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THE GEOLOGICAL CONTRIBUTION OF RUDOLF ERICH RASPE (1737-1794)

BY

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ABSTRACT

This paper describes the unusual conditions under which Rudolf Erich Raspe wrote in 1763 his theory of the earth entitled *Specimen Historiae Naturalis Globi Terraquei . . .* with essentially no geological training, but nevertheless obtaining success through an incredible feat of scientific acrobatics. The critical analysis of this work shows that it is not at all, as commonly thought, a simple illustration of Hooke's system, but an original contribution to some aspects of structural geology.

At first Raspe modifies the original concept of *Gang-Gebürge* introduced by J. G. Lehmann in 1756 giving it a much broader significance, equivalent to the modern term of " basement rocks ". Then he develops the dynamic concept of Hooke which is based on the uplifting forces of " earthquakes ", this last term meaning all vertical movements of the earth's crust. Raspe subdivides this process into four distinct mechanisms which in his opinion are capable of explaining the origin of islands, continents, and mountains within continents and at the bottom of the ocean.

Raspe's concept of uniformitarianism is worthy of Hutton and Lyell. Had it been written in English in 1763, Raspe would have been recognized as at least a precursor of that approach. His speculations on the faunal changes through geological time may be considered as an early statement of evolution, not hitherto recorded in any history of Pre-Darwinian evolutionary theories.

RÉSUMÉ

Cette étude passe en revue les conditions exceptionnelles dans lesquelles Rudolf Erich Raspe a écrit, essentiellement sans formation géologique, en 1763, sa théorie de la terre intitulée *Specimen Historiae Naturalis Globi Terraquei...*, et atteint le succès au moyen de cet exploit d'acrobatie scientifique. L'analyse critique de l'ouvrage montre qu'il ne consiste pas en une simple illustration du système de Hooke, comme on le pense en général, mais représente une contribution originale à certains aspects de géologie structurale.

Raspe a d'abord modifié l'idée originale de *Gang-Gebürge* introduite par J. G. Lehmann en 1756 en lui donnant un caractère plus compréhensif, semblable au concept moderne de « soubassement » ou de « socle ». Ensuite, il a développé l'hypothèse dynamique de Hooke qui est basée sur les forces de soulèvement des « tremblements de terre », ce dernier terme étant appliqué à tous les mouvements verticaux de l'écorce terrestre. Raspe a finalement subdivisé le processus envisagé par Hooke en quatre mécanismes distincts, qui pour lui, sont capables d'expliquer l'origine des îles, des continents et des montagnes au sein des continents et au fond des océans.

Les idées de Raspe concernant le principe d'uniformité en géologie se comparent à celles de Hutton et de Lyell. Si elles avaient été écrites en anglais en 1763, Raspe aurait été classé comme un des précurseurs de cette doctrine. Ses spéculations sur les changements de faunes au cours des temps géologiques peuvent aussi être considérées parmi les premières expressions de la théorie de l'évolution de la période prédarwinienne.

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The celebrated author of " Baron Munchausen's marvellous travels and campaigns in Russia ", who was a romantic poet, antiquary, embezzler, spy and industrial chemist,[1] wrote a theory of the earth as a consequence of the intellectual impact of the great Lisbon earthquake of November 1, 1755.[2]

Historians of geology have generally considered Raspe's *Specimen Historiae Naturalis Globi Terraquei* [3]..., his major geological contribution published in 1763, as a rather conventional illustration of Hooke's " Discourses of Earthquakes " [4] which was forgotten as quickly as the work it was supposed to have rescued from oblivion.[5] Therefore, doubts about the scientific competence of Raspe have apparently never been raised. However, the question should be considered of how a clever literary man could write, essentially without any scientific background, a theory of the earth which achieved notable success in its time.

From the vantage point of more than two hundred years this question may now be answered, and we can obtain a clear image of this feat of scientific acrobatics. Like all Raspe's endeavors, it shows true originality and brilliant imagination, skillfully blended with shameless dishonesty.

The year of the Lisbon earthquake, Raspe matriculated at the University of Goettingen. This ambitious, gifted, versatile young man must have listened to the discussion of this frightening event with more interest and perception than his fellows, for he had already developed a certain interest in geology. His father was an accountant in the department of mines and forests in the ancient state of Hanover whose work consequently brought him into frequent contact with mine operators in the Harz Mountains. It is known that as a youth Rudolf's holidays were often spent among his father's friends at Goslar, in the Harz, and that he came in contact at Clausthal with one of the oldest mining communities in Europe. He knew something of mining from hearing the miners talk and had actually gone underground himself to see them at work extracting ores of silver, copper and lead.[6] With his father he had also spent many happy hours collecting fossils and minerals in the vicinity of Goslar. Thus from the start Raspe accepted the applications of science in procuring wealth as naturally as he accepted science as a pedantic search for truth. And no wonder that later in life, when his fortunes were in ruins and when only his " hopes " sustained him, he put his extensive practical knowledge to work for him in earning his daily bread as an assay-master.

But at eighteen, Raspe was studying law at Goettingen and was expected to find his niche in the vast bureaucracy which bound the 700 German states into an empire. But this was not to be. After a year Raspe left Goettingen for Leipzig and law for the arts, thus establishing himself astride the intellectual currents of the day with a foot firmly planted in both science and letters. After three years at Leipzig, he took a master's degree at Goettingen, and in 1760 accepted a modest position in the Royal Library at Hanover where he remained until 1767.

Specimen is one of the three *lucubrationes* he produced during these years, a testimony to his gifts and to his activity. They were indeed lucubrations, for when Raspe was employed his duties were carefully spelled out and what writing he did was done by the midnight oil after an arduous day's work.

The unusual combination of the intellectual impact of the Lisbon earthquake of 1755 and of Raspe's position as a librarian clerk made him " discover " the almost completely forgotten " Lectures and Discourses of Earthquakes and Subterraneous Eruptions " of Robert Hooke, actually written in 1668 and published as a posthumous work in 1705, and of which *Specimen* is supposed to be an expanded illustration. Raspe, all through his life would be, as his friend J. G. von Herder called him, a " glücklicher Finder " — a fortunate finder.[7]

He became rapidly convinced that Hooke's system was the best explanation, not only for volcanoes and earthquakes, but also for the origin of islands and continents in general. Therefore he decided that he would not only defend Hooke's theory, but give a new presentation of it by means of additional historically proven data on new islands and mountains; in other words, present the work like Hooke would have written it had he lived in later times.[8] Raspe will eventually be led as far as saying that Hooke's system " is now mine as well ",[9] but it remains to be seen if Hooke himself would have approved of this new presentation by an ambitious young man twenty-six years old.

