

Chapter 2

Leibniz and the Petrifying Virtue of the Place

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Abstract The medieval account of fossils is that animals are sometimes changed into stones because of the petrifying virtue of certain places. This doctrine continues well into the second half of the seventeenth century. The standard account, then, is that fossils are the remains of animals; it inherits the difficulty of explaining how the remains are petrified, or are constituted by some matter different from that of the original animals. It is easy to see how this doctrine could evolve to become the view of Athanasius Kircher and others that fossils are the creation of the power of the place mimicking animals, without there being any actual remains of animals. Kircher and the others provide a ready answer for the obvious differences between fossils and living creatures, including the problem of the stony matter of the fossils, but they achieve this status at the cost of severing links between creatures and fossils. This is the background for Leibniz's writings on fossils. I trace Leibniz's development from a follower of Kircher to one of his critics (having been influenced by Nicolaus Steno among others). I also show the resilience of the original doctrine; ultimately Leibniz's rejection is only partial.

In his "Eloge de Monsieur Leibnitz," Fontenelle complained that Leibniz's interests were very wide-ranging, so broad, in fact, that he could not write about Leibniz's works chronologically because "Leibniz wrote about different matters in the same years, and this almost perpetual jumble, which did not produce any confusion in his ideas, these abrupt and frequent transitions from one subject to another completely different subject, which did not trouble him, would trouble and confuse this history." Clearly, Leibniz's interests were broad even by eighteenth century standards. Fontenelle continued: "In the same way that the ancients could

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manage simultaneously up to eight harnessed horses, Leibniz could manage simultaneously all the sciences”—and by all “the sciences” Fontenelle meant all the traditional sciences of mathematics, metaphysics, natural philosophy, and theology.”¹ Leibniz’s interests even encompassed the relatively newer sciences of geology, mineralogy, and paleontology. The collection of Leibniz’s writings published in the eighteenth century by Dutens, from the most readily available sources, gives three items dealing with fossils: a letter on fossils, a report to the Académie des Sciences de Paris about fossils² (both items having been published by Leibniz during his lifetime), and the unpublished book-length manuscript called the *Protogaea*,³ which is Leibniz’s single volume preface to his proposed three-volume history of the House of Hanover.⁴ Some sections from the *Protogaea* even made their way into the *Theodicy*, his major published philosophical treatise. But, as with much of what he theorized about, Leibniz completely changed his mind about the elements of geology, mineralogy, etc., and even about the origin and constitution of fossils. An early, unedited manuscript in his hand has him denying that fossils are the remains of animals:

I find it difficult to believe that the bones one sometimes finds in the fields, or that one discovers by digging in the earth, are the remains of real giants; similarly, that the Maltese stones commonly called serpent teeth are parts of fish, and that shells often found rather far from the sea are the certain marks of the sea having covered these places and, upon withdrawing, having left behind these shells, which then became petrified.

If that were true, perhaps the earth would have to be much older than is reported by the Holy Scriptures. But I don’t want to stop at this, and we need to give natural reasons here. Thus, I believe that these shapes of bones of animals and shells are often only games of nature, which have been formed apart without having come from animals. For it is invariable that stones grow and take on a thousand strange shapes, as testify the stones that the Reverend Father Kircher has amassed in his *Subterraneous World*.⁵

Clearly Leibniz was driven to his conclusions because of the creationist account in Genesis. He could not believe that fossilized bones of animals were the remains of extinct species and thought that the process of petrification that might produce fossilized shells would take much longer than the amount of time allegedly elapsed since the creation of the earth.

¹Bernard de Fontenelle, “Eloge,” in Leibniz (1768, I, xx).

²*Epistola ad authorem dissertationes de figuris animalium quae in lapidibus observantur & lithozoorum nomine venire possunt* and *Memoire sur les pierres qui renferment des plantes & des poissons desseches*, in Leibniz (1768, II.2, 176–77 and 178–80). “*Epistola...*” was published in *Miscellanea Berolinensia* ... 170, and “*Memoire...*” was published in *Histoire de l’Académie Royale des Sciences de Paris*, 1706. There is also a 2 pp. tract called *Protogaea autore GGL* in *Acta Eruditorum*, January 1693, not in Dutens.

³Though this may not have been Leibniz’s title. See Garber (2011, 65–66), Smith (2011, 219).

⁴Leibniz intended to preface his history of Hanover with a dissertation on the state of Germany as it was prior to all histories. As he says at the beginning of the book, “Even a slight notion of great things is of value. Therefore, those who would trace our region back to its beginnings must also say something about the original appearance of the earth, and about the nature of the soil and what it contains,” Leibniz (2008, 3).

⁵Cohen (1994, 79 and 1998, 140–141). See also (Garber 2011, 170–71).

Later on in his manuscript, Leibniz discusses the question of the petrified shells one finds on the tops of mountains. He expresses doubts that there could be enough water to have covered these mountains for a sufficient amount of time and wonders where the great quantity of water could have gone. He asserts that it is rather unlikely that a large part of the sea and of the earth had been compressed, then eventually dispersed, and these small shells could have escaped such a great upheaval. He adds, “one finds stony shells of several unknown species that one would seek in the sea in vain,” and concludes that these shells provide “an indication that they are games of nature, unless one maintains that they are lost species, which is not likely.” He also comments that “the more one finds such a great quantity of shells, bones, and fish piled on top of one another, the more reason one has to believe that the earth in which they lie has a particular force for producing them in such quantity than to imagine that the sea has brought them all to that specific place.” Leibniz then argues against the likelihood that bones are the remains of terrestrial giants, in the fashion of Kircher, but referring also to Galileo’s reasoning about the limits of terrestrial animals and the greater size of aquatic animals, which are better supported by water than by air. But he concludes that “even if we agree that there have been giant behemoths,” it should nevertheless be maintained that “often the alleged bones of terrestrial animals or fish we believe had been petrified some thousands of years ago are just real stones, formed perhaps not long ago by the plastic virtue of the earth.”⁶ Leibniz thus accepts the view that some fossils, having the shape of stony bones and shells, are the product of the earth, games of nature (*lusus naturae*), that have been formed and grown apart by some plastic virtue of the earth (*vis lapidifica*), without having to derive from animals.

In fact, Leibniz will ultimately deny just about every sentence of his early manuscript. With respect to the beginning paragraphs of his manuscript, he will assert that the bones one discovers by digging in the earth are the remains of real giants; that Maltese stones are parts of fish; that shells found far from the sea are the marks of the sea having covered these places and, after the sea withdrew, the shells became petrified. He will imply that the earth is much older than is reported by Genesis. He will deny that the shapes of bones of animals and shells are often only games of nature and reject Athanasius Kircher’s thesis that stones grow and take on a thousand strange shapes.

