THE GEOLOGIC AGE OF THE MISSISSIPPI RIVER

(With a Presentation of Basic Factors Pertaining to Age-Estimates of River Deltas*)

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The Mississippi-Missouri river system is the longest in the world, measuring some 4,221 miles in length. In flood season flat-land inundation below Cape Girardeau has always been a problem. About 1850 congress ordered General Andrew A. Humphreys to make a survey of the whole area, which was completed and published in 1861.

The English geologist, Charles Lyell, promoter of the Principle of Uniformitarianism, had made superficial examination of the river and delta, and gave the river system an age of 60,000 years, on the basis of a total depth of the delta of 528 feet. Humphreys showed these measurements to be erroneous, that the actual depth of the delta was only 40 feet. Below that was the blue clay layer and below that marine fossils, indicating that antedating the river was a marine estuary intruding far up into what is now the lower Mississippi River flood plain.

Therefore, using Lyell's formula for age computation, Humphreys got an age of about 4620 years, or approximately the time of the Flood of Noah. It is logical to believe that most of the present river drainage systems of the world were born at the close of the Flood.

There are less data available for computing the age of other major rivers of the world, but the data available seem to concur with the age of the Mississippi River.

If the river were as old as many uniformitarian geologists believe, the whole Gulf of Mexico would have been filled with sediment in some 10,000,000 years.‡

The rivers of the world owe their existence, location, and character to the differences in elevation of the land as expressed in mountains, plains and valleys. That this unevenness of surface was originally caused by up-and-down movements of the earth's crust, is apparent.

If these movements were of sufficiently sudden and severe occurrence they would have been of a catastrophic nature, the great bodies of water would have been unbalanced and set in violent motion, overflowing the land and creating a fresh surface for the start of entirely new river systems. If it can be shown by accepted facts of geology that the world's present river systems began simultaneously, then it would seem reasonable to conclude that the cause was just such a cataclysm of a world-wide scope occurring immediately prior to their birth.

The delta of a river, built by its conveyed sediments, is the chief source of information concerning the length of time the river has been flowing. The average volume of solid matter carried annually, the yearly increase in the length of the delta, and its total cubic content can all be measured with a surprising degree of accuracy. These facts form the basis for the calculation of the whole period of the river's existence from its origin to the present time. Thus the approximate date when a river began flowing can be established.

If, by this method, fair age-estimates can be obtained of a sufficiently large number of deltas to be considered as fairly representative of the world's rivers, and the life span is found to be substantially the same for all, the significance of such a result would be striking. Automatically the date would seem to be fixed, not only of the beginning of the world's rivers, but of the original catastrophe itself which must immediately have preceded the origin of the rivers.

If the date of this convulsion is found to correspond, within reasonable limits, to the chronology of the aqueous catastrophe as recorded in sacred history, supported as it is by archaeology, such coincidence will be of vital importance, both to science and to religious faith.

The Mississippi Delta, a Special Study. Inasmuch as the Mississippi river with its delta has been the subject of more scientific study than any other in the world, and since the main problems are very much the same for all rivers, it has been selected as an example for special study and will be given examination in detail. Basic principles pertaining to age estimates of all deltas will also be presented.

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†EDITOR'S NOTE: Clifford L. Burdick of Tucson, Arizona, knew Mr. Allen and had contact with the old Deluge Society in Los Angeles. As a note of historical interest, I include the following comments extracted from a letter of Clifford Burdick's to me, July 23, 1970:

> On the whole I think Allen did an outstanding piece of work on this paper. It always did stand out in my memory as one of his best. He was an indefatigable researcher. He was educated as a lawyer, graduate from the University of Arkansas. He had a logical mind, like Price . . . with whom he was associated in the old Deluge Society in Los Angeles, which had its meetings at the medical school at the White Memorial. . . . Allen was for years the head of the society. He had no formal training—like Price—in geology, but got interested in it. . . . Allen lived in a trailer, filled to the top with books. His main means of support was contributions from members of the society, such as Dr. George Rue. . . .

‡Abstract written by Clifford L. Burdick, consulting geologist, Tucson, Arizona.

Figure 1. An Apollo series view of the Mississippi River and gulf coast of Louisiana looking from West to East. The Mississippi River is seen as a thin twisting ribbon in the upper left. Clouds obscure the delta which is visible in Figure 2. The two fine photographs are supplied by the courtesy of National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Texas 77058, Edward O. Zeitler, Chief, Earth Resources Research Data Facility.

