PROLEGOMENA TO A STUDY OF CATACLYSMAL SEDIMENTATION

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"when we see the thing done, it is vain to dispute against it from the unlikelihood of the doing it."
John Ray
(Letter to Tancred Robinson/22 Okt./1684)

Sedimentation as it takes place today is a calm and slow process acting on a small scale—Holocene sediment is accumulating little by little in various sedimentary environments. If the greater part of the earth's sedimentary rock was deposited at this modern rate it would have required vast periods of time.

However, an abundance of phenomena which appear in most pre-Quaternary rock testify to a complete uncommon mode of sedimentation which might be called "cataclysmal"; i.e. sequences of considerable thicknesses were rapidly formed during a large-scale deposition. Likely, this cataclysmal event, as evidenced by the Work of God (Nature), fell together with the Noachian deluge, as narrated by the Word of God (Scripture).

In the present article the historical development of the concept of cataclysmal deposition is traced ever since the birth of geology as a science. Further, the lines of evidence in regard to this concept are partly viewed. Finally, some results of field-work are presented.

Referential procedures are changed according to the nature of subject-matters. In regard to terminology the Geological Nomenclature (English, Dutch, French, German) of the Royal Geological and Mining Society of the Netherlands is followed.

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I: Short History of Relevant Ideas

1) Nicolaus Steno (1631 -1687)

In the 17th century the true method of interpreting nature was proposed by Francis Bacon (1561-1626) in his *Novum Organum Scientiarum* (1620). He defended the value of methodically executed experiments against Aristotle (384-322 B.C.) and his mediaevel votaries. Generally speaking Bacon raised up the shield of empiricism as the means by which the physical world could be disclosed[1]

The first investigator who applied the empirical method to geological questions was Nicolaus Steno (Figure 1). His "Prodrome" on a dissertation entitled *De Solido intra Solidum naturaliter Contento (1669)* marked the birth of geology as a science, and especially of stratigraphy.

In this "Prodrome," to which the proper dissertation was never added, Steno expressed the then uncommon view that the strata of the earth are due to the deposits of a fluid[2]. Furthermore he conceived the principle of superposition in writing: "At the time when any given stratum was being formed, all the matter resting upon it was fluid, and, therefore, at the time when the lowest stratum was being formed, none of the upper strata existed" [3]

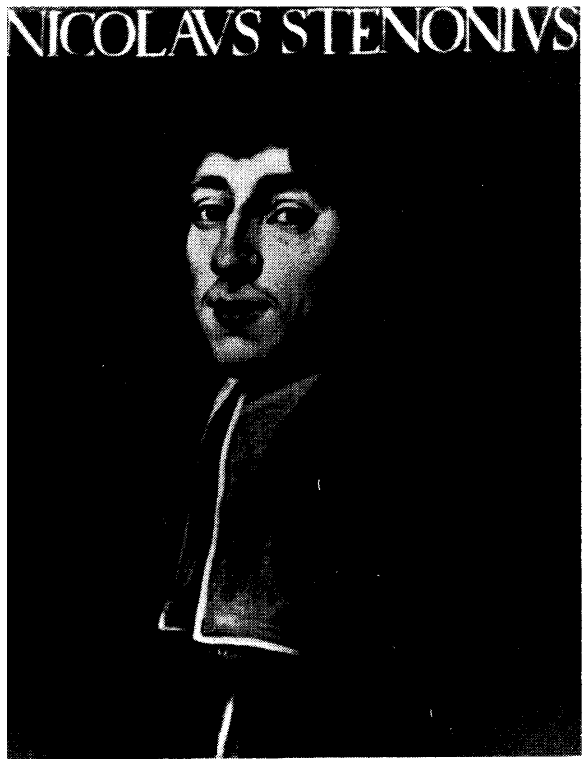

Figure 1. Nicolaus Steno. (After a portrait in the Pitti Palace).

Steno also grasped some causes of stratification. Strata lacking heterogeneous bodies, he argued, were of primeval origin, whereas fossiliferous strata were formed during the antediluvian period and during or since the Noachian deluge by inundations caused by violent winds or downpours. Among other things he wrote: "Different kinds of layers in the same place can be caused either by a difference of the particles which withdraw from the fluid one after the other, as this same fluid is gradually disintegrated more and more, or from different fluids carried thither at different times." [4]

Besides, Steno made a stand against Aristotle and his disciples, who upheld the view that fossil remains of buried organism were produced *in situ* by a certain "Vis Formativa," "Vis Plastica," or "Quid Vis." He maintained the real organic character of fossils, and gave it as his view "that the formation of many mollusks which we find to-day must be referred to times coincident with the universal deluge"[5].

The main effect of this universal and recent catastrophe Steno confined to the earth's geomorphogenical characteristics. In this context it is noteworthy that he concluded his "Prodrome" by showing that the biblical data of primeval creation and subsequent devastation constitute a framework wherein all results of geological observations could successfully be contained, arranged, and distinctly conceived.[6] Consequently the "Prodrome" was not only a landmark in the development of geology in general; it also made its author the founding father of deluge geology. Curiously this historical truth has not been stressed up till now as far as I know.

By reason of his scientific ability, uniformitarian geologists have tried to claim Steno-making him, in subscribing to the Noachian flood, a victim of church dogma and theological authority.[7] But on the contrary, a careful reading of Steno's "Prodrome" leads to the inference that his knowledge of biblical history stimulated his discovery that the earth's crust contains the record of a sequence of historical events, and made it a matter of course that fossils were the remains of mainly marine creatures thrown out on the continents by the running flood waters.[8]

2) John Ray (1627-1705)

Though Steno's "Prodrome" became widely known among his contemporaries, John Ray took the lead up to a point in geology. The latter's ideas in this case were couched in the celebrated *Three Physico-Theological Discourses, Concerning 1) The Primitive Chaos and Creation of the World, 2) The General Deluge, its Causes and Effects, 3) The Dissolution of the World and Future Conflagration* (1629).

The "Discourses" went through several editions until well into the 18th century. In those Ray brought up much of novelty and importance; e.g. his observations on the hydrological cycle.[9] However, as regards stratigraphy his "Discourses" did not represent an improvement upon Steno's "Prodrome," because Ray also attributed the earth's layers to local though tempestuous inundations, mainly occurring during antediluvian times.

He held the view that at first the earth was covered with water; that the land was raised up by subterranean fires; and that as a result the waters were driven back. He continued in writing: "Afterwards when the greatest part of the earth was thus raised, the skirts were alternated by the sediments of rivers and floods, whence and from the several inundations of the sea came the several beds or layers of earth."[10]

Yet Ray did not go beyond the framework of biblical history and in consequence he in fact was a deluge geologist. The outcome of the Noachian flood he mainly restricted to tectonical catastrophes. Amidst these he supposed the tearing apart of the continents where he guessed that the Old and the New World formerly were linked together.[11] This primitive pangea concept, also conceived by Adriaan Buurt (1711-1781) and other 18th century scientists, foreshadowed Alfred Wegener's continental drift theory.

Further, Ray adopted Steno's idea of fossils as organic remains, and disputed the opposite view of many of his contemporaries. He himself viewed the scattered fossil remains as a result of the universal deluge waters. To Edward Lhwyd (1660-1709) he expressed relating to his "Discourses": "I have inserted something concerning formed stones as an effect of the deluge, I mean their dispersion all over the earth. Therefore you will find all I have to say in opposition to their opinion who hold them to be primitive productions of nature in imitation of shells."[12]

In the presence of these data it is somewhat surprising to read in Byron C. Nelson's *The Deluge Story in Stone* (1931): "Of those in England who opposed the Flood theory because they did not believe that fossils were the remains of former living things, the most prominent was John Ray'';[13] by mischance this incorrect information entered into the otherwise excellent *The Genesis Flood* (1961) of John C. Whitcomb and Henry M. Morris.[14] As Nelson does cite the "Discourses," he seems to have read them; but unfortunately he did not read them well, ascribing to Ray opinions which, indeed, he expounded, but only in order to argue against these.

3) John Woodward (1667-1727)

Up to now a clear notion of the formation of stratified rock of considerable thickness was not presented. The first to take the right road in this case was John Woodward of Gresham College. This keen-witted scientist, being intimately acquainted with most of England's stratified formations, wrote in elucidation of these *An Essay towards a Natural History of the Earth, and Terrestrial Bodies, especially Minerals; as also of the Sea, Rivers and Springs. With an account of the Universal Deluge, and of the Effects it had upon the Earth* (1695). In it he proposed his theory of a Universal Solvent.

Woodward launched into speculations concerning the Noachian flood, assuming that the upper part of the earth's crust was wholly dissolved in the all covering waters, constituting a muddled mass. From this the solid constituents would have settled down according to specific gravities, thus bringing about stratum super stratum, in which the organic bodies and parts thereof would have sealed up after gravity sorting.

It is noteworthy that the main argument for the rapid formation of subsequent strata consisted in the phenomenon of stratification itself. The same phenomenon is taken up by modern catastrophists to make out a good case for their convictions, Specifically, Woodward stated in his "Essay" with regard to the mentioned muddle:

> That at length all the Mass that was thus born up in the Water, was again precipitated, and subsided towards the bottom. That this Subsidence happened generally, and as near as possibly could be expected in so great a Confusion, according to the Laws of Gravity; that Matter, Body or Bodies, which had the greatest quantity or degree of Gravity, subsiding first in order, and falling lowest: that which had the next, or a still lesser degree of Gravity, subsiding next after, and settling upon the precedent: and so on in their several courses; that which had the least Gravity sinking not down till last of all, settling at the Surface of the Sediment, and covering all the rest. That the Matter, subsiding thus, formed the Strata of Stone, of Marble, of Cole, of Earth, and the rest; of which Strata, lying one upon another, the terrestrial Globe, or at least as much of it as is ever displayed to view, cloth mainly consist.