To make sense of Leibniz’s transformation, we should set the context for his early views, namely, the scholastic account of fossils, leading to Kircher’s theory; we need to provide enough intellectual counter-balance to these accounts to overcome the resistance imposed upon him by the story in Genesis. Now, the standard scholastic doctrine, as represented by the tradition of commentaries on Aristotle’s *Meteorology* or such scholastic treatises as the *De mineralibus*, was that fossils are, in fact, the remains of animals.⁷ The scholastic tradition then had the difficulty of explaining how these remains are petrified, or are constituted by some matter

⁶Cohen (1998, 140–141).

⁷See, for example. Avicenna (1927, 46–47); Albertus Magnus (1559, I, i, Chap. 2 and ii, Chap. 9).

different from that of the original animals. The responses to such questions were seldom satisfactory: it is not obvious how the original animals could have left their form but not their matter or could have transferred their form from one matter to another. The view that had great currency was that the remains of the animals were turned into stone by the place itself and its petrifying power (the *vis lapidifactiva* or *virtute quadam minerali lapidifactiva*). Here is a typical expression of it from Albertus Magnus, using Avicenna as an authority:

It seems wonderful to everyone that sometimes stones are found that have figures of animals inside and outside.... And Avicenna says that the cause of this is that animals, just as they are, are sometimes changed into stones, and especially salty stones. For he says that just as Earth and Water are material for stones, so animals, too, are material for stones. And in places where a petrifying force is exhaling, they change into their elements and are attacked by the properties or the qualities which are present in those places, and the elements in the bodies of such animals are changed into the dominant element, namely Earth mixed with Water; and then the mineralizing power converts the mixture into stone, and the parts of the body retain their shape, inside and outside, just as they were before.⁸

The theory has its roots in Plato and Aristotle. One can detect many of its elements in the popular account of the formation of stones by Theophrastus, from his *History of Stones*. Theophrastus describes the origins of things formed in the earth as being from earth and water, and the mechanism of formation involving exhalations (“afflux” or “percolation”). He adds that stones have many properties or qualities, including the power of petrifying or converting other things wholly to stone.⁹ Theophrastus’ explanation, as far as it goes, is about inorganic bodies. According to him, stones originate from earth and they, not places, have the power of turning other things to stone. Albertus Magnus’ account that animals are sometimes changed into stone in places where a petrifying force is exhaling, seems to be something supplementary, something overlaid upon the account of Theophrastus, that earth and water are material for stones.

We can also see the Medieval explanation, with a few other twists, reflected in a seventeenth century context, for example, in the multi-volume textbook of the Dominican Antoine Goudin, *Philosophy, Following the Principles of Saint*

⁸Magnus (1967, 52).

⁹Of Things formed in the Earth, some have their Origin from Water, others from Earth. Water is the Basis of Metals, as Silver, Gold, and the rest; Earth of Stones, as well the more precious, as the common. ... All these we are (plainly speaking) to judge formed by the Concretion of Matter pure and equal in its constituent Parts, which has been brought together in that State by mere *Afflux*, or by means of some *Percolation*. ... There are in *Stones* of different Kinds many peculiar Qualities. ... These Qualities *Stones* have, therefore, from the common Differences of the Matter and Manner of the Affluxes of their constituent Parts; But besides these, they have others which arise from the more peculiar Powers of their concreted Masses; such are their acting upon other bodies, or being subject, or not subject to be acted upon them. Thus some are fusible, others will never liquefy in the Fire; some may be calcinated, others are incombustible. ... Some are said to have a Power of making Water become of their Colour, as the *Emerald*. Others of petrifying, or converting wholly into Stone, whatever is put into Vessels made of them” (Theophrastus 1746, 3–15).

Thomas. According to Goudin, fossils are mixed inanimate bodies formed in the bowels of the earth; they can be reduced to three classes: stones, metals, and fossils, commonly speaking, or minerals:

Their common matter comes from earth and water; but these elements are first purified and reduced into variously tempered exhalations, then distilled and combined among themselves, and finally concretized into these bodies. Their efficient cause is, on the one hand, the heat that produces certain exhalations from within the depths of the earth, and on the other, from the action which the sun and stars from above exercise on terrestrial products by modifying them secretly; finally it is also a certain force earth itself possesses variously, following the different places in which the mixed body is formed. This force, similar to the maternal bosom from which animals arise, assuredly plays a great role in the formation of these bodies; this is why, according to Aristotle and Saint Thomas, earth and water furnish to everything arising from the bowels of the earth their matter and bosom, as would a mother, while heaven and the stars fulfill the office of the father, who imparts the form.¹⁰

The elements used by Albertus Magnus are still in play (though they are now attributed to Aristotle and Thomas Aquinas). We are dealing with earth and water as material causes and still referring to the petrifying power of the place and to various exhalations. But an occult element is introduced, the action of the sun and stars on earthly places. This element plays the role of formal cause to the material cause of earth and water. Earthly places produce fossils, but they need the influence of the sun and the stars. We can also note the loosening of the link to animals, which are not mentioned, though, of course, Goudin's account is brief and general, covering the traditional rudiments about stones, metals, and minerals.

It is easy to see how this generic view could evolve to become the views of Kircher and Joachim Becher that fossils are the creation of the power of the place mimicking animals, without there being any actual remains of animals. The doctrines of Kircher and Becher, therefore, should be understood as continuous with the standard scholastic doctrines, as attempts to improve upon them. They provide a ready answer for the obvious differences between fossils and living creatures, including the problem of the stony matter of the fossils. These views achieve this status at the cost of severing the links between creatures and fossils and rejecting any historical account for the genesis of fossils.¹¹

The sequence of views from Avicenna and Albertus Magnus through the seventeenth century to those of Kircher and Becher, as a continuous series, diverges somewhat from the usual accounts in the history of paleontology, where the organic origins of fossils is often described as a triumph of modern mechanism over medieval mysticism. Here is one such analysis, from among many:

The Middle Ages retained the ideas of Aristotle, and almost unanimously adopted the theories of the spontaneous generation of fossils or petrifications under various formulas, such as plastic force, petrifying force, action of the stars, freaks of nature, mineral concretions, carved stones, seminal vapors, and many other analogous theories. These ideas continued to reign almost without opposition till the end of the sixteenth century. ... The

¹⁰Goudin (1859 [1668] III, 292: *De mixtis inanimatis; seu de fossilibus*).