In his Preface to the readers,[10] Raspe states that *Specimen* is only the first installment of " a complete history of the earth and of its successive physical changes " for which he is also " preparing a geographic map showing these changes since the remotest historical recollections ". Six years later, in 1769, in a letter to Sir William Hamilton,[11] Raspe will call *Specimen* " my System of the New Islands ", and thirteen years later in 1776, in the Preface of his English translation of Ferber's travels through Italy,[12] he announces an improved edition which he is allegedly preparing, although he calls *Specimen* " my System of the Earth " and my " Natural History of the Earth ", apparently contradicting the preface of the book itself. In 1777, in the Preface of his English translation of Born's *Travels through the Bannat of Temeswar, Transylvania and Hungary* he states that the improved edition of his " System of the Earth and Mountains " would consist of two volumes *quarto*.[13] Nevertheless, Raspe seems to give the impression that he is considering *Specimen* as a completed system, and not at all as the first installment of a greater work.

Actually this improved edition, announced so many times, will never be published, and was even never written at all by Raspe. It seems interesting to speculate on the reasons of this ambiguous situation. Raspe may well have dreamed about such a great geological work, but he was, in my opinion, too clever a man not to have realized at the same time his limitations, and particularly his lack of appropriate scientific training to succeed in such a project. I shall attempt to demonstrate this point later on by a thorough analysis of *Specimen*. Actually the only contribution that Raspe

could possibly make was a historical compilation, or " a very accurate history of the origin of new islands born from the sea through earthquakes and volcanoes, and of mountains uplifted within continents ",[14] to be combined with a new presentation of Hooke's system. Indeed, all the sections of the book corresponding to historical compilations are excellent, all those dealing with geological subjects represent either Hooke's ideas *verbatim*, or common knowledge of the time often poorly understood, with the exception of a few theoretical ideas on structural geology which are Raspe's sole original contribution. In other words, Raspe " exploited " Hooke's system and the earthquake fashion of the time as far as was possible, but could not, and actually did not proceed any further scientifically.

Following the premise that *Specimen* was only the first installment of a much longer work to come, Raspe took great care to set strict limitations to his contribution so that it would not, under any circumstances, extend beyond the field of Hooke's " Discourses of Earthquakes ". In Chapter I,[15] Raspe explains that only the crust of the earth and its changes are to be discussed, but not the fundamental questions pertaining to the cosmological origin of the planet. In Chapter III [16] he writes as follows: " I am not presenting all known theories since I am here writing neither a complete natural history of the earth, nor the unfortunate progression of conjecture and error ". Actually I feel that Raspe was covering himself by carefully avoiding the major geological issues of his time, which he could not master, in order to concentrate essentially on a catalogue of islands and mountains, more suited to his rather sound knowledge of classical antiquities.

Specimen is elaborately dedicated to the Royal Society of London and its president, with an inscribed copy sent to its foreign secretary. The reasons for this are not far to seek. Raspe was employed at the Royal Library of Hanover. George III who was on the throne of Great Britain was also Elector of Hanover and his grandfather, George II, had founded the University at Goettingen. *The Philosophical Transactions of the Royal Society* were certainly in the Library at Hanover, and Raspe must have read them and been impressed by the great interest generated by the earthquakes. This is particularly true of the *Transactions* for 1755/56 in which many letters appear from fellows all over Great Britain describing the strange behavior of waters in canals, moats and mill-ponds which had been observed with astonishment the morning of the Lisbon earthquake. Perhaps Raspe read Letter XIII: " In Oxfordshire, at Shirburn-Castle, the Seat of the Earl of MacClesfield, Pres. R. S. as appears by the following account, communicated by his son, the Lord Viscount Parker, F. R. S. then upon the Spot. " [17]

However, Raspe was apparently not aware of John Michell's memoir of 1760 on earthquakes and their causes,[18] also prompted by the great Lisbon earthquake and in which the author anticipated many modern views on seismology and structural geology.

The story of Raspe's life reveals a mind fertile for hatching schemes and plots for advancement of all kinds. Of course, he hoped to be elected a fellow of the

Royal Society, and in 1769 he was indeed elected. Both in the Dedication and in Chapter V of *Specimen* [19] he proposes an expedition to one of the newly born islands in order to demonstrate the truth of Hooke's system. Although he has used numerous sources, he readily concedes that written documentation is inadequate. But, " if an expedition were undertaken to one or two of the new islands under the leadership of a man skilled in this field, . . . " herein lies the solution. And with Hooke dead since 1703 who would be better qualified to lead such an expedition than the author of *Specimen*, R. E. Raspe, a man who had completed the spadework and demonstrated his competence by this very work. The main purpose of the expedition would be to determine if the new islands consisted, like the continents, of fossiliferous beds, hence demonstrating Hooke's system. Raspe apparently saw some possibility that the Royal Society of this maritime nation could be interested in such an expedition, especially to bring honor to Hooke, one of its members. This was the age of patronage and while the fawning and flattering phrase seems distasteful to us, the literary or scientific man of the eighteenth century without private means accepted patronage as one of the unpleasant facts of life, and was not ashamed to seek support for his projects in this way.

The major biographers of Raspe, R. Hallo [20] and J. Carswell [21] incorrectly praise *Specimen* as a piece of bold and original research, which introduced new concepts in geology, such as the climatic and local significance of fossils. The studied elegance of its Latin is supposed to have combined the English soberness of Hooke's ideas with Raspe's German erudition. Actually, the only claim of Raspe to scientific originality lies in some aspects of theoretical structural geology and not at all in paleontology, and becomes obvious only after a thorough analysis of *Specimen* in the light of modern geology, a task complicated by his often obscure Latin.

In order to evaluate correctly *Specimen*, we should at first examine Raspe's sources, and particularly Hooke's geological ideas, as expressed in his " Discourses of Earthquakes ", and second Raspe's own scientific qualifications as they appear through a perusal of the book itself.

Recently, historians of science have rescued Hooke from the obscurity in which he had fallen, reminding us that he had made important contributions to an astonishingly wide range of scientific subjects.[22]

Fundamental to all Hooke's geological speculations was his conviction that the vast majority of fossils represent the remains of former marine organisms turned into stone. However, the principal object of his work was to explain the manner in which fossils had been brought to the highest parts of the Alps, the Apennines and the Pyrenees, and in the interior of continents in general, their occurrence in such places being clear evidence that major changes in the distribution of land and sea had taken place since Creation.

Hooke attributed these important changes of the face of the earth essentially to the eruptions of some kind of subterranean fires or to *earthquakes*. It is funda-

mental to point out that Hooke used this word in a broad sense for any type of vertical displacement of the earth's crust, corresponding to the modern term of diastrophic movements, and not in the restricted sense of seismic disturbances. He considered that earthquakes could raise, lower and disrupt the earth, and even generate liquefactions, vitrifications, calcinations and sublimations. Hooke demonstrated by numerous examples the universal character of this active principle of terrestrial change. He also combined it with his keen understanding of the climatic and local significance of fossils, attributing the extinction of certain fossil species to the effect of earthquakes destroying some species in certain places by raising or lowering the crust, while other species continued to live uninterruptedly elsewhere.

Hooke's most remarkable contribution is the understanding that fossil Mollusks deserved to be considered as historical documents, no less valuable than coins and manuscripts. However, he added that it would be very difficult, although not impossible to unravel from them a *chronology* of the catastrophes and mutations which took place in the past.

