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ELIE BERTRAND'S CHANGING THEORY OF THE EARTH

BY

Marguerite CAROZZI ¹ and Albert V. CAROZZI ²

ABSTRACT

In 1752, Elie Bertrand proposed his first theory of the earth in *Mémoires sur la structure intérieure de la terre* where he classified all geological phenomena into three classes. The first dated from Creation, the second from the Deluge, and the third from recent events. He astonished his contemporaries with the outmoded concept of "figured stones" for his description of fossil remains which resemble living marine animals and plants. Johann Gottlob Lehmann retorted in his *Versuch einer Geschichte von Flötz-Gebürge...* (1756). While he accepted Bertrand's three classes of phenomena, he totally disagreed with the idea of "figured stones," placed in the original earth at Creation for reasons of analogy. According to Lehmann, the waters of the Deluge had transported animals and plants and deposited them in various layers of mud which later hardened and petrified. Because of regionalism, Lehmann was describing as "primitive" mountains highly tilted, non fossiliferous "Gang-Gebürge" in the Harz Mountains against which were leaning gently inclined fossiliferous secondary rocks, his "Flötz-Gebürge," while Bertrand was looking at regularly folded massive limestones in the Jura Mountains, very rich in fossils, and displaying no visible relationship to any older substratum, hence he considered them to be "primitive" mountains.

Bertrand read d'Holbach's translation of Lehmann's work, *Essai d'une histoire naturelle de la terre...* (1759) and stated in his *Dictionnaire universel des fossiles propres et des fossiles accidentels* (1763) that he now agreed that "figured stones" are indeed marine or terrestrial fossil remains. In his *Recueil de divers traités sur l'histoire naturelle de la terre et des fossiles* (1766), he mentioned his change of mind in a footnote. Bertrand, however, could not accept Lehmann's notion of transportation of animals and plants by the waters of the Deluge since he found their fossil remains in what he believed to be "primitive" mountains. Therefore, he had to invent a "new Creation" when a new world was created upon the ruins of a former destroyed one in which animals and plants had lived. This rather unorthodox theme was included in Bertrand's articles in the *Encyclopédie ou Dictionnaire universel raisonné des connaissances humaines*, Yverdon (1770-1776), namely "Couches de la terre," "Cailloux," and "Pétrifications." The first two were reprinted in the *Supplément à l'Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers*, Paris (1776-1777).

In *Le Thévenon* (1777), Bertrand finally compared the two kinds of mountains, the Alps and the Jura, and noticed that the former contain "granit" among other hard and weather-resistant rocks while the limestones in the Jura Mountains give easy access to underground water systems and caverns and dissolve rapidly at the surface. He was now skeptical of all theories of the earth, including his own, finding none of them capable of explaining how fossiliferous strata had been uplifted and folded.

¹ Research Associate, Department of Geology, University of Illinois at Urbana-Champaign, Urbana, Illinois, 61801, USA.

² Professor of Geology, same University.

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RÉSUMÉ

En 1752, Elie Bertrand a proposé sa première théorie de la terre dans ses *Mémoires sur la structure intérieure de la terre*, en divisant tous les phénomènes géologiques en trois classes: la première correspond à la Création, la seconde au Déluge, et la troisième à des accidents récents. Bertrand a étonné ses contemporains avec la notion démodée de «pierres figurées» pour tous les fossiles qui ressemblent à des animaux ou plantes marins vivants. Johann Gottlob Lehmann a répondu dans son *Versuch einer Geschichte von Flötz-Gebürge...* (1756). Il a accepté les trois classes de phénomènes, mais il a critiqué violemment l'idée de «pierres figurées» placées dans le sein de la terre à la Création pour des raisons d'analogie. Lehmann a pensé que les eaux du Déluge avaient transporté les animaux et les plantes pour les déposer dans diverses couches de limon. Par l'effet de la géologie locale, les deux naturalistes sont arrivés à des interprétations totalement opposées. Lehmann a décrit les montagnes «primaires» dans le Harz comme étant des couches fortement inclinées, sans fossiles, qu'il a appelées les «Gang-Gebürge», contre lesquelles s'appuient des couches «secondaires» presque horizontales, riches en fossiles, les «Flötz-Gebürge». Bertrand, par contre, a observé des couches massives de calcaires, riches en fossiles, fracturées et plissées de façon régulière, dans le Jura. Elles ne montrent aucune relation visible avec un substratum plus ancien et Bertrand les a interprétées comme des roches primitives.

Après avoir lu la traduction du livre de Lehmann, *Essai d'une histoire naturelle de la terre* (1759) par d'Holbach, Bertrand a accepté l'origine marine des «pierres figurées» dans son *Dictionnaire universel des fossiles propres et des fossiles accidentels* (1763). Dans le *Recueil de divers traités sur l'histoire naturelle de la terre et des fossiles* (1766), il a avoué, dans une note infra-paginale, qu'il avait changé d'avis. Il n'a cependant pas pu accepter la théorie diluvienne de Lehmann, étant donné que les fossiles marins se trouvaient dans ses couches «primitives». De ce fait il s'est trouvé dans l'obligation d'inventer une «nouvelle Création» d'un monde nouveau à partir des ruines d'un ancien monde détruit où vivaient des animaux et des plantes. Cette notion peu orthodoxe d'une «nouvelle Création» a été présentée dans les articles «Couches de la terre», «Cailloux», et «Pétrifications» que Bertrand a écrit pour l'*Encyclopédie ou Dictionnaire universel raisonné des connaissances humaines*, Yverdon (1770-1776), ainsi que dans le *Supplément à l'Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers*, Paris (1776-1777) sauf l'article «Pétrifications».

Dans son livre *Le Thévenon* (1777), Bertrand a confirmé que les Alpes et le Jura étaient composés de roches entièrement différentes. Dans les premières, il a trouvé du «granit» parmi d'autres roches dures résistantes à l'érosion, tandis que dans le Jura, le calcaire donne libre accès à l'infiltration des eaux tandis qu'à la surface il se dissout facilement. Bertrand est désormais contre toute théorie de la terre, même la sienne. Aucune, à son avis, ne peut donner une explication satisfaisante du soulèvement et plissement des roches fossilifères.

INTRODUCTION

This study analyses Elie Bertrand's changing ideas on the origin of the earth between the years 1752 and 1777, that twilight period in the eighteenth century, between Buffon's *Histoire naturelle* (1749) and Hutton's *Theory of the Earth* (Abstract 1785). Our aim is to explain the difficulties Bertrand encountered in the field before he accepted the organic origin of fossils, and the reasons why, even then, he was unable to point to any satisfactory theory for their occurrence in the Jura Mountains.

PREVIOUS WORK AND WORK IN PROGRESS

Besides Voltaire's correspondance with Bertrand which gives some insight into Bertrand's geological ideas (M. Carozzi, 1983, p. 57-58), we have consulted previous works on Bertrand and found that none treat his changing ideas on the origin of the earth. Ch. Berthoud (1870), Paul Dumont (1905), Louis-Edouard Roulet (1950), Charly Guyot (1955), Francis J. Crowley (1959), and Graham Gargett (1980) all refer to Bertrand's philosophical, theological, or moral ideas while Roger de Guimps (1855) included very few references to Bertrand, the naturalist. The study of his scientific works has been the subject of a recent paper by Kennard B. Bork (1984). The author was kind enough to send us the manuscript for comments. Since his study rests on Bertrand's work in the realm of natural theology, our approach will not coincide with his. Bertrand's in depth biography, based on unpublished letters and memoirs, on local and international publications in Bertrand's time, and other findings in the libraries and archives of Switzerland, is the subject of a current study by Marc Weidmann. It will contribute more than anything to shed some light on the mysteries which still surround Bertrand, the naturalist.

MÉMOIRES SUR LA STRUCTURE INTÉRIEURE DE LA TERRE (1752)

When Bertrand first proposed a theory of the earth in his *Mémoires...* (Figure 1), he was pastor of the French Protestant Church in Bern and member of the Royal Academy of Sciences of Prussia, Berlin. His work consists of three parts. In the first, he gave a description of the earth, in the second, he rejected all previous theories of the earth, and in the third, he stated his own theory.

Most of the geographical and geological descriptions in the first memoir are borrowed from others as mentioned in elaborate footnotes whereas Bertrand's personal observations pertain clearly to the Jura Mountains. There he spent most of his life and was greatly influenced by karstic phenomena such as caverns, fissures, underground water systems (p. 15-18), and by massive layers of limestones containing a multitude of fossils (p. 21-32). He had started collecting fossils in his youth (1763, p. xxix), and in his *Mémoires...* he expressed bewilderment about their quantity and variety: "It seems impossible that these animals all lived at the same time since no such quantities have been found in any sea" (p. 24), and "... in a very small portion of the Jura Mountains are more fossils which resemble shells, either known or unknown, from all the seas and all the beaches, than could possibly exist today on a much larger area in the ocean" (p. 31). Bertrand's surprise was legitimate before he read Vitaliano Donati's book on the Adriatic Sea (translated into French in 1758),

MEMOIRES
SUR
LA STRUCTURE INTERIEURE
DE LA TERRE,
PAR
M. ELIE BERTRAND.
M. D. S. É.
ET
*Membre de l'Académie Royale des Sciences
de Prusse.*



A ZURIC,

CHEZ HEIDEGGUER ET COMPAGNIE.
MDCGLII.

FIG. 1.

