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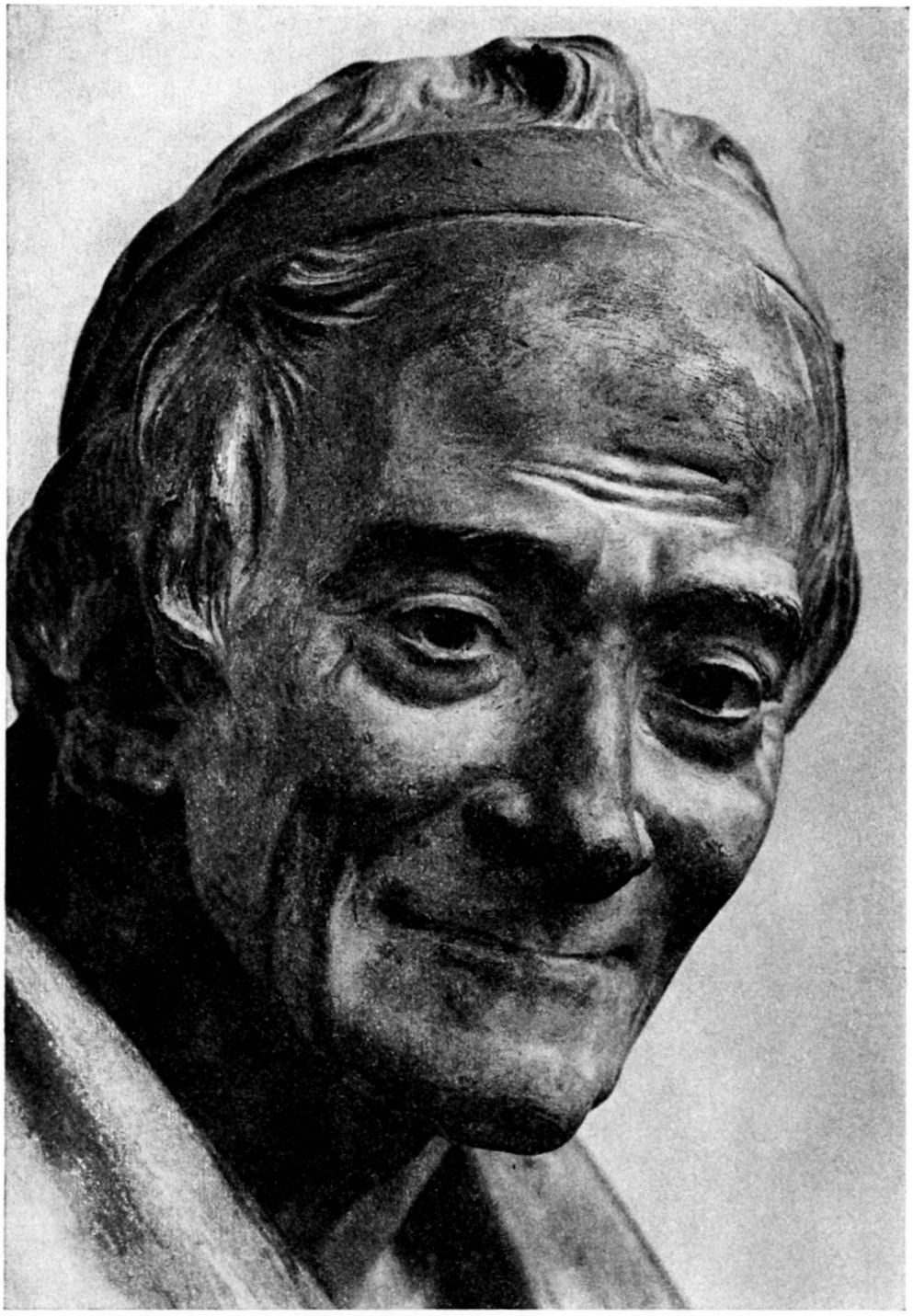
VOLTAIRE'S ATTITUDE TOWARD GEOLOGY

BY

Marguerite CAROZZI



FRONTISPIECE

Detail of Voltaire sitting, a statue by Jean-Antoine Houdon (1781)
commissioned by Beaumarchais.
Institut et Musée Voltaire, Les Délices, Geneva.
Photography by François Martin, Geneva.

VOLTAIRE'S ATTITUDE TOWARD GEOLOGY

Marguerite CAROZZI [1]

RÉSUMÉ

Les observations géologiques faites par Voltaire dans quelques uns de ses essais, en particulier la *Dissertation sur les changements arrivés dans notre globe et sur les pétrifications qu'on prétend en être encore les témoignages* (1746) et *Les Singularités de la nature* (1768) n'ont pas été analisées jusqu'à ce jour. Cette étude discute d'une part les opinions généralement acceptées au dix-huitième siècle sur l'origine des fossiles et la formation des montagnes et explique d'autre part la réaction de Voltaire envers ces idées, à la fois dans le contexte de son temps et dans celui de la géologie moderne. Voltaire par ses observations personnelles dans la région de Ferney, près du lac de Genève, a atteint la conclusion que les fossiles étaient d'origine lacustre et que les Alpes n'avaient pu être formées par la mer. En plus, à la suite de son étude de coquillages fossiles provenant des faluns de Touraine, un dépôt à l'époque considéré comme la preuve la plus indiscutable de l'existence ancienne de la mer sur la France, il a décidé que ces faluns étaient des dépôts lacustres. La géologie moderne donne raison à Voltaire en ce qui concerne les deux régions qu'il a étudiées, à savoir la molasse d'eau douce chattienne près de Ferney et les faluns miocènes de Touraine. Malheureusement les contemporains de Voltaire n'ont donné aucune importance à ses conclusions, et ses critiques modernes ont émis l'opinion injuste que ses préjugés et sa religion plutôt que la verité scientifique l'avait fortement influencé. Voltaire a rejeté la théorie généralement acceptée de son temps de l'origine marine des fossiles et des montagnes, en particulier dans ses derniers ouvrages, parce qu'aucun de ses contemporains n'était capable ni d'expliquer comment des montagnes comme les Alpes avaient pu s'élever du fond de la mer jusqu'à leur altitude actuelle, ni de distinguer entre fossiles marins et lacustres; en fait, n'importe quelle coquille fossile rencontrée à l'intérieur du continent était considérée comme une preuve de la théorie que la mer avait couvert toutes ces terres. L'attitude de Voltaire envers la géologie est celle d'un homme prudent qui demande aux savants de décrire de façon objective les phénomènes naturels et d'émettre des jugements qui ne soient pas trop influencés par l'imagination.

ABSTRACT

Voltaire's geological observations in some of his essays, in particular the *Dissertation sur les changements arrivés dans notre globe et sur les pétrifications qu'on prétend en être encore les témoignages* (1746) and *Les Singularités de la nature* (1768), have not been analyzed.

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This study describes some of the generally accepted ideas on the origin of fossils and on mountain-building in the eighteenth century and explains Voltaire's reaction to these ideas, both in the context of his time and in the light of modern geology. He produced independent evidence that in the neighborhood of his residence at Ferney, on the shores of Lake Geneva, Switzerland, fossils were of freshwater origin and that the Alps had not been shaped by the sea. Furthermore, he examined fossil shells in the faluns of Touraine which, at the time, were accepted as the most important evidence of the past presence of the sea in France and declared that these faluns were a terrestrial deposit. In regard to both areas, namely the Chattian freshwater molasse at Ferney, and some Miocene faluns in Touraine, Voltaire's investigation has proven correct by modern geology. Nevertheless, his contemporaries unjustly failed to consider his judgment of great importance and modern critics of Voltaire are equally unfair in concluding that prejudice and religious beliefs, not scientific truth influenced him. Voltaire rejected the generally received theory of a marine origin of fossils and mountains, in particular in his later works, because none of his contemporaries was able to explain how mountains such as the Alps had risen from below sea-level to their present height, nor could they distinguish marine from freshwater fossils: any fossil shell found inland was generally accepted as evidence for the theory that the sea had covered these lands. Voltaire's attitude toward geology is one of caution: he asked scientists merely to describe the natural phenomena they had seen without allowing any flight of imagination to influence their conclusion.

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INTRODUCTION

One of the great problems in treating works on science by eminent men of letters such as Voltaire or Goethe is that literary scholars, no matter how much scientific training they have had, never come to think like scientists whereas scientists are rarely interested to know how scientific ideas influenced literature, or how such ideas were accepted or rejected by a humanist who had little training in sciences but enough common sense to judge these ideas. Since in the eighteenth century and earlier most scientific ideas were discussed by both scientists and humanists, historians of science are aware that both sides ought to be consulted. Research of this kind requires such vast learning in science and literature, however, that some kind of teamwork seems to be necessary since a single man often cannot know about more than one science in more than one century.

My study of Voltaire's attitude toward geology does not coincide with any of the approaches previously used in American scholarship. [1] I am not merely commenting Voltaire's scientific remarks but I explain the state of knowledge in geology when Voltaire made those remarks so that this study can be read by literary scholars of Voltaire. However, I am not writing the history of geology of the eighteenth century, nor am I showing the influence of geology on Voltaire's literary career. He was not a romantic and hardly ever described a landscape. The only influence the beginning field of geology might have had on Voltaire was the idea of change. I mention his reaction to Ovid's *Metamorphoses* and to Lucretius and his followers in the eighteenth century: Diderot, Buffon, d'Holbach, as well as his criticism of Maillet's concept of transformism.

This study will most of all fill in a gap, that is, the almost universal neglect of Voltaire's attitude toward geology. Only two geologists have discussed the subject, and in brief fashion. Charles Lyell, a nineteenth-century geologist, dismissed Voltaire

[1] Literature and science as an area of study has been defined by G. S. Rousseau, a historian of literature (*Isis*, 1978, 69: 583-591). He described the major developments since 1950 and mentioned several approaches. "Traditionalist-philologists" were commenting scientific aspects in literature; they were taking courses in science only to "illuminate the literary text, not to shed light on the science studied" (p. 584). "Theorists" studied several authors in the course of many centuries. Arthur O. Lovejoy, for instance, studied the concept of "Great Chain of Being" from its origins to the twentieth century. According to Rousseau, theorists thus became historians of science. Another group headed by Marjorie Hope Nicolson studied the influence of science on literature, for instance, the influence of "eighteenth-century geologists on the Romantics" (p. 586). Rousseau states that historians of science disagreed with Nicolson's approach, saying that it was not "scientific" enough, that she did not distinguish, for instance, between the science of Newton and "soft Newtonianism" as perceived by the layman. Other approaches have been made by writers of science fiction, by structuralists such as Michel Foucault, by semioticians, Marxists, Maoists, neo-Freudians, etc.

saying: "The numerous essays written by him on geological subjects were all calculated to strenghten prejudices, partly because he was ignorant of the real state of the science, and partly from his bad faith" (1867,I:80). Emmanuel Fallot wrote in 1911 that Voltaire "a été le moins heureusement inspiré" when he turned to geology (p. 214-224). Literary scholars have discussed Voltaire's attitude toward science in general but have said very little about geology (Emile Saigey, 1873; Daniel Mornet, 1911; Abraham Wolf, 1938; Ira O. Wade, 1959; Otis Fellows, 1955; Jacques Marx, 1975, and Margaret Sherwood Libby, 1935). Libby has made the incredible effort to understand Voltaire's attitude toward all sciences; geology, however, has not received her best attention.

There is a general consensus among literary critics of Voltaire to assume that he was greatly influenced by his beliefs as a deist: if the world was formed by God, the sea, for instance, could not have shaped mountains, nor could life have started spontaneously in the sea and later extended to land. This study indicates that Voltaire's metaphysical beliefs were not crucial for his skepticism versus geology. To make a complete assessment of Voltaire's reaction toward all sciences and to affirm that his metaphysical beliefs did not influence his scientific views, one would have to study the history of astronomy, biology, and geology, as well as the modern approaches in these fields. Since such a teamwork is not available, I shall extract from Voltaire's essays, in particular the *Disseration*, the *Singularités*, and other works before and after these two essays, those ideas which pertain to geology, namely to fossils and to theories of mountain-building. If these ideas are closely connected with biology, the two sciences will be considered. A comparison of Voltaire's remarks on geology with those of his contemporaries and with modern science ought to permit us to judge Voltaire the "geologist." [1]

[1] The term "geology" in the modern sense did not exist in the eighteenth century. It was apparently used for the first time in 1778 by Jean André de Luc, a naturalist from Geneva, Switzerland, and the term then became gradually accepted in the nineteenth century (Taylor 1979: 78).

ACKNOWLEDGMENTS

Without my husband Albert V. Carozzi, professor of geology and historian of science, this inter-disciplinary study would not have been possible. He had studied the Jura Mountains and knew every outcrop and local geological features of that area. Thus, he was able to explain to me details typical of the vicinity of Ferney which Voltaire had observed. As a historian he had always been curious to know why Voltaire had called Maillet a "charlatan." His curiosity and collaboration will be for ever appreciated. I am also very grateful to Professor A. Owen Aldridge, a great scholar of Voltaire, who encouraged me to write this dissertation. He understood that my interest in Voltaire's attitude toward geology might be able to portray Voltaire's role in science in a new light.

Particular gratitude is expressed to Dr. Charles Wirz, Curator of the Institut et Musée Voltaire at Geneva, for his permission to publish a facsimile of the *Saggio*, for valuable bibliographical data on *Singularités*, and other relevant documents, and to Dr. Charles Ducloz, Head of the Department of Earth Sciences at the University of Geneva, who critically reviewed the manuscript. Dr. Edouard Lanterno, Curator of Geology at the Museum of Natural History of Geneva is also thanked for his technical help.

I am indebted to Dr. Jacques Deferne, Curator of Mineralogy at the Museum of Natural History of Geneva and Editor of the *Archives des Sciences* for his dedicated collaboration and to the *Comité de la Société de Physique et d'Histoire Naturelle de Genève* for having so generously accepted to publish this contribution.

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ABBREVIATIONS AND SPELLING

D. This letter refers to Voltaire's correspondence in the edition of the *Complete Works* by Theodor Besterman. Letters are cited according to a number in the edition rather than by volume and page.

DSB *Dictionary of Scientific Biography*. 1970-1980. C. C. Gillispie (ed.) New York. Charles Scribner's Sons.

Histoire *Histoire de l'Académie Royale des Sciences*, Paris (All segments mentioned in this study written by Fontenelle.)

M. *Œuvres complètes de Voltaire*. 1877-1885. Louis Moland (ed.) Paris.
Voltaire's *Dissertation* in M.XXIII and *Singularités* in M.XXVII will only be referred to by the page and not the volume in the respective chapters.

Mémoires *Mémoires de l'Académie Royale des Sciences*, Paris.

SVEC *Studies on Voltaire and the Eighteenth Century.*

USSR Catalogue of Voltaire's library at Ferney now in the Leningrad Library as catalogued by Alekseev and Kopreeva in 1961.

All quotations correspond to the original source in spelling, capitalization, and punctuation. The use of "sic" has been omitted since French grammar allowed different spelling in the eighteenth century and earlier.

CHAPTER I

VOLTAIRE'S DISSERTATION

Voltaire was not trained to become a naturalist but to please and serve the king of France. At the Collège Louis-le-Grand, the Jesuit fathers mixed religion with a taste for wordly goods and luxuries and Voltaire was taught ballet, poetry, good manners, and some piety (Pomeau 1956: 42-44). At the age of forty-four, however, he wrote about the property of light; the cause of refrangibility; the cause of colors; the laws of attraction; he even proposed a theory of the planetary world in his *Elémens de la philosophie de Neuton mis à la portée de tout le monde* (1738). In that essay he also mentioned geological phenomena for the first time. In order to understand his later reaction to geology, we should know why he turned from literature to science and how he became interested in fossils and theories of the earth after Newton's physics. We should understand whether he felt completely at ease with Newton's physics or whether he was more familiar with Newton's metaphysical ideas.

A. Madame du Châtelet and Newton

Voltaire might have turned to science because of the taste of French women who patronized young poets in the early eighteenth century. Indeed, some ladies seemed to have become bluestockings after reading Fontenelle's *Entretiens sur la Pluralité des Mondes.* Voltaire wrote to Fontenelle in 1721:

> Les dames qui sont icy se sont gastées par la lecture de vos mondes. Il vaudroit mieux que ce fût par vos Eglogues, nous les verrions plus volontiers bergères que philosophes, elles mettent à observer les astres un temps qu'elles pourroient bien mieux Employer, et nous nous sommes tous faits phisiciens pour l'amour d'Elles. (D.92)

Fontenelle (1657-1757) like Voltaire had been trained as a lawyer after a first education by Jesuits at Rouen; he wrote several operas and tragedies and was also the author of *Eglogues* to which Voltaire referred in the above letter and of *Entretiens...* which made a considerable impression on women. Between 1697 and 1740 Fontenelle was secretary of the Academy of Sciences at Paris.

The example of Fontenelle who seemed to have been able to cultivate both science and literature might have encouraged Voltaire to imitate him and bridge the gap between humanists and scientists, or at least to make science understandable to the former. In 1721 he wrote to Thieriot about an eclipse of the sun calling himself already "poète et phisicien" (D.93). It took, however, another ten years before Vol-

taire started to study physics seriously saying to Formot: "Je suis enfin déterminé à faire paraître ces lettres anglaises, et c'est pour cela qu'il m'a fallu relire Newton; car il ne m'est pas permis de parler d'un si grand homme sans le connaître" (D.542).

This re-education was not easy for Voltaire. In fact, according to his letters it was a constant battle between his desire to understand science and his need to do what he knew best. He would have wished to cultivate both at the same time and said: "Aucun art, aucune science ne doit être de mode. Il faut qu'ils se tiennent tous par la main, il faut qu'on les cultive en tout temps. Je ne veux point payer de tribut à la mode, je veux passer d'une expérience de phisique à un opera, ou à une comédie, et que mon goust ne soit jamais émoussé par l'étude" (D.863). His letters show that he did not succeed too well. In 1736, he complained, "Je me casse la tête contre Newton et je ne pourrais pas à présent trouver deux rimes" (D.1208). Then he changed his mind telling Thieriot: "Une tragédie nouvelle est actuellement le démon qui tourmente mon agitation. J'obéis au dieu ou au diable qui m'agite. Phisique, géométrie, adieu jusqu'à paques" (D.1404).

Voltaire wanted not only to imitate Fontenelle, but to surpass. He worked hard to be as clear as possible in his explanation of Newton's physics and said: "Si mon ouvrage n'est pas aussi clair qu'une fable de la Fontaine il faut le jetter au feu. A quoy bon être philosophe si on n'est pas entendu des gens d'esprit" (D.1823). Instead of explaining Cartesian physics to a fictitious French Marquise, as Fontenelle had done in his *Entretiens...*, Voltaire, in *Elémens*, explained Newtonian physics to a real Marquise: Madame du Châtelet.

Voltaire's love affair with Newton was enhanced by his great respect for this woman who well understood the English scientist. Even before the *Elémens* were finished, he wrote an "Epître sur la philosofie de Neuton" which he sent to Mairan, physicist and member of the Academy of Sciences since 1718, saying, "Je souhaiterais que ce petit ouvrage pût prouver que la phisique et la poésie ne sont point incompatibles" (D.1215). This "Epître" addressed to Madame la Marquise du Ch.** proved that physics could be explained by poetry. Voltaire said, however, that he was going to abandon literature and cultivate science and search for "truth":

> Tu m'appelles à toi vaste & puissant Génie,
> Minerve de la France, immortelle Emilie,
> Disciple de Neuton, & de la Vérité,
> Tu pénètres mes sens des feux de ta clarté,
> Je renonce aux lauriers, que longtemps au Théâtre
> Chercha d'un vain plaisir mon esprit idolâtre.
> De ces triomphes vains mon cœur n'est plus touché [...]

In the same poem Voltaire refuted Descartes' system and accepted Newton's new philosophy:

> [...] Déjà de la carrière
> L'auguste Vérité vient m'ouvrir la barriere,

Déjà ces tourbillons l'un par l'autre pressez,
Se mouvant sans espace, sans règle entassez,
Ces fantômes savants à mes yeux disparaissent.
Un jour plus pur me luit; les mouvements renaissent.
L'espace qui de Dieu contient l'immensité,
Voit rouler dans son sein l'Univers limité,
Cet Univers si vaste à notre faible vûe,
Et qui n'est qu'un atome, un point dans l'étendue.
Dieu parle, & le Chaos se dissipe à sa voix;
Vers un centre commun tout gravite à la fois,
Ce ressort si puissant l'âme de la Nature,
Etoit enséveli dans une nuit obscure,
Le compas de Neuton mesurant l'Univers
Lève enfin ce grand voile & les Cieux sont ouverts.
(1738: 3-4)

This is Voltaire's credo and he was never to abandon it: he firmly and continuously maintained the existence of a universe which is limited, orderly, and ruled by natural laws which Newton had explained and which evidently had been given by God. Thus he rejected Descartes's universe which was chaotic, dark, and followed no rules.

For Emilie, Voltaire said, he was going to renounce the vain pleasures of his former career as a playwright and search fo the "truth" in the philosophy of Newton. This promise, however, did not last. Letters to friends seem to prove that Voltaire was never quite comfortable with the scientific side of Newton's physics and geometry. He soon became aware that Emilie was a better student than he could ever be. To Frederick, he wrote when explaining his work on *Elémens*: "Minerve dictoit et j'écrivois" (D.1255). To Pitot who examined the *Elémens* as a friend and as a scientist Voltaire modestly confided: "J'ai un instinct qui me fait aimer le vrai; mais je n'ai que l'instinct [...] Je suis comme les petits ruisseaux; ils sont transparents parce qu'ils sont peu profonds" (D.1341). Whether Voltaire was modest in physics in order to forestall criticism or whether he actually knew his own limitations will remain unknown.

Compared to Voltaire, Madame du Châtelet was working at a different pace and seeking different results; she usually concentrated on one thing only whereas Voltaire continued to divide his time between literature and science. Also because Madame du Châtelet evidently had to prove what she was capable of doing in a world where she was alone she worked probably more carefully than her friend Voltaire. This feeling was mentioned in the preface to her translation of Mandeville's "Fable of the Bees": "Je sens tout le poids du préjugé qui nous exclut si universellement des sciences..." (Wade 1947: 135). According to Wade, "Mme du Châtelet had by 1748 profoundly entered into Newton's thought." She had translated the *Principia* and the *Solution analytique* and was by that time "far beyond the comprehension of Voltaire, who could admire even if he could not follow" (1941: 37).

I believe that under these circumstances Voltaire must have been left with mixed feelings toward Newton's physics, and it might be for this reason that he added his essay on Newton's metaphysics to the *Elémens* in the later edition because he felt more at ease in that subject. Since he had not been able to master Newton's physics as well as Mme du Châtelet, his attitude toward all sciences would leave him with a feeling of incompetence or ignorance. In fact, already in January 1738, he said mockingly to Maupertuis: "Il y a six mois que j'ay quitté toute sorte de filosofie. Je suis retombé dans mon ignorance et dans les vers" (D.1423).

Before leaving science, however, Voltaire finished what he had set out to do: to bridge the gap between literature and science and to explain Newton as well as possible. He sent a corrected version of *Elémens* with a first part on Newtonian metaphysics to a friend saying: "Je crois avoir enfin mis les Elémens de Neuton au point que l'homme le moins exercé dans ces matières, et le plus ennemi des sciences de calcul poura Les lire avec quelque plaisir et avec fruit" (D.2201). Thus, Voltaire had reached his goal to imitate Fontenelle's popularization of science. I am not enough versed in physics and astronomy to judge whether he surpassed Fontenelle.

More important for his later attitude toward sciences were his personal investigations. He sent two memoirs to the Academy of Sciences at Paris, *Essai sur la Nature du Feu et sur sa Propagation* (1738) and *Doutes sur la Mesure des Forces Motrices* (1741); both memoirs were based on personal investigation. As his many letters to Moussinot between June and December 1737 show, Voltaire would not leave one stone unturned. He ordered instruments and books, asked Moussinot to investigate secretely for him, and because he was in such a hurry he asked Moussinot to send a "savoyard" on foot all the way from Paris to Cirey so that he would receive some urgently needed thermometers (D.1351). Although Voltaire did not earn any prize, it is obvious that during these years at Cirey, he learned how to experiment. He understood that observation facts are fundamental in scientific investigation. It is possible that Voltaire would not have abandoned science had he won a prize; he might have aspired to replace Fontenelle and to imitate him by writing yearly reports *(Histoires)* to the Academy of Sciences.

As it turned out, Voltaire wrote only two more semi-scientific essays in his life, both concerning geology among other sciences: *Dissertation sur les changements arrivés dans notre globe et sur les pétrifications qu'on prétend en être encore les témoignages* in 1746 and *Les Singularités de la nature* in 1768. The first essay was written in Paris during the heydays of his success at the French court, the second at Ferney, when, at the age of seventy or more, he finally applied what he had learned at Cirey thirty years previously: personal investigation.

When Voltaire first turned to science he seemed to have the desire to cultivate both literature and science. He wanted to please Madame du Châtelet, imitate Fontenelle, and surpass him, and most of all bring Newton's physics to the French. The correspondence indicates that this task was not an easy one and that Madame

du Châtelet eventually became a better physicist than Voltaire so that he might have had some second thoughts about science in general. When writing his *Elémens* he happened to mention fossils and theories of the earth for the first time.

B. Eléments de la Philosophie de Newton and Bourguet's Criticism

This work, as it is entitled in the Moland edition, was published first in Amsterdam in 1738. Voltaire was only partly able to supervise it and subsequently kept correcting, adding, and deleting chapters and whole parts. The Amsterdam edition contains his first reference to geology which was repeated in chapters X and XI in the 1741 edition, deleted in 1748, and partially incorporated in the *Dissertation* (M.XXII: 548-555). Since Voltaire insisted that five to six chapters of the Amsterdam edition were "barbouillés" (D.1504) and that some chapters, in particular chapter XXIV and XXV, were not from his pen but the work of a "mathématicien à gages" (D.1519), one should perhaps only consider the last edition of the *Eléments* as the correct one. However, Voltaire's reference to geology in the Amsterdam edition of 1738, an edition which was translated into English the same year (John Hanna 1738), was read by many English speaking geologists of the nineteenth century and is still cited today (Schneer 1980). Therefore, I shall briefly discuss this first edition.

The original edition of 1738 with the "Epître" to Mme du Châtelet mentioned in Section A of this chapter, explains optics, attraction, the sun, the comets, and the satellites. The twenty-third chapter entitled "Théorie de notre Monde Planétaire" describes four different movements or revolutions of the earth: 1) the daily rotation around its axis, 2) the yearly revolution around the sun, 3) a movement of the poles achieved in 25,920 years, [today called the "wobbling" of the axis]. A fourth movement, or revolution, is described as much more bizarre "dont la cause est plus cachée, dont la longueur étonne l'imagination, & qui semblerait promettre au Genre Humain une durée que l'on n'oserait concevoir. Cette période est selon toutes les apparences d'un million neuf cens quarante-quatre mille ans" (1738: 296). Then under the title "Digression sur la Période de 1944000. ans nouvellement découverte" Voltaire reported in a hundred pages many vague and ancient traditions as well as modern astronomical theories.

It seems that Voltaire actually believed that the earth's axis had reversed its position in 1,944,000 years. These are his exact words: "Ainsi ce n'est que dans une Période de deux fois 1944000. années que notre Globe peut voir deux fois le Soleil se coucher à l'Occident, & non pas en 110 Siècles seulement, selon le rapport vague des Prêtres de Thèbes, & d'Hérodote, le Père de l'Histoire & du mensonge" (1738: 300). It may be also that Voltaire simply wanted to rectify Herodotus' beliefs according to which the earth had turned around twice on its axis in some eleven thousand years only. By coincidence Voltaire seemed to agree in this "Digression" that astro-

nomical changes had left marine fossils on land and in the mountains. Indeed, he reported:

> L'Egypte & une partie de l'Asie, d'où nous sont venues toutes les Sciences qui semblent circuler dans l'Univers, conservoient autrefois une Tradition immémoriale, vague, incertaine, mais qui ne pouvait être sans fondement. On disoit qu'il s'étoit fait des changements prodigieux dans notre Globe, & dans le Ciel par rapport à notre Globe. La seule inspection de la Terre donnoit un grand poids à cette opinion.
> On voit que les Eaux ont successivement couvert & abandonné les lits qui les contiennent; des Végétaux, des Poissons des Indes, trouvés dans les pétrifications de notre Europe, des Coquillages entassés sur des Montagnes, rendent assez témoignage à cette ancienne Vérité. (1738: 296-297)

Voltaire's first reference to geology appears right next to great changes which had occurred on the surface of the globe and even "dans le Ciel par rapport à notre Globe." Here he states that evidence of transgression and regression of the sea consists in petrifications from India found in Europe, even piled up on top of mountains. Influenced by his involvement with Newton, Voltaire seems to have stumbled into the field of geology.

Following the above Voltaire then cited Ovid's verses on Pythagoras' teaching, first in Latin, then freely translated into French. Pythagoras, who lived around 580 B.C., said that solid land had been converted into oceans; oceans had been changed into land; marine shells lay far from the beach; old anchors had been found on mountain-tops; valleys had been excavated by running water, and floods had washed down hills into the sea; marshes had become dry ground; dry lands had been changed into stagnant pools; during earthquakes some springs had been closed up, and new ones had broken out; rivers deserted their channels, and had been reborn elsewhere; waters of some rivers, formerly sweet, had become salty and brackish; islands had become connected with the main land by the growth of deltas and new deposits; peninsulas had been divided from the land, and had become islands; land had been submerged by earthquakes, plains had been upheaved into hills by the confined air seeking vent (I have borrowed freely from Ovid's *Metamorphoses* [trans. 1973: 373-374] and Charles Lyell's reporting in *Principles of Geology* [1867, I: 17-19]). Voltaire cited Ovid's verses every time he referred to changes on the surface of the earth in his later works and I shall discuss his different versions in Chapter II.

Voltaire apparently tried to suspend the edition in Holland in favor of a new one in Paris (D.1409). When the Royal censor finally approved, Voltaire said: "Mr. le chancelier a trouvé qué j'étois un peu hardi de soupçonner le monde d'être un peu plus vieux qu'on ne dit. Cependant je n'ay fait que raporter les observations astronomiques de Mrs. Louville et Godin" (D.1480). Voltaire repeated the astronomical period of 1,944,000 years in the new edition of 1741, chapter XI, which

replaced the "Digression" of the first edition, but was deleted in 1748 (M.XXII: 550). In that chapter Voltaire, however, omitted the promise to the human race of "une durée que l'on n'oserait concevoir," perhaps because of the Royal censor.

Voltaire's first reference to geology is repeated in 1741 with little change. The theory about the provenance from the Indian Ocean of petrified plants, fish, and sea-shells found in Europe is followed by the skeptical "dit-on" and Voltaire adds the notion "et la plupart de ces coquillages arrangés encore par lits, font voir qu'ils n'ont été ainsi déposés que peu à peu par des marées régulières, et dans une nombreuse suite d'années" (M.XXII: 550). This theory of the Indian Ocean had been popularized by Fontenelle who will be discussed below.

Another chapter on geology in the 1741 edition, also deleted in 1748, is entitled "De la figure de la terre, considérée par rapport aux changements qui ont pu y survenir. Les inégalités de notre globe ne sont point une suite d'un prétendu bouleversement. Le déluge ne peut être expliqué physiquement" (This was chapter X, M.XXII: 548-550). Here Voltaire refutes Thomas Burnet's diluvial theory according to which mountains, valleys, and oceans were ancient ruins of a former earth which God had destroyed to punish mankind during the deluge. Voltaire mentioned others who believed, to the contrary, that this world was arranged with kindness for the sake of man and that mountains and rivers were necessary for life on earth. He argued that the earth could not have been flat before the deluge, as Burnet would have it, but he compared mountains on the earth with the grain of an orange which appears smooth from a distance but is irregular at close view. He added, "C'est bien mal connaître la nature que de lui supposer ainsi des figures si régulières: il n'y en a qu'en mathématiques." (Diluvial theories will also be discussed later on.)

In the same chapter X, Voltaire referred to Edmond Halley, English astronomer and mathematician, who had demonstrated that water vapors from oceans and lakes, by the action of the sun, were sufficient to maintain clouds, rivers, and springs. Voltaire added that clouds could never cause any inundation larger than one hundred "toises." If such an inundation — even though possible — had occurred uniformly over the globe, the height of the waters would have had to surpass the highest mountains near Quito, for instance, namely more than ten thousand feet. Thus not eight oceans, as proposed by Burnet, but more than forty oceans would have been necessary to cover the highest mountains. This is impossible, "il vaudrait beaucoup mieux se borner à dire avec tous les docteurs des premiers siècles que la bande rouge de l'arc-en-ciel signifie que le monde périra par le feu, et que la bande bleuâtre signifie qu'il a été submergé." Strongly influenced by Newton's physics, Voltaire finished chapter X saying: "On voit par là quels usages on peut tirer de la physique newtonienne, je veux dire de la vraie physique." (Voltaire repeated his argument against Burnet in "Digression sur la manière dont notre globe a pu être inondé," published in 1748 [Bengesco 1885: II: 41] and in the articles "Déluge" and "Inondation" in the *Dictionnaire Philosophique*.)

Voltaire's reliance on Newton's physics could, however, not be applied to chapter XI, discussed above, since the traditions on which it rests were vague and unreliable astronomical measurements; only the plant and fish fossils found in France were palpable facts. Inspection of the earth was the next step to be taken. In chapter IX of *Elémens*, published in 1741 but not deleted in 1748, entitled "Théorie de la terre; examen de sa figure..." Voltaire promised: "Je m'étendrai d'avantage sur la théorie de la terre. D'abord j'examinerai sa figure..." (M.XXIII: 543). Voltaire kept his promise and entered thus the incipient field of geology: he criticized diluvial theories in chapter X of *Eléments* in 1741; he analyzed and criticized theories of the earth in the *Dissertation* of 1746, and again in *Singularités* in 1768.

Louis Bourguet, a naturalist from Nîmes who lived at Neuchâtel since 1709, harshly critized Voltaire's astronomical theory of 1,944,000 years and the way Voltaire had presented evidence for such enormous changes on the earth. Bourguet apparently believed that Voltaire's relation of fossils with the movements of the poles was not coincidental. He cited word for word Voltaire's remarks on long-term geological processes and retorted:

> Je réponds, que ces *végétaux*, ces *poissons*, ces *coquillages*, bien loin d'appuyer ces changements prodigieux, que M. de *Voltaire* voudroit persuader à ses Lecteurs, servent à démontrer précisément le contraire. Il ne suffit pas, en effet, de dire séchement, que *les eaux ont successivement couvert & abandonné les lits qui les contiennent*; il falloit le prouver, sans rien déguiser des phénomènes, & sans violer aucune des régles constantes de la méchanique en général, & de l'hydrostatique en particulier. (1742: 106-107)

(The underlined words are Bourguet's citation from Voltaire's *Elémens*.)

Bourguet's criticism of Voltaire was published in an anonymous book in 1742, addressed to "Monsieur de Réaumur de l'Académie Royale des Sciences..." (p. xiii), and contained various letters by naturalists from Neuchâtel objecting to a long presence of the sea on land. Bourguet observed that at a normal rate of deposition in Lake Geneva, or Lake Constance, it would take a hundred million years to fill these lakes. He asked: "Comment des bancs de dix, vingt, trente, quarante pieds, & davantage, tels que le sont ceux des montagnes, & les masses quelquefois énormes de granite placées au haut des Pyrenées & des Alpes, ou répandues en divers lieux dans des plaines, auroient-ils pû être formés sur les rivages de l'Océan"? (p. 9) It is possible that the short time alloted to the history of the earth by the Bible (Bourguet was protestant) and the clever mathematics of the Archbishop James Ussher according to which the world was created in the year 4004 B.C. (Annales 1650-1654: 1) compelled Bourguet to speed up geological processes. In a theory of the earth, never quite finished, he argued that fossils of former sea-shells had been introduced into rocks during a complete dissolution of the rocks of the ancient world followed by a general inundation (p. 26-28). In the passage cited above, Bourguet told Voltaire that fossils needed yet to be explained, and that their position was no evidence for long-term

deposition. Furthermore, explanations of the position of fossils should not violate the laws of hydrostatics in particular. In regard to the movements of the poles, he remarked that they could not have formed concentric layers of rocks on the surface of the earth which contain marine fossils and then raised them to some thousand feet above sea-level (p. 111). (Theories of the earth will be discussed later on.)

I believe that Bourguet's harsh criticism, and probably also his book, influenced the development of Voltaire's attitude toward geology. He became aware that astronomy and geology were widely different fields. Bourguet's book on petrifications was reviewed favorably in the *Journal des Sçavans* in January 1743 (Tome CXXIX: 147-167). The journal said very little on Bourguet's criticism of Voltaire, "cest une discussion qu'il faut voir dans le Livre même..." (p. 158). Since the journal was held in high esteem by the lettered class of France (O'Keefe 1974: 6), Voltaire might have read Bourguet's book, he might have wondered whether the general belief of the marine origin of fossils was correct — Bourguet did not think so — and he might have decided to be more careful in his attitude toward geology since Bourguet had said, "il fallait le prouver." Bourguet had mentioned that explanations of fossils should not violate the laws of hydrostatics, a notion which Voltaire was going to use himself: "La mécanique universelle est toujours la même" (*Dissertation*, p. 228).

C. Publication of the Saggio, the Translation in the Mercure de France, and the Dissertation

After being accepted as a member of the famous Academy of Bologna in January 1745 (Zanichelli 1881: 62) Voltaire amplified and corrected his material from the *Eléments* in an entirely new essay which he wrote in Italian and sent to the Academy in 1746: *Saggio intorno ai canbiamenti* [sic] *su'l* [sic] *Globo della Terra*, printed in Paris by Prault (reproduced in facsimile in the Appendix because of its extreme rarity). It was translated by an unknown person and published in the same year in the *Mercure de France* (July 1746). In 1748 Voltaire offered his own translation for publication in the Dresden edition: *Dissertation envoyée par l'auteur, en italien, à l'Académie de Boulogne et traduite par lui-même en français. Sur les changements arrivés dans notre globe, et sur les pétrifications qu'on prétend en être encore les témoignages.*

It has been suggested that Voltaire was "patently showing off" by sending his work to Italy (Libby 1935: 171). Perhaps all the success Voltaire had reaped in 1745 had gone a little bit to his head. His comedy "La Princesse de Navarre" was played in front of the king at the wedding of the Dauphin in February 1745 (D.3076); in March of the same year he was appointed "historiographe de France" and "gentilhomme ordinaire de la chambre du roi" (D.3092); in April the Philosophical Society

of Edinburgh had accepted him as a member (D.3099); a month later, he wrote the *Battle of Fontenoy* and was showered with favors by the king (D.3254); Voltaire had even a regular correspondence with Madame de Pompadour (D.3138, 3140), and the pope gave him papal benediction in September 1745 (D.3183). Last but not least, Voltaire was carrying on a love affair with Mme Denis as his correspondence shows (Pléiade, Tome II, 889-1120). Considering all these circumstances, Voltaire was bound to become self-assured and not as humble as he had been when writing his papers on physics for the Academy of Sciences.

Of course, Voltaire's *Saggio* cannot be compared to his scientific essays. Then, he wanted to win a prize for his scientific contribution; now, he abandoned the often dry but carefully outlined facts, hypotheses, and conclusion of scientific essays: he returned to literature. Instead of mentioning the names of authors he was refuting, he merely referred to "l'opinion de plusieurs sçavans," or "on conclut," "on prétend," "on se garde d'examiner," "on a donc vu," "on sait," etc. He did not bother to explain exactly what specific theory and what precise facts he was refuting. Furthermore, he nearly always grotesquely exaggerated the theories or conclusions reached by some general opinion so that the essay became a satire instead of a philosophical appeal to reason. The *Saggio* and the version in French entitled *Dissertation* thus bear nothing in common with Voltaire's earlier scientific papers to the Academy of Sciences, nor with the more philosophical *Eléments*, nor can they be compared with the purely satirical *Candide* or any one of the philosophical dialogues. The *Saggio* is a mixture of all these approaches, yet resembles none of them. One is never quite sure, therefore, whether certain statements are meant to be satirical, philosophical, or scientific.

It is quite obvious that the *Saggio* is a display of Voltaire's orthodox creed to impress some Italian academies and Italian dignitaries of the church, even the pope. Before it was printed, Voltaire had sent manuscripts to Cardinal Quirini in Rome, in October 1745 (D.3250), and if an "old manuscript copy" mentioned by Besterman is real (D.3192), Voltaire had also sent a manuscript of the *Saggio* to the pope. In one of his addresses to the pontiff he said,

> Vostra beatitudine concede a i minimi figli della chieza la licenza di porgere i loro voti al Padre commune. Sia lecito anche a un amatore delle scienze e della virtù di presentare umilmente questo piccolo saggio a quello che per le sue opere a insegnato e ammaestrato la cristianità prima di governarla. E ben justo e che una tragedia nella quale sono spiegati ed aborriti gli errori e la crudeltà di Mahometto sia offerta al vicario e l'imitatore d'un dio di verità e di mansuetudine. (D.3192)

This letter to the pope, however, is ambiguous because on the one hand Voltaire mentions "un piccolo saggio" and on the other he talks about the cruelty of *Mahomet*. However, the play could not have been called "un piccolo saggio", therefore Voltaire might have sent his *Saggio* together with *Mahomet* to the pope in the same manner as he had sent them to Cossinio in Bologna (D.3379).

Voltaire asked the pope in another letter which is now printed as a dedication of *Mahomet*: "... Vostra santita [sic] mi conceda dunque di poter mettere a i suoi piedi il libretto e L'autore, e di domandare umilmente la sua protezzione per L'uno, e le sue benedizzioni per L'altro..." (D.3192) Thus Voltaire pleaded for protection and benediction which he apparently received.

The date of publication of the *Saggio* is unknown. From Voltaire's correspondence it can be gathered that in March 1746 he asked Marville for five dozen prints which he needed for some Italian academies (D.3332). (Marville had succeeded Hérault as *lieutenant de police* in January 1742 and tried to stop the play *Mahomet* [D.2640]). According to another letter, the *Saggio* was to be sent to "quelques ministres d'Italie qui daignent, faute de me connaître, avoir plus de bonté pour moy qu'on n'en a dans ma patrie" (D.3335). Comte de Maurepas, Secretary of State, wrote to Marville: "La lettre de Voltaire est une pièce qui ne pouvait être imaginée que par lui; mais comme la singularité n'est pas une raison de la défendre, je ne vois point d'inconvénient, s'il l'avoue et s'il la donne au public signée de lui, de permettre qu'elle soit imprimée" (D.3332). Voltaire acknowledged authorship and as early as March 1746, Michel Giuseppe Morei, secretary and late historian of the Arcadians, acknowledged receipt of "il piccolo eruditissimo Trattato del saggio intorno ai cambiamenti avvenuti sul Globo della Terra" (D.3344).

How was Voltaire's *Saggio* received by the Italians? Cossinio, member of the Academy of Bologna, thanked Voltaire for having sent the *Eléments*, *Mahomet*, and the *Saggio*. He said in regard to the *Saggio*:

> Quanto agli sconvolgimenti, o cambiamenti sul Globo della Terra, io sono stato sempre dell'opinione vostra. I sapersi che l'opinione contraria è stata autorizzata dei Capi di Religione presso gli antichi Creci, e Romani, ha sempre fatto ch'io la riguardi come un ritrovato dell'impostura, atto ad ispaventare opportunam̄ e vantaggiosam̄ la moltitudine, che così non si muove per alcun' altra passione, come per lo timore, specialm̄ di grandi e meravigliose cose. L'essersi poi osservate nella superficie della terra queste, che dicono, reliquie diluviane, ha bastato per confirmarlo, e per istrascinarvi ancore di què filosofi, i quali ove intoppano in alcuna cosa alquanto difficile da intendersi, e da spiegarsi, anno ricorso ai portenti. (D.3379)

This letter explains that in certain circles of Italy the teaching by Pythagoras was not accepted. For this reason Voltaire had probably said in his *Saggio*, "così l'insegnava tutta la folla Pittagorica..." Indeed, the opinion of great changes as told by Ovid in the Teaching of Pythagoras was considered by Cossinio as some kind of "impostura" in order to keep people under control. The letter by Cossinio suggests that the two works, the *Saggio* and *Mahomet*, had one purpose in common with which Voltaire probably tried to impress certain people in Italy: they both condemn imposture, either by Mahomet or by philosophers who according to Voltaire "usurpano nel loro gabinetto la potenza di Dio" (*Saggio*, p. 11).