Hooke does not appear to have had any clear idea about the causes of earthquakes and volcanoes, although he visualized a close relationship between the two phenomena. He considered them as the effects of " the general congregation of sulphureous subterraneous vapors ": he thought that the observed greater frequency of earthquakes and volcanoes on islands and along sea-coasts may possibly be due to the saline quality of sea-water which may produce subterranean fermentations with the sulphureous minerals located under the sea-bottom. These fermentations would take fire, and therefore acquire enough force to either uplift parts of the earth by earthquakes, or find an escape by generating volcanoes.

The idea of the underground fermentation of sulphureous minerals certainly originated from the oxidation of pyrite which does indeed cause the spontaneous combustion of coal seams at depth and of mine dumps at the surface.

Hooke conceived the materials capable of producing conflagrations, eruptions or earthquakes as somewhat similar to gunpowder. Apparently, in the field of deep-seated geological agents, Hooke had not advanced any further than the ancient and medieval writers. However, other aspects of his geological thinking, such as a remarkable grasp of the cyclic nature of events at the earth's surface and an understanding of unconformities put him well ahead of his time and on the same level as Steno.[23]

Hooke, although implicitly accepting the Noachian Deluge, refuted it as a mechanism for depositing sedimentary beds and their enclosed fossils. Therefore, he felt compelled to present a diluvial theory of his own, becoming involved in many difficulties and contradictions which led him to a picture as extravagant as that reached by some of the Diluvialists. In this way, he became completely opposed to his earlier fundamental principles according to which he wanted to explain the former changes of the earth in *a more natural manner* than others had done. Possibly

for this reason, as suggested by Lyell,[24] his entire theory of earthquakes met with undeserved neglect.

It was previously mentioned that Raspe as a child and youth had ample contacts with miners in the Harz and actually went underground. This episode seems to have been his only geological experience before writing *Specimen*, and it is doubtful if he could, at that early age, have understood the features he saw within the earth. I shall now review the major aspects of *Specimen* and point out along the way features which indicate quite clearly, in my opinion, the deficiences of the scientific training of Raspe.

The discussion of mountains and of their relationships to ore deposits represents an important part of the work.[25] It discloses an obvious influence, although not specifically acknowledged, of the work of J. G. Lehmann published in 1756.[26] Raspe combines in a clever fashion some of the ideas of Lehmann with those of Hooke, and in doing so changes the original meaning of the fundamental term of *Gang-Gebürge*, introduced by Lehmann in the geological literature. This situation requires some elaboration because of its far-reaching consequences on the geological terminology of the eighteenth century.

Lehmann defined three classes of mountains. The first class or primitive mountains *(Uranfängliche Gebürge)*, were those which are the largest and the highest of the world. They are also interpreted as the oldest, having been formed, at the time of Creation, by precipitation in strongly agitated waters. Their rocks consist of poorly defined and thick beds of rather uniform mineralogical composition, devoid of fossils and steeply dipping into the depths of the earth. Whenever these primitive mountains contain veins of mineral deposits they are called *Gang-Gebürge*. The veins did not develop at the time of formation of these mountains, but later, when the waters withdrew and the materials dried up and contracted, allowing the rising of vapors from the earth's interior. These primitive mountains remained exposed until the Mosaic Deluge. Its waters overtopped them and finally deposited around their lower slopes a series of well-bedded and fossiliferous deposits, dipping away from them at a low angle and even becoming horizontal. Lehmann called these deposits *Flötz-Gebürge*, or second class of mountains.

Raspe uses the term *Gang-Gebürge* in a different and broader sense than Lehmann to describe the initial " rough and shapeless masses " of rocks forming the bottom of the ocean or the original surface of the earth, and which in general lie deeply buried and hidden beneath the bedded and fossiliferous sedimentary rocks. In other words, Raspe does not use the term for original primitive mountains, but more in the modern sense of " basement rocks ", particularly when the latter have been uplifted by the forces of earthquakes into high mountains in the middle of which they appear as a core. Under such conditions, and if the *Gang-Gebürge* are ore-bearing, they are reached by the miners through their sedimentary cover, which apparently has little or no mineral deposits according to Raspe. His lithologic description of the *Gang-Gebürge* is similar to that of Lehmann. Massive igneous types are distinguished,

which Raspe calls " quartz, granite and porphyry, made of harder and more homogeneous stone, generally vitreous and devoid of fossils ", as well as rare bedded types apparently corresponding to metamorphic rocks, such as gneisses and mica-schists.[27] However, the term of *Flötz-Gebürge* is never used, although Raspe will describe many sedimentary rocks, presumably because he did not believe in the reality of the Noachian Deluge.[28]

Lehmann interpreted the strong tilting of the *Gang-Gebürge* as a primary feature expressing their mode of deposition, and their cracks and fissures as an effect of the drying up of the materials before the Noachian Deluge. Raspe, using a more dynamic approach and following Hooke's ideas, considered all these features as structural characters or mechanical results of pressure due to the uplifting of the *Gang-Gebürge* by the forces of earthquakes. He does not give any particular age for the filling of the veins by the action of subterranean waters, except to state that at one time the fissures had been open and were filled during the succession of time.[29]

After having appreciably modified the original definition of *Gang-Gebürge* by introducing in it Hooke's concept of earthquakes, one would expect Raspe to describe some typical examples of ore deposits in such crystalline rocks. Unfortunately his lack of geological knowledge becomes apparent when he uses as an example the famous Rammelsberg Mine, near Goslar with which he should have been familiar. Raspe states [30] that this mine is located within the massive *Gang-Gebürge*, whereas it is actually a striking example of lenticular ore bodies within clearly bedded Devonian slates belonging to what Lehmann and later Werner would call the *Flötz-Gebürge*.

Raspe's discussion of the formation and occurrence of ores in general represents essentially the views of Agricola (1556) combined with miners' lore rather than any personal observations. This is in agreement with his great admiration for Agricola stated many times.[31] However, this part of *Specimen* contains an interesting and perceptive account of the famous secondary minerals of copper and of native copper found in the abandoned works of the old Rammelsberg mine.

On the subject of crystalline rocks, Raspe mentions the occurrence of their pebbles scattered over the plains of Northern Germany, far away from their outcrops and stresses their strong resistance to weathering when found in association with pebbles of other rocks in deposits along seashores and river banks.[32] These pebbles are erratics of the Pleistocene glaciations which originated from Scandinavia and not from the German Hercynian massifs, but of course Raspe could not possibly in his time have understood their origin and significance.