Title page of *Mémoires sur la structure intérieure de la terre.*

because European beaches bear no comparison with the extraordinary richness of fossils found in the Jura Mountains. Donati's study showed that the bottom of the sea could be compared to fossiliferous beds in mountains (Bertrand, 1766, p. 4).

[In the first memoir, Bertrand used the name "fossiles" in the broad sense, from *fodere*, to dig out, as used in the eighteenth century, namely everything dug out from the earth including minerals, metals, earths, and fossil remains. He pointed out that some naturalists consider fossils which resemble shells as well as marine fish and plants to be the remains of the sea, others confound them with congelations, amalgamations, crystallizations, petrifications, concretions of the earth or believe that they were in the earth since its origin (p. 22-23). In the second memoir, Bertrand used the word "figured stones" and said that they resemble marine animals and plants and are considered by some naturalists to be terrestrial bodies which have the same origin as other "fossils" (broad sense) which show some constancy and regularity. Other naturalists, however, view these bodies as the remains of the sea and of the animal and plant kingdom (p. 41). All through the second and third memoir, Bertrand used mostly the term "figured stones" for fossils of organic origin and we shall cite them as such.]

In the second memoir, Bertrand rejected all previous hypotheses on the origin of the earth and on "figured stones" enclosed in what he considered the "primitive" earth. His rejections are based either on his reliance on contemporary sources, on his strong belief in the Bible, or on personal observations.

As many of his contemporaries, Bertrand refuted as erroneous beliefs of the past those proposed by Carl Nicolaus Lang who had mentioned that "figured stones" originated from seeds, and by Robert Plot who believed that they were mere "jeux de la nature" (p. 45-46). Bertrand also rejected ideas by Joseph Pitton Tournefort and Elie Camerarius who believed that fossils actually grow in the earth by accretion and vegetation. Bertrand objected: "These 'figured stones' were not formed little by little, piece by piece, one after the other; since they form part of the total composition of the globe, or its external crust, they must have the same origin as this crust, at least whenever it is not broken or disrupted" (p. 47-48).

Bertrand also refuted theories held by Steno and by John Ray who proposed, in different ways, that particular accidents such as earthquakes, volcanic activity, inundations, as can still be witnessed today, are solely responsible for irregularities of the earth's crust. Bertrand argued that according to Moses, the earth is only six thousand years old and that no drastic accidents, as were recorded in antiquity, have occurred since, though during the last period of our time, records have become more reliable. Furthermore, he stated that these accidents could not explain the regular disposition of mountains with their uniform and constant layers of rocks. These accidents could merely explain disruptions and irregularities in these beds (p. 48-53).

He rejected, furthermore, the theory advocated by Leibniz which was accepted with much enthusiasm by many naturalists; it said that lands once covered by the sea formed mountains, either by their uplifting or by the diminution of the sea. Ber-

trand's main arguments were that layers of the earth surround the globe concentrically and continuously, both underneath land and sea. Secondly, that according to Moses, the earth is too young to have undergone all the various changes which would have required a long period of time (p. 56-57).

Attacking Buffon, in particular, Bertrand wondered how many centuries would have been necessary to lift mountains to a height of eight to ten thousand feet, and how many centuries more to "metamorphose" originally soft beds into hard rocks such as "marbles", limestones, and cherts (p. 65). His belief in an orderly universe created by God for the benefit of man and all living creatures, which implied the existence of mountains since Creation, coupled with his skepticism of a theory of mountain-building which was unable to explain high mountains such as the Alps, compelled Bertrand to reject the concept of mountain-building by the sea over a long period of time.

Bertrand's opposition to that theory was also influenced by personal observation in the Jura Mountains. He claimed that layers supposedly formed by the double movement of the sea (East-West, ebb and tide), according to Buffon's theory, ought to be rather thin and superposed in repeated sequences. In the Jura Mountains, however, Bertrand found layers of five, ten, fifteen, twenty feet, some even a hundred feet and more (p. 65-66). He mentioned, furthermore, that the many fissures which cut through beds in every direction must convince everybody that these effects were not caused by a simple process of drying up of layers in accordance with Buffon's theory. Bertrand referred to phenomena which pointed instead to some violent disruptions: "Displacement, uplifting of an upper layer leaving a considerable interval, elsewhere some kind of disruption and fracture. On both sides of rivers, or in deep valleys are signs of a violent separation forming fairly large intervals, sometimes several leagues long, but with corresponding beds on both sides" (p. 71-72). Bertrand also wondered why Buffon did not mention caverns. Because "caverns have visibly the same origin as the beds which surround them... a theory which explains the latter cannot ignore the former" (p. 72). It is evident that Bertrand's observations of local geology did not match Buffon's theory of mountain-building. Bertrand had spent many summer months in the Jura Mountains, in anticlinal valleys, in "cluses" (transverse valleys), and in caverns where he witnessed structural deformations not mentioned by Buffon. He noticed repeatedly a continuation of the same beds on both sides of valleys, sometimes including caverns. At Montcherand, near Yverdon, in the gorges of the Orbe, he observed a cavern forming one fourth of a circle which corresponded to a similar opening on the other side of the river near the village of Agiez (p. 14).

Diluvial theories by Thomas Burnet, William Whiston, and John Woodward were also rejected. Bertrand singled out Woodward because his system appeared closest to observation facts and seemed most likely to explain fossils inside various layers of the earth. Both Johann Jacob Scheuchzer and Louis Bourguet, whom Bertrand cited often, had been greatly influenced by Woodward's diluvial theory. It postulated

that fossils settled according to their specific weight in a diluvial sea after the complete dissolution of all rocks. To that theory, Bertrand objected that too many miracles would be necessary to dissolve rocks and preserve animals and plants and to harden soft beds instantly in order to form many layers of rocks (p. 84).

According to Bertrand, Woodward's theory of mountain-building sounded as follows: After the Deluge, God had to repeat the operations of the third day of Creation, namely to separate the waters from the earths. Thus the crust was broken, here and there, and part of the diluvial waters disappeared into the central "orbe", elsewhere beds were lifted or compressed and pushed down where part of the diluvial waters remained. This theory explained mountains, valleys, inclined beds, and fissures which give to the surface of the earth an appearance of ruins and destruction (p. 81). At the end of the second memoir, Bertrand concluded that Woodward's theory was too complex because a "dissolution of the world would imply obviously and literally a new Creation" (p. 86). Bertrand's reliance on contemporary sources worked in strange ways. He was going to use the theme of a "new Creation" in his later works, as discussed below, while he contested it here so strongly.

In the third memoir, Bertrand proposed his own theory. Since he did not believe in Woodward's miracles, he was forced to suggest another explanation for the presence of "figured stones" inside his "primitive" mountains. He declared that since we cannot explain by one theory alone the various structural phenomena observed today, we must distinguish causes and epochs (p. 97). He then divided all phenomena into three classes. Those belonging to the first class concern the interior of the earth, down to its greatest known depth. Layers corresponding to that class are uniform in composition, regularly arranged, and show relationships of general significance. More specifically, everything found in layers which appear continuous, related to each other, and superposed without interruption belongs to Creation and the works of the first two days (p. 98, 107). Phenomena belonging to the second class are mostly at the surface or at shallow depth. They are represented by isolated deposits, beds of sand or mud, particularly in low places and in marshes. These phenomena point to the presence of running water or flooding and were formed during the Deluge. Finally, phenomena which belong to the third class resulted from local disruptions and successive changes visible at various places and depths (p. 98-99). Still not satisfied, Bertrand rephrased his classification as follows:

This is the general rule: all which is part of the universal bottom, the general crust of the earth, or its substance, belongs to Creation. Every product of phenomena which cannot be explained by Creation has been introduced into fissures of beds, into intervals between strata, into fractures, or into new beds or deposits formed by accidents which have occurred since the beginning... (1766, p. 72).

Bertrand called rocks belonging to the first class "du roc, du marbre, de la pierre à chaux, de la pierre à fusil", namely hard rocks, "marbles", limestones, and cherts (p. 24, 65, 91, 103-104). Diluvial beds included sand, gravel, mud, bituminous earths,