¹¹Rudwick (1985, Chaps. I and 2, esp. 60–68).

seventeenth century saw little by little the antiquated theories of plastic force and of carved stones disappear, and the animal or vegetable origins of fossil remains was definitely established.¹²

This Whiggish history contains some true elements, of course, but it does not do justice to the history of paleontology. As we have indicated, influential medieval theories, such as those of Avicenna and Albertus Magnus, accepted the organic origins of fossils, even though they attributed their transformation to a petrifying force. Stephen J. Gould who quotes this passage and numerous other similar inaccurate historical accounts, rejects the claims that paleontologists before the scientific revolution “could not even conceptualize fossils as organic remains,” and “attributed the petrified likenesses of plants and animals to occult forces of the mineral world.” Gould makes the important point that both the inorganic and organic theory of the origins of fossils “were simultaneously and prominently ‘in play’ starting with the first printed paleontological texts,” from the opening decades of the sixteenth century, and that “no consensus ever existed for interpreting fossils as inorganic sports of nature.”¹³

Gould also disputes the representation of Kircher as “the last ‘pre-modernist’ holdout against the consequences (for the earth’s age and for historicity in general) of an organic origin for the petrified remains in the geological record.”¹⁴ He correctly points out that Kircher’s *Subterranean World*, Book VIII, “On the Stony Substances of the Earth; on Bones, Horns, Fossils, and on Subterranean Animals, Humans, and Demons,” is divided into four Sections, of which the First is “On Stones in Common,” and the Second “On the Transformation of Liquids, Salts, Herbs, Plants, Trees, Animals, and Humans into Rock, or on the Petrifying Force.”¹⁵ Because of the materials in his Sect. 1, it is clear that Kircher thinks of some fossils, perhaps even most fossils, as Gould would have it, as being of organic origin. In his Sect. 2, about the *transformation* of various things into rock, Kircher even asserts that he “will not speak here of the innumerable oysters, clams, snails, fungi, algae and other denizens of the sea that have been converted to stone, because these are obviously found everywhere in such a state, and hardly merit any mention.”¹⁶ But it is Kircher’s Sect. 1 that most captures the imagination. Chapters 8 and 9 of Sect. 1 are about the various shapes, forms, and images Nature constructed on rocks and gems, with Chap. 9 specifying that its subject-matter concerns “the remarkable natural pictures of works, forms, shapes, and images, which are drawn on rocks and gems and about their origins and causes.”¹⁷ The two chapters are accompanied with a multitude of figures, including representations of the

¹²Depéret (1909, 4–5).

¹³Gould (2004, 199 and 203). Gould cites the Depéret passage on 199 and provides numerous such quotations on 199–203.

¹⁴Gould (2004, 202).

¹⁵Gould (2004, 210–211). Kircher (1678, II, *Index Argumentorum*, 3 and 48).

¹⁶Gould (2004, 211). Kircher (1678, 50).

¹⁷Kircher (1678, 29 and 30–48).

*Typus Lapidum lineatorum, qui in Lapide quodam Schiftorum è genere, in Tolfensi,
& Bassanensi Agro reperiuntur.*



Fig. 2.1 The alphabet and geometrical shapes inscribed on the surfaces of stones (Kircher 1678, 23)

alphabet inscribed on the surfaces of stones, drawings of minerals, such as topaz and beryllium, imprints of ferns or leaves, human and animal shapes (containing the forms of monks and saints), the images of demons and devils, and fossilized fish. (See Figs. 2.1, 2.2, 2.3 and 2.4). It is clear as well that Kircher considers these works of the imagination. He asserts: "Consider how the human imagination leads us to see such a variety of things in heavenly clouds—now flying dragons; then ships, mountains, cities, and castles; then crosses, human figures, and similar fantasies composed of clouds and represented in our imaginations."¹⁸

Gould blames the caricature of Kircher on late eighteenth to early twentieth century historians of paleontology.¹⁹ However, as we have already indicated, Kircher's seventeenth century contemporaries, both friends and foes, with Leibniz taking both sides, also emphasized Kircher's games of nature and the petrifying

¹⁸Kircher (1678, 40), trans. Gould (2004, 217).

¹⁹Gould has a couple of arguments about the structure of the *Mundus Subterraneus*, that it contains a classification of fossils as inorganic or organic. According to Gould, Book 8 Sect. 1 is about shapes on the surface of rocks (i.e., two dimensional shapes) and Sect. 2 about three dimensional shapes. Thus Sect. 1 is about fossils that are of inorganic origin and Sect. 2 about those of organic origins. Gould gives as evidence an earlier sketch (*Prodromus*) of the *Mundus Subterraneus* in Kircher's (1657), in which Book V, *Metalloscopus* enumerates chapters without regard to their organic/inorganic origins. But I am not convinced of Gould's account, given Kircher's representations of trees, leaves, and fish in Sect. 1 and the argument that the fossilized bones of Sect. 2 are not the remains of giants. Even if Gould is right, what I find important is that Kircher's contemporaries understood him to argue that many fossils are games of nature produced by the petrifying force of the place.

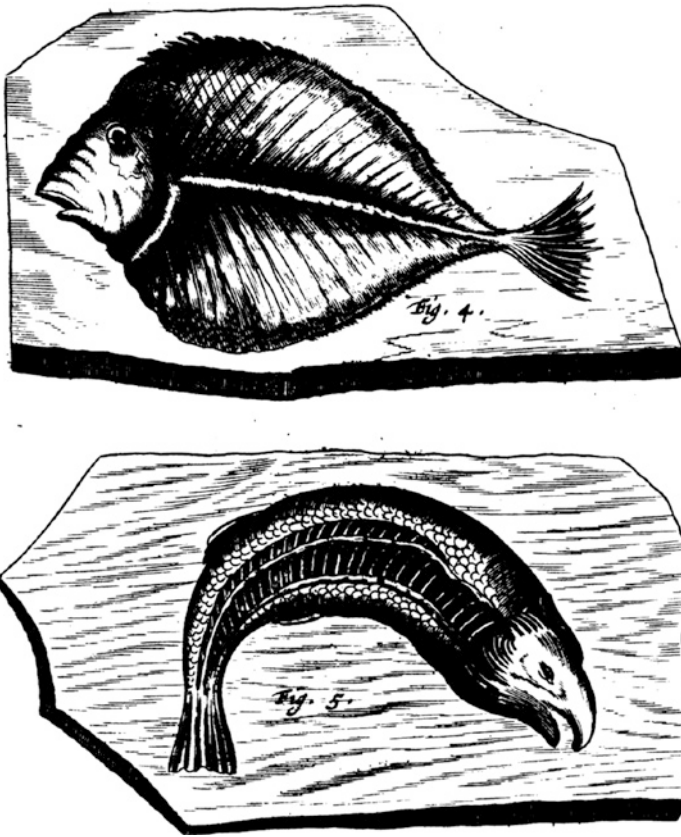


Fig. 2.2 Fossilized fish (Kircher 1678, 36)

force of the place. Seventeenth century theorists understood that Kircher and others who accepted games of nature and the petrifying force also thought that some fossils could be of organic origin. Even Leibniz in his initial manuscript, which specifically names Kircher and his *Subterraneous World*, ends by asserting the same: “Nevertheless, to show that I am fair-minded, I admit that one should say these stones were once parts of animals in the case where too perfect a resemblance would be found that could not be the effect of chance.”²⁰

In fact, the general attack on the views of Kircher in the seventeenth century took the form of a broad argument that went from a subsidiary claim establishing a class of stones as of organic origin to applying the result for all similar stones. The

²⁰Cohen (1998, 140–141). Another version of the manuscript bears the following marginal note “I always except the case when the conformity between the part of the animal and what one has found is too great, even in its least parts, to be able to be attributed to a game of nature.” See Garber (2011, 171).