It is important to point out that Raspe mentions columnar basalt as " the rarest kind of stone " and describes from the literature its supposedly unique occurrence at the Giant's Causeway in Ireland and a possible one in the Island of Réunion, among examples of clays and rocks having " a certain internal organization and structure ", but without making any reference to its possible origin.[33] It may be assumed from

the context that Raspe considered basalt at the time as a sedimentary rock. This assumption is confirmed by his letter to the Royal Society of London,[34] dated Cassel, November 29, 1769, but published only in 1771, and by his slightly earlier *Nachricht*,[35] dated October 20, 1769, and published in Goettingen also in 1771. The latter is, according to Goethe, an epoch-making paper of German geology since in it Raspe introduced to that country Desmarest's ideas of 1768 concerning the volcanic origin of basalt.[36] In his letter to the Royal Society Raspe described the basaltic rocks of Hessia and wrote as follows: " I was induced to attribute their origin to a watery crystallization which might have taken place, either at the first settling of chaos, or at the time of a dissolution of a great part of our globe. I had said the same thing in regard to the Giant's Causeway in my account of the formation of new islands. But I now begin to entertain some doubts about that opinion. . . "

On the subject of sedimentary rocks, Raspe confirmed " in our mountains ", an earlier observation of Count Luigi Marsigli on the occurrence of a clay-seam along bedding planes.[37] However, this supposed confirmation is nothing else but a *verbatim* reproduction of Marsigli's text.[38]

Raspe's terminology of sedimentary rocks remains extremely theoretical. The non-consolidated rocks are called garden-soil (topsoil), gravel, sand, clay and mud, whereas the consolidated rocks such as limestones, sandstones or shales are never mentioned specifically, but grouped under the vague designation of " indurated stones ". There are vague references to detrital rocks such as conglomerates and sandstones,[39] but this almost complete lack of concern for lithologies reveals very little evidence of personal field observations. The only possible exception is the description of Upper Cretaceous marls with peculiar fracturing pattern, at Linden, near Hanover, on the banks of the river Ihme.[40]

The occurrence and modes of preservation of fossils are discussed at length,[41] but with no original statements that may go beyond the ideas prevalent in Raspe's time. Fossils are correctly interpreted as the remains of continental, freshwater and marine organisms. Raspe describes oyster banks and fossiliferous limestones with abundant Pelecypods and Gastropods from the Wealdian (Lower Cretaceous) strata in the vicinity of Neustadt am Rübenberge, northwest of Hanover, but follows closely a previous account of this locality published in 1753 by his friend S. C. Hollmann.[42] Another interesting description pertains to " whole forests which lie buried between muddy and stony strata full of marine shells " in the vicinity of Cassel.[43] It is a typical eighteenth century interpretation for Miocene beds of lignite interbedded with brackish and marine fossiliferous strata.

Raspe's discussion of the climatic significance of fossils [44] pertains essentially to the famous occurrence of bones of Pleistocene elephants (mammoths) and rhinoceroses found inside and in the vicinity of the caves of Scharzfeld, near Herzberg, 30 kilometers northeast of Goettingen, and of Baumannshöhle, near Rübeland, on the northern slope of the Harz. These remains of large mammals had also been

described at length by S. C. Hollmann in 1752 and 1753.[45] In Raspe's time speculations were numerous concerning the possible processes, such as long-distance transportation by floods or by the Deluge, which could account for the occurrence in Germany, or elsewhere in Europe, of remains of exotic plants and animals supposedly still living in India, Africa or America. Raspe, following Hooke very closely on this subject, reaches the conclusion that fossil faunas and floras represent extinct local species indicating past changes of climate.

In the realm of structural geology, the extent and attitude of sedimentary beds, their folding, tilting and rupturing, and the associated systems of joints and fissures are correctly described. Raspe, following again Hooke, interprets all these features as consequences of the pressures due to the uplifting forces of earthquakes.[46] This will lead him to his original contribution, given only in Chapter IV, entitled " Hooke's system ", which consists of four mechanisms by means of which he visualizes the generation of islands, continents, mountains within continents and at the bottom of the ocean.

Raspe's fundamental premise is to consider the crystalline rocks forming the ocean bottom or the primitive surface of the earth as always overlain by a cover of sedimentary rocks. Then, expanding the dynamic concept of Hooke, he explains the observation facts by using the following four mechanisms, based on the uplifting forces of earthquakes:

1. A portion of the ocean floor consisting of the crystalline basement with its indurated sedimentary cover is pushed upwards (Fig. 1), above sea level, generating an island or by extension a continent.[47]

2. A portion of the ocean floor consisting only of the crystalline basement is pushed upwards with its cover of unconsolidated sediments (Fig. 1). These are dispersed by submarine currents, and the crystalline rocks become exposed as submarine mountains.[48]

   After an island or a continent by extension has been pushed out of the ocean, further differential action by the force of earthquakes may generate mountains and intervening valleys or depressions by the following two processes:

3. A portion of the crystalline basement with its indurated sedimentary cover is differentially pushed upwards (Fig. 2, mechanism 1). The sedimentary cover partially shaken and broken is subsequently destroyed by erosion, exposing the crystalline rocks at the top of the mountain.[49]

4. A portion of the crystalline basement is differentially pushed upwards *through* its indurated sedimentary cover (Fig. 2, mechanism 2), which becomes dislocated, tilted and folded.[50] By means of this real mechanical intrusion, the crystalline rocks again reach the top of the mountains, displaying important networks of fractures and fissures. (Actually, this mechanism would lead to lateral overthrust-