MERCURE
DE FRANCE,
DÉDIÉ AU ROI.
JUILLET. 1746.

A PARIS,

Chés { GUILLAUME CAVELIER rue S. Jacques.
La Veuve PISSOT, Quai de Conty à la deſcente du Pont-Neuf.
JEAN DE NULLY, au Palais

M. DCC. XLVI.

Avec Approbation & Privilege du Roi.

MERCURE
DE FRANCE
DÉDIÉ AU ROI.

PIÉCES FUGITIVES en Vers & en Proſe.

VOICI une traduction françoiſe dont l'original italien eſt d'un illuſtre Ecrivain François. M. de V. a compoſé ce morceau pour les Académies d'Italie, auſquelles il eſt agregé.

IL y a des préjugés vulgaires ; il y en a auſſi de Philoſophiques, & peut être doit-on mettre dans cette claſſe l'opinion de pluſieurs Sçavans qui voyent ou croyent voir ſur la terre les monumens d'une ruine entiere & d'une deſtruction totale.

FIG. 1. — Title page of *Mercure de France*, July 1746, and heading of the French translation of Voltaire's *Saggio*... sent to the Academy of Bologna.

The *Saggio* was never published at Bologna (Zanichelli, 1881), nor by the Royal Society of London (Index 1-70). In June 1746, Voltaire wrote in Latin to Gerhard Friedrich Müller, secretary of the Academy of Sciences of St. Petersburg, that he was going to translate the *Saggio* into Latin and send it to be judged by the Academy (D.3423).

Although Voltaire had promised Marville that the *Saggio* would not be published in Paris, "c'est un ouvrage qui ne sera point publié icy, mais qui sera seulement imprimé dans les journaux d'Italie..." (D.3335), the work was published, nevertheless, in the *Mercure de France* in July 1746. This is the only time that this journal departed from its policy to ignore Voltaire in regard to his work or to his whereabouts; otherwise it was indifferent to whether he lived in Paris, had left France or had died (Fields 1962: 175-215). According to Fields, "Que cette pièce hardie n'ait pas été arrêtée par le censeur peut sembler incompréhensible. Sans doute la laissa-t-on passer car Voltaire venait d'être reçu à l'Académie française" (Fields 1962: 184). Voltaire's publication in the *Mercure de France* bears no title except the words: "Voici une traduction françoise dont l'original italien est d'un illustre Ecrivain François. M. de V. a composé ce morceau pour les Académies d'Italie, ausquelles il est agrégé." This French text by an unknown translator is very close to the Italian version.

There is a noticeable difference between the *Saggio* and the later *Dissertation* depending upon the public Voltaire wanted to reach. Indeed, the *Saggio* was addressed to orthodox circles of Italy while the *Dissertation* was written for the French. For example, the *Saggio* mentions "la folla Pittagorica" while the *Dissertation* simply says: "l'école de Pythagore." The *Saggio* says that Burnet and Woodward advocated that mountains and valleys had been shaped by the biblical deluge although "la sacra Scrittura dica espressamente tutto il contrario," while the *Dissertation* omitted the Bible. The passage, "Il Mondo non è che una catena immensa; si tolga [sic] un'anello, la machina vien quasi distrutta. Perchè dar dunque una mentita ai sacri Scrittori..." was left out in the French version. The words "L'altra opinione cioè, che nella serie d'innumerabili secoli tutte le parti della Terra, abbiano servito alternativamente di fondo al Oceano, è altrettanto contraria alla ragione, quanto alla sacra Scrittura," were translated by: "L'autre opinion, qui prétend que dans la période de deux millions d'années l'axe de la terre, se relevant continuellement et tournant sur lui-même a forcé l'océan de changer son lit, cette opinion, dis-je, n'est pas moins contraire à la physique..." The difference between the *Saggio* and *Dissertation* thus lies mainly in Voltaire's changing tactic to appeal to a different audience.

The *Saggio* together with the *Dissertation*, however, is more than a compliment to the church, or a desire to show off: it represents Voltaire's best information about geology at that time. In *Elémens*, Voltaire had entered the field of geology by coincidence because he quoted Ovid's verses which included the first reference to the notion of changes which had occurred on the surface of the earth and because

he also mentioned the theory of the Indian Ocean then generally accepted by the Academy of Sciences. In chapter IX of *Eléments*, published in 1741, Voltaire actually promised a theory of the earth. Later he deleted two chapters in order to incorporate them partly into the *Saggio* and the *Dissertation*. Between 1741 and 1746, Voltaire had gathered additional information on fossils and on theories of the earth so that the ideas in *Dissertation* represent, indeed, Voltaire's first attitude toward geology. I shall analyze the *Dissertation* rather than the *Saggio* or the latter's French translation in the *Mercure de France* because it is Voltaire's own translation addressed to the French without too many religious overtones. Before first discussing his remarks on fossils, however, we need to know the opinion of his contemporaries on that subject.

D. The Fossil Controversy in France before 1746

Fossils [1] are crucial to geology because they indicate the past distribution of land and sea; they explain former climates and point to the vastness of geologic time through the earth's history. Antoine Jussieu, professor of botany at the "Jardin du Roi" from 1710 until 1758, considered fossils "la plus ancienne Bibliothèque du monde" (1718: 366).

In the first part of the eighteenth century, the fossil controversy seemed to be at its peak. Réaumur wrote in a memoir to the Academy of Sciences at Paris: "Il n'est point de recherche à laquelle les Naturalistes se soient plus generalement livrés depuis quarante à cinquante ans qu'à celle des Coquilles fossiles" (1720: 519). Bourguet cited sixty authors in France, Italy, Switzerland, Germany, England, Asia, Africa, and America who had written on fossils (1742: 20-28). Many naturalist referred to Ovid's verses on changes from land to sea and from sea to land. Pythagoras, however, had simply mentioned sea-shells lying far from the sea without giving any theory of the earth. Astronomers and physicists, including Voltaire, proposed movements of the earth's axis which might have allowed oceans to travel around the globe and deposit marine fossils in places later changed to land. These wandering oceans could also explain why some "exotic" fossils were found in Europe: some warm seas had perhaps covered the continent in the past. Fontenelle believed

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[1] Only in the nineteenth century had the meaning of fossils narrowed down to what we understand today. Before, the term "fossil" included everything dug out (from fodere) from the soil. The *Encyclopédie ou Dictionnaire Raisonné des Sciences, des Arts, et des Métiers...*, 1757, Tome VII, says:

> On distingue deux espèces de fossiles: 1° ceux qui ont été formés dans la terre, & qui lui sont propres; on les appelle *fossiles natifs*. Tel sont les terres, les pierres, les pierres précieuses, les cristaux, les métaux, &c. 2° ceux qui ne sont point propres à la terre, que l'on appelle *fossiles étrangers à la terre*. Ce sont des corps appartenans, soit au règne minéral, soit au règne végétal: tels que les coquilles, les ossements de poissons et de quadrupèdes, les bois, les plantes, &c. que l'on trouve ensevelis dans les entrailles de la terre où ils ont été portés accidentellement.

The study of fossils was called "lithographia," "lithologie," "conchyliologie," and "oryctologie." See Kenneth L. Taylor, *Geology in 1776*, p. 79.

in slow changes over a long period of time during which the Indian Ocean had transported "exotic" sea-shells and plants to Europe while Bourguet maintained that the earth, according to Scriptures, could not be so old. He believed that some catastrophic changes such as a complete dissolution of the rocks of the ancient world followed by a general inundation, when sea-shells were introduced into rocks, must have occurred in the past history of the earth.

Voltaire's century seems at first to have been only moderately influenced by earlier philosophies on the origin of fossils. Analysis of Voltaire's later work, however, will reveal that some beliefs in the supernatural were not abandoned so easily in the Age of the Enlightenment. For instance, as late as 1766, Jean-Baptiste Robinet still believed that "Dieu créa la matière séminale du monde & de tous les Etres qu'il devoit contenir" (III: 1ii). He thought that fossils were born from seeds occurring in rocks (I: 208) and was opposed to naturalists who were forecasting transformism and evolution of organisms (IV: 113). La Sauvagère, a correspondant of Voltaire, was also of the opinion that fossils were nothing but engendered seeds. When Voltaire refers to the term "fossiles" in *Dissertation*, he seemed to have in mind such ideas on the origin of fossils. Since such beliefs kept recurring in the eighteenth century, it is necessary to mention them shortly.

M. J. S. Rudwick has treated the fossil controversy in episodes corresponding to times of major advances in paleontology among which the eighteenth century does not qualify (1972: 86-95). He states that many naturalists in the sixteenth century, especially those with the training of a Renaissance man, did not distinguish between the organic and inorganic origin of fossils (p. 23). According to Neoplatonic doctrine, organic and inorganic mater was alive; a web of affinities, a natural magic, existed apparently between all parts of the cosmos. Thus, even if a fossil resembled a living animal, some "plastic virtue" or molding force inside the earth was made responsible for this likeness. Furthermore, some Aristotelian views on growth *in situ*, on seeds, and on spontaneous generation were also accepted in the sixteenth century. Rudwick says that these two trends of thought were powerful alternatives to the theory of organic origin (p. 20-22, 44-45).

Bernard Palissy, potter and naturalist, favored the view that fossil fish were of organic origin. In *Discours admirables* (1580) he claimed that he had not studied Latin and Greek and had not been influenced by Aristotle and Plato. He clearly demonstrated that fossils found in rocks were remains of some "poissons armés" which had lived and died in the places where they are found today (1961: 273).

Rudwick states that in the seventeenth century biological interests of Steno (Neils Stenson) and the beliefs of Robert Hooke that "Nature does nothing in vain" made them recognize the organic origin of several fossils (p. 50, 54). Steno even explained the position of fossils by subterraneous upheaval, while Hooke believed that earthquakes were responsible for their position (p. 54, 59, 60). These "modern" approaches remained, nevertheless, almost ignored in the seventeenth century because

of the continuing popularity of the Neoplatonic view spread by the German Jesuit Athanasius Kircher. His work in various sciences was extremely influential, says Rudwick, because of its encyclopedic approach which gave a satisfactory explanation to most natural phenomena. He attributed the stony matter of fossils to a "lapidifying virtue diffused through the whole body of the geocosm," and the form of fossils to a "spiritus plasticus," which formed both organic and inorganic matter (p. 56).

Agostino Scilla, the Sicilian painter and naturalist, argued strongly against the idea of *lusus naturae* and gave a rational and clear interpretation of fossil sea-shells and *Glossopetrae* (fossil shark teeth), found in Calabria and Malta. He claimed that these fossils were indeed the remains of animals of the sea that had lived in the past, were buried in sediments which had hardened and risen to the present position (1670: 15). Rudwick explains, however, that Scilla's fossils were "easy" ones because they belonged to recently deposited sediments close to the sea and could be readily identified with living analogues (p. 58). The English physician and naturalist Martin Lister found no such likeness in fossils from older rocks (Jurassic and Carboniferous) and thus rejected the theory of the organic origin (Rudwick: 61-63). John Ray, one of the most knowledgeable of naturalists at the end of the seventeenth century, remained uncertain, both about the nature of fossils — in particular ammonites and other fossils that had no living analogues — and their position far away from the sea (1713, 1978: 149-204). Thus, at the end of the seventeenth century the nature of fossils and their position could not be explained. Jesuit schools in charge of the training of most youths in France at that time, continued to funnel science through Kircher's view. In England, fossils were mostly explained by the biblical deluge as I shall mention later on.

One of the greatest promoters of new ideas on natural history in the early eighteenth century was Fontenelle. He was in charge of writing a yearly account of all memoirs presented to the Academy of Sciences since 1697, and his *Histoires* included also reviews of foreign publications. Voltaire seems to have read mostly Fontenelle's *Histoires* and not the original memoirs themselves which led to confusion as we shall see. It is of great importance to notice that some of these accounts reveal that Fontenelle did not always report scientific ideas faithfully. Thus was created, for instance, the theory of the Indian Ocean. In 1706 he reviewed Leibniz' *Protogaea*, published in the *Acta eruditorum* of Leipzig in January 1693, and reported:

> Il dit que dans le Païs de *Brunsvic* aux environs d'*Osteroda*, dans le Comté de *Mansfeld* aux environs d'*Eislebe*, & en beaucoup d'autres endroits d'*Allemagne*, on trouve des veines d'Ardoise horisontales à peu près, où il y a des représentations, mais très-exactes & très-finies, de diverses sortes de Poissons ou de Plantes, qui paroissent dans leur longueur & dans leur largeur naturelles, mais sans aucune épaisseur. Ces traces sont souvent marquées sur un mélange de Cuivre, qui contient même de l'Argent. Il y a quelques-unes de ces Plantes que l'on ne connoît plus en ces Païs-là, mais on les retrouve dans les figures des Plantes des *Indes*. (p. 11-12)

Fontenelle mentions here the famous copper-bearing Permian shale called "Kupferschiefer" which contains abundant fossil fish, the original substance of which has been replaced by copper (Speyer 1860: 507; Schwarz 1930: 25-26). Leibniz, however, did not mention any fossil plants in chapter XVIII of *Protogaea* "D'où proviennent les empreintes de poissons divers dans l'ardoise?" (Trans. 1859: 45-49) and he did not suggest that the sea of India had transported them to Germany. On the contrary, he proposed:

> Que peut-on nous opposer, si nous disons qu'un grand lac avec ses poissons, par suite d'un tremblement de terre ou d'une inondation, ou de toute autre cause majeure, a été enseveli sous des terrains qui, en se durcissant en pierre, ont conservé les vestiges, et comme la reproduction en relief des poissons dont le corps, d'abord empreint sur la masse encore tendre, a ensuite été pénétré et remplacé par une matière métallique? (p. 48)

Although Leibniz had proposed a freshwater origin of fossil fish found in Eisleben and had not mentioned any fossil plants, Fontenelle confused Leibniz' fossils with the discovery of some fossil plants elsewhere and stated: "Il est vrai qu'une représentation d'une Plante des *Indes* dans une Pierre d'*Allemagne* semble d'abord contraire au *Systême* de M. de *Leibniz*. Mais que la Plante représentée se retrouve aux *Indes*, c'est déjà un grand préjugé qu'il n'y a pas là de Jeu: il est aisé d'imaginer plusieurs accidents par lesquels une Plante aura été apportée des *Indes* en *Allemagne*..." (1706: 13). Fontenelle proposed that these fossils must be witnesses of great changes which had occurred on the surface of the earth: "M. *Leibniz* croit que la Mer a presque tout couvert autrefois [...] De-là viennent les Coquillages des Montagnes" (p. 13). Fontenelle thus reported that Leibniz had described fossil plants in Germany which resembled those still living in India and that, therefore, the Indian Ocean must have travelled to Europe: the theory of the Indian Ocean was thus created.

Between the years 1718 and 1722 a number of memoirs described fossil fish and fossil plants found in France. These memoirs and Fontenelle's accounts of them led more and more credibility to the theory according to which the Indian Ocean or some other sea from a warm country had indeed covered all of Europe.

In 1718, Jussieu found some imprints of "exotic-looking" fossil plants in the Lyonnais coal beds. Based on the evidence that they were mostly in a flat position, he deduced that they must have floated in water; since they were surrounded by marine shells, the environment must have been the sea; and because similar plants existed in India, or in other warm countries, an ocean from India or thereabouts must have brought them to France. Jussieu remarked that the biblical deluge could hardly account for their occurence (p. 363-376). In 1720, Réaumur described the faluns of Touraine: a sandy mass of fossil shell fragments mixed with other material depending on the location. He mentioned huge accumulations of marine shells in Touraine which were apparently deposited either by some ocean current from the Channel, by the ebb and flow of the sea, or by other accidents which caused the

ocean to change its bed. Réaumur pointed to the regular layers of marine shells and said that the deluge would have left these shells in disarray (p. 519-541). In 1721, Jussieu described fossil fish and plant remains which he compared with their analogues in India and China and concluded that these fossils were either transported by the ebb and flow of the sea from India, or they had lived in an ocean which later retreated, "il faut que nos terres ayent fait autrefois partie du bassin de la Mer dans lequel ces Animaux ont vécu dont les dépouilles ont été ensevelies dans nos terres, après que la Mer s'en est retirée..." (p. 89-98). Fontenelle conveniently disregarding the second proposition by Jussieu, wrote enthusiastically: "Après tout ce qui a été dit dans plusieurs des Volumes précédents, il seroit inutile de repeter que de grandes inondations inconnues aux Histoires ont dû apporter en *France* des Païs les plus éloignés & des Plantes & des Animaux, tels que des Coquillages ou des Poissons" (1721: 1). Only at the end of his account did he add: "Quelle étrange révolution a dû ou les apporter, ou les laisser ici!" (1721: 4) When Jussieu wrote another article on ammonites in 1722, Fontenelle said, "Après tout ce qui a été dit dans les Volumes précédens sur diverses petrifications, il est aisé de sentir la conclusion où M. de *Jussieu* veut venir. Les Mers des *Indes* ont donc couvert toute l'*Europe*. Ces grandes revolutions, dont nous n'avons plus d'exemples, si peu vraisemblables, horsmis pour les Philosophes, sont de jour en jour plus attestées par des monumens authentiques, & par des especes d'Histoires écrites de la main même de la Nature" (1722: 5-6).

This kind of unsupported generalization should be kept in mind for the discussion of Voltaire's *Dissertation*. Jussieu had proposed an ocean current from India or some other warm country or a diminution of the sea to account for fossils in France; Réaumur had suggested some localized ocean current from the Channel, the ebb and flow of the sea, or some other unknown accident. Fontenelle apparently found it earsier to stick to just one interpretation: the Indian Ocean was part of some unknown revolution in the past and had covered all of Europe.

Fontenelle made another generalization in regard to Bernard Palissy, which was also going to cause problems to Voltaire when he wrote *Singularités*. In his account of Réaumur's description of the faluns of Touraine, Fontenelle said in reference to Palissy: "Un potier de terre, qui ne savoit ni Latin ni Grec, fut le premier, vers la fin du 16^{me} Siécle, qui osa dire dans *Paris*, & à la face de tous les Docteurs, que les Coquilles fossiles étoient de veritables Coquilles déposées autrefois par la Mer dans les lieux où elles se trouvoient alors..." (1720: 7). Only the first part of Fontenelle's statement is correct. In *Discours Admirables* Palissy claimed that the *earth* produced as many "poissons portant coquilles" as the sea which lived in rivers, fountains, ponds. Fossils "limitroph" to the ocean only had been deposited by the sea, but fossils found far away from the seashore, and in mountains, were not of marine origin because they could not have been transported by the sea to these locations (1580, 1961: 273-281). Palissy was attacking the diluvial theory of Cardanus and stressed that according to Genesis, the waters of the deluge did not come from

the sea, but from the abysses and the rains. Personally, Palissy did not believe in the deluge but in some natural way of preservation of fossils. "Il faut donc conclure que auparavant que cesdites coquilles fussent petrifiées, les poissons qui les ont formées estoyent vivans dedans l'eau qui reposoit dans les receptacles dedites montagnes, et que depuis l'eau et les poissons se sont pétrifiez en mesme temps, et de ce ne faut douter" (1961: 279). When he found fossil oysters in the Ardennes which closely resembled those he had observed alive on the seashore, he suggested that some lakes must have been salty enough for their survival: "cela nous doit faire croire qu'en plusieurs contrées de la terre les eaux sont salées, non si fort comme celles de la mer: mais elles le sont assez pour produire de toutes espèces de poissons armez" (1961: 279). Palissy was thus clearly in favor of the origin in freshwater or slightly salty lakes for most fossils found inland.

I am amazed that when his work was rediscovered in 1663 by a Danish chemist Olof de Borch (Pallas 1782: 3) which then became famous in the eighteenth century, Palissy was incorrectly hailed as the first Frenchman who had proposed the theory that the sea had covered all lands. Not only Fontenelle, but also Buffon (1749: 267), Jussieu (1718: 370), Lamoignon-Malesherbes (1798: 226), and finally Voltaire believed Palissy to be the originator of the theory of marine invasion.

The two generalizations made by Fontenelle concerning the theory of the Indian Ocean and the idea that Palissy, already in the sixteenth century, had suggested that the sea had once covered all the lands meant that the Academy of Sciences admitted openly that not the biblical deluge but inundations, ocean-currents, or some other unknown events of the past were responsible for the presence of marine fossils on land. With these ideas Voltaire had agreed in the original version of *Elémens* in 1738; in 1741 he added the skeptical "dit-on" for fossils in mountains but added a deposit by "marées" over a long period of time, perhaps referring to the faluns of Touraine mentioned by Fontenelle. In the *Dissertation* and the *Singularités* Voltaire ridiculed the theory of the Indian Ocean by Fontenelle. It can be assumed that the anonymous "on" in *Dissertation* at times refers to Fontenelle.

Some statements in the *Dissertation* can also be traced back to the deceased Benoît de Maillet, consul of the king of France at Cairo between 1682 and 1702 and author of several manuscript versions about discussions between an Indian philosopher and a French missionary. Voltaire owned one of the manuscripts entitled "Nouveau système du monde ou entretien de Teliamed" (Havens and Torrey, SVEC, IX: 33) which circulated apparently for twenty years before publication in 1748 (Lamoignon-Malesherbes, 222). According to Maillet, the ocean had covered the whole earth as witnessed by the many fossil shells found everywhere on land. Mountains had been shaped by ocean currents on the bottom of the sea and later emerged during a gradual diminution of the sea. As the sea diminished, life developed in shallow waters, and with further retreat of the waters, sea-plants, sea-animals, and sea-men were forced to live on land. In *Dissertation* Voltaire criticized the theory

of mountain-building by the sea based on the occurrence of fossil shells on land. Another anonymous "on" is therefore Maillet.

E. Voltaire and Fossils

Voltaire's previous involvement with astronomy and physics did not help him to understand the origin of fossils. Before he eventually looked at them himself, he could only offer some more "natural" explanations.

In regard to fossil fish he said "On a trouvé dans les montagnes de la Hesse une pierre qui paraissait porter l'empreinte d'un turbot, et sur les Alpes un brochet pétrifié: on conclut que la mer et les rivières ont coulé tour à tour sur les montagnes." To this general opinion he retorted: "Il était plus natural de soupçonner que ces poissons, apportés par un voyageur, s'étant gâtés, furent jetés, et se pétrifièrent dans la suite des temps; mais cette idée était trop simple et trop peu systématique" (p. 221-222). Voltaire's more "natural" explanation about leftovers from some traveler's meal had been proposed earlier by Palissy in 1563 (1961: 37); Voltaire, however, did not refer to Palissy before 1768.

Fossil fish were never mentioned again. In his later *Singularités*, Voltaire ignored those in Hesse, and in treating the Alps he simply mentioned some oyster-shells (M.XXVII: 144-145). This apparently means that since fossil fish were so easily recognizable and comparable with living analogues, he did not question their origin in his later works.

In the following paragraph of *Dissertation*, Voltaire again seemed to give a more "natural" explanation:

> On dit qu'on a découvert une ancre de vaisseau sur une montagne de la Suisse: on ne fait pas réflexion qu'on y a souvent transporté à bras de grands fardeaux et surtout du canon; qu'on s'est pu servir d'une ancre pour arrêter les fardeaux à quelque fente de rocher; qu'il est très vraisemblable qu'on aura pris cette ancre dans les petits ports du lac de Genève; que peut-être enfin l'histoire de l'ancre est fabuleuse; et on aime mieux affirmer que c'est l'ancre d'un vaisseau qui fut amarré en Suisse avant le déluge. (p. 222)

Ever since antiquity anchors found in mountains had been mentioned as evidence of the theory of marine invasion. This idea is found in Ovid's *Metamorphoses* who recalled the teaching of Pythagoras. Burnet (p. 86) and Maillet (Carozzi A. 1968: 92) referred to anchors in the same sense as Ovid had. The legend of old anchors was expanded into petrified ships found in the Alps by Fulgose in the fifteenth century and repeated by Maillet in the eighteenth (Carozzi A. 1968: 92). Some naturalists explained the presence of ships and anchors as proofs of the biblical deluge; Maillet used it to explain the diminution of the sea; Hooke assumed that earthquakes "overthrew some mountains which collapsed into the lake of Geneva sinking the

DISSERTATION,

ENVOYÉE PAR L'AUTEUR, EN ITALIEN
à l'Academie de Boulogne, & traduite par lui-même
en français.

SUR LES CHANGEMENS ARRIVÉS DANS NOTRE GLOBE,

ET SUR LES PETRIFICATIONS

qu' on prétend en être encore
les témoignages.

Il y a des erreurs qui ne ſont que pour le peuple. Il y en a qui ne ſont que pour les Philoſophes. Peut-être en eſt-ce une de ce genre, que l'idée où ſont tant de Phyſiciens qu'on voit par toute la terre des témoignages d'un bouleverſement general. On a trouvé dans les montagnes de la Heſſe une pierre qui paraiſſoit porter l'empreinte d'un turbot ; & ſur les Alpes un brochet pétrifié. On en conclut, que la mer & les rivieres ont coulé tour à tour ſur les montagnes. Il étoit plus naturel de ſoupçonner, que ces poiſſons, apportés par un voyageur, s'étant gatés furent jettés, & ſe pétrifierent dans la ſuite de tems ; mais cette idée étoit trop ſimple & trop peu ſiſtématique. On dit, qu'on a découvert un ancre de vaiſſeau ſur une montagne de la Suiſſe : on ne fait pas reflexion qu'on

FIG. 2. — Title page of Voltaire's *Dissertation...* in the sixth volume of *Œuvres de Mr. de Voltaire* published at Dresden by George Conrad Walther in 1748.

ship and filling the basin of the lake up to the shorelines on a level with the adjacent lands" (Carozzi A. 1968: 273). Voltaire's more "natural" explanation was certainly reasonable. Perhaps he had also tried to reduce the importance of fossils found in Hesse and in the Alps with the implication that they are parallel to the fabulous anchors found in mountains.

After fossil fish Voltaire discussed shark teeth and conches:

> La langue d'un chien marin a quelque rapport avec une pierre qu'on nomme *glossopètre*; c'en est assez pour que les physiciens aient assuré que ces pierres sont autant de langues que les chiens marins laissèrent dans les Apennins du temps de Noé; que n'ont-ils dit aussi que les coquilles que l'on appelle *conques de Venus* sont en effet la chose même dont elles portent le nom! (p. 222)

Glossopetrae or "tongue-stones" had been identified for quite some time as petrified teeth of once living sharks or dogfish. Voltaire did apparently not read Steno on the origin of *Glossopetrae* but he could find an explanation in Maillet's manuscript where they were called "dents d'un poisson appellé Chien-marin" (Maillet 1755, II: 29) or in *La vana speculazione disingannata dal senso* by Scilla which he owned (Havens and Torrey, SVEC IX: 64; they give only the title of the book but not the author). Legends had named shark teeth "serpent's tongues" or "serpent's eyes" turned into stone fallen from the sky or formed during lightning. Another legend said that they were snakes turned into stone when a viper had tried to poison St. Paul on the Island of Malta (Carozzi A. 1968: 341-342). Voltaire decided to mix together all the legendary names and make a pun on nomenclature in general. After reading Scilla's explanation of the origin of *Glossopetrae* Voltaire was certainly aware that these "tongue-shaped stones" were indeed fossils of shark teeth. Furthermore, fossils of Venus shells had been known as such since antiquity. Therefore, Voltaire could not give a more "natural" explanation of these fossils and resorted to jokes.

He returned to a more serious attitude in regard to extinct ammonites. Leibniz admitted that they might still be living in some deep ocean (1693, trans. 1859: 68). Many naturalists, however, remained skeptical in the early eighteenth century while others believed that they were of the same species as *Nautilus* still living in India. Voltaire proposed:

> Les reptiles forment presque toujours une spirale, lorsqu'ils ne sont pas en mouvement; et il n'est pas surprenant que, quand ils se pétrifient, la pierre prenne la figure informe d'une volute. Il est encore plus naturel qu'il y ait des pierres formées d'elles-mêmes en spirales; les Alpes, les Vosges, en sont pleines. Il a plu aux naturalistes d'appeler ces pierres des *cornes d'Ammon*. On veut y reconnaître le poisson qu'on nomme *nautilus*, qu'on n'a jamais vu, et qui était produit, dit-on, dans les mers des Indes. Sans trop examiner si ce poisson pétrifié est un *nautilus* ou une anguille, on conclut que la mer des Indes a inondé longtemps les montagnes de l'Europe. (p. 222)

In the above passage, Voltaire first proposed that ammonites were some kind of petrified reptile, perhaps because of Maillet's account of a serpent at the court of

the Spanish King Philippe V: "On trouva dans une pierre qui fut sciée un serpent enterré sans aucune altération. On l'en tira; & on remarqua sa place creusée dans le marbre en spirale, selon la position de son corps" (1755, I: 94). Then Voltaire turned again to a more "natural" idea, namely that ammonites were simply stones of a peculiar shape. He doubted the opinion that ammonites belonged to a species of *Nautilus* still living in India.

Further on in the *Dissertation* Voltaire questioned whether fossil shells found in Italy and France were originally from the sea of Syria (Syria formerly included the present Syria, Lebanon, Israel, and adjacent areas as part of the Roman Empire until A.D. 636):

> On a vu aussi dans des provinces d'Italie, de France, etc. de petits coquillages qu'on assure être originaires de la mer de Syrie. Je ne veux pas contester leur origine; mais ne pourrait-on pas se souvenir que cette foule innombrable de pèlerins et de croisés, qui porta son argent dans la Terre Sainte, en rapporta des coquilles? Et aimera-t-on mieux croire que la mer de Joppe et de Sidon est venue couvrir la Bourgogne et le Milanais? (p. 222)

(The reference to the sea of Syria might also have been inspired by Maillet [Carozzi, A. 1968: 89].) Voltaire questioned that the sea of Syria had brought fossil shells to France and Italy and, for the first time, he mentioned pilgrims from the Holy Land as transporters of these shells, adding, however, immediately:

> On pourrait encore se dispenser de croire l'une ou l'autre de ces hypothèses, et penser, avec beaucoup de physiciens, que ces coquilles, qu'on croit venues de si loin, sont des fossiles que produit notre terre. On pourrait encore, avec bien plus de vraisemblance, conjecturer qu'il y a eu autrefois des lacs dans les endroits où l'on voit aujourd'hui des coquilles; mais quelque opinion ou quelque erreur que l'on embrasse, ces coquilles prouvent-elles que tout l'univers a été bouleversé de fond en comble? (p. 222-223)

Voltaire's attitude toward geology became notorious because of his pilgrim story, according to which pilgrims had transported shells to Italy and France from the Holy Land, which he repeated, drastically changed, twenty years later. All the evidence indicates that it never was a serious proposition. For instance, in the above passage Voltaire mentioned in fact three other hypotheses: a) fossil shells found in Italy and France might be originally from the sea of Syria ("je ne veux pas contester leur origine"); 2) these shells might be "fossiles" produced by the earth (the meaning of this expression will become clearer in *Singularités*), and 3) lakes might have existed in these areas where fossil shells are found today. Of these three theories, Voltaire seemed to prefer the last one since he said "avec bien plus de vraisemblance." All of this suggests that in 1746 Voltaire was not particularly fond of his pilgrim story, it was merely one suggestion among others. (I shall show in Chapter II, Section F, how the story changed in twenty years.)

Another reference to fossils appears immediately following Voltaire's translation of Ovid's verses which described changes from land to sea according to the teaching of Pythagoras:

> Cette opinion a été plus que jamais accréditée par l'inspection de ces lits de coquillages qu'on trouve amoncelés par couches dans la Calabre, en Touraine, et ailleurs, dans des terrains placés à une assez grande distance de la mer. Il y a en effet très-grande apparence qu'ils y ont été déposés dans une longue suite de siècles. (p. 223)

In his *Dissertation* Voltaire seemed to accept the marine origin of shells found in Calabria and Touraine. Why should he suggest marine origins there and not in the provinces of Italy and France mentioned in the same essay, a page earlier? For those he had just given the four hypotheses including the pilgrim story? This fifth hypothesis of the marine origin of shells might have originated from Voltaire's reading of Scilla's description of fossils in Calabria and Fontenelle's account of the faluns of Touraine. Scilla's book had been highly praised by Bourguet (1742: 21) and by Maillet (Carozzi A. 1968: 143). Most important, Voltaire owned a copy of Scilla. A comparison between this work and Voltaire's *Saggio* shows that there is one important similarity: the concept of being "elevated" or "rialzato." The paragraph on fossils in Calabria reads in the *Saggio*:

> Fù questa opinione di nuovo accreditata coll'inspezione d'alcuni mucchi di conchigliette, o *rialzalti* nei sassi della Calabria, o stesi sul pian terreno di *Touraine*, ed in alcuni altri luoghi in distanza del Mare. In effetto, pare che cotali letti di chiocciole, siano là stati disposti a poco a poco in lunga serie d'anni. (p. 6-7)

A comparison of the Italian text with the French one shows that Voltaire had read about heaps of shells either *elevated* in the rocks of Calabria or extended over the flat country of Touraine. Scilla had mentioned in his work:

> Essendo per camino nella bassa Calabria, poche miglia sopra la città di Reggio, nella via, che conduce ad une terra, per nome Musorrima, mi si se incontro alla veduta un mõte ben considerabile di chiocciole, e conche striate, e simili altri gusci nõ per anche impietrati [...] parendomi assai, ch'elleno si siano potute conservare per tanto, e sì grande spazio di tempo, e massimamente lungi, e *rialzate* dal livello del mare, per più di sei miglia di camino nell'asprissimo di quelle montagne. (1670: 15)

(The underlining of "rialzati" and "rialzate" in the two paragraphs above is mine.)

A comparison of the *Saggio* and Scilla's work reveals that Voltaire might have borrowed the latter's expression of "rialzato." His vocabulary on fossils is also richer in *Saggio*: "chiocciole," "conchigliette," "conche" than in *Dissertation*: "coquilles" and "coquillages." Since he owned Scilla's work, I believe that this was indeed Voltaire's source:

At the end of the *Dissertation* Voltaire mentioned fossils once more, adding Mont Cenis for the location of the "brochet" and the city of Frankfurt for shells from Syria:

> Je sais bien qu'il se trouvera toujours des gens sur l'esprit desquels un brochet pétrifié sur le mont Cenis, et un turbot trouvé dans le pays de Hesse, auront plus de pouvoir que tous les raisonnements de la saine physique; ils se plairont toujours à imaginer que la cime des montagnes a été autrefois le lit d'une rivière ou de l'océan, quoique la chose paraisse incompatible; et d'autres penseront, en voyant de prétendues coquilles de Syrie en Allemagne, que la mer de Syrie est venue à Francfort. (p. 229)

In this passage a petrified pike on Mont Cenis, a turbot found in Hesse, and shells from Syria found in Frankfurt seem to point to the fact that Voltaire cared little about the exact location of fossils; he argued that fossils cannot explain past changes on the surface of the earth. It is evident, nevertheless, that he knew more about them than when he had been writing the *Eléments* where he only quoted Fontenelle's account of the Indian Ocean and Ovid's verses. Since then he had evidently done some reading and was familiar with the most important names of fossils. He had probably read Scilla's book; Maillet's manuscript of *Telliamed*; Bourguet's *Traité des Pétrifications*, and John Woodward's *Géographie Physique*, (to be discussed in the next section) but he had not looked at fossils himself.

These books, however, failed to explain the presence of fossils on the highest mountain peaks in a fashion that Voltaire could accept. Only Scilla's fossils in Calabria could, in fact, be easily interpreted as ancient marine organisms which had lived and died in the sea and had become petrified together with the surrounding mud on the seafloor and then lifted to the present position by some earthquake. Voltaire almost accepted their marine origin. He was also not denying the marine origin of fossils close to the sea, as in Touraine, accepting some changing shorelines over a long period of time, but not Fontenelle's Indian Ocean. Both Bourguet and Woodward believed in a complete dissolution of the first earth and some mechanic introduction of fossils during the following deluge, an idea which Voltaire found unacceptable. He never mentioned Maillet's theory on a diminution of the sea to account for marine fossils on land but ridiculed only the idea that the sea could have covered all the lands in the past. At a time when mountain-building could not be explained by any other mechanism than the sea or the deluge, Newton's physics were of little help to Voltaire for the understanding of the position and the origin of fossils. In the absence of personal investigation of geological features and fossils, a little imagination was all Voltaire could offer at this point.

F. Voltaire on Theories of the Earth

According to Voltaire, "Il faudrait plus de temps que le déluge n'a duré pour lire tous les auteurs qui en ont fait de beaux systèmes..." That he was certainly right is proved by Bourguet's list of theories in the following passage from his *Mémoire sur la Théorie de la Terre :*

> La Théorie de la Terre est une Science toute nouvelle, elle consiste à déduire des Phénomenes de la Nature, la formation de nôtre Globe; les changemens qui y sont arrivés depuis, & ceux qui doivent y arriver encore. Les Anciens ont absolument ignoré cette Science. Ils n'ont débité sur les sujets qui s'y rapportent, que des Conjectures avancées au hazard, ou de simples Traditions. Leurs Conjectures ont été renouvellées au XVI Siécle, & l'on n'est pas allé beaucoup plus avant; si ce n'est depuis environ quarante à cinquante ans [. . .] on peut réduire à trois Hypothéses, tout ce que les Modernes ont dit là-dessus.
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> La premiére Hypothése est celle de la Chute de l'ancien Monde de *François Patrice*, empruntée de *Platon* & differemment expliquée par *Gonçales de Salas* & par *Thomas Burnet*, qui le prémier a traité la *Theorie de la Terre* d'une maniére systêmatique.
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> La seconde Hypothese est celle de *Bernard de Palissi* sur le séjour naturel de Lacs d'eau salée, ou de la Mer, dans les lieux où l'on trouve des Coquillages, prise d'*Aristote* & d'autres Anciens; & suivi en tout ou en partie par *Alexandre ab Alexandro*, *Cesalpin*, *Fracastor*, *Columna*, *Scilla*, *Boccone* & par Mess. *Leibniz*, *Vallisnieri*, de *Jussieu*, de *Réaumur*, *Mayran*, & divers autres Savans de ce temps: Ou jointe à la premiére Hypothese en diverses façons par *Stenon*, & Messieurs *Whiston*, *Halley*, *Hartsoeker*, *Buttner*, *Gautier*, & le *R. P. Castel.*
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> La troisiéme & derniere Hypothese est celle de la Dissolution du prémier Monde, de Monsieur *Jean Woodward*, que Messieurs *Scheuchzer*, *Monti*, & quantité de Savans d'Angleterre, d'Allemagne & d'Italie ont soutenuë avec beaucoup d'érudition & de force. (1729: 177-180)

Although Bourguet mentions three different theories of the earth, apart from Leibniz' view on the origin of mountains by fire and water, the main difference among all of them in the eighteenth century is whether the biblical deluge — originating from the sky and the abysses, but finally covering the whole earth, thus mingling with oceans — or a general inundation, or some ocean current had deposited *marine* fossils on land. In order to understand Voltaire's reaction to the two sets of theories, I need to summarize some of the most important works to which Voltaire was referring.

In England, the most widely accepted account of the history of the earth in the seventeenth century and later was the Bible. It is not surprizing, therefore, that the first "geologists" in England mixed science with religion since the Scriptures say: "And the flood was forty days upon the earth; and the waters increased, and bare up the ark, and it was lift up above the earth..."; "Fifteen cubits upward did the waters prevail; and the mountains were covered..."; "And the waters prevailed upon the earth an hundred and fifty days" (Genesis, Ch: 7: 17, 20, 24). When these naturalists found fossil remains inside their mountains, it did not surprize them since the Bible said that the mountains had been covered by waters. (Fifteen cubits — one cubit being 17 to 21 inches — allows, however, for rather small mountains.) What bothered them, however, was the problem of how to account for the volume of water during the deluge and to understand how the mountains had been formed. They produced interesting theories, none of them alike.

In *Telluris theoria sacra*, first published in 1681 and reedited in English in 1684 under the title *The Sacred Theory of the Earth*, Thomas Burnet was greatly concerned with the amount of water necessary to cover the highest mountains. According to his computation, at least a volume corresponding to eight oceans would be necessary for the waters of the deluge to cover all the highest peaks (1965: 29). Finding this impossible, he adopted Descartes's theory of the broken earth-crust. Descartes had proposed different layers of matter around a hard core. These layers were constantly crossed by moving particles which managed to leave empty spaces. Since nature must replace voids, cracks appeared in the same manner as in mudcracks in summer. Where too many cracks existed, the crust collapsed, and the positions assumed by the different layers of matter accounted for mountains, valleys, and seas (Descartes 1664, 1973, III: 352-386). Borrowing from Descartes, Burnet proposed that before the deluge (which Descartes did not mention) the earth had been completely flat with concentrically arranged layers of matter of different density and consistency around a hard core. A very thin outer crust broke and opened the way for the water underneath to gush out and cover the earth completely during the time of the deluge. After the deluge, said Burnet, the earth was in ruins and "according as the fragments fell, some would make Islands or Rocks in the Sea, others would make Mountains or Plains upon the Land" (1965: 91). Burnet used a much plainer language than Descartes and tried to reconcile science with religion. Both ignored fossils altogether.

John Woodward made it his task to explain how fossils were found inside rocks and mountains. He advocated a complete dissolution of the first earth which, unlike Burnet's globe, had mountains, valleys, and seas, followed by a settling of all the materials by gravity in the waters of the deluge. *Essay Toward a Natural History of the Earth*, first published in 1695, went through many editions and was translated into Latin, French, Italian, and German (Eyles 1969: 163). The French translation of 1735 which Voltaire probably read states: "Dans le temps du déluge, lorsque l'eau couvroit toute la terre, la pierre, le marbre, les métaux, toutes les concrétions minérales: en un mot, tous les fossiles qui avoient auparavant quelque solidité [apparently excluding fossil animals and plants], furent entièrement dissous & les particules qui les composoient furent séparées & désunies (leur cohésion ayant cessé)." The dispersed and floating bodies finally reassembled and, said Woodward, "se précipitèrent de nouveau & tombèrent au fond: ils descendirent généralement selon les loix de la pesanteur." According to density, heavy shells would lie together with heavy rocks at the bottom of a geological section and light shells with light chalk at the top. Thus Woodward explained the vertical distribution of fossil animals and plants within horizontal layers; for the vertical position of rock layers, he suggested later produced fractures and violent disturbances or revolutions, apparently while the earth crust was still pliable (1735: 45-51). Woodward's explanation of the preservation of the original fossil animals and plants while all other material was completely dissolved is the weakest point of his theory. He tried to explain this

difficulty by saying that animal and plant remains were of a different composition (fibres entrelassées & embarassées) while ordinary stones and minerals were composed of "petits grains contigus & appliqués l'un contre l'autre sans être liés ou entrelacés, retenus par la compression & la pesanteur de l'air extérieur: donc pour les séparer & causer la dissolution, il faut suspendre la cause de leur solidité, la pesanteur de l'air." Woodward concluded that the deluge was a change in gravity (1735: 236-237). His approach is thus a curious mixture of Descartes's theory on matter and Newton's laws of attraction.