Woodward continued with treating of gravity sorting and he went on to say:

> That for this reason the Shells of those Cockles, Escalops, Perewinckles, and the rest, which have a greater degree of Gravity, were enclosed and lodged in the Strata of Stone, Marble, and the heavier kinds of Terrestrial Matter; the lighter Shells not sinking down till afterwards, and so falling among the lighter Matter, such as Chalk, and the like, in all such parts of the Mass where there happened to be any considerable quantity of Chalk, or other Matter lighter than Stone; but where there was none, the said Shells fell upon, or near unto, the Surface.[15]

It stands beyond all argument that Woodward's theory of a Universal Solvent was an inadequate theory. Nevertheless it contained some constructive notions; e.g. that of gravity sorting which foreshadowed Henry M. Morris' concept of hydrodynamical selectivity.[16] Such, in some measure modern ideas, went beyond the grasp of several of Woodward's contemporaries who cried down his "Essay." Even Ray turned against him, though they basically took the same position, as Karl A. von Zittel rightly stated.[17]

Aside from stratigraphy, Woodward's writings were of lasting value for paleontology. He took pains to demonstrate that the fossils were organic remains laid down in the deluge. Consequently he scorned the ideas of Edward Lhwyd on the one hand and Martin Lister (1638-1712) and Robert Plot (1640-1696) on the other that fossils were but "Lapides sui generis" or resulted from an "Aura seminalis." Woodward wrote in this case:

> "that they are so far from being formed in the Earth, or in the Places where they are now found, that even the Belemnites, Selenites, Marchasits, Flints, and other natural Minerals, which are lodged in the Earth, together with these Shells were not formed there, but had Being before ever they came thither: and were fully formed and finished before they were reposed in that manner.[18]

Thus Woodward swept away forever the wrong opinion concerning fossils; and he showed together with his adherent Johann Jacob Scheuchzer (1672-1733), [who translated the "Essay" into Latin (1704) and also wrote the *Herbarium Diluvianum* (1709) and other excellent writings], the way for a better understanding of the fossiliferous strata.[19]

In this context it is worth noting that Johann Jacob's brother Johann Scheuchzer (1684-1738) used a half water filled bowl in showing that the Noachian flood could have been caused by a sudden stopping of the earth's rotation and a consequent gushing forth of violent tidal waves. An account of this experiment was given in a dissertation on *Lapides Figurati* read in the year 1710 before l'Academie Royale des Sciences. Irrespective of the adequacy of this elucidation to the historical events two conclusions are at hand; viz. that, to my knowledge, it was Johann Scheuchzer who was the first to execute a geological experiment and not Horace-Benedict de

Saussure (1740-1799), as claimed by Ph. H. Kuenen;[20] and that with this experiment the cataclysmic character of the Genesis Flood was distinctly conceived.[21]

4) **George-Louis Leclerc, Comte de Buffon (1707-1788)**

During the second half of the 18th century, geology was retarded in its auspicious development by the impact of the writings of George-Louis Leclerc, Comte de Buffon; viz. by his *Theorie de la Terre* (1749) and *Des Epoques de la Nature* (1778), constituting the initial parts of his voluminous *Histoire Naturelle* (1749-1782) .

In this matter Buffon was preceded actually by his compatriot Benoit de Maillet (1656-1738), who drew up a cosmic system after Cartesian fashion, published posthumously in 1748 under the title of *Telliamed, ou Entretiens d'un philosopher indien avec un missionaire francois sur la diminution de la mer, la formation de la terre, l'origine de l'homme, etc.*, in which "Telliamed" represented the anagram of "de Maillet."

De Maillet maintained that the strata of the earth and even the mountains were built up beneath the level of the sea by the ocean currents and by the flux and reflux of the tides. Consequently the earth's stratified rock could not have been deposited in a short space of time but only gradually during several millennia. De Maillet wrote about certain strata: "Undoubtedly they were formed in that place by a current coming from north-west, and from the sea-side, which manufactured them there successively one after another in a period of many thousands of years" (Translated from the French).[22]

In an article, "Sur la Production des Couches ou Lits de Terre," Buffon lined up with de Maillet's assertions in this case.[23] Moreover, on the subject of time he did not mere guess-work but introduced a time-dimension, based on an alleged refrigeration of the globe which he had brought into being as a glowing mass torn from the sun by a striking comet.[24]

Thus a dating method was introduced within the framework of evolutionary cosmogony. Yet Buffon's maximum estimate of the earth's age remained in the order of 75,000 years.[25] None the less it was plain that his system was contradicted by the biblical cosmogony. As a result Buffon tried to explain away all physical implications of the Noachian deluge, substituting the cataclysm concept by his tranquil theory, in which any geological effect of the deluge was denied. The passage in question in Buffon's *Preuves de la Theorie de la Terre* ran as follows:

> After all, it is easy to convince oneself that it is neither in one and the same time, nor by the effect of the deluge, that the sea left uncovered the continents which we inhabit; because it is certain, by the testimony of the sacred books, that the earthly paradise was in Asia, and that Asia was a continent inhabited before the deluge; in consequence, it is not in that time that the seas covered that considerable part of the globe. So the earth was, before the deluge, broadly the same as she is today; and that enormous quantity of water, which the divine justice brought down on the earth to punish the culpable men, caused in fact the death to all creatures; but it produced not a single alteration on the surface of the earth; it destroyed not even the plants, because the pigeon brought back an olive-branch (Translated from the French).[26]

So Buffon introduced the concept of an earth history passed off quietly in the course of periods of long duration; and although Buffon took a lot of geological data from Woodward's "Essay," he frequently made a stand against him and thus Woodward's influence was eclipsed by Buffon on account of the latter's eloquent diction.[27]

5) **Jean-Andre Deluc (1727-1817)**

Still a new champion of biblical catastrophism appeared on the scene in the person of Jean-Andre Deluc (de Luc) who became an adversary of the Buffonian cosmogony. This Swiss naturalist made himself a name by his meteorological observations and experiments and by his travels through many parts of the European continent. His name was attended by authority for most of his contemporaries and he wielded great influence in his day.

In one of his early writings, viz. *Lettres Physiques et Morales, sur l'Histoire de la Terre et de l'Homme. Adressees a la Reine de la Grande Bretagne* (1778-1780), Deluc introduced the term "geology" instead of the until then usual designation "cosmology."[28] Next to these "Lettres" are to be named his *Lettres sur l'Histoire Physiques de la Terre, adressees au Professeur Blumenbach* (1798) and his *Abrege de Principes et de Faits concernant la Cosmologie et la Geologie* (1802).

In these Deluc set himself to bear out Moses' account of cosmogony by natural history. Unfortunately he took his stratigraphical data from Horace-Benedict de Saussure, being the contemporary leading mineralogist, who held the view that granitic rock took shape as a layered deposit, being precipitated by a process of crystallisation in a primordial fluid.[29] In consequence this chemical process must have been a gradual one and would have taken up much space of time.

In order to fall in with Saussure's view in this case, Deluc conceived of the days of creation as of periods of indeterminate length.[30] In elucidation of the Noachian flood he conjectured that the mainland of before, hanging over huge cavities, collapsed by which an enormous basin came into being, taking in all ocean waters. As a result the ocean-floor of old became the mainland which we inhabit today.[31] Thus he rendered an account of fossils and of a lot of other geological data.

Deluc's idea's were enunciated by one of his intimates, namely the Dutch poet Willem Bilderdijk (1756-1831), in a treatise on *Geologie, of Verhandeling over de Vorming en Vervorming der Aarde (* 1813), which constituted the first original Dutch dissertation on geology. Bilderdijk turned against the Buffonian doctrine of a geomorphogenical history of long duration. He wrote:

> It was, since Buffon, a cherished idea, that awe-inspiring space of time in which he led us about. The hugeness thereof startled and interested. But, actually, he who accounts for an effect by a force which must have acted infinitely to produce the effect to be accounted for does not make clear anything. Everything in the corporeal world takes place in a time-dimension (Translated from the Dutch).[32]

Bilderdijk referred to the physical chronology, drawn up by Deluc, for the period since the universal flood.

In doing this Deluc had made use of some dating methods based on natural processes; e.g. the formation of vegetable mould; the reduction of tongues by marine abrasion; or stream erosion.[33] He proved to be aware of the fact that the last mentioned process could not have worked uniformly. He wrote: "at first the rivers carried away to the ocean a quantity of materials incomparably larger than that which they carry away today" (Translated from the French) .[34] From these Deluc inferred "that our continents are not old; and that not any other phenomenon contradicts that inference" (Translated from the French).[35]

Unfortunately Deluc's influence was largely eclipsed by the "Discours sur les Revolutions de la Surface du Globe" (introductory part of the *Recherches sur les Ossemens fossiles* (1812) and published separately in 1826) of George Cuvier (1769-1832) who got the theory accepted that the present-day condition of the earth's crust resulted from a sequence of cataclysms in the course of lengthened periods.[36]

6) James Hutton (1726-1797). .

The philosophy of uniformitarianism in the earth's science, advanced in the "Telliamed" and advocated by Buffon, was brought into vogue by the writings of James Hutton and his countryman Sir Charles Lyell (1797-1875). Hutton made his doctrine public before the Royal Society of Edinburgh in a paper entitled "Theory of the Earth; or an Investigation of the Laws observable in the Composition, Dissolution, and Restoration of Land upon the Globe" (read 1785), which paper was afterwards developed into his renowned *Theory of the Earth, with Proofs and Illustrations* (1795).

In these works Hutton upheld the view that the laws of nature had acted uniformly throughout history. Thus the phenomena of the earth's crust were to be made clear by means of changes still in progress today. In consequence these changes would have taken up vast periods of time in order to account for the earth's characteristics. As a result Hutton scorned the idea of catastrophism, and he wrote in his paper of 1785:

> But though, in generalizing the operations of nature, we have arrived at those great events, which, at first sight, may fill the mind with wonder and with doubt, we are not to suppose, that there is any violent exertion of power, such as is required in order to produce a great event in little time; in nature, we find no deficiency in respect of time, nor any limitation with regard to power.[37]

In persuance to this time-philosophy Hutton maintained that the strata now exposed on our continents were deposited little by little in the course of geological time; treating of limestone he stated:

> We are led, in this manner, to conclude, that all the strata of the earth, not only those consisting of such calcareous masses, but others superincumbent upon these, have had their origin at the bottom of the sea, by the collection of sand and gravel, of shells, of corralling and crustaceous bodies, and of earths and clays, variously mixed, or separated and accumulated.[38]

These assertions led to a vigorous controversy in which Deluc took action as an adversary of stature against the uniformitarian doctrine.