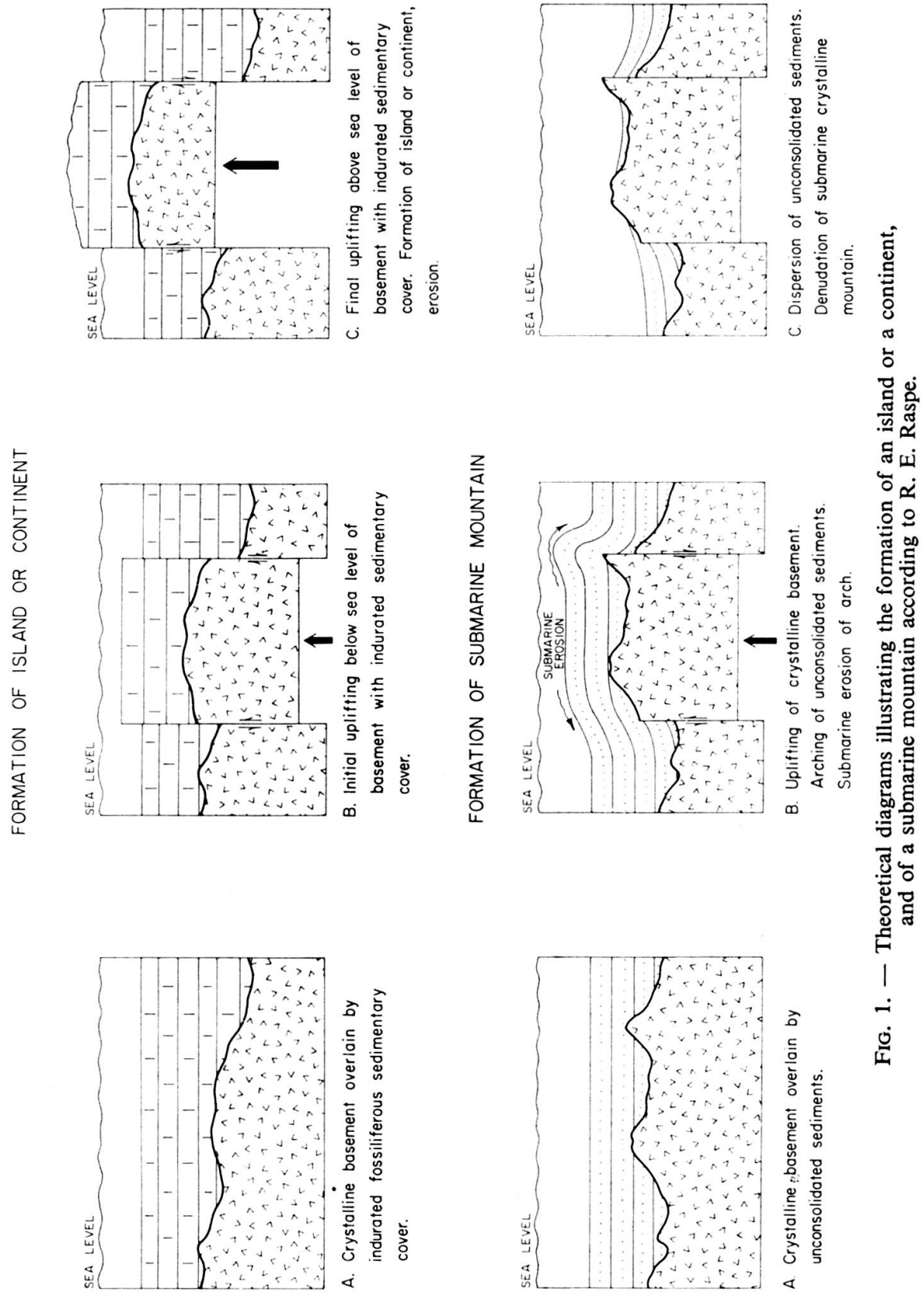

FIG. 1. — Theoretical diagrams illustrating the formation of an island or a continent, and of a submarine mountain according to R. E. Raspe.

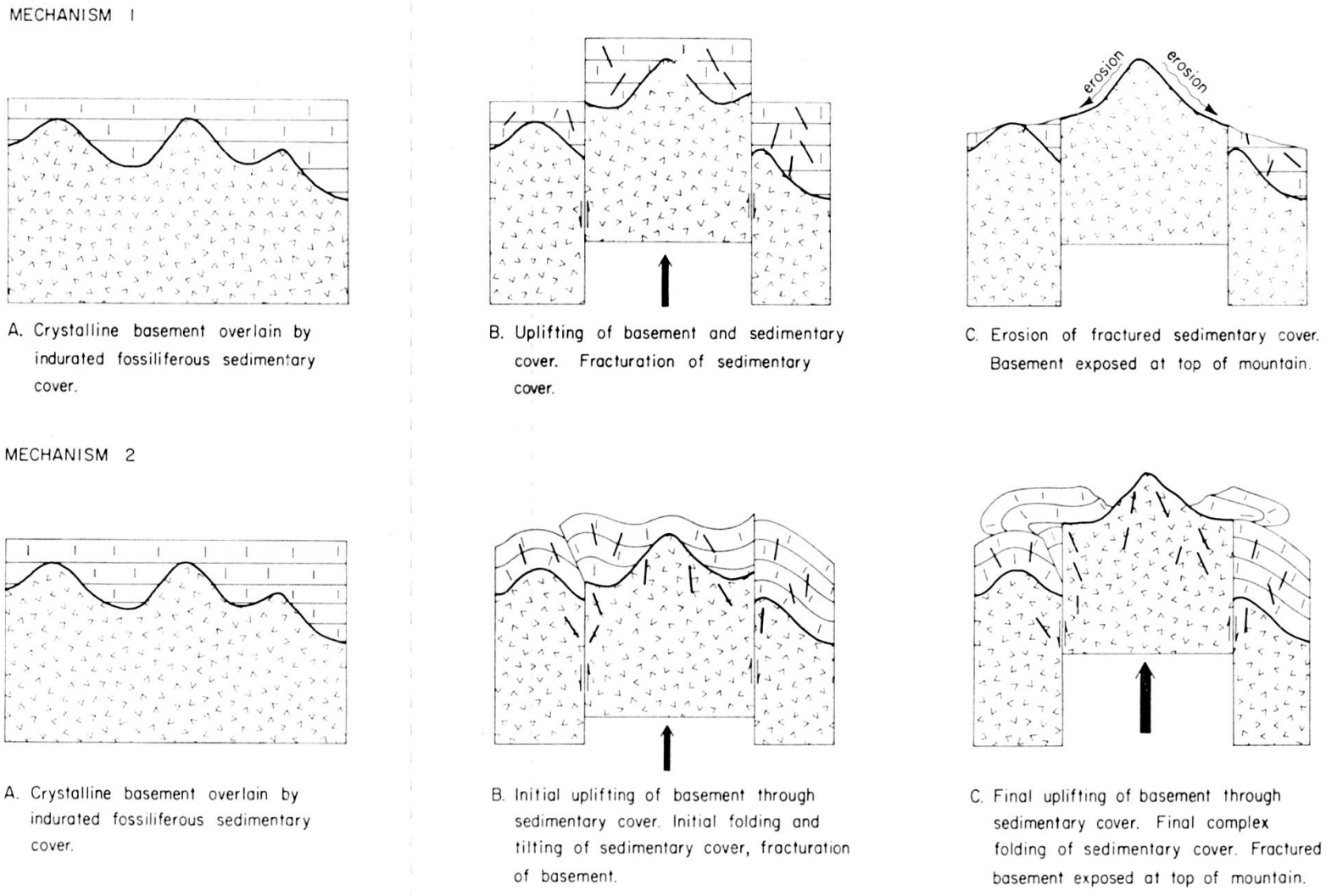

FIG. 2. — Theoretical diagrams illustrating two mechanisms of mountain building within a continent according to R. E. Raspe.

ing of the cover which Raspe did not visualize, and the effect of erosion should also be considered.)

These four mechanisms necessarily involved in Raspe's mind the generation of subterranean or submarine caverns. Although I have used here essentially uplifting for demonstration purposes, the sinking of adjacent areas, as well as alternating phases of uplifting and sinking, are part of the same process, all being different aspects of the effects of the subterranean force of earthquakes. It should be recalled here that vertical movements have again been considered as an important process in some recent orogenic hypotheses.[51]

The examination of Plate I of *Specimen* is very revealing, not only of Raspe's ideas about mountain building but of important aspects of his personality (Fig. 3). Although this plate should not, in all fairness, be considered as the equivalent of a modern geological cross-section, it is a graphic synopsis of all the assumed effects of earthquakes. On the left half is a horizontal succession of beds dislocated by a subsided section which appears as a graben. On the left portion of its bottom is a granite submarine mountain (9), and from its right part an island is uplifted creating a corresponding subterranean cavern (7). The center portion of the plate shows the same succession of beds concentrically folded into anticlines and synclines with radial V-shaped fractures, apparently mineralized. At the extreme right, the " rough and shapeless masses " of crystalline rocks (6) display sharp peaks and appear indeed to have broken through the envelope of tilted bedded rocks with their joint system, a more detailed sketch of which is given in the upper left part of the plate.