Even more influenced by Newton's laws of gravity was William Whiston who wrote in 1696, one year after Woodward, a *New Theory of the Earth...* He dedicated the work to Newton saying: "The now undoubted property of the Universal Gravitation of Matter, contradicts and overthrows this fancy of the Heavenly Bodies having been originally included in, and at the Creation extracted from the Chaos [...] This hypothesis would make the Earth the Center of the world." He said that Scriptures talked only about the Earth and not the other planets and that there was a different formation for each body. Therefore, the "Mosaik Creation is confin'd to our Earth" (p. 36-41). In the same affirmative tone he pointed out several inconsistencies in the Bible: insufficiency of time; the light appearing before the creation of the sun; "the Channel of the Ocean and the Elevation of the Mountains" seeming "unnatural and indecent." He concluded that "all these points are unworthy of the Writer and Author of the Sacred History" (p. 51-78). Whiston believed that the Bible was addressed to the Jews and that "it agreed with their cosmogony, and that their capacities were very low and mean. They were rude and illiterate, newly come from the Egyptian Bondage and destitute of the very first Elements of Natural Knowledge." Furthermore, "the generality of Mankind's Apprehensions are too narrow" (p. 80-83). Therefore, he wanted to prove that the "Mosaick Creation extends no farther than this Earth and its Appendages, because the Deluge and Conflagration, whose Boundaries are the same with that of the Mosaick Creation extend no farther" (p. 86).

Whiston went on to correct all these errors. In Book I he explained that attraction — gravity must be the effect of a divine power, and that if gravity were rightly understood, it does not lead to Atheism. In Book II, he gave astronomical evidence of the exact day when the deluge started, namely when a comet passed just in front of the Earth. In Book III, he covered the six days of creation giving to each day its needed time. According to his theory the waters of the deluge originated from the tail of the comet and the fountains of the abyss. Whiston was a physicist-astronomer and less interested in fossils. Thus he simply followed Woodward's explanation. In his last book, IV, he said that God alone had created all matter in the universe, the seeds of animals and plants, the motion of bodies, and Adam and Eve. The Earth itself, moreover, was created by the direct interposition of God, and the placing of the earth in its primitive circular orbit was due to an immediate power or a peculiar

providence of God (p. 218-237). Whiston's theory did not please everybody in England and he lost his chair at Oxford. He had to leave the university, and Newton to whom he had addressed his book "did nothing at all to help him..." (Roger, DSB).

The theories of the three English diluvialists have all gone beyond what the Scriptures said. Burnet was still read in the eighteenth century because of his many sources and because of his convincing language. Indeed, even Buffon was impressed (1749: 181). Woodward was consulted because of his knowledge in paleontology. He corresponded with many naturalists all over the world and helped to establish a practical approach to that discipline. Bourguet became his disciple in the sense that he accepted the notion of a dissolution of an ancient world.

In *Lettres philosophiques*, Voltaire dismissed "un géomètre anglais nommé Whiston, non moins chimérique que géomètre" (M.XXII: 138), in *Eléments*, he refuted Burnet's diluvial theory, and in *Dissertation* Burnet and Woodward are put side by side. (Voltaire had thus read Woodward's translated version of 1735.):

> Un auteur qui s'est rendu plus célèbre qu'utile par sa théorie de la terre a prétendu que le déluge bouleversa tout notre globe, forma des débris du monde les rochers et les montagnes, et mit tout dans une confusion irréparable; il ne voit dans l'univers que des ruines. L'auteur d'une autre théorie, non moins célèbre, n'y voit que de l'arrangement et il assure que sans le déluge cette harmonie ne subsisterait pas; tous deux n'admettent les montagnes que comme une suite de l'inondation universelle. Burnet, en son cinquième chapitre, assure que la terre avant le déluge était unie, régulière, uniforme, sans montagne, sans vallées, et sans mers; le déluge fit tout cela, selon lui: et voilà pourquoi on trouve des cornes d'Ammon dans l'Appennin.
> Woodward veut bien avouer qu'il y avait des montagnes; mais il est persuadé que le déluge vint à bout de les dissoudre avec tous les métaux, qu'il s'en forma d'autres et que c'est dans cette nouvelle terre qu'on trouve ces cailloux autrefois amollis par les eaux, et remplis aujourd'hui d'animaux pétrifiés. Woodward aurait pu à la vérité s'apercevoir que le marbre, le caillou, etc. ne se dissolvent point dans l'eau, et que les écueils de la mer sont encore fort durs. N'importe; il fallait pour son système que l'eau eût dissous, en cent cinquante jours, toutes les pierres et tous les minéraux de l'univers, pour y loger des huîtres et des pétoncles. (p. 225-226)

Voltaire's criticism of Burnet and Woodward [1] is scientifically correct with the exception of the reference to Burnet having mentioned ammonites: Burnet never talked about fossils.

Naturalists who did not believe in the biblical deluge proposed various other theories to explain how fossils had been introduced into rocks now forming part of

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[1] Moland's note in Vol. XXIII, p. 225, incorrectly mentions Buffon and Maillet as the authors referred to by Voltaire in the first paragraph mentioned above. The first author is certainly Burnet, and not Buffon, since Voltaire had already mentioned him in *Eléments* with the same words, "nous n'habitons que des ruines", and since Buffon's work was only published in 1749. Maillet's book was published in 1748 although his manuscript version might be referred to. However, he did not propose the biblical deluge. The second author is certainly Woodward although he was not mentioned in *Eléments*, but it seems logical that Voltaire should mention him together with Burnet as the author of another famous theory.

mountains and lands. John Ray, Fellow of the Royal Society of London, dared to contradict the Bible and said that huge amounts of fossils "could hardly be the Effect of a short Deluge, which if it had carried any Shell-Fish so high, would in all Likelihood have scattered them very thin" (1713, 1978: 146). Staying close to Scriptures, however, he said, "at the first Creation, the whole Earth was not all at once uncovered, but only those Parts whereabout *Adam* and the other Animals were created, and the rest gradually afterwards, perchance not in many Years; during which time these Shell-Fish might breed abundantly all the Sea over, the Bottom whereof being elevated and made dry Land, the Beds of Shell-Fish must necessarily be raised together with it." But Ray immediately added: "This Conjecture hath no sufficient Ground to support it, and therefore I do not insist upon it" (1978: 172). Ray was not sure whether earthquakes and subterraneous fires had raised up and elevated land and for how many "Years" the land was once a breeding ground for shell-fish. He refused to give any theories as long as he was not certain.

Leibniz, a born synthesizer, had written in 1693 a theory of the earth, *Protogaea*, which was not published in full until 1749. He considered two major causes for the formation of mountains: fire and water. The primitive earth was first a ball of fire, and the earth crust, while cooling unequally, solidified and crumbled to form valleys, or remain upright to form mountains (Buffon was going to adopt this part of Leibniz' theory in 1778.). Water erupted from the abysses through the broken crust, and combined with rivers and rain, caused huge inundations which left sediments in certain places: "Ces sédiments se sont durcis; et, par le retour de la même cause, les couches sédimenteuses se sont superposées, et la face de la terre, peu consistante encore, a été ainsi souvent renouvelée, jusqu'à ce que, les causes perturbatrices ayant été épuisées et équilibrées, un état plus stable c'est enfin produit" (Trans. 1859: 8-9). Once the earth had stabilized, minor changes occurred such as "embrasements secondaires, des tremblements de terre, des déluges partiels, et sur certains points une accumulation nouvelle des sédiments par suite du séjour des eaux..." (1859: 12)

Leibniz added an improvement to Burnet's theory of the broken earth-crust, namely that there existed two great cavities, one containing water, the other air. After the rupture of the first, the waters rushed up to the highest mountains while the opening of the second cavity gave passage to the water to recede inside the earth (1859: 17). Descartes's theory had thus been transformed, first by Burnet, then by Leibniz, and finally by Buffon who will be discussed in the next chapter.

As mentioned earlier, when Fontenelle reported Leibniz' theory in the Academy of Sciences in 1706, he misread the description of the freshwater origin of fossil fish found at Eisleben. Leibniz actually stated that these fish might have lived in some ancient lakes which disappeared during some earthquake so that the fish became enclosed in mud which when hardened preserved the imprints of the former fish. Voltaire used a similar explanation. Leibniz agreed with his predecessors that marine fossils found elsewhere must have been brought by the sea. "Mais depuis

longtemps déjà les anciens en ont dit autant, et ce n'est point ici le lieu d'accumuler les témoignages épars. Ce qui importe, c'est de constater le fait, et de reconnaître *les preuves qui établissent que ce sont là des animaux ensevelis*" (1859: 61-62). Apparently, Leibniz could not explain why fossils were found in mountains, he only suggested that they were former animals.

In 1746, no theory of the earth could explain how rocks including petrified seashells had been lifted from below sea-level. Voltaire thus wondered "donc autrefois les baleines ont nagé pendant des siècles sur le mont Taurus et sur les Alpes, et le fond de la mer a été peuplé d'hommes" (p. 224), and "On en conclut que la mer et les rivières ont coulé tour à tour sur les montagnes..." (p. 222), and he concluded: "Il n'y a donc aucun système qui puisse donner la moindre vraisemblance à cette idée si généralement répandue que notre globe a changé de face, que l'océan a été très-longtemps sur la terre habitée, et que les hommes ont vécu autrefois où sont aujourd'hui les marsouins et les baleines" (p. 228).

Did Voltaire have any better idea? In the original version of *Elémens* he seemed to have favored some movement of the earth's axis during two million years to explain ocean-wandering and marine shells on land (1738: 296). After Bourguet's criticism in 1742 of Voltaire's astronomical figures and notion of long-term geological processes, Voltaire may have reacted to this criticism in the *Dissertation* by espousing the point of view that nothing or not much had changed: "Rien de ce qui végète et de ce qui est animé n'a changé; toutes les espèces sont demeurées invariablement les mêmes; il serait bien étrange que la graine de millet conservât éternellement sa nature, et que le globe variât la sienne" (p. 228). This is another notorious Voltairian expression which taken out of context seems to say that neither living things, nor inorganic matter had ever changed and that the earth had always been the same. Leaving the biological question for later, let us find out whether Voltaire was now admitting that the earth's axis has never changed? At first, Voltaire said in the *Dissertation*: "Pourquoi, disait-on s'effrayer d'une période de deux millions d'années? Il y en a probablement de plus longues entres les positions réciproques des astres[...] quelques philosophes conclurent que chaque climat ayant été à son tour tantôt pôle, tantôt ligne équinoxiale, toutes les mers avaient changé de place" (p. 224-225). Then he considered this idea "contraire à la physique. Un mouvement qui relève l'axe de la terre de dix minutes en mille ans ne paraît pas assez violent pour fracasser le globe; ce mouvement, s'il existait, laisserait assurément les montagnes à leurs places..." (p. 227). Finally, he decided, "Il n'y a donc aucun système qui puisse donner la moindre vraisemblance à cette idée si généralement répandue que notre globe a changé de face..." (p. 228). It seems clear that Voltaire had not reached any conclusion about astronomical changes in the past. Since there is nothing approaching the above notorious sentence about the fixity of the universe in *Singularités*, it is possible that he offered it in 1746 merely in order to contradict those who believed in great revolutions in the past, in particular, Fontenelle.

Voltaire's attitude toward all theories of the earth which involved the biblical deluge or slow changes of unknown origin over a long period of time is rejection. He was correct in both assumptions because the sea alone could not have built mountains and raised them to such heights, and the biblical deluge was too short to account for depositing the many layers of fossiliferous beds in many countries. Thus, at first sight, Voltaire's attitude seems to be based on the fact that the emergence of mountains could not be explained in the eighteenth century. Did Voltaire have other reasons for rejecting any great changes on the surface of the earth? No positive answer can be based upon the *Dissertation* because even the French version was written with many religious overtones to avoid aggravating the church. When he said "Mon dessein n'est pas de les imiter [those who proposed systems], et je n'ai point du tout l'espérance de découvrir les moyens dont Dieu s'est servi pour former le monde, pour le noyer, pour le conserver: je m'en tiens à la parole de l'Ecriture, sans prétendre d'expliquer, et sans oser admettre ce qu'elle ne dit point" (p. 226), we know quite well that this passage was merely a satire since he did not believe in Scriptures.

It appears, however, that Voltaire had difficulties in separating the antiquity of the earth from that of man's origin. He seemed to believe that mountains, rivers, animals, and men had existed on this earth ever since the beginning. He asked: "S'il avait été un temps où l'océan eût été sur nos montagnes; si les hommes et les animaux eussent alors vécu dans ce fond qui sert de base à la mer, eussent-ils pu subsister? De quelles montagnes alors auraient-ils reçu des rivières? Il eut fallu un globe d'une nature toute différente" (p. 227). Such a different globe, Voltaire could or would not imagine. In the *Saggio* (p. 17) he drew a sketch to show that water being attracted toward the center of the earth according to natural laws, could never have surpassed the mountains. In the *Dissertation*, he abandoned this idea and replaced it with the argument that an ocean never remains on top of mountains but would return to its natural basin (p. 227).

Since Voltaire had promised a theory of the earth, he chose one which provided an orderly arrangement of mountain-chains which were necessary for stability and irrigation and for survival of all living things. Such a theory had been given by Athanasius Kircher in *Mundus Subterraneus* and Voltaire had probably read it in his early youth.

G. Voltaire and Kircher's Mundus Subterraneus

Kircher had been called to Rome in 1633 by Urban VIII and Cardinal Bellarmine, both initially interested in the development of scientific ideas. After the imprisonment of Galileo in 1632, Kircher was set up by the church to work out a compromise between science and religion. He did as best he could: he returned

the earth to the center of the universe, keeping its stability by a web of mountain-chains that encircled the earth; he declared that the earth had been created by a benevolent God for the sake of man, and in particular for Christ to live and die on this earth in order to redeem man's original sin; he also believed that mountains had been created at the very beginning of the earth to hold together this globe and restrain its waters, and also to provide irrigation for men and other living things. Voltaire had no sympathy for the heliocentric system, the idea of man's original sin, and other strange ideas in *Mundus Subterraneus*; however, the idea that mountains had always existed since the creation of the earth because they were necessary for man to exist seems to have impressed him.

Indeed, this notion seemed more reasonable than the two generally received sets of theories of the earth. On the one hand, the English diluvialists declared that the wrath of God had brought the deluge upon mankind to punish it by destroying the first world and building a new one; on the other hand, the French academicians were of the opinion that the sea alone and some unknown past changes on the surface of the earth could explain mountains and marine fossils found there. Voltaire was neither in favor of a world built by a wrathful God, nor receptive to one having undergone unknown past changes. He preferred to adhere to a theory which said that the earth had been created by God for the sake of mankind and remained essentially unchanged.

Kircher said:

> The universal mechanism of the world was forseen and foreordained from eternity to this end; it came into existence not just for its own sake, but so that it might be of service to the earth, which is, as it were, the beginning and the end of the entire universe, and which must work together with all the forces of the heavens, without which it could not have been preserved, for the salvation of the human race.
> [... ergò universa Mundi machina in hunc finem ab aeterno praevisa & praeordinate fuit, non ut sui tantùm gratiâ condita existeret, sed ut telluri, veluti totius Mundi principi & fini, & ipsa cum universis coelorum exercitibus famularetur, & ad humani generis salutem, sine quibus conservari non poterat, cooperaretur.]
> (Tome I, Book II, Chapter I: 55)

Voltaire claimed in *Dissertation* that unlike other philosophers he was not going to create a universe with words, that is to propose a theory of the earth; all he wanted to do was to look with his eyes. However, Voltaire simply looked at a map and apparently remembered very clearly a certain sketch in *Mundus Subterraneus* when he said:

> J'examine d'abord ces montagnes que le docteur Burnet et tant d'autres regardent comme les ruines d'un ancien monde dispersé ça et là, sans ordre, sans dessein, semblable aux débris d'une ville que le canon a foudroyée; je les vois au contraire arrangées avec un ordre infini d'un bout de l'univers à l'autre. C'est en effet une chaîne de hauts aqueducs continuels, qui, en s'ouvrant en plusieurs endroits, laissent aux fleuves et aux bras de mer l'espace dont ils ont besoin pour humecter la terre.

> Du cap de Bonne-Espérance naît une suite de rochers qui s'abaissent pour laisser passer le Niger et le Zaïr, et qui se relèvent ensuite sous le nom du mont Atlas, tandis que le Nil coule d'une autre branche de ces montagnes. Un bras de mer étroit sépare l'Atlas du promontoire de Gibraltar, qui se rejoint à la Sierra-Morena; celle-ci touche aux Pyrénées; les Pyrénées, aux Cévennes; les Cévennes, aux Alpes; les Alpes, à l'Apennin, qui ne finit qu'au bout du royaume de Naples; vis-à-vis sont les montagnes d'Epire et de la Thessalie. A peine avez-vous passé le détroit de Gallipoli que vous trouvez le mont Taurus, dont les branches, sous le nom de Caucase, de l'Immaüs, etc., s'étendent aux extrémités du globe: c'est ainsi que la terre est couronnée en tout sens de ces réservoirs d'eau, d'où partent sans exception toutes les rivières qui l'arrosent et qui la fécondent; et il n'y a aucun rivage à qui la mer fournisse un seul ruisseau de son eau salée. (p. 226)

Voltaire described above mountain-chains which circle the globe and play the role of water reservoirs. While not following exactly Kircher's outlined sketch of mountain-chains, Voltaire repeats the same geographical error as found in *Mundus Subterraneus*, namely that of a mountain-chain starting at the cape of Good Hope and stretching all the way up to the Atlas mountains in Morocco.

In *Mundus Subterraneus* (Tome I, Book II, Chapter IX: 69) is an impressive sketch of the earth surrounded by mountain-chains. Two chains circle the earth from pole to pole where they meet at right angle and three East-West circles hold the earth together like iron circles around a barrel. Kircher said:

> The first chain of mountains, arranged in a circular pattern, proceeds from the North Pole through Iceland, Scotland, England, and Germany in a continuous series of mountains and with a straight path up to the Alps. The Alps represent, as it were, a kind of knot or articulation in the great chain, by which the mountains, drawn out in an uncontinuous fashion, incur a kind of flaw in their connection and are bound and hardened to a firmer consistency. [Prima catena montium in circulum ordinata deducitur à Polo per Islandiam, Scotiam, Angliam, Germaniam, continuata montium serie, rectoque tramiteusque ad Alpes, quae sunt veluti nodus quidam catenae magnae, quo, qui discontinuo ordine extensi montes nonnullam connexionis labem incurrerint, vinciantur, constringanturque ad firmiorem consistentiam.] (Tome I, Book II, Chapter IX: 68)
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> Then from the Alps the mountains, entwined in a kind of a new ringed arrangement, are joined to the Apennine chain, by which the entire central portion of Italy becomes little other than a kind of spine of the back. By the finest of bony structures, the chain is connected in a continuous series through Sicily to those African mountains which are called the Lunar Mountains.
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> Another chain from the great knot extends to the furthest promontory of the south, called the cape of Good Hope. [Ab Alpibus verò, novo veluti annulari ordine implexi montes, Apennino junguntur, quo totius meditullium Italiae haud secus ac spina quaedam dorsi, optimâ ossium compage, continuata serie per Siciliam montibus Africae connectitur, & quos Lunae vocant.
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> Alter catenae magna nodum, usque ad ultimum Austri promontorium, Bonae spei nuncupatum, extenditur. . .] (Tome I, Book II, Chapter IX: 68)

Voltaire did not mention the Lunar Mountains, or Mountains of the Moon, in the Ruwenzori Range (on the border of the Congo and Uganda, slightly north of the equator, and apparently first referred to by Ptolemy), and Voltaire did not exactly follow Kircher's North-South trend in Europe. But he did so in Africa: he mentioned, as did Kircher, the "ultimo promontori d'Africa" (in *Saggio*) while Kircher said "ad ultimum Austri promontorium." Voltaire mentioned the rivers Zaire, Niger, and the Nile as Kircher did (p. 68). As Kircher, Voltaire described an imaginary South-North trend of mountains in Africa between the cape of Good Hope and the Atlas Mountains, obviously a sign that Voltaire was indeed following the *Mundus Subterraneus.*

According to Kircher, mountains were necessary for the stability of the earth and irrigation of that land. He said that God had "set up the mountains to serve, so to speak, as a kind of restraint to the spread of the waters, on the one hand to check the violence of floods and on the other to irrigate the earth with a constant, never-ending quantity of fluid." [Montes aquarum diffusioni veluti repagula quaedam opposuit, tum ad retundendam fluctuum contumaciam, tum ad aendem perpetuâ humoris nunquam deficientis copiâ irrigandam...] (Tome I, Book II, Chapter II: 56) Kircher's hydrological theory described a series of underground reservoirs which he thought to exist in every continent under the highest mountains. Voltaire discarded this idea of irrigation and replaced it with a more modern one by Halley, whom Voltaire had already mentioned in the deleted chapter X of *Eléments*: "Le docteur Halley a démontré par des calculs très-justes que l'eau, élevée des mers et des lacs par l'action du soleil, suffit à entretenir les nuages, les rivières et les fontaines; on sait que les nuages ne sont autre chose que les eaux atténuées flottantes dans l'air à une très-petite distance de la terre" (M.XXIV: 549). In the *Dissertation*, Halley's ideas are mixed with Kircher's notion of a "universal mechanism" for the benefit of mankind:

> Il n'y a pas un seul climat sur la terre sans montagnes et sans rivières qui en sorte. Cette chaîne de rochers est une pièce essentielle à la machine du monde. Sans elle, les animaux terrestres ne pourraient vivre: car point de vie sans eau. L'eau est élevée des mers, et purifiée par l'évaporation continuelle; les vents la portent sur les sommets des rochers, d'où elle se précipite en rivières; et il est prouvé que cette évaporation est assez grande pour qu'elle suffise à former les fleuves et à répandre les pluies. (p. 227)

Kircher's theory of mountain-building is a compromise between science and religion. Indeed, Kircher was not merely a spokesman of the church, he had also observed stone-quarries and had visited mines. He was aware that the earth had not remained the same since creation. He cited the opinion of the Ancients in relation to changing coastlines, decreasing mountains through erosion, and newly created ones through volcanic eruption and concluded that the world was not perfect (Tome I, Book II, Chapter XII: 83). However, he said that this was merely to warn mankind

of the uncertainty of human fortune. He believed that mountains existed since the beginning for the stability of the physical earth:

> And so it is first asked whether rocky mountains existed from the beginning of things or whether they came into existence over the passage of time from the silt or after the flood from the accumulation of an immense amount of mud. I will resolve this doubt with a few words, so that it retain no difficulty. And so I say that rocky mountains in the form of huge chains of mountains stretching from pole to pole and from east to west, as we have shown in *Book Three* were set up by the divine architect at once at the beginning of things, when by the divine will dry land appeared after the division of the waters. This is the opinion of many interpreters of the Holy Scripture: for unless the soft earth during those chaotic times at once hardened into hard rocks, the earth because of the excessive softness of the mud, could not have endured or performed its functions, as we have demonstrated at length at the place cited. And so the rocky structure of mountains was obviously necessary to stabilize and sustain the earth against the force of the sea and the tempestuous storms of rains and showers.
> [Quaeritur itaque primò: Utrum montes saxosi ab initio rerum extiterint, utrum successu temporis ex limo, aut post diluvium ex immensi luti coacervatione? Hoc dubium, uti nullam difficultatem habet, ita paucis quoque dissolvam. Dico itaque montes saxosos, cujusmodi, uti in *Tertio Libro* ostendimus, ingentes montium catenae, tum à polo ad polum; tum ex ortu in occasum protensae, statim ab initio rerum, dum Divino nutu post aquarum divisionem Arida compareret, à Divino Architecto constitutos fuisse, plerorumque Sacrarum Scripturarum Interpretum sententia est: Nisi enim limus ille Chaoticus in saxeam molem statim coaluisset, Tellus ex nimia limi mollitudine neque consistere, neque operationes suas exercere potuisset, uti citato loco fusè ostendimus. Saxosa itaque montium compages, ad terram contra maris impetum atque imbrium pluviarumque procellosas tempestas stabiliendam sustentandamque prorsus necessaria fuit.] (Tome II, Book VIII, Chapter II: 5)

In this passage Kircher gives a rather logical explanation for mountain-building on an earth created by God for the sake of man. This theory which neither accepted the idea of a wrathful God, nor any long-range processes fitted right into Voltaire's needs.

After the above passage Kircher, however, goes on to say:

> I would not deny, however, that muds and sands, accumulated into huge heaps, hardened into rocks over the passage of time from the various revolutions of the world and the many inundations; nor do I speak here of those stones or marbles which today are used in the construction of homes, temples, and other buildings, but only about the rocky substance of mountains, by which the body of the earth is sustained for the proper fulfillment of its functions — the structure which is, as it were, a kind of skeleton or mass of substructure intended by God for the firmer consistency of the entire geocosmos.
> [Non negarim tamen, è variis Mundi revolutionibus inundationumque diffusione, limum lutumque in ingentes cumulos coacervatum, successu temporis in lapidosam substantiam induruisse: neque loquor hîc de iis lapidibus seu marmoribus, quae quotidiano usu ad aedium, templorum, aliarumque fabricarum constructionem cedunt, sed de lapidosa tantum montium, qua Telluris corpus ad functiones suas probè subeundas,

sustentatur, substantia, quae est veluti ossatura quaedam, seu substructionis moles, à DEO ad totius Geocosmi firmiorem consistentiam intenta.]

In this passage Kircher clearly separated earlier rocks from later ones. These ideas were repeated in the eighteenth century by Bourguet, Bertrand and many others. For Voltaire's purpose, all he needed was a theory of the earth in which he could believe.

In the *Dissertation* Voltaire followed some of the basic tenets expressed in *Mundus Subterraneus* in regard to the utility of mountains which circle the globe and provide irrigation for all living things. In 1746, Voltaire did not insist with Kircher on the fact that the first mountains had been created at the very beginning of the earth. I have the impression, however, that the idea of an earth created by God for the benefit of mankind, as so convincingly expressed by Kircher, has left an indelible impression on Voltaire. It was difficult for him to replace that idea by a modern one which seemed much less convincing. It should be noticed that Voltaire was willing to replace Kircher's ideas of irrigation by the more modern explanation of Halley, but apparently he found no better substitute for Kircher's theory of the earth during his life.

H. Reaction of Contemporaries to Voltaire's Dissertation

Voltaire received from Italy a letter by C. Cossinio from the Academy of Bologna who agreed entirely with Voltaire's rejection of the Pythagoran thesis of great changes on the earth (D.3379).

In a memoir by Abbé Sauvages from Montpellier to the Academy of Sciences at Paris Voltaire seems to have been anonymously criticized:

> On remarquera que la quantité de coquillages pierreux de notre chaîne est si prodigieuse [...] qu'on ne peut les regarder comme les debris des tables d'une ville [...] Ces objections que des personnes d'esprit, mais peu versées dans l'Histoire Naturelle, m'ont fait bien sérieusement, ne méritent pas une plus ample réfutation. Il seroit donc absurde de penser que les coquillages pierreux eussent été portés de main d'homme sur notre chaîne. (Mémoires 1746: 1077-8)

The most famous reaction to Voltaire's *Saggio* was that of Buffon published in 1749 in the chapter on fossils in his *Histoire naturelle*:

> En lisant une lettre italienne sur les changemens arrivés au globe terrestre, imprimée à Paris cette année (1746), je m'attendois à y trouver ce fait rapporté par La Loubère, il s'accorde parfaitement avec les idées de l'auteur; les poissons pétrifiés ne sont, à son avis, que des poissons rares, rejetés de la table des Romains, parce qu'ils n'étoient pas frais; & à l'égard des coquilles, ce sont, dit-il, les pèlerins de Syrie qui ont rapporté dans le temps des croisades celles des mers du Levant qu'on trouve actuellement pétrifiées en France, en Italie & dans les autres États de la chrétienté, pourquoi n'a-t-il

> pas ajouté que ce sont les singes qui ont transporté les coquilles au sommet des montagnes & dans tous les lieux où les hommes ne peuvent habiter, cela n'eût rien gâté & eût rendu son explication encore plus vraisemblable. Comment se peut-il que des personnes éclairées & qui se piquent même de philosophie, aient encore des idées aussi fausses sur ce sujet? nous ne nous contenterons donc pas d'avoir dit qu'on trouve des coquilles pétrifiées dans presque tous les endroits de la Terre où l'on a fouillé, & d'avoir rapporté les témoignages des auteurs d'Histoire Naturelle; comme on pourroit les soupçonner d'apercevoir, en vue de quelques systèmes, des coquilles où il n'y en a point, nous croyons devoir encore citer les voyageurs qui en ont remarqué par hasard, & dont les yeux moins exercés n'ont pu reconnoître que les coquilles entières & bien conservées: leur témoignage sera peut-être d'une plus grande autorité auprès des gens qui ne sont pas à portée de s'assurer par eux-mêmes de la vérité des faits, & de ceux qui ne connaissent ni les coquilles, ni les pétrifications, & qui n'étant pas en état de faire la comparaison, pourroient douter que les pétrifications fussent en effet de vraies coquilles, & que ces coquilles se trouvassent entassées par millions dans tous les climats de la Terre. (1749: 281-282)

The whole paragraph, including the satirical reference to monkeys as carriers of seashells, was meant for Voltaire; no wonder he could never forget the insult or slander in a book which became a bestseller (Mornet: 248). No wonder that he subsequently devoted several years to investigate geological phenomena personally, to read more about the subject, and finally to criticize Buffon in turn.

Buffon knew quite well that the author of the Italian letter was Voltaire and not La Loubère since Voltaire had acknowledged authorship of the *Saggio* as I mentioned in section C. (See also the *Saggio* in the appendix.) Simon de La Loubère was the author of *Du royaume de Siam* (1691) where he mentioned birds, apes, and Hottentots as possible carriers of fossils on top of Table Mountain in South-Africa (1969, II: 183). After Voltaire's death, Buffon wrote in 1778 a footnote which presents his excuses to Voltaire, whether sincerely or not. He presumably wanted the posterity to know that he had been ignorant of the authorship of the Italian letter, and that he would never have criticized such a genius as Voltaire (1850-1860: 161-162). Nevertheless, Voltaire seems to have been deeply hurt and would never forget in his later essays on scientific matter to jeer at "l'auteur estimable de l'Histoire naturelle."

I. Voltaire's Attitude toward Geology in 1746

In order to compare Voltaire's attitude toward geology in his *Dissertation* with his later *Singularités*, it is necessary to summarize what Voltaire believed in 1746.

The *Dissertation* is written in a style which makes it difficult to judge whether or not Voltaire was simply laughing at all systems. There is, however, a stylistic change from the impersonal "on" to the personal "je" which gives me the impression that underneath all that laughter, Voltaire tried seriously to reach for some personal "truth" on how the world was formed. His work on Newton's physics had given

him an introduction to all sciences. He had read about laws of nature and acquired an interest in scientific problems which would remain for the rest of his life.

Voltaire, nevertheless, had started out on the wrong foot. His involvement with Newton seems to have made a frustrated scientist out of him. Not being versed in astronomy and physics myself, I find it impossible to appreciate how close to an understanding of Newton Voltaire had come. From his correspondence I can only guess that his lack of training in mathematics and his simultaneous involvement with literature, history, and science during his years at Cirey must have given him an understanding of Newtonianism which was inferior to that of Mme du Châtelet, the woman he had originally wanted to please with his interest in Newton, or of Maupertuis and others who concentrated on one thing at a time. Moreover, his papers to the Academy of Sciences received no prize and the doors to that Academy remained shut to Voltaire. He must have felt rejected, both as a person and as a scientist.

His fear of being considered incompetent and ignorant in sciences made Voltaire resort to various approaches. He shrouded all his remarks on science in satire so that nobody would guess whether he was serious or not. He also tried to learn as much as possible on new sciences such as geology; I believe that he read the Italian Scilla, perhaps to discover "truth" outside of France. Once he had done his homework, he took pleasure in criticizing systems which were based on fallacious interpretation.

His attitude toward fossils shows that he had read many books and that in reference to some "easy" fossils in Calabria and Touraine — that is those close to the sea and not extinct — he was almost ready to accept the idea that the sea had indeed deposited these fossils in the past. However, in the same essay, just one page earlier, he showed his uncertainty by wavering between four different hypotheses: either the sea of Syria had transported sea-shells to France and Italy; they had been carried by pilgrims from the Holy Land; they might be "fossiles" engendered by the earth; or they might have lived and died in ancient lakes. All these arguments show that in 1746 Voltaire had not examined one single fossil personally and did not know whom to believe. The *Dissertation* is therefore a retaliation against systems when he himself had nothing more than common sense to propose; in general, all he could do was to suggest some more "natural" means such as petrified leftover fish from some traveler's meal to account for fossil fish in mountains.

While reaching for his own theory of the earth, Voltaire refuted both the academicians and the diluvialists and turned to a theory that he must have read in his early youth: Kircher's *Mundus Subterraneus*. Voltaire could not visualize a globe with a different surface and without life although he had made the effort to explain wandering oceans by the movements of the earth's axis. He finally rejected the theory of the Indian Ocean by Fontenelle while he agreed that coastal areas had been invaded by the sea during a long period of time. Scilla's theory of mountain-building could

only explain mountains in Mediterranean countries where fossil shells are easily accounted for by the proximity of the sea and the uplifting action of volcanism. Voltaire was, however, speaking about great mountain-chains which crossed the earth. These mountains could hardly be the result of ocean-currents at the bottom of the sea as proposed by Maillet, where would men have lived during that time? Voltaire seemed particularly reluctant to separate the history of the earth and the history of man and thus retained Kircher's theory of mountain-chains which were necessary to irrigate and provide life to animals and plants.

Voltaire's attitude toward geology in *Dissertation* contains, in an embryonic stage, many tendencies that he was going to develop more fully in *Singularités*: a personal retaliation against the ideas of some academician; an awareness that many proposed systems were unsound and could not explain mountain-building; a scientific attitude which opposed generalizations and preferred exact identification and description of natural phenomena such as that which he had found in Scilla; an adherence to a theory of the earth which promised life to plants and animals and was the most logical or least unsound theory of mountain-building at that time. Lastly, the *Dissertation* expresses a need for satire to ridicule systems, probably as a defense against criticism and as a weapon. It took, however, Buffon's criticism of Voltaire's ideas on fossils to make him realize that if he wanted to criticize others, he had to base his view on personal investigation.

CHAPTER II

LES SINGULARITÉS DE LA NATURE

After the publication of the *Dissertation* Voltaire remained silent on geological subjects for a long time. Small remarks here and there, however, point to the fact that he had not forgotten Buffon's criticism nor had he failed to read Buffon's *Théorie de la Terre*, Maillet's *Telliamed*, and probably some of Bertrand's work which he received while living on the shores of Lake Geneva. Before discussing Voltaire's later remarks on geological features found in that area, we must return briefly to works which were published after 1746.

A. New Theories of the Earth after 1746

In the *Théorie de la terre*, included in the first volume of *Histoire naturelle*, published in 1749, Buffon, like Maillet, assumed a long geological time for the deposition of sediments on the bottom of the sea and their shaping into mountains by ocean currents. Like Maillet he assumed that conforming angles in mountains were proofs that ocean-currents had cut through sediments on the sea floor and had created these conforming angles. Buffon also accepted Maillet's view that marine fossils existed everywhere, even on the highest mountains. However, Buffon never mentioned any diminution of the sea to account for the dry lands. How then did his mountains emerge from the sea? Frankly, Buffon had no answer but he proposed:

> Lorsqu'une fois on a commencé à soupçonner qu'il se pouvait bien que notre continent eût autrefois été le fond d'une mer, on se le persuade bien-tôt à n'en pouvoir douter; d'un côté ces débris de la mer qu'on trouve par-tout, de l'autre la situation horizontale des couches de la terre, & enfin cette disposition des collines & des montagnes qui se correspondent, me paraissent autant de preuves convaincantes... (1749: 581-582)

Buffon never went beyond this assumption in his theory of 1749 and it was criticized by many naturalists and philosophers, including Voltaire.

The problem with all theories in the eighteenth century is clearly stated by Buffon:

> Mais comment est-il arrivé que cette terre que nous habitons, que nos ancêtres ont habitée comme nous, qui, de temps immémorial est un continent sec, ferme & éloigné des mers, ayant été autrefois un fond de mer, soit actuellement supérieure à toutes les eaux & en soit si distinctement séparée? Pourquoi les eaux de la mer n'ont-elles pas resté sur cette terre, puisqu'elles y ont séjourné si long-temps? Quel accident, quelle cause a pu produire ce changement dans le globe? Est-il même possible d'en concevoir une assez puissante pour opérer un tel effet? (1749: 95)

Buffon's way out of this dilemma was to give many proofs of geological features as they were reported either to him, or described in travel stories. Based on these uncertain facts he wavered between long-lasting and catastrophic events:

> Si nous prêtons un instant à supposer que l'ancien & le nouveau monde ne faisoient autrefois qu'un seul continent, & que, par un violent tremblement de terre, le terrain de l'ancienne Atlantide de Platon se soit affaissé, la mer aura nécessairement coulé de tous côtés pour former l'océan Atlantique, & par conséquent aura laissé à découvert de vastes continens qui sont peut-être ceux que nous habitons; ce changement a donc pu se faire tout-à-coup, [. . .] il a fallu peut-être beaucoup de temps, mais enfin il s'est fait, & je crois même qu'il s'est fait naturellement; car pour juger de ce qui est arrivé, & même de ce qui arrivera, nous n'avons qu'à examiner ce qui arrive. (1749: 96)

Buffon was influenced by horizontal layers of rocks as he had observed them in the Paris Bassin and did not believe that earthquakes had formed mountains:

> Il n'y aurait donc pas d'impossibilité absolue à supposer que les montagnes ont été élevées par des tremblemens de terre, si leur composition intérieure aussi bien que leur forme extérieure, n'étoient pas évidemment l'ouvrage des eaux de la mer. L'intérieur est composé de couches régulières & parallèles, remplies de coquilles; l'extérieur a une figure dont les angles sont par-tout correspondans, est-il croyable que cette composition uniforme & cette forme régulière aient été produites par des secousses irrégulières & des explosions subites! (1749: 524-525)

The theory of the earth, as it was published in 1749, included thus a synthesis of earlier works and many speculations which Voltaire was going to criticize in many of his works after 1760. He never saw Buffon's additions and corrections published in 1778, the year of Voltaire's death, where Buffon finally accepted that the sea alone could not have formed mountains.[1]
(A more detailed discussion of Buffon's theory is in chapter IV.)

In regard to fossils, Buffon refuted the ideas of the English diluvialists. He pointed to the huge accumulations of thousands of feet of fossil shells all over the world, in particular in Touraine, and cited Fontenelle's entire account of Réaumur's memoir on the faluns of Touraine as the main evidence noticed in France (1749:

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[1] This acceptance is in Buffon's complete works (1850-1860, Paris, Poulain et Cie. p. 146. According to the editor Jean Piveteau of *Œuvres philosophiques* (1954, Paris, Presses Universitaires, p. 110, 524) the *Additions* and *Corrections* for the different chapters of the *Preuves* were published in 1778. There Buffon said:

> ... depuis trente-quatre ans que cela est écrit, j'ai acquis des connaissances et recueilli des faits qui m'ont démontré que les grandes montagnes, composées de matières vitrescibles et produites par l'action du feu primitif, tiennent immédiatement à la roche intérieure du globe, laquelle est elle-même un roc vitreux de la même nature: ces grandes montagnes en font partie, et ne sont que les prolongements ou éminences qui se sont formées à la surface du globe dans le temps de sa consolidation; on doit donc les regarder comme des parties constitutives de la première masse de terre, au lieu que les collines et les petites montagnes qui portent sur des argiles, ou sur des sables vitrescibles, ont été formées par un autre élément, c'est-à-dire le mouvement et le sédiment des eaux dans un temps bien postérieur à celui de la formation des grandes montagnes produites par le feu primitif. (p. 146)

266-271). Buffon suggested that ammonites and other fossils which had no living analogues might still be living at the bottom of some deep ocean, or they might have perished (1749: 290). The Sorbonne objected to fourteen propositions made by Buffon in his theory of the earth, in particular to the theories of the change from land to sea, to the creation of the earth by a comet, and to the possible extinction of the sun in the future. Other propositions concerned the philosophical notions of "truth" and "soul" (Piveteau 1954: 106-109). It is strange that his negation of the deluge, his unbiblical time-scale, and his theory of the possible extinction of species were not criticized.

Buffon's unorthodox view on geology was rejected by Bourguet, as mentioned above, and by Elie Bertrand, naturalist and theologian, also living at Neuchâtel. Bertrand developed Bourguet's ideas in his *Mémoires...* published in 1752. Like Bourguet he was hampered by the belief that the earth was only some six thousand years old and he was therefore searching for some explanation to oppose the view of a long-lasting invasion by the sea. He rejected catastrophic events as proposed by the English diluvialists and argued that he had not witnessed any catastrophe in his life — this was before the Lisbon earthquake of 1755. Furthermore, catastrophes mentioned by the Ancients could not have deposited such huge quantities of fossils in such a short time. Therefore, he believed in 1752 in three different origins of fossils. 1) Fossils of regular and constant shape (for instance belemnites, geodes, shark teeth, agates, etc.) were created at the same time as the primitive rocks, at the beginning of the earth. God had made some fossils resemble living marine organisms in order to excite our admiration. 2) After the retreat of the universal deluge, the surface of the Earth suffered some less important changes of which the remains of plants and marine fossils, mixed with terrestrial fossils, provide evidence. 3) Subsequent accidents such as a change of the position of the oceans may have provided a third kind of fossils. "Ainsi prétend-on que ce quartier de la Touraine, où l'on trouve cet amas prodigieux de Coquilles marines, a été couvert de la Mer. Mais on ne fournit aucune preuve à cette supposition (1752: 96-132).

Elie Bertrand, who was the protestant minister of the French church at Berne between 1744 and 1765 probably allowed his scientific attitude to be dominated by his religion. Once he was free of his religious duties, however, he published all his former works in a *Recueil* (1766) where he made a complete turn-about and wrote in a footnote that he now believed in the marine origin of most fossils (p. 74). However, he never accepted Buffon's ideas of mountain-building.

Both Bertrand and Bourguet — and as we shall see also Voltaire — were influenced by geological surroundings. They lived at the foot of the Jura Mountains facing the Alps and could not visualize how the sea might have brought marine fossils into these regions. For Réaumur, Jussieu, and Buffon, on the other hand, it was quite easy to imagine transgression and regression of the sea because they lived in the relatively flat regions of Lyons, Tours, Paris, and Montbard (the home of

Buffon in the Côte d'Or), and observed mostly horizontal or gently inclined layers of rocks.

Pierre Barrère, professor of medicine at the University of Perpignan, published in 1746 a small book which gave the impression that, at last, the fossil controversy had come to an end. He rejected all earlier theories on the origin of fossils, namely "des semences, des pierres figurées, des moules indépendens des corps organisés, des formes Plastiques, des jeux de hasard que d'anciennes hypothèses d'une Physique stérile avait autrefois adoptées" (Barrère 1746: 21-22). He described personal observations made in the Pyrenees and those made by others and said that all these observations showed clearly that fossils were remains of the plant or animal kingdom. He was a student of medicine and had compared fossils with living analogues. He could not explain ammonites found in mountains, however, nor how they had been transported there. Like Fontenelle, he believed that the sea must have covered the continent (p. 41, 43).

