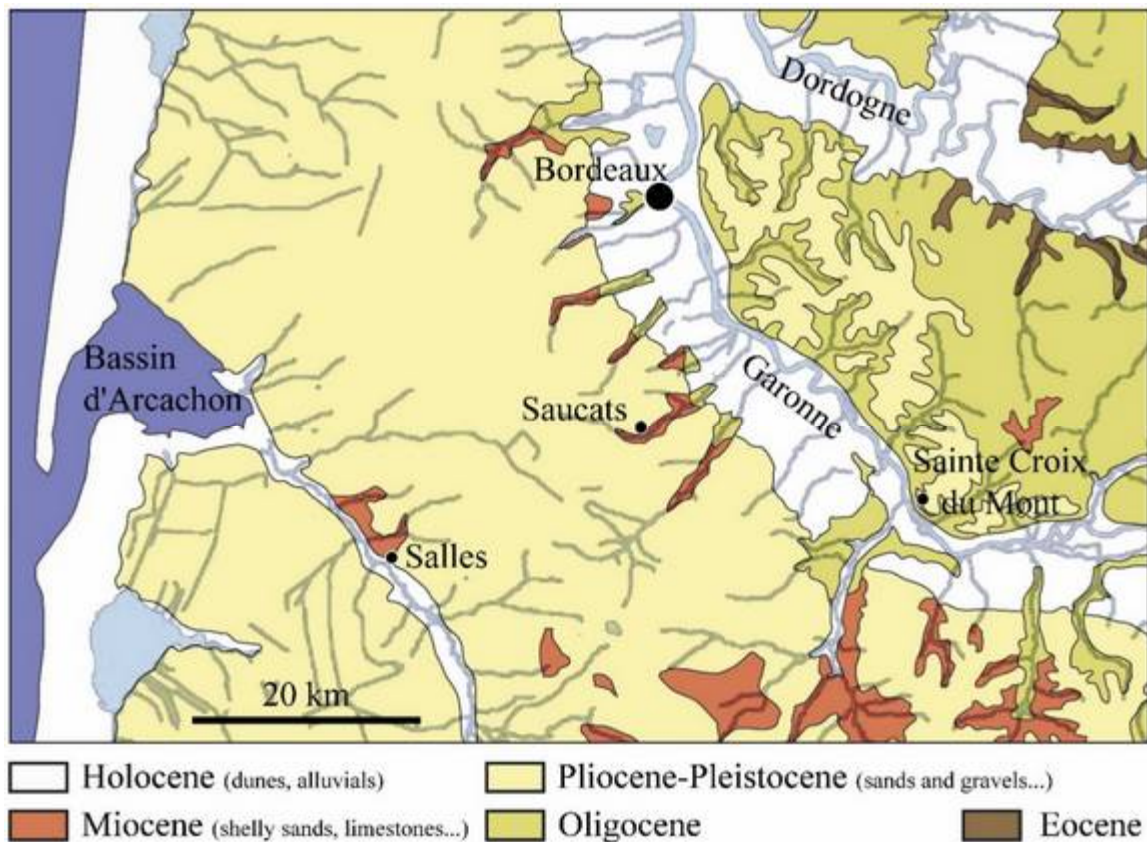


Fig. 1. Geological sketch map of the Bordeaux region

2. Pierre de L'Ancre gives Louis XIII a lesson in geology (1622)

Pierre de Rosteguy de L'Ancre (1553–1631), a counsellor to the Parliament of Bordeaux¹, is known for his books on demonology (L'Ancre, 1612, 1617, 1622, 1627) and for having persecuted and condemned to the stake the alleged witches of Labourd (Basque country) (e.g., Communay, 1890; Français, 1910, pp. 150-159). He is remembered as a fanatical and cruel judge – an obvious criminal by today's standards –, as rec-

ently highlighted by a French television series (*Filles du feu*)², broadcasted in 2023, which deals with his story and that of his victims.

In 1622, in order to convince the sceptics of the merits of his policy of terror against witches, he published *L'incredulité et mescreance du sortilege plainement convaincue* (L'Ancre, 1622; Fig. 2), a rare book that was printed in 40 copies (Climens, 1884), but which is now available online³. With the exception of Auguste Petit-Lafitte (1846, 1867), naturalists and geologists did not pay any atten-

¹¹ Before the French Revolution, parliaments were courts of justice that enacted laws and administered justice on behalf of the king. The main parliament was in Paris, but there were others in Aix-en-Provence, Dijon, Rouen, Rennes, Bordeaux, etc., so the law was not uniform throughout the kingdom. In each parliament, justice was administered by "counsellors", who were appointed, not elected.

² Available for streaming (6 × 52 min) at: <https://www.france.tv/france-2/filles-du-feu/> (accessed 13 September 2023).

³ <http://gallica.bnf.fr/ark:/12148/bpt6k763251>

tion to this book, although its *Advertissemens* contain one of the earliest, if not the first, memoirs on the geology of Aquitaine, devoted to the famous fossil oyster deposit of Sainte-Croix-du-Mont. Although this topic was completely unrelated to the subject of the book, the author included it because he was proud that King Louis XIII, to whom the book was dedicated, had visited the oyster deposit at his home of Loubens two years earlier. Pierre

de L'Ancre, although very disappointed to have been absent on that occasion, was obsequious enough to display a « Prayer for the King » in his private chapel of Notre-Dame at Loubens (Communay, 1890, pp. 34-35)⁴. Because of its interest for the history of geology, we have already transcribed this text (Godard, 2018a), of which we provide an English translation here (see Appendix).



Fig 2. Title page of *L'incréduité et mescreance du sortilège...* by Pierre de L'Ancre (1622). © *Bibliothèque nationale de France*; the title can be translated as « The incredulity and unbelief of witchcraft, plainly guilty... ».

⁴ According to Communay (1890), Pierre de L'Ancre was buried in the church of Sainte-Croix-du-Mont, in front of the high altar, where we can still see the site of an ancient tomb. However, at an unknown date, the burials of the church were transferred to an ossuary under the cross located outside the church, to the left of the nave; it is therefore probable that Pierre de L'Ancre's ashes are there.