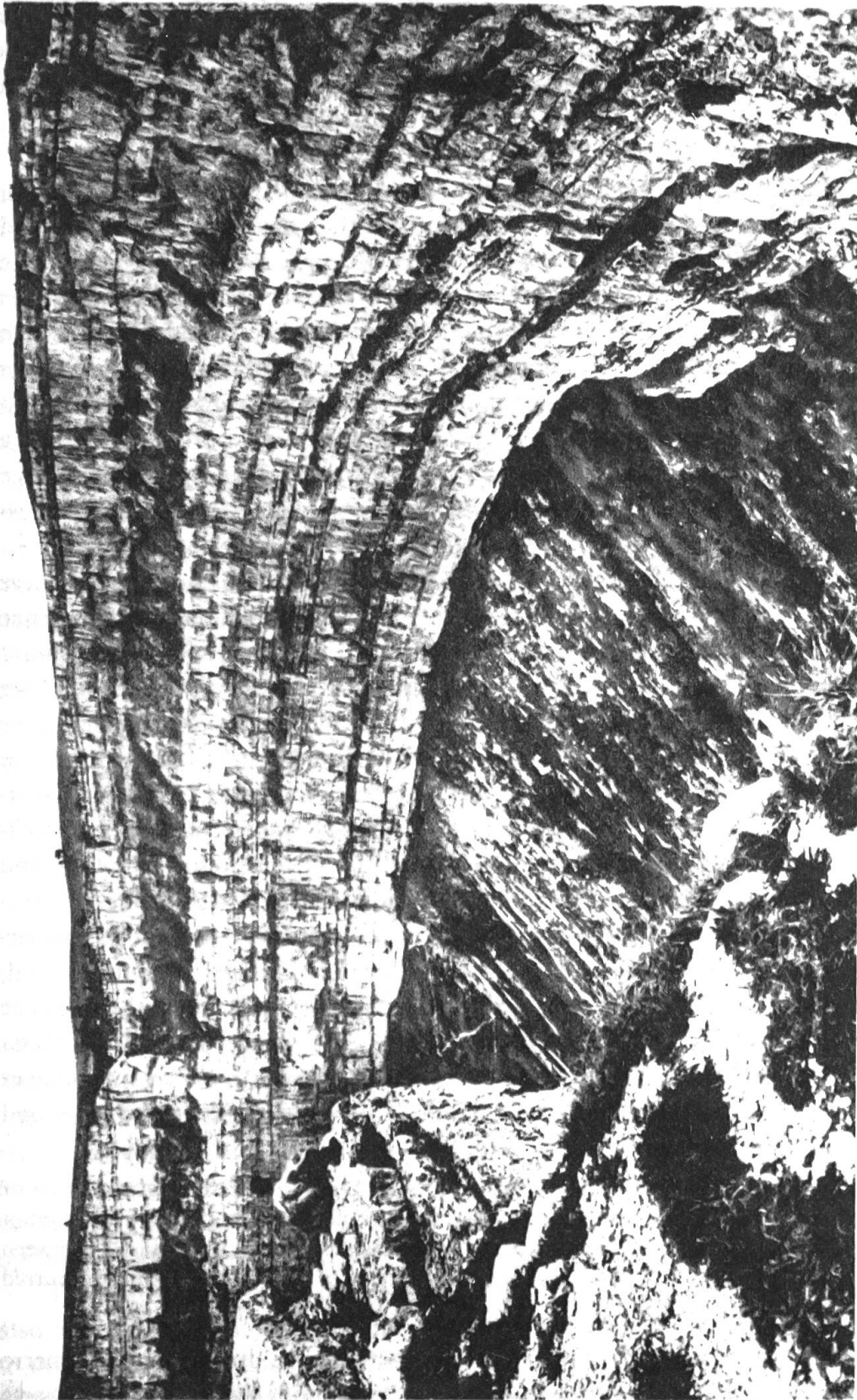


FIG. 2.

Le Creux-du-Van, Jura near Neuchâtel, showing opened anticlinal structure of massive beds of Upper Jurassic limestones (Sequanian-Kimmeridgian) resting on Argovian shales (covered).

tufa, terrestrial animals and plants, and the remains of a few marine organisms (p. 120-121). Recent changes Bertrand recognized with difficulty. Nevertheless, he believed that they had been caused by inundations, landslides, earthquakes, movements of the sea, works of men, and weathering (p. 124-131).

What Bertrand actually saw in the Jura Mountains were thick and massive or uniformly stratified gray limestone series of the Upper Jurassic (Sequanian to Kimmeridgian) which build the backbone of most of the Jura anticlinal folds (Figure 2). He saw, furthermore, yellowish limestones of the Lower Cretaceous (Valanginian, Hauterivian, and Barremian) which extend mostly along the flanks of the anticlinal folds and the synclinal depressions. Both series are extremely rich in fossils. These limestone units alternate with hard, sparsely fossiliferous limestones, so-called "marbles" in the eighteenth century, in French "marbres bâtards". Chert nodules are present in all units, particularly in Cretaceous limestones. Bertrand apparently did not make any distinction between Jurassic and Cretaceous limestones and associated them in his rocks of the first class or "primitive". Although these limestone units actually rest on an older Hercynian substratum, the contact is nowhere visible in the Swiss Jura Mountains so that he was sure that they were part of the "universal bottom" and hence belonged to Creation. Bertrand's second class of rocks which he attributed to the Deluge correspond to the superficial mantle of Tertiary to Recent deposits which occur in pockets or in fissures over the anticlinal structures (Eocene Siderolitic sands, clays from decalcification of limestone, and loess) but is mostly filling synclinal areas and transverse valleys: freshwater and marine molasses, lacustrine chalks, tufas, peats, gravels, and sands of local glacial and interglacial origin. There are no signs of volcanic activity in the Jura Mountains, hence Bertrand included among recent events those mentioned in literature, and local inundations in his region.

What influenced Bertrand's classification of rocks? As in his rejection of theories of the earth, it was the opinion of contemporaries, the Bible, and personal observation. His first arguments rested, nevertheless, on observation:

Since all "fossils" or all "figured stones" are of the same material as the beds in which they are enclosed, since they are impregnated with the same salts which dominate there, are filled with the same mineral or metallic matters that occur there, we have the right to conclude that they must be of the same age, of the same origin, and were produced at the same time as these beds or that they were placed in the latter when they were formed. If such fossils are found at the foot of mountains and in valleys and are mixed with earth or stones, then they were detached from their beds by some accident. Buried at great depth, in entire beds of "roc" or "marbre", as they are, we can think of no accident since Creation which might have transported and assembled these fossils in these beds (p. 91).

In order to stress his belief that fossils enclosed in rocks must have the same origin, Bertrand referred to Linnaeus' idea that fossil shells, corals, and other marine animals found in the rocks of a Swedish cavern must have floated over a distance of 1000 leagues, attached to sargasso grass, from the Tropics to Sweden. "How", asked

Bertrand, “were these foreign bodies incorporated into rocks of the caverns and are now part of them? Who does not understand that the cavern and the shells have the same origin which can be no other than Creation?” (p. 91-92).

As a second fundamental observation, Bertrand repeated his earlier statement that there are simply too many fossils in the Jura Mountains in comparison with marine life in the ocean and that they vary greatly from place to place. He asked: “Where is the sea which shows us in the same place such variety and such richness?” (p. 93). It was not only the quantity and the variety of fossils which puzzled Bertrand in the Jura Mountains, he was also faced with such phenomena as perhaps caused by landslides leading to unusual juxtaposition of different beds (D. Aubert, pers. comm., 1984), and perhaps by problems of rapid lateral facies changes:

If the movements of the sea have transported them [fossils], why are there distinct separations of certain parts in one place and a curious mixture of all kinds in another? I have seen in the same mountain close to Vaullion, in the Baillage of Romainmôtier, Canton of Bern, two beds, one dipping South, the other South-East. Although they were contiguous, they contained different fossils. In the first one are only small “Trompettes”, in the second are various forms of “Dactyles” or “Belemnites” and up to fifteen kinds of shells (p. 93).

Since Bertrand could rely neither on his contemporaries before he read Donati's book, nor make any sense of his own observations, he followed the time-honored theory that God had created mountains for the benefit of man. He relied heavily on William Derham, an English clergyman and Fellow of the Royal Society of London who had written a much cited book, *Physico-Theology or a demonstration of the being and attributes of God from his works of creation...* based upon sermons preached in the years 1711 and 1712. It is a work of which Voltaire owned two French translations, *Théologie astronomique...* (1729) and *Théologie physique...* (1730, see Alekseev, p. 309). It is listed as the tenth most popular book after Buffon's *Histoire naturelle* in the eighteenth century (Mornet, p. 248) and Bertrand must have owned more than one edition since he donated “Physique et Astronomique” in two volumes to the Library of Yverdon (Régître de la Bibliothèque Publique d'Yverdon, p. 23). With reference to Derham, Bertrand thus accepted the opinion that mountains were not formed randomly but according to a wise and powerful Being (p. 96).

When Bertrand formulated a theory of mountain-building, he turned to Woodward's theory: After the second day of Creation, the waters separated from the earths. The latter had been deposited in concentric layers with no interruptions nor elevations. While these layers were still soft, they were uplifted in certain places, and “according to the laws of the air and the Creator”, they became hard. During uplifting — caused perhaps by the movements of the earth itself — beds were broken here and there. They became inclined, interrupted, and irregular. Thus were created mountains, valleys, caverns, fissures, waterholes, and underground water systems. The waters partly disappeared into these underground passages and partly remained on land to form

lakes and seas (p. 110-112). We clearly recognize here some of Woodward's ideas (1735, p. 48-49) which seemed to fit Bertrand's observations of karstic phenomena in the Jura Mountains. Woodward's theory, however, refers to mountain-building during the Deluge — his earth had no mountains before the Deluge — whereas Bertrand described mountain-building at Creation. He believed, moreover, that more violent disruptions had caused abrupt valleys, steep mountain cliffs and peaks, as well as huge boulders found in plains. Both phenomena must have resulted from the breaking of harder beds (p. 111). Bertrand is here parting from Woodward and evidently described the spectacular anticlinal and transverse valleys (*cluses*) in the Jura Mountains and erratic boulders littering the plains and resting against the foot of the Jura (erratics will be discussed in the last section, *Le Thévenon*). Bertrand remained, nevertheless, visibly hesitant about the precise "movements" which the earth had experienced during mountain-building. He suggested that it was perhaps unnecessary to search for the means God used to create irregularities on the surface of the earth since he certainly used the best (p. 113).

It was also God who had placed "figured stones" which resemble live marine analogs in the original earth in order to create a link between the various kingdoms so that "figured stones" were, in fact, the intermediate between inert stones and organic kingdoms (p. 105-107). Bertrand's use of the theme of the Great Chain of Beings, often cited in the eighteenth century, was perhaps borrowed from Woodward's *Géographie physique...* (1735) where reference is made to Camerarius, Professor of medicine at Tübingen, who had suggested that some fossils were placed in the earth at Creation, and that it was not absurd to imagine that God created some analogy or resemblance between the various kingdoms (p. 295, 302).