Despite Barrère's attitude of certainty, the fossil controversy did not cease before the end of the eighteenth century. But after Barrère, many naturalists preferred simply to classify, catalogue, and describe fossils without explaining their origin or their position. Fontenelle had proposed in 1720 that maps should be drawn showing the different locations where fossils occurred (1720: 11-12). This was done in 1780 by Jean-Etienne Guettard (Rappaport 1969: 273-287). He wrote several memoirs on fossils which were published after the death of Voltaire. Rhoda Rappaport described Guettard as a "fact-gatherer of inexhaustible energy," and that "the talent he most conspicuously lacked was that of generalization, of seeing the implication of his own observations" (1969: 277). A study of Guettard's memoirs, however, reveals that the state of knowledge in paleontology, comparative anatomy, botany, and zoology probably did not allow generalization of this kind. Guettard said, for instance: "L'anatomie comparée n'est pas encore avancée, sur-tout pour ce qui regarde les squélettes, de façons à pouvoir porter dans cette matiere, tout le jour & toute la clarté qu'elle demande... (1768, I: v). Elsewhere he said: "Nous sommes encore peu avancés sur cette partie de l'histoire des fossiles, & que cela doit beaucoup engager les Naturalistes à ne négliger aucuns des corps fossiles qu'on trouve dans la terre ou qu'on pêche dans la mer; ce n'est qu'en ne négligeant aucun de ces corps, si peu frappant qu'il soit par sa figure, qu'on parviendra à reconnoître les analogues les uns des autres..." (II: xx-xxj). And, "Il est donc encore très-difficile de constater quelles peuvent être les especes de corps marins que l'on pêche journellement, & dont les Cabinets d'Histoire naturelle s'enrichissent tous les jours, qui peuvent être regardées comme étant celles que nous rencontrons dans la terre, & qui y sont dans un état de pétrification" (II: 171). Guettard's remarks show the uncertainty that still existed in the study of fossils, even after the middle of the century.

The eighteenth century has been called a "period of assimilation, consolidation, and stock-taking, the age of popularizers, classifiers, and systematizers; of Fontenelle,

Linnaeus, and Buffon, of the *Philosophes* and *Encyclopédistes*" (Koestler 1975: 228). Colm Kiernan also mentioned that the "central problem of the intelligentsia was to come to terms with the scientific achievement of the previous century," in particular with Descartes's and Newton's mechanistic propositions (1968: 21). Indeed, Fontenelle accepted Descartes's "tourbillons" in *Entretiens sur la pluralité des mondes*, while Voltaire explained Newton's laws of attraction or gravity in his *Eléments* to the laymen. Fontenelle and Voltaire were popularizers while Buffon and Linnaeus built systems and classified phenomena in natural history. However, theories of the earth could not go much beyond what had been said before as long as related sciences failed to shed some light on the complexity of natural processes. Whether mountains were built by the sea or by fire could not be answered before the nature of rocks was understood. Fossils found on land could not be explained before living things were better understood and before more was known about the geologic history of the earth and, last but not least for Voltaire's interpretation of fossils, before freshwater organisms could be distinguished from marine ones.

B. The Incident of the Singularités

Voltaire's correspondence helps us somewhat to understand why Voltaire wrote *Les Singularités de la nature*. The written word, however, does not record the conversations Voltaire had with many naturalists while he lived on the shores of Lake Geneva. For instance, he knew personally the young Horace-Bénédict de Saussure from Geneva, naturalist and active Alpinist since 1760 (Freshfield 1924: 123); Voltaire received the visits of his naturalist friends from Neuchâtel Elie Bertrand, with whom he corresponded between 1755 and 1773, and Samuel Fréderic d'Osterwald, the "banneret" of Neuchâtel who wrote an essay on the geology of the Jura Mountains (De Beer 1952: 96). The English naturalist John Strange, F.R.S., also visited Voltaire at Ferney (De Beer 1952: 98), as well as Guettard from France (Guettard 1738, IV: 12). Thus while the text of *Singularités* indicates that Voltaire had observed rocks and fossils and that his conclusions were often based on his personal observations, we cannot tell whether his conclusions were influenced by the opinion of his neighbors and naturalist friends. Although some influence of Bertrand's cosmology can be detected, we shall never know how much Voltaire owned to others, for instance to the younger Saussure whose ideas became very influential in the latter part of the eighteenth century. We can only guess that Guettard's visit might have left some marks on Voltaire, a topic to be discussed later in this chapter.

Undoubtedly, Voltaire's relationship with Elie Bertrand, who was both a naturalist and a theologian, must have influenced Voltaire's attitude toward geology. By 1773, the latter had received most of Bertrand's works: *Mémoires sur la structure*

LES

SINGULARITÉS

DE

LA NATURE.

PAR

Un Académicien de Londres, de Boulogne, de Petersbourg, de Berlin, &c.

A BASLE,

1768.

FIG. 3. — Title page of the original edition of *Les Singularités de la nature*, printed by Cramer, Geneva, not at Basel.

intérieure de la terre (1752); *Essai sur les usages des montagnes* (1754); *Instructions chrétiennes* (1756); *Mémoires sur les tremblemens de terre avec quatre sermons* (1756); *Mémoires historiques et physiques sur les tremblemens de terre* (1757); *Dictionnaire universel des fossiles propres et des fossiles accidentels...* (1763); *Essai sur l'art de former l'esprit, ou premiers élémens de la logique* (1764); *Elémens d'oryctologie, ou Distribution méthodique des fossiles* (1773). All these works figure in the catalogue of books formerly owned by Voltaire and now in the Leningrad Library (Nos. 378-386) and many of them are mentioned in Voltaire's letters as having been received.

The relation between the two men seemed to be one of "sympathie intéressée [...] de part et d'autre," (Roulet 1950: 66-67). Indeed the correspondence is heaviest between 1755, when Voltaire settled on the shores of Lake Geneva, and 1765, when Bertrand quit his job as minister in Bern. During that time, Bertrand was able to provide contacts with the proper authorities at Bern for Voltaire's protection at Lausanne (Lausanne belonged then to the Republic of Bern) and to hush up scandals related to Voltaire's antichristian works (Roulet 1950: 68-70, 91, 167). Voltaire in turn helped Bertrand to publish articles in the French *Encyclopédie* (D.7729), to become a member of the Academy of Lyons (D.8146, 8170, 8202, 8255), to sell his cabinet of natural history to the Elector of Saxony (D.11527, 11640), and to find employment for some of Bertrand's relatives (D.18017, 12058). Voltaire and Bertrand thus seemed to have developed a relationship of mutural benefit on the social level.

On the scientific level, the two men seemed to agree that an intelligent "architect" had created the earth. Voltaire told Bertrand: "J'attends avec la plus grande impatience votre dissertation sur les tremblements de terre. Vous connaissez si bien les montagnes que vous devez connaître aussi les cavernes. Vous nous instruisez sur tous les recoins de notre habitation et principalement sur le grand architecte qui l'a bâtie..." (D.6766).

Voltaire had become interested in earthquakes after the Lisbon earthquake and sent to Bertrand some accounts on the earthquake at Syracuse saying, "il faut qu'il soit enregistré dans le greffe de mon cher philosophe" (D.7428).

Voltaire had also expressed great enthusiasm about the usefulness of Bertrand's dictionary on fossils (D.10894). They both doubted the marine origin of fossil shells found in mountains and considered ammonites, for instance, as "figured stones" or petrifications. In a letter Voltaire entertained Bertrand with his cherished pun on Venus shells: "On vous a envoyé des pétrifications, Eh bien y en a-t-il de plus singulière que la conche *veneris* et la langue de chien marin? Cependant ni les chiens marins ne sont venus déposer leur langue en Calabre, ni Venus n'y a laissé son bijou." I have mentioned in chapter I that in the eighteenth century both shark teeth and Venus shells were interpreted as marine fossils.

Following this pun on Venus shells, Voltaire formulated very clearly his opinion on freshwater fossils:

> On vous a montré des coquilles. Eh bien y avait-il de meilleures huîtres que dans le lac Lucrin? et tous les lacs n'ont-ils pas pu fournir des huîtres et des poissons? Que la mer soit venue à cinquante lieues dans les terres, qu'elle forme, et qu'elle absorbe des îles, cela est commun, mais qu'elle ait formé la chaîne des montagnes du globe, cela me paraît phisiquement impossible. Tout est arrangé, tout est d'une pièce. *Si quid novisti rectius sistis, candidus imperti...* [If you know better, tell me] (D.7481)

In the above letter, Voltaire agreed, as he had in the *Dissertation*, and as he was to agree until 1767, that the sea had probably invaded the continents as far as fifty leagues. He immediately added, however, that the sea had not formed the mountains and that, on the contrary, fossils found there were probably of lacustrine origin (Lake Lucrin was in the former Campania in Italy.). Voltaire had mentioned freshwater fossils for the first time in his *Dissertation* (p. 223); however, in this letter he referred to fossil shells found in mountains rather than in plains since he agreed that the sea had invaded the land up to fifty leagues.

The correspondence between Bertrand and Voltaire gives no further clues about how the *Singularités* were conceived. There was indeed no exchange of letters between 1766 and 1770. After 1765 Bertrand was for a while privy councillor to Stanislas Poniatovsky, King of Poland, and then he returned to live at Yverdon (De Beer 1952: 99). In a *Recueil* of all his former works he added in a footnote: "J'avoue que depuis 1752 que j'écrivois ces Mémoires, j'ai changé d'idée & reconnu qu'il n'étoit pas possible de nier que les pétrifications des corps Marins n'ayent été des corps animés ou Végétaux, qui ont en effet appartenu à la mer" (1766: 74). Earlier Bertrand had maintained that God created all these "figured stones" (1766: 75), in particular those that had no living analogues such as ammonites. Apparently, Bertrand did not send this book to Voltaire, at least it is not in his library and there is no exchange of letter mentioning it, and we do not know whether Bertrand told Voltaire of his change of mind. There are no letters after October 1773 from the "vieux malade" to Bertrand.

I am unable to attribute the publication of Voltaire's *Singularités* to any correspondence between Voltaire and any other naturalist. The work was published simply in connection with a series of other works involving Larcher and Buffon. After the printing of *La Philosophie de l'histoire de feu l'Abbé Bazin* in 1765, Pierre Henri Larcher criticized Voltaire in *Supplément à la Philosophie de l'Histoire de feu l'Abbé Bazin* in 1767. Voltaire's reply to Larcher was *La Défense de mon oncle*, published in June or July 1767. Because the first chapter of *La Philosophie de l'histoire* had mentioned some geological theories, Voltaire had to mention geology again in *La Défense de mon oncle*. Whereas the names of naturalists had not been mentioned in *La Philosophie...*, Voltaire in his character of the "neveu de feu l'abbé Bazin" decided to take revenge both on Larcher and Buffon in *La Défense de mon oncle*. We should remember that Buffon had criticized Voltaire's pilgrim story in his first edition of *Histoire naturelle* in 1749 and that Voltaire had been remarkably quiet for almost

twenty years. It is possible that Buffon came into the picture as a result of the publication of his *Complete Works* which were sent to Voltaire by Panckoucke. The first edition of the complete fifteen volumes was finished in 1767 (Piveteau 1954: 522) and a letter by Voltaire (March 1768) acknowledges receipt of these volumes (*Œuvres*, ed. Furné & Cie, vol. 12, p. 883; this letter is missing in Besterman). Thus, the republication of Buffon's works with its ironical reference to the pilgrim story in the *Théorie de la terre* might have inspired Voltaire to retaliate against Buffon.

In February 1768, Voltaire took a second step. He was well aware that many of Buffon's ideas had been mentioned before by Maillet and in *L'Homme aux quarante écus*, he criticized Maillet's theory on mountain-building as well as his beliefs on transformism. This work was condemned September 24, 1768 by the Parlement of Paris (Pléiade, *Romans*, p. 686) which may have incited Voltaire to publish another essay in a semi-scientific tone, the *Singularités*.

Compared to *La Défense de mon oncle* and *L'Homme aux quarante écus*, *Les Singularités de la nature* strike indeed as a more serious essay. A letter to Mme du Deffand indicates that Voltaire believed that *Singularités* would be too serious for her: "Vous souciez-vous, madame, d'un petit ouvrage nouveau dans lequel on se moque, avec discretion, de plusieurs systèmes de philosophie? Cela est intitulé *Les Singularités de la nature*. Il n'y a d'un peu plaisant, à mon gré, qu'un chapitre sur un bâteau de l'invention du maréchal de Saxe, et l'histoire d'une Anglaise qui accouchait tous les huit Jours d'un lapin. Les autres ridicules sont d'un ton plus sérieux" (February 3, 1769, D.15459). Apparently Mme du Deffand had not asked for the essay and Voltaire reminded her: "Je ne vous les envoie pas, car c'est une affaire de pure phisique qui ne pourrait que vous ennuier (March 8, 1769, D.15506). These letters show that Voltaire considered *Singularités* to be a scientific work and that it could not be compared with the other essays published shortly before.

C. Voltaire's Ideas on Geology in Works previous to Singularités

Since many ideas on mountain-building and on fossils existed in embryonic form in some of Voltaire's works written a short time before the *Singularités*, it is necessary briefly to analyze the relevant parts of these works in chronological order.

When Voltaire wrote *Histoire de l'Empire de Russie sous Pierre le Grand*, he introduced the idea that there were no great mountain-chains from Petersburg to Peking in China, and that from Northern France to Petersburg, there existed hardly any hill. "Cette observation peut faire douter de la vérité du système dans lequel on veut que les montagnes n'aient été formées que par le roulement des flots de la mer..." (M.XVI: 395). In a letter to Jean Schouvalow, at the court of Catherine II, Voltaire admitted that there were some mountains in China, but added, "on pourrait aller par terre, et très aisément, de Petersbourg au fond de la France, presque toujours

par des plaines. C'est une observation physique assez importante, et qui sert de réponse au système, aussi faux que célèbre, que le courant des mers a produit des montagnes qui couvrent la terre" (D.9818). These remarks on mountains and their absence in some lowlands of Europe show that Voltaire had apparently not forgotten Buffon's system which he considered "aussi faux que célèbre." It should be noticed, nevertheless, that Buffon's theory never stipulated that mountains were to cover every inch of exposed land but that ocean currents had formed mountains and valleys or plains (1749: 97).

In *La Philosophie de l'histoire*, published in 1765, Voltaire admitted some changes on the surface of the earth: "Il se peut que notre monde ait subi autant de changements que les états ont éprouvé de révolutions." This introduction was apparently addressed to the Empress of Russia, Catherine II, to whom Voltaire said:

> Il paraît prouvé que la mer a couvert des terreins immenses chargés aujourd'hui de grandes villes et de riches moissons. Vous savez que ces lits profonds de coquillages qu'on trouve en Touraine, & ailleurs, ne peuvent y avoir été déposés que très lentement par le flux de la mer dans une longue suite de siècles. La Touraine, la Bretagne, la Normandie, les terres contigues, ont été partie de l'Océan bien plus longtemps qu'elles n'ont été des provinces de France & des Gaules. (*The Complete Works of Voltaire*, 59: 90-91)

Voltaire accepted in 1765 the general opinion of the Academy of Sciences according to which fossil shells had been deposited as far as Touraine, as he had in the *Dissertation* (p. 223), and in his letter to Elie Bertrand (D.7441). In *La Philosophie de l'histoire* Voltaire also agreed with naturalists of his century who believed that many past changes had taken place along the sea shores and in volcanic areas. He did, however disagree with them on one point:

> Je n'oserais pourtant assurer que la mer ait formé ou même côtoyé toutes les montagnes de la terre. Les coquilles trouvées près de ces montagnes peuvent avoir été le logement des petits testacées qui habitaient des lacs; & ces lacs qui ont disparu par des tremblements de terre, se seront jettés dans d'autres lacs inférieurs. (p. 90-91)

For the second time, Voltaire repeated in this passage the freshwater origin of fossils found in mountains. His words are similar to those mentioned earlier by Leibniz (1693, trans. 1859: 48). He then proceeded to repeat the pun on Venus shells, shark teeth, and other strange "petrified stones," and referred to a story told by Plato about a sunken continent "Atlantide," suggesting that this continent might be the island of Madeira. In the *Third Paris Notebook*, Voltaire had sketched his first ideas on that continent: "Il faut commencer par l'ancienne géographie, éxaminer si l'île Atlantide n'était pas l'île de Madère; comparer l'Amérique à l'ancien monde." He had also said there: "L'océan peut avoir pénétré jusqu'à deux ou trois cents milles dans les terres, et s'être ensuitte retiré; mais il n'a pu former la chaîne de montagnes qui couvrent le globe, ni s'être élevé sur ces montagnes. Quelques coquil-

lages qu'on trouve dans certaines montagnes peuvent servir à prouver qu'il y a eu autrefois des lacs, lesquels se seront ensuite confondus dans d'autres lacs moins élevés" (*The Complete Works of Voltaire*, 82: 492-493).

In *La Philosophie de l'histoire* many opinions on past changes on the surface of the earth held by contemporaries are repeated. Voltaire agreed with all of them, even the marine invasion of Touraine and other coastal areas, with the exception of the fact that fossils found in mountains must be of freshwater origin and that the sea had not formed mountains. In this work, Voltaire did not mention the "pilgrim story" nor the possibility of some "fossiles" formed in the earth as he had in the *Dissertation*.

In the *Avant-Propos* to *Essai sur les Mœurs*, apparently written after the *Philosophie de l'histoire* (since he said in the latter work: "c'est ce que vous avez déjà vu dans la Philosophie de l'histoire"), Voltaire repeated that the sea had invaded "toutes les campagnes basses arrosées par les fleuves du Rhin, de la Meuse, de la Seine, de la Loire" during a long period of time. He then refuted the theory of mountain-building by the sea in four points: 1. Several mountains are as high as 15,000 feet above sea level. 2. Mountains are necessary structures of the earth; they are reservoirs and are indispensable for the life of animals. 3. Mountains underlying the ocean would be a violation of the laws of nature, in particular of gravity and hydrostatics. 4. The present bottom of the sea does not contain any new mountain-chains, therefore, the great mountain-chains must have always been the same. Voltaire warned that one should not generalize and say that the sea once covered the Alps just because it once covered the lower parts of France. The *Avant-Propos* again, contains no mention of the "pilgrim story" nor of any formation of fossils in the earth (M.IX: 163-164).

In *La Défense de mon oncle*, published in June-July 1767, chapter XIX, "Des montagnes et des coquilles", Voltaire criticized Buffon: "J'avouerai ingénument que mon oncle avait le malheur d'être d'un sentiment opposé à celui d'un grand naturaliste qui prétendait que c'est la mer qui a fait les montagnes; qu'après les avoir formées par son flux et son reflux, elle les a couvertes de ses flots, et qu'elle les a laissées toutes semées de ses poissons pétrifiés" (M.XXVI: 405). Referring to Buffon's criticism of the pilgrim hypothesis in the first volume of *Histoire naturelle*, he said:

> Quand je lus, il y a quarante ans, qu'on avait trouvé dans les Alpes des coquilles de Syrie, je dis, je l'avoue, d'un ton un peu goguenard, que ces coquilles avaient été apparemment apportées par des pèlerins qui revenaient de Jérusalem. M. de Buffon m'en reprit très-vertement dans sa *Théorie de la Terre*, page 281. Je n'ai pas voulu me brouiller avec lui pour des coquilles; mais je suis demeuré dans mon opinion, parce que l'impossibilité que la mer ait formé les montagnes, m'est démontré. (M.XXVI: 408)

(Voltaire might be referring to Maillet's manuscript which he had read forty years previously.)

Voltaire then proved in nine points why Buffon's theory was wrong. 1. If the mountains had been shaped by the ebb, the flow would have destroyed them. 2. The ebb might have created the dunes at Dunkerque but nothing more. 3. If it takes six thousand years to accumulate forty feet of sand, it would have taken thirty million years to reach 20,000, the highest peak in the Alps, and they would still consist of sand only. 5. Ocean currents could not have formed circular mountains. 6. If the sea had covered the highest mountains, thirty-nine oceans would have been necessary. 7. At that time only fish would have lived on our globe. 8. If the sea had covered the Alps, there would have been no freshwater for animals (M.XXVI: 405-406).

The ninth and final point is based on personal observations:

> Je sais qu'on parle beaucoup de coquilles. J'en ai vu tout comme un autre. Les bords escarpés de plusieurs fleuves et de quelques lacs en sont tapissés; mais je n'y ai jamais remarqué qu'elles fussent des dépouilles des monstres marins: elles ressemblent plutôt aux habits déchirés des moules, et d'autres petits crustacés de lacs et de rivières. Il y en a qui ne sont visiblement que du talc qui a pris des formes différentes dans la terre. Enfin nous avons mille productions terrestres qu'on prend pour des productions marines. (M.XXVI: 406)

It appears as if Voltaire had personally looked at fossils and had found them lining rivers and lakes, and to him they resembled freshwater mussels and crustaceans. Talc was often confused with mica and tests of shells in the eighteenth century. Subsequently Voltaire expressed doubts concerning the marine origin of the faluns of Touraine. It is of great importance to notice that Voltaire's personal investigation of actual fossils seems to have coincided with his questioning of the received opinion concerning the faluns of Touraine:

> Je suis même tenté de croire que ce fameux falun de Touraine n'est autre chose qu'une espèce de minière: car si c'était un amas de vraies dépouilles de poissons que la mer eût déposées par couches successivement et doucement dans ce canton, pendant quarante ou cinquante mille siècles, pourquoi n'en aurait-elle pas laissé autant en Bretagne et en Normandie? Certainement si elle a submergé la Touraine si longtemps, elle a couvert à plus forte raison les pays qui sont au delà. Pourquoi donc ces prétendues coquilles dans un seul canton d'une seule province? Qu'on réponde à cette difficulté. (M.XXVI: 407)

Nobody could answer this question in the eighteenth century. It was generally believed, apart from Réaumur (1720), that the sea had covered all lands but not in the form of a limited embayment as in Touraine.

The ideas on geology in *La Défense de mon oncle* are very close to those in *Singularités*; in both essays Voltaire questioned the marine origin of the faluns in Touraine. While the former remained a satire, the latter treats the subject in more depth. Before publishing that work Voltaire produced yet another satire in which Buffon was criticized indirectly: *L'Homme aux quarante écus.* There he refuted

Maillet's system largely accepted by Buffon and said in reference to the faluns in Touraine: "J'ai bien peur que ce falun tant vanté ne vienne pas plus de la mer que les hommes" (M.XXI: 332). This essay is extremely facetious, particularly the chapter on Maillet's system where Voltaire, the actor, talks to some buffoon. Maybe for that reason, Voltaire resurrected his pilgrim story which I shall discuss in section F of this chapter. In *L'Homme aux quarante écus* Voltaire repeated his newly cherished ideas on freshwater fossils: "Il y a des coquillages partout; mais est-il bien sûr qu'ils ne soient pas les dépouilles des testacées et des crustacées de nos lacs et de nos rivières, aussi bien que de petits poissons marins"?

In conclusion, Voltaire's reaction, in works immediately before *Singularités*, toward the theory of mountain-building by the sea on the one hand and the invasion of the sea as far as Touraine on the other is quite different. He never accepted Buffon's theory of mountain-building while he originally believed that shells in Touraine and other coastal regions were of marine origin. On fossil shells found in mountains, however, and not in lowlands such as Touraine, Voltaire proposed in 1759 in a letter to Bertrand that these shells might have lived in ancient lakes, an idea which he repeated in his *Third Paris Notebook* and *La Philosophie de l'histoire*. In *La Défense de mon oncle*, Voltaire suddenly sounded rather certain that many freshwater fossils existed on the banks of rivers and lakes as if he had observed them personally in the vicinity of Ferney. From that moment on he started to question the marine origin of shells in Touraine (and not only in mountains). I believe that he realized, as I shall explain later on, that marine and freshwater fossils were not distinguished as belonging to different environments by his contemporaries. Nevertheless, in *L'Homme aux quarante écus* Voltaire was ready to abandon the faluns to the buffoon as long as he could keep his mountains: "Je vous abandonne, si vous voulez, votre falun, pourvu que vous me laissiez mes montagnes." This was said before he had personally inspected these faluns. In other words, while Voltaire never admitted that the sea had covered the Alps and thus was willing to propose ancient lakes to account for fossil shells there, he was ready to accept the theory of marine invasion as far as Touraine before he had personally investigated these faluns.

D. Publication of Singularités

The exact date of publication is not known. *Singularités* was first mentioned in a list of books to be smuggled from Ferney to France (D.15386). The first edition was published at Geneva by Cramer and its title was *Les Singularités de la nature par un Académicien de Londres, de Boulogne, de Petersbourg, de Berlin, &c.* A Basle 1768, in-8. Many other editions followed almost immediately; I have seen five at the Institut et Musée Voltaire in Geneva:

— *Les Singularités de la nature.* Par un Académicien de Londres, de Boulogne, de Petersbourg, de Berlin, &c. A Basle, 1768 (probably printed at Paris); in-8.

— *Les Singularités de la nature.* Par M. de Voltaire. A Genève, 1769; in-8.

— *Les Singularités de la nature.* Par M. de Voltaire. A Dresde, chez Conrad Walther, Imprimeur-Libraire de la Cour, 1769; (edition identical to the preceeding one with the exception of the location) in-8.

— *Les Singularités de la nature.* Par Voltaire. Au Château de Ferney, 1769; in-12.

— *Les Singularités de la nature.* Par M. de Voltaire. A Genève, 1769; in-12.

I have compared the original version with the five later editions and found them identical in every respect except print and form. (Bengesco mentions three other editions besides the above mentioned: Amsterdam [Paris] 1769, in-8; Lausanne, Pott, 1772, in-8; Londres, 1772, in-8. He also states that the essay was included in tome IV of *L'Evangile du jour* in-8. See vol. II: 228-231).

The *Singularités* then appeared in Tome VIII (Genève, Cramer) in 1769 of *Nouveaux mélanges philosophiques, historiques, critiques, &c. &c.* The text has remained unchanged. However, when the chapters concerning shells, XII to XVIII of *Singularités*, appeared in the *Questions sur l'Encyclopédie* in 1770 (Quatrième Volume), Voltaire undertook some important changes. In this work, the chapters on fossils were given slightly different headings: "Des coquilles et des systèmes bâtis sur les coquilles" instead of "Des pétrifications d'animaux marins"; "Du falun de Touraine et de ses coquilles," instead of "Du fallun de Touraine"; "Idées de Palissy sur les coquilles prétendues" instead of "De Bernard Palissi," and "Du système de Maillet, qui, de l'inspection des coquilles conclut que les poissons sont les premiers pères des hommes" instead of "Du système de Maillet qui fait les poissons les premiers pères des hommes." These new headings are found in the Moland edition of *Œuvres Complètes.* The most important changes in the text concern the faluns of Touraine which I shall discuss below.

Footnotes in the Moland edition indicate when Voltaire's words and whole passages in *Singularités* are identical to some articles in the *Dictionnaire Philosophique* or other works. I have found that of the thirty-eight chapters in *Singularités* only a few contain new material or ideas not repeated elsewhere. Voltaire mentioned corals, polyps, snails, oysters, and bees in chapters II-VI of *Singularités* as well as in the *Dictionnaire philosophique.* The same applies to "Causes finales" (chapter X), remarks on generation (chapter XIX), on Needham's "anguilles" (chapter XX), and on the women who gave birth to "lapins" (chapter XXI). Similarly, Voltaire also discussed the elements, air, water, and the earth in *Dictionnaire philosophique* and light in the *Eléments* as these subjects are now presented again in chapters XXVIII-XXXII of *Singularités.* Anatomy, monsters, and various races (chapters XXXV and XXXVI of *Singularités*) are also mentioned in the *Dictionnaire philosophique*, and so is "Population" and various other remarks here and there. Chapter XI in *Singu-*

larités "De la formation des Montagnes" contains ideas already expressed in *La Philosophie de l'histoire*, *La Défense de mon oncle*, and *L'Homme aux quarante écus*, all pertaining to Buffon's theory. Fossils were mentioned before: they are, however, treated much more in detail in *Singularités*.

The *Singularités* contain four chapters with new topics: "Des Pierres figurées," (Chapter I); "De la Pierre," (Chapter VII); "Du Caillou," (Chapter VIII) and "De La Roche" (Chapter IX). These topics had not been treated earlier and do not appear in later works; perhaps Voltaire was least certain or informed how to distinguish stones from "figured stones" so that he would not repeat his ideas on these subjects.

The title itself suggests that Voltaire probably wrote this essay to contradict those who held the view that nature could be explained by a few simple laws. Voltaire had found that nothing in nature was simple but instead full of "singularités" that could not be explained as yet. Thus he concocted a catalogue of these "singularités" promising it among others to Touraille, "Je vous enverrai *Les Singularités de la nature*. Cette nature est bien plus singulière dans nos Alpes qu'ailleurs; c'est tout un autre monde" (5 January 1969, D.15413).

E. Voltaire's Distinction between "figured stones," Stones, and Fossil Shells

Voltaire began his *Singularités* by pointing out some of the most controversial issues in natural sciences discussed during the eighteenth century: How does one distinguish a stone which bears the imprints of fossil fern leaves from a stone that shows very similar figures which are, however, mere impregnations of some foreign material? (Chapter I) What is the difference between organic and inorganic matter? (Chapter II on corals) or between the plant and animal kingdom? (Chapter III on polyps). How do animals regenerate new heads? (Chapter IV on snails). Is there a chain of beings? (the philosophical question in Chapter V on oysters). Finally, how does the social structure of bees and other insects work? (Chapter VI) Naturalists were still in disagreement about all these different questions of which I shall discuss only Chapter I concerning geology.

On the issue of fossil imprints versus sports of nature Voltaire remarked:

> Ces pierres, soit agates, soit espèces de marbres et de cailloux, sont fort communes: on les appelle *dendrites*, quand elles représentent des arbres; *herborisées*, ou *arborisées*, lorsqu'elles ne figurent que de petites plantes; *zoomorphites*, quand le jeu de la nature leur a imprimé la ressemblance imparfaite de quelques animaux. On pourrait nommer *domatistes* celles qui représentent des maisons. Il y en a quelques-unes de cette espèce très-étonnantes. J'en ai vu une sur laquelle on discernait un arbre chargé de fruits, et une face d'homme très-mal dessinée, mais reconnaissable. (p. 128)

Voltaire was not joking: various kinds of strange figures which resemble trees, plants, houses, or heads are found on or in certain stones or minerals due to the presence of some foreign material which has penetrated these stones. Curiosity cabinets were filled, and still are, with these bizarre stones which include also agates. Voltaire claimed that these sports of nature were believed by some people to have come from India:

> Dire qu'on a vu sur ces dendrites des empreintes de feuilles d'arbres qui ne croissent qu'aux Indes, n'est-ce pas avancer une chose peu prouvée? Une telle fiction n'est-elle pas la suite du roman imaginé par quelques-uns que la mer des Indes est venue autrefois en Allemagne, dans les Gaules et dans l'Espagne? Les Huns et les Goths y sont bien venus: oui; mais la mer ne voyage pas comme les hommes. Elle gravite éternellement vers le centre du globe. Elle obéit aux lois de la nature et quand elle l'aurait fait ce voyage, comment aurait-elle apporté des feuilles des Indes pour les déposer sur les agates de Bohême? (p. 128)

When Voltaire used the neutral "on" we can speculate that he either introduced a confusion between fossil imprints and sports of nature to confuse all kinds of oddities of nature, or that he had indeed heard somebody make this assumption about dendrites.

It is very probable that Voltaire read much of this material in *De la Nature* by Jean-Baptiste Robinet, philosopher and grammarian (1735-1820). Robinet was accused by Voltaire for having published *Lettres secrètes* in 1765; Robinet also collaborated in *Histoire universelle* (dite des Anglais) and in 1766 he published *De la Nature* in which he developed a theory of hylozoism which says, for instance, that all matter is necessarily alive and that God created organic and inorganic matter alike, giving to both seeds which developed according to preformation into minerals, stones, plants, or animals. Robinet, therefore, did not believe in the organic origin of fossil imprints as reported by Jussieu and other naturalists, but classified them among "figured stones." Robinet said: "Cette malheureuse illusion des formes a enfanté toutes les erreurs dont l'histoire naturelle est remplie." He believed that one would laugh about the simplicity of a savage if he would confuse the painting of a man with a real man. That is exactly how naturalists reason: they see imprints of fish on shales as one can see the human figure on an agate. "Pourquoi une pierre quelconque ne pourroit-elle pas porter naturellement l'image d'un poisson comme celle d'un homme"?

Robinet then developed the following idea:

> Tout le monde reconnoit la realité des dendrites, c'est-à-dire des pierres naturelles arborisées qui représentent des arbrisseaux, des buissons, des mousses, des bruyeres, &c. Pourquoi donc faire venir des capilaires, des polypodes, des adiantum, des lonchites, des osmodes & toutes sortes de fougeres, jusques des Indes orientales & occidentales au centre de l'Europe pour s'y pétrifier ou se coller artistement sur des ardoises & autres pierres [. . .] l'amour du merveilleux exige que les images des capillaires & des fougeres

> tirent leur origine de ces plantes qui croissent sous un ciel étranger, comme si elles ne pouvoient pas être naturelles aux pierres sur lesquelles elles se voient, ainsi que les autres. On est encore à chercher une bonne raison de la différence que l'on met entre ces pierres arborisées qu'il faut toutes également rapporter aux pierres figurées. Les éléments de leurs figures singulières étoient dans les germes dont elles sont le produit. Ce système est simple: il fait tout rentrer dans l'unité de plan. (1766, IV: 212-214)

Voltaire owned Robinet's work in his library (USSR 3000) although he did not seem particularly fond of him, writing to Damilaville: "J'ai une troisième requête à vous présenter au sujet de ce Robinet qu'on dit être l'auteur de la nature, et qui certainement ne l'est pas; car l'auteur de la nature sait le grec, et ce Robinet, l'éditeur de mes prétendues lettres cite dans ces lettres deux vers grecs qu'il estropie comme un franc ignorant..." (D.13540). Elsewhere he said "Ce Robinet est encore du fatras" (D.18425). Nevertheless, it is possible that Voltaire was intrigued by Robinet's passage on dendrites and decided to start his *Singularités* with this controversy.

Naturalists of the eighteenth century were mostly well aware of the distinction between dendrites and fossil imprints. Dezallier d'Argenville said that "dendrittes" were mere sports of nature and could be compared to strange figures on frosted windows (givre) while imprints of fish, plants, and insects on stones could be distinguished as such because of some unmistakable details of spores, leave-forms, or teeth which indicate the organic nature of animals or plants; these fossil imprints are therefore not sports of nature (Dezallier 1755: 148-149). Similarly, Jussieu had explained in his memoir of 1718 that imprints of plants which still grew in India and which were found as fossil imprints in the shales of coal-mines near Lyon were real fossil plants and should not be confused with dendrites, that is stones impregnated with some foreign material to a great depth while fossil plants had only slight superficial imprints. Fontenelle reported Jussieu's memoir (1718) but did not specify that these fern leaves were not dendrites. Bertrand, an author Voltaire could have consulted since he owned his dictionary of fossils, mentioned: "*Dendrites; Pierre de Florence ou Pierre arborisée et herborisée* [...] On donne ces noms à une pierre ordinairement fissile, ou platte, qui lors qu'elle est fenduë, représente des deux côtés de la superficie des villes, des montagnes, des paysages, & plus communement des arbres, des bruyères, des arbrisseaux, & des mousses..." Metallic matter and fluids, he said, entered into fissures of stones and randomly produced these astonishing designs. Figures that are superficial were called *Dendrites*; agates, where figures penetrated deeper, were called *Dendrachates* (1763: 189). According to Bertrand, dendrites were thus simple sports of nature and not imprints of fossil leaves.

Not everybody, however, seemed to be able to distinguish the two kinds of imprints. Even a footnote in the Kehl edition says: "Il y a des dendrites qui sont véritablement des empreintes de plantes; d'autres sont produites par des parties métalliques déposées sur ces pierres ou dans leur intérieur; d'autres sont formées par des bulles d'air" (M.XXVII: 128).

Since Voltaire used dendrites to start his discussion about oddities of nature and since he later labeled ammonites, shark teeth, and Venus shells as "pierres" (chapter VII), lose stones lying in the fields as "cailloux" (chapter VIII), and material found in mountains as "roche" (chapter IX), it seems necessary to understand what distinction, if any, Voltaire made between "figured stones" and stones, and fossil shells. Bertrand, whom he might have read, followed the interpretations of many different authors without ever giving his own. Voltaire could not follow Bertrand, nor did he believe that fossil shells were "figured stones" as did Robinet, therefore, he decided to classify stones in his own way.

Dendrites and other imprints on stones which were sports of nature (p. 128), as well as "pierres lenticulaires" (tests of large foraminifers called Nummulites), ammonites, sharkteeth, and Venus shells (p. 135-136), he classified as "figured stones" or sports of nature. "Coquilles" or "coquillages," however, he considered fossil shells, preferably of freshwater origin (p. 144-157). Thus, Voltaire made a clear distinction between fossil shells which he could easily recognize and compare with living analogues, such as snails, mussels, oysters, and those he called "figured stones" such as dendrites, ammonites, and shark teeth because he could not compare them to any living analogue. He included Venus shells among "petrified stones" because they lent themselves to his pun.

F. Voltaire's Pilgrim Story

There are six different versions of Voltaire's notorious pilgrim story (Carozzi M. 1979: 82-97), namely, in the *Saggio*; in its French translation in the *Mercure de France* of 1746; in the *Dissertation* (1748); in *La Défense de mon oncle* (1767); in *L'Homme aux quarante écus* (1768), and in *Singularités* (1768). I have found that *Singularités* was published after, rather than before, *L'Homme aux quarante écus*, the more serious essay following the two satires.

The text in the *Saggio* and in the French translation of 1746 varies slightly from the *Dissertation*, particularly in regard to *fossil fish*. While Voltaire first interpreted fossil fish in Germany and in the Alps as discarded spoiled fish which had later become petrified, he was less affirmative in 1748 and used the past tense, "il était plus naturel de soupçonner" as if he had already given up this interpretation. Indeed, he never mentioned fossil fish again in later versions of the pilgrim story.

The French translation of the *Saggio* in the *Mercure de France*, July 1746 said:

> Quand on découvrit sur les montagnes de Hesse, une pierre qui avoit la figure d'un turbot, on en conclut qu'autrefois la mer avoit couvert ces montagnes. On ne daigna pas conjecturer que ce poisson fut porté là pour quelque repas & qu'étant gâté on le jetta sur ces rochers, où depuis il s'étoit pétrifié. Un brochet pétrifié s'est trouvé sur la cime des Alpes. Il a donc été un tems où les fleuves ont coulé sur les montagnes, & dans un autre tems l'Allemagne a été le sein de la mer. (p. 8)

The slightly different text in the *Dissertation* reads:

> On a trouvé dans les montagnes de la Hesse une pierre qui paraissait porter l'empreinte d'un turbot, et sur les Alpes un brochet pétrifié: on en conclut que la mer et les rivières ont coulé tour à tour sur les montagnes. Il était plus naturel de soupçonner que ces poissons, apportés par un voyageur, s'étant gâtés, furent jetés, et se pétrifièrent dans la suite des temps; mais cette idée était trop simple et trop peu systématique. (p. 221-222)

In regard to *fossil shells* found in France and Italy, both versions propose that they might have been transported by pilgrims from the Holy Land or by the sea of Syria. A third interpretation "fossiles" is enlarged in 1748 into "fossiles que produit notre terre," words which do not explain whether Voltaire meant "produced from seeds in the earth" or whether he merely thought about some sports of nature. Only the 1748 version gives a fourth interpretation: these shells might be of lacustrine origin.

The French translation of the *Saggio* mentioned:

> La France & l'Italie sont pleines de petites coquilles qu'on prétend se former sur les côtes de Syrie. Je ne veux point révoquer en doute leur origine, mais les Philosophes ne pourroient-ils pas se rappeler cette multitude innombrable de Pèlerins qui autrefois couroient en Palestine? On sçait qu'ils y portèrent leur argent & n'en rapportèrent que des coquilles; vaut-il mieux croire que le terrain sur lequel Paris & Milan sont bâtis ait servi pendant long-tems de lit à la mer de Syrie? Il ne seroit peut-être pas insensé d'avancer que ces coquilles sont fossiles. Plusieurs Philosophes l'ont cru, mais quelque système ou quelques rêveries que nous puissions adopter, il ne paroît pas possible de prouver par ces coquilles un renversement total du monde.

The 1748 version said:

> On a vu aussi dans des provinces d'Italie, de France, etc. de petits coquillages qu'on assure être originaires de la mer de Syrie. Je ne veux pas contester leur origine; mais ne pourrait-on pas se souvenir que cette foule innombrable de pèlerins et de croisés, qui porta son argent dans la Terre Sainte, en rapporta des coquilles? Et aimera-t-on mieux croire que la mer de Joppe et de Sidon est venue couvrir la Bourgogne et le Milanais? On pourrait encore se dispenser de croire l'une et l'autre de ces hypothèses, et penser, avec beaucoup de physiciens, que ces coquilles, qu'on croit venues de si loin, sont des fossiles que produit notre terre. On pourrait encore, avec bien plus de vraisemblance, conjecturer qu'il y a eu autrefois des lacs dans les endroits où l'on voit aujourd'hui des coquilles; mais quelque opinion ou quelque erreur qu'on embrasse, ces coquilles prouvent-elles que tout l'univers a été bouleversé de fond en comble? (p. 222-223)

I mentioned earlier that Voltaire's pilgrim story as told in his own translation of 1748 never was a serious proposition. Of the four hypotheses proposed he seemed to prefer the last one, namely that fossil shells found in Italy and France were of freshwater origin.

Buffon, however, criticized Voltaire's Italian letter as I mentioned in chapter I and Voltaire replied in *La Défense de mon oncle :* "Quand je lus, il y a quarante ans, qu'on avait trouvé dans les Alpes des coquilles de Syrie, je dis, je l'avoue, d'un ton un peu goguenard, que ces coquilles avaient été apparemment apportées par des pèlerins qui revenaient de Jérusalem..." (M.XXVI: 408). Even though Voltaire had been reprimanded by Buffon, he had not wanted to be bothered about a few shells.

Voltaire then repeated the same ideas in *L'Homme aux quarante écus* where the pilgrim story is grotesquely blown out of proportion:

> — Mais, monsieur l'incrédule, que répondrez-vous aux huîtres pétrifiées qu'on a trouvées sur le sommet des Alpes?
>
> — Je répondrai, monsieur le créateur, que je n'ai pas vu plus d'huîtres pétrifiées que d'ancres de vaisseau sur le haut du mont Cenis. Je répondrai ce qu'on a déjà dit, qu'on a trouvé des écailles d'huîtres (qui se pétrifient aisément) à de très-grandes distances de la mer, comme on a déterré des médailles romaines à cent lieues de Rome; et j'aime mieux croire que des pèlerins de Saint-Jacques ont laissé quelques coquilles vers Saint-Maurice que d'imaginer que la mer a formé le mont Saint-Bernard. Il y a des coquillages partout; mais est-il bien sûr qu'ils ne soient pas les dépouilles des testacées et des crustacées de nos lacs et de nos rivières, aussi bien que des petits poissons marins?
>
> — Monsieur l'incrédule, je vous tournerai en ridicule dans le monde que je me propose de créer.
>
> — Monsieur le créateur, à vous permis; chacun est maître dans son monde; mais vous ne me ferez jamais croire que celui où nous sommes soit de verre, ni que quelques coquilles soient des démonstrations que la mer a produit les Alpes et le mont Taurus. Vous savez qu'il n'y a aucune coquille dans les montagnes d'Amérique. Il faut que ce ne soit pas vous qui ayez créé cet hémisphere, et que vous vous soyez contenté de former l'ancien monde; c'est bien assez.
>
> — Monsieur, monsieur, si on n'a pas découvert de coquilles sur les montagnes d'Amérique, on en découvrira.
>
> — Monsieur, c'est parler en créateur qui sait son secret, et qui est sûr de son fait. Je vous abandonne, si vous voulez, votre falun, pourvu que vous me laissiez mes montagnes. Je suis d'ailleurs le très-humble et très-obéissant serviteur de votre providence. (M.XXI: 332-333)

Using a theatrical style, Voltaire transformed his earlier pilgrim story into a new form. His reference to America was probably based on the following passage in Buffon:

> Par tout ce que nous venons de dire, on peut être assuré qu'on trouve des coquilles pétrifiées en Europe, en Asie & en Afrique, dans tous les lieux où le hasard a conduit les Observateurs; on en trouve aussi en Amérique, au Bresil, dans le Tucuman, dans les terres Magellaniques [...] Cependant M. de la Condamine, qui a demeuré pendant plusieurs années au Pérou, m'a assuré qu'il n'en avoit pas vu dans les Cordillières, qu'il avoit cherché inutilement, & qu'il ne croyait pas qu'il y en eût [...] j'avoue que malgré

> le témoignage de ce célèbre observateur, je doute encore à cet égard, & que je suis très-porté à croire qu'il y a dans les montagnes du Pérou, comme par-tout ailleurs, des coquilles & d'autres pétrifications marines, mais qu'elles ne se sont pas offertes à ses yeux [...] je persiste à croire qu'on trouvera des coquilles sur les montagnes du Pérou... (1749: 294-295)

Voltaire's words "vous savez qu'il n'y a aucune coquille dans les montagnes d'Amérique" are those originally used by Condamine and "on en découvrira" by Buffon.