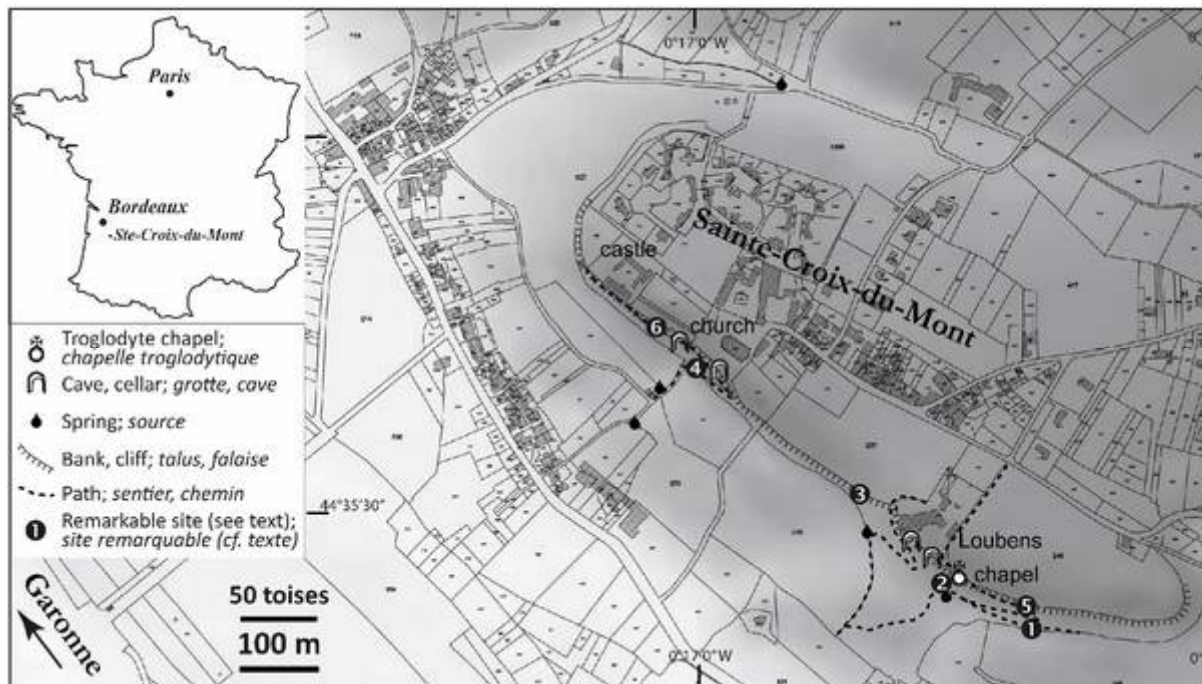


Fig. 3. The surroundings of Sainte-Croix-du-Mont. According to the cadastral map, superimposed on a digital terrain model from the *Institut Géographique National*.

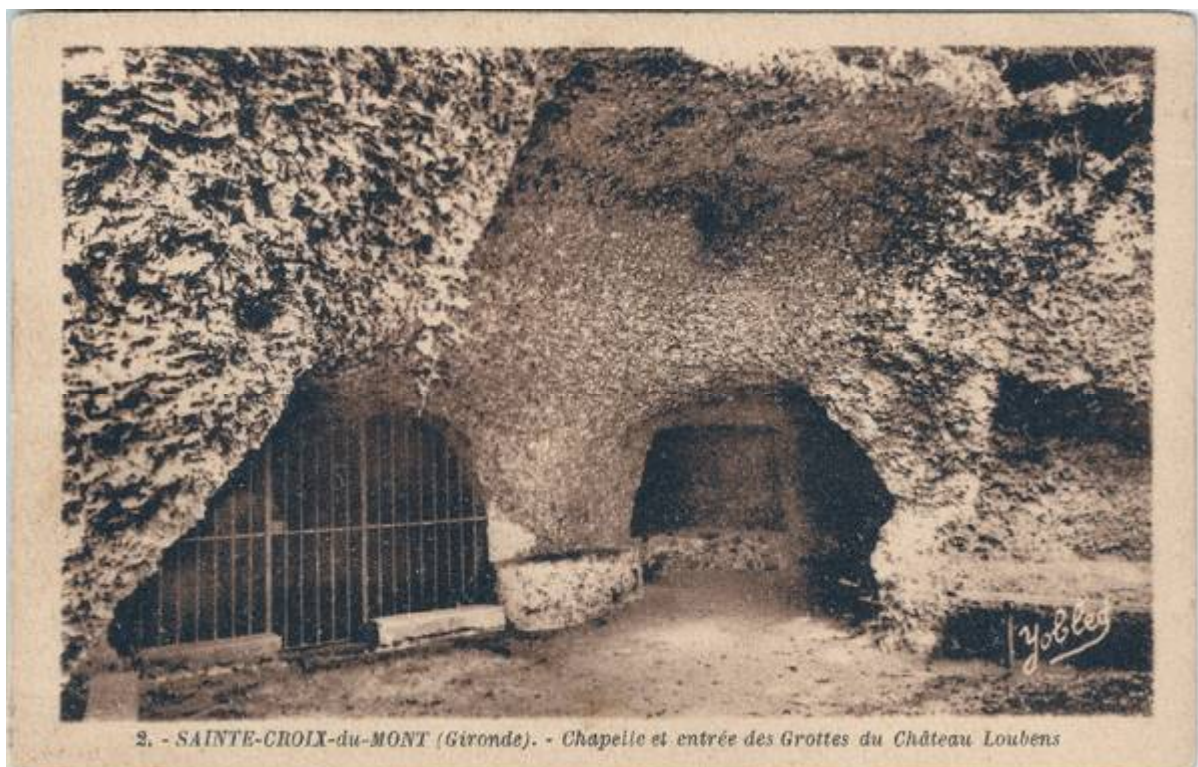


Fig. 4. The troglodyte chapel of Loubens, visited by Louis XIII in 1620. Early 20th century postcard. The chapel was excavated in the Burdigalian oyster level, the base of which is about 40 cm above ground level. The « Prayer for the King » (*i.e.*, Louis XIII) has apparently been removed, but the portraits of Pierre de L'Ancre and his wife, though very faded, can still be seen inside the chapel.