Fig. 2.3 Human shapes in stone (for example, John the Baptist, St. Jerome, and Christ on the cross) (Kircher 1678, 39)

class of stones that were argued to be of organic origins was glossopetrae, or tongue stones. Agostino Scilla and Nicholas Steno both published widely read treatises arguing that glossopetrae are fossilized shark's teeth. Scilla, an Italian painter, wrote an informal work²¹ in 1670 proposing that the shells, or stones in the likeness of shells found in hills and quarries, once enclosed fish that became fossilized inside those shells: the shells acted like molds for the liquid matter that got in after the fish was consumed. Scilla's overall argument was by analogy to a

²¹Scilla (1670, 74–75) and elsewhere.



Fig. 2.4 Giants, the smallest being common man, then Goliath, etc. Kircher (1678, 59)

process by which shark teeth become glossopetrae. He compared glossopetrae with the teeth in the jawbones of sharks and found them to be not just similar to, but the same as, the shark teeth. For Scilla, the great variety and disorderliness of the glossopetrae at a particular place entailed that they were not originally grown there or generated and created by a fixed seminal principle. And if there were such a seminal principle, it is not likely that it should be common to fish, shells, and glossopetrae. The argument, of course, was directed against those who asserted that the shells were originally formed by a plastic power of the earth. Scilla

maintained that the shells were once real and scattered by a flood, not formed by a vegetative virtue in the particular soil in which they lay that determined them to their peculiar shape.²²

Steno studied medicine in his native Denmark. His skills in dissection were legendary. In the 1660s, he investigated the musculature of the heart and brain anatomy, both inquiries yielding conclusions at odds with those proposed by Descartes, who was a powerful influence on him from the beginning.²³ The dissection of the head of a great shark led him to examine its teeth and to hypothesize that glossopetrae, usually treated as magical objects, were not-so-magical fossilized shark teeth.²⁴ This also brought him to consider the problem of solids within solids—that is, fossils—which resulted in the publication of his greatest work, the *Prodromus*, in 1669. Steno was trying to prove that fossils did not grow in situ by giving an account of their formation as the mechanical layering of sand and the action of water over a long time. In the *Prodromus*, he attacked the thesis that fossils are produced by some kind of petrifying force that place possesses. He first examined the thesis that glossopetrae are produced by the earth and argued that “if we grant the earth the power of producing these bodies, we cannot deny to it the possibility of bringing forth the rest.” Similarly, with other bodies dug up from the earth, “if one should say that these bodies were produced by the force of the place, one must confess that all the rest were produced by the same force.” And if that is so, we should be able to ascertain “whether a fossil was produced in the same place in which it is found; that is, one must investigate not only the character of the place where it is found, but also the character of the place where it was produced.”²⁵ Ultimately, Steno held that “he who attributes the production of anything to the earth names the place indeed, but since the earth affords place, at least in part, to all the things of earth, place alone does not account for the production of the body.”²⁶

In their broader context, the seventeenth-century doctrines of Steno and Scilla should be considered in part as a return toward the older theories of Avicenna and Albertus Magnus, that fossils are the remains of animals, but with a different, mechanistic or Cartesian account, as opposed to an account based upon some kind of virtue or power, for the process of petrification. The evidence for Steno and Scilla being indebted to Cartesianism or being counted as Cartesians is strong.²⁷ In the *Prodromus* Steno adopts the outlines of the corpuscular theory of matter: a body is an aggregate of particles; a fluid differs from a solid in having its particles

²²Scilla (1698, 181–187).

²³Steno (1669a). He particularly criticizes Descartes’ description of the pineal gland and Descartes’ alleged function for it.

²⁴Steno (1667). The first part of the book is a treatise written *in more geometrico* about muscle action, in mechanistic terms.

²⁵Steno (1669b, 8–9).

²⁶Steno (1669b, 15).

²⁷Roger (1973, 23–48).

in constant motion.²⁸ Steno even cites Descartes as an authority: “And Descartes also accounts for the origin of the earth’s strata in this way.”²⁹

So the question is, when did Leibniz first read Scilla or Steno? And when did he write the early manuscript in which he holds views rejected by Scilla and Steno? The issue is complicated by the fact that the early manuscript is undated. Still, we can set some upper and lower limits for the answer. Leibniz wrote his manuscript after Kircher’s *Subterraneous World* was published in 1665, and could not have been acquainted with Steno’s views before 1667 or Scilla’s before 1670. Since the manuscript in Leibniz’s hand was written in French, one can infer that Leibniz wrote it after going to Paris in 1672. Leibniz’s early letters and works are written in Latin. In the early 1670s, one can find some letters written to him in French (by Carcavy, for example), with Leibniz replying in Latin. Leibniz wrote a long letter in French (to Mariotte) in 1673. Similarly, Leibniz’s early philosophical treatises are written in Latin. There are some notes about optics written in French in 1672, but even so, French Leibnizian manuscripts are more common from 1675 on, with some articles in French published in the *Journal des savans*. One can readily conclude with his biographers that “when Leibniz arrived in Paris his mastery of the French language needed improvement.”³⁰ So the early manuscript was most likely written after 1672, but before 1678. Leibniz met Steno at the court of Hanover in 1677 and purchased a copy of the *Prodromus* in 1679. By 1678, he had already become convinced that the shell and bones found in the ground are often the remains of animals that were once alive, thus rejecting his own earlier views.³¹

In the *Protogaea* Leibniz follows the path constructed by Scilla and Steno. One can see this clearly in Chaps. 31–32, “Glossopetrae are shark teeth,” and “The Use of Glossopetrae in Medicine is well-known.” Leibniz sometimes gets the credit in the secondary literature for demystifying glossopetrae, but, as he himself indicates, he was simply repeating the views of previous Italian naturalists,³² and among them, Scilla, to whom he refers: “One hardly doubts any more that [glossopetrae] are teeth from some kind of whale fish or from sea dogs. ... And just as these animals have mostly curved teeth that are turned toward the inside of their mouth, so it is with glossopetrae, that is with fossil teeth. It is therefore possible, as the painter Scilla noted, to recognize whether they sat on the right or on the left.”³³ Leibniz even reproduced Steno’s drawing of glossopetrae and a monstrous shark from his treatise on the dissected shark head: “I would like to append images

²⁸Steno (1669b, 10–11).

²⁹Steno (1669b, 28).

³⁰Antognazza (2009, 140).

³¹Garber (2011, 172) and Roger (1968, 137).

³²Cf. Accordi (1977, 33), who credits Fabio Colonna as the first to recognize glossopetrae as shark’s teeth.