With all its limitations, Bertrand's *Mémoires...* present some concrete observation facts. Unwilling to accept any one theory alone in order to explain the variety and quantity of fossiliferous beds in the Jura Mountains, Bertrand separated all phenomena into three classes and wanted to study the causes which might explain the presence of these fossils. His personal observations of these bodies which he compared with what he knew in 1752 on marine life — mostly on beaches and probably from geographical works — resulted in a legitimate surprise before he actually read Donati's book on the Adriatic Sea (Figure 3). Bertrand's observations of massive layers in the Jura Mountains which have no visible relationship with any substratum of older rocks convinced Bertrand that they must be "primitive" mountains such as the Alps and had been created at the beginning of time. Since they contained fossil remains which resembled marine analogs, he chose the answer given earlier by Camerarius, namely that these "figured stones" were placed in the earth for reasons of analogy at Creation. Compared to other often rambling works by naturalists of the eighteenth century, Bertrand's is to the point, well-organized, and unusually well-based on precisely quoted sources.

E S S A I
 S U R
 L'HISTOIRE NATURELLE
 D E
 LA MER ADRIATIQUE
 PAR LE DOCTEUR
 VITALIANO DONATI,
 AVEC UNE LETTRE DU DOCTEUR
 LEONARD SESLER,
 SUR UNE
 NOUVELLE ESPECE
 D E
 PLANTE TERRESTRE,
 TRADUIT DE L'ITALIEN.



A L A H A T E,
 CHEZ PIERRE DE HONDT,
 M. DCC. LVIII.

FIG. 3.

Title page of *Essai sur l'histoire naturelle de la Mer Adriatique* by Vitaliano Donati,
 translated from the Italian.

ESSAI
SUR LES
USAGES
DES
MONTAGNES,
AVEC UNE
LETTRE SUR LE NIL;

PAR
E. BERTRAND. M. D. S. E.
de l'Académie Royale de Prusse.

Sed prior hæc hominis cura est dignoscere
terram,

Et quæ hujus miranda tulit natura notare.

CORN. SEVERUS.

A ZURIC, Chés Heidegguer & Comp. 1754.

FIG. 4.

Title page of *Essai sur les usages des montagnes, avec une lettre sur le Nil*.

ESSAI SUR LES USAGES DES MONTAGNES (1754)

One might wonder why, after only two years, Bertrand published another book related to geology but with a completely different content (Figure 4). With a style reminiscent of Rousseau's, the essay includes many romantic poems by Albrecht von Haller on the Alps. God and its work is the subject and no further personal investigation is offered. The work is perhaps an apology to some of the clergy who had not appreciated his earlier book. Indeed, in the introduction he wrote that it was his duty as a minister to study the works of Creation in order to make them the subject of admiration to others.

Only in the chapter on fossils, did he repeat what he had said in his *Mémoires...*, namely that "figured stones" originated during Creation when God placed them in the earth to emphasize harmony and beauty in his work, and to provide some link among the various kingdoms, or to avoid a "hiatus" among the various reigns. Bertrand also repeated the three classes of rocks as outlined in his earlier work.

The almost totality of the book is borrowed from various sources. We have already mentioned Derham's *Physico-Theology*... to which Bertrand referred shortly in his *Mémoires...* In *Essai sur les usages des montagnes* he explained at much greater length each of the concepts advocated by Derham: that mountains are necessary for mankind's health; that they provide space for habitation, as well as for various herbs and trees, different kinds of animals, minerals and metals, rivers and springs; that they act as boundaries or bulwarks between nations, and that their ridges direct vapors to produce rain and make the region habitable. From Athanasius Kircher's *Mundus Subterraneus*, Bertrand borrowed the idea that mountains are necessary to stabilize the earth and to retain the waters (Tome I, Book II, Chapter II, p. 56, Chapter IX, p. 69), and from Camerarius, Bertrand adopted the concept of "figured stones" as mentioned above.

Bertrand's essay on the use of mountains can hardly be compared with his earlier work. Nevertheless, it was this work which Jean-Etienne Guettard chose to criticize in a memoir to the Royal Academy of Sciences of Paris. He politely refuted Bertrand's "figured stones" as a "theory which plunged into obscurity a truth which has been so well-established and so often demonstrated" (Guettard, 1765, p. 195). We used the word "polite" because Guettard is well-known for his harsh criticism of Voltaire (Guettard, 1768-1783, vol. IV, p. 12) and Buffon (Roger, p. cxxxix).

LEHMANN'S FLÖTZ-GEBÜRGE (1756)

When Johann Gottlob Lehmann became interested in mining and metallurgy, he traveled widely through Bohemia, the Prussian provinces, and in Thuringia where

he observed many gently dipping to horizontal layers of sedimentary rocks, in particular around the Harz Mountains, abutting against highly tilted rocks which appeared much older. He became member of the Royal Prussian Academy of Sciences in 1754 where Bertrand was a member since 1752. Lehmann's *Versuch einer Geschichte von Flötz-Gebürge...* (Figure 5) may be considered a reaction to Bertrand's *Mémoires...* which he mentioned in great detail, and in particular against the concept of "figured stones".

In the Introduction, Lehmann stated that he was going to analyse the interior of the earth more carefully than his predecessors Leibniz, Whiston, Woodward, Newton, Büttner, Mylius, Moro, Bertrand, Kiessling, Spangenberg (p. A1). He evidently had much respect for certain parts of Bertrand's theory saying: "If a system is very close to nature, then it is the one by Bertrand... his three postulates are good but in their explanation he has gone too far" (p. 54-55). Lehmann also referred to Bertrand as one of the authors who believed, as he did, that mountains existed since the beginning of the world because they were necessary for the earth (p. 10). He quoted Bertrand word for word in his opposition to Woodward's theory, namely that too many miracles would be necessary to dissolve rocks and leave shells unaffected (p. 32); Lehmann also appreciated Bertrand's view that not all phenomena belong to the universal Deluge (p. 53).

Lehmann accepted Bertrand's three postulates, namely the three classes of mountains (p. 96). His "primitive" mountains, called "Gang-Gebürge", contained, however, no organic fossils (p. 113). He described them as massive layers of rocks which are often in vertical or oblique position and disappear into unknown depths (p. 111). They contain minerals and metals and such rocks which he said to be either "feuerwackig" and "hornsteinig", or "kieselig" and "quartzig", or "kalckartig" and "spathig" (p. 117). Elsewhere he described these rocks as "componirte Körper" (p. 112) and mentioned once that the same kind of rock continues throughout the whole mountain (p. 118). Lehmann was apparently describing metamorphic to sedimentary rocks of Lower Paleozoic age: graywackes, siliceous shales, quartzites, calcareous sandstones, shales, and rare limestones. He never mentioned the word "granite". "Flötz-Gebürge" he described as hills or mountains containing various horizontal to gently inclined layers of "Flötzen", often as many as forty, which are superposed and consist of material torn away from the "primitive" mountains during the Deluge: limestone, sandstone, marl, shales, coal, etc. These layers included many fossils. He drew stratigraphic profiles to show how these layers abut against "primitive" rocks forming the core of the Harz Mountains. As Bertrand, Lehmann believed that a third class of rocks originated during recent and successive accidents (p. 83, 116-240).

Lehmann strongly disagreed with Bertrand's "figured stones" which he considered fossil remains of real animals and plants which were transported during the Deluge. He found those of mussels and snails close to the surface, underneath the "Damm-erde" in limestones; those of fish and land animals somewhat deeper in shales; he

Versuch
 einer
Geschichte
 von
Flöz-Gebürge,
 betreffend
 deren Entstehung, Lage,
 darinne befindliche
 Metallen, Mineralien und Fossilien,
 größtentheils
 aus eigenen Wahrnehmungen,
 chymischen und physicalischen Versuchen,
 und aus denen Grundsätzen der Natur-Lehre
 hergeleitet,
 und
 mit nöthigen Kupfern versehen,
 von
D. Johann Gottlob Lehmann,
 Königl. Preuß. Berg-Rath, Mitglied der Königl. Acad. der
 Wissenschaften, wie auch der Churmainzischen Acad.
 nützlicher Wissenschaften.

 Mit Königl. Pöhl. Churf. Sächs. allergn. Privilegio.

Berlin,
 zu finden bey Gottlieb August Lange.
 i 7 5 6.

FIG. 5.

Title page of *Versuch einer Geschichte von Flöz-Gebürge...* by Johann Gottlob Lehmann.

found petrified wood at still greater depth, and deepest in the earth he noticed imprints of flowers (p. 66). He explained how these fossil remains had arrived at these various places. Since mussels and snails are light-weight, they remained floating in the waters of the Deluge much longer than other animals and plants. When the waters receded, they came to rest on sand and mud from which they absorbed matter over a period of time until they were petrified together with the sand and the mud. Land animals died immediately at the beginning of the Deluge and sank to the bottom of the diluvial sea where they became embedded in mud. Fish, in particular small ones, are known to bury themselves in mud during storms. Thus, during the Deluge, they were there and remained there. Because soft parts of fish and land animals wasted away before being petrified, only imprints of hard parts of fish and land animals are usually found in shales. Petrified wood occurs at greater depth because trees were uprooted during the first impact of the Deluge and later they became covered by earth, stones, and mud. Flowers were the very first victims of the Deluge because they were swept away from the highest mountains. Lehmann thus found from bottom to top imprints of flowers, petrified wood, petrified fish and land animals, and finally on top snails and mussels (p. 69-70).