Regardless of its intrinsic interest, Plate I is at the most a crude sketch, in which the relationships between the different geological units leave much to be desired, and the representation of grass and waves appears as important as the rocks. There are furthermore so many discrepancies between the references to Plate I in the text and the figures drawn on it that the reader quickly reaches a point of complete confusion. Plate I as the major illustration of *Specimen* is certainly not the expression of a very meticulous attitude. Plate II, which shows an unidentifiable object of unknown origin described as a marine fossil, and Plate III which represents a deposit of secondary copper minerals on a timber of the old Rammelsberg mine, appear also somewhat irrelevant, although better drafted. It should be pointed out here that, according to Carswell,[52] Raspe fancied himself as an artist in spite of the fact that his draftmanship, including even the plates of *Baron Munchausen Travels*, always remained extremely crude. This lack of accuracy so visible in the plates of *Specimen* also extends to the text itself, as shown by occasional errors, random capitalization, very incomplete references and, Latin titles given for books Raspe himself admits appeared in German.

Before discussing Raspe's historical compilation of newly born islands and mountains, and his review of preceding systems, it seems appropriate to draw some conclusions about his geological ideas as presented above and which form essentially

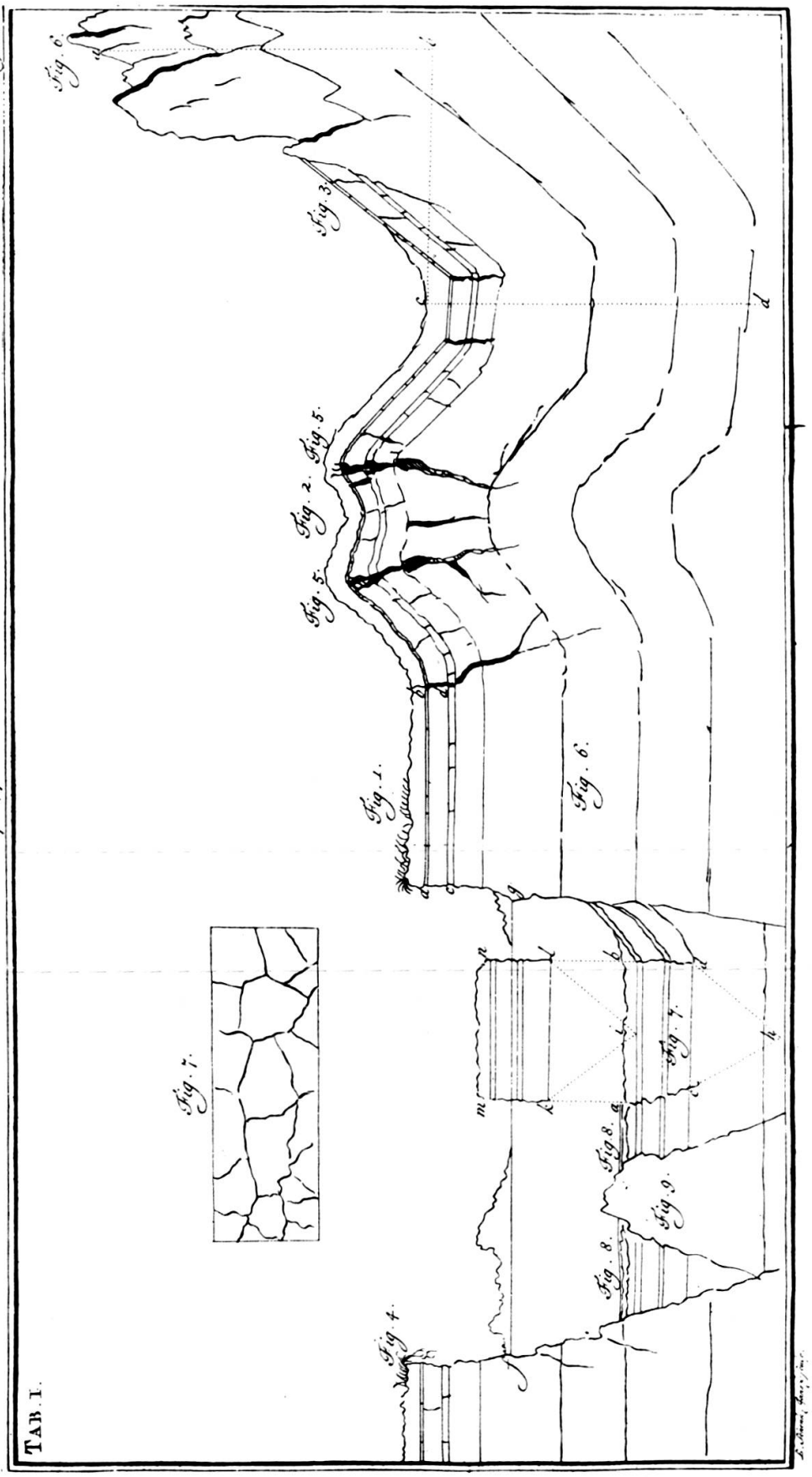

FIG. 3. — Reproduction of Plate I of Raspe's *Specimen Historiae Naturalis Globi Terraquei...* (1763).

Chapter I and IV of *Specimen*. They include small-scale and local observations concerning ore-deposits, rocks and fossiliferous localities, considerations on the climatic and local significance of fossils, and hypothetical large-scale processes capable of explaining the origin of continents and mountains. Obviously the data of local nature are of poor quality and often obtained from miners or other authors. In his defense it should be observed that Raspe wrote *Specimen* in his leisure time, mostly in the evenings after long days of clerical work in the Royal Library, and that he was already laboring under his perpetual financial difficulties which certainly prevented him from taking extensive fieldtrips.

His discussion of the climatic significance of fossils is borrowed from Hooke's work, but the four distinct processes explaining the origin of continents and mountains represent his original amplification of the action of earthquakes.

Raspe's historical compilation corresponds to Chapter II of *Specimen* entitled " New islands and mountains born as the result of earthquakes ". It is a remarkable show of Raspe's erudition, although Hallo [53] says that its classical portion may not satisfy the most sophisticated philologist. The purpose of this chapter is to provide new, historically proven data in favor of Hooke's theory. Strangely enough, many of them are taken directly from Hooke's " Discourses of Earthquakes ".[54] The reader will notice that Raspe appears in this chapter, in spite of his own shortcomings, very conceited and extremely critical of inaccuracies or apparently erroneous interpretations of other authors, particularly Buffon. He seems to enjoy applying literally the following policy: " According to the same just rule imposed also on me, I will mention the errors of very great men so that others may not be led astray influenced by their names ".[55] In that respect, it is interesting to point out his violent and repeated opposition to the theory of the diminution of the sea, as advocated in particular by B. de Maillet, A. Celsius and C. Linnaeus.[56]

In Chapter III entitled " Possible hypotheses and systems of the earth ", Raspe gives a well-written and pertinent critical review of the major theories of the earth from antiquity to his time. After a brief mention of Eratosthenes, Xanthus the Lydian, Strato and Strabo, he briefly examines the contributions of Thomas Burnet, John Woodward, William Whiston and Elie Bertrand. Then he discusses in detail the systems of John Ray, Lazzaro Moro, Buffon and of his friend Samuel Christian Hollmann, a rather obscure naturalist who certainly seems an incongruous addition to the list of famous cosmogonists.