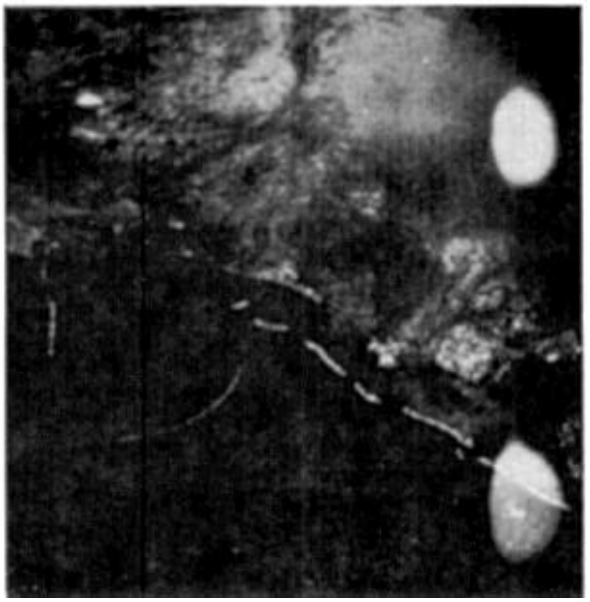

Figure 2. Apollo series view of the Mississippi River Delta. Lake Pontchartrain and Lake Borgne are clearly visible as is also the mouth of the Mississippi River and part of the amazing delta (compare this photograph with a map). This splendid Apollo shot will help illustrate the delta itself which figures so prominently in B. F. Allen's strong argument for the young-earth Flood concept.

Though given at the risk of tiring some readers, this careful attention to detail is indispensable to the main object of establishing a reliable basis for calculating age-estimates of all rivers. While firmly establishing the age of the Mississippi river, the object of this study is also to lay a foundation for age-estimates of other rivers.

It should be borne in mind that the present paper is intended as little more than a suggestive outline of the subject, which it is hoped others may be encouraged to follow in a more comprehensive investigation. In the present paper, only the age of the Mississippi river will be calculated.

The Problem and Its Outline

For more than twenty-five years there was a disagreement between Sir Charles Lyell and General A. A. Humphreys over scientific interpretations with regard to the age of the Mississippi river delta. Sir Charles Lyell, professor in Kings' College, London, and leading English geologist of his day, had estimated its age as 60,910 years.[1] General Humphreys, by different methods, had estimated it as from 4,400 to 5,000 years.

During a large part of that time Humphreys was in charge of the U. S. Army Corps of Engineers working on the river and delta, and, with his staff of experts and the aid of professor E. W. Hilgard, state geologist of Louisiana, and other contemporary geologists, had accumulated a vast array of facts and a thorough knowledge of the whole delta area.

Hilgard quotes Humphreys as saying in an early report: "The river is flowing through the delta region in a channel belonging to an epoch antecedent to the present."[2] Lyell had challenged this statement. The contest was on, and has continued to the present day, into the second or third generation of geologists.

There are seven general features of the problem which should be considered. (1) Is the channel bed of the river antecedent to the river? Could the bed of the river have been an estuary? (2) What is the significance of the layers of gravel beneath the river, the Gulf, and the delta, and do they demand cataclysmic waters for their origin? (3) Shall we accept General Humphreys' data, and the reports of his staff, as the approved basis for the age of the delta? (4) Do the subsequent and latest views on the factors vital to the age of the delta, which sharply oppose each other on certain items, still fairly sustain the originally discovered facts? (5) The main problem being the general theory of deltaic subsidence, does the actually observed subsidence in the Mississippi delta, considered in the light of the established principles of geo-physics, sustain that

theory? (6) Is Lyell's estimate of the age of the delta based upon a consistent conception of its depth? (7) Do Humphreys' two methods of calculating the age of the delta rest upon a reasonable interpretation of all available facts, and do they properly check with each other?

The most important question of all is the theory of deltaic subsidence. It assumes that deltas, by their increasing weight, depress the crust of the earth, and thus grow downward many times faster than upward. The data given here mainly refer to the Mississippi delta, though the opposing general theories are discussed. In order to make clear first the less technical features in preparation for this problem, and to give an adequate conception of its significance, this discussion of subsidence will be reserved till the last, just before entering upon the final computations of the age of the Mississippi delta.

The "Antecedent Bed"

Hilgard and the U. S. Army Engineers had discovered what they interpreted to be an ancient "estuary bottom," extending some six hundred miles up the river, as far as to Cairo at the mouth of the Ohio. Into the sediment forming this ancient bed, the river had cut its channel from low water downward through many of its strata.

This same material had been found, so they stated,[3] beneath New Orleans in an artesian well, the log of which had been carefully preserved. In this well the upper stratum, approximatetly 38 to 41 feet in thickness, was of typical delta alluvial deposits. The bottom of this stratum was marked by a thin layer of white quartz sand at the 41-foot level, which was the beginning of a distinctly different formation, carrying layers of a certain "blue clay" interspersed with other clay and layers of various types of sand and shell fragments—this being the first occurrence of the shells. This formation continued on down to the bottom of the well, a depth of 630 feet.

These men pointed out that the depth of the Gulf on each side of the delta corresponded with the 41-foot level of the well. All along its lower course the river deepens from 150 to 200 feet in places, and in its bed they found the same ocean shells. The supposition of these engineers was that the present river is flowing over the site of an ancient "estuary," its bottom now deeply eroded by the river. Hilgard,[4] in describing it, said:

> It is shown that the delta, or alluvial deposits proper, cover the older formations to a comparatively slight depth only, the river running on paludal [marshy] deposits and then on an ancient sea-bottom of corresponding age, from above New Orleans to near its mouth.