Nevertheless the Huttonian modernism gained grounds–mainly because John Playfair (1748-1819) interfered in the controversy in support of Hutton's "Theory of the Earth," of which that English mathematician prepared an exposition, easy of access, under the title of *Illustrations of the Huttonian Theory of the Earth (1802).* How important a place was awarded to time in uniformitarianism was put into words by Playfair as follows; alluding at a vast progression of daily operations, he wrote: "TIME performs the office of *integrating* the infinitesimal parts of which this progression is made up; it collects them into one sum, and produces from them an amount greater than any that can be assigned."[39]

Yet the Huttonian "Theory" did not win a wide acceptance among geologists until it was championed by Sir Charles Lyell. He brought the matter up in his *Principles of Geology: Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes now in Operation* (first vol. 1830 and completed in 1834) —the title constituted the summary of Lyell's work. In this he stated that his method "endeavors to estimate the aggregate result of ordinary operations multiplied by time"; and further on he wrote: "For this reason all theories are rejected which involve the assumption of sudden and violent catastrophes and revolutions of the whole earth, and its inhabitants."[40] Lyell frequently challenged the catastrophic school of geologists, primarily in the person of Woodward, and as a result he completely expelled all deluge geology from the professorial chair.[41]

7) George Fairholme (dates unknown)

Up to now hardly any examination of the earth's strata was carried out in order to decide in the time-energy dilemma. In his *Geologie* Bilderdijk wrote in view of the uniformitarian systems: "Fortuitous observations, suggested by mining, and partly ill-noticed or -imagined, being always insufficient, defective, and only local, produced false and rash conclusions, upon which the imaginations, which passed for demonstrations or real inferences, were built" (Translated from the Dutch).[42] Even Lyell in his celebrated *Principles of Geology* did nothing but lining out the probability of slow deposition of sedimentary rock and by no means did he establish the actuality of it.

The search for the testimony of stratified rock itself with regard to the rate of its formation was initiated by some 19th century deluge geologists. Among these the sharp-witted George Fairholme took the lead in writing the *New and Conclusive Physical Demonstrations, Both of the Fact and Period of the Mozaic Deluge, and of its having been the only Event of the Kind that has ever occurred upon the Earth* (1837 and 2nd edit. 1840). These "Demonstrations" constituted a landmark in the development of deluge geology. In it Fairholme exposed sedimentary structures, bespeaking a rapid deposition of successive strata to a very great thickness, and he conjectured that the earth's stratified rock was built up by an abnormal tidal action–afterwards called the tidal theory.[43]

Fairholme's work was elaborated by some 19th century votaries. Yet a deluge geologist of stature did not appear on the scene until the 20th century when George McCready Price (1870-1963) published his epoch-making *The New Geology* (1923). The main merit of Price has been his having taken hold of the crystallized time-table of geological ages, Price's arguments in this case are for the most part couched in his *Evolutionary Geology and the New Catastrophism* (1926). Unfortunately, in dealing with the order of the earth's strata little attention was given to the rate of formation of stratified rock.

Now then, even after one got well posted as to the earth's crust, Huttonian geology was not scorned—primarily in consequence of its being connected with a non-biblical philosophy of life. Francis C. Haber observes: "Hutton's thought was a development of natural theology and the timeless world-machine view."[44] Today this philosophical heritage is playing a trick with the greater number of the world's geologists.

Though it is attempted to justify uniformitarianism on account of the great number of adherents of this philosophy it should be born in mind that the "majority" cannot be an argument in science and its problems; for as noted by German poet and scientist Johann Wolfgang von Goethe (1749-1832): "Nothing is more repulsive than the majority: for it consists of not many forceful leaders, of scapegraces who accommodate themselves, of weaklings who assimilate themselves, and the crowd who trundles behind, without any acquaintance of its own mind" (Translated from the German).[45]

Next following I have dealt with some conclusive data on the rapid formation of much of the earth's stratified rock.

II: Main Arguments to Rapid Deposition

1) Polystrate Fossils

In spite of the prevailing hypotheses of graduality and, along with this extreme length of the earth's history, the conditions in which most fossils all over the world are unearthed bear testimony to an extraordinary, rapid and often cataclysmal process of sedimentation. One of those conditions is displayed by a group of fossils in what I propose to call a "polystrate position." By this concept is meant the fossil remains of huge animals and petrified tree-trunks, extending through a thick bed or, properly speaking, through two or more strata of sedimentary rock.

Such–so to be termed–''polystrate fossils" are found in many parts of the world; their height may be tens of meters and, despite this, their *topmost parts are as well preserved as the basal ones.* These facts indicate that the petrified remains were sealed up before decay and, in consequence, were buried in their polystrate position by rapidly deposited layers of sediment shortly after or even when they died or were torn up by the roots.

It is not as common to come across polystrate animal remains as those of upright tree-trunks; yet they are found. Van der Vlerk and Kuenen (1962) report: "In the United States a thick, apparently uninterrupted deposition of sands and clays is found, in which the entire bodies with the skin-impression of huge pre-historic reptiles are met with" (p. 63) (Translated from the Dutch). In case the sedimentation had been uniform the giant carrions would not be covered within 5000 years; therefore, van der Vlerk and Kuenen conclude: "The only possibility is that immediately after the death the dead body was covered and as it were ensiled by a thick bed of sediment" (p. 64) (Translated from the Dutch) .

Other polystrate fossils are mainly restricted to truncated tree-trunks. These are found chiefly in the Carboniferous series; though they are found as well in exposures of Mesozoic and Cenozoic formations (Fairholme, 1837, p. 392; Shrock, 1948, p. 293; Nilsson, 1953, p. 718). Geikie (1903) writes: "It is not uncommon in certain Carboniferous sandstones to find huge sigillarioid and coniferous trunks imbedded in up-right or inclined positions" (p. 654).

Further he states: "It occasionally happens that an erect trunk has kept its position even during the accumulation of a series of strata around it" (p. 654). Geikie concludes: "We can hardly believe that in such cases any considerable number of years could have elapsed between the death of the tree and its final entombment" (p. 654).

This inference is the more conclusive when the tree-trunks are 6 to 9 meters high. It is noteworthy that such dimensions are not exceptional. About a decenniad ago in the neighbourhood of Essen-Kupferdreh in Germany over the seam Angelika, a series of *Lepidophyta* was unearthed at interspaces of 3 to 5 meters. Klusemann and Teichmuller (1954) report: "The stumps are 7.5 m. in height and must have been still higher before they were cut down by the Rurh in the Riss glacial epoch" (pp. 374-375) (Translated from the German) (Figure 2).

Afterwards, when in the same area the deposits over the seam Sonnenschein were exposed, again upright tree-trunks standing over 7 meters came to light, which likewise must have been still higher before the glacial age. The mentioned authors remark: "Because the *Sigillaria* properly speaking constituted only bark-tubes when their insignificant wood-body had become putrefied they may have been more transitory than for instance the solid oak or Sequoia trunks of today" (p. 379) (Translated from the German). As a result the enclosure of the truncated tree-trunks cannot have taken up much space of time. Klusemann and Teichmuller conclude: "Perhaps it were some months, perhaps some years, but certainly not much longer" (p. 379) (Translated from the German); and this estimate is even the maximum one.

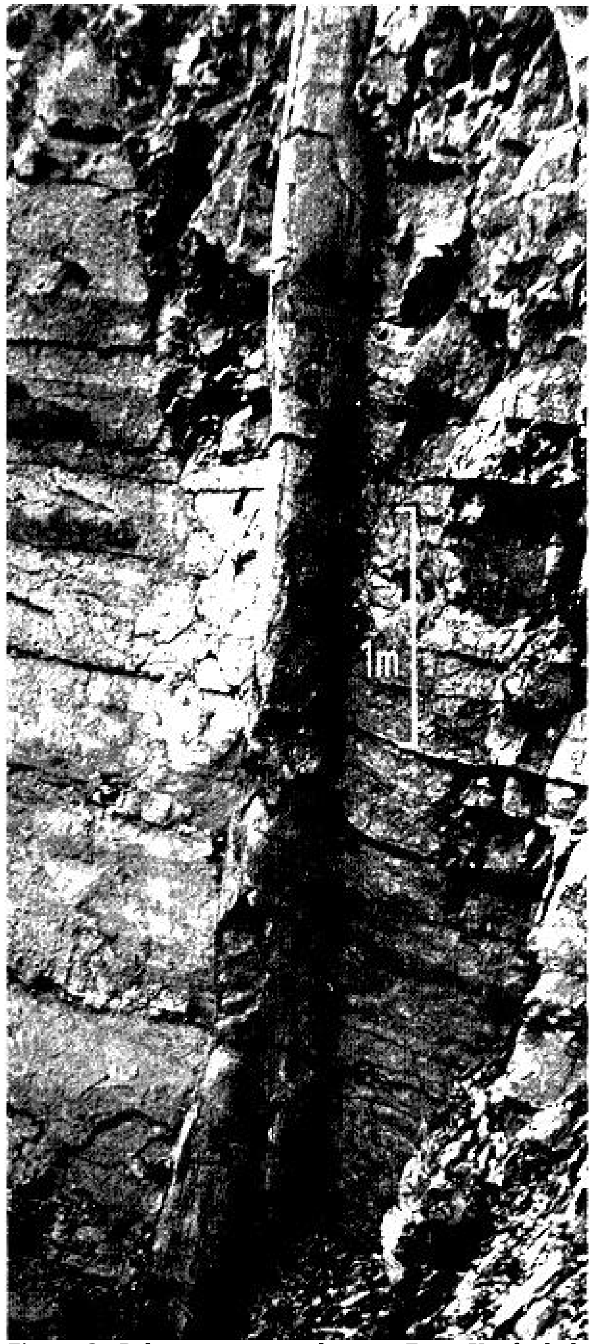

Figure 2. Polystrate tree-trunk near Essen-Kupferdreh (Germany). (Photo by Klusemann).

These polystrate trunks were found over a wide area. It also occurs that such fossils display a remarkable vertical dispersion; e.g. at The Joggins on Nova Scotia. Dunbar (1960) writes: "Here erect trunks are recorded at 20 horizons distributed at intervals through about 2,500 feet of beds" (p. 227). Only a wholly uncommon process of sedimentation can account for conditions like these.

The fossilized tree-stems are not only found erect, They also occur in positions, forming an angle with the lie of the strata, varying from nothing up to 90°. A striking example of this was reported by Tayler (1857; and Nelson, 1931, p. 111) who made reference to a lofty trunk, exposed in a sandstone quarry near Edinburgh, which measured no less than over 25 meters and, intersecting 10 or 12 different strata, leaned at an angle of about 40° (Compare with Figure 3).