To Bertrand's objections that too many fossils occur in rocks while the sea has comparatively little life, Lehmann answered that, on the contrary, the bottom of the sea is teeming with live animals and plants (p. 55). To Bertrand's observation that fossil spines of sea-urchins are extremely plentiful while the whole animal is never found, Lehmann answered that he had found both fossil remains together in one place (p. 59). Bertrand's main argument that rocks and enclosed fossils must have the same origin, and that Linnaeus' idea on transportation of fossils from the Tropics to Sweden could therefore not explain fossiliferous rocks in a Swedish cavern, was refuted by Lehmann in the following manner: All hard rocks were soft at the beginning because 1) stones are still growing underground in abandoned quarries; 2) many stories record abandoned iron mines where iron is presently growing again; 3) according to Henckel's *L'origine des pierres*, limestones and sandstones are still being formed and keep growing; 4) during the long stay of the diluvial waters, the earth became water-soaked to a great depth, and 5) how else can anyone explain the origin of "Flötzen" if not as the effect of inundations and earth-slides which occurred after Creation? (p. 65).

A comparison of the ideas by the two naturalists reveals that they were both influenced by local geology. Lehmann's observation of numerous horizontal to gently dipping fossiliferous layers abutting against older, harder, highly tilted ones brought logically to his mind that the former were deposited by water long after the "primitive" mountains had been formed. Since the only written record was the Bible, Lehmann accepted its authority (p. 82). Bertrand found very few and isolated "diluvial" deposits which, moreover, did not form numerous superposed layers as observed by Lehmann. In addition, Bertrand's "primitive" mountains consisted of massive, sometimes horizontal, sometimes tilted, sometimes fractured layers which were very rich in fossils.

He never saw any older rocks underneath his "primitive" ones because they are buried at depth under the Jura. He concluded, therefore, that the Jura Mountains, with the exception of a few diluvial deposits, were created at the beginning and that fossils resembling marine animals are merely "figured stones". Under these circumstances and regional influences, Lehmann was able, with his knowledge of mines and metallurgy, to draw an early stratigraphic cross-section whereas Bertrand hung on to the outmoded notion of "figured stones" because his "primitive" mountains contained fossils.

D'HOLBACH'S TRANSLATION OF LEHMANN'S WORK (1759)

Paul Henri Tiry d'Holbach had a talent for discovering bright new ideas which in the field of mining, metallurgy, chemistry, and mineralogy came most often from Germany in the middle of the eighteenth century. He skillfully translated works by Johan Gottschalk Wallerius, Johann Friedrich Henckel, Christlieb Ehregott Gellert, and Georg Ernst Stahl, as well as Lehmann's *Kurtze Einleitung in einige Theile der Bergwercks-Wissenschaft...* (1751); *Abhandlung von den Metall-Müttern...* (1753), and *Versuch einer Geschichte von Flötz-Gebürgen...* (1756) in *Traité de physique...* (1759) in three volumes. D'Holbach wrote at least 400 signed articles and probably as many unsigned for Diderot's *Encyclopédie* of Paris and was acquainted with the most brilliant minds in Paris (Schwab *et al.*, v. 93, p. 102-108; Naville, p. 67-75). His translations and his relations with Buffon and his works gave d'Holbach enough knowledge to write about mineralogy, metallurgy, fossils, and mountain-building in the field of earth sciences and to add pertinent footnotes to his translations. His personal convictions made him a believer in science divorced from religion.

In the preface and the footnotes of his translation of Lehmann's third book, entitled *Essai d'une histoire naturelle des couches de la terre...* (translation of *Versuch einer Geschichte...*), he stated that he was not in favor of the Biblical Deluge and that layers of rocks are the work of many centuries during which sediments were deposited by the sea and not by the Deluge according to the laws of gravity (p. xij). He mentioned that most naturalists of his century adhere to Buffon's theory (p. x) and wondered why Lehmann had not even quoted Buffon's *Histoire naturelle* (p. 83). D'Holbach also objected to Lehmann's theory of mountain-building which was unable to explain mountains such as the Alps (p. 96-97). He agreed with the idea that many small mountains were formed by volcanic activity, but that big mountain chains were not products of volcanoes. The latter, furthermore, imply earlier revolutions because coal and bituminous beds, probably causing volcanic activity, derive from great forests which were buried during earlier revolutions (p. 143). He refuted some of Lehmann's objections to Bertrand, for instance, Lehmann's belief that small fossil shells cluster together while larger ones are found isolated (p. 153-154). This is generally not true, said d'Hol-

bach, large marine shells are often intermingled with smaller ones. Observations by Rouelle show that some "amas" or assemblages of marine fossils have their analogs in living communities in the sea (p. 155-156).

D'Holbach, moreover, added an interesting article by Schober, published in the *Magazin of Hamburg* (Tome III, p. 490 ff., no date) which proves that given time, small causes can produce great effects. Schober measured how much earth becomes mixed with river-water during rainfalls and is then deposited in the sea. His studies showed that rivers can indeed transport great amounts during one rainfall and more so over many centuries. This quantitative approach showed, according to d'Holbach, that a universal Deluge is not necessary to explain the deposit of layers (p. 359-364).

D'Holbach's translation of Lehmann's work, together with his footnotes and introduction, brought to the attention of Bertrand and French speaking naturalists not only Lehmann's careful observations of "Flötz-Gebürge", but also d'Holbach's interpretation and conclusion that such layers could have been deposited in the sea over a long period of time, and hence not by the Deluge.

DICTIONNAIRE UNIVERSEL DES FOSSILES PROPRES ET DES FOSSILES ACCIDENTELS (1763)

In the *Dictionnaire*, Bertrand answered two critics of his *Mémoires...: Lehmann* and d'Holbach. He agreed with the former and accepted the marine origin of fossils, but he disagreed with d'Holbach's theory of mountain-building by the sea (Figure 6).

Under the entry "Pétrifications", Bertrand admitted that he had formerly believed that some petrified bodies had been formed by God and placed inside the earth for reasons of analogy between the various kingdoms. "Now I believe that these bodies are indeed 'fossiles accidentels' which from the sea or from the surface of the earth have entered the earth, were buried in layers which formed during various accidents and hardened over time" (1763, vol. 2, p. 113). He then referred to Donati according to whom "the bottom of the sea shows great accumulations of marine bodies buried in mud. After the retreat of the sea, these layers hardened and petrified; 'voilà' precisely the layers found today in our mountains and valleys" (vol. 2, p. 115).

Although he agreed with the marine origin of fossils, Bertrand continued to ask the question how these foreign bodies became entrapped inside the earth. Perhaps all the theories together might explain the present state of our earth because there are "petrifications which have preceded the Deluge, others originated during the Deluge, still others were formed during the many accidents which have occurred after the Deluge" (vol. 2, p. 115-116).

Under the entry "Couches de la terre" (vol. 1, p. 162-163), Bertrand acknowledged Lehmann's work, namely d'Holbach's translation, but he did not disclose Lehmann's rebuttal of "figured stones". Instead he referred to the anonymous translator who

**DICTIONNAIRE
UNIVERSEL**
 D E S
FOSSILES PROPRES,
 E T D E S
FOSSILES ACCIDENTELS,
 CONTENANT UNE DESCRIPTION

Des terres, des sables, des fels, des foudres, des bitu-
 mes, des pierres simples & composées, communes &
 précieuses transparentes & opaques, amorphes &
 figurées, des minéraux, des métaux, des pétrifi-
 cations du règne animal, & du règne végétal
 &c. avec des recherches sur la formation
 de ces fossiles, sur leur origine,
 leurs usages &c.

PAR MR. E. BERTRAND,

*Premier Pasteur de l'Eglise Française de Berne; Membre des
 Acad. de Berlin, de Goettingue, de Stockholm, de Flo-
 rence, de Leipzig, de Mayence, de Bavière, de
 Lyon, de Nanci, de Bâle, de la Société
 Oeconomique de Berne &c.*

TOME PREMIER:



A L A H A Y E,
 Chez { **PIERRE GOSSE Junior,**
 E T
 DANIEL PINET.
M. DCC. LXIII.

FIG. 6.

Title page of *Dictionnaire universel des fossiles propres et des fossiles accidentels...*

“assumes that the sea once covered the whole earth and either retreated little by little, or while the largest portion of the continent was formerly at the bottom of the sea, these layers were formed there”. Bertrand claimed that “this hypothesis presents more difficulties than any other. To distinguish epochs and assemble all possible causes of the formation of layers appears to me a more philosophical method”. He then repeated his earlier view on the three classes of rocks and stated that the first might be called “couches primitives”, the second “couches diluviennes”, and the third “couches marines & accidentelles”, namely primitive, diluvial, and marine and accidental. When these beds were soft, foreign bodies were introduced which according to prevailing circulating fluids in the earth became transformed over time and either calcified, petrified, or mineralized.

Bertrand then proposed a new idea: “If one could assume that another globe existed and was destroyed before this terraqueous one, and that out of the remains of that former world God created a new one, then we might explain the irregularities of beds, the mines, and the foreign bodies”. He thus accepted in 1763 the occurrence of organic fossils in “primitive” beds of the Jura Mountains but was unable to explain how they had arrived there. We shall discuss his new theory in more detail below.