In this new version of the pilgrim story, a number of things have changed drastically. First of all, the pilgrims now travel from Saint-Jacques-de-Compostelle in Spain to Rome, apparently through the Alps where they might drop a few shells. Before, pilgrims returning from the Holy Land dropped them in some provinces of Italy and France. Why this change in direction? The most obvious reason is probably the fact that Voltaire needed the pilgrim shells in the Alps to explain some oyster-shells or other petrifications since he said that he preferred that story to the theory which said that the sea had formed the mountain of Saint-Bernard. It is also possible that Voltaire had learned that, in general, pilgrims going to and from Saint-Jacques-de-Compostelle brought back some "coquilles St. Jacques," either wearing them on their hat, or on their coat, while pilgrims returning from the Holy Land carried palms of Jericho but no shells. A third pilgrimage ended in Rome starting from different Christian places all over the world (Pasteur 1968: 135-179) and this is the pilgrimage Voltaire seems to be referring to here. It is quite evident that this funny story is concocted to amuse and to undermine the different systems on the presence of fossils in mountains. Thus, he would rather have pilgrims carry fossils than believe in the marine origin of some petrifications found in mountains.

Finally, in the last version, *Les Singularités de la nature*, chapter XII, Voltaire said:

> On prétend qu'il y a des fragments de coquillages à *Montmartre et à Courtagnon auprès de Reims*. On en rencontre presque partout, mais non pas sur la cime des montagnes comme le suppose le système de Maillet. Il n'y en a pas une seule sur la chaîne des hautes montagnes, depuis la Sierra-Morena jusqu'à la dernière cime de l'Apennin. J'en ai fait chercher sur le mont Saint-Gothard, sur le Saint-Bernard, dans les montagnes de la Tarentaise: on n'en a pas découvert. (p. 145)

[The reference to fossil shells at Montmartre is rather vague and may correspond to any of the countless Cenozoic fossiliferous beds well exposed in the numerous quarries in the town and vicinity of Paris. The occurrence at Courtagnon, in the Forêt de la Montagne de Reims, Marne, is a well-known set of open pits located 1 km S.W. of Pourcy. They display the so-called "Falun de Pourcy" (Sparnacien, Lower Eocene) which consists of deltaic-lagoonal sands with an abundant fauna of pelecypods and gastropods (*Corbicula*, *Melania*, *Melanopsis*, *Cerithium*, etc.) associated with numerous bones and teeth of mammals (Pomerol and Feugueur, 1968: 107-115, 153)].

Voltaire's citation of Montmartre and Courtagnon seems to be a reply to Buffon, who in his *Théorie de la Terre*, immediately after the satirical reference to Voltaire affirmed that, "tout le monde peut voir par ses yeux les bancs de coquilles qui sont dans les collines des environs de Paris [. . .] il en est de même à Courtagnon près de Reims" (1749: 282). Voltaire objected that fossils might be found everywhere but not in the highest mountain-peaks. He points here to inconsistencies in Buffon who maintained that there were fossils in the highest mountains (1749: 76, 77, 279, 291) and elsewhere that there were none (1749: 277).

Further on in the *Singularités* Voltaire gave his explanation of freshwater mussels in the vicinity of Mont Cenis:

> Un seul physicien m'a écrit qu'il a trouvé une écaille d'huître pétrifiée vers le mont Cenis. Je dois le croire, et je suis très-étonné qu'on n'y en ait pas vu des centaines. Les lacs voisins nourissent de grosses moules dont l'écaille ressemble parfaitement aux huîtres; on les appelle même *petites huîtres* dans plus d'un canton. (p. 145)

This is at least the sixth time that Voltaire referred to freshwater fossils in mountains: first in a letter to Bertrand (D.7441); then in *La Philosophie de l'histoire*; *La Défense de mon oncle*; *L'Homme aux quarante écus*; in his letter to Turgot (D.14741), and finally in the *Singularités*.

Following the above, Voltaire then gives the sixth version of the pilgrim story:

> Est-ce d'ailleurs une idée tout à fait romanesque de faire reflexion sur la foule innombrable de pèlerins qui partaient à pied de Saint-Jacques en Galice, et de toutes les provinces, pour aller à Rome par le mont Cenis chargés de coquilles à leur bonnets? Il en venait de Syrie, d'Egypte, de Grèce, comme de Pologne et d'Autriche. Le nombre de romipètes a été mille fois plus considérable que celui des hagi qui ont visité la Mecque et Médine, parce que les chemins de Rome sont plus faciles, et qu'on n'était pas forcé d'aller par caravanes. En un mot, une huître près du mont Cenis ne prouve pas que l'océan Indien ait enveloppé toutes les terres de notre hemisphère. (p. 145-146)

It appears that Voltaire made his pilgrims reverse their steps as he had already done in *L'Homme aux quarante écus*. We can only wonder what the pilgrims from Syria, Egypt, and Greece had to do with this argument.

If we are supposed to believe Voltaire's pilgrim story, we should at least know which one. In 1748, Voltaire had presented four different hypotheses for *fossil shells* found in the lowlands of Italy and France; perhaps even five, if we consider his description of shells in Calabria and Touraine. In 1748, he had also mentioned two *fossils fish*, one in Hesse, and the other in the Alps, perhaps on Mont Cenis. These might be leftovers from some traveler's meal as Voltaire had suggested rather undecisively. In 1768, he apparently considered imprints of fossil fish as undeniable evidence of former living fish since he never mentioned them again. Thus the former petrified "brochet" on Mont Cenis was changed into a fragment of a fossilized oyster-shell. Since mussels resembling oysters were living in nearby lakes, these fossil shells might therefore be the remnants of former freshwater mussels. On the other

hand, pilgrims now coming from Saint-Jacques-de-Compostelle wearing "coquilles St.Jacques" on their hats may have scattered them on Mont Cenis on their way to Rome. Voltaire's second pilgrim story is certainly not a repetition of the first one. Had he ever believed it, he would have repeated it word for word. It is not his pilgrim story that was repeated unchanged, however, but his interpretation of freshwater fossils. I have the impression, therefore, that Voltaire never really believed in his pilgrim story but rather in the freshwater origin of fossils in mountains.

G. Voltaire's Geological Observations at Ferney and in the Jura Mountains

A careful analysis of *Singularités* reveals that Voltaire had carried out his own independent investigation at Ferney and in the Jura Mountains. This conclusion is based on his description of several geological features which are typical of that area: sandstones containing freshwater fossils; glacial phenomena; spectacular weathering processes typical of limestone countries, and a very smooth limestone used for lime-making. Observations of this kind had not been explained or even mentioned by contemporaries of Voltaire.

When he lived at Ferney, he farmed his own land, built houses with stones from his own quarry at Tournay (Caussy 1912: 158) and apparently examined rocks and fossils in the local molasse whenever he had a chance to do so. Molasse is a grayish or reddish, soft — as the name molasse indicates — calcareous sandstone with fossils of freshwater snails, *Helix ramondi* (Paréjas, "Essai," 1938: 1-50, 1951: 6-7). Modern geologists tell us that freshwater molasse occurs on the shores of Lake Geneva and on the banks of rivers crossing the countryside between the Jura Mountains and the lake, and even in the first valley of the Jura. Indeed, every time a small river or road cuts through recent sediments, freshwater molasse is exposed. The houses at Ferney were built with molasse as are most houses in the Geneva area. Voltaire apparently noticed that the fossils enclosed in this molasse resembled the snails which destroyed his fruit-trees and vineyards during the rainy season.

He observed in his garden fragments of hardened shells of recently dead snails, compared them with fragments of fossil shells which are exposed along the banks of the Rhône and other rivers, such as the Vengeron (in the freshwater molasse), and came to the conclusion that these fossils or fragments were alike. He reported:

> J'ai vu quelquefois des débris de moules et de colimaçons qu'on prenait pour des coquilles de mer. Si on songeait seulement que, dans une année pluvieuse, il y a plus de limaçons dans dix lieues de pays que d'hommes sur la terre, on pourrait se dispenser de chercher ailleurs l'origine de ces fragments de coquillages dont les bords du Rhône et ceux d'autres rivières sont tapissés dans l'espace de plusieurs milles. Il y a beaucoup de ces limaçons dont le diamètre est de plus d'un pouce. Leur multitude détruit quelquefois les vignes et les arbres fruitiers. Les fragments de leurs coques endurcies sont partout. (p. 147)

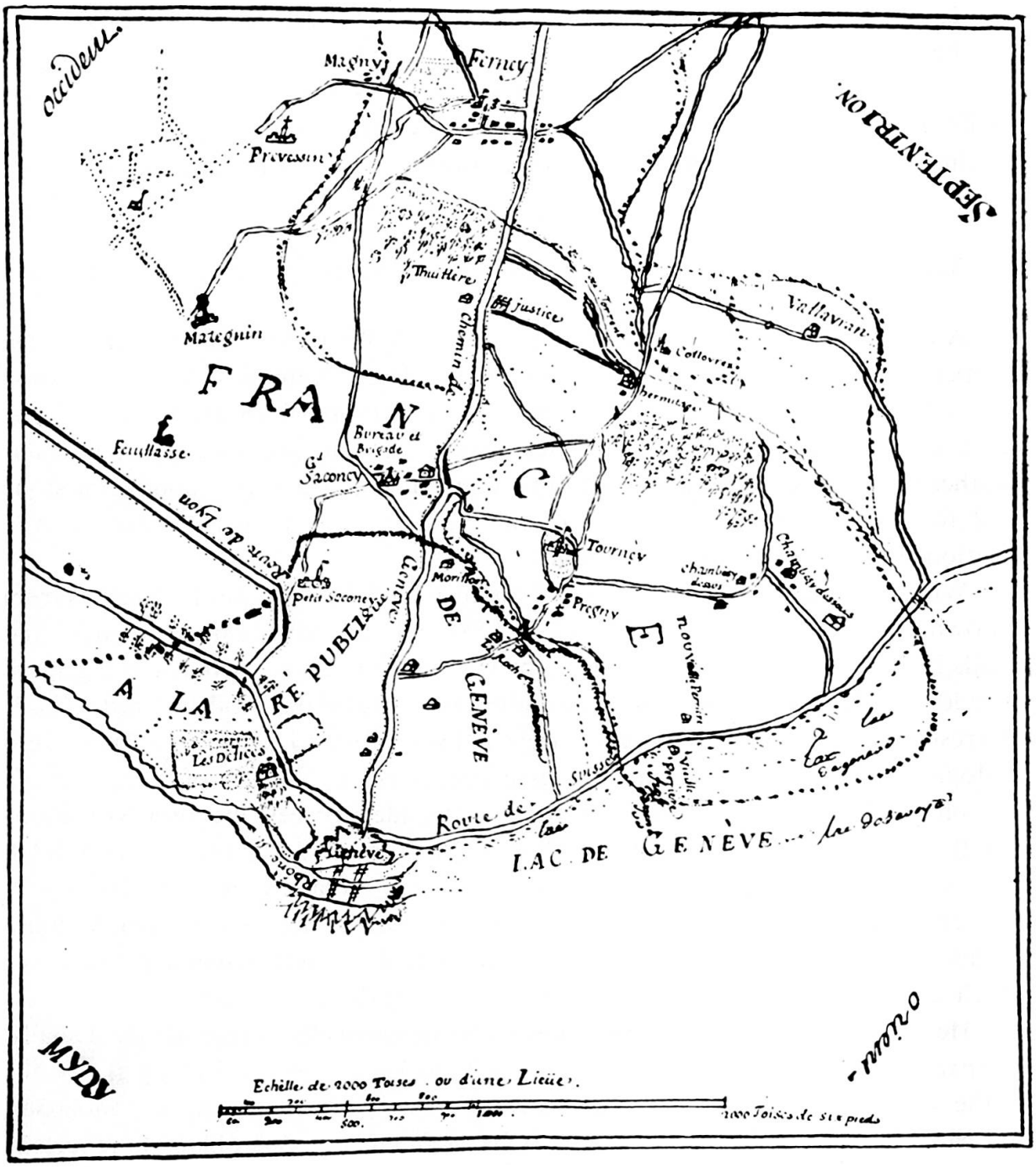

FIG. 4. — Map of the area of Ferney and Tournay drafted by Voltaire's secretary Wagnière. Reproduced from F. Caussy, *Voltaire Seigneur de Village*, Paris, 1912, facing p. 64. The words *nan* or *torrent*, *lac de Genève*, *petit chemin*, *etc.* are by Voltaire's pen.

The first sentence repeats the essence of what he had said in *La Défense de mon oncle*, namely, "nous avons mille productions terrestres qu'on prend pour des productions marines" in a more modest manner. In a letter to Turgot, written in the same year as *Singularités*, Voltaire was more specific about the occurrence of fossil shells: "Les bords du Rhône en sont tapissés à sa naissance, et à son éruption du lac de Genève. Je n'y ai jamais vu une seule coquille de mer..." (D.14741) According to this letter, Voltaire seemed to have observed freshwater fossils in the molasse which crops out at both ends of Lake Geneva, and at many other places as mentioned above (*Guide* 1967: 86-94). A hundred years later, Lyell would explain that in order to distinguish nonmarine from marine fossils, one had but to compare the fossil shell with a living analogue in some lake or pond (Lyell, 1864,I:45). This is exactly what Voltaire had done in the eighteenth century.

After observing fragments of fossils and comparing them with freshwater snails, he suggested:

> Pourquoi donc imaginer que des coquillages des Indes sont venus s'amonceler dans nos climats quand nous en avons chez nous par millions? Tous ces petits fragments de coquilles, dont on a fait tant de bruit pour accréditer un système, sont pour la plupart si informes, si usés, si méconnaissables, qu'on pourrait également parier que ce sont des débris d'écrevisses ou de crocodiles, ou des ongles d'autres animaux. Si on trouve une coquille bien conservée dans le cabinet d'un curieux, on ne sait d'où elle vient; et je doute qu'elle puisse servir de fondement à un système. (p. 147-148)

In this passage Voltaire refuted the idea that the Indian Ocean had transported fossil shells to Europe as he had done earlier. He also argued that most fossils were merely small, shapeless, abraded fragments and as such utterly unrecognizable while complete and well-preserved fossils, as exhibited in the cabinets of the "curieux" were rare and of unknown provenance. This argument can be appreciated by anyone who has been looking for fossils, especially in the freshwater molasse. They are scarce and mostly fragmentary, and much patience is needed to find a specimen worthy to be placed in a museum. Furthermore, collections of fossils in the eighteenth century often displayed many exotic fossils, or curiosities which were of unknown origin.

Voltaire concluded in the above passage that such flimsy evidence as poorly preserved fossil shells ought not be used for any theory of the universe. He emphasized the fact that too little was known about plants and animals in his century in order to identify all these small fragments of shells. This cautious attitude is supported by Guettard who hesitated, as I have mentioned at the beginning of this chapter, to build any systems based on a science which was as yet little advanced. Indeed, when Voltaire suggested that many so-called marine fossils were of freshwater origin, eighteenth-century naturalists were not able to distinguish between marine and freshwater fossils.

Modern geology confirms Voltaire's opinion on freshwater fossils. Indeed, the basin of Geneva shows evidence of freshwater deposits dating from the Chattian of the Upper Oligocene Epoch (about 38 million years ago). Freshwater molasse was deposited in vast lagoons and lakes between the Alps and the Jura Mountains, and at times even in the first valleys of the Jura itself. These sediments were originally deposited as fluvial sands and muds washed down from the newly formed Alps and subsequently hardened into friable red and mottled calcareous sandstones (molasse) containing freshwater fossils such as *Helix ramondi*, a freshwater snail. On the shores of the lagoons and lakes grew subtropical plants and algae which were transformed into lignite. Certain ponds evaporated and precipitated gypsum. Indeed thin layers of gypsum occur throughout the molasse of the Geneva area and also impregnations of heavy oil have been known for a long time in the molasse of the Nant de la Roulavaz, near Dardagny, 10 km S.W. of Ferney. (Voltaire referred both to bituminous material and gypsum p. 137, 152 in *Singularités.*) After this period of freshwater deposit, the sea returned during the Burdigalian (Lower Miocene, about 25 million years ago) covering areas of the present cities of Bellegarde and Lausanne and the Swiss Plateau, and depositing marine molasse which contains pecten, large oysters, and shark teeth. These marine fossils, however, *do not occur* in the vicinity of Geneva and many other places, such as Tournay, either because the sea did not reach this area, or because marine deposits were later eroded, or because the Burdigalian sea at that place had changed into a lagoon or a lake (Paréjas, "Essai" p. 30; and *Atlas géologique de la Suisse*, 1938). In short, we know that the Chattian freshwater molasse forms many hills around lake Geneva and that Voltaire's observations were correct.

When Voltaire tried to apply the same method of investigation he had used for snails in the molasse to ammonites which abound in the extensive marine limestone outcrops on the slopes and the crests of the Jura chains, he failed because he had no existing living animals to be compared to ammonites. These animals appeared in the Triassic Period (225 million years ago) and became extinct at the end of the Cretaceous (about 70 million years ago). Ammonites had an external shell that was coiled in a flat spiral and divided into chambers very similar to that of the modern Nautilus. Some reached a size of six feet, others were very small, a difference which confused many naturalists of the eighteenth century. Voltaire reported them as follows:

> J'ai vu de ces cornes d'Ammon qui paraissent nouvellement formées, et qui ne sont pas plus grandes que l'ongle du petit doigt; j'en ai vu d'à demi-formées, et qui pèsent vingt livres; j'en ai vu qui font une volute parfaite, d'autres qui ont la forme d'un serpent entortillé sur lui-même, aucune qui ait l'air d'une corne. On dit que ces pierres sont l'ancien logement d'un poisson qui ne se trouve qu'aux Indes... (p. 135)

Voltaire observed correctly that some ammonites were sometimes half-formed, that is, poorly fossilized, a condition which occurs indeed in some large ammonites when

calcification of the shell remains incomplete. However, since he had not seen any similar animal, Voltaire preferred to doubt their origin and classify them with other unknown "petrified stones."

The geological history of the Geneva area indicates that during the Pleistocene Ice Age, Alpine glaciers extended over the Swiss Plateau and deposited erratic blocks as far as the foothills of the Jura Mountains. Voltaire noticed:

> Au milieu de nos champs, nous découvrons souvent des cailloux énormes, depuis trois pieds jusqu'à vingt de diamètre; et à côté il y en a qui paraissent aussi anciens et qui n'ont pas un demi-pouce d'épaisseur; d'autres n'ont que deux ou trois lignes de diamètre; leur pesanteur spécifique est inégale: elle approche dans les uns de celle du fer, dans d'autres elle est moindre, et dans quelques-uns plus forte. (p. 136)

In a letter to the Président de Brosses, the previous owner of Tournay, Voltaire had referred to the same enormous rocks:

> ... j'ai fait sauter plus de soixante gros rochers qui étaient répandus dans les champs de froment, qui cassaient toutes les charrues et rendaient une partie de la semature inutile: il y en a encore autant pour le moins à déraciner; et je consomme, pour labourer, plus de poudre à canon qu'au siège d'une ville. (D.8580)

Also during the Ice-Age, outwash gravels were deposited in the area of Ferney. Outwash consist of kames and eskers aligned parallel to the frontal chain of the Jura, i.e. a concentration of very irregularly stratified gravels and sands with occurrence of large mammalian bones (Carozzi, A. 1945: 88-92). Voltaire described the difference between small isolated mountains and the continuous mountain chains and said: "Les isolées sont des amas hétérogènes composés de matières étrangères entassées sans ordre, sans couches régulières. On y trouve des restes de végétaux, d'animaux terrestres et aquatiques, ou pétrifiés, ou friables, des bitumes, des débris de mineraux" (p. 137). Moreover, he noticed an uneven distribution of stones in his fields and asked: "Pourquoi dans plusieurs de nos campagnes ne voit-on pas un seul caillou, et que d'autres à peu de distance en sont couvertes"? (p. 136) The fields around Ferney are all covered by ground moraine from the latest Ice-Age. This moraine is usually a mixture of clay and pebbles but certain fields contain almost pure clay and no pebbles while others are strewn with pebbles only. Glaciers and glacial phenomena were not understood in Voltaire's time.

Voltaire was particularly intrigued by a spectacular weathering process called "karst," after a limestone plateau near Trieste. There and in all limestones and other soluble rocks develop karstic phenomena by the action of surface and underground water when calcite, the main component, is attacked by water and small amounts of carbonic acid and undergoes rapid chemical weathering. Thus, limestones of the Jura Mountains allow rivers to disappear into narrow openings, sinkholes, and caves to form underground streams. Voltaire noticed:

> Mille endroits sont remplis de mille débris de testacés, de crustacés, de pétrifications. Mais remarquons, encore une fois que ce n'est presque jamais ni sur la croupe ni dans les flancs de cette continuité de montagnes dont la surface du globe est traversée; c'est à quelques lieues de ces grands corps, c'est au milieu des terres, c'est dans des cavernes, dans des lieux où il est très-vraisemblable qu'il y avait de petits lacs qui ont disparu, de petites rivières dont le cours est changé, des ruisseaux considérables dont la source est tarie. Vous y voyez des débris de tortues, d'écrevisses, de moules, de colimaçons, de petits crustacés de rivière, de petites huîtres semblables à celles de Lorraine; mais de véritables corps marins, c'est ce que vous ne voyez jamais. (p. 146-147)

In the above passage Voltaire makes a distinction between the two kinds of mountains which surrounded him: the Alps and the Jura Mountains. In the latter he found caverns, dried up lakes and rivers, and streams which had changed their course. These are typical features of the Jura Mountains, where rivers disappear into sinkholes, caverns and underground streams, leaving behind remains of former lake-animals. Some freshwater molasse occurs in the first valley of the Jura Mountains and it is possible that Voltaire found there fossils of turtles, shrimps, mussels, and snails.

A typical aspect of karstic phenomena is also represented by fossiliferous limestone outcrops which display porous and spongy texture resulting from dissolution at the surface. This process gives these rocks a honeycomb aspect, and many of their cavities are inhabited by insects, particularly under grass cover. Voltaire failed to recognize fossils in these stones because their fragments were perhaps too small. He described these stones as follows:

> Quelque pesant, quelque opaque, quelque lisse qu'un caillou puisse être, il est percé comme un crible. Si l'or et les diaments ont autant et plus de pores que de substance, à plus forte raison le caillou est-il percé dans toutes ses dimensions; et un million d'ouvertures dans un caillou peut fournir autant d'asiles à des insectes imperceptibles. p. 136)

Voltaire's subsequent words show that he himself seems to have tested sandstones with a hammer and attempted to melt them:

> C'est un assemblage de parties homogènes dont résulte une masse souvent inébranlable au marteau; il est vitrifiable, à la longue, à un feu de fournaise, et on voit alors que ses parties constituantes sont une espèce de cristal; mais quelle force avait joint ces petits cristaux? d'où résultait ce corps si dur que le feu a divisé? (p. 136)

From the above description, this sandstone appears to have been a pure quartz arenite from the "Sidérolithique," a continental deposit of the Eocene commonly encountered on paleokarstic surfaces developed on various types of Cretaceous limestones in the Jura Mountains.

The process by which caverns are produced by the chemical weathering of limestones and other soluble rocks was not understood in the eighteenth century.

Buffon, for instance, believed that caverns were produced by earthquakes and volcanic activity: "Dans tous les volcans, dans tous les pays qui produisent du soufre, dans toutes les contrées qui sont sujettes aux tremblements de terre, il y a des cavernes..." (1749: 548). Thus, Voltaire's observations of karstic phenomena in the Jura Mountains might have taught him that erosion observed in this part of the country contradicted the idea by Buffon that all mountains were eroded by rivers and eventually disappeared into the sea (1749: 124). In the Jura Mountains, on the contrary, rivers disappear and mountains seem to crumble in place. Voltaire expressed this enigma with these words, "en supposant cette chaîne de montagnes écroulée, dispersée sur notre continent, n'en n'élèvera-t-elle pas la surface"? (p. 142). Indeed, in the Jura Mountains, weathered surface material is not shown to be carried away by rivers to the sea.

Voltaire's investigation of limestones used for lime-making reveals further differences from Buffon's assumptions:

> L'auteur estimable de l'*Histoire naturelle*, aussi profond dans ses vues qu'attrayant par son style, dit expressément: « Je prétends que les coquilles sont l'intermède que la nature emploie pour former la plupart des pierres. Je prétends que les craies, les marnes, et les pierres à chaux, ne sont composées que de poussière et de détriments de coquilles. »
> On peut aller trop loin, quelque habile physicien que l'on soit. J'avoue que j'ai examiné pendant douze ans de suite la pierre à chaux que j'ai employée, et que ni moi ni aucun des assistants n'y avons aperçu le moindre vestige de coquilles.
> A-t-on donc besoin de toutes ces suppositions pour prouver les révolutions que notre globe a essuyées dans des temps prodigieusement reculés? (p. 155)

Buffon's speculations quoted above by Voltaire have proven correct. Sedimentary rocks, in particular limestones, which are the most frequently exposed rocks, contain many fossils; at times they are the only ingredient as Buffon had pointed out (1749: 272-273). Geology of the Geneva area, however, shows that there are exceptions to the general rule and that Voltaire's statement on limestones used for lime-making (pierre à chaux) is also correct. Indeed, these limestones were quarried at the foot of the Jura Mountains, the best stones being Lower to Middle Cretaceous limestones (135 million years old). Both kinds are smooth without visible fossils, the first one is even called "marbre bâtard" because of its marble-like smoothness (Falconnier 1951: 11). The quarry of "marbre bâtard" closest to Ferney is located about 10 km to the W.N.W. at Crozet at the foot of the Jura. Thus Voltaire's investigation had shown him that there were no fossils in limestones as Buffon had maintained.

Voltaire's personal inspection of freshwater molasse and freshwater fossils, of glacial phenomena, of karstic processes, and of limestone for lime-making in the area of Ferney presumably convinced him that many elements in Buffon's theory were wrong. Even before he had observed freshwater fossils he had been convinced that according to physical laws of gravitation and hydrostatics (as he called them)

the sea could not have shaped mountains. Modern science, I repeat, considers mountain-building by the sea alone impossible. Some mechanism is needed to lift sediments from below sea-level. In conclusion, Voltaire had become suspicious of all generally accepted ideas and sent for a case of shells from Touraine to investigate further.

H. Voltaire's Interpretation of Freshwater Fossils in the Faluns of Touraine

Faluns are a sandy mass of fragments of fossil shells in Touraine dating from the Miocene (25 million years), formerly used by French farmers to aerate their fields. Many naturalists of the eighteenth century considered the faluns of Touraine the most important evidence for the sojourn of the ocean on the continent during a long period of time. This opinion originated with Réaumur's memoir in 1720 who described the use of this material to aerate (ménager des vuides) clayey soils (1720: 530). Réaumur described five different types of preservation of shells and said that those in Touraine belonged mostly to a variety of shells which had lost their luster and part of their hardness, were almost decomposed, very friable, easily reduced to powder, and usually as white as lime (1720: 522, 534). He suggested that these fossil shells might have been transported either by an ocean current from the Channel, or by the ebb and flow of the sea, or perhaps these fossil shells had become exposed after the diminution of the sea (1720: 537-540).

Fontenelle's abstract of Réaumur's memoir was superficial and inaccurate. He reported that fragments of marine shells were recognizable by their "canelures très-bien marquées" (1720: 8), and instead of giving Réaumur's interpretation of how the faluns were used, he said that they were used as fertilizer in the same manner as marl (1720: 9). In fact, marl, a calcareous clay, or intimate mixture of clay and particles of calcite or dolomite, is used to fertilize acid and lime-deficient soils, while the faluns were used to aerate clayey soils, quite the opposite of what marl does.

Buffon stated in the *Preuves de la Théorie de la terre* that marine shells were found everywhere in huge quantities, in beds of 100 to 200 leagues of length and "c'est par collines & par provinces qu'il faut les toiser, souvent dans une épaisseur de 50 ou 60 pieds, & c'est d'après ces faits qu'il faut raisonner." He then continued: "Nous ne pouvons donner à ce sujet un exemple plus frappant que celui des coquilles de Touraine; voici ce qu'en dit l'Historien de l'Académie..." (1749: 266). Instead of citing Réaumur, Buffon cited Fontenelle's account word for word and neglected to investigate personally (1749: 266-271).

I have mentioned in section C of this chapter that Voltaire in 1765 also accepted the marine origin of fossils when he wrote *La Philosophie de l'histoire*. After making his own observation of (freshwater) fossils in the molasse of the Geneva basin, he

seemed to have become convinced that marine fossils were not as common as generally believed. For a first-hand inspection of the earth of Touraine he sent for a crate of the faluns and reported: (The following quotations are from the first edition of *Singularités* which differs from the text of the Moland edition.)

> Le fonds de cette minière est évidemment une espèce de terre calcaire & marneuse, dans laquelle une grande quantité de coquillages se trouve mêlée. Les morceaux purs de cette terre pierreuse sont sallés au goût. Les laboureurs l'emploient pour féconder leurs terres, & il est très-vraisemblable que son sel les fertilise. Si ce n'était qu'un amas de coquilles, je ne vois pas qu'il pût fumer la terre. J'aurai beau jetter dans mon champ toutes les coques déssechées des limaçons & des moules de ma province, ce serait comme si j'avais semé sur des pierres. Un naturaliste prétend que rien n'est meilleur pour faire croître du bled qu'un cabinet de coquilles, au lieu de fumier. Il a plus de connaissance de la phisique que moi; mais j'ose dire que je suis meilleur laboureur que lui; & quoique je sois sûr de peu de choses, je puis affirmer que je mourrais de faim si je n'avais pour vivre qu'un champ de vieilles coquilles cassées. (p. 54)

Voltaire added in a footnote: "Tout ce que ces coquillages pourraient opérer, ce serait de diviser une terre trop compacte. On en fait autant avec du gravier. Des coquilles fraîches & pilées pourraient servir par leur huile; mais des coquillages desséchés ne sont bons à rien." He continued:

> ... En un mot, il est certain, de la plus grande certitude, que cette marne est une espèce de terre, & non pas uniquement un assemblage d'animaux marins qui seraient au nombre de plus de mille milliars. Je ne sais pourquoi l'académicien qui, le premier apès Palissi, fit connaître cette singularité de la nature, a pu dire: « *Ce ne sont que de petits fragments de coquilles très reconnaissables pour en être des fragments; car ils ont leurs cannelures très bien marquées; seulement ils ont perdu leur luisant & leur vernis.* » (p. 55)

The words cited by Voltaire are from Fontenelle's account of Réaumur's memoir which Voltaire had probably read in Buffon's *Théorie de la terre*. Therefore, Voltaire failed to understand how the faluns were used in Touraine, namely to aerate compact and clayey soil, and not to add fertilizer as Fontenelle had said. Voltaire decided therefore that faluns were some salty earth which might fertilize soil: gypsum at Ferney was used for the same purpose, but shells alone could never fertilize any soil. Voltaire also objected to the idea reported by Buffon that falun was nothing but fragments of marine animals which were, moreover, still recognizable as such. The material sent to Voltaire, however, did not match this description: long-distance transportation apparently played havoc with the original deposit. This convinced him that Palissy and his followers were mistaken about this "singularité de la nature."

Voltaire mistook Palissy for the originator of the idea that the sea had covered all of Europe because Jussieu (1718), Fontenelle (1720), and Buffon had said he was. In fact, Palissy accepted only the marine origin of fossils close to the coast, others

he believed to be of lacustrine origin (1580, trans. 1961: 276-281). Voltaire, moreover, thought that Palissy had mentioned the faluns of Touraine whereas Palissy, on the contrary, had described the use of marl in the fields of Saintonge, but not in Touraine as Voltaire understood (Palissy, 1580, trans. 1961: 325). This misunderstanding might have happened because Fontenelle (1720), Réaumur (1720), and Buffon all first referred to Palissy's originality and then introduced the faluns of Touraine as an example of marine shells without, however, showing any relation between the two subjects.

Voltaire continued:

> J'ai été étonné de trouver, dans la boëte qu'on m'a envoyée, de petits univalves & un coquillage qu'on nomme vis de mer, ou piramide à cannelures aussi frais, aussi brillants, & d'un aussi beau vernis qu'on puisse en trouver sur le bord de la mer de nouvellement formés. Mais ce qui m'a le plus surpris, c'est d'y voir une coque de limaçon qui paraît être de l'année passée, & trois dents qui ressemblent parfaitement à des dents de brochet. Les curieux qui voudront les venir examiner en jugeront beaucoup mieux que moi. Si les petites coquilles mêlées dans ma boëte à la terre marneuse sont réellement des coquilles de mer, il faut avouer qu'elles sont dans cette fallunière depuis des temps reculés qui épouvantent l'imagination, & que c'est un des plus anciens monuments des révolutions de nôtre globe. Mais aussi, comment une production enfouïe quinze pieds en terre pendant tant de siècles, peut-elle avoir l'air si nouveau? Comment y a-t-on trouvé la coquille d'un limaçon à côté de petites univalves marines? Ces univalves, dont la dimention n'est pas le quart du petit doigt, paraissent n'avoir pas une date plus ancienne que la coquille du limaçon qui était mêlée avec la terre. L'expérience de Mr. de La Sauvagère qui a vu des coquillages semblables se former dans une pierre tendre, & qui en rend témoignage avec ses voisins, ne doit-elle pas au moins nous inspirer quelques doutes sur l'origine de ce fallun?
>
> Enfin, si ce fallun a été produit à la longue dans la mer, ce qui est très-vraisemblable, elle est donc venue à près de quarante lieues dans un pays plat, & elle n'y a point formé de montagnes. Il n'est donc nullement probable que les montagnes soient des productions de l'Océan. (first ed. p. 55-57)

This confused statement appeared in six later editions and seems to point to Voltaire's dilemma: he still could not decide whether the faluns were a marine or freshwater deposit. He was surprised by two things: first the shine of these so-called marine shells, and second, to find these shells next to a shell of a freshwater snail. Voltaire could not conceive that some shells deposited thousand or million years ago would retain their original luster. He seemed to find it plausible merely that very recently dead garden snails should retain their shiny exterior. Furthermore, he seemed to have recognized a form of snail as he had found them in his garden at Ferney. Puzzled by these two facts, he even considered the idea of "spontaneous vegetation" by La Sauvagère as a possible answer although he fought "spontaneous generation" by Needham elsewhere (see Section I). Then again, he found it "très-vraisemblable" that the faluns were really a marine production. But why had the sea not formed any mountains in Touraine?

In the next chapter of *Singularités*, Voltaire added another objection to the opinion that faluns were of marine origin:

> L'expérience, comme on l'a dit, est trompeuse; il faut donc examiner encor ce fallun. Il est certain qu'il pique la langue par une légère âcreté, c'est un effet que des coquilles ne produiront pas. Il est indubitable que le fallun est une terre calcaire & marneuse. Il est indubitable aussi quelle renferme un nombre étonnant de coquilles à dix à quinze pieds de profondeur. (first edition p. 58)

The bulk of Voltaire's objections in 1768 was all based on observation: the faluns did not taste like shells; the so-called marine shells were as shiny as the younger freshwater snail; faluns could not be used as fertilizer as gypsum was used at Ferney, and last, he recognized the shell of a freshwater snail.

In 1770 Voltaire incorporated chapters XII through XVIII of *Singularités* in *Question sur l'Encyclopédie par des Amateurs* (Quatrième Partie) under the heading "Des Coquilles et des systèmes bâtis sur les Coquilles" and revised the chapter on the faluns of Touraine.

Voltaire omitted a few remarks against Buffon (or Réaumur?) here and there in which he had indulged in mild sarcasm. His greatest change, however, consisted in eliminating from the text all references to the presence of marine fossils. Instead of the passage "J'ai été étonné de trouver..." ending with "productions de l'Océan," he said:

> Il est reconnu que, dans cette mine de pierre calcaire et de talc, on n'a jamais vu une seule écaille d'huître, mais qu'il y en a quelques-unes de moules [freshwater], parce que cette mine est entourée d'étangs. Cela seul décide la question contre Bernard Palissy, et détruit tout le merveilleux que Réaumur et ses imitateurs ont voulu y mettre. (p. 152-153)

The rest of chapter XVI is similar to the original edition of 1768 with the exception of the sentence in the last paragraph, "Enfin si ce falun a été produit à la longue dans la mer, ce qui est très-vraisemblable, elle est donc venue à près de quarante lieues dans un pays plat..." In that sentence, Voltaire deleted "très-vraisemblable." In chapter XVII, he repeated the experiment of the faluns and found them slightly "âcre." He deleted the words "un nombre étonnant de coquilles" and replaced them by "quelques coquilles de moules."

A comparison of the original with the 1770 edition shows that Voltaire now seemed convinced that the sea had never covered Touraine and that the faluns were merely freshwater deposits which contained some mussels that had been transported there from nearby ponds. He had given a similar interpretation for the "écaille d'huître" found on the mont Cenis saying that freshwater mussels in nearby lakes resembled oysters since they were called "petites huîtres" by local inhabitants (p. 145).

After his investigation of the faluns, Voltaire made some changes in other works where he had mentioned the invasion of the sea as far as Touraine. In the *Avant-Propos* to *Essai sur les Mœurs* he deleted the fifteen words after "campagnes" in the sentence: "Toutes les campagnes arrosées par les fleuves du Rhin, de la Meuse, de la Seine, de la Loire, ont été couvertes des eaux de la mer pendant une prodigieuse multitude de siècles", thus omitting the name of the river Loire which runs through Touraine (*Œuvres*, ed. Beaumarchais, XVI: 3). He also deleted in the first chapter of *La Philosophie de l'histoire* starting from "Vous savez que ces lits profonds de coquillages qu'on trouve en Touraine" to the end of the paragraph and substituted for it: "Il n'y a point de rivage que le temps n'ait éloigné ou rapproché de la mer" (*The Complete Works of Voltaire*, 59: 90-91). This consistent change in other works shows that Voltaire sincerely doubted the generally accepted theory and that he had more faith in his own observations.

Modern investigation indicates that Voltaire's opinion on freshwater fossils was correct. In the past Touraine was invaded by one or several marine embayments which deposited most of the faluns (Lecointre: 13, 185). It is uncertain, however, how many times the sea retreated and what precise regions were exposed and filled with freshwater lakes and what localities were estuaries with a mixture of both marine and freshwater fauna. It is known that the faluns contain marine, freshwater, and terrestrial fossils (Lecointre: 135-136, 143). Lecointre (1947, plate VI) shows a *Helix turonensis*, a *freshwater snail* which looks so similar to *Helix ramondi* in the Chattian freshwater molasse that we are not surprised that Voltaire immediately recognized "une coque de limaçon qui paraît être de l'année passée." In other words, while the sea invaded Touraine several times, some faluns, nevertheless, contain exclusively freshwater fossils, and others in ancient estuaries contain mixed or only marine fauna. Thus, depending on the location of the faluns, both Voltaire's and Buffon's opinion were correct. Buffon, however, had merely followed a general opinion, had copied Fontenelle's account, had made no personal investigation while Voltaire based his opinion on personal observation.

I believe that Voltaire rejected the presence of marine fossils in the faluns in 1770 because he doubted the interpretation of his contemporaries. Indeed, his observations of the faluns revealed that they were not merely a mass of shell fragments as reported by Buffon, nor could they be used to fertilize fields such as Voltaire owned, nor did the faluns taste like shells. On the contrary, the sample he inspected after long-distance transportation had changed into powdery calcareous earth with some shiny shells. The shine of the shells, the taste and the general appearance of the faluns, and the fact that they could not be used as fertilizer caused Voltaire to distrust the opinion of his contemporaries. Furthermore, he might have encountered in Buffon and in Bertrand the idea that terrestrial and freshwater shells occurred only in quarries of encrusting tufa, a present-day soft deposit around mineralized springs (Buffon 1749: 276; Bertrand 1763: 141). Voltaire, however,

had discovered freshwater fossils in the considerable older molasse at Ferney (about 38 million years old) and in the faluns of Touraine (about 20 million years), fossil shells which greatly resembled snails in his garden and which he therefore believed to be freshwater or terrestrial fossil shells.

It is possible that Voltaire guessed that nobody was able to distinguish freshwater from marine shells. Today we know that gastropods (snails), pelecypods (clams and mussels), and ostracods (crustaceans) are classes of animals which live both in the sea and in freshwater (Picard and High 1972: 117). These are also the most common *nonmarine* invertebrate fossils. Paleontologists are now able to distinguish more accurately a freshwater snail from a marine one (Picard and High 1972: 118). In the eighteenth century, however, naturalists who believed in the theory that the sea had been everywhere held that all fossils found outside of tufa were of marine origin. Voltaire's so-called "vis de mer" (probably a spiral-shaped snail, either marine or freshwater) together with a snail which he compared with one from his own garden, might have been the product either of a freshwater environment, or of an estuary or brackish environment where marine and freshwater fauna live mixed together. Considering the elementary state of knowledge of his century, it is not surprising that Voltaire interpreted the faluns according to his personal observations at Ferney. This belief that fossils in Touraine came exclusively from freshwater ponds was, however, never expressed clearly for reasons I shall explain in the next section.