Similar examples are mentioned by Geikie (1903, p. 655), In addition he states that the internal microscopic structure of the relevant trees was well preserved. Further Geikie conjectures: "In such examples, the drifted trees seem to have sunk with their heavier or root end touching the bottom, and their upper end pointing upward in the direction of the current" (p. 655). Moreover, as stated by Arber (1912, p. 114), in some districts the prone stems far exceed those still upright.

Now then, as already noted by Fairholme (1837, pp. 393-394), an inclined stem constitutes a stronger testimony to rapidity in deposition than even an upright one;

> for while the latter might be supposed to have been capable of retaining an upright position, in a semi-fluid mass, for a long time, by the mere laws of gravity, the other must, by the very same laws, have fallen, from its inclined to a horizontal position, had it not been *retained* in its inclined position, by *the rapid accumulation* of its present stony matrix (p. 394) (Emphasis added).

A special class of polystrate stems is constituted by stumps which extend up through a coal seam, together with some layers of sandstone and sandy slate, or even through two or more of these coal seams and all interbedded strata. Curiously few references are made to this and, if any, for the most part by earlier authors (Bolsche, 1918, p. 34; Price, 1923, p. 462). Even so examples are unusually abundant; consequently, the coal beds were rapidly deposited just as well as the above mentioned inorganic sequences.

Sometimes the upright position of the erect stumps is claimed to prove their having grown where they now stand – *in situ* (Brongniart, 1828, pp. 183-184; Schuchert, 1924, p. 401; Dunbar, 1960, p. 227). However, there are several facts which invalidate the hypothesis that they were of an autochthonous origin. More often than

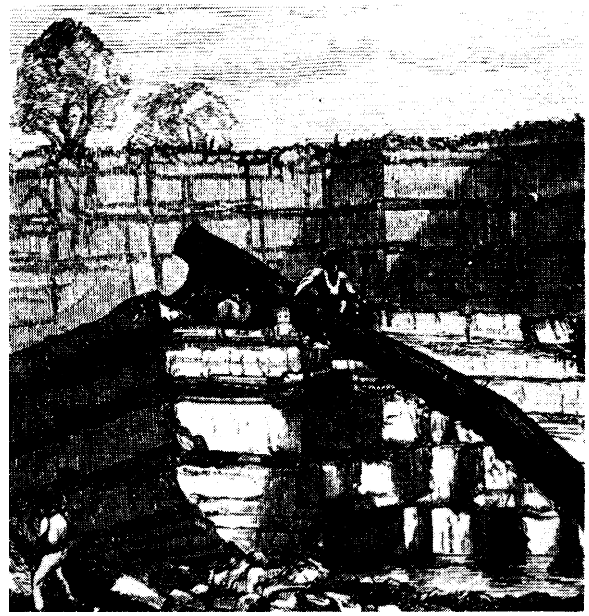

Figure 3. Polystrate tree-trunk near Edinburgh (England). (After Witham).

not they are devoid of both branches and roots; and, as a result, they cannot have grown where they now stand. They also are found at various heights. Whereas, had they grown ***in situ,*** their basal parts must be rooted in one particular stratum.

In view of these facts Arber (1912) writes: "It is not certain that these trunks, despite their upright position, are *in situ*. They are much more probably drifted material, like the sandstones which enclose them" (p. 101). And, what's more, examples are found which appeared to be *upside down,* or, in other words, which have their root end uppermost. On account of these facts, there is no question but that the relevant stems were of an allochthonous origin (Compare with Figure 4).

Besides, it must be remembered that a drifted tree-stem will often float upright, for its centre of gravity is situated at the lower end of that stem, which constitutes the heavier one. In this context Fairholme (1837) wrote: "the stem of a heavy tree, especially if it be long, and have consequently a great disproportion between the weight of its two extremities, would naturally sink in a fluid, and perhaps still more, in a semi-fluid, with its root end downwards" (p. 393). This actually is observed along the banks of the great rivers; Arber (1912) writes: "in the deltas of large rivers to-day, the bases of trees of large size, sometimes with fragments of roots still attached, may be deposited in a more or less upright position, though they have been transported for a considerable distance" (p. 106).

Figure 4. Polystrate tree-trunks near Saint-Etienne (France). (After Brongniart).

Moreover, as pointed out by Grand'Eury (1890, p. 244, compare with pl. XIII, fig. 7) the petrified tree-stems more often than not display a thickened trunk-base. Now Horbiger (Fauth, 1913, p. 443) conjectured that the relevant trunks functioned like the spindle of a natural hydrometer (Senkwaage) by which the massive rhizome constituted the bulb (Senkgewicht); as a result they tended to float upright and were deposited in that position as soon as the current quieted. Accordingly Nilsson (1953) states: "The anatomical structure of a plant-part determines its position in a measure" (p. 716) (Translated from the German).

Curiously the upright stems usually are cut off according to a shear plane which coincides with a bedding plane. They are not fractured obliquely, as often occurs today when a tree has broken off above the roots. It is asserted by Potonie (1910, p. 120) that the shear planes were brought about by a water level of old. However, this contention cannot be supported by any modern analogy whatsoever.

On the contrary a comparison between the mentioned features and recent analogs brings to light an unequivocal discrepancy. An examination of Stump Lake in North Dakota by Aronow (1957) showed considerable level fluctuations within a few centennia: "The lake levels seem to respond in a very sensitive manner to slight climatic changes" (p. 410). Among the many stumps once rooting *in situ* only one specimen was left. It was found in an advanced state of decomposition and all similarity with fossil examples was lacking.

In addition, something else excludes that a water level came into play here; viz. that there are fossil tree-stems which are sheared off at various heights (compare with Grand'Eury, 1890, pl. XIII, fig. 7). In order to elucidate this enigma, Horbiger (Fauth, 1913, p. 445) conjectured that the relevant trunks were embedded by a huge tidal wave, bringing about stratum super stratum, during a furious cold. As a result the upper parts of the soaked trunks, standing above the frozen level of the last bed, became as hard as nails and were sheared off on a level with the bedding plane by the next tidal wave; to this Nilsson (1953, p. 718) adds that on account of certain causes some tree-stems were not snapped off until a fresh bed was deposited and their parts, still standing out, were struck by a next impetus.

Personally, I am of the opinion that the polystrate fossils constitute a crucial phenomenon both to the actuality and the mechanism of cataclysmal deposition. Curiously a paper on polystrate fossils appears to be a "black swan" in geological literature. Antecedent to this synopsis a systematic discussion of the relevant phenomena was never published. However, geologists must have been informed about these fossils. In view of this it seems unintelligible that uniformitarianism has kept its dominant position.

In order to make this clear, as best I can, I present a historical analogue: in his *Tabulae Anatomicae Sex* (1538), the anatomist Vesalius (1514-1564) pictured the human liver with five lobes; three of these he never could have observed. Nevertheless, Vesalius pictured them—apparently in imitation of Galenus (131-200) whose conceptions were true dogmas until well into the 16th century. Nowadays most geologists uphold a uniform process of sedimentation during the earth's history; but their views are contradicted by plain facts. Nevertheless uniformitarianists insist on their point–obviously they line up with Huttonian philosophy. A case like this is no more a matter of geological argument; I can but present it as a curious example to those who intend to trace the psychology of scientific dogmas.

2) Ephemeral Markings

A classification of sedimentary structures may be executed on the basis of several criteria; e.g. according to the time and site of formation (Nagtegaal, 1965, p. 347-352). In that manner the structures are divided into non-organic and organic types; the latter being produced by all sorts of organisms. The former are divided into "syndepositional structures" (produced by the mode and site of deposition of the settling material) and "non-syndepositional structures" (produced by the disturbance of the deposited particles).

If the disturbance of the boundary plane between sediment and water, i.e. of the depositional interface, is produced from above then the structures are called "metadepositional," and if from below "postdepositional." The meta- and postdepositional structures are not distinguished in regard to time. Among the non-organic, as well as the organic structures, a profusion of specimens are very transient–primarily those located on surfaces. When the depositional interface moves upwards as sedimentation continues they easily are obliterated.

Sedimentary structures, characterized by pronounced transiency, I propose to classify as "ephemeral markings." As a rule they are not preserved in the sedimentary complexes of the Quaternary–in which system also bedding is scarce. On the other hand the ephemeral markings are frequently recorded in all earlier systems. Their preservation more often than not requires quite a rapid deposition of covering sediment; and their astounding abundance suggests that the sedimentation was cataclysmal both to rapidity and extent. Dozens or even–when subdivided— hundreds of types of ephemeral markings are known at present and their number is still swelling. In this paper only certain types can be treated; e.g. ripple marks, rain prints, trails and tracks,

Ripple Marks

As early as the middle of the previous century two basic types of ripple marks were clearly discerned; viz. the symmetrical or oscillation ripple marks, and the asymmetrical or water-current ones. The former are produced by wave action in stagnant water, the latter by water currents not exceeding certain critical current velocities. Gradually an amplified division was proposed; e.g. by Bucher (1919, p. 208), by Kindle and Bucher (1932, p. 654), and by van Straaten (1953, pp. 1-2). However, it only applies to recent ripple marks. Concerning fossilized structures obviously identical with ripple marks the binary division may be still useful.

The conditions producing the structures at issue have been thoroughly studied for a long time; int. al. by Darwin (1883, pp. 18-43) or recently by Kirchmayer (1960, pp. 446-452) and Tanner (1963, pp. 307-311), Curiously the factors which favour or prevent the preservation of ripple marks are barely given attention. An attempted systematic discussion is contained in Bucher's paper of 1919. In this context it is worthy of mention that ripple marks are extremely transitory. As a rule they are wiped out soon after they are produced. Geikie (1903) states: "On an ordinary beach, each tide usually effaces the ripple-marks made by its predecessor, and leaves a new series to be obliterated by the next tide" (p. 643).

However, ripple marks–chiefly mud ripples–become preserved in recent deposits–as reported by Trusheim (1929, p. 76, Abb. 6) or by van Straaten (1951, p. 54). Nevertheless examples are extremely exceptional–especially with regard to sand ripples. Accordingly Kemper (1965, p. 79) remarks that only endogenous structures stand a good chance of becoming preserved. As a rule surface markings are destroyed by the currents and the sustained reworking of the sea-bottom material ("standige Material-umlagerung am Meeresboden").