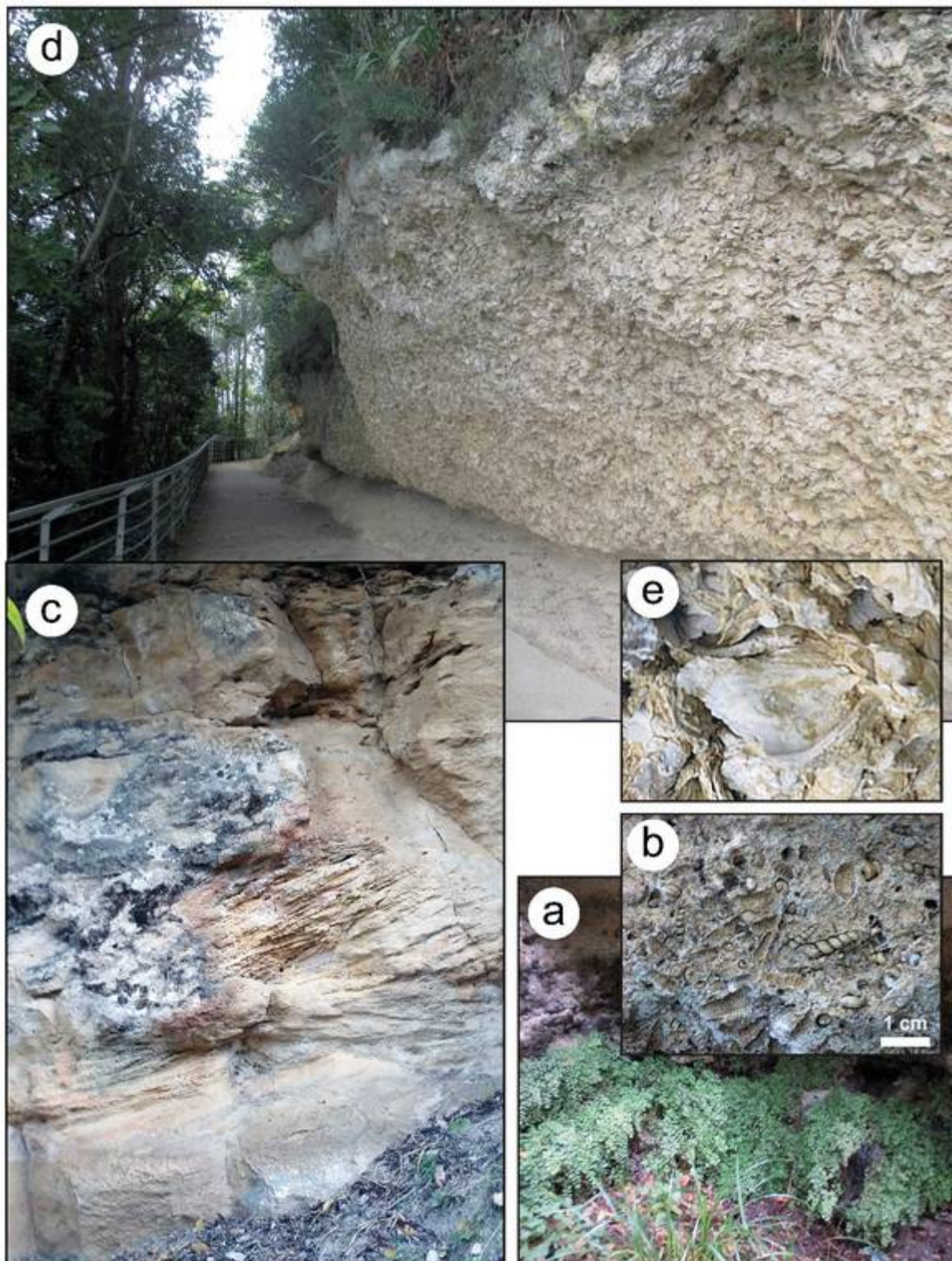


Fig. 5. Some outcrops along the cliff at Saint-Croix-du-Mont. From bottom to top: (a) One of the springs at the foot of the Loubens cliff, which gushes out at the Oligocene-Miocene boundary, showing the fern *Adiantum capillus-veneris* also observed by Abel Brunyer in 1620 (see notes 18, 20-22; 2 in Fig. 3); (b) The fossil gastropods (« *limassons entortillez* ») from the second stage of Pierre de L'Ancre (1622), observed at the same level as the springs; (c) Base of the cliff made up of crossbedded calcareous sandstone, with *Parascutella bonali* and *Amphiope ovalifera*; (d) At the top of the cliff is the « third stage of stacked oysters » described by Pierre de L'Ancre, here below the castle of Sainte-Croix-du-Mont (6 in Fig. 3); (e) Detail of oyster shells, showing adductor muscle scars (centre), which in 1718 were the key argument for an organic origin.

In 25 pages, interspersed with many digressions, the author describes the shelly sediments – now known to be of Miocene age – that occur on the slopes of Sainte-Croix-du-Mont (L'Ancre, 1622, pp. 17-42 of the *Advertissemens*), where Pierre de L'Ancre owned the estate of Loubens, including the troglodyte chapel dug into the level of fossil oysters (Fig. 4). After recounting the visit made by Louis XIII and his young brother Gaston d'Orléans to this site on their way to Béarn in October 1620, he describes « *huïstres* [oysters...], *coquillages* [shells...], *langues de serpent* [*Glossopetrae*, i.e., shark teeth], & *limaçons à plusieurs retortillons* [gastropods] ».

Pierre de L'Ancre wondered about the origin of these oysters. He was undecided between a transport by the biblical Flood and an in-situ generation by a sport of nature, which he called « *esbatement de la nature* », while also considering that marine sediments which emerged after the withdraw of the sea could have been consolidated over long ages (« *par de longs siecles* », p. 35). He wrote: « we see [...] the seas which are in constant motion, some receding, others flooding, and

the shape of innumerable places changing »⁵. He quoted many ancient authors, more to demonstrate his classical culture than to enlighten the debate, and reported on observations made during a tour of Italy between 1574 and 1579, during which he visited Calabria, Naples, Florence, Ravenna and Venice. After lengthy discussion and numerous reservations, he did not reach a clear and definitive conclusion.

The text is mainly worthy of note for the passage (p. 40; see Appendix) in which the author described the sequence of layers: he enumerated them from bottom to top and names them « *estages* » (i.e., stages). This rudimentary geological cross-section was observed at Loubens, where an embankment some 25 metres high is crowned by the famous fossil oyster level and extends north-westwards as far as the castle of Sainte-Croix-du-Mont (from 1 up to 6 in Fig. 3). Pierre de L'Ancre's description is precise enough to assign these « stages » to the various formations described by modern geologists (e.g., Alvinerie & Dubreuilh, 1978; Tastet *et al.*, 2003; Londeix *et al.*, 2014; Londeix, 2018; see Fig. 6, and Table 1).

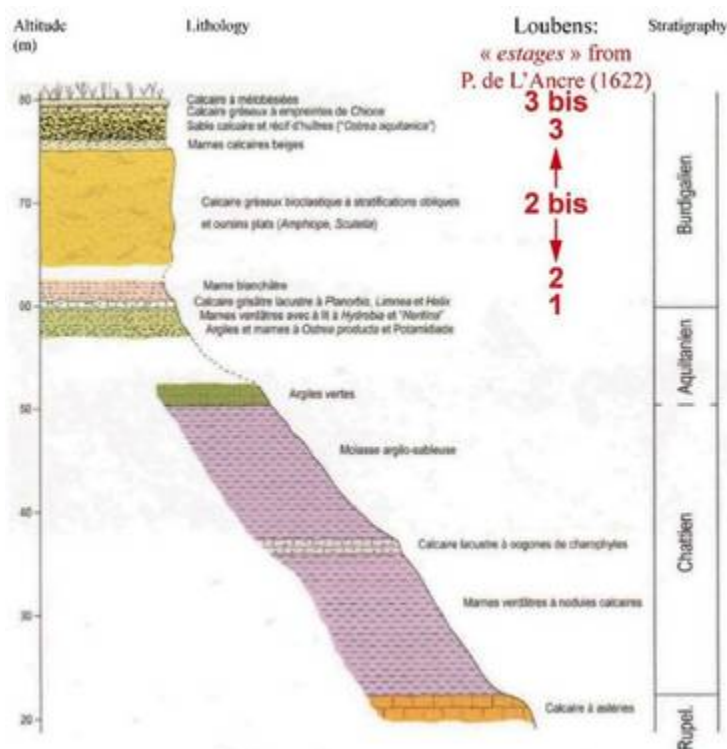


Fig. 6. Stratigraphic sequence at Sainte-Croix-du-Mont. Based on Dollfus (1913), Tastet *et al.* (2003) and Londeix (2018). The position of the « estages » of P. de L'Ancre has been added (see text and Table 1, and p. 40 of Appendix).

⁵ L'Ancre (1622, p. 35): « nous voyons tous les jours croistre les Montagnes & Rochers, & les lieux fossoyez & creusez se remplir d'eux mesmes, & d'autres se diminuer & changer: Et les Mers qui sont en perpetuelle agitation, les unes se reculer, les autres inonder; & la face d'une infinité de lieux se diversifier ».