³³Leibniz (2008, Chap. 30, 79). Cf. also Chap. 29, 75: “to these I oppose a learned painter, who declared in a recently published book that, though he had been shown many such things, the more carefully one observed them, the more tenuous the similarity.”

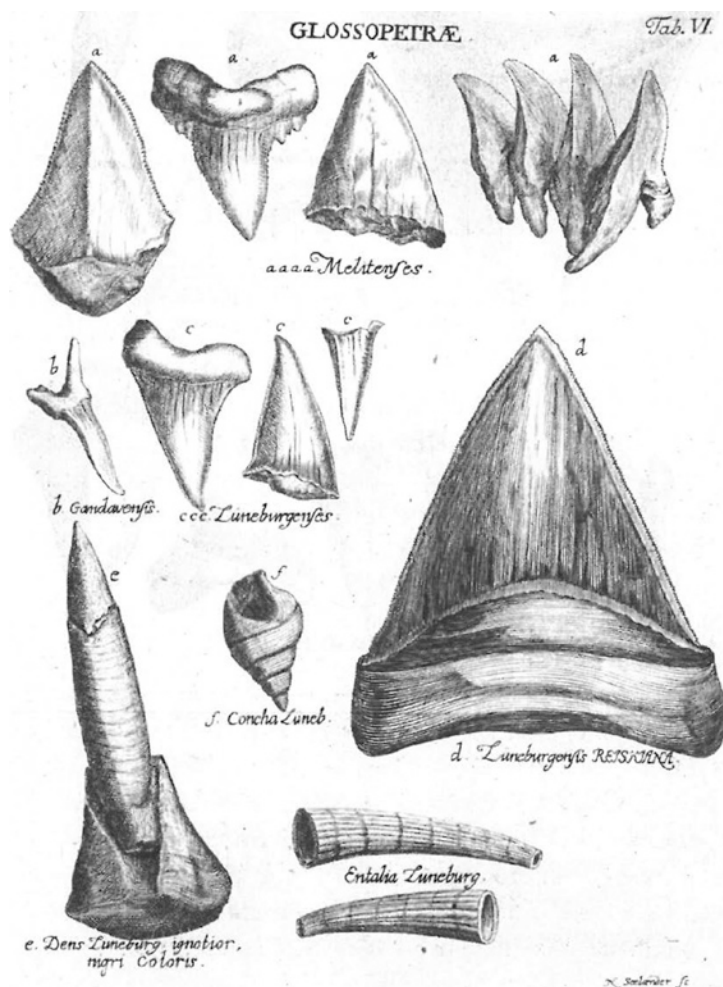


Fig. 2.5 Fossilized shark teeth (Glossopetrae) (Leibniz 1768, Tab. VI)

of our glossopetrae and of the Maltese, so that whoever has seen shark teeth can testify as an eyewitness that there is no difference. I would also like to append, by way of comparison, the head of a great shark with its teeth, from a drawing by Steno.”³⁴ (See Figs. 2.5 and 2.6). Thus Leibniz compares glossopetrae with shark teeth and reaffirms the conclusions of Scylla and Steno. And he continues the removal of glossopetrae from the realm of magic. He relates the various claims made for their curative properties: an antidote against poisons, a medicine for

³⁴Leibniz (2008, Chap. 30, 79). The drawing is from *Canis Carchariae dissectum caput, et dissectus piscis ex Canum genere*.

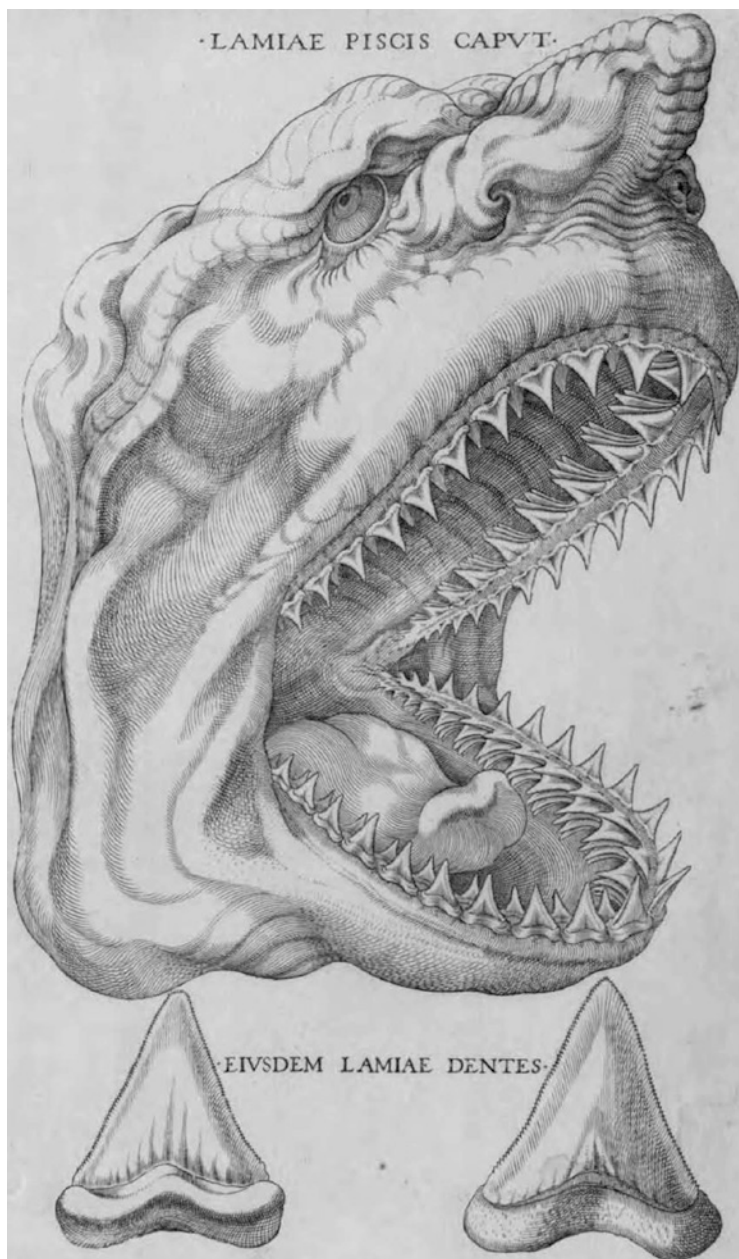


Fig. 2.6 The head of a shark (Leibniz [1768](#), Tab. VII)

stomach aches, sore throats, blisters that arise from sour humors, and internal acids. He claims that they have “a certain healing power, which has been exaggerated by the credulous. ... But of all the uses of glossopetrae, I believe that none is more reliable than for cleaning teeth; the powder from crushed teeth is recommended because of a certain hardness and roughness, and because tooth against tooth seems to be the least harmful.”³⁵