Another more recent authority is cited by Trowbridge,[5, 6] who says:

> The whole of the immediate valley of the river in the driftless area of Wisconsin, Illinois, Minnesota and Iowa, appears to have been cut out since the close of the Tertiary, and there is no evidence that the river existed in Tertiary time. The Pliocene Citronelle formation, the outcrop of which is crossed by the river above Baton Rouge, is not a part of the delta, and was eroded by the river so that it forms the erosional walls of the valley there.

Hilgard[7] long before had pointed out the nature and order of the various deposits in this supposedly old sea-bottom beneath the river. First there was found the very thick strata far beneath the bed of the river consisting of ocean sediments containing marine shells, mingled with land sediments. This, as was later discovered, reached to a depth of 3,000 feet, where a layer of coarse gravel was spread out under the river and delta and well out into the Gulf and under all the north Gulf Coast states.

Much nearer the surface were found other layers of similarly wide extent. These layers constitute the "antecedent bed," the first consisting of coarse sediments, pebbles and gravel mixed with sand and clay, which he called "Orange Sand." Next above came the "Bluff," or "Loess," thought to have been originally a wind-blown deposit brought from the north by the supposed estuarian waters, and spread out over the "Orange Sand." Apparently it fell from the atmosphere *in standing water,* by no means river water. Then followed the fine "Yellow Loam" mixed with clay, which seemed more like the deposit of strait-like waters from the glaciated area, but not by river action.

Each of these layers was laid down evenly and, regardless of topography, at much the same thickness all over the bottom of the supposed "estuary." After these came the formation of the "upper terraces," which was pointed out as of ocean origin, and the "lower terraces," the formation of which was attributed to the river.

The Meaning of the Terraces. Terraces along river valleys are ancient shore lines, or strand lines, originating from two sources: the lower were cut by rivers and occur only in connection with them, sloping with their gradients in every case. The upper, or higher terraces were cut by the ocean and can be traced for the most part around the continents of the world. They follow their own ocean level, independently of the river terraces, around all ocean embayments, and up all river embayments as well, which proves that the ocean was over all so-called "estuarian" river beds.

Hilgard's view regarding the oceanic character of the Mississippi "antecedent" bed receives strong confirmation in the fact that wherever these higher terraces are found in deltas the world over, they lend themselves only to the interpretation of true ocean terraces, but never as river terraces. Had they been formed by gigantic rivers in a past era, *then in connection with them would be found the remnants of gigantic deltas, and these do not exist anywhere in the world.* There are plenty of gigantic sedimentary plains reaching down into the water, but these are not deltas, and cannot be attributed to rivers.

Professor Price[8] recently reviewed the subject of terraces which in all their aspects bear an important relation to Deluge Geology.

Significance of Pebbles Beneath River, Delta, and Gulf. Hilgard[9] described his conceptions of the causes of widespread pebbles and sediments, as follows:

> The great torrent which spread the northern drift is seen to have swept over the southern coast with sufficient force to transport pebbles of five or six ounces in weight [one-third of a pound] from far distant regions, the nearest being Tennessee and Arkansas.

Note the recent confirmation of a much deeper bed of gravel by a later geologist:

> Gravels below New Orleans, thought to be equivalent in age . . . lie at least 3,000 feet below sea-level. . . . Pleistocene glaciation caused streams to carry heavy loads of gravel and other debris, overloading them to such an extent that they anastomosed and spread their coarse deposits widely over the Gulf Coast States.[10]

Another recent authority says of the shallow bed:

> Littlefield, who made a special study of the bars below the mouth of the Arkansas river and found that between 400 and 700 miles below Cairo there was a gravel bar consisting of pebbles as large as 64 mm. [about two and one-half inches] in diameter just downstream from almost every bend, concluded that most of these gravels were locally derived from a valley fill, probably of Pleistocene age. He said, "Below the mouth of the Red River the quantity and size of the pebbles decrease, except where the river crosses the Citronelle formation, and no gravel was found in the lower 150 miles of the river."[11, 12]

This interpretation of a "valley fill" conforms approximately to the findings of Hilgard in the local well at New Orleans, that no gravel was found in the delta, but coarse white quartz sand at a depth of from 38 to 41 feet, and between that and eight inches farther down "chiefly coarse silicious sand, part sharp, mixed with fragments of shells."[13]

Trowbridge, in describing the gravels out in the Gulf off the delta, said:[14]

> The coarsest sediment shown on the map by the oblique lines which lies on the surface of a submarine dome[15] that stands more than 100 feet above its surroundings, did not come to the Gulf through the river, at least not through the river as it is now.[16]

After making every effort to uphold Lyell's view of the depth of the delta, but still expressing doubts, another reputable geologist[17] makes a more recent statement concerning these sediments:

> Even more necessary are further offshore investigations, where the pioneer work of Trowbridge has indicated some of the many problems awaiting solution. Glauconite[18] is said to be present "on the outer steep slope of the Gulf bottom," and coarse sediments cap mounds well beyond the pass mouths on the floor of the Gulf.