For all that, Kemper came across well preserved current ripples in the Bentheimer Sandstein. He writes: "The more startling is a slab with current ripple marks . . ." (p. 79) (Translated from the German). The preserved ripple marks constitute a serious problem-especially in regard to the symmetrical type. Kindle and Bucher (1932) write:

> The preservation of typical oscillation ripples under a thick layer of coarse sand, as is frequently seen in many sandstone formations, offers a more difficult problem than the preservation of current ripples, as the very existence of oscillation ripples excludes the possibility of any current erosion in the vicinity of the sedimentary surface (pp. 652-653).

However, fossilized ripple marks constitute one of the most common sedimentary structures in pre-Quaternary sequences. They are found in most exposures of any group all over the world; and, as a rule, they are markedly well preserved. Relating to sand ripples, Inman (1958) states: "they are one of the sedimentary structures frequently preserved in the geologic record" (p. 522). For obvious reasons the ripple marks must have been rapidly covered with sediment shortly after they were formed. Bucher's (1919) words are: "They must all, soon after their formation, be sufficiently covered with sediment settling on them from above" (p. 242).

As a rule the ripple marks occur only at the bedding planes of the layers–curiously not within these. This absence of ripples within the layers itself suggests that the latter were formed by an uninterrupted sedimentation. Often the ripple marks are seen from bedding plane to bedding plane in a series of layers of which each more often than not stands several feet. Practically invariably the layers succeed each other with an astounding regularity. These conditions suggest a periodical deposition, as of ebb and flow, though it must have been of an uncommon rapidity and on a large scale i.e. cataclysmal.

Presumably the sediment conveyors were huge tidal waves as assumed in the tidal theory (Nilsson, 1953, passim)—which waves must have been generated abundantly during the Noachian deluge (Whitcomb and Morris, 1961, passim). However, it cannot be clear at first sight why the sediment conveyors did not obliterate the ripple marks. Some possibilities are proposed here–though it does not concern the actuality but only the mechanism of cataclysmal sedimentation.

Perhaps some ripples were of the firm type not seldom found on sandy beaches. Kindle and Bucher (1932) write: "Such ripple marks would survive the passage of sand-bearing currents, and speedy burial might result without damage to their form" (p. 653). Perhaps the sediment conveyors were inter- or overflows in a large body of water and did not scrape along the bottom. Perhaps the ripple marks were frozen during deposition intervals–as supposed by Nilsson (1953, p. 689). As a matter of fact fossil ice crystal marks are found on sandstone surfaces (Twenhofel, 1932, p. 677).

Rain Prints

From the metadepositional structures the rain-prints are found. A rain-drop falling on a surface of soft sand or wet mud produces a pit margined by a ragged rim. When the wind drives aslant the rain-drop, the imprint is ridged up to one side. The raised margin indicates the direction toward which the wind blew.

Obviously these structures are extremely ephemeral. As a rule they are washed out within a few hours. Despite this rain-prints are often found in the fossil record. Geikie (1903) writes: "The familiar effects of a heavy shower upon a surface of moist sand or mud may be witnessed among rocks even as old as the Cambrian period" (p. 644). However, as remarked by Twenhofel (1932, pp. 677-680), it is doubtful if they really have so frequent an occurrence as suggested in the literature.

Perhaps the supposed rain-prints were produced by agents similar to rain-drops though not identical with them. The imprints may be hail-, drip-, or spray, and splash-prints. The tendency for these imprints is to have a greater width and depth than the rain-prints. Nevertheless there cannot have been a difference in regard to transiency worth the name. Consequently, all mentioned types require a rapid deposition of the layers covering them. Add to this the fact that the imprints are often found at successive bedding planes. As a result a large-scale deposition seems to have built up the relevant sequences in a short space of time.

Trace Fossils

The occurrence of some types of trace fossils leads to identical conclusions. A variety of animal trails and tracks is produced in unconsolidated sand and mud. Generally–by reason of the softness of the sediment–the markings are quickly wiped out by wind- or water-action. Especially this holds good in regard to sand; for, as stated by Shrock (1948), "the nature of this material is such that markings made on its surface have relatively little chance of being preserved" (p. 174). Lately the same is stressed by Whitcomb and Morris (1961, pp. 166-168). For all that, trails and tracks may become fossil (compare Shrock, ubi sup.). However, this does not alter the fact that examples of preserved trails and tracks in recent deposits are singular to a high degree.

Now then, despite this, they are found in the fossil record in countless numbers and sometimes over vast areas. Moreover, they may be classified among the phenomena to be observed in all systems and even in all series. The types are diverse. Twenhofel (1932) writes:

> They consist of worm trails from the rocks of all ages since the Proterozoic; tracks of crustaceans, as perhaps *Climatichnites* from the Cambrian of Wisconsin, which resembles the trail of a small automobile and may be an algal impression, and double rows of pits, as in the Richmond of Anticosti, where they have been followed over a 6-inch bed of limestone for 75 miles; tracks of amphibians from the Kansas Coal Measures; and the famed reptile tracks of the Newark sandstone (p. 675).

Frequently the interpretation of trails and tracks is still doubtful. A relevant structure consists of parallel, concentric furrows, about *2* mm. in width, which is classified as “Helminthoida” and, usually, is described as “guided meander” or “spiral track” (Seilacher, 1954, passim; Moore, 1962, p. 200; Schafer, 1962, p. 334), It is known through thousands of examples from the Cambrian system till the Tertiary. Schafer (1965, pp. 83-90) connects it with analogues produced on a recent mud flat. About the recent traces, he states that they cannot become fossils–even with favorable sedimentation circumstances. Thus from the outset the preserved specimens must have been much more deepened. However, even then their preservation can only be brought about by the covering with sediment soon after they were produced.

Bird Tracks

Also bird-tracks are reported; e.g. by de Raaf, Beets and Kortenbout van der Sluijs (1965, p. 146-148) in the Lower Oligocene of Navarra and Zaragoza in Northern Spain. The basal part of the formation is made up by calcareous shales intercalated with siltstones. Upwards the sequence grades into a much more arenaceous succession with scores of beds with bird-tracks. de Raaf *et al.* write: “Bird-tracks, both on sandstones or siltstones (occasionally on ripple-marked surfaces or associated with salt pseudomorphs) and on shales (evidenced as natural casts on the sole of overlying arenaceous beds), occur in the entire arenaceous succession, although more frequently in its lower parts." These numerous and well preserved bird-tracks require a rapid deposition of the capping layers.

In the conclusion of their report de Raaf *et al.* remark:

> It finally remains to consider the extraordinary, and often beautiful, preservation of a truly amazing abundance of bird-tracks in an area of the order indicated. It is hard to see how tracks abounding in all directions so repeatedly could be preserved at all with such regularity without invoking eolian action. Only thus can we envisage the much-repeated mechanism of quick burial and most successful preservation of the tracks after their imprint in exposed wet arenaceous to clayey sediments, first with wind-blown silt and sand derived from drying flats and only later by more sediment transported by water,” p. 147.

The mechanism of preservation here postulated may have played a part—but the mentioned conditions imply a wholly uncommon process of sediment-conveying and -settling.

More often than not various ephemeral markings are found on one and the same bedding plane, i.e., ripple marks, rain prints, mud cracks, and trails or tracks occurring together and mutually strengthening the testimony of each to cataclysmal sedimentation. It should be noted that together with the mentioned bird-tracks observed by de Raaf *et al.*, ripple marks, rain prints and mud cracks were also perceived.

The rapidness by which these markings must have been covered is emphasized by very recent observations on flysch and graded graywackes. The term “flysch” refers to sedimentary complexes made up of shaly-marly sediments and medium-thick sandstones. The hard, dark rock, denominated as “graywacke,” often occurs in flysch-like sequences and it resembles the flysch sandstones. Whenever cropping out, the lutite layers easily crumble away, exposing the undersides or “soles” of the sandstones, Mostly the soles are sharply defined and show a variety of surface markings, which as a rule were designated as “hieroglyphs”-a term applied to any markings found on bedding planes. Today the term “sole markings” is generally accepted.

These markings are the casts of structures in the underlying shales or marls produced there by organisms, currents, or other agents. The diverse types are described by Kuenen (1957), Pettijohn and Potter (1964), Dzulinsky and Walton (1965), *et al.* There are tracks, burrows, rill marks, flute casts, etc. Now then, the typical features of flysch and graded graywackes are interpreted by Kuenen and Migliorini (1950) in terms of a certain type of density current, viz. the “turbidity current” (“troebelingsstroom”).

The relevant deposits are considered according to the turbidity current hypothesis, as “resedimented rock” or, usually, as “turbidites. ” Kuenen

(1957) summarizes the now widely accepted hypothesis:

> Briefly, the hypothesis of resedimentation assumes that the detrital sediment is first deposited near the coast, e.g., on a delta. At intervals a mass of this material starts to slide down the slope and changes to a turbulent current, propelled by its excess weight over that of the clear surrounding water. On reaching a decrease in slope, the current is retarded, becomes overloaded, and starts to loose sediment (p. 232).

So the pre-existing structures on the superface were preserved and casts of these formed upon the bases of the capping layers. Concerning the preservation of these structures it is stated by Kuenen (1957): "The fact that such delicate markings as grazing tracks and trails, if that is what they are, have been imprinted on the graywackes of resedimented series apparently demonstrates that some turbidity current caused no erosion but started deposition at once and thus conserved pre-existing bottom markings" (p. 233). This deposition came about "very suddenly and swiftly" (Kuenen, 1957, p. 232).

More often than not the material involved must have been really immense and the velocity of the currents may have come to some 100 km an hour (compare Kuenen, 1958, p. 3). Besides, the amazing rhythmic bedding of flysch deposits, which is without modern analogue, suggests that the entire sequences were built up by a periodical and—as it were—pulsating succession of turbidity currents. If the turbidity current hypothesis is right, then the turbidites were, strictly speaking, deposited in a cataclysmal way.