I. Spontaneous Vegetation according to La Sauvagère

In chapter XIV, "Observation importante sur la Formation des Pierres et des Coquillages," Voltaire stated:

> M. Le Royer de La Sauvagère, ingénieur en chef, et de l'Académie des belles-lettres de la Rochelle, seigneur de la terre Desplaces en Touraine, auprès de Chinon, atteste qu'auprès de son château une partie du sol s'est métamorphosée deux fois en un lit de pierre tendre dans l'espace de quatre-vingt ans. Il a été témoin lui-même de ce changement. Tous ses vassaux et tous ses voisins l'ont vu. Il a bâti avec cette pierre, qui est devenue très dure étant employée. La petite carrière dont on l'a tirée commence à se former de nouveau. Il y renaît des coquilles qui d'abord ne se distinguent qu'avec un microscope, et qui croissent avec la pierre. Ces coquilles sont de différentes espèces: il y a des ostracides, des gryphites, qui ne se trouvent dans aucune de nos mers; des cames, des télines, des cœurs, dont les germes se développent insensiblement, et s'étendent jusqu'à six lignes d'épaisseur. N'y a-t-il pas là de quoi étonner du moins ceux qui affirment que tous les coquillages qu'on rencontre dans quelques endroits de la terre y ont été déposés par la mer? (p. 148-149)

The rich vocabulary about oysters and other shells displayed here derived from a memoir written by La Sauvagère (1764). Voltaire acknowledged its receipt saying

(11 June 1764): "Je m'applaudis de penser comme vous. J'ai toujours cru que la nature a de grandes ressources. Je suis dans un pays tout plein de ces productions terrestres que les savants s'obstinent à faire venir de la mer des Indes..." (D.11920). In October 1770, he sent a copy of *Singularités* to La Sauvagère with the following words:

> ... il y a des choses dans ce petit ouvrage qui sont assez analogues à ce qui se passe dans votre château: je m'en rapporte toujours à la nature qui en sait plus que nous et je me défie de tous les systèmes. Je ne vois que des gens qui se mettent sans façon à la place de dieu, qui veulent créer un monde avec la parole.
> Les prétendus lits de coquilles qui couvrent le continent, le corail formé par les insectes, les montagnes élevées par la mer, tout cela me paraît fait pour être imprimé à la suite des mille et une nuits.
> Vous me paraissez bien sage, monsieur, de ne croire que ce que vous voyez; les autres croient le contraire de ce qu'ils voient... (D.16727)

Voltaire's letters to La Sauvagère imply that he preferred to believe in observations made by this gentleman rather than theories on mountain-building by the sea. I have not seen the memoir by La Sauvagère; however, Guettard wrote a lengthy memoir (Tome 4, Mémoire 1, p. 1-22) to refute La Sauvagère by often citing complete passages of the latter's memoir. Guettard said that the pond which apparently produced a soft rock from a calcareous deposit and shells was situated at the bottom of a sandy hill, about thirty feet high, in Touraine. During the rainy season this pond collected waters and rose to eight or ten feet while it dried out during the dry season. A spring located at the northern end of the pond never dried out. La Sauvagère could see from his château the famous "falunières" described by Réaumur in 1720 and shells in the "falunières" were similar to those found in the pond (*Cames*, *Tellines*, *Gryphites*). He analyzed the shells in the soft mud, and those attached to tree branches, or to other objects fallen into the pond: they were *Ostracites*, *Gryphites*, and other species of oysters. Furthermore, La Sauvagère found some *Cames*, *Tellines*, and *Cœurs* measuring from five to six lines (A line is a term of measurement equivalent to a mark or stroke made by a pen.). All these shells had grown slowly in the pond; at first they were *Semina*, visible only under the microscope. In a bottle of frozen water retrieved from the bottom of the pond, he found all the seeds of these different shells; children and servants recognized some common oyster and mussel shells by looking through the ice which was acting as a magnifying glass. La Sauvagère then described a deposit or "encroûtement" formed by the material washed into the pond by the rains. The rapid growth of this deposit which enclosed shells made him believe that shells were growing into rocks by some miracle. Guettard mentioned, furthermore, that La Sauvagère also tried to explain the origin of fossils found in the faluns as having simply grown from seeds (p. 19) or as having been blown by high winds from the plains to the hills of the faluns (p. 22).

From the above memoir by La Sauvagère quoted by Guettard it is evident that Voltaire, in chapter XIV of *Singularités*, while being in favor of the theory of spontaneous vegetation did not accept the views by La Sauvagère about the origin of the faluns. Before discussing what I consider Voltaire's reasons of adhering to the theory of spontaneous vegetation, I would like to give Guettard's criticism of the memoir which coincides with modern views on encrusting and mineralized springs.

Guettard mentioned that the château of La Sauvagère was built on parts of the "falunières" (p. 13): the shells in the faluns and in the pond were identical. He wondered why La Sauvagère did not understand that most of the shells found in his pond came indeed from these faluns: "Son étang se remplit dans les grandes pluies de l'eau de ces pluies, qui tombe de la bute de sable, au pied de laquelle cet étang est situé, & qui a coulé sur un terrain qui fait partie des falunières: & M. de La Sauvagère n'imagine pas que les coquilles, qu'il trouve dans son étang, sont de celles que les eaux entraînent en lavant les terres..." (p. 15) (In other words, the pond itself was resting on faluns containing shells while waters from the rain carried some more shells from the sandy hill underneath which other layers of faluns existed. At the same time, the spring which had also resulted from the surrounding faluns was staurated with calcareous material which produced the encrusting fountain.) Guettard mentioned that the spring in La Sauvagère's pond was an encrusting and mineralized fountain or spring. The same kind existed in the gardens of the former Princess de Conti; at Issy near Paris; at the fountain of Gregi, near Meaux, and a deposit was being formed in the ponds near Frescati (p. 15). The spring in La Sauvagère's pond was nothing more than water "chargée d'une matière qui se dépose peu-à-peu & donne ainsi naissance à des masses pierreuses plus ou moins considérables" (p. 16). Given these simple principles of encrustation, La Sauvagère's miracle can be explained, said Guettard. Anything that had fallen into the pond or that lived in it became enclosed in a calcareous material: branches, flowerpots, and shells. Shells that resembled marine fossils came from the surrounding "falunières," and those that resembled freshwater snails had lived recently in the pond before being encrusted. (It was thus a mixture of recently dead freshwater organisms and ancient marine fossil shells from the faluns.) Guettard's criticism of La Sauvagère's ideas on the origin of the faluns of Touraine do not matter here because Voltaire did not accept them.

Modern explanations of encrusting and mineralized fountains are the same as those given by Guettard. Modern studies do not mention any encrusting spring in the region of Chinon; but Guettard's interpretation seems to be correct since water that ran through the faluns would naturally be very rich in calcareous material and generate an encrusting spring. The formation of the soft rock called tufa or travertine is extremely rapid.

It seems contraditory that Voltaire adhered to the theory of *spontaneous vegetation* although he rejected at the same time, and in the same essay, Needham's

spontaneous generation (p. 159-160). Was there any difference in the eighteenth century? The following letter by La Sauvagère, sent to Voltaire in June 1777, explains spontaneous vegetation as he saw it:

> Un nouveau phénomène doit vous être annoncé, & j'ai cru devoir en faire part au plus universellement savant, à vous, monsieur, qui avez si bien discuté le miracle qui s'opère dans la petite pièce d'eau du jardin de mon château des Places, d'après le mémoir imprimé dans le *Journal de Verdun* il y a 14 ans, où j'ai dit que j'en avais enlevé un banc de pierre, qui s'y était formé sur la superficie du fond de cet étang, & cela pour la seconde fois: que cette pierre était remplie, tant par dessus, qu'au dedans, d'une grande quantité de coquilles, dont j'ai analysé les différentes espèces, & qu'il s'était trouvé sous ce banc de pierre *(après l'avoir cassé & enlevé)* une vase molle, glutineuse remplie de germes de ces mêmes coquilles... (D.20712)

After the above, which had already been said in his memoir of 1764, La Sauvagère announced to Voltaire: "Cette vase n'est plus vase; la *repétrification* a recommencé." The pond had become dry and La Sauvagère had been able to inspect during three months this "nouveau sol *repétrifié* sur lequel on s'est promené tout le temps, & dont j'ai fait arracher *(de ce pavé de roc neuf formé par la nature)* plusieurs morceaux que je conserve, où se trouvent, dans la classe des infiniment petits, toutes les différentes espèces de coquilles, semblables aux anciennes." He informed Voltaire that he had written a second memoir and said: "voilà donc la nature reprise sur le fait une seconde fois par moi, & cela sans réplique [...] C'est une production, je l'avoue, miraculeuse, dont la nature m'a fait dépositaire" (D.20712).

The difference between generation of shells from seeds and spontaneous generation of animals appears very slight to modern readers. However in the eighteenth century, it was perhaps a question of design versus randomness: little animals appeared spontaneously out of nothing in Needham's boiled mutton gravy (1748, Reprint 1963) while miniature shells were engendered from pre-existing seeds which had been distributed by God. Some people saw no difference between organic and inorganic matter and believed that God had created matter including seeds of the whole universe and that minerals, stones, and fossils were all engendered seeds (Robinet 1766, I: 109; IV: 1ii). Robinet even believed that fossils were actually living and dying: "les animaux fossiles passent leur vie dans les entrailles de la terre: ils y naissent, ils s'y nourrissent, ils y croissent, ils y murissent, ils y répandent leurs semences, ils y vieillissent, ils y meurent..." (1766, IV: 173). Thus, spontaneous generation meant randomness to some naturalists, and Voltaire refuted it violently in *Singularités* (p. 159-160), while spontaneous vegetation meant design which Voltaire was apparently less reluctant to accept.

Nevertheless, I believe that Voltaire adhered to the idea of spontaneous vegetation for other reasons: one, it provided another evidence against the marine theory; two, he was never sure about his personal observations at Ferney.

Indeed, when Voltaire wrote *Singularités*, he doubted not only the ideas of others but also his own. In the last two sections of this chapter I have mentioned that his independent observations of fossil shells in the neighborhood of Ferney did not match those of his contemporaries. Thus, he argued that many so-called marine fossils might well be of freshwater origin. However, Voltaire never felt quite confident among naturalists about his own observations and thus often added some ideas that completely contradicted what he had just said thus shrouding his personal views in doubts. For instance, in chapter XIII, after he had just declared that fossils lining the banks of many rivers looked very similar to fragments of freshwater snails, he added in a last paragraph:

> Je ne nie pas, encore une fois, qu'on rencontre à cent milles de la mer quelques huîtres pétrifiées, des conques, des univalves, des productions qui ressemblent parfaitement aux productions marines; mais est-on bien sûr que le sol de la terre ne peut enfanter ces fossiles? La formation des agates arborisées ou herborisées ne doit-elle pas nous faire suspendre notre jugement? Un arbre n'a point produit l'agate qui représente parfaitement un arbre; la mer peut aussi n'avoir point produit ces coquilles fossiles qui ressemblent à des habitations de petits animaux marins. L'expérience suivante en peut rendre témoignage. (p. 148)

This passage reveals that Voltaire seemed to have misgivings about the origin of some fossils which resembled marine organisms although he had declared in the same chapter, "de véritables corps marins, c'est ce que vous ne voyez jamais" (p. 147). Thus, he proposed that these fossils might be either imprints as in agates or they might have been engendered by the soil in a process related by La Sauvagère.

I believe that Voltaire lacked faith in his own observations, which might be partly due to Guettard's visit at Ferney. This naturalist wrote in his memoirs (1768-1786, IV: 12) that he had visited Voltaire at Ferney where he had apparently tried to explain to Voltaire that all fossil shells were of marine origin. Guettard wrote that some philosopher could not imagine that the sea had deposited marine shells on land and would therefore take "le parti désespéré de croire que ces coquilles se sont formées dans la terre." He continued:

> On a beau lui représenter que ces coquilles ont la même figure, la même contexture, souvent la même grandeur, les mêmes accidents, rien ne peut le convaincre; & quoiqu'il proteste qu'il est docile, que ce sont des doutes, des problèmes qu'il propose, il ne se rend point aux démonstrations, la lumière l'éblouit, & il reste opinâtrément dans sa fausse opinion [...]
> M. de Voltaire a avancé un sentiment sur les corps marins fossiles, qu'on auroit pris pour une plaisanterie, si il ne l'eût pas fait reparoître dans quelques-uns de ses ouvrages postérieurs... (p. 10)

Guettard was referring to Voltaire's belief in spontaneous vegetation which he called "naissance spontanée" (p. 8).

This is the only recorded conversation between Voltaire and any naturalist of the eighteenth century that I know of. It might partly explain why Voltaire was never too certain about his own observations in the freshwater molasse at Ferney. Guettard had studied the faluns of Touraine (Tome 4, *Mémoire* 1) and the geology of the vicinity of Paris (Tome 5, *Mémoire* 3) and never doubted the marine origin of fossils found there. He had observed their resemblance to living analogues, but was also aware that some forms had no living counterpart. He was cautious and disliked systems as did Voltaire. Unlike Voltaire, he had traveled widely in France, the Low Countries, Italy, Switzerland, and Poland since 1752 to gather material for the national geological survey (Rappaport, DSB). Guettard's knowledge of fossils must have impressed Voltaire. It is interesting to notice that he remained docile but stubbornly attached to his own views when Guettard tried to convince him of his errors. It is quite possible, that Guettard was pointing at freshwater snails *(Helix ramondi)* and interpreted them as marine while Voltaire was, or had been, convinced that these fossils ressembled freshwater snails. Perhaps he remained stubborn in the presence of Guettard, while he might have had second thoughts when he finally wrote *Singularités* and thus wavered between his own beliefs and those of others. Indeed in chapter XIII, he wavered between the freshwater origin of fossils and spontaneous vegetation or sports of nature, as mentioned above, and in chapter XIV he wavered between freshwater fossils and spontaneous vegetation.

A second reason for Voltaire's adherence to spontaneous vegetation might be his rhetorical tactics which consist in piling up evidence upon evidence in order to make a point. Voltaire himself said about his tactics: "J'ai pu les siffler prendre un peu trop de soin: Eh! quel auteur, hélas! ne va jamais trop loin"? (*Les Cabales*, M.X: 183) The following passage at the end of chapter XIV also shows that Voltaire used La Sauvagère's argument to add more evidence against the marine theory:

> Si on ajoute à tout ce que nous avons déjà dit ce phénomène de la terre Desplaces; si d'un autre côté, on considère que le fleuve de Gambie et la rivière de Bissao sont remplis d'huîtres, que plusieurs lacs en ont fourni autrefois, et en ont encore, ne sera-t-on pas porté à suspendre son jugement?... (p. 149) [1]

This passage shows Voltaire's technique of piling up of evidences ("si on ajoute à tout ce que nous avons déjà dit [...] si d'un autre côté...") which I believe was one of the reasons why he adhered to the theory of spontaneous vegetation.

When in 1770 Voltaire included chapter XIV on spontaneous vegetation in *Questions sur l'Encyclopédie* he presented, on the one hand, his agreement with

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[1] In the river Gambia in West Africa and Bissâo in Portuguese Guinea small oysters live in the brackish waters of the river deltas which is true also of all large rivers where oysters cling to mangroves. These oysters are therefore not of marine origin. As to oysters that had lived in ancient lakes, Voltaire was probably referring to those he had mentioned in the vicinity of Mont Cenis where freshwater mussels were mistaken for "petites huîtres" by local inhabitants.

the notion of spontaneous vegetation (chapter XIV), on the other his intuition that many so-called marine fossils were indeed of freshwater origin (chapter XIII, p. 147; chapter XVI on the faluns of Touraine). This paradox could be explained if we consider his uncertainty about his own observations and his tactics to accumulate as much evidence as possible.

J. Ovid, Lucretius, Telliamed, and Stories of Changing Forms

Many naturalists of the eighteenth century cited Ovid's verses in their theories of the earth because the "Teaching of Pythagoras" (ca. 500 B.C.) in Ovid's *Metamorphoses* (Book fifteen) had mentioned changes from land to sea and from sea to land, sea-shells lying far away from the coast, erosion of rivers, and other geological features that showed that the surface of the earth had undergone many changes:

> Nothing, I am convinced, can be the same
> Forever. There was once an Age of Gold,
> Later, an Age of Iron. Every place
> Submits to Fortune's wheel. I have seen oceans
> That once were solid land, and I have seen
> Lands made from ocean. Often sea-shells lie
> Far from the beach, and men have found old anchors
> On mountain-tops. Plateaus have turned to valleys,
> Hills washed away, marshes become dry desert,
> Deserts made pools. Here Nature brings forth mountains,
> There shuts them in; when the earth quakes, new rivers
> Are born and old ones sink and dry and vanish...
> (Trans. Humphries, p. 373)

Buffon found his theory of the earth confirmed by this ancient philosophy and prefaced it with Ovid's verse:

> Vidi ego, quod fuerat quondam solidissima tellus,
> Esse fretum; vidi fractas [sic] ex aequore terras;
> Et Procul a pelago conchae jacuere marinae,
> Et vetus inventa est in montibus anchora summis;
> Quodque fuit campus, vallem decursus aquarum
> Fecit, & eluvie mons est deductus in aequor. (1749: 64)

When *Telliamed* was published in 1748, the Abbé Le Mascrier, in charge of its publication, added in a footnote, "Vidi ego quod fuerat quondam solidissima tellus, / Esse fretum: vidi factas ex aequore terras; / Et procul à pelago conchae jacuere marinae" to support the idea of the diminution of the sea (1755, I: 147). Le Mascrier was master in concealing shocking and unorthodox facts by referring to the beliefs of the ancients.

Voltaire also quoted Ovid's verses in chapter XI of *Elémens* in 1738 but deleted them from the edition of 1748:

> Nil equidem durare diu sub imagine aedam
> Crederim. Sic ad ferrum venistis ab auro,
> Secula. Sic toties versa es, fortuna locorum.
> Vidi ego, quod fuerat quondam solidissima tellus,
> Esse fretum; vidi factas ex aequore terras;
> Et procul a pelago conchae jacuere marinae;
> Quodque fuit campus, vallem decursus aquarum
> Fecit; et eluvie mons est deductus in aequor.
> Eque paludosa siccis humus aret arenis. (M. XXII: 551)

In the above quotation Voltaire omitted the line on the anchor: "Et vetus inventa est in montibus ancora summis," an omission which he later explained in a footnote in *Singularités*: "Cela ressemble un peu à l'ancre de vaisseau qu'on prétendait avoir trouvée sur le grand Saint-Bernard: aussi s'est-on bien gardé d'insérer cette chimère dans la traduction" (p. 151). Indeed, the story told by Ovid of anchors found in mountains was repeated by many writers such as Burnet and Maillet as mentioned earlier. The former used the tale to confirm the idea that the sea had once covered the whole earth and that anchors were remnants of earlier sea-going vessels; the latter said that anchors were witnesses of the diminution of the sea. Voltaire simply omitted the whole story.

In *Elémens* of 1738, Voltaire then freely translated Ovid's verse:

> Le temps qui donne à tout le mouvement et l'être,
> Produit, accroît, détruit, fait mourir, fait renaître,
> Change tout dans les cieux, sur la terre et dans l'air;
> L'âge d'or à son tour suivra l'âge de fer:
> Flore embellit des champs l'aridité sauvage;
> La mer change son lit, son flux et son rivage;
> Le limon qui nous porte est né du sein des eaux;
> Le Caucase est semé du débris des vaisseaux;
> Bientôt la main du Temps aplanit les montagnes,
> Il creuse les vallons, il étend les campagnes;
> Tandis que l'Éternel, le souverain des temps,
> Et seul inébranlable en ces grands changements.

Apart from the omission of the anchor, the greatest change in Voltaire's translation of Ovid's verses is the introduction of "l'Eternel, le souverain des temps" who apparently governed time and changes, an idea which Pythagoras had not expressed. Ovid tells of Pythagoras as an exiled man from Samos whose thought "reached far aloft, to the great gods in Heaven, and his imagination looked on visions beyond his mortal sight." He then sat among people and explained the beginning of the world, "the primal cause, the nature of things, what God is," natural phenomena

such as earthquakes, stars, that souls are deathless, that all things change but never die:

> Nothing is permanent in all the world.
> All things are fluent; every image forms,
> Wandering through change. Time is itself a river
> In constant movement, and the hours flow by
> Like water, wave on wave, pursued, pursuing,
> Forever fugitive, forever new.
> That which has been, is not; that which was not,
> Begins to be; motion and moment always
> In process of renewal [...]
> Nothing remains the same: the great renewer,
> Nature, makes form from form, and oh, believe me
> That nothing ever dies... (p. 371-373)

"Nature" was Pythagoras' great renewer while for Voltaire an Eternal Being governed time and Changes.

Another change in Voltaire's translation is the omission of sea-shells which he replaced with "le limon qui nous porte est né du sein des eaux." Voltaire did not use Maillet's interpretation of "limon" (1755: 264) where life actually started with the right temperature and the right combinations. Moreover, the word "limon" does not have the connotation of "earth containing sea-shells." In 1738, the Abbé Banier translated Ovid and the sentence reads: "On rencontre bien loin de ses rivages [the sea], des coquillages qu'elle a formés..." (Tome III: 307). Therefore, Voltaire apparently omitted marine shells either to make a better rhyme, or because he doubted their marine origin as early as 1738.

In the *Saggio* of 1746, Voltaire cited only two lines in Latin: "Vidi ego quod fuerat quondam solidissima tellus / Esse fretum, vidi factas ex aequor terras, etc." (p. 6) calling the followers of Pythagoras "la folla Pittagorica." In the *Dissertation*, translated by Voltaire in 1748, he reintroduced the whole French translation of Pythagoras' teaching as "l'Opinion des Indiens et de Pythagore," addressing his essay to the French and not the Italian audience.

In *Singularités*, chapter XVI, Voltaire again cited Ovid's verse in Latin and in French, basically unchanged, as in the *Elémens* of 1738. With the exception of the translation of marine shells into "limon" and the introduction of a superior Being governing time and change, Voltaire's reaction toward geological changes on the surface of the earth as described by Pythagoras was rather low-key.

Pythagoras, however, also believed in spontaneous generation. He mentioned small hornets produced from horses; green frogs generated from seeds in the mud. He believed that "The heavens and all below them, earth and her creatures, / All change, and we, part of creation, also / Must suffer change..." (p. 379) We know that Voltaire reacted strongly against the view that something could come out of nothing; however in chapter XX in *Singularités* "De la prétendue race d'anguilles

formées de farine et de jus de mouton" he did not criticize the followers of Pythagoras, but those of Lucretius.

Lucretius, a Roman poet who preceded Ovid by about four centuries, wrote *De Rerum Natura* where he advocated the view that although nothing could come from nothing, the worlds like atoms were continuously created and destroyed. A combination of primordial seeds but not divine power was responsible for the beginning of life. In his words:

> Neither by counsel did the primal germs
> 'Stablish themselves, as by keen act of mind,
> Each in its propre place; nor did they make,
> Forsooth, a compact how each germ should move;
> But, lo, because primordials of things,
> Many in many modes, astir by blows
> From immemorial aeons, in motion too
> By their own weights, have evermore been wont
> To be so borne along in all modes
> To meet together and to try all sorts
> Which, by combining one with other, they
> Are powerful to create..." (Trans. Leonard 1957: 204)

In the eighteenth century the two strands of beliefs, spontaneous generation by Pythagoras and random creation and destruction of atoms by Lucretius, were combined by many naturalists and philosophers. It was, however, Lucretius who was quoted, or rather misquoted, according to Voltaire: "Un nouvel auteur d'une traduction élégante et exacte de Lucrèce, enrichie de notes savantes, s'efforce dans les notes du troisième livre, de combattre Lucrèce même à l'appui des malheureuses expériences de Needham, si bien convaincues de fausseté par M. Spallanzani, et rejetées de quiconque a un peu étudié la nature" (p. 160). Here, Voltaire appears, in particular, to criticize the translator who misquoted Lucretius.

Among some philosophers such as Diderot and d'Holbach, Lucretius had apparently become popular. (I shall discuss their works in the next sections.) Adrienne Redshaw mentions that two new translations of *De Rerum Natura* by Lagrange had appeared in 1768 and that the "subsequent reprinting of these is a clear indication of a new interest in Lucretius, coinciding predictably with the rapid growth of materialism in the latter part of the eighteenth century" (1980, 189: 20). Voltaire owned five editions of Lucretius, including the latest translation by Lagrange (USSR No. 2223-2227) and it is possible that the renewed interest in Lucretius prompted Voltaire to react to the latest theories on the beginning of life. He attacked Maupertuis, Needham, Buffon, and in connection with geology, Maillet.

I have mentioned in the first chapter that Maillet believed that mountains were formed during a gradual diminution of the sea. Half of his book *Telliamed* explains this process while the other half gives a theory about the beginning of life and transformism of earlier marine forms into terrestrial ones. Voltaire owned the Amster-

dam edition of 1748, published after Maillet's death (Havens and Torrey SVEC IX: 41). More important, Voltaire had also in his library at Ferney "Nouveau système du monde ou entretien de Teliamed," one of the many manuscripts that circulated during twenty years before publication. Thus, Voltaire had been familiar with Maillet's ideas since 1728 but had commented on them only sparingly. In 1756 in the *Catalogue de la plupart des ecrivains dans le Siècle de Louis XIV* (M.XIV: 99-100) he called the manuscript "une philosophie hardie," in other words unorthodox, and about the published work he said:

> On y trouve l'opinion que la terre a été toute couverte d'eau, opinion adoptée par M. de Buffon, qui l'a fortifiée de preuves nouvelles; mais ce n'est et ce ne sera longtemps qu'une opinion. Il est même certain qu'il existe de grands espaces où l'on ne trouve aucun vestige du séjour des eaux; d'autres, où l'on n'aperçoit que des dépôts laissés par les eaux terrestres.

In 1756 Voltaire seemed to be more concerned with geology than biology. Only after 1768 did Voltaire start to make fun of Maillet's ideas on transformism which was the time of renewed interest in Lucretius.

In *L'Homme aux quarante écus*, Voltaire referred to

> ... un descendant de Thalès, nommé Telliamed, qui m'apprit que les montagnes et les hommes sont produits par les eaux de la mer. Il y eut d'abord de beaux hommes marins qui ensuite devinrent amphibies. Leur belle queue fourchue se changea en cuisses et en jambes. J'étais encore tout plein des *Métamorphoses* d'Ovide, et d'un livre où il était démontré que la race des hommes était bâtarde d'une race de babouins: j'aimais autant descendre d'un poisson que d'un singe. (M. XXI: 331)

In the *Singularités* the same cliché is used: "Si la mer a été partout, il y a eu un temps où le monde n'était peuplé que de poissons. Peu à peu les nageoires sont devenus des bras; la queue fourchue..." (p. 145)

Maillet had gone beyond the views of Pythagoras and Lucretius. He presented the following pre-Darwinian ideas:

> Car il peut arriver, comme nous sçavons qu'en effet il arrive assez souvent, que les poissons aîlés & volans chassant ou étant chassés dans la mer, emportés du désir de la proie ou de la crainte de la mort, ou bien poussés peut-être à quelques pas du rivage par les vagues qu'excitoit une tempête, soient tombés dans des roseaux ou dans des herbages, d'où ensuite il ne leur fut pas possible de reprendre vers la mer l'essort qui les avoit tirés, & qu'en cet état ils ayent contracté une plus grande faculté de voler. Alors leurs nageoires n'étant plus baignées des eaux de la mer, se fendirent & se déjetterent par la sécheresse. Tandis qu'ils trouverent dans les roseaux & les herbages dans lesquels ils étaient tombés, quelques alimens pour se soutenir, les tuyaux de leurs nageoires séparés les uns des autres se prolongerent & se revêtirent de barbes; ou pour parler plus juste, les membranes qui auparavant les avoient tenus collés les uns aux autres, se métamorphoserent. La barbe formée de ces pellicules déjettées s'allongea elle-même; la peau de ces animaux se revêtit insensiblement d'un duvet de la même

> couleur dont elle était peinte, & ce duvet grandit. Les petits aîlerons qu'ils avoient sous le ventre, & qui, comme leurs nageoires, leur avoient aidé à se promener dans la mer, devinrent des pieds, & leur servirent à marcher sur la terre. (1755, II: 166-167)

Maillet believed in the beginning of life in the sea, and the above passage gave some explanation of how flying fish might have started to live on land by accident and by transformation of their bodies. For humans, he resorted to many tales told by travelers of sea dogs, sea wolves, sea men, and sea women. One tale witnessed by six persons including the Jesuit father Julien Simon, told of a creature of human form from "the waist upward and terminating below like a fish. His tail was large and split..." (Carozzi, A. 1968: 194). Other stories by Maillet relate to men with tails, to dwarfs, and to other monsters, in general promoting the idea that transformation of human bodies is quite possible. Many details are given about the sexual parts of these strange sea-men. I have the impression that Voltaire could not take Maillet's theory seriously since it was intermingled with hearsay and travel stories. He wondered in chapter XXXVI "Des monstres et des races diverses": "Est-il bien vrai que, dans quelques îles des Philippines et des Mariannes, il y ait quelques familles qui ont des queues, comme on peint les satyres et les faunes? Des missionnaires jésuites l'ont assuré: plusieurs voyageurs n'en doutent pas; Maillet dit qu'il en a vu [...] Mais qu'il y ait eu quelques hommes à queue ou non, cela est fort peu important, et il faut ranger ces queues dans la classe des monstruosités" (p. 186)

In conclusion, Voltaire used Ovid's verses with discrimination, omitting the anchor and the sea-shell, and imposing an Eternal Being to govern time and changes. His stand toward Lucretius has been thoroughly traced by Redshaw in regard to creation, void, and God as a prime mover. She suggests that "Voltaire's final stand on the eternity of matter and the possibility of creation from nothing was not, in fact so very far removed from that of the early atomists, although he maintained a belief in a divinely ordering intelligence" (p. 27-28). In my study of Voltaire's attitude toward geology, I have not found enough evidence to make any better judgment.

In *Singularités* Voltaire's criticism of Maillet was stronger in matters of biology than geology. Indeed, Voltaire tacitly agreed with many unorthodox propositions made by Maillet on the deluge, the arch of Noah, the tower of Babel. But he did not recognize in Maillet a forerunner of Darwin and jeered:

> Cette nourriture des étoiles n'aurait pas réussi dans notre temps; et malgré les sermons du poisson Oannès,[1] les arguments de Thalès, les imaginations de Maillet, malgré l'extrême passion qu'on a aujourd'hui pour les généalogies, il y a peu de gens qui croient descendre d'un turbot et d'une morue. Pour étayer ce système, il fallait absolument que toutes les espèces et tous les éléments se changeassent les uns en les autres. Les *Métamorphoses* d'Ovide devenaient le meilleur livre de physique qu'on ait jamais écrit. (p. 156-157)

[1] God of the Chaldeans, allegedly the first teacher of civilization, half-human, half-fish, who instructed men about literature, science, art, and agriculture.

K. On Mountains and Final Causes

Voltaire's opinion that mountains had existed on the earth ever since its beginning never changed. In *Dissertation* he affirmed that mountain-chains encircle the earth in order to provide stability and irrigation to the continents. There he had followed Kircher's cosmology since he mentioned some imaginary mountains between South Africa and the Atlas mountains as Kircher had described. In *Singularités*, he spent a whole chapter on "Des Montagnes, de leur necessité, et des causes finales." He distinguished small mountains from a great mountain-chain saying that the latter is formed "d'un roc continu, tantôt de roche dure, tantôt de pierre calcaire, tantôt de graviers. Elle s'élève et s'abaisse par intervalles. Ses fondements sont probablement aussi profonds que ses cimes sont élevés." (The last statement strikes as similar to the modern concept of isostasy, i.e. equilibrium of the earth's crust.)

This mountain-chain, he said,

> paraît une pièce essentielle à la machine du monde, comme les os le sont aux quadrupèdes et aux bipèdes. C'est autour de leurs faîtes que s'assemblent les nuages et les neiges, qui de là, se répandant sans cesse, forment tous les fleuves et toutes les fontaines, dont on a si longtemps et si faussement attribué la source à la mer [...]
> Les chaînes de ces montagnes qui couvrent l'un et l'autre hémisphères ont une utilité plus sensible. Elles affermissent la terre, elles servent à l'arroser; elles renferment à leurs bases tous les métaux, tous les minéraux. Qu'il soit permis de remarquer à cette occasion que toutes les pièces de la machine de ce monde semblent faites l'une pour l'autre. (p. 138)

These words recall Kircher's as well as Bertrand's cosmology.

In *Essai sur les usages des montagnes* Bertrand had maintained that mountains were necessary to "affirmer la Terre par les rochers dont elles sont composées. Ces rochers sont dans le Globe, qu'on a nommé le *Macrocosme* ce que les os sont dans le Corps humain, qu'on appelle le *Microcosme*" (1766: 118). Without mountains the earth and the oceans would fly away during the daily rotation. Bertrand stated that Kircher's ideas were a bit too marvelous and that mountain-chains need not be so regular and so neatly arranged (1766: 119). He believed that God had created mountains for various usages, one was to bring forth springs which would water all the lands. He concluded: "Il résulte évidemment de toutes nos observations que notre globe, destiné aux usages auxquels il sert, n'a jamais pu se passer des Montagnes; elles subsistent donc depuis la création" (1766: 205).

Voltaire mentioned only once in *Singularités*, never in *Dissertation*, that God had created mountains (p. 141) and discussed final causes in chapter X of *Singularités*, in *Candide* (M.XXI: 138) and in *Questions sur l'Encyclopédie* under "Causes finales." in *Singularités* he said:

> Quelques philosophes affectent de se moquer des causes finales rejetées par Epicure et par Lucrèce. C'est plutôt, ce me semble, d'Epicure et de Lucrèce qu'il faudrait se moquer. Ils vous disent que l'œil n'est point fait pour voir; mais qu'on s'en est servi pour cet usage quand on s'est aperçu que les yeux y pouvaient servir. Selon eux, la bouche n'est point faite pour parler, pour manger, l'estomac pour digérer, le cœur pour recevoir le sang des veines et l'envoyer dans les artères... (p. 138)

In the *Dictionnaire philosophique* (Causes finales) Voltaire distinguished final causes from efficient causes: "Si une horloge n'est pas faite pour montrer l'heure, j'avouerai alors que les causes finales sont des chimères; et je trouverai fort bon qu'on m'appelle *cause-finalier*, c'est-à-dire un imbécile." In *Singularités* he said "Pour qu'on puisse s'assurer de la fin véritable pour laquelle une cause agit, il faut que cet effet soit de tous les temps et de tous les lieux." Therefore, the nose was not made to bear glasses, nor hands to wear gloves. Mountain-chains and their rivers and fountains which feed mankind and animals, were, however, not "l'effet d'un cas fortuit et d'une déclinaison d'atomes..." (p. 139-140). Voltaire was obviously thinking about philosophers who believed in the possibility of creation from nothing without any divinely ordering intelligence such as Diderot, Buffon, and d'Holbach.

Indeed, perhaps as a result of the publication of a new translation by Lucretius in 1768, materialistic theories about the beginning of life — either through spontaneous generation or a simple combination of atoms — received new interest among certain philosophers and naturalists. Diderot wrote *Le Rêve de d'Alembert* in 1769 and mentioned: "Suite indéfinie d'animalcules dans l'atome qui fermente, même suite indéfinie d'animalcules dans l'autre atome qu'on appelle Terre" (1951: 893). Here Diderot mixed fermentation (spontaneous generation) with a certain combination of atoms. Elsewhere he expressed the consoling thought that he would never die since matter continued endlessly: "La vie, une suite d'actions et de réactions. Vivant, j'agis et je réagis en masse... mort, j'agis et je réagis en molécules... Je ne meurs donc point?... Non, sans doute, je ne meurs point en ce sens, ni moi, ni quoi que ce soit... Naître, vivre et passer, c'est changer de formes..." (1951: 900).

Buffon has similar views which were based on Needham's experiment of spontaneous generation: "Le corps de chaque animal ou de chaque végétal est un moule auquel s'assimilent indifféremment les molécules organiques de tous les animaux ou végétaux détruits par la mort et consumés par le temps; les parties brutes qui étaient entrées dans leur composition retournent à la masse commune de la matière brute; les parties organiques, toujours subsistantes, sont reprises par les corps organisés; d'abord repompées par les végétaux, ensuite absorbées par les animaux qui se nourrissent de végétaux..." (1850-1860, VII: 174-175) All this promised a continual succession of living things.

Meanwhile, d'Holbach was in the process of putting these new ideas together in his *Système de la nature*, published in 1770, which I shall discuss in the next chapter. It should be noticed, however, that these new ideas about the beginning of life do

not concern mountains arranged according to final causes. Indeed, Diderot, Buffon, and d'Holbach were merely concerned with spontaneous generation and its application to natural laws. Nevertheless, Voltaire's reaction toward d'Holbach is often identified with Voltaire's reaction toward all sciences, including geology. Indeed, it is often claimed that Voltaire's metaphysical beliefs alone were responsible for his attitude toward sciences in general (Roger 1963: 748; Vartanian: 119; Marx: 178). In geology Brumfitt misinterpreted Voltaire saying that the latter withdrew the concession that the faluns were of marine origin in later editions of *La Philosophie de l'histoire*, and thus refused to accept the theory that the earth had once been covered by the sea because he was "defending deism against atheistic attempts to interpret the world materialistically" (*The Complete Works of Voltaire*, 59: 39).

I have just discussed in this chapter that Voltaire had compared fossils at Ferney with those in the faluns of Touraine. If it had been merely for metaphysical reasons that Voltaire claimed all fossils in Touraine to be of freshwater origin, he would not have sent for a crate of the material to investigate personally; he would not have described the different shells found there and compared them with those at Ferney; he would not have written to Bertrand (D.7481), and in *La Défense de mon oncle*, and in *L'Homme aux quarante écus* that he was suspicious about the marine origin of faluns. And when he wrote to Turgot in February 1768, when he was probably in the process of writing *Singularités*, Voltaire suggested that he wanted to see the faluns personally before they had been reduced to powder after a long shipment:" Si j'étais jeune j'irais voir le phalun de Touraine. Je soupçonne fort que ce phalun est une production très-terrestre, une mine particulière, car si la mer avait déposé ses coquilles dans cet endroit, pourquoi n'aurait-elle pas fait la même faveur à la Normandie, à la Picardie, et aux côtes d'Angleterre"? (D.14741). In conclusion, Voltaire's belief in final causes did not dictate his reaction toward geological problems as has been so often assumed.

L. Comparison between Voltaire's Dissertation and his Singularités

In *Singularités* Voltaire applied what he had learned when writing his *Eléments de la philosophie de Newton* in his two essays for the Academy of Sciences at Paris, namely, personal investigation. This was entirely lacking in *Dissertation* where he had simply proposed some more "natural" ideas on the origin of fossils and rejected all theories of the earth. In the *Dissertation* (1746) and as late as 1765 in *La Philosophie de l'histoire*, he accepted the generally held idea that the faluns of Touraine had been deposited over a long period of time by the sea. After personal investigation he started to become suspicious about the marine origin of these faluns. When he wrote *Singularités* he was still uncertain; only in 1770 did he decide that these faluns were merely a freshwater deposit.

This was an original view at a time when most naturalists of the early and mid-eighteenth century believed that the sea was responsible for all fossils found on land. Voltaire did not make an unequivocal statement, however, that he had actually seen a similarity between freshwater snails in the faluns and in his garden. Why was he so modest? I believe that he knew that none of his contemporaries would ever agree with him. Even his friend Bertrand believed, as expressed in a footnote in 1766, that most fossils were of marine origin. Guettard who actually talked to Voltaire tried to convince him that fossils in the vicinity of Ferney were comparable to marine animals still living in the sea. Having been accused by Buffon and earlier by Bourguet of meddling in sciences of which he understood nothing, his feeling that he was an amateur made him uncertain. He never knew that he had guessed correctly.

Without realizing it, Voltaire had encountered at Ferney and in the faluns of Touraine one of the most difficult problems in geology, even today (Carozzi M. 1981: 695-702). Indeed, when trying to reconstruct an ancient landscape, geologists must rely on a variety of criteria to decide whether an ancient lake had existed at a certain place. The most important criteria are still the absence of marine fauna or the existence of proven freshwater fauna (Picard and High, 1972). The first is negative evidence and therefore difficult to prove and the second is still not easily demonstrated. Thus, Voltaire's guess although we know today that it was correct, would have hardly impressed any of his contemporaries who did not distinguish marine from freshwater fossils. Even today the faluns of Touraine are still called "la mer des faluns" which shows how deeply anchored the idea of marine fossils was and still is. Only recently have geologists begun to study in detail how far the sea had advanced, what deposits were either marine or freshwater, or a mixture of the two.

The *Singularités* tried to prove that nature did not follow a few simple laws as some systems advocated, that on the contrary many phenomena were not understood. Voltaire ridiculed naturalists who made too many generalizations based on too little facts.

The title of *Singularités* "par un Académicien de Londres, de Boulogne, de Petersbourg, de Berlin, &c." shows that this work, like the *Dissertation*, is a retaliation against some members of the French Academy who had not accepted him. In the former work Voltaire's opponents were not named while in *Singularités* he mentioned the deceased Maillet and Palissy, but in regard to geology his main criticism was directed against Buffon.

As in *Dissertation*, Voltaire retained his faith in a universe governed by an intelligent Being. He continued to adhere to a theory outlined by Kircher who stated that mountains had to exist ever since the beginning of the earth in order to stabilize the earth and provide water to all living things. I believe, however, that he remained stubbornly attached to that theory because none of his contemporaries was able

to provide a better or more logical theory of mountain-building. Therefore, in the field of geology, Voltaire was not in particular defending metaphysical ideas but scientific truth. Indeed, most of his arguments are based on observation facts: the taste, the size, and the shine of the shells. Furthermore, unlike Buffon, he was facing the Alps and could not accept the idea that these mountains had been shaped at the bottom of the sea and then lifted to their present height by some unknown cause. I shall discuss in more detail Voltaire's criticism of Buffon in chapter IV.

Voltaire's satirical style confounds the most careful reader. Although he promised at the beginning of *Singularités* that "il faut bannir, autant qu'on pourra, toute plaisanterie dans cette recherche" (p. 125) he rarely kept his promise. As mentioned before, Voltaire used satire in his essays on scientific subjects in order to protect himself from further attacks by naturalists; he also tried to ridicule the whole issue hoping that naturalists would be a little less self-assured.

In short, *Singularités* and *Dissertation* show similarities in style and purpose. In the later essay, however, Voltaire was able to establish his views by independent investigation and thus provide a scientific basis for his criticism of Buffon.

CHAPTER III

REMARKS ON GEOLOGY AFTER SINGULARITÉS

A. D'Holbach's "Systeme de la nature" and Voltaire's answer: "Dieu" (1770)

Although d'Holbach's work contains no geology, it is necessary to take some notice of Voltaire's reaction to this atheistic work because his attitude toward it appears to be an example of a deistic reaction toward all sciences, and because in regard to Buffon, he made a brief remark on geology.

In addition to many references in his correspondence, Voltaire treats d'Holbach in an essay "Dieu, réponse au Système de la nature" (now in the *Dictionnaire philosophique* under "Dieu"). This essay is based on at least three different grounds: scientific, personal, and moral which are not connected to any specific theological concept. In the field of science, Voltaire was particularly outspoken against the concept of spontaneous generation which d'Holbach used as basis for his philosophical system. Furthermore, Voltaire wrote this essay for personal reasons in order to dissociate himself from atheists. Finally, his concern for the common people made him fear that d'Holbach's atheistic views might harm them. Had Voltaire merely acted to defend his personal deistic beliefs, he would have insisted that the theory of spontaneous generation was in contradiction with the theory of preformation according to which every germ was preformed by God. Voltaire, however, merely stated in his essay that nobody knows how matter becomes alive.

D'Holbach's *Système de la nature, Ou des lois du monde physique et du monde moral* was written at about the same time as Diderot's *Le Rêve de d'Alembert* where d'Alembert was dreaming that he would actually never die (mentioned in the previous chapter). D'Holbach similarly consoled mankind that some natural laws of necessity not only dictate events in the physical world but also man's actions and feelings. As an example he said that in a duststorm, the smallest molecule of dust acted according to a certain natural law, while among men, "Dans une révolution, il n'y a pas une seule action, parole, pensée, passion dans les agents qui concourent à la révolution qui ne soit nécessaire, qui agit comme elle doit agir" (1966: 62). This consoling fatalism was based on the belief that "nature" was not a work of God but merely a perpetual chain of different combinations of movements without beginning and without end, and on Needham's experiment which seemed to prove that inorganic matter was able suddenly to produce life (p. 28). D'Holbach, however, could not explain natural laws: "On ne peut pas tout savoir, on ne peut pénétrer l'essence des choses" (p. 106). Nevertheless, he based a whole philosophical system on one

scientific experiment, and this is the point that Voltaire took greatest pains to refute in his essay "Dieu."

To d'Holbach's opinion that inert matter can take action and intelligence when combined in certain ways, Voltaire retorted: "C'est là précisément la difficulté. Comment un germe parvient-il à la vie? L'auteur et le lecteur n'en savent rien. De là les deux volumes du Système." This answer clearly shows that Voltaire preferred skepticism to any theory on the beginning of life. Other questions about life, man, the eternity of matter, and the necessity of vice were briefly refuted, then he went to the fundamental error in d'Holbach's system:... "je viens au fondement du livre, et à l'erreur étonnante sur laquelle il a élevé son système. Je dois absolument répéter ici ce qu'on a dit ailleurs." Voltaire then explained Needham's experiment and cited d'Holbach's acceptance of it. Voltaire's essay "Dieu" thus seems to be based first of all on scientific grounds.