Gravel Calls for Water Cataclysm

The utter impossibility of transportation by the river of these great strata of gravel-bearing clay and sand should at once be apparent. Not only is the gradient of the whole valley too slight to admit of it, but our greatest rivers in capacity and power afford no comparison to the magnitude of force, volume and expanse required for such a transcendent accomplishment.

Add to this the phenomenon, impossible to a river, of distinct layeration with each layer composed of its own peculiar grade of sand, the differing layers ranging from the finest to the coarsest, with the interspersion between of other layers of the finest clays—clearly, *overspreading waters* laid down *one kind at a time*, impossible for a river.

Then, capping off the whole series of pre-river formations, is the final overspreading layer of "Yellow Loam," apparently not greatly altered or shifted by the waters. But as though these all were still not convincing enough, the climax of evidence is furnished by the deposits of seashells in the sands and clays of some of these underlying layers. In the face of these astounding facts, Lyell's doctrine of uniformity breaks down completely—and just where it is counted on most heavily.

The gravels and sands are much coarser in the upper regions of the deposits, becoming less coarse as the Gulf is approached. It was perhaps this fact that led the geologists to believe they

were dealing with river action, especially since there is a river there now.

Even Hilgard, whose more acceptable theory of a "great torrent that produced the northern drift" of coarse gravels, shells and landward fragments, and "swept over the southern coast," did not seem to realize that it could not have been river action. A gradient such as that of the Mississippi, at least from Cairo on down to the Gulf, would be utterly insufficient for the task, much less an estuary such as Hilgard postulated, with its opposing force of ocean waters and the tides opposing the river waters.

Nowhere in operation today can be found an example of such a tremendous feat of transportation. Catastrophic action is apparently demanded.

General Humphreys on the foundations Beneath the Mississippi Delta. The long and close personal study given to the river and delta by General Humphreys, with his staff of engineers, and Professor Hilgard and other eminent geologists called in for collaboration, lends great weight and authority to his official findings, more than to those of more widely known geologists who visited the area only briefly.

During their practical labors, Humphreys and his associates observed and identified in many localities the same "Blue Clay" as that discovered in the artesian well at New Orleans. In this well the blue clay first appeared at a depth of 41 feet, and frequently from that depth downward.

Following is General Humphreys' summary of the main facts he offered concerning the Blue Clay and the depth of the delta:

The Blue Clay

Inferences Respecting the Blue Clay and Facts Bearing Upon Its Probable Age.

The facts are very important for they prove either that the peculiar Blue Clay in the bed of the river is alluvial deposit, or that the thickness of the alluvial stratum in the delta region has been greatly overestimated, and that the river is flowing through it in a channel belonging to a geological epoch antecedent to the present. The following data have been collected:

1. *Its physical characteristics.* The clay is quite different in appearance, color, etc., from any deposit now made by the river. As long as it remains wet, it seems nearly insoluble, resisting for years the strong current of the river. If it is thoroughly dried, however, and then again placed in water, it rapidly disintegrates into a powder. The clay itself has a somewhat gritty feel between the teeth and a peculiar taste. It effervesces less with acids than the present deposits of the river, judging by the samples of the latter collected by the survey.

2. *It underlies the Yazoo Bottom* below the greater sand stratum, if we may judge from the fact that it constitutes the bottom of the Yazoo and the Sunflower rivers, as well as that of the Mississippi; and all three are on the same level.

3. *It underlies the Vicksburg Bluff,* which is a Tertiary formation. In this bluff it underlies the stratum which contains marine shell, and which Sir Charles Lyell and Dr. Harper both pronounce Eocene Tertiary; that is, it is the oldest Tertiary stratum. . . . It undoubtedly underlies other of the river bluffs. . . . It is visible only at low water.

4. *It underlies New Orleans* [below 41 feet] in strata alternating with sand and marine shells for at least 630 feet, as shown by the artesian well which was begun in that city in February 1854 and carried to that depth. Dr. N. B. Benedict, recording secretary of the New Orleans Academy of Sciences, in behalf of a committee of that body, of which he was a member, devoted himself to the study of the well, securing samples of every stratum pierced, and otherwise thoroughly investigating the subject. . . . The geological age of the strata pierced is well established, but it is evident that none below the depth of 41 feet from the surface were deposited by the river. The same must be acknowledged in reference to the channel of the river itself, for it is identical in character with the sample of the very last stratum, which was presented for comparison by Dr. Benedict. . . . [Here follows the log of the well as prepared by the Academy.]

5. *It crops out under sandstone on the east coast of Texas.* Mr. A. M. Lee, of Knoxville, Tennessee, an engineer of high scientific attainments, formerly of the army, states that this identical clay with which he is familiar, crops out under calcareous sandstone at a depth of 24 feet below the level of the Gulf at Aranas Bay and Lagune Madre on the coast of Texas.