Fig. 6	Description of the different « estages » by Pierre de L'Ancre (1622, p. 40)	Modern geological description of the same levels
3 bis	« Above and almost at the top of the scabrous boulders, there are large oyster shells attached » (« <i>Et encores au dessus & presque au sommet des pieces de Rocher scabreuses, [...] il y a de grandes Escailles [d'huîtres] attachées</i> »).	The roof of the troglodytic chapel and cellars is made of a hardened layer inlaid with oysters, crowning the cliff.
3	Then comes « a third stage of other stacked oysters » (Fig. 5d, e; « <i>un troisieme estage d'autres Huîtres amoncellées</i> »). The troglodyte chapel visited by Louis XIII at Loubens was excavated in this level (Fig. 4; near 2 in Fig. 3).	This famous oyster bed of the Burdigalian (Lower Miocene) is rich in <i>Ostrea aquitanica</i> MAYER (now <i>Hyotissa undata</i>), and can reach a thickness of 4 m (Fig. 5d, e; 5 and 6 in Fig. 3). Some cellars and caves were dug in this level, at Loubens and under the church and the castle of Sainte-Croix-du-Mont.
2 bis	« Above, there is another bed of hard stone, and after there is a high cliff » (Fig. 5c; « <i>Au dessus il y a encore une couche de Pierre dure: & apres se trouve une grande levée</i> »).	The 15 m thick cliff, with meter-thick strata of cross-bedded calcareous sandstone (Fig. 5c; 3 and 4 in Fig. 3), contains Burdigalian (Lower Miocene) <i>Parascutella bonali</i> and <i>Amphiope ovalifera</i> .
2	« The second stage, upwards, contains shells in the shape of small twisted snails, which Tertullian calls <i>Buccinae</i> » (Fig. 5b; « <i>Le second estage allant à mont, est d'un coquillage en forme de petits limassons entortillez, que Tertullien appelle Buccinae</i> »): L'Ancre insists that this « stage » contains « another kind of shells, smaller and all different » from the oysters of the highest levels (p. 19: « <i>il s'y trouve encor une autre sorte de coquilles plus menues, & toutes differentes des premieres</i> »).	These small « twisted » gastropods could be <i>Potamides</i> , very abundant in the sandy clays of the Aquitanian (Lower Miocene), which pass into sandstones rich in numerous internal moulds of lamellibranches and gastropods (Fig. 5b). Pierre de L'Ancre observed this level at the foot of the Loubens cliff, along the path walked by Louis XIII, which de L'Ancre called « <i>Allée des Fontaines</i> » because it is lined with springs formed in relation to the underlying clay levels (Fig. 5a; 2 in Fig. 3).
1	« The base and the foot of the Rock are of hard and clean stone, without any other mixture » (« <i>La base & pied du Rocher est de pierre dure & nette sans autre meslange</i> »).	This could be a fluvio-lacustrine limestone with traces of <i>Planorbis</i> dated to the Upper Oligocene. We have not been able to identify this first « stage » of « hard stone » with certainty, but it seems to outcrop near the small stream below the cliff.
	Not described by Pierre de L'Ancre.	The Oligocene is represented by marls and clays, resulting in a gentle topography of meadows and vineyards.

Table 1. The different « estages » visible at Loubens, according to Pierre de L'Ancre (1622) and their modern stratigraphic descriptions. The first column refers to the levels in Figure 6.

Describing the rocks and fossils shown to Louis XIII at Loubens, Pierre de L'Ancre (1622) used the word « *estage* » (*i.e.*, stage) long before it was introduced by Alcide d'Orbigny (1840–1867) to indicate a chronostratigraphic division. Whereas Louis XIII and his entourage went through this geological section from top to bottom, L'Ancre listed these stages in the opposite direction, from bottom to top, as a modern geologist would, suggesting that he had intuitively assimilated the principle of superposition and the chronological order of the strata before Nicolas Steno formally stated them (Steenen, 1669).

In the 16th and 17th centuries, there were two main opposing theses on the origin of fossils (*e.g.*, Rudwick, 1972; Ellenberger, 1994). The « sport of nature » or *lusus naturae* thesis, which Pierre de L'Ancre charmingly called the « *esbatement de la nature* », attributed the origin of fossils to

spontaneous formation from the rock masses; the second hypothesis, that of an organic origin, clashed with the remoteness of the sea and therefore (it was thought) required the transport of the shells, for example thanks to the biblical Flood, which seemed to be a convenient mechanism. Pierre de L'Ancre (1622), as well as Louis XIII's entourage (according to his reports), was undecided between the two theses, whereas a more recent manuscript, written around 1650 on the shelly sands of Salles, 50 km to the west (Fig. 1; formerly Sallomacian, now Serravallian), clearly supported the *lusus naturae* origin (Godard, 2019). Although very cautious and somewhat confused in his conclusions, L'Ancre was audacious enough to imagine sea-level fluctuations, which were rarely invoked at the beginning of the 17th century. He imagined the mobility of the seas over « long centuries » in addition to a possible transport by the Flood (L'Ancre, 1622, p. 35; see Appendix),

suggesting a dynamic evolution of the Earth: « every day we see the mountains and rocks growing, the depressions and hollows filling up [with sediments] by themselves, and others shrinking and changing ». He quoted Ovid's famous verses: « I have seen myself what was once solid land become the sea. I have seen earth made from the waters, and seashells lying far away from the sea, and an ancient anchor has been found on a mountaintop » (Metamorphoses 15, 262-265), to end with a bit of humour: he was himself an ancient anchor (L'Ancre means « the anchor », in French), ready to welcome the reader at the top of his « mountain » of Loubens to show him these shells.

3. The studies of the Bordeaux Academy (1718) and the opinion of de Maillet

At the beginning of the 18th century, the *Académie royale des belles-lettres, sciences et arts de Bordeaux* began to discuss the origin of the oyster shells of Sainte-Croix-du-Mont (Godard, 2018a, 2018b). A memoir on this deposit, sent by Jules Bellet, priest of Cadillac, was read at the meeting of 8 May 1718⁶. Father Bellet did not doubt that it was made up of « marine oyster shells ». He quoted ancient and modern authors who had reported the presence of such shells on land, and was convinced that the sea was once present in the area and « left [the shells] here when it retreated ». On the basis of ancient texts, he stated that the presence of the sea at Sainte-Croix-du-Mont dated back to the Flood, which he believed to have occurred 4115 years ago – the author covered the margins of his manuscript with numbers relating to this calculation. In the rest of the memoir, Father Bellet briefly described some of the out-

crops, recalled Louis XIII's visit to Loubens in 1620 and transcribed the « Prayer for the King » composed for the occasion by Pierre de L'Ancre.

Bellet's report aroused the curiosity of the Academy. During the summer of 1718, several members of the Academy travelled to Sainte-Croix-du-Mont, and on 25 August 1718, Isaac de Sarrau de Boynet read a new manuscript on the subject before the Academy⁷. He described the outcrops and the « vein of shells » between two « beds of hard stone ». He also studied the fossil shells, noting their effervescence in vinegar and the scars left by the adductor muscle, and concluded that the fossils were similar to modern marine shells. Convinced of the organic origin, Boynet hesitated between transport by the Flood and deposition by the sea, which was difficult to imagine given the altitude of the area. Finally, he suggested that, for some (admittedly obscure) reason, ancient men could have transported the oysters to their present location⁸. This surprising thesis reflected Boynet's frustration with the incomprehensible. Montesquieu, who chaired the meeting, disingenuously expressed apparent satisfaction: « When one cannot be sure of the truth », he declared, « it is good to have something that resembles it »⁹.

A copy of Bellet's memoir was sent to the regent Philippe d'Orléans in 1718, together with a map drawn up by Barrelier de Bitry, chief engineer at the Bordeaux fortress of Château-Trompette. This map, entitled *Vüe de la Coste de Ste Croix du mont*, is now kept in the *Bibliothèque de l'Institut* in Paris¹⁰ (Fig. 7), where there is no trace of the accompanying memoir. However, it is almost certain that copies of this memoir were circulating in Paris, since it is mentioned in the famous manu-

⁶ *Mémoire sur les coquilles d'huîtres de Sainte-Croix du Mont*, by l'abbé Jules Bellet, read on 8 May 1718, *Bibliothèque municipale de Bordeaux*, ms 828/017 (n° 5), 16 p.; see Godard (2018b).

⁷ *Mémoire touchant les coquillages de Ste Croix du Mont*, by Isaac Sarrau de Boynet, read on 25 August 1718, *Bibliothèque municipale de Bordeaux* {BmB}, ms 828/002 (n° 6), 24 p.; *Mémoire sur les coquillages de Ste Croix du Mont*, by Sarrau de Boynet, 25 August 1718, BmB, ms 828/016 (n° 24), 12 p.; see Godard (2018b).

⁸ Although seemingly extravagant, the hypothesis of an anthropogenic origin of oyster masses has been demonstrated for other deposits, notably the famous km-long shell middens of Saint-Michel-en-l'Herm in western France (see historical review in Godard, 1995). In the latter case, however, the deposit, resulting from medieval oyster farming, is neither hardened nor stratified like that of Sainte-Croix-du-Mont.