This chapter displays a gradual building up of suspense during which theory after theory is discarded, leading to Chapter IV entitled " Hooke's system " in which by means of 38 propositions Raspe presents the system " as Hooke would have written it had he lived in later times ". Actually the picture is a composite one in which Raspe has combined Hooke's concepts with those of Lehmann and his own. However, just before this presentation of Hooke's system, Raspe discusses again [57] the major argument of the book: whether non-volcanic islands and continents with

their bedded and fossiliferous sequences may be explained, as Hooke maintains, by the uplifting of the sea-bottom through the forces of earthquakes and subterranean fires. He seems to realize now that unfortunately most of the newly born islands and mountains described in Chapter II are essentially volcanic in origin and cannot really be taken into account. He tries desperately to emphasize the few islands which display sedimentary or metamorphic rocks, but he is unable to dispel the alarming thought that Buffon could well have been right when he stated that newly born islands and mountains in general consist only of disordered masses of volcanic materials and not of bedded sedimentary rocks.

Specimen ends with Chapter V, entitled " The weaknesses of Hooke's system and how it must be strengthened ". Raspe first states that he does not pretend to give any duration to the action of earthquakes which have changed sea into land and land into sea, and that he will certainly not defend Hooke's suggestion that most of the earthquakes took place during the Noachian Deluge. After some considerations on the climatic significance and the changes of fossil faunas through geological time,[58] he returns to the doubt introduced by Buffon as expressed in Chapter IV. But this could not be, Raspe is sure that there is the " highest probability " that the investigation of newly born islands will prove him right rather than Buffon. He therefore ends his book with an eloquent exhortation to naturalists to undertake the examination of the islands which rose in 1707 in the Grecian Archipelago and in 1720 in the Azores, and not to neglect such a splendid opportunity of studying nature " in the act of giving birth to lands ".

In my opinion the analysis of *Specimen* clearly shows that Raspe lacked the required first hand geological knowledge to accomplish original research. His book appears as a composite work in which the concepts of Hooke and Lehmann have been unfortunately deeply modified and combined with Raspe's small original contribution. Therefore *Specimen* is far from being an expanded illustration of Hooke's ideas on earthquakes and volcanoes as the major agents for uplifting islands and continents; actually it raises doubts about the validity of the entire process, as wisely pointed out by Buffon. However, for Raspe, the volume had accomplished its purpose, being the brilliant firework, although the final « bouquet » at the same time, which had brought him the scientific fame he was eager to obtain at any costs.

Raspe's opportunistic attitude is shown again in 1776, when he publishes in England, where he is in exile after his embezzlement scandal, a translation of his earlier observations on the ancient volcanoes of Hesse which had led him to the far-reaching conclusion that prismatic basalts represent submarine eruptions.[59]

This work is of great interest when compared with *Specimen*, because it seems to confirm the reality of Hooke's ideas that volcanoes and earthquakes are agents capable of uplifting the sea-bottom and of forming islands and continents. Indeed, Raspe is convinced of having found not only the physical evidence of such volcanoes but also of having demonstrated that their prismatic basalts indicate the submarine

eruptions which preceded their appearance as islands in the middle of the sea.

Although he still recommends investigating the newly born islands of the Grecian Archipelago, this time it is no longer to prove his former conviction, as expressed in *Specimen*, that they should consist of bedded fossiliferous strata, but to demonstrate on the contrary that they are volcanic in origin. Raspe has therefore changed his mind completely and implicitly adopted the idea of Buffon he had so bitterly fought. In fact, he has reached the point of being no longer interested in defending Hooke's ideas, having another concept to use for his immediate benefit. Indeed, his intent is to establish a new reputation in Great Britain, where he plans to remain in exile, by spreading his new theory of the origin of the prismatic basalts " established upon facts " in a country where, contrary to the Continent, the volcanic origin of basalt has not as yet created much interest.

The original statement of presenting the work of Hooke as the latter would have done it himself, had he lived in later times, is but a memory fallen victim to Raspe's new attempt to regain scientific fame.

REFERENCES

I am greatly indebted to my colleague George W. White for many helpful comments and critical reading of the manuscript.

[1] For a detailed biography of Raspe and a complete list of his published works see: J. CARSWELL, *The Prospector, being the life and times of Rudolf Erich Raspe (1737-1794)* (London: The Cresset Press, 1950) and R. HALLO, *Rudolf Erich Raspe, ein Wegbereiter von deutscher Art und Kunst* (Stuttgart-Berlin: W. Kohlhammer, Göttinger Forschungen, Heft 5, 1934).

[2] T. D. KENDRICKS, *The Lisbon earthquake* (Philadelphia-New York: J. B. Lippincott, 1957).

[3] R. E. RASPE, *Specimen Historiae Naturalis Globi Terraquei, praecipue de novis e mari natis insulis, et ex his exactius descriptis et observatis ulterius confirmanda Hookiana telluris hypothesi, de origine montium et corporum petrefactorum* (Amsterdam and Leipzig: J. Schreuder and P. Mortier, 1763). An annotated English translation is being prepared with Mrs. Audrey N. Iversen under the title of " An introduction to the natural history of the terrestrial sphere ": New York, Hafner Publishing Company.

[4] Robert HOOKE, *The Posthumous Works of Robert Hooke Containing His Cutlerian Lectures and Other Discourses Read at the Meetings of the Illustrious Royal Society*, edited by Richard Waller and R. S. Secret (London: Smith and Walford, 1705).

See in particular Chapter 5. Lectures and Discourses of Earthquakes and Subterraneous Eruptions, explicating the Causes of the Rugged and Uneven Face of the Earth; and what Reasons may be given for the frequent finding of Shells and other Sea and Land Petrified Substances scattered over the whole Terrestrial Superficies, pp. 279-450.

[5] F. D. ADAMS, *The birth and development of the geological sciences* (New York: Dover Publications, Inc. 1964), pp. 186-188.

A. GEIKIE, *The Founders of Geology* (New York: Dover Publications, Inc. 1962), pp. 173-174.

C. LYELL, *Principles of Geology* (New ed., New York: D. Appleton & Co. 1857), pp. 42-43.

K. A. VON ZITTEL, *History of Geology and Palaeontology*, translated by M. M. Ogilvie-Gordon (London: W. Scott, 1901), pp. 46 and 60.

[6] CARSWELL, *op. cit.*, pp. 17-18.

[7] CARSWELL, *op. cit.*, p. 32.

[8] *Specimen*, Chap. IV, pp. 168-169.

[9] *Ibid.*, Chap. IV, p. 164.

[10] *Ibid.*, pp. XIV-XVI.