6. *It possibly underlies the Estacado.* (A well was drilled by Capt. John Pope, Topographical Engineer). . . . The close analogy between the physical characteristics of such a formation and that underlying the Vicksburg Bluff, together with the similarity of the supposed geological ages, suggest that they may be identical. . . .

7. *Found in the Missouri River Valley.* Lieutenant S. K. Warren, Topographical Engineer, states that this peculiar Blue Clay very closely resembles a formation which covers a great area in the immediate valley

of the Missouri east of the Black Hills. His geological assistant, Dr. Hayden, assigns a place for this formation near the middle Cretaceous, and describes it as follows: "Bluish and dark-gray plastic clays, containing *Naubilus De Kayi, Ammonites placenta, Baculites ovatus,* and *B. compussus,* with numerous other marine molusca . . . remains of *Mosasauras.* Thickness 350 feet." . . .[19]

Gulf Depth Compared. Humphreys, in a letter to Colonel Theodore Lyman, well summarized his data, saying:

> There can be no misapprehension as to the identity of the clay found below the depth of 41 feet in the artesian well with that in the bluffs at Columbus, Vicksburg, etc., and in the bed and channel-way of the river. There is an unmistakable difference between this clay and that deposited by the river. . . . Further, the original depth of the Gulf of 41 feet at New Orleans is at least as great as that of the Gulf off the coast of Alabama and Mississippi, where the sandy bottom indicates that the original marine bottom has not been covered with the mud of the Mississippi river.[20]

He then refers to maps published in his Professional Paper 13, herein frequently quoted from. These maps give the contours drawn from extensive soundings by the U. S. Coast Survey, showing that there is no reason for supposing the bottom of the delta to be any deeper than the bottom of the Gulf on each side where no river sediments have been deposited upon it.

> Concerning this point, he wrote to Sir Charles Lyell, as follows:
>
> When I came here in the fall of 1850, I was familiar with your views upon the subject, but I could not accept them. There was no instance on the whole Tertiary coast of the United States of a sound, or bayou inlet of a sea, with the great depth which you assigned to the ancient sound into which the Mississippi river originally emptied. Nor was there anything in the form and character of the adjacent coast and country to render such an original depth probable.[21]

The coast country is low and flat.

Portales' Report of the Coast Survey. Portales, a leading authority on shore and ocean geology, dredged samples of the clay formation from the bottom of the lower part of the river and delta from Carrolton to the mouth. These contained, besides the characteristic clay, corals and marine shells in abundance. In the summary of his report to General Humphreys, he said:

> The most general conclusion which can be drawn from this examination is the confirmation of your opinion that the bed of the river is not composed of recent alluvium, or in other words, that the river has not contributed to any considerable extent to the formation of its bed in the localities examined, but in flowing over a former sea-bottom.[22]

Of the peculiar clay beneath the river and delta, (after over 30 more years of research,) Hilgard says: "This is called the 'Blue Delta Clay' by Humphreys and Abbott; it will here be called Port Hudson Clay, because it is entirely independent of the modern delta formation built up by the river."[23]

Again, at this late date, 1912, speaking of the formations below the Blue Clay, he said: "But these formations, as well as the Port Hudson Clay, have nothing to do with the present problems of the delta, beyond serving *as the floor on which it is built forward.* The depth of the sands and silts of the true delta is from 30 to 40 feet, and rarely reaches 60 feet." Elsewhere in the same paper he said:

> As is well known, a continual shelf covered by a comparatively shallow depth of water, runs out for 30 miles beyond the present mouth of the river, then breaks off into the deep waters of the Gulf. The original stratum of this shelf is the Port Hudson Clay, (the "Blue Clay" of Humphreys and Abbott): but this is now coming to be gradually covered with the delta deposits and river sediments.

Later Views vs. Undisturbed Original Facts

The old controversy still has not come to an end. But the basic facts supporting these older views are still acknowledged to a surprising degree, though interpretations may vary. A study of the late literature discloses that many of the detailed data and thorough observations which determined and supported the older views are now seldom considered. They are lost or ignored beneath the weight of standard geological doctrines that postulate the very slow but continuous general upheaval and subsidence together with other features of uniformitarianism.

Forty years after the appearance of the Humphreys-Abbott report, even as late as 1912, Hilgard, then at the University of California, and still the leading authority on the Mississippi delta, noted that the well-established facts which he and Humphreys had patiently established were being ignored by later men, regardless of the absence of anything new by way of refutation of the original conclusions. Even today their careful and accurate report seems to be among the most valuable of all geological contributions to the subject.

That some still hold to the old view that the river cut its channel through a Tertiary sea-bed

is shown by the short statement by Mr. Trowbridge[24] given previously and here repeated: "The whole of the immediate valley of the Mississippi river in the Driftless Area of Wisconsin, Illinois, Minnesota, and Iowa, appears to have been cut since the close of the Tertiary, *and there is no evidence that the river existed in Tertiary time.*" He continues, stating that this condition extended down approximately to Baton Rouge. Here, he says, the delta begins, and "does not, as many textbooks teach, extend up to the mouth of the Ohio river and include all of the Tertiary formations of the Mississippi embayment."