⁹ *Résomption de la dissertation de M. de Sarrau sur les coquillages de Ste Croix du Mont*, by Montesquieu, *Bibliothèque municipale de Bordeaux*, ms 828/006 (n°7), 1 p.; see Godard (2018b).

¹⁰ *Vüe de la Coste de Sainte-Croix-du-Mont*, colour map by Barrelier de Bitry presented to the *Académie Royale des Belles-Lettres... de Bordeaux*, 1718, *Bibliothèque de l'Institut de France*, Paris, ms 2721/51, 51.55 cm × 53.55 cm, scale of 59.54 cm for 100 toises.

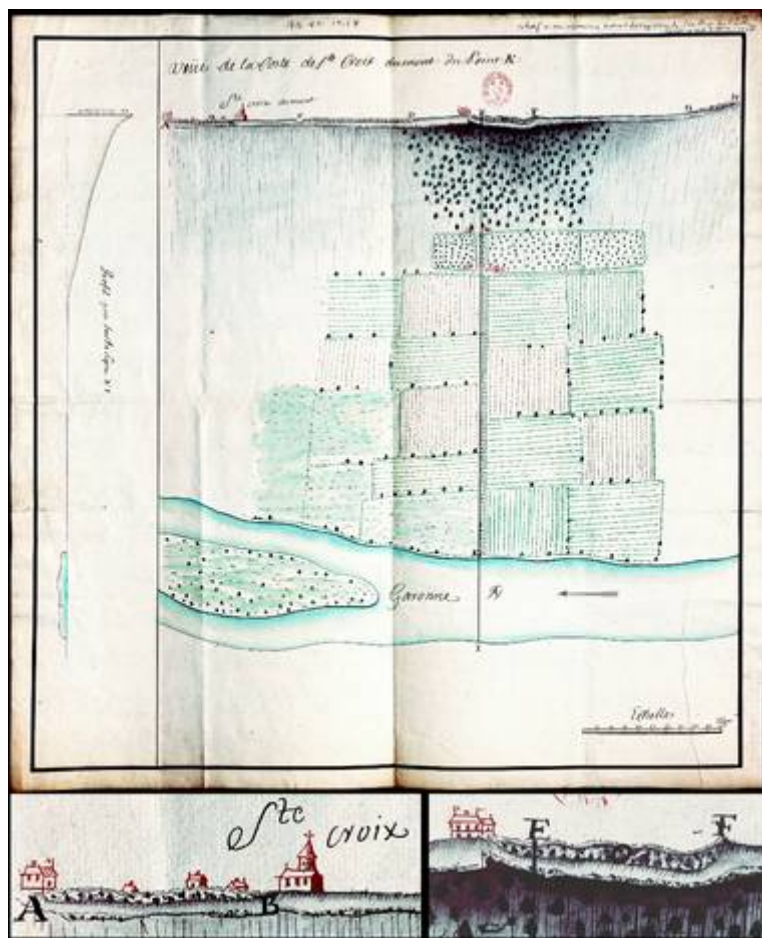


Fig. 7. « *Vüe de la Coste de S^{te} Croix du mont* » (1718)
 Manuscript 2721/51 from the *Bibliothèque de l'Institut de France*, Paris. Map and perspective view made by Barrelier de Bitry in 1718; 51.5 cm × 53.5 cm at a scale of about 1/2100, with the topographic profile (left) from I to E. The cliff (at the top) is shown in perspective view from point K; the marbling represents the oyster level (e.g., between A and B, between E and F); A, castle; B, church; C, gorge (?); D, E, F, Loubens; O (between E and F): troglodyte chapel; K: place where Louis XIII landed in 1620. Enlargements: Sainte-Croix-du-Mont, bottom left; Loubens, bottom right.

script *Telliamed*, written in secret by Benoît de Maillet who put forward bold theories on the origin of fossils and the history of the Earth (translated from Maillet, 1748; written after March 1719): Oyster shells can be seen « six leagues from Bordeaux in the parish of Sainte Croix du Mont [...]. There, on the crest of a rather high mountain, [...] between two beds of stone, the upper of which may be five or six feet thick, one sees a deposit of oysters that is twenty or twenty-four feet thick, and which is visible for an extent of about one hundred fathoms [*i.e.*, about 200 m], the rest being hidden in the rock. A chapel has been built there, fifteen feet deep, where mass is celebrated. Most of these oysters are closed and contain a small amount of clay. This is probably the substance of the oyster that has deliquesced. These oyster shells are united in this bed by a sand, which, mixed and petrified with them, now makes them a

single substance. The scholars who work in Bordeaux on the history of the Earth will undoubtedly be able to tell you how this layer came to be, if the prejudices in which they were brought up do not prevent them from seeing the reason for this phenomenon. For me, it is impossible not to be convinced by the sight of these layers of oysters [...] that they were all oyster beds when the sea completely covered them, similar to those it contains today in an infinite number of places from which we collect the oysters we eat. »

Father Jules Bellet continued to send to the Bordeaux Academy handwritten chronicles, proudly entitled *Voyages littéraires*, describing fossil occurrences in the region¹¹. Other members of the Academy, notably Godefroy de Baritault and Jacques-François Borda d'Oro [1718–1804], described fossils from Aquitaine and had no doubts

¹¹ *Voyage littéraire à Sainte-Foy...*, par l'abbé Jules Bellet, 1736, *Bibliothèque municipale de Bordeaux*, ms 828/017 (n° 7), 20 p.; *Observations d'histoire naturelle extraites des voyages littéraires de M. l'abbé Bellet*, by Sarrau de Boynet, 1736, *Bibliothèque municipale de Bordeaux*, ms 828/016 (n° 14), 12 p.; see Godard (2018b).

about their organic origin (see Courteault, 1909; Godard, 2018b). In the mid-eighteenth century, the Academy of Bordeaux organised two essay competitions (Courteault, 1909): the first, in 1743, on the « origin and formation of figured stones [*i.e.*, fossils] having a regular and determined figure, both internally and externally »; the second, in 1745, on the « figured stones ». The postulants unanimously accepted the idea of an organic origin, but did not consider the shelly sediments of the region. One of them, Pierre Barrère, surprisingly expressed some of the concepts of uniformitarianism as early as 1745 (Godard, 2018b).

4. The rise of modern geology

Dezallier d'Argenville, one of the contributors to Diderot's *Encyclopédie*, briefly mentioned the fossils of Sainte-Croix-du-Mont in his *Enumerationis fossilium* (Dezallier d'Argenville, 1751, p. 53): « In a place called Sainte Croix du Mont, in front of the castle gates [*i.e.*, between 6 and 4 in Fig. 3], a large oratory has been dug into a cliff of oysters; the vault and the pillars supporting it are constructed of the same material. »¹²

In 1761, Nicolas Desmarest, then working for the intendant of Bordeaux, wrote a travel journal of two journeys from Bordeaux to Périgueux and from Bordeaux to Agen, in which he described the (Cenozoic) sediments of these regions¹³. He only mentioned the « *pierres aux huîtres de Sainte Croix* », but elsewhere described fossil « *madrepores* », shells, sea urchins, etc., which he clearly attributed to a marine origin. Desmarest later reproduced some of these observations in his *Encyclopédie méthodique*, devoted to physical geography and geology (Desmarest *et al.*, an III-1828). Authors of the second half of the 18th century, like Desmarests, had no doubts about the marine origin of the fossils and explained their presence in Aquitaine by some invasions of the Atlantic Ocean (*e.g.*, Godard, 2018b).

