

Les singularités de la nature

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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:

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 prolongemens 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 Frédéric 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 owed 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,

1 7 6 8.

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 mutual 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 tremblemens 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 bateau 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 physique qui ne pourrait que vous ennuyer (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 Petersburg 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 terrains 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, examiner 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 ensuite 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 preceding 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'Évangile 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, polyyps, 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 *Éléments* 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 1769, 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 réalité des dendrites, c'est-à-dire des pierres naturelles arborisées qui représentent des arbrisseaux, des buissons, des mousses, des bruyères, &c. Pourquoi donc faire venir des capillaires, des polypodes, des adiantum, des lonchites, des osmodes & toutes sortes de fougères, 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 fougères

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 "dendrites" 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, leaf-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 fendue, 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 *Dendraches* (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), loose 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 huitres pétrifiées qu'on a trouvées sur le sommet des Alpes?

— Je répondrai, monsieur le créateur, que je n'ai pas vu plus d'huitres pétrifiées que d'ancre de vaisseau sur le haut du mont Cenis. Je répondrai ce qu'on a déjà dit, qu'on a trouvé des écailles d'huitres (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 hémisphère, 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 Brésil, 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 Cordillères, 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 nourrissent 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 hemisphere. (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)

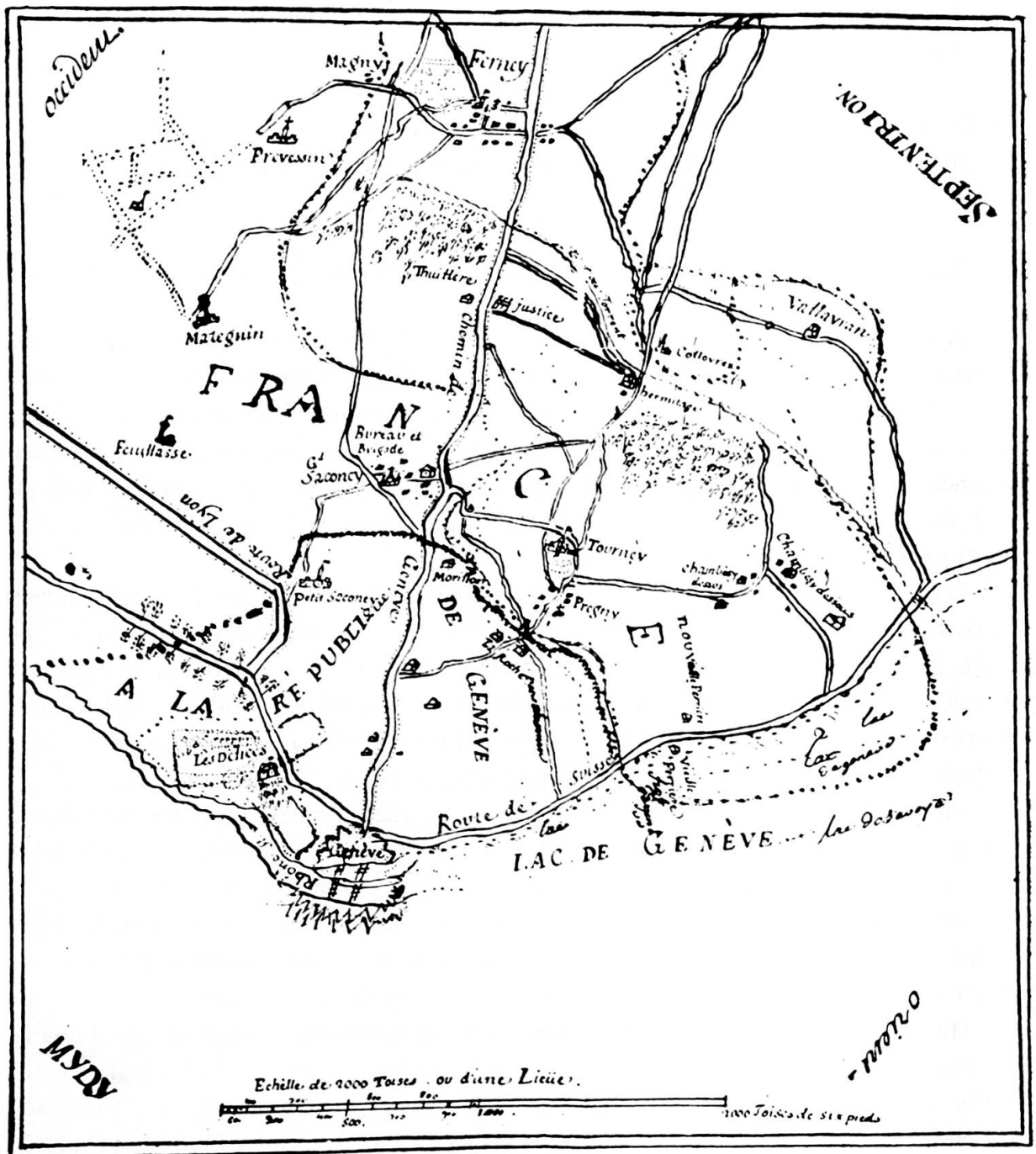


FIG. 4. — Map of the area of Ferney and Tournay drafted by Voltaire's secretary Wagnière. Reproduced from F. Caussy, *Voltaire Seigneur de Village*, Paris, 1912, facing p. 64. The words *nan* or *torrent*, *lac de Genève*, *petit chemin*, etc. are by Voltaire's pen.

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 minéraux" (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 sink-holes, 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 diamants 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 débris 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 jeter dans mon champ toutes les coques déséchées 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 physique 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 milliers. Je ne sais pourquoi l'académicien qui, le premier après Palissy, 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 boîte qu'on m'a envoyée, de petits univalves & un coquillage qu'on nomme vis de mer, ou pyramide 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 boîte 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 notre globe. Mais aussi, comment une production enfouie 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 dimension 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 comes, 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 butte 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 saturated 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 contradictory 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 mémoire 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 resembled 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

¹ In the river Gambia in West Africa and Bissão 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, accroit, détruit, fait mourir, fait renaître,
 Change tout dans les cieus, 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'Éternel, 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 écrivains 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 devenues 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 ailés & 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'essor 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 métamorphosèrent. 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 ailerons 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 nécessité, 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 faites 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'avouerais 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.