Another view, almost opposite to this, yet bearing out some of the main fundamentals of the older view, was expressed as late as 1941. As these late geologists view the size of the delta, instead of its being from 12,500 to 12,600 square miles in area as originally estimated by Lyell, Hilgard, Humphreys, and others, the position is taken that it "extends from Louisiana to central Texas," and begins in southeastern Missouri, progressing 600 miles southward. They say: "More than 200,000 square miles have been filled by the river to depths ranging from something over 100 to more than 12,000 feet; and the river has probably been working several million years to make the deposits."[25]

Yet continuing they make the following statement as to the character of the bed on which the river flows, which, after all, is basically not far from the older views: "The 200,000 square miles of the landward part of the delta was once all sub-oceanic, so that, in drilling wells through the delta sediments, most of the material encountered were deposits below the sea. This is determined by fragments of sea shells found in well cuttings."

As to the depth of the river sediments, they wrote:

> In drilling wells for oil or water in the delta, drills cut through a few feet to possibly 100 feet of sand and clay deposited above the ocean level. Below this are found a few feet deposited in shallow water, and below that a few thousand feet of clay and fine sand deposited far from shore.

The "100 feet deep of sand and clay" coincides with the Hilgard-Humphreys report that the delta is 100 feet deep at the outer part. But that it is "deposited above the ocean level" is questioned, especially if applied anywhere on the real delta, because at its highest point up river it is not over 15 or 20 feet above sealevel and less than that in its lower parts, most of it being only five feet or less.

In this report, however, the distinct identity of the bottom of the real delta and the original bottom of the Gulf can be easily seen; though why these geologists should add to the deeper "few thousand feet of clay and fine sand" the words, "deposited far from shore," is not apparent. *Such materials are certainly not being deposited now in any sea "far from shore,"* a fact to which authorities on shore deposits abundantly testify.

Thus we see that Benson and Tarr, while extending the delta to such extreme widths, still constructively admit that it is as shallow as reported by the Humphreys group. Trowbridge, on the other hand, while still clinging to the excessive depth advocated by Lyell, flatly disagrees with Benson and Tarr as to the wide extent of the delta. He would narrow it down even more than the original workers.

Though holding opposite opinions on these vital points, these men all agree to excessive age-estimate of the delta involving many millions of years, *and use opposing arguments to sustain it.* Yet none of them offer any newly discovered facts of importance; and no facts at all that in any way invalidate the careful work of those earlier geologists, but they ignore many basic facts upsetting to their theory.

It would seem that the late opinions are governed more by the standard doctrines of uniformity than by any new supporting evidence. The original position of the Humphreys group, the only one ever held with any unanimity, is still apparently the only logical position to hold, as all subsequent discoveries, though meager, seem to harmonize with it.

Dana,[26] also one of the former generation of geologists, demonstrates that the Mississippi river alone, with its generally agreed sedimentary load of 1/2600 of the bulk of its water, *could fill the whole Gulf of Mexico with silt in only 10,400,000* years. And this period is not far from the figure vaguely intimated for the delta alone by these later and more doctrinaire geologists than Dana.

Benson and Tarr, as well as Russell and Russell, and also Trowbridge, take the position that the 30 to 100 foot delta of Humphreys, Abbott, and Hilgard is only the "top-set bed" of the real delta, that is, only that part laid down above the ocean water by river overflow. Subsidence, they say, enables a delta to grow downward hundreds of times faster than upward.

But, if the delta "has been working several million years to make the deposits," as they claim, why is not this top layer hundreds of times thicker than the bottom layers? Why does it not constitute almost the whole supposed thousands of feet, since only in the original shallow depth of the Gulf shore there could form the bottom-set and fore-set beds?[27] This position thus breaks down under mere logic.

It has become clear that the general theory of deltaic subsidence is the most important ob-

stacle to establishing the age of any delta. If true, especially would this apparently forbid the possibility of any two or more rivers being the same age. Lyell insisted that the necessary variation in the rate or amounts of subsidence of different deltas renders any general coincidence in the age of the rivers of the world utterly impossible.[28]

The Significance of Deltaic Subsidence

All geologists assume that deltas subside, but they do not agree as to the cause or extent of that subsidence. The main issue is the question of whether the sediments merely settle into more compact form, or the crust of the earth itself actually gives way beneath their weight, or whether both occur.

Obviously, this question is most fundamental, especially in its relation to the depth of deltas. Therefore, because it is so vital in calculating delta age, it has been reserved to the last.