The systematic study of the shelly sediments (called « *faluns* ») of Aquitaine actually started in the 1830s, with the beginning of modern geology, in particular with the detailed work of Jean-Pierre

Sylvestre de Grateloup (*e.g.*, Lesport *et al.*, 2012). These studies eventually led to the definition of two Miocene stratotypes, the Aquitanian (23.03–20.44 Ma) and the Burdigalian (20.44–15.97 Ma), which are still internationally recognised. It was in 1857 that the Aquitanian stage was created by Karl Mayer (or Mayer-Eymar) (Mayer, 1857; see Cahuzac in Londeix *et al.*, 2014, for the historical details). The name Aquitanian comes from *Aquitania*, the Latin name for the Gallic province of Aquitaine, as mentioned in the writings of Caesar and Pliny. In 1892, Charles Depéret created the Burdigalian stage, which he named after the city of Bordeaux (*Burdigala* in Latin). He defined it as « the horizon of the faluns of Saucats and Léognan », and placed it stratigraphically above the Aquitanian (Depéret, 1892). These stratotypes, protected within the Saucats-La Brède geological Reserve (see Saucats in Fig. 1), have overshadowed Sainte-Croix-du-Mont, some 25 km away, because of their scientific interest and the numerous studies they have given rise to. However, Sainte-Croix-du-Mont remains an exceptional site for its spectacular oyster beds and for its relevance to the history of geology.

5. Conclusions

The 17th and 18th century memoirs on the fossils of Sainte-Croix-du-Mont (Aquitaine Basin, France) echoed the debates of the time on the origin of the « figured stones » – which we now call fossils. The authors were undecided between an organic origin with transport of the shells by the biblical Flood and an in-situ origin resulting from an « *esbatement de la nature* » (a game of nature). A few authors however endorsed more original ideas. The most notable was Pierre de L'Ancre, a learned and cultured man, but also a fanatical and cruel judge. His text (L'Ancre, 1622), although marred by his untimely digressions, considered, in addition to the two hypotheses mentioned above, that seas could be mobile and that sediment consolidation took place over « lengthy ages » after the retreat of the sea; he also described the superposition of layers, which he called « *estages* » (« stages »), which suggests that he had an intuit-

¹² « *in loco dicto Satte [sic] Croix du Mont, ex adverso portarum Castelli, facellum magnum in monticulo Ostreis composito incisum est: testudo & columnæ, quæ eam sustentant, eâdem materiâ constructæ sunt.* »

¹³ *Voyage dans une partie du Bordelois et du Périgord, suivi d'une Tournée du Bazadois, du Condomois et d'Agenois*, initiated on 27 October 1761, *Bibliothèque municipale de Bordeaux*, ms 0721, 317 p. + 40 f.; see Godard (2018b).

tive understanding of the principle of superposition before Nicolas Steno formally stated it (Steensen, 1669). In 1718, Isaac Sarrau de Boynet, secretary of the Academy of Bordeaux, demonstrated the organic origin of fossil oyster shells on the basis of the scar left by the adductor muscle, but he did not adopt the idea of the intrusion of the Atlantic Ocean into Aquitaine, as Benoît de Maillet did in his *Telliamed*. In 1761, Nicolas Desmarest was also convinced of the marine origin of the fossils found in northern Aquitaine, an idea that was definitively accepted with the rise of modern palaeontology at the beginning of the 19th century.

These writings on Aquitaine show us that the history of geology is richer than we might think at first sight. Alongside famous scientists such as Galileo, Steno, Woodward, Buffon, Hutton, Lyell and others, there were a number of humble

scholars, whose contributions remained unpublished and unknown. After centuries in the shadows, their writings, brought to light by the modern means of digitisation, cataloguing and diffusion, are shedding new light on the history of geology.

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Appendix: *L'incrédulité et mescreance du sortilege* (1622)

Below we have translated into English and annotated large extracts from the *advertissemens* of *L'incrédulité et mescreance du sortilege* (L'Ancre, 1622). We have removed the numerous digressions not clearly related to geology. An annotated version has been published in French by Godard (2018a), and the full original version is available on Gallica (<https://gallica.bnf.fr/ark:/12148/bpt6k763251>).

[...; p. 17] Please know, dear reader, that in 1620, around the 2nd of October, the King [Louis XIII], having come to Guyenne, stopped for a few days in the parish of Preignac. Waiting for news from Béarn, he crossed the Garonne River, and I do not know by what good fortune, while he was going hunting, he saw in passing and was led to a house that I have on the Garonne, called Loubens¹⁴, which I hold in faithful homage to him, and which His Majesty could well see from the place where he was lodged, because it is on the top of a hill. When the King had climbed to the top, he did not stop and passed on; but on the way back, they [p. 18] showed him what was unique about this house.

I won't mention the gardens and the orchards [...¹⁵]. I will only say that, from the entrance, His Majesty saw an avenue of about five hundred steps, where there is a pine tree every six toises, with an echo so good and so clear that no other could be in a better situation. From there, he was led down to a place where there were caves and a chapel composed of oysters, piled and heaped up, which I value more than the oysters and mother-of-pearl from which were taken the pearls of Lollia Paulina, of Cleopatra, and those that this great Caesar gave to his favourite Servilia [Cepione], mother of Brutus, and where Monseigneur the Constable¹⁶ had stopped to inquire to those who showed him these singularities, whether these oysters or shells had formerly been brought by the Flood, or whether it was a mere amusement of Nature, [p. 19] which,

wishing to form hard stone, had ceased, and had formed only shells, in which were found serpent's tongues¹⁷, snails with several turns¹⁸ and an infinity of other kinds of shells; even that during the excavation of the chapel, a stag's antler had formerly been found among these oysters.

The main topic of conversation among the countless princes and lords who were close to the King was to contemplate these oysters and this chapel, and, further down, to see another walkway lined with springs¹⁹, where there is still another kind of shell, smaller and all different from the first. They admired an infinite number of medicinal plants that grow in the springs and testify to the goodness and excellence of the waters.

His Majesty, despising these little pleasures in order to think of the war that was to follow²⁰, went down on foot at an extraordinary speed and crossed the Garonne again. The reason for this was that His Majesty was anxiously waiting at Preignac for the latest news from Béarn, where the inspiration of God had urged him to go to bring happiness and blessing. And when he arrived there [at Preignac], the recommendation of the place, which came from his royal mouth, had such an effect that in less than five or six days that he remained in that village, there was such a great influx and concourse of people to visit that hill, that there was not a prince or lord who did not very willingly undertake the task. And indeed, the King's brother Monseigneur [Gaston d'Orléans]²¹, with all his household, went there the next day to look at

¹⁴ In the present commune of Sainte-Croix-du-Mont (Gironde). Mr. Arnaud de Sèze welcomed us in this house during the Inhigeo excursion.

¹⁵ Digressions on the crops, fountains and landscape of the place follow.

¹⁶ In October 1620, the office of constable was vacant, but Charles d'Albert, Duke of Luynes [1578–1621], who took part in the king's expedition to Béarn in 1620, was constable from 31 March until his death on 15 December 1621, during the probable writing of the book, which was published in 1622.

¹⁷ *Glossopetrae* (*i.e.*, shark teeth).

¹⁸ Gastropods, probably of the *Potamidae* group (Fig. 5b).

¹⁹ There is a small aquifer in the Miocene sandstones and limestones, which emerges at the Oligocene-Miocene boundary, forming an « *Allée des Fontaines* » (alley of springs) under the Loubens cliff (2 in Fig. 3; Fig. 5a).

²⁰ Louis XIII arrived to Pau on 15 October 1620 to apply the Edict of Nantes and restore Catholic worship in the small kingdom of Navarre (Béarn), of which he was king as well as king of France.