By now, for Leibniz, fossils are the remains of animals. They are the real products of a natural furnace, the earth, created on analogy with goldsmiths who produce a golden insect by pouring gold into a mold made by covering an insect with some suitable metal and driving away its ashes.³⁶ He understands his thesis as a direct attempt to oppose the views of Kircher. As he says, “whoever believes the contrary is seduced by the fairy tales of Kircher and Becher, and of other credulous or vain writers of this sort, who describe the wonderful games of nature and its formative power, all embellished with a great display of words.”³⁷

Leibniz summarizes his thoughts on fossils in his *Mémoire* to the Académie des Sciences on *Stones Containing Dried Plants and Fish*. There he argues that some kind of earth has covered up various lakes and buried plants and fish. That earth then hardened into clay, and time, or some other cause, then destroyed the delicate matter of the plants or fish, in the same way flies and ants wither away in amber. The matter of the plants or fish, having been consumed, left behind in the clay an imprint that was then filled by some other matter and baked by the subterranean fire. Having given his naturalistic account of fossils as the petrification of the remains of animals, Leibniz then takes on his opponents:

Several authors have called these kinds of representations of fish or of plants in stones, *Games of Nature*; but that is a purely poetic idea.... If nature played, it would play with greater liberty; it would not subject itself to express so exactly the smallest traits of the original, and, what is still more remarkable, to conserve their dimensions so strictly. When this exactness is not found, the things can be games, that is, arrangements that are in some sense fortuitous.³⁸

There is a similar story in the *Protogaea*; Chaps. 36–37 of the work depict some local German caves and the bones found in them: “the earth is black and filled ... with many animal bones. These are indeed broken and scattered about, but you can still easily distinguish the body parts. There are many kinds of teeth of various colors; they are often shiny and, not infrequently, are still inserted into pieces of jawbones. Some are so large that they cannot be ascribed to any animal

³⁵Leibniz (2008, Chap. 31, 85–87).

³⁶Leibniz (2008, Chap. 18, 31): “We find something similar in the art of the goldsmith, for I gladly compare the secrets of nature with the visible works of men. They cover a spider or some other animal with suitable material, though leaving a small opening, and bake this material to stone in the fire. Then by pouring in some mercury, they drive away the animal’s ashes through the hole, and finally, they pour in silver in the same way. When the shell is removed, they uncover a silver animal with its entire complement of feet, hairs, and fibers, which are wonderfully imitated.”

³⁷Leibniz (2008, Chap. 29, 73).

³⁸Leibniz (1768, II.2, 179).

known to us.”³⁹ Leibniz continues with his description of the contents of the caves: “In one column, they think they see a monk; in another, Moses with two horns.” But he concludes “the games of nature presented in those caves demand the support of the imagination.”⁴⁰ Having definitively argued for the organic origins of fossils, he can describe the games of nature found in his caves and underscore that they require help from the imagination to be seen as the head of Moses, etc., what is not the case for fossils and other remains. Basically, Leibniz wishes to divide the world between fossils and games of the imagination, with neither of these two categories being games of nature.⁴¹ It is clear, however, that he is not dogmatic about the nature of the process resulting in petrification. Although he denies the accounts of contemporaries, such as Kircher and Becher, he specifically allows the account of older scholastics, suggesting that he could accept fossils as remains of creatures *transformed* by some petrifying force:

If however, someone does not want to accept that nature burns rocks, and prefers to think that the mud enveloping the fish turned to stone, either through time alone and according to the nature of the material, or through some petrifying spirit, or through some other cause, ... then I do not oppose it, though I find it hard to understand. I do not dare to assert anything with certainty, except one thing, which suffices for us here: namely, that the coppery fish are the imprints of real ones.⁴²

We have seen Leibniz reject the hypotheses of his early manuscript: “that the Maltese stones commonly called serpent teeth are parts of fish ... that these shapes of bones of animals and shells are often only games of nature, which have been formed apart without having come from animals ... that stones grow and take on a thousand strange shapes, as testify the stones that the Reverend Father Kircher has amassed in his *Subterraneous World*.” We have also seen him suggest that he would accept the thesis “that the bones one sometimes finds in the fields, or that one discovers by digging in the earth, are the remains of real giants.”⁴³ Leibniz, in

³⁹Leibniz (2008, Chap. 36, 108–09).

⁴⁰Leibniz (2008, Chap. 37, 113). See also Chap. 29: “ludicra imaginationis”; “fictas pleraque aut semivisa ... imaginatio in rerum signaturis ludit”; “sed haec imaginationis judicia sunt, non oculorum.”

⁴¹Leibniz (2008, Chap. 20, 53): “As to the supposed appearance of the Pope’s tiara, of Luther, and all sorts of other shapes etched in the stone of Eisleben, I consider these to be, not games of nature, but of the human imagination, which sees battles in the clouds and hears its favorite melodies in the sounds of bells or the beating of drums.”

⁴²Leibniz (2008, Chap. 20).

⁴³Here the giants are terrestrial or aquatic animals. Human giants would offer their own special difficulties. If they were generated spontaneously at a particular place, they would then belong to the “class of creatures that ‘are similar to people in all respect except in having a soul,’” and not to genuine humans; (Gliozzi 1977, 310–311). These are very complex issues that are extremely well covered in great detail by Gliozzi (1977).

fact, embraces the possibility of terrestrial giants and extinct species.⁴⁴ In *Protogaea*, Chap. 35, entitled “The unicorn’s horn, and an enormous animal unearthed in Quedlinburg,” he even admits some remains as originating from unicorns, considered initially as an aquatic animal, that is, as fossilized narwhal teeth.⁴⁵ However, Leibniz does not think that all the remains of unicorns can be accounted for in the same way: “Nevertheless, we should not disguise the fact that a four-footed unicorn of the size of a horse has been found in Abyssinia The skeleton that was found in 1663 near Quedlinburg on the Zeunikenberg in the rock, while lime was being excavated, also looked more like a land animal.” So Leibniz concludes that the skeleton, whose picture he reproduces (see Fig. 2.7), discovered by Otto von Guericke, was indeed the remains of an extinct terrestrial species, a unicorn: “In the book about the vacuum, Guericke, mentions in passing that the skeleton of a unicorn was found with the rear part of its body bent back, as is common with animals, but with a raised head and carrying on its forehead an extended horn about five yards long; the horn was the width of a human leg and tapered gradually.”⁴⁶

As for the other hypotheses that once troubled Leibniz: shells found far from the sea being “the certain marks of the sea having covered these places and, upon withdrawing, having left behind these shells, which then became petrified” and the earth needing “to be much older than is reported by the Holy Scriptures,” Leibniz also made accommodations for both possibilities: “As in the beginning, before the light had separated itself from darkness, fire seized everything, just so does one reckon that later, after the fire had been extinguished, everything was plunged under water. These things have been passed on through our sacred histories, which agree with the old stories of other people, but the inland vestiges of the sea offer

⁴⁴In fact, Leibniz even considers the possibility of changes in animals resulting or having resulted in new species; in the *New Essays* he suggests that “Perhaps at some time or some place of the universe there are or were or will be species of animals more subject to change than those at present, and several cat-like animals, such as the lion, tiger, and lynx, could have been of the same race and may now be like new subdivisions of the ancient species of cat,” Leibniz (1890, V, 296). Similarly, in a 1696 letter to Thomas Burnett of Kemney, Leibniz indicates that “species can be radically changed by the duration of time as well as by the interval between places, as is testified by the differences between the animals of America and ours,” Leibniz (1993, 201–202). A similar claim is made in a letter to 1696 Bussingius, (Leibniz 1718, 30–31). See Smith (2011, 255–258).