In discussing the general features of the problem, certain questions naturally present themselves. (1) How is the basis of the theory of deltaic subsidence related to uniformitarianism, and how is it applied to the Mississippi delta? (2) What is the relation of the ocean and river terraces to the supposed subsidence of the Mississippi delta, and do they prove the general theory? (3) Does the supposed deep trough or syncline beneath the Mississippi delta agree with field observations, and with the principles of geophysics involved? (4) Does the relative thickness of the beds of deltas, as compared with that of the beds beneath them, indicate that such subsidence has occurred? (5) Are local earthquakes which are accompanied by sinking of land proof of the general subsidence theory? (6) Do the facts from coal deposits sustain the theory that coal was formed in subsiding delta swamps? (7) Can lava flows and extensive erosion cause lands to sink or to rise, or, do the observed conditions defeat the theory of current subsidence and upheaval?

Though to the lay reader these questions may seem extraneous to the main subject and objectives, it will soon become apparent that they go to the most vital parts of the whole problem of the geologic age of the Mississippi delta and other deltas. Nearly all of the data are from the Mississippi delta, and the remainder are pertinent and necessary in establishing the broad general principles of *a long-needed science of delta formation,* on which to base age estimates of the Mississippi river and other rivers of the world.

The Basis and Implications of the Theory. The general theory of crustal deformation is based on the supposition that vaguely-defined forces beneath and upon the surface of the earth are continuously exerted to cause changes of level, both of subsidence and emergence. Excepting the work of erosion, these forces are credited with producting the continents, the islands, the mountains, the valleys, and also all irregularities of surface under water.

Almost infinitely slow movements, acting through eons of time, are postulated, though certain movements are supposed to be more rapid than others. This is the principal feature of the doctrine of uniformity and one of the main supports of the theory of geological evolution. But it is very vague and vulnerable to attack.

As applied to deltas, it teaches that the crust of the earth is depressed or bent downward by the weight of the increasing delta sediments. The accumulating sediments in all basins are supposed to be depressing the bottoms of these basins so as to make room for more and more of the sediments.

The theory teaches that deltas grow downward hundreds of times faster than upward, and that after a billion or more years an extremely thick bed of deltaic sediments results. This body of sediments is called a "lens," because it is supposed to be very much thicker in the central portion than around the edges.

Typical uniformitarian views are expressed by Russell and Russell[29] as follows: "Louisiana and the adjacent areas in Texas and Mississippi have been the theater of deltaic sedimentation for such a long period of time that it is impractical, if not impossible, to assign either date or stratum of rock as marking the beginning of Mississippi river history."

Every sedimentary layer from the surface down to an unknown depth where there is no more mingling of ocean fossils with land fossils, they conceive to be the work of delta-sedimentation. Describing it, they say: "The geo-syncline[30] presumably has been increasing in depth, and the base of the Tertiary is thought to lie possibly as deep as 30,000 to 40,000 feet in the vicinity of New Orleans." Clearly, these men out-Lyell Lyell, doubtless who would have been pleased to know of such a vast increase in the estimated depth of the delta, and therefore of its age.

The Evidence of the Terraces. These men report that in the central part of the state of Louisiana, certain of the highest ocean terraces above the alluvial plain of the river slope slightly more than do the lower terraces along the river. They stress this fact in support of their theory, reasoning that in the immense lapse of time between the making of these two sets of terraces, the delta subsided enough to cause this difference, which is only from one to two or three feet per mile.

These isolated terraces are more than 100 miles from the delta and many miles from the river itself, toward the west on the edge of rising land.

It would seem that they are too far distant from the delta to bear any particular relation to it.

Professor Price has shown that these upper terraces were not formed by the river at all, as were the lower terraces, but by the ocean itself before the river existed.[31] This view was originally brought out in detail by Hilgard, in presenting his evidence of the supposed estuary of pre-river history; and he voiced the opinion of the entire Humphreys group.

Price suggests that all of the ancient ocean beaches may have been only very temporary, the result of a brief halt in the general withdrawal of the oceans from the lands; or that each of these strand lines might have been cut by a single storm. The depth of the ancient beaches cut by the waters is only trivial compared to modern beaches, and this is generally true the world over.

He also offers and approves the generally accepted view that because these ancient strand lines as a whole have the same elevation above the oceans all the world over, they mark retrogressive stages by which the oceans, due to some general or very large subsidence somewhere on the ocean floor, sank to their present level. He suggests that the occasional local and irregular tilting of these old ocean beach lines may indicate that while parts of the ocean floor were then undergoing final adjustments, *so also were parts of the land.* Indeed this would be seemingly inevitable.

From the viewpoint of the student of Deluge Geology, these ocean terraces were apparently cut while the sediments were freshly deposited. The sediments were especially deep towards the Gulf where they would settle the most. Therefore, if not disturbed, they might naturally have tilted somewhat in that direction. No doubt there might be found some of these irregular lines that show a northward slope.

The ocean terraces often are locally tilted in other parts of the world. In any case, no dependence can be placed in them to shed light on the subsequent formation of the delta. They are too far away from the delta. Besides, the greatest degree of tilting claimed is not worth considering by comparison with the extreme tilting that would be indicated if caused by the enormous delta subsidence (30,000 to 40,000 feet) which these men postulate.