²¹ Gaston d'Orléans was 12 years old; he went on to build a famous cabinet of curiosities, including a collection of « very rare shells », which was unfortunately lost (Schnapper, 1988).

this pile of oysters at length, and to see the rest of the singularities. The physician who takes care of his health²², having discovered *Capilli veneris*²³ in very large quantities, was very happy to find himself in [p. 20] a position of make syrup for half the court. These are the hairs of my fountains, which are reborn almost as soon as they are plucked or shorn.

And that wasn't all: As pleasure turned to devotion, the chapel, located in a natural cave, was considered by many to be a holy place, so much so that lords and gentlemen gave *pistoles*²⁴ to the priests of the village where the King was staying, to come and say mass, and give them communion there. Many of them did this as devoutly as if it were a pilgrimage or a solemn vow, and they will remember for the rest of their lives that they were in the chapel of Notre Dame de Sainte Croix du Mont²⁵, for it bears that name.

There was nothing for me to wish for, except that this royal visit should have been accompanied by the eye of the master of the house. I was then in the city of Bordeaux, grumbling and tormented by a furious and violent attack of gout (which unfortunately visits me whenever it pleases), which deprived me of the good and honour of seeing my King, my sovereign Prince (whom I do not hope to see again), on the Mount Parnassus of my muses. Though many would wish, on such an occasion, to avoid the crowd of a court so large and populous as it was then, I have no displeasure more bitter than this [...²⁶].

[p. 24] But I do not wish to close this discourse without giving some satisfaction to those who wish to know whether the oysters or shells which we see on the top of the mountains were carried there by the Deluge or by the runoff of water; or whether it is a trick of nature²⁷, or of some other greater labourer who has produced them of himself.

Therefore, it can be said that the rocks that are on earth sometimes have wonders and admirable singularities, but those that are in the abysses and depths of the sea seem to have even more. I am not going to mention the examples because they are too long-winded [...²⁸; p. 25]. What will seem stranger and more unheard of: to find oysters or shells bearing pearls of such high value at the bottom of the sea, or to find only priceless shells on the tops of the mountains, the places closest to the sky and furthest from the sea? [...²⁹]

[p. 27] But let us look for the reason of these oysters, or shells, which are seen on the top of my mountain [at Loubens], and which set the whole court in turmoil when is Majesty deigned to cross the Garonne to see them. Everyone, both learned and ignorant, has searched for it on the spot, and I do not know whether they have found it, nor whether I shall find it myself, although I have searched for it in the books, which have spoken of it only very soberly, leaving it rather among the wonders of nature, the secrets of which we must not delve into any further, and among the number of doubtful things, of which we can find neither the truth, nor the reason, nor the clarification [...].

It seems, therefore, that we must ascribe it: Or to the Deluge, which changed the face of the Earth, and made the sea and the rivers stretch out and rise, and lifted up the abyss and the things that were at the bottom thereof, to set them up and lift them up in the highest of the mountains. Or to nature, which has tried and succeeded in creating great heights that are sometimes neither earth nor rock.

Among those who ascribe it to the Deluge, which brought the deepest things over the mountains and changed the face of the Earth, Tertullian seems to have said it clearly in these words, rebuking Plato for believing the opposite:

²² Abel Brunyer [1572–1665] was the physician of Gaston d'Orléans. A specialist in botany, he published the catalogue of Gaston's garden in Blois, in which he mentions « *Adiantum solii Coriandri Bauh. in pin. Capillus Veneris versus Ger* » (Brunyer, 1653, p. 4; see note below).

²³ The Venus' hair fern (*Adiantum capillus-veneris*) grows on shady, damp walls. It was used for infusions and syrups. The same fountains of Loubens are still lined with them (Fig. 5a).

²⁴ A currency of the time.

²⁵ Troglodytic chapel dug into the oyster bed, near the Loubens house (Fig. 4).

²⁶ Three pages of apologetic speech about Louis XIII follow.

²⁷ « *esbatement de la Nature* » in the original text.

²⁸ Digressions follow on the magnet, various marine wonders and the seasickness that prevents their observation.

²⁹ New digression on pearls.

« *Mutavit & totus orbis aliquando aquis omnibus obsitus: adhuc maris Conchæ & Buccinæ peregrinantur in montibus, cupientes Platoni probare, etiam ardua fluitasse: sed & enatando rursus in forma mutavit, rursus orbis alius idem mutat, & nunc localiter habitus cùm situs læditur.* »³⁰

Now, that the Flood changed the face of the Earth in such a way that what was in the depths of the sea is sometimes found on the highest summits of the mountains, anywhere in the world, the Holy Scripture formally testifies it in Genesis 6: « *Ecce ego adducam aquas diluvii super terram, ut interficiam omnem carnem, in qua spiritus vitæ est subter cælum, & universa quæ in terra sunt consumentur.* »³¹ And on the seventh day our Lord said: « *Adhuc [enim] & post dies septem, ego pluam super terram quadraginta diebus, & quadraginta noctibus, & delebo omnem substantiam quam feci, de superficie terræ.* »³²

Where do these great cavities in the rocks come from, and these perforated and scabrous boulders, and these long openings in the mountains, through which even great rivers pass and flow with such rapidity? Though from afar and under cover, they eventually find their way out and resume their course; sometimes, they only divide themselves into two, but they do not fail to hide one of their branches, so as to keep the larger one in its straight path, so as not to disturb navigation, and not to be useless to the cities, for the trade of which Nature seems to have intended them from their origin.

What does Freculphus, the Bishop of Lisieux, mean when he says, in speaking of the philosophers' view of the Flood, that there is a place which the Armenians call « *Egressorium, ubi Arcæ solutæ reliquias provinciales ostendunt. Huius autem diluvii indicium hactenus videmus in lapidibus, quos in remotis montibus Conchis & Ostreis scabros, etiam sæpe cavatos aquis visere solemus* »³³?

But no one should speak of the Deluge, or of what such a great and universal flood [p. 30] left upon the mountains, lest they should be like Ovid, whom Seneca honestly mocked, in his third book of Natural Questions³⁴, while pretending to praise his brilliant mind [...³⁵; p. 31].

Alexander ab Alexandro³⁶ went a little further, but still left the question open as to whether these oysters found on the tops of the mountains were the work of the Flood or the freak of Nature. Curiosity, he says, has so aroused the minds of many that they have wanted to know the origin and causes of Nature, and what is the principle of this great universe in which we live [...³⁷].

It may have happened that, in such a great machine, several things of different forms and kinds were joined together and incorporated in the ground. What we see proves that the ground, which is formless, changes, contracts, hardens and becomes stone by length and lapse of time, and several things of different kinds become even bodies in the insides of the stones, and are condensed together in all eternity. This good

³⁰ Tertullian [155–ca. 220], *De pallio* 2: « The whole world has changed, for it was once all covered by the waters. Even now, sea shells and whelks are lying around on the mountains, no doubt to prove to Plato that even high places were under water. When the waters receded, the globe, modified but still the same, returned to its original shape. Its appearance still changes accidentally when a region is disturbed. »

³¹ Genesis 6.17: « And I will bring a flood of waters upon the Earth, to destroy every living creature under the sky; everything on Earth will perish ».

³² Genesis 7.4: « Seven days more, and I will send rain upon the Earth forty days and forty nights, and I will destroy from the face of the Earth all the creatures that I have made ».

³³ Fréculf (*Freculphus Lexoviensis*) was bishop of Lisieux, Normandy (France), from 825 to 852; *Chronica* 1.1.25.2: « *Quem locum egressorium Armenii vocant, illic enim arcæ solitæ reliquias provinciales ostendunt. Huius enim diluvii indicium hactenus videmus in lapidibus, quos in remotis montibus conchis et ostreis scabros etiam sæpe cavatos aquis visere solemus.* » (The Armenians call this place « the landing place »; in fact, the inhabitants of the country show there the relics of the Ark [of Noah]. Even today, we see there a proof of the Flood by the presence, on the mountains isolated, of shells and oysters in rocks often ravaged by water). This text, roughly quoted by P. de L'Ancre, is inspired by the book of Raban Maur (*Rabanus Morus*), *De Universo*, itself inspired by Paulus Orosius (5th century), *Adversus paganos historiarum libri septem* (Histories against the pagans) 1.3.