Some of the entries in Bertrand's *Dictionnaire* point to serious problems of nomenclature in the eighteenth century. It appears necessary to understand what Bertrand meant by “cailloux”, “roches”, “pierres”, and “granit” in order to know whether he was referring to sedimentary or other rocks which certainly influenced his theory of the earth.

1. “Cailloux”, in Latin *Silices*, in German “Kieselstein” have a coarse outer texture, underneath they are fine-grained and composed of a compact matter like glass. They are vitrescible and sometimes occur together with sand, gravel, or earth, but they never form entire beds. One kind is called “cailloux grossiers”, *silices gregarii*, “grober Kiesel”, the other “pierres à fusil”, *silex igniarius*, “Feuerstein”.

Bertrand's “cailloux” are chert nodules.

2. “Roches” or “Pierres composées”, in Latin *Saxa*, or *Lapides mixti*, *Petrae vulgares*, in German “Felssteinarten”, “grauer Felsstein”, are a mixture of calcareous stones, vitrescible and refractable, composed of sand, chert nodules (pierres à fusil), “spath”, quartz, and mica. A lapidifying juice has glued all these various parts together. According to their composition, mixture, texture, and juice, these stones may vary indefinitely from place to place. “I have seen this kind of rocks in the Jura Mountains between the County of Burgundy and the Diocese of Basel where they vary greatly... According to P. Tilas, these rocks are very old. I have seen, however, a bed of sandy ‘roches’, mixed with ‘cailloux’, mica, and ‘spath’ where I found various petrifications such as mussels, pecten, ‘ostreo pectinites’,

and *Glossopetrae*. These rocks were coarse-grained, very hard, and formed large blocks. The quarry is half a league from Zofingen, Aargau, in a place called Mühlethal, close to a beech forest".

What Bertrand actually saw at Mühlethal were fossiliferous feldspathic arenites of the Burdigalian Upper Marine Molasse. In the Jura Mountains, between Burgundy and Basel, he probably observed sandstones of the Stampian-Aquitania lower freshwater molasse.

3. "Pierres", in Latin, *Lapides*, in German "Steinarten", are bodies of different hardness. Some can be easily broken between your fingers as talc and pumice, while others are extremely hard such as marble or limestones for construction. Some are as hard as diamonds. They can be distinguished into a) "Pierres calcaires", in Latin, *Lapides calcarei*, in German, "Kalkstein". These are limestones, marble, gypsum, and "spath". b) "Pierres vitrifiables", in Latin *Lapides vitrescentes*, in German, "Glasarten". These are "ardoises", "grès", "pierres à fusil", agates, jasper, quartz, and precious stones. c) "Pierres réfractaires", in Latin, *Lapides apyri*, in German "Feuerfeste Steine". These are mica, talc, soapstone, amianthus, asbestos. d) "Pierres composées", in Latin *Saxa*, in German, "Felsteinarten".

Bertrand's "roches" and "pierres composées" are the same, while the nomenclature of most other rocks and minerals has not changed.

4. "Granit", in Latin, *Granites*: "A kind of red marble in various shades. The ancients called them *pyrrhopaecilus syenites* according to Hill in Theophrastus, p. 30. Other naturalists call by this name a coarse stone which is hard, unpolished, and composed of grains. It shows grayish-green specks on a background of a dirty white".

From Bertrand's entries in his *Dictionnaire* it appears that "cailloux" are chert nodules while "roches composées" are sandstones of freshwater or marine molasse. Bertrand's description of "granit" is rather ambiguous and no German name is given. Lehmann did not refer to "granit" at all although he might have seen some in the Harz Mountains. The word "granit" was obviously not well — established at that time and whatever Bertrand was describing as "primitive" rocks was not granite.

Besides these problems of nomenclature, Bertrand's *Dictionnaire* represents his best contribution to the unravelling of the various names, classifications, and systems for fossils (in the broad sense). In his entry "Spath", he said, "Sooner or later we shall have in natural history so many names and synonyms for each substance that the same will happen to us as happened to the Chinese in their language problem: their life is not long enough to study each word so that there is no time left to under-

stand anything" (vol. 2, p. 190). Voltaire was well aware of that when he wrote to Bertrand: "Your dictionary must make a fortune my dear philosopher; it is new, it is useful, and it seems to me very well-made. I believe that from now on all should be put into dictionaries. Life is too short to read the many voluminous books, to hell with long dissertations!" (Besterman D10894). Bertrand's *Dictionnaire* together with his *Mémoires historiques et physiques sur les tremblements de terre* (1757) are in the eleventh rank among books read in the eighteenth century (Mornet, p. 248, 250). Even Guettard was pleased with this work saying: "Mr. Bertrand is one of the authors who has used more distinction and order than any other in his description of 'crapaudines' and other fossils which are petrified teeth", and "Bertrand has worked better than anybody else to throw some light on the confusion which reigns among fossils described as *Glossopetrae*" (Guettard, 1768-1783, vol. V, p. 210-211).

RECUEIL DE DIVERS TRAITÉS SUR L'HISTOIRE NATURELLE DE LA TERRE ET DES FOSSILES (1766)

With the exceptions of Bertrand's *Dictionnaire*, the Recueil (Figure 7) includes his major works on natural history, namely:

1. *Mémoires sur la structure intérieure de la terre* (1752).
2. *Essai sur les usages des montagnes* (1754).
3. *Mémoires historiques et physiques sur les tremblemens de terre* (1757).
4. *Essai de minéralogie ou distribution méthodique des fossiles propres et accidentels à la terre* (1754).
5. *Essai de la minérographie et de l'hydrographie du Canton de Berne* (1754).
6. *Index realis mineralogiae Bernensis...* (added in 1766).
7. *Eliae Bertrandi Museum* (no date).
8. *Lettre sur les inondations du Nil et l'usage des montagnes de l'Abissinie*, addressed to M. de Vattel, Ambassador to the King of Poland.
9. *Lettre sur la diminution des mers, et l'origine des montagnes*, addressed to M. Formey, Perpetual Secretary of the Royal Academy of Sciences of Prussia.

Most of the above works had already been published in 1754 in a slightly different order with the exception of No. 3, 6, and 7. A comparison of *Essai de minéralogie...*, called *Idée générale d'un arrangement méthodique des fossiles* in 1754, with *Index realis...* and *Eliae Bertrandi Museum* shows that in the first two works "figured stones" are classified under "Les Pierres" while in the last work they were no

RECUEIL
DE
 DIVERS TRAITÉS
sur
 L'HISTOIRE NATURELLE
 DE LA TERRE
 ET DES FOSSILES.

*Par M. E. BERTRAND, ci-devant premier Pasteur de l'Eglise
 Françoisise de Berne, & Secrétaire de la Société Économique,
 maintenant Conseiller de la Cour du Roi de Pologne; des
 Académies de Berlin, de Goettingue, de Suede, de Florence,
 de Leipzig, de Mayence, de Munich, de Lyon, de Nancy,
 de Bâle; des Sociétés d'Agriculture de Paris, de Lyon, de
 Rouen, de Dublin; &c. &c.*



A A V I G N O N ,
 Chez LOUIS CHAMBEAU, Imprimeur - Libraire,
 près les RR. PP. Jésuites.

M. DCC. LXVI.

FIG. 7.

Title page of *Recueil de divers traités sur l'histoire naturelle de la terre et des fossiles*.

longer called “figured stones” but were classified as either belonging to “pétrifications” or “corps marins”. Ammonites, for instance, are listed under both categories. The three classifications, however, are obsolete in comparison with the *Dictionnaire* of 1763 where Bertrand accepted the marine origin of “figured stones”, including ammonites. (He was going to write his most up-to-date classification in *Elémens d'oryctologie ou Distribution méthodique des fossiles*, 1773.) The *Recueil* does not strike as an updated work but is, as the title says, a mere collection of his earlier works.

Only the *Mémoires...* show substantial changes. In regard to “figured stones” Bertrand added the following important footnote:

I admit that since I wrote these Mémoires I have changed my mind and am now convinced that it is not possible to deny the marine origin of petrified bodies. Whether these fossils were introduced into the earth during the Deluge is not easy to decide. If the world were older than historical records seem to show, if it could be proven that changes occurred at the center of the earth in regard to gravity, or that the earth's axis or its ecliptic changed position, then we might find in these changes the causes of a successive translation of the sea over the lands and the origin of marine fossils embedded almost everywhere. But in order to decide about these changes, we need more reliable observations... (1766, p. 74).

According to this footnote, Bertrand appears less skeptical about a longer geological time and various changes and revolutions which might have occurred to alter the surface of the earth. We speculated earlier that this new outlook was perhaps made possible by his resignation as pastor in Bern (M. Carozzi, 1983, p. 53). Bertrand's unpublished correspondence, now in the process of being studied, might provide reliable evidence.

In the *Recueil*, Bertrand made corrections and added some new material to the *Mémoires...*, some of which we have already mentioned (Donati's study on the Adriatic Sea, p. 4, and Bertrand's rephrasing of his three classes of rocks, p. 72). It is surprising, however, that so few of these additions — which are included in the text and not merely in footnotes — bear on the marine origin of fossils with the exception of the above footnote. Indeed, most additions only add new studies, new localities where fossils were found while Bertrand kept his statement unchanged that God had placed “figured stones” in the earth during Creation (p. 74-82). It is possible that he added the footnote at the last minute and left the resulting inconsistencies untouched.