⁴⁵Leibniz (2008, Chap. 35, 101): “Bartholinus has demonstrated that the horns of unicorns, which were in the past the most celebrated ornaments in the displays of cabinets of curiosities, and which today still amaze the eye of the crowd, come from fish of the Polar Sea. It is still right to believe that fossil unicorn, which also appears in our region, was of the same origin.”

⁴⁶Leibniz (2008, Chap. 35, 101). Leibniz’s figure was originally printed in 1704 by Michael Bernhard [Valentini], who drew it from notes and sketches by von Guericke and descriptions of it by Johann Mayer (Accordi 1977, 42). Accompanying the unicorn is another figure, which, it is alleged, is sufficiently natural that contemporary geologists can identify it as a fossil elephant molar. The inference is then drawn that Leibniz’s unicorn was an imaginative reconstruction of the bones of an elephant with only one tusk: “C’est de reste à la suite de la découverte par Otto von Guericke à Quedlemburg, dans le Harz, en 1663, des fragments d’un squelette (les ossements d’un éléphant, mais avec une seule défense), que Leibniz fut convaincu de la réalité des licornes,” Schnapper (1988, I, 94).

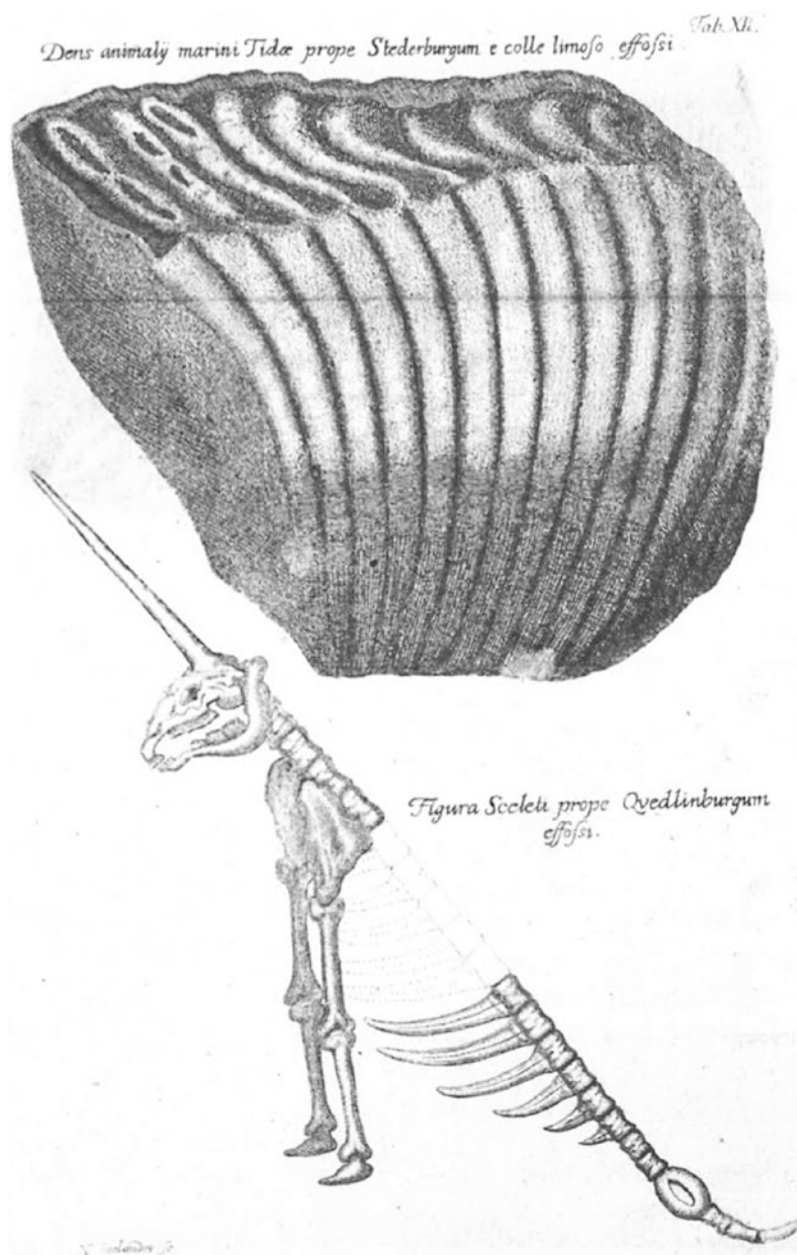


Fig. 2.7 A fossilized tooth (said to be from a marine animal) and a reconstructed skeleton found at Quedlinburg (alleged to be the remains of a unicorn) (Leibniz 1768, Tab. XII)

the best support. For seashells have been transported onto the mountains.”⁴⁷ Leibniz therefore investigates “the source of so much water which rose above the mountains, and where it eventually flowed when they became dry again.” He gives a number of tentative answers: “Some, by means of a scheme more clever than it is clear, explain the matter purely through a shift of the earth’s center; according to this theory, the [inclination] of heavy things changed direction and, though the surface was preserved, yet the height and depth of places changed completely; they cannot therefore be measured for themselves, but according to their distance from the center.”⁴⁸ But Leibniz rejects this and similar hypotheses as insufficiently plausible: “I do not dare to adduce external causes, such as the near passage of a comet, or the moon that was closer than today, whose attraction could have caused the waters to gush forth. Nor do I trust a change in the direction or the center of heaviness.” He thinks more plausible that

the water could have penetrated the inner depths of the globe through hidden passages that were just ripped open for the first time, before being swallowed up by vast caverns; ... nothing appears more sure than our belief that the vault of the earth collapsed at the point where it was buttressed by weaker supports, that a huge mass then crashed into the sea which lay under it and had previously been enclosed, and that the mountain peaks were thereby exposed. Having thus been forced up out of the caverns, the waters flooded the highest mountains.⁴⁹

And the waters receded because the masses that were thrown into the depths broke through caverns filled with air.