³⁴ *L. Annei Senecæ Naturalium quaestionum libri VII*, III.27.

³⁵ Long digression on the ideas of Seneca and Ovid on the Flood.

³⁶ A. degli Alessandri (1532, lib. 5, cap. 9).

³⁷ Digression on Epicurus and atomism.

working Nature always gives things different aspects [...³⁸; p. 32].

Or, as some have said, because the waters were brought from various places, or the sea was overflowing and the rains were abundant, the world was flooded by some deluge. And then, after all things had mingled with the sea and the waves, and the storm had ceased, and the earth had dried up after so many overflows and torrents, the firm and solid land was discovered and appeared, so that now we find in the mountains, though very far from the sea, many things that are usually found on its shores and which, although half terrestrial, nevertheless appear to be maritime [...³⁹; p. 35].

If this property [of petrification] is given to the waters, either by their own faculties or by the advice of God (who makes and orders the rest of the wonders of the universe), to consolidate and harden sand, clay, and other similar things: How much probable is it that the mother of things, Nature, has been able, over many centuries, by virtue and physical reason, to consolidate distinct and separate bodies of various kinds? For every day we see the mountains and rocks growing, the depressions and hollows filling up by themselves, and others shrinking and changing. And the seas, which are in constant motion, some receding, others flooding, and the shape of innumerable places changing.

Albert the Great [... said] that the intelligences that move the heavens influence the seeds of things here below. But as all things that depend on these influences are agitated by the winds and other inconstancies of the air, it often happens that what should fall on the sea falls on the earth; and for this reason, shells and other fish figures formed in the mountains and rocks are sometimes found in places far from the sea.

[...⁴⁰] Truly I do not know if there is a [Hermit Crab] in the shells of my Rock, seeing that in those which are closed, when we open them, in some

there is something inside, which we cannot say whether it is one of these small dried-up fish, or the oyster itself, or some other small animal which wanted to be housed in this way [...⁴¹; p. 37]. Nevertheless, for some of the reasons which we have given above, that it comes from the Deluge, there is much more reason to believe that it is rather a game of Nature, which wanted to make stone, and made oysters or shells mixed with stone and cemented with earth, and left her work unfinished. And let us carefully consider all the other rarities which are found in the good authors, and which everyone says he has seen: There is not a man in his right mind who does not say that this is rather the work of this ingenious worker [*i.e.*, Nature] than of the runoff of the waters.

It is strange to see shells of all kinds enclosed in hard stone, and fish enclosed in shells. Is it not also strange to see a lizard which has chosen its tomb in a large piece of yellow amber, as I have seen in the collections of the Grand Duke of Tuscany, where it is enclosed on all sides, without any appearance of opening? [...⁴²; p. 39] So the Flood did not make all these enclosures; on the contrary, Nature seems to have had more of a hand in them. As there are an infinity of sacred mysteries which Nature has enclosed in the hardest marbles, to the honour and glory of the Creator of the world, it would be almost better not being able to give any plausible reason for it (not even probable) from this diversity of opinion of the ancient philosophers, to attribute them not to the length of centuries, nor to hazard, nor to the Flood, nor to Nature herself, but to the sole Author and Master of Nature, to ascribe and consider all these wonders among his least and smallest works [...⁴³; p. 40].

That is to say, in the presence of so many ancient philosophers, each of whom has attributed different origins to these shells, and with all those princes, cardinals and lords who accompanied His Majesty when he saw my mountain composed of different shells, and who did the same, having

³⁸ A few sentences about marbles of different colours, which are rich in their variety, follow.

³⁹ Dissertation on marbles and their induration, in particular the fossiliferous marbles of Calabria, observed by the author during his tour.

⁴⁰ Quote from Pliny the Elder, and digression about shells and hermit crabs.

⁴¹ Digression on grey amber.

⁴² Scholarly digressions on Cleopatra, the King of Rome Servius Tullius and the Emperor Nero.

⁴³ Text on the marbles of the churches of Saint-George in Venice and Saint-Vital in Ravenna, whose marbling seems to represent holy images.

clearly seen that the base and the foot of the cliff are of hard and clean stone, without any other mixture, that the second stage, upwards, contains shells in the shape of small twisted snails, which Tertullian calls *Buccinae*. Above this, there is another bed of hard stone, and after this, there is a high cliff, and like a third stage of other stacked oysters, the nacre of which appears in some cases as white as the most natural and common ones, and some of them are closed and complete, showing only their rough and unpolished exterior. And again, above and almost at the top of the scabrous boulders, there are large shells, attached like those on the rocks often found in the sea. I must frankly confess that it is easier to list several opinions than to find one that is true. For to believe that [p. 41] all that part of my mountain made of oysters could be made of that stone which Pliny [the Elder] calls ostracite, consisting entirely of oyster shells, I believe that there are not so many in the whole world.

So, I remain in suspense, not daring, after so many serious and different authors as irresolute as myself, to decide or say absolutely whether it is an effect of the Flood, or a game of Nature; or if we must attribute it to God alone, who made a mockery of all those philosophers and naturalists, leaving them more to doubt and admire than he gave them the insight and presumption to explain these wonders and a hundred thousand other greater ones. Anyone who attributes it to anyone

other than the Omnipotent Creator of all things seems to want to deprive him of his true name, or at least change it. To put it in Christian terms, with Seneca⁴⁴: « *Sive hunc Naturam vocas, seu Fatum aut Fortunam, omnia ejusdem Dei nomina sunt, variè utentis sua potestate* [⁴⁵]. *Num intelligis, cùm hæc dicis, te mutare nomen Dei?* »⁴⁶. The order of things comes and is given by Nature, but God alone is the author of that which gives that order.

If anyone knows better reasons or thinks he can explain it better, let him take the trouble to come to the scene, where he will see more closely what a poet [Ovid] seems to have said about it: « *Vidi ego quod fuerat quondam solidissima Tellus. Esse fretum, vidi factas ex æquore terras. Et procul à pelago Conchæ jacuere marinæ, Et vetus inventa est in montibus Anchora sumis.* »⁴⁷. He will certainly find on my mountain an old ANCHOR, which is myself⁴⁸, ready to receive him and his good advice with all the honour, applause [p. 42] and courtesy he could desire. I hope that before he leaves, the mere sight of it will throw him into such different opinions that he will be compelled to return as perplexed and irresolute as I am forced to leave him by this bad discourse, which I very humbly ask him to receive in such a good way and with such affection that I present it to everyone, especially to those who have already been there and who will still want to take the trouble to return.

⁴⁴ Seneca was obviously not a christian but a monotheist.

⁴⁵ Seneca, *Lucius Annaeus, De beneficiis* 4.8: « Whether you call God nature, destiny or fate, these are only different names for the same God, who changes himself in the various exercises of his omnipotence ».

⁴⁶ *Ibidem* 4.7: « Do you understand that by speaking in this way you are only changing the name of God? » (Pierre de L'Ancre has combined two quotations from Seneca into one).

⁴⁷ Ovidius Naso, *Publius* [Ovid], *Metamorphoses* 15, 262–265: « I have seen myself what was once solid land become the sea. I have seen earth made from the waters, and seashells lying far away from the sea, and an ancient anchor has been found on a mountaintop ».

⁴⁸ L'Ancre means « the anchor », in French.