BERTRAND'S ARTICLES IN ENCYCLOPÉDIE OU DICTIONNAIRE UNIVERSEL RAISONNÉ DES CONNAISSANCES HUMAINES, YVERDON (1770-1776)

In the last volume of the plates (10 vols. 1775-1780), the editor and printer of the *Encyclopédie* of Yverdon, Fortuné-Barthélemy Félice, published the names of the contributors (This fact was generously provided by Henri Cornaz, author of an article

on the life of Félice, 1981). Félice wrote that the letters B. C. refer to "Elie Bertrand, member of several academies and private councilor to the King of Poland. As a naturalist he has treated the subject of mineralogy; he has, moreover, furnished excellent articles on morals and religion" (*Encyclopédie*, Yverdon, vol. 10 of plates, p. 2). "B. C." stands for "Bertrand Conseiller", a title of which Bertrand was obviously proud. Félice mentioned, furthermore, that one third of all articles in the *Encyclopédie* of Yverdon were either new with the letter (N) or redone with the letter (R). Most of the articles written by Bertrand on natural history were new, or redone.

Not counting articles on religion and morals, we found fifty articles signed "B. C." in the forty-eight volumes (Figure 8). These are:

| | |
|---|--|
| <i>Arsenic</i> | Gypse |
| <i>Azoth</i> (Philos. hermét.) | Hematite |
| Basalt | <i>Hermeneutique</i> (Art, Philos. Logic.) |
| Belemnite | <i>Houille</i> |
| Buccins | <i>Huître</i> |
| Charbon | <i>Hydrologie</i> |
| Cobalt | <i>Iule</i> (insect.) |
| <i>Caillou</i> | <i>Lepidoptères</i> (insect.) |
| <i>Chapeau</i> (Art. méch.) | <i>Marcassite</i> |
| <i>Chaufournier</i> (Arts) | <i>Marne</i> |
| <i>Couches de la terre</i> | <i>Mouche</i> (insect.) |
| <i>Corse</i> (Hist. Géogr. Droit publ.) | <i>Mouche à tarrière</i> (insect.) |
| <i>Clos</i> (Agric.) | Ovaire ou Oolithe |
| Coquille | <i>Oursins de mer fossiles</i> |
| Coquillage | Pétrifications |
| Crystallisation | Pétrole |
| Diamant | Pierre Judaïque |
| Etoile de mer | <i>Pierres fibreuses</i> |
| <i>Fahlertz</i> | Spath |
| <i>Feuilles pétrifiées</i> | Pyrites |
| <i>Fossiles</i> | Quartz |
| <i>Frigane ou Phrigane</i> (insect.) | Sable |
| <i>Glaciers</i> | <i>Sexe des plantes</i> (Botan.) |
| Glaise | Talc |
| Grenat | Tellinites |

The articles *in italics* were reprinted in the *Supplément* to the French *Encyclopédie* as mentioned below. Of interest to Bertrand's changing theory of the earth are the articles "Couches de la terre", "Caillou", and "Pétrifications".

Under the entry "Couches de la terre", Bertrand said:

We need more historical records, observations, and facts in order to suggest a satisfactory explanation on the formation of these beds and on the introduction of the many foreign bodies. It is easier to imagine a hypothesis than to search in the field and assemble more facts and more observations. Some of these hypotheses have been examined and discussed in the cited memoirs "Sur la structure intérieure de la terre". All we need to do now is to choose among all these hypotheses from Aristotle to Buffon. Could one not say, in a few words, that the Creator, having judged the present structure and disposition of rock layers necessary for the earth and its inhabitants, has formed them at the beginning more or less the way they are now? or that a former world, after having been destroyed by some accident, was reconstructed by the powerful and wise Being who built upon its ruins the earth which we now inhabit? This is why we find in our earth the remains of the sea and of so many heterogeneous bodies which are fossil remains of the animal and plant kingdom of a former world. Since this epoch of the reestablishment of our globe — which was a real Creation since it was a new order of matter, a new arrangement, a new life given to another generation of creatures — since then our globe has suffered numerous accidents, considerable revolutions, and changes which disrupted these layers of rocks, which formed new ones, and which introduced foreign bodies into these beds, either from the sea or from the surface of our present earth. Therefore, we ought to have on our globe materials which come from the ruins of a former world, others which are here since the reestablishment of this earth of which the Sacred History has preserved the memory: I mean since Creation according to Moses. Finally, there are effects caused by other accidents which have happened since that epoch: Noah's Deluge, changes in the position of the sea, particular inundations, changes in the course of rivers and streams, considerable silting-up of rivers, earthquakes, etc. There is no phenomena in the layers of the earth, in the structure, and in the bodies found in these layers that cannot be explained by one of the causes mentioned.

To this entirely new theory, Bertrand added modestly: "Since this simple system did not need much efforts of imagination, I declare that I am less attached to it than to the smallest fact which might demolish it and which would instruct me".

Bertrand's theme of a "new Creation" shows that he was faced with a dilemma. We mentioned above that in the *Dictionnaire* (1763) he agreed with Lehmann upon the fact that "figured stones" were fossil remains of real animals and plants. He then declared that the three classes of rocks might be called "primitive", "diluvial", and "marine and accidental" all of which contained fossils. In order to explain fossils in his "primitive" rocks *before the Deluge*, he had to resort to a "new Creation" at a time when the remains of a former world were introduced into his "primitive" rocks. Bertrand's new theory resulted in four classes of rocks: 1) those dating from the first Creation of a former world which became inhabited with plants and animals and was then destroyed; 2) those dating from a "new Creation" (Creation according to the Bible); 3) those which originated during the Deluge; 4) those which are the products of recent changes. The following sketch shows the major differences between the ideas by Lehmann and Bertrand.

ENCYCLOPÉDIE,
O U
D I C T I O N N A I R E
UNIVERSEL RAISONNÉ
D E S
CONNOISSANCES HUMAINES.

Mis en ordre par M. DE FELICE.

*E tenebris tantis tam clarum tollere lumen
Quis potuit? LUCRET.*

T O M E I.



Y V E R D O N ,

M. D C C. L X X.

FIG. 8.

Title page of the first volume of *Encyclopédie, ou Dictionnaire universel raisonné des connaissances humaines*, published and edited by F. B. Félice.

LEHMANN'S THREE CLASSES

1. **CREATION**
 Formation of primitive mountains similar to present ones:
Gang-Gebürge
 include minerals and metals
 consist of massive, hard rocks
 Beginning of life: animals, plants
2. **DESTRUCTION BY DELUGE**
 Remains of plants and animals were transported by the waters of the Deluge and buried in soft sediments which hardened while organic remains petrified
 These layers form the *Flötz-Gebürge*

content: limestone, sandstone, coal, organic fossils
position: horizontal to slightly inclined beds which abut against Gang-Gebürge
3. **LATER CHANGES**
 earthquakes, volcanic activity, landslides, local inundations

BERTRAND'S FOUR CLASSES

1. **CREATION**
 A former world was formed:

Unknown rocks

 Beginning of life: animals, plants
2. **DESTRUCTION BY UNKNOWN FORCES**
 Remains of plants and animals were transported by water and buried in newly formed layers which hardened while organic remains petrified

 These layers form the *Primitive Mountains*
content: massive limestone beds, organic fossils
position: in thick continuous beds which show uplifting, disruption, fracturation caused during mountain-building of new world.
 No relation to an older substratum
3. **DELUGE**
 The waters of the Deluge transported terrestrial and marine animals and deposited them in isolated places, in beds of sand, mud, peat in the plains, in anticlinal and transverse valleys, and in some fissures of primitive rocks: These are the *diluvial beds*
4. **LATER CHANGES**
 earthquakes, volcanic activity, landslides, local inundations, advances and retreat of sea, work of men, weathering

Under the entry “Caillou” in the *Encyclopédie* of Yverdon, Bertrand referred to a jumble of various interpretations. According to Buffon, “cailloux” were glassy materials which originated during the cooling of the globe. Bertrand disagreed: “If this globe has suffered any revolution in the past, if from the remains of a former world a new one was created as we see it today, then it is rather water than fire that destroyed it...” We can understand now the reasons which Bertrand had in mind when he disagreed with Buffon. He was looking at sedimentary rocks in the Jura Mountains which show signs of transportation by water but none which point to generation by fire.

Under the entry “Pétrifications”, Bertrand explained in more detail what he meant by a “new Creation”:

It is necessary to know when, at what time, how, by what accident these foreign bodies have become embedded in the earth layers in mountains and plains all over the world. Some have thought that these fossils were created as crystals. Others believed that each fossil or mineral originated from seeds... Others thought that this earth was created and arranged by the Author of all things from the ruins of a former world which was destroyed and that Creation as mentioned by Moses was in fact merely a reestablishment. According to these authors, animals and plants similar to those which exist today, already lived in the former world. When it was destroyed by some accident or revolution according to the will of the Creator, these bodies were transported by water to various places, and thus became buried in soft beds which thereafter hardened. After some time, they became petrified and these are the bodies which we consider foreign today. That is how in a big old castle recently remodeled, several parts of the first construction and of the old architecture are still included.

To the above, Bertrand then added all the other theories without giving to any one his preference. Although his theme of a “new Creation” is by far better explained than all the other theories, Bertrand did not dare say again that this was *his* theory. Blaming Buffon and others for their system-making, how could he possibly produce one himself? Blaming furthermore Buffon for his unorthodox approach which was not in accord with the Mosaic chronology, how could he proclaim his theory of a “new Creation” which is nowhere recorded in the Bible?