[11] R. E. RASPE, " Anhang eines Schreibens an den Königl. Grosbritt. Gesandten Herrn William Hamilton, zu Neapolis ", *Deutschen Schriften der Kgl. Societät der Wissenschaften in Göttingen*, 1771, *1*: 84-89, dated October 31, 1769.

[12] J. J. FERBER, *Travels through Italy in the Years 1771 and 1772 described in a Series of Letters to Baron Born on the Natural History, particularly of the Mountains and Volcanos of that Country, by John James Ferber* . . . Translated from the German . . . with Explanatory Notes and a Preface on the Present Status and Future Improvement of Mineralogy (London: Lockyer Davis, 1776), pp. VIII, XIII-XIV, 255.

[13] I. VON BORN, *Travels through the Bannat of Temeswar, Transylvania and Hungary in the Year 1770; described in a Letter to Professor Ferber, on the Mines and Mountains of these Different Countries by Baron Ignat. Born; to which is added John James Ferber's Mineralogical History of Bohemia* (London: C. and G. Kearsley, 1777), pp. XXXVI-XXXVII.

[14] *Specimen*, p. XVI.

[15] *Ibid.*, p. 2.

[16] *Ibid.*, p. 130.

[17] *Phil. Trans. Roy. Soc. London*, 1755, *49*: 368-370.

[18] John MICHELL, " Conjectures concerning the Cause, and observations upon the Phaenomena of Earthquakes; particularly of that great Earthquake of the First of November 1755, which proved fatal to the City of Lisbon, and whose Effects were felt as far as Africa, and more or less throughout almost all Europe ", *Phil. Trans. Roy. Soc. London*, 1760, *51*: 566-634.

[19] *Specimen*, pp. 188-191.

[20] *Op. cit.*, pp. 35-36.

[21] *Op. cit.*, pp. 28-30.

[22] E. N. da C. ANDRADE, " Wilkins Lecture. Robert Hooke ", *Proc. Royal Soc. London*, 1950, Series A, *201*: 439-473, also Series B, *137*: 153-187.

[23] G. L. DAVIES, " Robert Hooke and his conception of earth-history ", *Proc. Geol. Assoc.*, 1964, *75*: 493-498.

[24] C. LYELL, *Principles of Geology* (New ed., New York: D. Appleton & Co. 1857), pp. 27-30.

[25] Chap. I entitled " The surface of the terrestrial sphere ", Sections 49-54.

[26] J. G. LEHMANN, *Versuch einer Geschichte von Flötz-Gebürgen* (Berlin: Klüter, 1756).

[27] *Specimen*, Chap. I, Sections 49 and 53.

[28] *Ibid.*, Chap. V, p. 185.

[29] *Ibid.*, Chap. I, Section 59.

[30] *Ibid.*, Chap. I, Section 57.

[31] *Ibid.*, for instance Chap. II, Section 29.

[32] *Ibid.*, Chap. I, Sections 55 and 56.

[33] *Ibid.*, Chap. I, Section 25.

[34] R. E. RASPE, " A Letter Containing a Short Account of Some Basalt Hills in Hassia ", *Phil. Trans. Royal Soc. London*, 1771, *61*: 580-583, dated November 29, 1769, read February 8, 1770.

[35] R. E. RASPE, " Nachricht von einigen niederhessischen Basalten, besonders aber einem Säulenbasaltstein Gebürge bei Felsberg und den Spuren eines verlöschten brennenden Berges am Habichtswalde über Weissenstein nahe bei Cassel ", *Deutschen Schriften der Kgl. Societät der Wissenschaften in Göttingen*, 1771, *1*: 72-83, dated October 24, 1769.

[36] « *Basalte d'Auvergne* », *Recueil de Planches, sur les sciences, les arts libéraux et les arts méchaniques avec leur explication* (Paris: Briasson, David, Le Breton, 1768), livr. 5 ou vol. VI. See description of Plate VII in *Histoire naturelle, Règne minéral*, pp. 3-4.

[37] *Specimen*, Chap. I, Section 8.

[38] L. F. MARSIGLI, *Danubius pannonico-mysicus, observationibus geographicis, astronomicis, hydrographicis, historicis, physicis, perlustratus et in sex tomos digestus ab Aloysio Ferd. Com. Marsili* (Hagae Comitum: P. Gosse, 1726), III, De Mineralibus circa Danubium effossis, p. 32, § ix.

[39] *Specimen*, Chap. I, Section 30.

[40] *Ibid.*, Chap. I, Section 25.

[41] *Ibid.*, Chap. I, Sections 31 to 48.

[42] S. C. HOLLMANN, " Commentatio de corporum marinorum, aliorumque peregrinorum, in terra continente origine ", *Comm. Reg. Soc. Sc. Goettingensis*, 1753, *3*: 285-374.

[43] *Specimen*, Chap. IV, Prop. XXXVIII.

[44] *Ibid.*, Chap. I, Sections 35-36 and Chap. V, pp. 186-187.

[45] S. C. HOLLMANN, " Ossium fossilium insolitae magnitudinis in praefectura vicina Herzbergensi A. 1751 e marga erutorum descriptio ", *Comm. Reg. Soc. Sc. Goettingensis*, 1752, *2*: 215-241.
——, " De ossibus fossilibus in praefectura Herzbergensi repertis altera dissertatio ", *Ibid.*, 1752, *2*: 242-280.
——, " Commentatio de corporum marinorum, aliorumque peregrinorum, in terra continente origine ", *Ibid.*, 1753, *3*: 311.

[46] *Specimen*, Chap. I, Sections 9 to 29.

[47] *Ibid.*, Chap. IV, Prop. XVIII.

[48] *Ibid.*, Chap. IV, Prop. XIX to XXI.

[49] *Ibid.*, Chap. IV, Prop. XXXIV.

[50] *Ibid.*, Chap. IV, Prop. XXXIV.

[51] V. V. BELOUSSOV, *Basic Problems in Geotectonics* (New York: McGraw-Hill Book Company, Inc., 1962).

[52] *Op. cit.*, p. 191.

[53] *Op. cit.*, p. 35.

[54] *Op. cit.*, pp. 298-312, 416-422 and 428-433.

[55] *Specimen*, p. 118, Section 28.

[56] B. DE MAILLET, *Telliamed or Conversations between an Indian Philosopher and a French Missionary on the Diminution of the Sea*, translated and edited by Albert V. Carozzi (Urbana: University of Illinois Press, 1968).

[57] *Specimen*, pp. 166-167.

[58] It should be pointed out in this context that Raspe had a clear understanding of the principle of uniformitarianism, well worthy of Hutton and Lyell. Had it been written in English in 1763, Raspe would have been recognized as at least a precursor of this approach. Similarly, Raspe's speculations on the faunal succession through geological time may be considered as an early statement of evolution, not hitherto recorded in any history of Pre-Darwinian evolutionary theories.

[59] R. E. RASPE, *An Account of Some German Volcanos and their Productions with a New Hypothesis of the Prismatical Basaltes Established upon Facts ; being an Essay of Physical Geography for Philosophers and Miners, Published as Supplementary to Sir William Hamilton's Observations on the Italian Volcanos* (London: Lockyer Davis, 1776).