None the less, Kuenen (1953, p. 7; 1957, p. 232 and compare with 1964, passim.) claims that the lutites were formed slowly by pelagic sedimentation and, as a result, the intervals between the deposition of successive sandy beds tended to be long. However, evidence is growing that the lutite layers were rapidly formed. Dzulinsky and Walton (1965) write: "Although emphasis has been laid on the operation of turbidity currents in the formation of sands, the hypothesis may also be applied to fine-grained beds. There is little doubt that the lower parts of most shaly layers associated with flysch sandstones commonly belong to the same sedimentary episode as the underlying arenite" (p. 11).

And further they remark: "Even in seemingly homogeneous shales, close examination frequently reveals a number of graded units. True pelagic deposits are probably very insignificant in flysch sediments and this contention finds some support in the evidence that thick shaly-flysch units have accumulated in short time intervals" (p. 11).

However, if the original material was "first deposited near the coast, e.g., on a delta" (Kuenen, 1957, p. 232), accumulating there gradually, then a succession of turbidity currents, rapidly generated after each other, cannot be accounted for. A succession of turbidity currents can be accounted for if the sediments of entire coastal regions and marine slopes were loosely packed and easily to disturb; and if agents, generating the turbidity currents, were abundant and intensive.

Typically, these conditions are existing within the framework of deluge geology. As regards the period when the deluge waters fell, Whitcomb and Morris (1961) write:

> The newly-deposited sediments were still relatively soft and unconsolidated, and the imposition of new gradients and currents over them when the lands began to rise would have immediately induced scouring action on a large scale. The mixture of water and mud thus formed would, in flowing downslope, itself cause tremendous submarine erosion and ultimate redeposition (p. 269).

During this period, eustatic movements, earthquake; and volcanic activity, competent to generate turbidity currents, must have been very numerous.

Lack of space prevents continued enunication of the arguments for cataclysmal deposition—though a profusion of arguments might be brought to the front, e.g. (1) the thanatocoenoces or "fossil graveyards," (2) the excellent preservation of even soft parts of single or packed up organisms, or (3) the phenomenon of stratification as an indication of some recurrent tidal wave phenomena of abnormal character (compare MacFarlane, 1923; Price, 1923, 1926; Nilsson, 1953; Velikovsky, 1956; Whitcomb and Morris, 1961; *et al.).* These lines of evidence are commonplace since Buckland (1836-1837) and Miller (1840).

On the other hand, the facts classified here as "polystrate fossils" and "ephemeral markings" are barely referred to in the literature on catastrophic geology–though the former phenomena are most conclusive and the latter are much more common in sedimentary complexes than any of the other facts. Without question they constitute strong arguments in favor of cataclysmal deposition, and, generally, support catastrophism as a scientific principle to interpret the earth's history. It would be gratifying if competent scientists were alive to collect and publish examples of the mentioned fossils and markings. In conclusion of this article I present some results of field work in The Netherlands (Winterswijk) and in Belgium (The Ardennes).

Figure 5. Ripple marks in the Winterswijk Muschelkalk (The Netherlands). (Specimen from the author's collection).

III: Some Results of Field-work

1) Winterswijk

In the Netherlands the Mesozoic is covered practically everywhere with complexes of Tertiary and Quaternary sediments. Only in some areas they crop out; e.g., in the Geldersche Achterhoek where int. al. Triassic limestones are only covered with thin beds of Pleistocene till or niveo-eolian cover-sands. The limestones contain *Myophoria* species and consequently are classified as Muschelkalk; generally, it is assumed that the deposits belong to the Lower Muschelkalk. In the vicinity of Winterswijk on the Vossenveld the limestone is being exploited by the N. V. Winterswijkse Steen- en Kalkgroeve. In that area the Muschelkalk has a formation thickness of 40-50 meters and is excavated in two quarries; viz. the Old Quarry and about 1 kilometer eastward, the New Quarry. Both I have visited several times.

In the Old Quarry the limestone displays a layered structure; it is built up of thin beds or even of laminae. On the surfaces of most beds ripple marks occur. They are of various sizes and types—though for the most part they consist of interference wave ripple marks. On an average the wave length is 1.5 cm. and ranges from 1 to about 2.5 cm. As a rule the crests are sharply defined and the specimens show no indication of levelling of the ripple ridges (Figure 5). The Old Quarry abounds with ripple marks; they are found at various horizons and I traced them ever an area of some 20-30,000 square meters. It is a riddle to me how Faber (1959, p. 25) can say that ripple marks are rarely seen in this exposure.

Figure 6. Rain print in the Winterswijk Muschelkalk (The Netherlands). (Specimen from the author's collection).

In this same quarry many pits occur which look like imprints made by rain-drops; they do not extend in the limestone underneath and consequently are not crossed burrows. The average diameter is 4.5 mm., whereas imprints of 2 and 7 mm. are also found. For the most part the imprints are but few or not rimmed-though I recorded also rain prints with extremely well preserved rims. Now and then the impressions are elliptical and margined but to one side; the elevated side indicates the direction in which the rain-drop came down (Figure 6). In places the prints abound and they are found at *various horizons*. Frequently they are found on slabs with fossilized mud cracks; the cracks are restricted to thin beds or laminae being only some few mm. thick. For instance, on a surface, enclosed by superficial mud cracks and being about 10 $cm.^2$, some 10 to 15 rain prints occurred.

In the New Quarry also thin beds and laminae are extant; in addition thick layering is observable. On the relevant surfaces ripple marks are relatively infrequent—whereas rain prints are very abundant and often occur on laminae criss-crossed by mud cracks.

Frequently surface markings of puzzling character appear which were not described or determined until now; Faber (1959, p. 31) seems to make reference to it when he writes that he came across some patterns which he could not place. In figure 7 a specimen is pictured. Kuenen suggests, by personal communication, that the structure was produced during consolidation–though he does not vouch for the truth of his guess. Personally, I incline to the opinion that the structure was produced by streamlets of flowing water which eroded minute channels—called rill marks. I observed a recent ephemeral structure identical to Figure 7 on the beach of the Dutch isle Schiermonnikoog.

On beaches the back washing wave is followed by a film of water which finally divides into streamlets. Sometimes the streamlets flow back in zigzag line and produce tiny channels round about rhomboid patches which are not eroded away; the extremities of some diamonds may run out into tongues of sediment. The same was observed by Twenhofel (1932) who states:

> On beaches composed of fine sands, the returning waters of waves may be succeeded by a

> net-work of anastomosing rills or small currents whose minute erosion produces a sculpturing of the beach surface resembling the surface of a *Lepidodendron* tree, the uneroded surface or polygons between the minute currents being diamond-shaped, with the long axes of the diamonds normal to the water's edge (p. 671).

Now then, the mentioned features are displayed by the pictured surface; viz. the uneroded diamonds and the tongues of sediment (e.g. middle left) –though on a small scale as compared with rill marks on sandy beaches. Little joints which are of secondary character confuse the original structure as does also the clearly visible trial.

Trails and tracks are not abundant though they are found (compare with Figure 7); a trackway is recorded of *Chirotherium* (sic!) *peabodyi* (Faber, 1958, pp. 317-321; p. 448; van Regteren Altena, 1958, pp. 447-448),

Evidently both the Old and the New Quarry hold a profusion of ephemeral markings; viz. ripple marks, rain prints, mud cracks, rill marks, and, incidentally, trails and tracks. Without question the delicate structures here determined as rill marks are very transient. Consequently, all recorded markings must have been rapidly covered with sediment.

Within the framework of Huttonian geology, it is assumed that the limestone sequences were deposited by the settling of calcareous skeletons of marine micro- and macro-organisms. On account of rain prints, mud cracks, etc. it is assumed that the Winterswijk Muschelkalk originated in shallow water, e.g. a lagoon. Van Straaten (1963, pp. 12-13) supposes that in the north half of the Adriatic some 20 grams of lime per square meter per annum, i.e. 0.00008 cm. per annum, is deposited.

In regard to the Winterswijk limestone, the rate of lime deposit could not have been much more—for the distinct bedding and lamination and other phenomena are thought to prove that conditions of life were unfavorable. It is beyond dispute that in sedimentary environments like this no ephemeral markings could have been rapidly covered and preserved; in other words, uniformitarianism cannot account for the Winterswijk Muschelkalk.

In order to account for the excellent preserved conditions of countless ephemeral markings which occur through the entire deposit it is necessary to assume that lime beds were rapidly deposited after each other. This implies that the calcareous materials were not auto- but allochthonous, and were transported from elsewhere. Moreover, the regular bedding suggests that the sediment transport was governed by rhythmic and—as it were—pulsation depositional patterns.

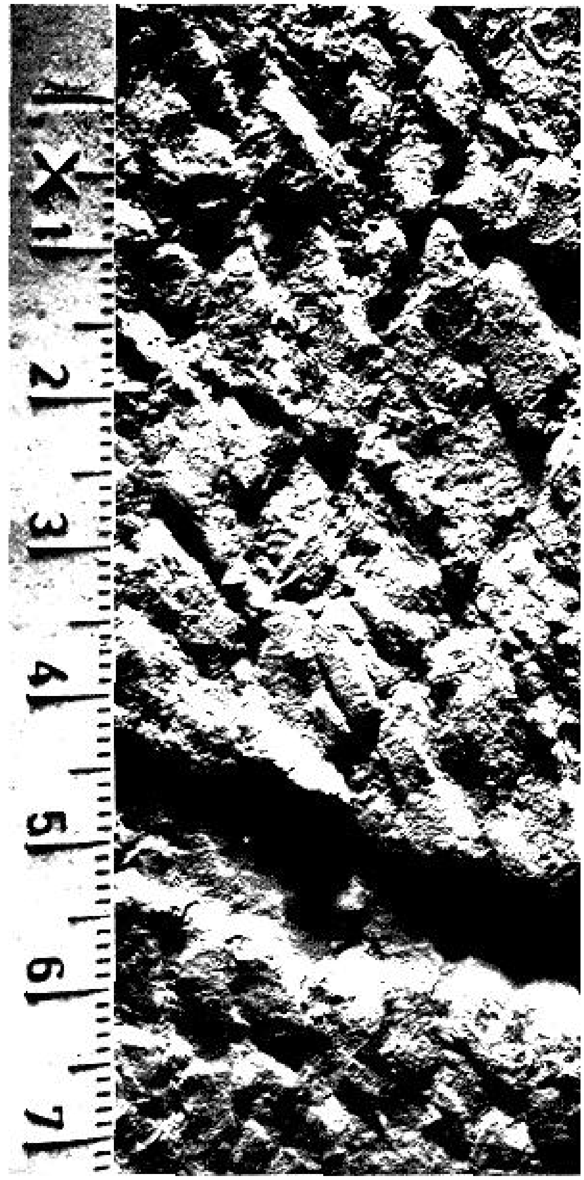

Figure 7. Rill marks (?) in the Winterswijk Muschelkalk (The Netherlands). (Specimen from the author's collection).