Leibniz’s explanations constitute an attempt to give an account of fossils and the Flood as physical phenomena subject to the laws of nature, occurring in a historical timeframe that stretches well beyond the account of Genesis. But Leibniz is cautious with such materials. When he discusses the supposition that “when the ocean covered everything, animals that now live on land were aquatic” and when the waters departed, “these animals became amphibians, until their descendants eventually left that original home,” he rejects it because he says that it “conflicts with the sacred writers, with whom it is impious to disagree.”⁵⁰

As we have asserted, Cartesianism seems to be a driving force behind much of seventeenth-century geology. It is easy to see the appeal of the main Cartesian doctrine: the universe, except for the special creation of man, can be explained from an initial chaos, using only the laws of motion; geology becomes a historical science. Leibniz does deviate from this doctrine in some ways, but still, it is a major theme with him, as it is with Scilla and Steno. Where Leibniz and Steno part

⁴⁷Leibniz (2008, Chap. 6, 15).

⁴⁸Leibniz (2008, Chap. 6, 15). The translation has “descent” where I have “inclination.” The hypothesis probably depends on some dubious earth-centered physics. But Leibniz rejects it for different reasons; he says: “This hypothesis could hold if the seas and mountains occupied separate regions of the globe and were not intermixed on the same hemisphere.” (Leibniz 2008, Chap. 6, from MS B, 14 fn. 20).

⁴⁹Leibniz (2008, Chap. 6, 15–17).

⁵⁰Leibniz (2008, Chap. 6, 15).

company concerns secondary forces, the action of fire, for example. Steno attempts to explain geological phenomena primarily using the action of water, while Leibniz stresses that he needs the effects of both water and fire. That is what he explains:

Insofar as it is possible for human knowledge to reach back, whether through reasoning or through the tradition of the scriptures, the first step in the formation of things is the separation of light from darkness, that is, of the active from the passive. The second step involves the differentiation of passive things from one another, that is of the wet from the dry. Wet and dry things, in turn, are separated from one another by their power of resistance and degrees of firmness. Bodies are therefore transformed by fires and waters in different ways. In all likelihood, those that now seem opaque and dry were initially ablaze; then they were swallowed by the waters; and after the separation of elements, they assumed their present appearance.⁵¹

Leibniz considers this doctrine significant enough to repeat it in the *Theodicy*.⁵² In addition, he can place his geological theory into the framework of his theology; instead of being mere disorder, geological phenomena provide Leibniz with the image of order arising from disorder:

the upheavals ceased finally, and the globe assumed the shape we see. Moses hints at these changes in a few words: the separation of light from darkness indicates the melting caused by the fire; and the separation of the moist from the dry marks the effects of inundations. But who does not see that these disorders served to bring things to the point where they are now, that we owe to them our riches and our comforts, and that through their agency this globe became fit for cultivation by us. These disorders passed into order. The disorders, real or apparent, that we see from afar are sunspots and comets; but we do not know what uses they supply, nor the rules that prevail in them. There was a time when the planets were held to be wandering stars; now their motion is found to be regular. Perhaps it is the same with the comets: posterity will know.⁵³

The *Protogaea* suggests that some regular forms arise through the separation of light and darkness. The original fire engenders natural rocks, which can be detected by means of their crystal structures.⁵⁴ The doctrine of an original fire also fits well with Leibnizian cosmology. As Leibniz tells us:

This conforms with what certain priests of wisdom have constructed, in the form of hypotheses, to explain more distinctly how such a separation of elements might have occurred. Indeed, they suggest that there were once huge globes, like the fixed stars or our sun, that either produced light or were jettisoned by a sun. Then their matter boiled and foamed until they were covered by the slags extruded during fusion. Similarly, as the ancients supposed, the sun would be veiled by increasing numbers of spots that would

⁵¹Leibniz (2008, Chap. 3, 5).

⁵²Leibniz (1890, VI, 262).

⁵³Leibniz (1890, VI, 263). He repeats his theological thesis a few years later, when in a letter to Bourguet, he defends himself against the claim that he alleges there is no chaos. According to Leibniz, there are disorders, but they are only apparent, something like what is caused by perspective: "Thus the apparent chaos is only a kind of distancing, as in a reservoir full of fish or, rather, as in an army seen from afar in which one cannot distinguish the order it deploys." To Bourguet, (Leibniz 1890, III, 565).

⁵⁴Leibniz (2008, Chap. 19, 49). Roger (1973, 139).

darken and eventually obscure it, something actually observed in our time, after the invention of the [telescope]. Still, the accretion of accumulated material extinguished the internal heat, with a cooled crust hardening all around. Thus was born an opaque star that would reflect external rays, just like the planets. They either suppose or imagine that we inhabit a volcano fashioned, as Moses wrote, through the division of light from darkness.⁵⁵

Although Leibniz attributes these hypotheses to “certain priests of wisdom (*quidam sapientiae mystae*),” it is clear that they are consistent with the other doctrines of the *Protogaea*, and that Leibniz is adopting them as his own. We live on a sun whose sunspots have hardened into a crust. There is a general homogeneity among all bodies, in this post-Scholastic cosmology; this is in direct opposition to the usual heterogeneity among sublunar and supralunar bodies. Leibniz is, of course, indebted to Descartes for the doctrine; it is simply lifted from the *Principles of Philosophy*.⁵⁶ Leibniz specifically attributes the view to Descartes in the letter to Bourguet, though he distinguishes between his hypothesis and Descartes’: “I therefore lean toward Descartes’ opinion, that our earth was once a fixed star or toward mine, that it could once have been part of a fixed star.”⁵⁷

However, the heterodoxy of such explanations is apparent. Even Descartes understood that he could not contradict the account of Genesis. When he discusses the relation between his views and Genesis, Descartes says that the simple and intelligible principles he assumes—all the bodies in the universe are composed of the same matter, a matter divisible into parts that are variously moved in circular motions, that there is always an equal quantity of motion in the world, and that God at first divided the matter into equal parts, etc.—these principles are false, because they are contrary to the account of creation from Genesis, which he takes to be true.⁵⁸ As Descartes notoriously states:

There is no doubt that the world was created right from the start with all the perfection it now has. The sun and earth and moon and stars thus existed in the beginning ... and Adam and Eve were not born as babies but were created as fully-grown people. This is the doctrine of the Christian faith, and our natural reason convinces us that it was so. For if we consider the infinite power of God, we cannot think that he ever created anything that was not wholly perfect of its kind.⁵⁹

So Descartes calls his own explanations false and Leibniz is driven to ignore the vast amount of time required for the processes he sets out, pretending that the accounts he carefully lays out are generally consistent with the story of Genesis, when he understands they are not.⁶⁰

⁵⁵Leibniz (2008, Chaps. 3, 5). The translation has “armed eye” for *oculi armatura*—clearly the telescope.

⁵⁶Descartes, *Principles of Philosophy* III, art. 94–96.

⁵⁷Leibniz, To Bourguet (1890, III, 566).

⁵⁸Descartes, *Principles of Philosophy* III, art. 45.

⁵⁹Descartes, *Principles of Philosophy* III, art. 44.

⁶⁰See Roger (1973, 141–44). See also Smith (2011, 219–222).

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