Second, Voltaire's letters show that he refuted d'Holbach on personal grounds. He was greatly concerned with the damage being done by d'Holbach's atheistic work to all philosophers at the court of France. He wrote nearly thirty letters to friends, ministers, important people at the French court to show his disapproval.[1] He was afraid that the king, the ministers, the French government and the church were about to take measures against all philosophers, him included, and warned D'Alembert, "Ce livre a rendu tous les philosophes exécrables aux yeux du Roi" (D.16739, November 2, 1770) and that the king had reaffirmed the central power against the parliament: "Vous avez bien remarqué, sans doute, dans l'édit du roi contre le parlement, ce qu'on dit de l'esprit de système. Il se trouve que les philosophes ont gâté le parlement" (D.16841, December 19, 1770). To Frederick he wrote: "Il faut avouer que l'auteur du *système de la nature* a trop impudemment cassé les vitres [...] Il a rendu la philosophie odieuse..." (D.16980, January 19, 1971). Louise Gallatin confirmed Voltaire's fears when she wrote to Frederick II from Geneva:

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[1] D.16335 to Jacob Vernes on May 7, 1770; D.16523 to D'Alembert on July 16, 1770; D.16540 to Baron von Grimm on July 23, 1770; D.16548 to D'Alembert on July 27, 1770; D.16549 to Frederick II on July 27, 1770; D.16554 to Elie de Beaumont on July 30, 1770; D.16565 to M^me^ du Deffand on August 8, 1770; D.16569 to Thieriot on August 8, 1770; D.16574 to D'Alembert on August 11, 1770; D.16585 to Gabriel Cramer in August, 1770; D.16605 to Maupeou on August 22, 1770; D.16607 to Saint-Lambert on August 22, 1770; D.16667 to Frederick II on September 26, 1770; D.16682 to Gabriel Cramer on October 1, 1770; D.16684 to the Duchesse de Choiseul on October 5, 1770; D.16693 to Baron von Grimm on October 10, 1770; D.16695 to D'Alembert on October 11, 1770; D.16718 to Allamand on October 22, 1770; D.16731 to Frederick II on October 30, 1770; D.16736 to duc de Richelieu on November 1, 1770; D.16739 to D'Alembert on November 2, 1770; D.16753 to Joseph Vasselier on November 9, 1770; D.16768 to Marquis de Villevielle on November 16, 1770; D.16841 to D'Alembert on December 19, 1770; D.16980 to Frederick II on January 19, 1771; D.17066 to Comtesse d'Argental on March 9, 1771; D.17336 to D'Alembert on August 19, 1771.

In the last letter Voltaire told D'Alembert about the edition of *Système de la nature* published at Neuchâtel by the "Banneret" Osterwald: "Les dévotes de Neufchatel, éprises d'une sainte rage sont venues brûler son édition. Le gonfalonier de la République a été obligé de se démettre de sa charge..." This is an example of the hostile reaction against d'Holbach's unorthodox work.

"A l'Egard de ce que vous me dites sur la grande anciclopédie il est vray qu'actuellement en France on n'ose pas La réimprimer, Le Clairgé se déchaînant Contre tous ceux qui L'ont faite, et Cela à Cause de ce Livre du *système de la nature* [...] Ce livre est Cause que l'on est si attentif à ce qui paroit" (D.16827, December 15, 1770). Voltaire was well aware that without the approval of the government and the church, philosophers and their cause would be lost: the enlightenment would become extinct. To D'Alembert he wrote, "Il faut que les deux partis se réunissent" (D.16548, July 27, 1770), obviously meaning atheist and deist philosophers against the clergy. Since Voltaire's correspondence between June 1770 and August 1771 reveals that he was primarily concerned with the future welfare of philosophers in France, including himself, it is, therefore, possible that in his essay "Dieu" he overreacted against atheism because he wanted to be looked upon as a God-fearing philosopher at this particular time. Indeed, Mme Denis had tried to rehabilitate Voltaire at the French court in 1769 (D.15886, 15905, 15918, 15945, 15956). D'Holbach's atheistic work risked to ruin his chances and the reputation of all philosophers.

Third, I have the impression that Voltaire was also seriously concerned about the moral effect on common people. He said in his essay, "Pour le fond des choses, il faut s'en défier très souvent en physique et en morale. Il s'agit ici de l'intérêt du genre humain." Redshaw mentioned that Voltaire was perhaps opposing materialistic and atheistic ideas because he knew that these ideas should remain among philosophers and not be spread to the public at large (1980: 29). Indeed, some time after the Abbeville affair, where the young La Barre was beheaded for blasphemy and Voltaire's *Dictionnaire philosophique portatif* burned (1766), Voltaire reduced the intensity of his attacks on Christianity. For instance, instead of pubblishing the testament of the Curé Meslier in its original form, Voltaire said: "Pourquoi adresser ce testament à des hommes agrestes qui ne savaient pas lire? Et, s'ils avaient pu lire, pourquoi leur ôter un joug salutaire, une crainte nécessaire qui seule peut prévenir les crimes secrets? La croyance des peines et des récompenses après la mort est un frein dont le peuple a besoin. La religion bien épurée serait le premier lien de la société..." (M.XXVI: 511-512). In other words, Voltaire believed that people ought to be left to their religious beliefs and without interference from d'Holbach's *Système de la nature*. Voltaire himself, as well as other philosophers could believe whatever they pleased.

In the same essay, Voltaire could not refrain from refuting naturalists who had accepted Needham's theory such as Buffon: "Ce qu'il y a de plus déplorable, c'est que des physiciens plus instruits adoptèrent le ridicule système du jésuite Needham, et le joignirent à celui de Maillet, qui prétendait que l'Océan avait formé les Pyrénées et les Alpes, et que les hommes étaient originairement des marsouins, dont la queue fourchue [...] De telles imaginations peuvent être mises avec les anguilles formées par la farine."

In conclusion, Voltaire's reaction toward d'Holbach's work is thus based on scientific, personal, and moral grounds and not merely his "deistic beliefs."

B. Lettre sur un écrit anonyme (1772)

An English visitor to Ferney wrote in April 1775 about Voltaire's intellectual activities: "The fact is that he reads little or none, his mind exists by Reminiscence & by doing over & over what it has been used to do, Dictates Tales, dissertation & Tragedy, even the latter with all his Elegance tho not with his former force" (D.19445). If that is so, Voltaire would then have said nothing new and he would have clung to old ideas, even in geology. Another opinion, however, is expressed by Voltaire himself in one of his letters to M^me^ du Deffand in November 1773 who had asked him why he did not tire of reading all the new productions, even the most boring ones: "Il faut avoir ma persévérance et la passion que j'ai de m'instruire sur la fin de ma vie pour chercher, comme je fais, des pierres précieuses dans des tas d'ordures" (D.18629). An analysis of Voltaire's remarks on geology in his later years ought to tell which of the two opinions is correct.

In an anonymous pamphlet, *Réflexions sur la Jalousie, Pour servir de Commentaire aux derniers Ouvrages de M. de Voltaire* (1772), Voltaire was accused of jealous feelings in his later works toward famous authors, in particular "ceux qui étaient morts, ou parmi les vivans, ceux qu'il a sçu disposés par caractère & par principes à garder le silence sur ses satires; & même à les mépriser. C'est ainsi qu'il en a usé à l'égard de M. de Buffon" (Leroy 1772: 9). The author of the pamphlet, Charles-Georges Leroy was especially resentful of Voltaire's treatment of Buffon, a friend of his (D.17756), and said:

> M. de Buffon & beaucoup d'autres ont avancé & prouvé que la mer a occupé successivement une grande partie du globe. Cela est démontré par d'immenses amas de coquilles de mer qui se trouvent dans plusieurs montagnes, & ailleurs dans le sein de la terre. Ces médailles incontestables du séjour de la mer rendent peut-être ce fait un des plus avérés qu'il y ait dans aucune histoire. M. de Voltaire, pour qui les monumens ne sont rien, & qui souvent dans l'histoire a jugé des faits par des vraisemblances, ne veut pas absolument que nous ne croyons nos propres yeux. Il ose soutenir que ces coquilles ne viennent pas de la mer, d'abord parce qu'il ne sçait pas comment elles auroient pu en venir; ensuite, parce que leurs débris ont le goût salé, car il les a goûtés, enfin par ce qu'ils fécondent nos terres, ce que ne feroient pas, dit-il, des coquilles de mer. (p. 10-11)

Voltaire retorted in *Lettre sur un écrit anonyme* (April 20, 1772) first in regard to the falun de Touraine, his ideas on that subject being considered those of "un vieillard en délire" by Leroy. Voltaire carefully avoided any reference to Buffon but mentioned Palissy instead:

> L'on m'apprend que je suis indignement jalou de Bernard Palissy, qui vivait sur la fin du XVI[e] siècle. Il avança que le falun de Touraine n'est qu'un amas de coquilles, dont les lits s'amoncelèrent les uns sur les autres pendant cinquante mille siècles plus ou moins, lorsque la place où est la ville de Tours était le rivage de la mer. Ma jalouse fureur ayant fait venir une caisse de ce falun, dans lequel je n'ai trouvé qu'une coquille de colimaçon, j'ai pris insolemment ce falun pour une espèce de pierre calcaire friable, pulverisée par le temps. J'ai cru y reconnaître évidemment mille parcelles d'un talc informe; et j'ai conclu, avec un orgueil punissable, que c'est une mine qui occupe environ deux lieues et demi. J'ai hasardé cette idée criminelle avec une audace d'autant plus lâche que ce falun ne se trouve dans aucun autre pays, ni à quarante lieues de la mer, ni à vingt, ni à dix; et que si c'était un monceau de coquilles déposé par la mer dans une prodigieuse suite de siècles, il y en aurait certainement sur d'autres côtes. C'est avec cette espèce de marne qu'on fume les champs voisins; et j'ai eu l'impudence de dire, moi qui suis laboureur, que des coquilles de cinquante mille siècles ne me donneraient jamais du blé. Mais j'avoue que je ne l'ait dit que par jalousie contre les Tourangeaux. (M. XXVIII: 489-490)

It is evident from the above passage that Voltaire has not changed his attitude toward the faluns: his arguments are the same as two years before, namely that he found a freshwater snail in the faluns, that there are no accumulations of shells in other places besides Touraine, and that faluns cannot be used as fertilizer. As earlier, Voltaire was mistaken about Palissy who never referred to the faluns of Touraine. Already in *La Défense de mon oncle* Voltaire had referred to a possible confusion of fragments of shells and crustaceans with some kind of flaky talc. In the above passage, he repeats that he had recognized "mille parcelles d'un talc informe." In the eighteenth century talc, a mineral, was often confused with mica or even tests of shells (Bertrand 1763: 210; Bourguet 1742: 9).

Instead of referring to Buffon in regard to fossils found in mountains and to mountain-building, Voltaire now mentions the deceased Maillet instead:

> Cette détestable jalousie que j'ai toujours eue des succès du consul Maillet m'a porté jusqu'à douter qu'il y ait des amas de coquilles sur les Hautes-Alpes. J'avoue que j'en ai fait chercher pendant quatre ans, et qu'on n'y en a pas trouvé une seule. On n'en trouve pas plus, dit-on, sur les montagnes de l'Amérique; mais ce n'est pas ma faute [...]
>
> Cette même jalousie m'a fait douter aussi que l'Océan eût produit le mont Atlas, et que la Méditerranée eût fait naître le mont Caucase. J'ai même osé soupçonner que les hommes n'ont pas été originairement des marsouins, dont la queue fourchue s'est changée visiblement en cuisses et en jambes, comme Maillet le prétend avec beaucoup de vraisemblance. (M. XXVIII: 490)

The following passage clearly refers to Buffon's opinion on limestone for lime-making: "C'est avec une malice d'enfer qu'ayant examiné la chaux dont je me sers depuis vingt ans pour bâtir, je n'y ai trouvé ni coquilles, ni oursins de mer" (M.XXVIII: 490). Indeed, as mentioned in Section G of Chapter II, this is a direct

LETTRE

DE M. DE V...

SUR UN ECRIT ANONYME

1772.

FIG. 5. — Title page of *Lettre de M. de V... sur un écrit anonyme.*

attack against Buffon and not Maillet. However, Voltaire does not mention Buffon by name as he had in *Singularités*, evidently avoiding any further trouble.

Dropping the satirical tone, Voltaire continued in *Lettre sur un écrit anonyme*: "Quoique j'aie passé à deux reprises quarante ans loin de Paris, dans une profonde retraite, je connais les cabales de la littérature et du théâtre, et même les autres cabales. Je sais combien on se passionne pour un système chimérique..." (M.XXVIII: 493) From these words we can guess that Voltaire's mind had already sketched two new poems: "Les Cabales" and "Les Systèmes." Both poems contain accusations against Maillet, but none against Buffon: Maillet remained the scapegoat in 1772. *Lettre sur un écrit anonyme* contains no new ideas on geology.

C. Les Cabales — Les Systemes (1772)

Leroy's anonymous pamphlet revived the seventy-eight year old Voltaire enough to compose two poems which Frederick II considered to be those of a man of twenty (D.17861). Both poems contain quips on Maillet's ideas on geology and biology.

Both poems contain also lengthy footnotes by M. de Morza, Voltaire himself. In *Les Cabales*, one of these footnotes calls Maillet a "charlatan" (M.X: 183) because he was imitating God and created a universe with words. In the text of the poem, Voltaire seemed torn between believers in atheism and believers in God. He declared: "Je crois pourtant en Dieu, puisqu'il faut vous le dire." The atheist answered: "Ah, traître! ah, malheureux! Je m'en étais douté. / Va, j'avais bien prévu ce trait de lâcheté, / Alors que de Maillet insultant la mémoire, / Du monde qu'il forma tu combattis l'histoire..." (M.X: 183) The atheist threatens to abandon him to his archenemies and Voltaire pleads: "Ah! bachelier du diable, un peu plus d'indulgence: / Nous avons, vous et moi, besoin de tolérance. / Que deviendrait le monde et la société, / Si tout, jusqu'à l'athée, était sans charité"? (M.X: 183-185)

There is no such apology in *Les Systèmes*. The poem is an affirmation that God exists: "Lorsque le seul puissant, le seul grand, le seul sage, / De ce monde en six jours eut achevé l'ouvrage, / Et qu'il eut arrangé tous les célèstes corps, / De sa vaste machine il cacha les ressorts, / Et mit sur la nature un voile impénétrable" (M.X: 167). Voltaire's wit is at its best in this poem where he tries to win over philosophers who had gotten lost with their systems. St. Thomas d'Aquinas, Descartes, Gassendi, Spinoza, Malebranche, Leibniz, and Maillet are called upon by God to explain their systems. Maillet is no longer called a "charlatan": "Notre consul Maillet, non pas consul de Rome, / Sait comment ici-bas naquit le premier homme: / D'abord il fut poisson. De ce pauvre animal / Le berceau très-changeant fut du plus fin cristal; / Et les mers des Chinois sont encore étonnées / D'avoir, par leurs courants, formé les Pyrénées..." God was not angry upon hearing all these system-makers; he simply

scheduled a new meeting and sent the angel Gabriel to tell church authorities: "Messeigneurs [. . .] le bon Dieu vous ordonne / De vous bien divertir, sans molester personne. / Il a su qu'en ce monde on voit certains savants / Qui sont, ainsi que vous, de fieffés ignorants..." (M.X: 174-175). In this poem Voltaire talks like Pyrrho the skeptic and puts the system-makers together with atheists and intolerant christians.

Neither poem contains any new ideas about geology.

D. Voltaire's new Ideas on Geology not included in Singularités

I have already mentioned that many articles in the *Dictionnaire philosophique* contain the same words and the same ideas as in *Singularités*. For instance, under "Polypes" he repeated his doubts on shark teeth, fossils in limestone, corals, and the marine origin of mountains. Under "Déluge" he simply rephrased the same ideas he had used in *Eléments* in 1738 in regard to the biblical deluge advocated by Burnet. It is possible that he used these clichés in order to make people laugh: "Tout passe, tout s'oublie, tout s'anéantit. Le déluge fit autrefois beaucoup de bruit, et actuellement on n'en parle plus que pour en rire" (D.18805).

There are, however, some gems. For instance, in "Chaîne des êtres créés" in the *Dictionnaire philosophique* Voltaire denied that any link existed among plants and animals: "Cette chaîne, cette gradation prétendue n'existe pas plus dans les végétaux et dans les animaux; la preuve en est qu'il y a des espèces de plantes et d'animaux qui sont détruites. Nous n'avons plus de murex..." (Murexes are spiny marine gastropods which live in tropical seas. One of the species yielded the royal purple dye used by the ancients.) Voltaire had no qualms to say that some species had died out or, in his words, were destroyed. The same could happen to lions and rhinos because of English hunters. He affirmed that there existed no link between ape and man and that certain races of men did not exist anymore. Never before had Voltaire mentioned the "extinction" of a sea-shell; he would rather swear that ammonites which had no living analogues were "figured stones" or sports of nature. I do not know, however, who had told him that murexes were extinct because they are not (Moret 1940: 404).

The article "Changements arrivés dans le Globe" in Voltaire's dictionary shows how much he himself changed after his *Dissertation sur les changements arrivés dans notre globe...* He now reported many changes he had himself witnessed while living on the shores of Lake Geneva:

> Quand on a vu de ses yeux une montagne s'avancer dans une plaine, c'est-à-dire un immense rocher de cette montagne se détacher et couvrir des champs, un château tout entier enfoncé dans la terre, un fleuve englouti qui sort ensuite de son abîme, des marques indubitables qu'un vaste amas d'eau inondait autrefois un pays habité aujourd'hui, et cent vestiges d'autres révolutions, on est alors plus disposé à croire les grands changements qui ont altéré la face du monde...

In other words, Voltaire seems to have seen with his own eyes some landslides which might have happened during an earthquake in the Valais. Indeed, while living at Montriond he wrote: "Un village a été abimé à quelques lieues de nous par un tremblement de terre le 9 du mois" (26 December, 1755, D.6652). He had seen rivers disappear and reappear at some other places (résurgence) in the karstic landscape of the Jura Mountains as I have indicated in the last chapter. Changing shorelines evidenced by such cities as Aiguemorte, Fréjus, and, Ravenna which were no longer harbors as in the past were already mentioned in *Dissertation*. In the above passage Voltaire seems to be ready to accept vast changes on the surface of the earth, more than he had admitted before. He was reluctant, however, to give up a former idea and phrased his acceptance as shown in the continuation of the above quotation:

> [... on est alors plus disposé à croire les grands changements qui ont altéré la face du monde] que ne l'est une dame de Paris qui sait seulement que la place où est bâtie sa maison était autrefois un champ labourable. Mais une dame de Naples, qui a vu sous terre les ruines d'Herculanum, est encore moins asservie au préjugé qui nous fait croire que tout a toujours été comme il est aujourd'hui.

Voltaire clearly calls the idea that nothing has ever changed a prejudice. This is a great change since his *Dissertation* where he had said: "Rien de ce qui végète et de ce qui est animé n'a changé; toutes les espèces sont demeurées invariablement les mêmes; il serait bien étrange que la graine de millet conservât éternellement sa nature, et que le globe variât la sienne" (p. 228). Taken out of context, Voltaire is often blamed on sentences like this. Libby wrote that "Voltaire used the grain of millet to disprove the geological theories of his day..." and "Voltaire does not change. He sees in his old age as he saw in 1746..." (1935: 184, 181). In the above passage, however, Voltaire clearly admits that things have changed and that not to admit it would be a prejudice.

The above passage also includes Voltaire's realization that geological surroundings are of great influence on any observer so that, for instance, a lady in Naples was less prone to accept the prejudice that nothing ever changed because she had seen the ruins of Herculanum buried under the famous lava flows of the Vesuvian eruption of A.D. 79. These rocks were obviously older than the field in Paris. The thinking of modern geologists is still deeply affected by the "regionalism" of their science.

Also in the *Dictionnaire philosophique*, under "Inondation" Voltaire described changing shorelines which might after many centuries result in some kind of ocean-wandering:

> Y a-t-il eu un temps où le globe ait été entièrement inondé? Cela est physiquement impossible.
>
> Il se peut que successivement la mer ait couvert tous les terrains l'un après l'autre; et cela ne peut être arrivé que par une gradation lente, dans une multitude prodigieuse de siècles. La mer, en cinq cents années de temps, s'est retirée d'Aigues-Mortes, de

> Fréjus, de Ravenne, qui étaient de grands ports, et a laissé environ deux lieues de terrain à sec. Par cette progression, il est évident qu'il lui faudrait deux millions deux cent cinquante mille ans pour faire le tour de notre globe...

This concept is not repeated in *Singularités* where he merely said: "Quand la mer n'aurait abandonné et couvert tour à tour les terrains bas de ses rivages que le long de deux mille lieues sur quarante de large dans les terres, ce serait un changement sur la surface du globe de quatre-vingt mille lieues carrées (M.XXVII: 155). In other words, he only mentioned that the sea invaded or abandoned coastal areas without saying that the ocean displaced itself slowly. The concept of ocean-wandering was clearly stated again in 1802 by J. B. Lamarck, famous for his ideas on evolution, paleontology, and geology:

> Indeed, the huge masses of oceanic water obviously move, or rather, continuously displace their basin and their limits. These constant and inappreciably slow displacements generally take place in such a way that the ocean basin, which necessarily loses on one side the amount it gains on the other, has occupied every point of the earth's surface not only once, but several times. (Carozzi A. 1964: 61-62)

It is interesting that Voltaire mentioned a concept used by Lamarck more than twenty-five years later. It shows that Voltaire was in the vanguard of theoreticians of the earth. Today, geologists consider the concept of ocean-wandering unrelated to the modern theory of plate-tectonics where oceans and continents move together while Voltaire indicated only the movement of oceans.

The beginning field of geology was also during the second half of the eighteenth century investigating volcanoes and the possibility of mountain-building through volcanic activity. Voltaire corresponded with and met sir William Hamilton, ambassador of Great Britain to the Court of Naples, who wrote several accounts on volcanoes in Italy (Carozzi A. DSB). Voltaire told Hamilton that small mountains had been produced by volcanic activity; these volcanoes were, however, mere anthills compared to the great mountain-chains such as the Alps (D.18429). He refused, therefore, to consider the explanation of mountain-building by volcanic activity as any better than mountain-building by the sea.

On the whole, Voltaire's few remarks here and there point to the fact that in his later years he had come to believe that the earth had undergone vast changes and that the geological time needed for such changes was immense. In agreement with his new outlook on geology, Voltaire made some additions to *Singularités* in 1774. In chapter XVII, he admitted "qu'il est démontré aux yeux qu'il a fallu une prodigieuse multitude de siècles pour opérer toutes les révolutions arrivées dans ce globe, et dont nous avons des témoignages incontestables" (M.XXVII: 155). In chapter XVIII he added in 1774: "Notre globe a eu sans doutes ses métamorphoses, ses changements de forme, et chaque globe a eu les siennes, puisque en étant en mouvement, tout a dû nécessairement changer" (M.XXVII: 157).

It appears as if Voltaire was not skeptical of great changes in the past; he was skeptical of man-made systems which tried to explain catastrophes in the past which he had not seen and would not believe until he had seen concrete evidence concerning them. He had also realized that scientists were just as bickering as men of literature. Voltaire's humanism made him add the following:

> Ces épouvantables révolutions accablent notre esprit. Elles ne sont rien du tout pour l'univers, et presque rien pour notre globe. La mer qui laisse des coquilles sur un rivage qu'elle abandonne, est une goutte d'eau qui s'évapore au bord d'une petite tasse; les tempêtes les plus horribles ne sont que le léger mouvement de l'air produit par l'aile d'une mouche. Toutes nos énormes révolutions sont un grain de sable à peine dérangé de sa place. Cependant que de vains efforts pour expliquer ces petites choses! Que de systèmes, que de charlatanisme pour rendre compte de ces légères variations, si terribles à nos yeux! Que d'animosités dans ces disputes! (M. XXVII: 157)

E. Dialogues d'Evhémère (1777)

Voltaire spent his last years writing and his neighbor in Geneva, Pierre Michel Hennin, said of him: "Il a l'air de dire à la mort: Attends cette page..." (D.18214) He also received many works by others, among which Hamilton's observations on volcanoes to the Royal Society of London (D.18429); Buffon's *Supplément* to *Histoire naturelle* (D.19187, 19149 [1774]); La Sauvagère's memoir on spontaneous vegetation with a reply by a priest from Angers (D.19846); Jean-Sylvain Bailly's *Histoire de l'astronomie ancienne...* (1775, D. 19890) and *Lettres sur l'origine des sciences, et sur celles des peuples de l'Asie, adressées à M. de Voltaire* (1777, D.20576); Lazzaro Spallanzani's *Opuscoli di fisica animale e vegetabile* (on spontaneous generation, 1776, D.20133) and *Prodromo di un'opera da impremersi sopra le riproduzioni animali* (on animal reproduction and regeneration) (1776, D.20148); and Barthélémy Faujas de Saint-Fond's revision of *Œuvres de Bernard Palissy* (D.20642). The question that I have asked at the beginning of this section is repeated here: did Voltaire read all these works or was he simply reminiscing when he wrote on the subjects with which they are concerned?

Voltaire's correspondence shows that he wrote to Hamilton specifying that the Alps "ces énormes masses paraissent avoir plus de consistance que Monto Nuovo, & la prétendue nouvelle île de Santorin" (D.18429), that he told Bailly that he did not believe in a central fire (D.19912), and that he disagreed with Bailly's history of sciences (D.20581). Moreover, Voltaire perhaps conceived an answer to Bailly's history of science by writing *Dialogues d'Evhémère*. Voltaire must have been especially pleased to hear from Spallanzani that spontaneous generation was indeed a dead issue. Spallanzani had sent his *Saggio di osservazioni microscopiche concernenti il sistema della generazione de' Signori di Needham e Buffon* to Voltaire in 1765 (D.13097). Spallanzani's *Opuscoli* of 1776 was a confirmation of new exper-

iments against spontaneous generation. Voltaire acknowledged receipt saying: "Vous donnez le dernier coup, Monsieur, aux anguilles du jésuite Need'ham..." At the same time he speculated about his own experiments with snails: "Je croiais avoir coupé des têtes à quelques uns de ces animaux [limassons], et que ces têtes étaient revenues. Des gens plus adroits que moi, m'ont assuré que je n'avais coupé que des visages, dont la peau seule avait été reproduite..." (D.20133). Spallanzani promised to send Voltaire his *Prodromo di un'opera da imprimersi sopra le riproduzioni animali* (1768) and confirmed that snails can indeed generate new heads (D.20148). Voltaire was delighted and answered: "Votre lettre du 31 May ranime mes anciens goûts, et mes anciennes espérances. J'avais renoncé à l'honneur de rendre des têtes à des Colimassons. J'avais la modestie de croire que je n'étais point du tout propre à faire des miracles" (D.20158). All these letters written during Voltaire's last years show that he was not merely reminiscing.

Dialogues d Evhémère contains some last criticism of Buffon, which is surprizing since the two men had apparently mended their differences. Indeed, Buffon had told Voltaire in a reconciliatory letter:

> Avec plusieurs années de moins, je suis plus vieux que vous. Autre supériorité dont je suis loin d'être jaloux; mais n'est-il pas juste que la nature, qui, dès vos premières années, vous a comblé de ses faveurs, et dont vous êtes l'ancien amant de choix, continue de vous traiter avec plus d'égards et de ménagements, qu'un nouveau venu comme moi, qui n'ai jamais rien obtenu d'elle qu'à force de la tourmenter? (D. 19187)

While Voltaire had spared Buffon in *Les Cabales* and *Les Systèmes*, he apparently could not, in spite of Buffon's flattery, refrain from criticizing — or teasing — Buffon once more.

Voltaire might have been prompted to do so after his correspondence with Condorcet. Condorcet (1743-1794), mathematician, permanent secretary of the Academy of Sciences at Paris since 1776, and friend of Voltaire received the following letter from Voltaire on February 28, 1777:

> On nous avait flattés que l'illustre secrétaire, nous avertirait incessamment du jour et de l'heure, où notre globe de verre s'en irait en fumée, et quand la comète qui produisit autrefois la terre reviendrait la détruire. Si on a besoin de quelques montagnes élevées par le flux de la mer à deux mille toises de hauteur, j'en ai vis à vis mes fenêtres une douzaine à vôtre service. Je vous prierais de vouloir bien m'envoier quelques molécules organiques pour me paier de mes montagnes. (D. 20583)

It is obvious that Voltaire was referring here to the author of *Histoire naturelle* who had mentioned the formation of the earth by a comet, the shaping of mountains by the sea, and organic molecules to explain organic matter. Condorcet answered on March 5, 1777:

> J'ignore absolument si la terre sera gelée ou si elle sera reduite en poussiere par le choc d'un comète, si elle sera brûlée par une explosion du feu Central ou si elle retour-

> nera dans le sein du soleil. Il n'y a que M. le Comte de Buffon et frère illuminé Bailli qui sachent toutes Ces belles choses. Quant aux montagnes je suis for ignorant encore sur cet objet. Il paraît clair que celles qui Contiennent des Coquilles dont les analogues se trouvent dans La mer ont été formées par elle, mais quand et comment? Nous le saurons peut-être un jour; mais ce qui est prouvé c'est que La manière dont on l'a expliqué dans La grande histoire naturelle répugne un peu aux Lois de L'hidrostatique. (D. 20593)

"Frère illuminé Bailli" is Jean-Sylvain Bailly, astronomer and author of the two works mentioned above which were sent to Voltaire. (Bailly had been in competition with Condorcet for the job of secretary of the Academy of Sciences which Condorcet had won; Granger DSB). According to the above letter, Condorcet was not in favor of Buffon's theory of the earth; however, he accepted the fact that mountains containing marine shells had been formed by the sea. It is possible that Condorcet's letter induced Voltaire to mention Buffon once more in his *Dialogues d'Evhémère.*

Dialogues d'Evhémère are dialogues between Evhémère, a skeptic and a deist, and Callicrate, Epicurian and atheist. In a footnote Voltaire said: "Evhémère était un philosophe de Syracuse, qui vivait dans le siècle d'Alexandre. Il voyagea autant que les Pythagore et les Zoroastre. Il écrivit peu; nous n'avons sous son nom que ce petit ouvrage." All the important questions asked in the eighteenth century are raised again. Most remain unanswered, however, including those on geology: "si cette terre a toujours été peuplée d'hommes" and "si la terre elle-même a toujours existé." Voltaire's own history of science is offered, perhaps in reply to Bailly's *Lettres sur l'origine des sciences.*

To the question "Si les montagnes ont été formées par la mer" Evhémère answers:

> A huit cent quarante-quatre stades de l'Océan, près d'une ville nommé Tours, on trouve, à dix pieds de profondeur sous terre, une étendue d'environ cent trente millions de toises cubiques d'une matière un peu marneuse, qui ressemble à du talc pulvérisé; les cultivateurs s'en servent pour fumer leurs champs. On trouve dans cette mine excavée, souvent imbibée de pluie et d'eau de source, plusieurs dépouilles d'animaux, soit reptiles, soit crustacées, soit testacées.
>
> Un virtuose, potier de son métier, qui s'intitulait inventeur des figulines rustiques du roi des Gaules, prétendit que cette mine de mauvais talc mêlé d'une terre marneuse n'était qu'un amas de poissons et de coquilles, qui étaient là du temps du déluge de Deucalion. Quelques philosophes ont adopté ce système; ils se sont seulement écartés de la doctrine du potier, en soutenant que ces coquilles devaient avoir été déposées dans ce souterrain plusieurs milliers de siècles avant notre déluge grec.
>
> On leur a répondu: Si un déluge universel a porté dans cet endroit cent trente millions de toises cubiques de poissons, pourquoi n'en a-t-il pas porté la millième partie dans les autres terrains également éloignés de l'Océan? Pourquoi ces mers, toutes couvertes de marsouins, n'ont-elles pas vomi, sur ces rivages seulement, une douzaine de marsouins?
>
> Il faut avouer que ces philosophes n'ont point éclairci cette difficulté; mais ils sont demeurés fermes dans l'idée que la mer avait couvert les terres, non-seulement jusqu'à huit cent quarante stades au delà de son rivage, mais qu'elle s'est avancée bien plus

DIALOGUES

D'EVHÉMÉRE.

Publiés par M. de VOLTAIRE.

LONDRES.

M. D. CC. LXXIX.

FIG. 6. — Title page of *Dialogues d'Evhémère* (modern spelling) of a 1779 edition at the Institut et Musée Voltaire, Geneva, not mentioned by Bengesco (vol. II: 349-351).

> loin [. . .] Enfin le philosophe gaulois Telliamed a soutenu que la mer avait été partout pendant cinq ou six cent mille siècles, et qu'elle avait produit toutes les montagnes. (M. XXX: 516-517)

Besides being hilariously funny and blown out of proportion, Voltaire's interpretation of the faluns of Touraine turns up with one great difference: Faluns, a marly and pulverized matter with a few fossils, as he had said before, were now described as saturated by spring- or rain-waters when extracted from the ground. In *Singularités* and *Lettre sur un écrit anonyme*, Voltaire had not mentioned any such spring- or rain-water. In the former he said that he had found one shell of a (freshwater) snail in some calcareous and pulverized earth; in the latter he described faluns as some calcareous and marly earth which contained some (freshwater) mussels at a depth of ten or fifteen feet. In 1777 Voltaire might have realized that many of the excavations made during extraction of the faluns were quickly filled with rain- or spring-water, an observation described by Réaumur's original memoir (1720: 527).

Following this additional precision on the mode of occurrence of faluns, he repeated his earlier description of Palissy's errors and Maillet's acceptance of the idea that the sea had once covered all the continents.

He said on the latter's ideas on transformism:

> Il n'ose pas dire qu'il a vu des hommes marins, mais il a parlé à des gens qui en ont vu: il juge que ces hommes marins, dont plusieurs voyageurs nous ont donné la description, sont devenus à la fin des hommes terrestres tels que nous sommes, lorsque la mer, se retirant des côtes pour aller élever ses montagnes, a laissé ces hommes dans la nécessité d'habiter sur la terre. Il croit de même ou il veut faire croire que nos lions, nos ours, nos loups, nos chiens, sont venus des chiens, des loups, des ours, des lions marins, et que toutes nos basses-cours ne sont peuplées que de poissons volants, qui à la longue sont devenus canards et poules. (M. XXX: 518)

This is a perfect example of Voltaire's sense of humor, of his art to say in a few words what took Maillet a whole chapter, and also of his apparent superficial reading. Indeed, according to Maillet the sea did not retreat from the coast to shape mountains elsewhere, but mountains had been formed at the bottom of the sea before they became exposed by the diminution of the sea. Voltaire seemed to have understood that Maillet's sea had moved away from one part of the continent to shape mountains on the other half of the globe, perhaps according to the concept of ocean-wandering which he had mentioned in "Inondation." Of course, we should never forget that *Dialogues d'Evhémère* is referring to ideas which were deliberately falsified to fit the story told by Evhémère, the philosopher from Syracuse. Therefore, Voltaire might have read Maillet correctly but changed his ideas on purpose.

In the same dialogue, Voltaire uses Evhémère to tease Buffon for the last time about his theory which he had adopted from Maillet: "il a pris du moins sous sa protection les montagnes formées par les courants et par le flux des mers, il a fortifié

cette idée de Telliamed. On l'a comparé à un grand seigneur qui élève dans ses domaines un orphelin abandonné..." (M.XXX: 518-519)

From Voltaire's remarks on geology after *Singularités* and some articles from the *Dictionnaire philosophique*, which were probably written before 1770, it is evident that he had kept up with scientific ideas although he tended to "rabâcher" many other ideas, in the words of the Président des Brosses (D.15431). In the field of geology Voltaire seemed to remain aware of the newest works done. For instance, he corresponded with Hamilton on volcanoes; he mentioned extinction among sea-shells, a topic which was to become officially accepted by Cuvier in the nineteenth century (Rudwick 1972: 101); he made some additions in *Singularités* in 1774 showing that he was aware of vast changes on the surface of the earth and a long geological time necessary for these changes; he had even considered the possibility of ocean-wandering, a concept later developed by Lamarck. In *Dialogues d'Evhémère* Voltaire added a field observation to his earlier description of the faluns which indicates that he might have read Réaumur's original memoir or received the information from another source. In conclusion, from the standpoint of geology, I believe that Voltaire was telling the truth about his scientific attitude when he told M^me^ du Deffand: "Il faut avoir ma persévérance, et la passion de m'instruire sur la fin de ma vie pour chercher comme je fais des pierres précieuses dans des tas d'ordures" (D.18629, Nov. 16, 1773).

CHAPTER IV

VOLTAIRE'S MOTIVES FOR HIS ATTITUDE TOWARD GEOLOGY

Voltaire's attitude toward geology reveals that he was not defending a particular system of religion or metaphysical ideas, as argued by many critics, but that he was defending scientific truth. I have mentioned in chapter II (On Mountains and Final Causes) that Voltaire's reaction toward d'Holbach's materialistic work is often identified with his deistic reaction toward all sciences. I have shown, however, in chapter III, that Voltaire's essay "Dieu" which represents his response to d'Hobach's *Système de la nature* is based above all on scientific, personal, and moral grounds. Voltaire refuted Needham's spontaneous generation saying that nobody knows how matter becomes alive; he personally believed that d'Holbach's work might harm the cause of all philosophes, him included, and lastly he warned atheists that religion was necessary for the common people. I do not see in Voltaire's reaction toward d'Holbach's atheistic work merely a defense of his own deistic beliefs.

In chapter II I have shown that Voltaire's attitude toward geology was greatly influenced by his personal observations at Ferney and his reliance on concrete facts. Voltaire did not withdraw his earlier acceptance of the marine origin of faluns because he was "defending deism against atheistic attempts to interpret the world materialistically" as maintained by Brumfitt. Voltaire compared fossil shells in the faluns with freshwater snails at Ferney; he based his views on the taste, the size and the shine of shells in the faluns as compared to the properties of the freshwater snails at Ferney.

Even Voltaire's refutation of Buffon's theory of the earth was based on observational criteria. Since his refutation represents his final stand toward geology, it requires special attention. Jacques Roger's study of Voltaire's attitude toward Buffon is based on Voltaire's attitude toward life sciences, however, and not geology. Roger, nevertheless, states that Voltaire refused fossil shells, spontaneous generation, and the animality of polyps for all the same reasons, namely, that he was defending his deistic faith (1963: 748). It seems to me that in the field of geology Voltaire's attitude has not been studied from the point of view of modern geology coupled with the history of geology but rather by simply comparing his "scientific" interpretation with that of naturalists of his century as they are interpreted today, in particular Buffon. In that view, Voltaire's interpretation of freshwater fossils at Ferney and in the faluns appears to show that Voltaire was either ignorant of the work of his contemporaries or so prejudiced that he refused their interpretation. Modern geology, however, shows that his opinion is correct. Furthermore, we should take a closer look at Buffon's work as it was read by Voltaire and find out

how Buffon's theory was accepted during Voltaire's time. Then we should try to judge Voltaire's attitude toward Buffon.

A. Buffon's Théorie de la terre of 1749

Buffon's theory of 1749 was based upon three concepts all mentioned earlier by Maillet: 1. The formation of mountains by the ebb and flow and ocean currents on the bottom of the sea. 2. The presence of marine fossils everywhere on land, even on top of the highest mountains. 3. The conformity of angles witnessed in mountains. No wonder Lamoignon-Malesherbes asked: "Qu'est-ce que donc qui appartient à M. de Buffon dans cette théorie de la terre" (p. 240). Buffon parted from Maillet's model by stating that he did not know how mountains had emerged from the sea, whether the earth crust had collapsed as related by Plato, or whether changes had occurred slowly over a long period of time. Nevertheless, he affirmed that changes must have occurred "car pour juger de ce qui est arrivé, & même de ce qui arrivera, nous n'avons qu'à examiner ce qui arrive" (1749: 96). This is an interesting early insight of actualism in geology.

Today Buffon's image as a geologist is based on his complete *Histoire naturelle* which contains the *Théorie de la terre* originally written in 1749, *Les Epoques de la nature*, published in 1778, and many important changes and additions made in 1778. The most important change is added to Art. IX "Inégalités de la terre": "Sur la formation des montagnes" (1850-1860: 195-196). There he states that he accepted now two causes of mountain-building: fire and water. Primitive mountains were formed during the cooling of the earth crust; some "boursouflures" created the skeletons of mountains and the related abysses. After the cooling period, the sea covered the whole earth and, by the action of the ebb and flow and ocean currents, the form and position of the original mountains and valleys was changed. The ebb and flow formed hills in the former valleys, covered and surrounded the foot of former mountains with new sediments. Ocean currents produced conforming angles in mountains and valleys. Elsewhere he explained his error, "... mon explication ne pêche qu'en ce que j'ai attribué la première formation des rochers qui forment le noyau de ces pics à l'intermède de l'eau, au lieu qu'on doit l'attribuer à l'action du feu" (1850-1860: 192). Thus Buffon explained in 1778 two kinds of mountains: the first were produced by fire and do not include fossil shells; they are irregularly formed structures composed of "vitreous" rocks; the second were formed by the sea and consist of younger rocks which contain marine fossils. These rocks are mostly found in horizontal layers (1850-1860: 196). This important change was not made public until after Voltaire's death.

Today, Buffon's complete work in geology is considered a benchmark in the history of geology because it is a synthesis of earlier works and contains some

daring speculations later demonstrated to be correct. Voltaire, however, never read it.

The reaction of many eighteenth-century naturalists and philosophers toward Buffon's original theory was similar to Voltaire's. I have already mentioned Condorcet who said in a letter to Voltaire that he considered Buffon's explanation of mountain-building contrary to the laws of hydrostatics (D.20593).

Turgot also strongly disagreed with Buffon's theory as it had first appeared and wrote *Lettre à M. de Buffon* in October 1748 which was published after the death of both in 1801 (Tome II: 93-101). In regard to mountain-building by the ebb and flow of the sea, he said:

> J'avoue que je ne connois pas bien comment le flux et le reflux de la mer a pu élever des montagnes à plus d'une lieue au-dessus de sa plus grande hauteur, car les volcans n'on jamais pu élever celles dont les aiguilles sont disposées régulièrement, parmi lesquelles on ne peut nier qu'il n'y en ait de très-hautes. Il ne paroît point que la mer puisse agir où elle n'est pas, et sûrement elle n'a jamais été portée à plus d'une lieue au-dessus de sa surface ordinaire. (p. 99)

Lamoignon-Malesherbes, "secrétaire d'Etat de la Maison du roi," also criticized Buffon, apparently in 1750, but his comments were published only in 1798 (Roger 1963: 687). Lamoignon-Malesherbes claimed that Buffon's theory contained nothing new: the surface of the earth had been explained earlier by Bourguet (Lamoignon-Malesherbes 1798: 221); the system which said that the sea had covered all the lands had been adopted by Bernard Palissy and further developed by the author of *Telliamed* (Lamoignon-Malesherbes 1798: 222).

Buffon was also criticized by shocked Catholics in France such as the Abbé Lelarge de Lignac, who tried to refute Buffon on both religious and scientific grounds. His *Lettres à un amériquain* were first published in 1751. In the third and fourth letter he opposed Buffon's theory in regard to fossiliferous rocks which were apparently proofs of the long sojourn of the sea on all the continents. He remarked that he had seen high mountain-peaks and sheets of slate without fossils (vol. II, 4th letter, p. 11). Lignac's main criticism, however, was against Buffon's unorthodox explanation of the beginning of the earth and the beginning of life.