2) The Ardennes

The relief of eastern Belgium is dominated by an orogen called the Ardennes; in the folding process only Paleozoic sequences were implicated; they are intersected by the Meuse and her tributaries-e.g. the Ambleve or the Bocq. In their valleys, often Devonian and Carboniferous sand- and limestones are exposed. The Famennien–a stage of the Upper Devonian–consists for the most part of psammites. They are excavated on a large scale for the purpose of paving and building; as a result the Famennien is largely exposed and most data are obtained from the relevant quarries.

On entering a psammite exposure the regular bedding is striking; beds of psammite succeed each other with astounding regularity—more often than not *thin beds of shale* constitute the partings of the arenaceous units.

Almost invariably on the bedding planes, ripple marks occur which are of various types. Both symmetrical and asymmetrical ripple marks are found–though the former more frequently than the latter. Often it is possible to trace these marks over the entire surface of an exposed bed. When ripple marks are first exposed they appear to be–for the most part–extremely well preserved. In this connection, I offer two examples:

In Figure 8A, symmetrical wave ripple marks are pictured which occurred in a quarry near Aywaille sur Ambleve; on an average the wave length is 4-6 cm.; the crests are still sharp.

In Figure 9A, asymmetrical current ripple marks are pictured—though the pattern was altered by wave action. This specimen occurred in a quarry near Yvoir in the valley of the Bocq. The wave length is about 3.5 cm.; there is no sign of levelling of the ripple ridges. In this context it is worthy of mention that these ripple marks occurred on sandy slabs.

Rain prints are not abundant in the psammites; van Straaten (1954) even reports that “he did not find one single unambiguous example” (p. 36). However, they in fact are found, since I came across an example in the quarry near Aywaille sur Amb1eve (Figure 10). The surface shows two imprints being slightly rimmed on the right, toward which the water-drops must have been directed. Otherwise, the imprints may –properly speaking–present spray- or splash prints. The imprints occur isolated, being about 1.5 cm. in width while one is clearly elliptic. In the splash zone of a beach I observed two nearby splash prints of identical feature; both the fossil and the recent imprints were without great depth.

In regard to trails there is no shortage; on the contrary, they are typical of the Famennien. In Figure 11, a trail is depicted which I found in the quarry near Yvoir in the valley of the Bocq. It occurred on a rippled surface, and lengthwise to a trough; the surface marking is rimmed on both sides and the little ridges are amazingly well preserved. Perhaps the trail was produced by a worm though it is difficult to determine the true nature of the agent.

It is believed by van Straaten (1954) that the Psammites du Condroz–the arenaceous facies of the Upper Famennien in the Ardennes—were formed in “a tidal lagoon, bordered by tidal flats and receiving a more or less periodical supply of fluvial material” (p. 25); the supply must have been limited by a minimum of 0.03 mm. per annum and a maximum of 0.6 mm. per annum (compare with van Straaten, (1954) p. 45) .

However, these uniformitarian suppositions cannot be brought into agreement with the mentioned phenomena. It is true that an alternation of sandy and shaly laminae may be brought

Figure 8A. Ripple marks in the Aywaille psammite (Belgium). (Photo by Rupke).

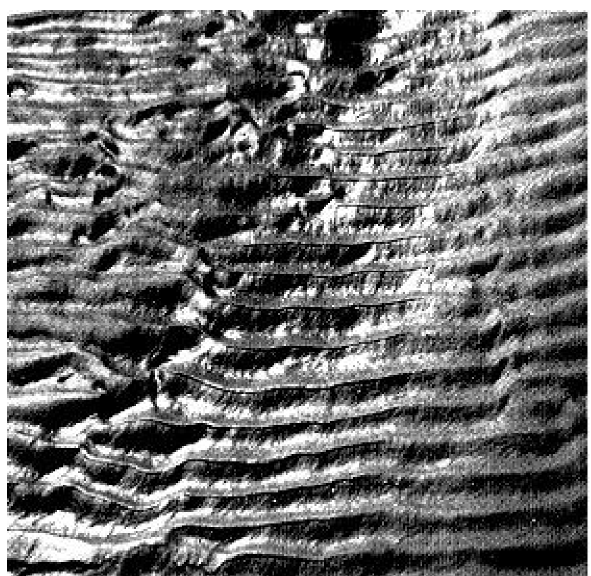

Figure 8B. Ripple marks on the beach of Schiermonnikoog (The Netherlands). (Photo by Rupke).

Figure 9A. Ripple marks in the Yvoir psammite (Belgium). (Photo by Rupke).

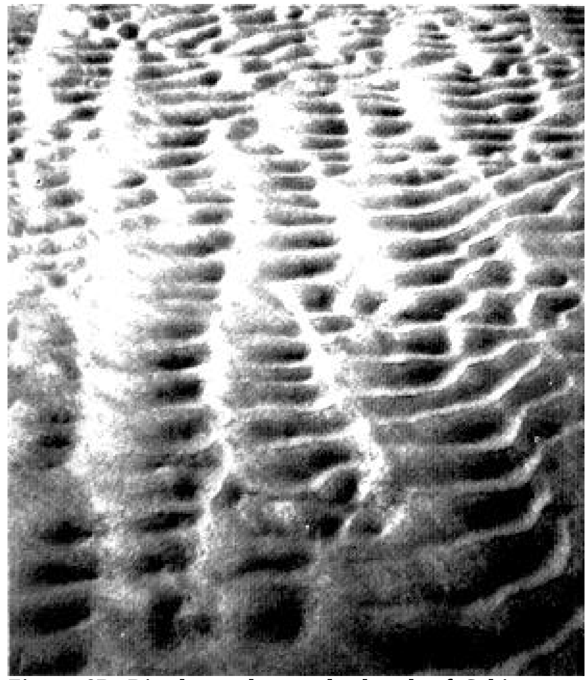

Figure 9B, Ripple marks on the beach of Schiermonnikoog (The Netherlands). (Photo by Rupke).

about in recent deposits; viz. as tidal- or storm-surge lamination on tidal-flats or marshes (Richter, 1926, p. 306; 1929, pp. 25-26). However, such laminae are only some few mm. or, at most, some cm. thick. But the sandstone- and limestone beds, parted by shaly units, as observed in exposures of the Famennien and—just as well—of various other sequences in the Ardennes, more often than not measure several decimeters in thickness and occasionally even much more. In fact, the distinct alternation of sandstone or limestone beds with shales suggests a tidal action and a consequent periodical deposition. But from the outset these tides must have acted much more intensively and extensively than the known tides of today in order to bring about beds of the mentioned thickness. Perhaps a periodical succession of tidal waves of great sedimentary competency came into play here.

In Holocene deposits ripple marks are preserved, but it applies mainly—maybe exclusively—to ripple marks in mud. Ripple marks in sands are extremely transient. In Figures 8B and 9B, ripple marks are depicted as observed on the sandy beach of Schiermonnikoog. Figure 8B represents symmetrical wave ripple marks which are somewhat modified by erosion. Figure 9B shows asymmetrical current ripple marks—downstream slope on the left, so current from the right—and crosswise symmetrical wave ripple marks which likewise are modified by erosion.

These patterns were photographed shortly after they were laid bare; nevertheless, the ripples became already blurred on account of sun- and wind action (Figure 8B on the right and Figure 9B on the left), For that in the mentioned Ardennes exposures, many specimens are extant of amazingly well preserved ripple marks occurring on sandy bedding planes covered by shale- or sandstone beds. These conditions, bespeaking rapid deposition of successive beds, are absolutely unequaled in Holocene sediment. This statement is even more valid in regard to splash marks and worm (?) trails—being extraordinary ephemeral, but nevertheless preserved in the Famennien. As a result uniformitarianism is deficient in accounting for the sedimentary phenomena of the Famennien, and of analogous sequences in the Ardennes.

Undoubtedly the actuality of cataclysmal deposition is apparent from a profusion of sedimentary phenomena. Yet the mechanism of rapid formation of sedimentary complexes is somewhat difficult to conceive–though enlightening elucidations are already given (Price, 1923, pp. 679-692 to be compared with Twisden, 1877, pp. 35-48; Nilsson, 1953, passim).

Perhaps–as to limestone–ooze from antediluvian deep-seas was stirred up and transported by tidal waves, generated during the Noachian deluge. Then due to current-sorting, the finer materials (e.g. lime- and clay particles) were deposited in one locality, and the coarser (sands etc.) in another—though frequently not per-

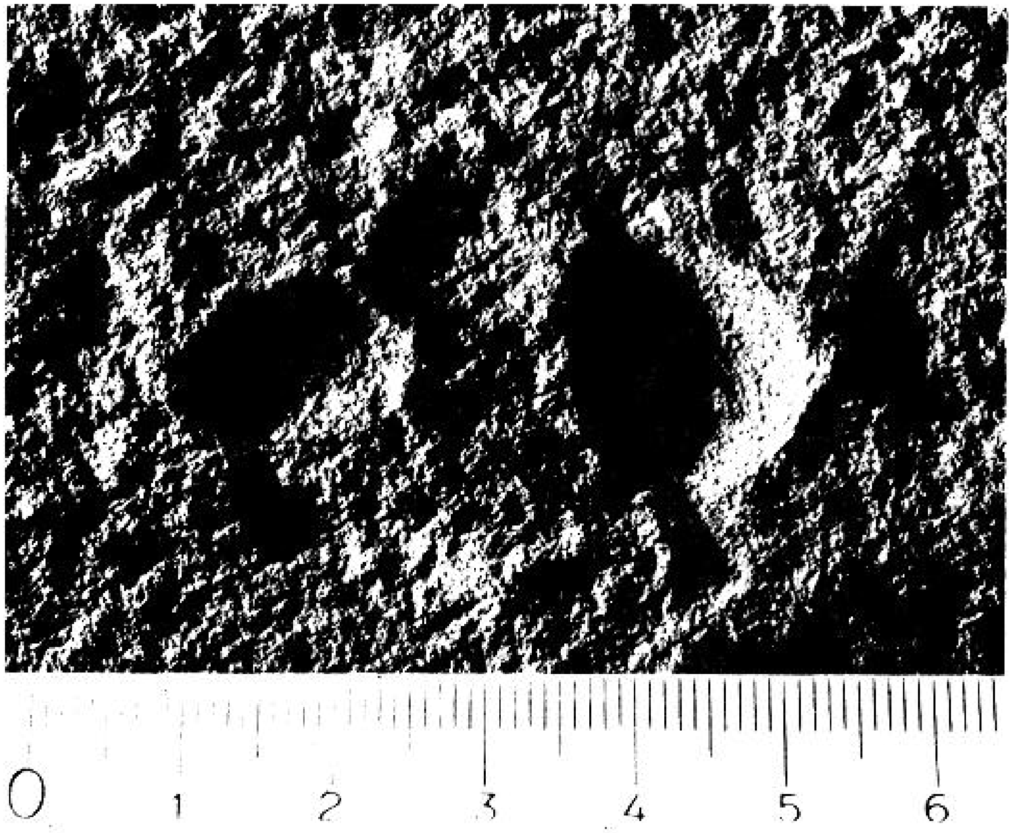

Figure 10. Splash (?) prints in the Aywaille psammite (Belgium). (Specimen from the author's collection).