SUPPLÉMENT À L'ENCYCLOPÉDIE OU DICTIONNAIRE RAISONNÉ DES SCIENCES, DES ARTS ET DES MÉTIERS, PARIS (1776-1777)

Since Bertrand's ideas on fossils, on layers of rocks, and on “cailloux” found their way to Paris, we shall include here some related background. It has been established that Bertrand signed only two articles for the *Encyclopédie* by Diderot, namely “Joux, vallée de”, and “Kératophites” (Schwab *et al.*, vol. 93, p. 29). An unknown contributor to foreign editions who signed “B.C.” wrote twenty-six articles in the *Supplément* (Schwab *et al.*, vol. 93, p. 258). These articles are the ones *in italics* in our

list of entries for the *Encyclopédie* of Yverdon: they are indeed by Elie Bertrand. Most entries were taken word for word from that source although the editor, Jean Baptiste Robinet, claimed in the "Avertissement" to the *Supplément* that articles from foreign editions had been changed, especially those with the mark "§" (*Supplément*, vol. I, p. iij).

What was the purpose of the *Supplément* and why were Bertrand's articles chosen? According to Raymond Birn, a group of publishers had decided to revise the first edition of the *Encyclopédie* by Diderot. Charles Joseph Panckoucke, one of the publishers from Paris, had bought from the former editor, Le Breton, all rights to the text of this work. Finding, however, no editor, no investors, and no contributors, he decided merely to reedit the Paris version with two or three volumes of *Suppléments*. With Félice's fast advancing publication of the *Encyclopédie* of Yverdon in mind, Panckoucke published the first three volumes of the reedition by 1771. The police raided his shop and locked the freshly bound volumes in the Bastille. It was decided that the printing had to be done outside of France, namely at Geneva, from where the work could be smuggled back into France. After much haggling, Robinet, author of *De la nature* (1766), was chosen as editor-in-chief (Birn, p. 108-120). The purpose of the *Supplément* was to record scientific and scholarly discoveries made within the past twenty-five years, to insert important omissions of the first edition of the *Encyclopédie*, to correct errors, and to make use of any worthwhile corrections, additions, or remarks found in foreign editions (Birn, p. 138). Robinet was told not to publish any article which might harm "public peace" (*Encyclopédie*, Lausanne, 1778, p. lxxxvij-lxxxvijj). The articles chosen from Félice's *Encyclopédie* written by Bertrand were, however, not of that kind so that we must believe that Bertrand's articles were considered worthwhile to be published at Paris.

There are only three articles which concern us in regard to Bertrand's theory of the earth, namely "Couches de la terre", "Fossiles", and "Caillou". His other important article "Pétrifications" was omitted and so were all entries on "Terre" or "Montagnes" perhaps because the publishers were running out of time and money so that the fourth volume had to include half of the alphabet.

In the *Supplément*, the entry "Couches de la terre" is by Bertrand alone while in the first edition, it was written by d'Holbach. The entry "Fossiles" gives first the article written by d'Holbach in the Paris edition to which is added Bertrand's article lifted out from the Yverdon *Encyclopédie*. Under the entry "Caillou", d'Holbach's article from the Paris edition is again printed first with the editor's comment: "Although this article is already very long in the *Dictionnaire raisonné des Sciences &c.* we must add observations made by the author of the *Dictionnaire des Fossiles* who describes with much care the nature, the kind, and the species of 'cailloux'". Bertrand's theory about a "new Creation" thus found its way to Paris, then the largest city of Europe and the Americas, counting in 1760 some 589.000 inhabitants compared to 25.000 in Geneva and 18.000 in New York.

LE THÉVENON OU LES JOURNÉES DE LA MONTAGNE (1777)

Bertrand spent his last summer months each year in a farm above Yverdon near a locality called Le Thévenon writing a romantic and nostalgic last work which includes some interesting geological remarks. In *Le Thévenon*, he compared at last the two kind of mountains, the Alps and the Jura, and found that they had very different geological features:

In the Alps, the rocks are more continuous and more compact. They contain layers of 'roches composées', beds of marble, sometimes of 'grès' or 'granit' [new word!]. Elsewhere there are layers of argillaceous and schistose rocks, sometimes of gypsum. Most types are vitrifiable and refractable and resist erosion and weathering. Some beds are of soft or hard clay, impervious to rain and snow waters... In the Jura Mountains, on the contrary, water is rare... Not only are there no eternal snow-covered peaks, but these mountains are also composed of 'pierres détachées', or interrupted beds, mostly limestones, which are easily split by the combined action of summer heat and winter freeze. These highly fissured rocks allow water to penetrate and disappear into underground water systems and to reappear some distance away at the foothills. Besides these layers of rocks which consist normally of limestone, we find in our mountains enormous boulders of detached rocks resting here and there against some foothills, or being half buried or emerging irregularly above the ground in valleys. These boulders are of an entirely different nature than rock layers in our mountains. They consist of sand, gravel, small pebbles, mica, parts of a rather hard 'spath', all material which is alien to the rocks on which they rest... Here and there, at the surface or buried beneath, are large slabs of schistose rocks of flaky consistency and often mixed with mica (p. 76-78, all references to 1780 edition).

Bertrand wondered about the origin of these foreign-looking rocks: "How were they formed? What brought them here? Above Le Thévenon, I found some with a size greater than thirty feet which have no resemblance with rocks from the summit of our mountains from where they might have fallen. Some of these rocks consist of 'granit'" (p. 87).

In his description of erratic boulders, Bertrand came closest to compare rock types found in the Jura Mountains with those found in the Alps although he did not guess the connection between erratics and the former extent of Alpine glaciers. It is evident, however, that Bertrand no longer believed, as in 1752, that erratic boulders broke loose during Creation and rolled into valleys. He now distinguished two very different types of rocks and asked the question where these alien-looking rocks originated.

Bertrand was now of the opinion that all the fossils encountered in the Jura Mountains were of marine origin: "Only those who have not seen these petrifications or who have not compared them carefully with their marine analogs, can still doubt their marine origin" (p. 83). He believed that the Jura Mountains had once been covered by the sea and that its foothills had once been beaches were various marine bodies were abandoned. But he found nowhere a sound explanation on how this had happened.

ned. "More dogmatic, perhaps because I knew less, I tried in the past to explain these phenomena. Now I know that there is no hypothesis which does not encounter great difficulties" (p. 83-84). Again he enumerated all the hypotheses proposed and discussed in his earlier works, including his "new Creation" theme. He gave more details on astronomical theories and referred more specifically to the theory of underground fires which might have uplifted these mountains filled with shells, plants, and marine animals from the bottom of the sea (p. 84-85).

It is clear that Bertrand has evolved since 1752. While he still believed that God had created the earth and its first mountains, he no longer held that "figured stones" were created by God, nor that huge boulders were detached during Creation. He was searching quite seriously for a cause of secondary nature such as changes in the position of the earth's axis in order to permit changes in the position of lands and seas, or uplifting caused by underground fires. His ideas were very close to those of most of his contemporaries who still believed in divine Creation. Nevertheless, in 1777 Bertrand was no longer in the mood for breaking any new ground in the field of earth sciences; he preferred to remain skeptical of all theories.

CONCLUSIONS

This study has shown that between 1752 and 1777 Elie Bertrand changed drastically from a belief in the outmoded concept of "figured stones" to a theme of a "new Creation", and finally to a skeptical attitude toward all theories.

In 1752, Bertrand proposed that God had created "figured stones" and had placed them in their respective beds during Creation. When he learned from Lehmann that layers found in the "Flötz-Gebürge" in Germany were replete with fossils similar to those described by Bertrand in the Jura Mountains, he accepted the organic origin of fossils but not Lehmann's diluvial theory. Regionalism caused Bertrand and Lehmann to look at two entirely different sets of rocks. Lehmann observed gently inclined to horizontal secondary fossiliferous rocks, the "Flötz-Gebürge", leaning against highly tilted, non fossiliferous primary rocks, the "Gang-Gebürge", and thus accepted the diluvial theory as the most logical explanation for these facts. Bertrand, however, was looking at regularly folded, very fossiliferous, massive limestones which display no visible relationship to any older substratum, hence he interpreted them as "primitive". Diluvial deposits were few and isolated and not comparable to the many superposed layers found around the Harz Mountains.

In 1763, when Bertrand accepted the organic origin of "figured stones", he was forced to explain the abundance of fossils in his "primitive" mountains and thus invented a "new Creation" of a world built upon the ruins of a former destroyed one where plants and animals had lived. As far as we know, Bertrand did not follow any pre-

viously stated theory. Both Woodward and Lehmann explained fossils in sediments formed during the Deluge whereas Bertrand's "new Creation" explained fossils before the Deluge.

In 1777, Bertrand seemed skeptical of all theories of the earth although he accepted the idea that the sea had covered the Jura Mountains. But none of the theories of mountain-building could explain uplifting and folding of fossiliferous strata. It is evident that neither the origin of fossils, nor the reliance on the Mosaic chronology, was the greatest handicap for Bertrand's understanding of the occurrence of these fossiliferous strata. It was above all local geology because he saw no substratum of older rocks beneath the Jura Mountains, hence he accepted first the concept of "figured stones" and then the theme of a "new Creation". What the average Eighteenth-Century naturalist was lacking was a theory of mountain-building which explained when these fossils were embedded, how fossiliferous strata were lifted, and why some fossils have no living analogs. Total "truth" was usually expected of the new sciences and nothing short of that. We doubt that Bertrand would have accepted a working hypothesis which keeps scientists comfortable today.

Urbana, November 4, 1984.

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