The most important reaction toward Buffon came from a naturalist, Peter Simon Pallas (1741-1811) from Berlin, who had been invited to work at the St. Petersburg Academy of Sciences in 1767. He observed rocks, fossils, plants, and animals during several expeditions across Russia. He wrote a small essay *Observations sur les Montagnes et les Changements arrivés à notre Globe...* which was published in Paris in 1782. Pallas refuted all systems including Buffon's theory of the earth saying:

> C'est pour ainsi dire avec des préjugés nationaux, ou avec les idées puisées dans la sphère particulière des connaissances de chacun de ces auteurs, qu'ils ont jugé de la structure du globe en entier d'après les montagnes de leurs parties; & comme plusieurs

> de ces créateurs en hypothèses n'ont pas même connu par leurs propres yeux la nature des grandes chaînes de montagnes, ou tout au plus n'ont été au fait que de celles qui traversent l'Europe, leurs théories ont été adaptées à la structure particulière de celles-là, & bien souvent d'une petite partie des mêmes, qui était le plus à leur portée, (tout comme les anciens & quelques ultramontains modernes ont jugé du flux & du reflux de l'Océan, par les petits mouvements de la Méditerranée, qu'ils étaient à portée de connaître). — *Woodward*, par exemple, sans s'inquiéter de ces chaînes de vieille roche, étayait son système sur la formation des couches & des montagnes pendant le déluge, sur la persuasion où il était, que toutes les montagnes de l'Univers fussent composées de couches à-peu-près horizontales. M. le Comte *de Buffon* de même ne semble avoir jugé des montagnes en général, que par celles de la France, qui pour la plûpart sont composées de couches à-peu-près horizontales ou simplement dérangées par l'effet de quelques Volcans. Il n'aurait pas sans cela déduit la formation des cailloux & de l'ancienne roche même, de matières charriées & déposées par les courants de mer; ni avancé que les traces de la mer se voient jusqu'aux sommets des plus hautes montagnes, que ces montagnes sont toutes composées de couches horizontales, ainsi que les plaines, & que les Volcans ne se trouvent que dans les hautes Alpes; toutes assertions totalement ou en partie contraires à l'ordre général de la Nature. (p. 8-10)

Pallas thus pointed to the fact that Buffon had observed local geology and deduced that the whole earth contained the same structures, that he therefore adopted the theory of ebb and flow and stated that all mountains are composed of layered fossiliferous rocks. This is very close to what Voltaire had said in *Singularités*, which I shall discuss below. Pallas destroyed one by one Buffon's arguments in his theory of the earth: the comet, the fossils in the highest mountains, the horizontal beds, the idea of ebb and flow, and the corresponding angles of mountains. To explain the past history of the earth, Pallas believed that one must combine the different effects caused by volcanoes, underground forces, a deluge or several violent inundations by the sea (p. 67).

Voltaire's detailed criticism of Buffon in chapter XI of *Singularités*, which I have not previously discussed, contains no personal observations but merely common sense, very similar to that of Pallas:

> Il est trop visible que la mer ne fait point une chaîne de roches sur la terre. Le flux peut amonceler un peu de sable, mais le reflux l'emporte. Des courants ne peuvent produire lentement, dans des siècles innombrables, une suite immense de rochers nécessaires dans tous les temps [...] Sur quelles raisons apparentes appuie-t-on ce paradoxe? Sur ce qu'on prétend que, dans les vallées des Alpes, les angles saillants d'une montagne à l'occident répondent aux angles rentrant d'une montagne à l'orient. Il faut bien, dit-on, que les courants de la mer aient produit ces angles. La conclusion est hasardée. Le fait peut être vrai dans quelques vallons étroits; il ne l'est pas dans le grand bassin de la Savoie et du lac de Genève; il ne l'est pas dans la grande vallée de l'Arno, autour de Florence, mais à quelles branches ne se prend-on pas quand on se noie dans les systèmes! (M. XXVII: 140-141)

Voltaire mentions here the concept of corresponding angles, a notion which had also been criticized by Pallas (1782: 67) and Lamoignon-Malesherbes (1798: 247-249).

With this concept Buffon apparently tried to prove that when the earth was covered by the sea, ocean currents had cut across accumulations of sediments at the bottom of the sea, thus leaving corresponding angles once this part of the sea was lifted (?) or became dry land by some other miracle.

Pallas had also objected to generalizations based on local phenomena; Voltaire had said before him: "Quoi! Parce que des aterrissements ont reculé la mer de plusieurs lieues, et qu'elle aura inondé d'un autre côté quelques terrains bas, on nous persuadera qu'elle a inondé le continent pendant des milliers de siècles! Nous voyons des volcans, donc tout le globe a été en feu; des tremblements de terre ont englouti des villes, donc tout l'univers a été la proie des flammes. Ne doit-on pas se défier d'une telle conclusion? Les accidents ne sont pas des règles générales" (M.XXVII:141).

In the same chapter Voltaire also pinned down various inconsistencies in Buffon's theory which even Pallas had not noticed. Voltaire said that on the one hand Buffon claimed: "Ce sont les eaux rassemblées dans la vaste étendue des mers qui, par le mouvement continuel du flux et du reflux, ont produit les montagnes, les vallées, etc." (citation from Buffon's theory p. 124). On the other hand "Il y a sur la surface de la terre des contrées élevées qui paraissent être des points de partage marqués par la nature pour la distribution des eaux..." (citation from Buffon's theory p. 359). Yet another idea by Buffon said "les eaux du ciel détruisent peu à peu l'ouvrage de la mer, et ramenant tout au niveau, rendront un jour notre terre à la mer, qui s'en emparera successivement, en laissant à découvert de nouveaux continents, etc." (Buffon, p. 124). Voltaire, after these citations pointed out that mountains could not have been shaped by the sea while at the same time forming mountain-chains for irrigation. Another contradiction existed between the erosion of mountains by "les eaux du ciel" and Buffon's assumption "c'est la mer qui s'est retirée insensiblement dans la suite des siècles, de la Bourgogne, de la Champagne, de la Touraine, de la Bretagne, où elle demeurait, et qui s'en est allée vers le nord de l'Amérique." Which assumption is one to believe, asked Voltaire (M.XXVII: 142-143). It is true that Buffon never explained how, on the one hand, mountains were formed on the bottom of the sea while, on the other, they were eroded and disappeared again into the sea, or how they became exposed after the retreat of the sea.

Voltaire found another contradiction in Buffon's propositions when he read Buffon's *Première Vue de la nature* (1850-1860, VII: 165-171). There, visibly tired of scientific facts, Buffon had managed a poetic interlude saying, "nous retournerons ensuite à nos détails avec plus de courage; car j'avoue qu'il en faut pour s'occuper continuellement de petits objets dont l'examen exige la plus froide patience, et ne permet rien au génie" (p. 165). His poetic prose contradicted what he said in his theory of the earth; as Voltaire was quick to point out:

> « La mer irritée, dit-il, s'élève vers le ciel, et vient en mugissant se briser contre des digues inébranlables, qu'avec tous ses efforts elle ne peut ni détruire ni surmonter. La terre, élevée au-dessus du niveau de la mer, est à l'abri de ses irruptions. Sa surface

émaillée de fleurs, parée d'une verdure toujours renouvelée, peuplée de mille et mille espèces d'animaux différents, est un lieu de repos, un séjour de délices, etc. »

Voltaire is here citing Buffon's prose and then adds:

Ce morceau, dérobé à la poésie, semble être de Masillon ou de Fénélon, qui se permirent si souvent d'être poëtes en prose; mais certainement si la mer irritée, en s'élévant vers le ciel, se brise en mugissant contre des digues inébranlables, si elle ne peut surmonter ces digues avec tous ses efforts, elle n'a donc jamais quitté son lit pour s'emparer de nos rivages, elle est bien loin de se mettre à la place des Pyrénées et des Alpes. (M. XXVII: 143)

Bertrand Russel said of Voltaire's wit: "I cannot find words in which to express my delight in his sharp, swift wit which penetrates in a moment to the inner core of humbug beneath pretentious trappings" (1958: 162).

To refute Buffon in chapter XI in *Singularités* Voltaire used common sense. He objected to inconsistencies, weaknesses, and unjustified generalities. He might have accepted Buffon's theory of 1778 which advocated what Voltaire himself believed, namely that some primitive mountains had existed ever since the beginning of the earth and that they did not contain fossils. There is only one sentence in chapter XI where Voltaire uses a metaphysical idea: "Quel est donc le véritable système? Celui du grand Être qui a tout fait, et qui a donné à chaque élément, à chaque espèce, à chaque genre, sa forme, sa place, et ses fonctions éternelles. Le grand Être qui a formé l'or et le fer, les arbres, l'herbe, l'homme et la fourmi, a fait l'Océan et les montagnes" (p. 141). This sentence has been quoted by every critic of Voltaire who believed that his attitude toward science was dictated by his deistic beliefs. It is possible that this was indeed a system which he had accepted in his early youth with the Jesuit fathers and while reading *Mundus Subterraneus*. This does not mean, however, that he was not open to new ideas later on. Since he had not found any better explanation for mountain-building, he kept repeating a theory which seemed to him the most logical.

B. Voltaires' scientific Attitude

Voltaire was no longer a young man when he decided to look at fossils and other geological phenomena to refute Buffon. Indeed, Voltaire was not aware of geological problems before the age of forty-eight. He stumbled accidentally into geology when he mentioned in *Elémens* (1738) that astronomical changes such as slow movements of the poles might have left marine fossils on the continents, even in mountains. In the revised edition of 1741 he added the skeptical "dit-on" in regard to fossil shells found in mountains and in many layers closer to the sea. Bourguet's criticism of Voltaire in 1742 made him probably realize that astronomical figures

were difficult to verify whereas fossil shells could be investigated. He was then forty-eight.

In 1746, Voltaire still had not looked at any fossil. In his *Dissertation* he simply proposed some more "natural" explanations for fossil fish in Hesse and on Mont Cenis: not the sea, but travelers had discarded some fish which petrified later. For fossil shells found in Italy and France, he said that maybe the sea of Syria had carried some, or pilgrims of the Holy Land, or that they were "fossiles" produced by the earth, or the remains of animals who had lived in ancient lakes. He practically accepted the marine origin of fossil shells in Calabria and Touraine. In the *Dissertation* he rejected diluvial theories as well as the theory of the Indian Ocean or any sea that had covered all of Europe up to the highest mountains and turned to the theory by Kircher that seemed more logical: mountain-chains have necessarily existed ever since the beginning for irrigation and for stabilization of the earth.

When Voltaire first lived on the shores of Lake Geneva, at Prangins near Nyon, then at "Les Délices" in Geneva, and Montriond, near Lausanne, he seemed to have little time for natural history. When he finally settled at Ferney, however, he supervised the construction of houses which used molasse quarried at Tournay, plowed fields and arranged gardens and forests; in other words, he lived close to nature for the first time in his life. He saw rocks of all sizes, observed karstic phenomena in the Jura Mountains, noticed fragments of fossil shells exposed on the banks of rivers and lakes and compared them with garden snails. He even experimented on snails; cut their heads to find out whether they would grow back. They did and he accepted it as a fact: "Qu'il revienne une tête à un animal assez gros, visiblement vivant, et dont le genre n'est point équivoque, c'est là un prodige inouï mais un prodige qu'on ne peut contester. Il n'y a point là de supposition à faire, point de microscope à employer, point d'erreurs à craindre" (M.XXVII: 131). He also repeated the so-called experiment by Hannibal, immersed some granite — "une de ces roches à grains qui composent la plus grande partie des Alpes" — into vinegar and found it to be soluble (M.XXVII: 137). He wondered about the composition of rocks: "D'où résultait ce corps si dur que le feu a divisé? est-ce l'attraction qui rendait toutes ses parties si unies entre elles et si compactes? [...] Est-ce le premier principe de la cohésion des corps?" (M.XXVII: 136). Indeed, Voltaire had become an observer of natural phenomena in his old age.

Voltaire's scientific attitude should not be confused with that of a young man. He was certainly no longer the young intellectual who had been looking for systems such as he had described in his *Lettres philosophiques*: "Aujourd'hui tous les recueils des académies de l'Europe ne font pas même un commencement de système: et approfondissant cet abîme, il s'est trouvé infini" (M.XXII: 132). At that time he deplored the absence of systems: he was in his thirties; in *Singularités* he refuted all systems": he was seventy-four.

When Voltaire wrote *Singularités* he had passed the age of speculations and dreams. He had probably seen too many systems come and go. At Ferney he decided simply to observe, and he told his contemporaries repeatedly to do so. The eighteenth century, said Koestler, was a period of "assimilation, consolidation, and stock-taking, the age of the popularizers, classifiers, and systematizers; of Fontenelle, Linnaeus, and Buffon, of the *Philosophes* and *Encyclopédistes.*" The seventeenth century, on the other hand, was the "heroic age of science" who produced Gilbert, Kepler, Galileo, Pascal, Descartes, Leibniz, Huygens, Harvey, and Newton." In the eighteenth century, an observer "born early in the century, and making the Grand Tour, would have been an old man before he came across, in the Paris of Lavoisier, anyone worthy of Newton" (1964: 228). Voltaire had practiced all the things mentioned by Koestler except classification and the making of systems. He spent his last ten years refuting systems and advocating observation, description, and classification. He often lamented how scientists of his century brought nothing new but instead spoiled what their predecessors had achieved:

> Ainsi après que Newton a découvert la nature de la lumière, arrive un Castel qui veut enchérir, et qui propose un nouveau clavecin oculaire. A peine a-t-on découvert, avec le microscope, un nouveau monde en petit, que voilà Needham qui imagine avoir fait une république d'anguilles, lesquelles accouchent sur le champs d'autres anguilles, le tout dans une goutte [...] Sitôt que de vrais philosophes eurent calculé l'action du soleil et de la lune sur le flux et le reflux des mers, des romanciers au-dessous de Cyrano de Bergerac, écrivent l'histoire des temps où ces mers couvraient les Alpes et le Caucase, et où l'univers n'était habité que de poissons [...] Ainsi, monsieur, dans tous les arts dans toutes les professions, les charlatans succèdent aux bons maîtres... (D. 20103, letter to Baron de Faugères, 3 May 1776)

There seems to have existed a slowdown in the history of scientific ideas, or at least as far as we are concerned, in the history of geology, which lasted almost until the beginning of the nineteenth century. During Voltaire's life, there were the publications of posthumous works by Leibniz and Maillet, the memoirs by the Academy of Sciences, Buffon's theory of the earth in 1749, and then nothing until Werner in Germany (1774), Hutton in England (1795), Saussure in Switzerland (1779-1795), and Pallas in Russia (1782). These are considered the first geologists. They travelled, observed, described, did all the things Voltaire had advocated. If Voltaire's voice, therefore, appears unusually skeptical in matters of geology, it is parly due to these two reasons: his mature age and the lack of any major advancement in geology in his century.

Voltaire's skepticism did perhaps as much good as speculations. Indeed both are necessary, and it seems that often they work together. T. H. Huxley said that

> the advancement of natural knowledge has been effected by the successive or concurrent efforts of men, whose minds are characterized by tendencies so opposite that they are forced into conflict with one another. The one intellect is imaginative and synthetic;

> its chief aim is to arrive at a broad and coherent conception of the relations of phenomena; the other is positive, critical, analytic, and sets the highest value upon the exact determination and statement of the phenomena themselves."

Huxeley wrote that men of the first category held "wild hypotheses, for the power of ordering and grasping the endless details of natural fact which they confer." Science is indebted to these men for their "moral stimulus which arises out of the desire to confirm or confute them; and last, but not least, for the suggestion of paths of fruitful inquiry, which, without them, would never have been followed." These men "lighted upon verities while following illusions [. . .] On the other hand, there is no branch of science which does not owe at least an equal obligation to those cool heads, which are not to be seduced into the acceptance of symmetrical formulae and bold generalisations for solid truths because of their brilliancy and grandeur." These men "cannot overlook those small exceptions and insignificant residual phenomena which, when tracked to their causes, are so often the death of brilliant hypotheses." These men have "shown the limits of human knowledge which are set by the very conditions of thought, have warned mankind against fruitless efforts to overstep those limits" (1879: vi-viii).

One would think that Huxley was writing about Buffon and Voltaire whereas he actually described two biologists, Haeckel and Virchow, who apparently enacted similar roles. Today Buffon is looked upon as having "lighted upon verities while following illusions" while Voltaire has "warned mankind against fruitless efforts to overstep those limits." Both men, I believe, were defending scientific truth.

CONCLUSIONS

Voltaire's interpretations of geological phenomena have not been analyzed before. Nevertheless, numerous critics have found his pilgrim story, his beliefs in an unchanging universe, and his negative attitude toward system-makers the product either of prejudice, ignorance, or his deistic beliefs. The purpose of this study was, therefore, to analyze first of all Voltaire's geological observations in the light of modern science and in the context of his time, and then to make a judgment.

My study has shown that Voltaire's negative attitude toward the theory of marine invasion of all the continents was based on his personal investigation in the neighborhood of Ferney. He compared the shells of some recently dead garden snails with fragments of fossil shells exposed on the banks of rivers and the shore of Lake Geneva. Thus Voltaire's opinion that the sea had not formed any mountains is directly related with his observation of a freshwater environment. Modern science confirms that the Chattian molasse which forms many of the little hills on the shores of Lake Geneva, and which crops out whenever a river crosses the fields between the Jura and the lake, is indeed a freshwater sandstone and contains the freshwater snail *Helix ramondi*. Voltaire's contemporaries believed that freshwater fossils were only found in very recently deposited tufa but not in older rocks such as molasse. Only a hundred years later, did Lyell make the distinction between freshwater and marine shells.

The opinion that the faluns of Touraine were merely a terrestrial or freshwater deposit, as stated first in 1767 in *La Défense de mon oncle* and repeated several times until 1777 in *Dialogues d'Evhémère*, reveals that Voltaire continued obstinately to believe only what he had observed himself. Unfortunately, the faluns he had sent for arrived in a pitiful state: a powdery mass of unrecognizable fragments of shells mixed with earth and one shiny shell which resembled fossil shells in the molasse at Ferney and garden snails. Modern geology tells that the faluns, according to their location, may contain marine, freshwater, terrestrial, or a mixture of all these fossil shells and that Voltaire was not mistaken. His contemporaries Réaumur, Fontenelle, Buffon and others were convinced that the faluns of Touraine had been deposited by the sea alone.

Further geological observations in the Jura Mountains such as glacial and karstic phenomena made Voltaire aware that the latest theories of the earth by Buffon or Maillet had not mentioned such geological features. The karstic phenomena, in particular, seemed to contradict Buffon's idea that rivers were able to erode mountains and transport all the detrital material to the sea. In the Jura Mountains

rivers dry out, disappear into caverns, and reappear later on, but they do not transport much sediment. Voltaire's geological observations show that he valued only what he could see, touch, taste, and measure, qualities which were going to be used by geologists in their description of rocks and minerals.

Analysis of Voltaire's various essays on geological subjects and remarks in other works reveals that this remarkable man remained interested in every aspect of this struggling new science until the end of his life. His skeptical and often negative attitude toward geological theories was due to two reasons: his mature age which made him disenchanted with the speculative nature of most contemporary works and the fact that geology as a science was then in its infancy. It did not begin to develop before Werner, Saussure, Hutton, and Pallas.

Although I have not treated Voltaire's attitude toward biology, I mentioned some of his reactions when they were combined with geology. In the eighteenth century, some naturalists believed in preformation of all living things, others thought that some combinations of atoms and the right conditions produced life spontaneously. Voltaire had to take sides in this controversy and chose to agree with Spallanzani who refuted Needham. Voltaire was, however, not a strict preformationist since he declared in the essay "Dieu" that he did not know how a germ comes to life.

In conclusion, Voltaire's attitude toward geology was not influenced primarily by metaphysical beliefs but it was based on personal investigation and his search for scientific truth. Analysis shows that Voltaire was ready to change when he found a new theory more plausible. For instance, he replaced Kircher's ideas on irrigation by the more modern concept by Halley. Apparently, he did not find a better theory of mountain-building than stated in *Mundus Subterraneus* and thus remained faithful to the view that mountains had existed since the beginning of the earth.

APPENDIX

SAGGIO
INTORNO
AI CANBIAMENTI
AVVENUTI
SU'L GLOBO
DELLA TERRA.

IN PARIGI,
Stampato da PRAULT ſulla ripa di Gêvres.

M. DCC. XLVI.

Facsimile reproduction of *Saggio intorno ai canbiamenti avvenuti su'l Globo della Terra*, Paris, 1746.

SAGGIO
INTORNO
AI CANBIAMENTI
AVVENUTI
SU'L GLOBO
DELLA TERRA.

VI ſono errori popolari ; vene ſono Filoſofici. Di queſto ſecondo genere è forſe l'opinione di molti Eruditi, che veggono, o credono di vedere ſopra tutta la Terra monumenti d'una generale ruina, e diſtruzzione.

Fù ſcoperta fra i monti di Haſſia una pietra, che portava il ſembiante d'un *Rombo*. Sene conchiuſe ſubito, che il Mare copriſſe anticamente i monti di Haſſia; ſenza darſi briga di congetturare, che quel rombo

portato per la menſa d'un Signore di quel paeſe, ſi corruppe, fù gettato via, e poi s'impietrì. Un Luccio petrificato fù trovato ſulla cima delle Alpi; i fiumi dunque in un tempo correvano sù i monti, ed in un' altro la Germania era il ſeno del Mare!

Diceſi eſſer ſtata trovata ne' più alti monti di Helvezia un'Ancora di nave; nè ſi cercò a riflettere, che ſpeſſo ſopra quelle rupi furono tratti peſanti carichi, maſſime d'artiglieria, che s'impiegò qualche ancora per fermare il carico a qualche feſſura di rocca; che l'ancora fù preſa probabilmente da un naviglio del Lago di Genevra, e che infine (non con minor probabilità) l'iſtoria dell'ancora è falſa. Sembra più bello il dire, che queſta ancora appartenne anticamente ad un vaſcello, che navigaſſe avanti il Diluvio ſopra le montagne degli Svizzeri?

La Lingua del Peſcecane ſomiglia un poco alla *Gloſſapietra*. Baſta queſto per affermare, che tutte le Gloſſepietre ſiano altrettante lingue di Peſcicani, le quali eſſi laſciarono tra i noſtri monti al tempo di Noè? Perchè non dire ancora, le Conche chiamate *Veneris* eſſere l'iſteſſa coſa petrificata, che viene in eſſe figurata? I piccoli ſaſſi che vengono ſotto il nome di *Corna d'Ammone*, inchiudono ſpeſſo un non sò che rettile. Si ſtudiò di vedere in eſſi il peſce *Nautilius*, riputato eſſere ſtato prodotto nel Mare Indico, e non mai veduto altrove, che nella ſoſtanza di queſti ſaſſi: e ſenza eſaminare, ſe queſto animale impietrito ſia un peſce di mare, o una anguilla, affermano, che il Mare di Bengala inondò per un tempo le noſtre regioni.

In Italia, ed in Francia ſi ritrovano molte chiocciole, che paſſano per eſſere formate nei lidi di Soria. Non voglio dubitare punto della loro origine; ma i Filoſofi potevano ricordarſi dì quegl' innumerabili pellegrini, che andavano in frotta a guerreggiare, o vaneggiare anticamente verſo la Paleſtina, dove portarono i loro danari, e donde riportarono conchigliette. Non sò ſe ſia meglio credere, che il Mar di Soria copriſſe per un gran tempo Parigi, e Milano. Non ſarebbe forſe ſtravagante la congettura, che queſte conche ſiano foſſili. Molti Filoſofi lo penſarono così; ma in qualunque opinione, o errore che poſſiamo dare, non pare, che da queſte chiocciole ſi poſſa

arguire eſſere ſtato tutto il Mondo intieramente roveſciato.

I monti di Calais, e Douvres contengono in ſe molta creta : l'Oceano dunque altre volte non fù frapoſto tra loro. Il terreno verſo Tanger, e Gibraltar è dell' iſteſſa natura ; l'Africa dunque, e l'Europa erano ſtrettamente congiunte, e non v'era niente del Mare Mediterraneo ?

I Pirenei, le Alpi, l' Appennino non ſono nella mente d'alcuni Filoſofi, che nudi avanzi, e le ruine orrende d'un Globo fracaſſato, la di cui forma è mutata, e rimutata molte volte. Così l'inſegnava tutta la folla Pittagorica ; e molti altri Savj aſſicuravano la parte del Globo, oggi abitata, eſſere anticamente ſtata un vaſto Mare, e che il ſeno dell' Oceano foſſe allora un' aſciutto, ed arido terreno. Dichiara Ovidio il ſentimento di tutti i Filoſofi d'Oriente ; quando introduce Pittagora, che canta

Vidi ego quod fuerat quondam ſolidiſſima tellus
Eſſe fretum, vidi factas ex æquore terras, &c.

Fù queſta opinione di nuovo accreditata coll'inſpezione d'alcuni mucchi di conchiglie-

te, o rialzati nei ſaſſi della Calabria, o ſteſi ſul pian terreno di *Touraine*, ed in alcuni altri luoghi in diſtanza del Mare. In effetto, pare che cotali letti di chiocciole, ſiano là ſtati diſpoſti a poco a poco in lunga ſerie d'anni. Il Mare che in un luogo s'è retirato dai ſuoi lidi per qualche miglia, hà compenſato queſta perdita inſenſibile, col ricoprire alcuna parte d'un' altro terreno ; ma non vien ben dimoſtrato da tale avvenimento, eſſere ſtato il rimanente per molti ſecoli inghiottito, ed affogato. Ferrara, Frejus, *Aiguesmorte* furono un tempo ſpazioſi, e belli porti ; e la mezza parte dell' Oſtfriſia fù ſommerſa dall' Oceano Germanico. Le Balene dunque nuotarono molti ſecoli sù la cima del Caucaſo, ed il fondo dell' Oceano fù popolato di uomini ?

Queſto ſiſtema, queſte concluſioni ſi rinvigorirono in alcuni Filoſofi, dalla diſcoperta vera, o falſa del Cavaliere de Louville. Si sà eſſerſi egli traſportato a Marſiglia, per oſſervare, ſe l'obbliquità dell' Eclittica, foſſe ancora la medeſima, che era ſtata aſſegnata in quella Città venti ſecoli fà, dall' Aſtronomo Greco Piteas, s'accorſe, o credette accorgerſi, che ſi foſſe

ſcemata di venti minuti, cioè che nel traſcorſo di due mila anni, il circolo dell' Eclittica ſi foſſe avvicinato all' Equatore d'una terza parte d'un grado; e per conſeguenza che in ſei mila anni, l'Equatore, e l' Eclittica diventarebbero più vicini d'un grado intiero. Dato queſto, è manifeſto, che la terra, oltre i moti ſuoi già conoſciuti, ne avrebbe ancora un nuovo, il quale la farebbe girare d'un Polo all' altro ſopra ſe ſteſſa; di maniera che dopo 138000 anni, il Sole rimarrebbe un gran pezzo nell' Equatore, in riſpetto della Terra; e che dopo due milioni d'anni incirca, tutti i climi del Globo ſarebbono traſportati a vicenda ſotto la Zona torrida, e ſotto i Poli.

Queſto ſmiſurato periodo (dicono coſtoro) non dee ſpaventarci; vene ſono probabilmente de' più lunghi fra gli Aſtri. Fù ſcoperto già un moto della Terra, che non ſi fà compito ſe non in venti cinque mila e più anni, e queſto è la preceſſione degli Equinozj. Revoluzioni di cento mila milioni di ſecoli, ſono infinitamente più rapide innanzi agli occhi dell' Eterno Δεμιαμιεου, che non è ai noſtri ſenſi il giro d'una rota d'orologio compito in un batter d'occhio.

Queſta nuova revoluzione della Terra inventata dal Louville, mantenuta, e corretta da alcuni altri Aſtronomi, li induſſe a ricercare le antiche oſſervazioni di Babilonia, traſmeſſe ai Greci per comando d'Aleſſandro, ed accennate nell' Almageſte di Tolomeo. I Caldei al tempo d'Aleſſandro ſi davano il vanto d'avere una ſerie d'oſſervazioni di quattro cento mila anni.

S'affaticarono i Filoſofi a conciliare le favole di Babilonia colla nuova ipoteſi, ed alcuni ne arguirono che ogni paeſe eſſendo ſtato a vicenda o Polo, o Equatore, ogni Mare aveſſe cangiato il ſuo lido, e'l ſuo fondo. Il grande, il vaſto, le mutazioni del Mondo incantano ancora il cervello dei Savj. Si paſcono di queſte ſtupende cataſtrofi, come fà il Popolo nelle rappreſentazioni ſceniche. Dal punto inſenſibile di noſtra eſiſtenza, da quell' iſtante di noſtra durata, ſi ſpicca la noſtra mente, e s' inoltra negl' infiniti ſecoli, per rappreſentarſi, non ſenza piacere, il Canadà girando verſo la Linea equinoziale, ed il Mare agghiacciato traſportato ſull' erte cime d' Atlante.

Un' Autore, la di cui teorica della Terra lo reſe più famoſo, che utile, ſoſtenne, che il

Diluvio avendo conquaſſato tutto il Globo, fece di ſue ruine, ſaſſi, e montagne, e laſciò il Mondo immerſo nella maggiore confuſione; infine non vede in eſſo, ſe non ſtragi, e ruine. Un' altro Autore, non meno celebre, vede, ed ammira in ogni parte ordinanza, e ſimetria; ma afferma, che il Diluvio ordinò così l'Univerſo. Queſti due Autori s'accordano nel dire, che i monti, e le valli ſi ſono fatte per mezzo del Diluvio, benchè la ſacra Scrittura dica eſpreſſamente tutto il contrario.

Burnet nel ſuo quinto capitolo, non dubita, che la Terra foſſe avanti il Diluvio tutta eguale, unita, regolarmente formata come una bella palla, ſenza montagne, ſenza valli, ſenza mare. Se a coſtui ſi crede, il Diluvio fù la ſola cagione di queſta varietà chiamata da lui difformità; ed ecco la ragione, perchè le Corna d'Ammone ſi cavano dai monti Appennini.

Il *Vouduardo* confeſſa bene, che vi erano montagne prima che la Terra foſſe inondata, ma crede dimoſtrare eſſere i monti ſtati affatto diſſoluti dalle acque, coi metalli, e minerali; e che invece di loro ne furono altri formati; ed aſſeriſce queſta

nuova Terra, eſſere ripiena ancora di frammenti dei primi ſaſſi ammolliti dal Diluvio, e poi induriti, nei quali ſi ritrovano oggi animali antidiluviani, anguille, e topi d'India impietriti in Europa.

Il *Vouduardo* poteva ben' avvederſi, che l'acqua non diſſolve mai ſaſſi, e marmi; ma biſognava per credito del ſuo ſiſtema, che fra cento, e cinquanta giorni il Diluvio aveſſe tutto ridotto in paſta, affinchè egli trovaſſe antidiluviane beſtie nelle pietre d'Inghilterra. Si richiederebbe più tempo, che non durò il Diluvio per leggere tutti gli Autori, che hanno compoſto bei ſiſtemi ſopra d'eſſo. Ciaſcun di loro diſtrugge, e riproduce un Mondo a ſua poſta, come *Renato Deſcartes* ne hà creato uno. La maggior parte dei Filoſofi uſurpano nel loro gabinetto la potenza di Dio, ſi luſingano di fare un Mondo con la parola. Non voglio imitarli, e non hò conceputa la vana ſperanza di ſvelare i mezzi, e l'arte divina, che il Creatore poſe in uſo per formare la Terra, annegarla, riſtorarla, e mantenerla. Mi baſta la ſacra Scrittura; non mi dò il vanto diſpiegarla, nè l'ardire di dare ajuto alle ſue parole.

Piglio ſolamente la libertà d' eſaminare ſecondo le regole della probabilità, ſe debba crederſi, che il noſtro Globo abbia avuto, e ſia per acquiſtare uno ſtato diverſo da quello in cui lo vediamo. Ci fà ſol d'uopo avere occhi, oſſervare le opere della Providenza, e renderle grazie.

Miriamo prima quei monti, e ſaſſi, che *Burnet*, e molti altri giudicano eſſere le ruine d'un' antico Mondo, diſperſe di quà, e di là, ſenza ordine, come le diroccate mura d'una Città fulminata dal cannone. Io veggo al contrario (con ſua pace) i monti diſpoſti in un' ordine meraviglioſo da un termine della Terra all' altro; veggo una continua ſerie di alti acquidotti interrotti a propoſito in alcuni luoghi per dar paſſaggio ai fiumi, ed anche agli ſtretti del Mare, che corrono bagnando, ed umettando la Terra. Dall' ultimo promontorio d'Africa s'inalzano quei monti, che poi abbaſſandoſi aprono un paſſaggio al Zair, e al Niger, mentre che il Nilo ſcende d'un' altra parte, e poi ſi ricongiungono coll' Atlante tra il quale è Calpe, vien ſcavato il profondo Stretto di Gibraltar, il Calpe và ſerpendo inſino alla Sierra Morena; queſta ſi giunge

ai Pirenei, quali da un lato s'uniſcono colle Sevenne, che ſono parte dell' Alpi: all' Alpi ſono incatenati gli Appennini ſteſi inſino al Mare d'Otranto. Dirimpetto a loro appariſcono le montagne d'Epiro, e di Teſſaglia; di là paſſato lo Stretto di Gallipoli, trovaſi il Tauro, che ſotto il nome di Caucaſo, o d'Immao, ſi ſtende inſino ai confini del Mondo.

Così la Terra è d'ogni lato coperta d'un' immenſo, e continuo reſerbatojo d'acque, dal quale precipitandoſi tutti i fiumi, vanno irrigandola, mentre che nè dall' Oceano, nè dal Mediterraneo eſce un ſol ruſcello. Il Burnet fece ſtampare una carta del Globo diſtinta in montagne invece di Reami, e Provincie. S'ingegna coll'uſo di queſta figura, e colle ſue parole, di darci l'idea della più ſpaventevole, ed orrenda confuſione; ma nè dalla ſua ſtampa, nè da' ſuoi ragionamenti non ſi può veramente arguire, ſe non armonia, utilità, e beneficenza. *Le montagne Andes*, dice egli, *ſi ſtendono nell' America ſettentrionale per lo ſpazio di mille leghe. Il monte Taurus divide l'Aſia in due parti. Un'uomo che potrebbe da lungi vedere il tutto ad una viſta, s'accorgerebbe che il Globo è*

ancora più difforme di quel che ſi penſa.

Tutto il contrario (colla ſua pace.) Un' uomo di ſenno, che vedrebbe l'uno, e l'altro Emisferio traverſato da una catena d'alte ciſterne, e d' immenſi acquidotti, dai quali cadono tutti i fiumi, non potrebbe aſtenerſi dall' ammirare, e dal ringraziare l'alta ſapienza, e bontà del Creatore; non eſſendovi un ſolo clima ſenza montagne, e ſenza fiumi. La ſerie dei ſaſſi, che parve così brutta al Burnet, è un principale ordigno della grande machina. Tolta queſta ſerie, gli animali terreſtri non potrebbono vivere, giacchè non ſi vive ſenza acqua dolce, la quale prodotta ſpecialmente dal Mare benchè ſalſo, medianti i vapori continui, eſtratti dall' Oceano, vien traſportata dai venti sù la ſommità dei monti, dove ſi trasforma in torrenti, e fiumi: e viene calcolato dal grande Aſtronomo Halley, e dimoſtrato, che l'evaporazione univerſale è baſtante a ſomminiſtrare le pioggie, ed a riempire il letto di tutti i fiumi. Il Mondo non è che una catena immenſa; ſi tolgà un'anello, la machina vien quaſi diſtrutta. Perchè dar dunque una mentita ai ſacri Scrittori, a fine di privare la Terra delle ſue montagne, che

le furono ſempre neceſſarie? O perchè ſognare, che eſſe furono diſſolute dalle acque; e che invece di eſſe ſene ſono formate delle nuove?

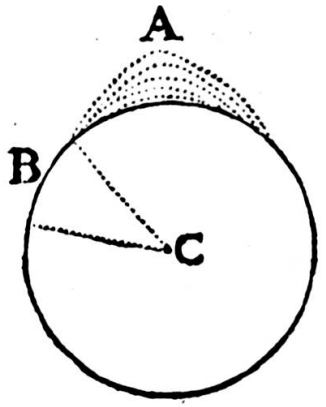
L'altra opinione cioè, che nella ſerie d'innumerabili ſecoli tutte le parti della Terra, abbiano ſervito alternativamente di fondo all' Oceano, è altrettanto contraria alla ragione, quanto alla ſacra Scrittura.

Un moto che inalza il Polo dell' Eclittica di dieci minuti in mille anni, non è violento abbaſtanza per fracaſſare il Globo. Se queſta revoluzione eſiſteſſe, laſciarebbe per certo le montagne dove la natura le hà poſte; e per dire il vero, non ſembra che il Caucaſo, e le Alpi ſiano ſtate traſportate, nè poco a poco, nè in un batter d'occhio in Aſia, ed in Italia dalle coſtiere di Congo, e d'Angolà. La ſola inſpezzione dell' Oceano reca un' argomento, che fà crollare tutto il ſiſtema romanzeſco. Il letto dell' Oceano è incavato di maniera, che quanto più ſi diſlunga dalla ſpiaggia, tanto più diviene profondo. Quando ſi naviga in alto mare (da alcune iſolette infuori) non appare nè pure un ſaſſo. Ora ſe ſi daſſe un tempo, dove l'Oceano foſſe inalzato ſulla

ſommità dell' Alpi, ſe gli uomini, ed i bruti aveſſero viſſuto nel fondo arenoſo, dove è poſto l'Oceano, donde, e da qual parte ſarebbero ſceſi i fiumi ? Dove ſi ſarebbero formate l'acque neceſſarie alla vita ?

Veramente biſognerebbe, che la natura a quei tempi, foſſe ſtata tutta diverſa da quella che pare oggidì; ma di grazia come un tal Globo incavato da un lato, e dall' altro portando montagne, e l'Oceano addoſſo, avrebbe potuto girare ſu'l ſuo aſſe egualmente ogni giorno ? Tutte le regole della gravità, e quelle dei fluidi verrebbero violate. Come rimarrebbe un' Oceano ſoſpeſo in alto, ſenza ſcorrere in queſta eſcavazione immenſa, che la natura adoprò per riceverlo ? O che tutti i Filoſofi, che inventano un Mondo, lo fanno ridicolo ! Io ſuppongo con quelli, che ammettono il periodo di due milioni d'anni, che ſiamo arrivati a quel punto dove l'Eclittica capiterà nel circolo dell' Equatore, non ſi dee credere, che in tal tempo, nè mai l'Oceano ſia per cangiare di luogo. Verun moto della Terra può attravviare le leggi della gravità. Fate girare la Terra dal Ponente all' Oriente, dalla Tramontana al Mezzodì ; ogni particella

d'acqua, e di terra tenderà ſempre verſo il centro. Il meccaniſmo univerſale non ſi muterà un punto: ſia il monte A. parte dell' Oceano B. tutte le parti d'acqua ſaranno ſempre dirette al centro C. e non v'è legge di natura, che in niun caso poſſa dirigere l'acqua nella linea B A: queſti ſono i primi principi della Filoſofia naturale.



Non v'è dunque alcun ſiſtema che poſſa recare la minima veriſimilitudine all'opinione corrente, della quale molti ſi ſono invaghiti, cioè che il Globo è tutto cangiato, che l'Oceano ondeggiò molti ſecoli fà dove ſono ora le noſtre Città, e che gli uomini ebbero la loro dimora dove nuotano

oggi i Peſcicani, e le Balene. Tutto ciò che vegeta, tutto ciò che viene animato, i minerali, i metalli ancora, hanno ritenuto la loro natura. Ogni ſpecie, ogni genere di vermi, e d'erbe s'è mantenuto ſenza corruzzione, o alterazione alcuna. Veramente ſarebbe una coſa ſtrana, ſe mentre la ſemenza di ſenapa, o di fungo, rimane eternamente la medeſima, il Globo il quale produce invariabili ſemi, cangiaſſe affatto la ſua natura!

Quel che dico dell' Oceano, biſogna dirlo del Mediterraneo, e del gran Lago Caſpiano. Se queſti Mari frappoſti nel mezzo di terre, non ſono così antichi come il Globo, certo è che l'Univerſo fù eſſenzialmente differente da quello che pare. Numeroſa è la turba degli Autori, che ci hanno informato d'una non ſò che ſcoſſa di terra, d'un gran monte inghiottito dall' Oceano, tra Calpe, ed Abila, il quale diede ſubito paſſaggio all'acque dell' Oceano, e ne conſtituì il Mar Mediterraneo, il quale ſi ſteſe infino a mille, e cinque cento miglia verſo la Tartaria. Cioè in un tratto un letto di mille, e cinque cento miglia fù cavato dalla natura, e tutti i fiumi d' intorno s'accordarono ad imboccarſi in queſto nuovo Mare. Il caſo di Calpe, ed Abila, è veramente molto meraviglioſo: e ſi può dire che queſta iſtoria non fù ſcritta da un contemporaneo.

Se ſi voleſſe ſolamente conſiderare il corſo di tanti fiumi dell' Aſia, e dell' Europa, che ſcendono da tutte le parti del Mondo di là di Gibraltar, e che vanno l'uno all' incontro dell' altro, ſarebbe coſa facile d'accorgerſi, che tutti queſti fiumi dovevano naturalmente produrre un immenſo Lago. Certo che il Tanaïs, il Boriſtene, l'Iſtro, il Rodano, &c. non potevano avere la loro imboccatura nell' Oceano; o ſarebbero ſtati coſtretti di correre tutti inſieme, e di perforare i Pirenei per andare di compagnia al Mar di Biſcaja.

Nondimeno molti Filoſofi aſſeriſcono, che il Mediterraneo fù prodotto caſualmente da una irruzzione dell' Oceano. Si domandava che ſarebbe avvenuto di tanti fiumi ſenza imboccatura? Che ſi ſarebbe fatto d'un gran Lago ſenza uſcita? Che penſare ancora del Mare Caſpiano? Si riſpondeva eſſervi una vaſta ſotterranea cavità;

un ſecreto canale, al favor del quale il Mare Caſpiano comunicava le ſue ſuperflue onde al Mediterraneo, come il Mediterraneo era creduto portare le ſue all' Oceano. In oltre ſi diceva, che queſta comunicazione veniva comprovata da molti peſci gettati nel Mare Caſpiano con un' anello alle nari, e poi peſcati a Conſtantinopoli, o in Africa. In queſta guiſa fù trattata da molti l'Iſtoria, e la Filoſofia; ma la Critica mandò fuori le favole; la Fiſica eſperimentale cacciò i ſiſtemi. Cotali ciancie non devono più eſſere accreditate, giacchè è calcolato, che la ſola evaporazione, è baſtante ad impedire, tutti i mari d'inondare le loro ſpiaggie. E dunque aſſai veriſimile che il Mediterraneo, e l'Oceano ſiano ſempre ſtati fermi nel loro ſeno, eccetto li cento cinquanta giorni del Diluvio, e che la coſtituzione fondamentale del Mondo fù ſempre l' iſteſſa.

Sò bene che vi ſaranno ſempre uomini, lo ſpirito de' quali ſarà più percoſſo d'un luccio inſaſſito ſul monte *Ceni*, e d'un rombo petrificato in Haſſia, che di tutti i ragionamenti della vera Filoſofia. Si compiaceranno nell' immaginare, che i fiumi corre-

vano anticamente sù l'erte cime dell' Alpi, che l'Oceano copriva la Germania; e vedendo certe conchiglie affermeranno, che il Mar di Soria è venuto a Francfort. Il guſto del meraviglioſo produce i ſiſtemi ſtravaganti, ma la natura è altrettanto uniforme, ſemplice, e coſtante, quanto le noſtre immaginazioni ſono invaghite di prodigj, e di ſegnalate revoluzioni.

VOLTAIRE.

Aprile 1746.

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