Figure 11. Worm (?) trail in the Yvoir psammite (Belgium). (Specimen from the author's collection).

fectly sorted, Indeed, the Winterswijk Muschelkalk is composed of limestone, and also of marl, shaly marl, marly shale, and even of some calcareous sandstones.

However, and most importantly, the reader should bear in mind that the conceivability of cataclysmal sedimentation cannot constitute a criterion as to the actuality of it. It is unsound to argue: "Non est, nam non potest," as is frequently done by Huttonian geologists. In this connection, the words of John Ray, cited at the beginning of the present article, are worth laying to heart, and accordingly I claim with all authority of empiricism: "Potest, nam est."

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Notes and References

[1]Francis Bacon, *Novum Organum Scientiarum,* Lib. I, Cap. LXXXII, Lib. II, Cap. X et passim.

[2]Nicolaus Steno, *De Solido intra Solidum naturaliter Contento,* pp. 26-32; Facsimile-Edition, ed. W. Junk, no. 5, 1904. An English translaltion entitled *The Prodromus of Nicolaus Steno's Dissertation concerning a Solid Body enclosed by Process of Nature within a Solid* with an introduction and explanatory notes by John G. Winter appeared in 1916, University of Michigan Studies, Humanistic Series, Vol. XI, Part II.

[3]John G. Winter, Ubi sup., p. 230.

[4]*Ibid.,* p. 227.

[5]*Ibid.,* p. 258.

[6]Compare, pp. 67-76; original edition.

[7]Sir Andrew Geikie, *The Founders of Geology,* 1897; Dover Republication 1962, p. 60.

[8]G. W. von Leibnitz wrote concerning Steno: "saepe ipsum nobis narrantem audire memini, ac gratulantem sibi, quod sacrae historiae and generalis diluuii fidem naturalibus arguments, non sine pietatis fructu, astrueret"; Protogea, Par. 6; *Summi Polyhistoris Godefridi Gvilielmi Leibnitii Protogea,* pp. 12-13; 1749.

[9]John Ray, *De Wereld cvn haar Begin tot haar Einde. In drie Natuurkundige Godgeleerde Redeneringen, II: Den algemeenen Zuudvloed, desselfs Oorzaken en Uitwerkingen,* pp. 62-98; 1765 (being the Dutch translation of his "Discourses").

[10]Because I only had the disposal of a Dutch edition of Ray's work I cite from Charles E. Raven, *John Ray, Naturalist, His life and Works,* 1950, p. 438.

[11]John Ray, Ubi sup., p. 148.

[12]Charles E. Raven, Ubi sup., p. 431.

[13]Byron C. Nelson, *The Deluge Story in Stone,* 1931. p. 37.

[14]John C. Whitcomb and Henry M. Morris, *The Genesis Flood,* 1961, p. 90.

[15]John Woodward, *An Essay toward a History of the Earth,* p. 73-76; 1702. Extracts are given by Melvin E. Jahn and Daniel J. Woolf (See "The lying stones of Dr. Johann Bartholomew Adam Beringcr being his Lithographiae Wirceburgensis," Notes, pp. 176-178; 1963.)

[16]John C. Whitcomb and Henry M. Morris, *The Genesis Flood,* pp. 273-274.

[17]Karl Alfred von Zittel, "Geschichte der Geologie und Paleontologie," p. 41; *Geschichte der Wissenschaften in Deutschland, Neuere Zeit,* Band 23, 1899.

[18]John Woodward, Ubi sup., p. 19.

[19]In almost every publication dealing with Woodward, he is put on a level with Thomas Burnet (Compare *Telluris Theoria Sacra: orbis nostri originem and mutations generales, quas aut jam subiit, aut olim subiturus est, complectens* 1681) and with William Whiston (Compare *A New Theory of the Earth, From its Original, to the Consumation of all Things. Wherein The Creation of the World in Six Days, The Universal Deluge, And the General Conflagration, As laid down in the Holy Scriptures, Are shewn to be perfectly Agreeable to Reason and Philosophy* (1696).

This trio is taken as representative as regards early deluge, geology; however, wholly unjustly. Burnet and Whiston did not leave intact the biblical framework of early history and undermined at will the inspired authority of scriptural passages or even of whole books; consequently, they were no more deluge geologists than theistic evolutionists are real creationists.

A recent evaluation of Woodward's work is given by V. A. Eyles, "John Woodward, F.R.S. (1665-1728)," *Nature,* Vol. 206, No. 4987, May 29, 1965, pp. 868-870.

[20]PhH. Kuenen, "Experiments in Geology," *The Transactions of the Geological Societt of Glasgow,* Vol. XXIII. 1858, p. 1.

[21]See *Histoire de l'Academie Royale des Sciences,* Annee 1710. *Avec les Memoires de Mathematique et de Physique, pour la meme* Annee, pp. 19-21, 1712. Compare *Journal des Scavans,* Octobre 1713, p. 459, 1713.

[22]Benoit de Maillet, *Telliamed,* Tome II, pp. 19-20: Compare p. 58; Nouvelle edition 1755.

[23]See "Preuves de la Theorie de la Terre," Art. VII, *Oeuvres Completes de Buffon et de ses Continuateurs,* Tome I, pp. 150-162; 1828.

[24]*Ibid.,* Art. I, pp. 110-123.

[25]Buffon, "Des Epoques de la Nature," passim.

[26]Loc. cit., Art. V; Ubi sup., p. 135. Compare Gen. 8:11; this biblical passage constitutes a classical argument against biblical catastrophism; it was dealt with by Samuel Bochart, *Hierozoicon,* Lib. I, Chap. 6; Bocharti Opera, Tom. III, pp. 27-30; 1712; by Mattheus Polus and Simon Patrick, *Verklaring van Mozes eerste Boek, genoemd Genesis, uit de Engelsche Verklaringen van de heeren Patrik, Polus Wels, en andere voorname Engelsche Godgeleerden,* H.1., pp. 98-99; 1741–being the Dutch translation of their exegetical studies; by Theodorus Christophorus Lilienthal, *Die gute Sache der in der hl. Schrift Alten und Neuen testaments enthaltenen gottlichen Offenbarungen,* Chap. XV, Par. 8; 1760-1780; and a recent discussion of the question is given by John C. Whitcomb and Henry M. Morris, *The Genesis Flood,* pp. 104-106.

[27]George Cuvier, *Histoire des Progres des Sciences Naturelles, depuis 1789 jusqu'a ce jour,* p. 184; presente 1808; 1826.

[28]Jean-Andre Deluc, *Lettres Physiques et Morales, sur l'Histoire de Terre et de l'Homme,* Tome, 1779, p. 7.

[29]Horace-Benedict de Saussure, *Voyages dans les Alpes, precedes d'un Essai sur l'Histoire naturelle des Environs de Geneve,* Tome I, pp. 145-149; Tome II, pp. 376-386; 1803.

[30]Jean-Andre Deluc, Ubi sup., Tome V, Partie II, p. 836.

[31]*Ibid.,* pp. 649-650.

[32]Willem Bilderdijk, *Geologie,* p. 109; 1813-published anonymously.

[33]Jean-Andre Deluc, Ubi sup., pp. 490-505; compare Willem Bilderdijk, Ubi sup., Chap. 6.

[34]Jean-Andre Deluc, Ubi sup., p. 498.

[35]*Ibid.*, p. 505.

[36]George Cuvier, "Discours surles Revolutions de la Surface du Globe," pp. 6-8 et passim.

[37]*Transactions of the Royal Society of Edinburgh,* Vol. I, Part II, 1788, pp. 293-294.

[38]*Ibid.*, p. 221.

[39]John Playfair, *Illustrations of the Huttonian Theory Of the Earth,* facsimile reprint, Dover Republications 1956, p. 117.

[40]Sir Charles Lyell, *Principles of Geology* (or the modern changes of the earth and its inhabitants considered as illustrative of geology), Vol. I, Bk, I, Ch. XIV, 1867. p. 325.

[41]The controversy between catastrophism and uniformitarianism is discussed as a whole by R. Hooykaas, *Natural Law and Divine Miracle,* 1960, 2nd impr. 1963; the view of many geologists of today in this case is expressed by M. G. Rutten, *The Geological Aspects of the Origin of Life on Earth,* 1962; Dutch edit., 2, 1965, pp. 23-39.

[42]Willem Bilderijk, Ubi sup., p. 104.

[43]George Fairholme, *New and conclusive Demonstraions,* 1837, pp. 392-404. (I should appreciate a reader's informing me on the dates of George Fairholme.)

[44]Francis C. Haber, "Fossils and the Idea of a Process of Time in Natural History" in *Forerunners of Darwin: 1745-1859,* ed. Bentley Glass, Owsei Temkin, William L. Straus, Jr., 1959, p. 244.

[45]Johann Wolfgang von Goethe, *Ueber Naturwissenschaft,* IV; Goethe's *sammtliche Werke in vierzig Banden,* Dritter Band, 1840, p. 300.

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