Russell and Russell further insist:[32] "Evidences of subsidence are so overwhelming in the lower parts of the delta, and agree so closely with the hypothesis that subsidence is the result of sedimentary loading, that escape from the idea that deltaic sedimentation is the most potent factor in the Gulf Coast disastrophism[33] seems impossible."

They describe the subsidence of Indian mounds, buildings, streets, and other landmarks, and sum up as follows: "Survey markers near the mouths of the most active passes[34] subside at the rate of nearly eight feet a century. Twenty miles inland the rate is about two feet a century."

The facts here brought out are all granted, but they appear directly against the theory propounded. *They merely indicate that the fresher, softer, and deeper the sediments are, the more and faster they settle.*

The Geophysics of Subsidence. According to this theory of delta subsidence, not only the immediate site of deposition settles, but the weight of the delta supposedly depresses the crust of the earth in the whole surrounding region, carrying down with it the entire delta and vicinity. The crust of the earth is supposed to be rigid enough to cause this.

Geologists point to certain lakes and embayments on the far flanks of deltas, affirming that these were carried downward by the regional subsidence of the deltas. From the principles of geo-physics, the most rapid subsidence should be *beneath the center of gravity of the delta as a whole.* From this point the subsidence should be less in all directions. This is the theory of the formation of the geo-syncline or deepening trough through the continuous deposit of sediments.

But as a matter of fact, the actual subsidence is *most rapid in whatever portion of the delta the deposition happens, for the time being, to be greatest.* Such locations may be many, and the areas of deposition may vary in size, and shift about widely from time to time, each perhaps sinking at a different and changing rate. These facts, seemingly so fatal to the modern interpretation of deltaic subsidence, are ignored by proponents of the theory.

Inasmuch as the theory of deltaic subsidence is thus lacking in the proper geo-physical behavior essential to the theory, the existence of these lakes and bays can be attributed just as well to other causes. Now, as always, they occupy delta areas farthest from the river and have been least affected by sedimentation. River overflows lose most of their sediments within a mile or two after leaving the river. It would seem, therefore, that they merely have not as yet been filled up, or that sedimentation is too slow or has not as yet been sufficient to overcome the local settling of the sediments they have received.

The theory of the deltaic geo-syncline demands a downward dip on all sides toward the delta to indicate the 30,000 to 40,000 feet of thickness claimed for deltaic material by Russell and Russell, the present leading proponents of the theory. If Trowbridge's claim be allowed of a small delta area of about 150 miles long by 50 or 60 miles

wide, this great depth within such a small area would call for the strata to dip at an extremely steep angle, causing a syncline that would be nothing but a deep sinkhole.

But though these same authorities are also leading oil geologists and as such would never think of drilling into a syncline for oil, and though their sole purpose in recent studies of the delta region has been to understand the relation of modern river deltas to the formation of oil, and though oil is now being produced from beneath parts of the delta, yet, not one stratum has been reported from those wells as actually indicating any syncline.

There is also another very significant fact that stands squarely in the way of this theory. The famous "Blue Clay" that underlies the delta and the Mississippi river above for several hundred miles, instead of dipping steeply underneath the delta as called for by the syncline theory, follows the present Gulf bottom gradient without deviation or break all the way underneath the delta and all the surrounding regions.

Shallowness of Deltas Misinterpreted as Subsiding Top-set Beds. Bear in mind how the capping of all of these supposedly deep beds with only the thin top layer from 20 to 100 feet thick is utterly inconsistent with the "deep delta" theory. These men hold that this cap is the top-set bed, the bed formed above the level of the Gulf after the delta had emerged from the ocean, *formed by river overflows on land.*

Their theory is that, as it thus formed, it was gradually lowered by regional subsidence. But they say the many thousands of feet of deltaic sediments below it were laid down *under water,* (some say, "far from land"). Now the thing that seems to defeat this theory is *the thousand-fold thickness of those underlying beds as compared to the supposed top layer.* If this top layer has been growing thicker and pressing down the delta for millions of years, *why is it so remarkably thin as compared to the beds below it?*

Could the bottom beds be also thousands of times thicker, by subsidence, than the depth of the Gulf at the site of the delta? In other words, how could beds 30,000 to 40,000 feet thick be laid down in water only 20 to 60 feet deep?

It would seem, also, that the up-river part of the delta, that nearest the original shore, *the oldest part,* in that case, *should have the deepest top layer,* under the theory, *instead of the shallowest, because it has had the longest period above water.* Therefore, logic alone seems to defeat this theory. How does it happen that this supposed top layer is so thin *in all deltas* as compared to the thickness of the theoretically deep deltaic beds below them?

The marvel of geologists (from their viewpoint) is this extreme shallowness of deltas, or what some presume to be the top layer only. It is little wonder that some of them have invented the theory that these thin deltas are only the top-set beds of the supposedly very deep deltas which supposedly "have grown hundreds of times faster downward," by subsidence of the crust of the earth by the mere weight of the sediments. On the shallowness of the deltas, in flat denial of this theory, the following statement is by perhaps the leading authority on the origin of sedimentary strata:

> The depth of delta deposits on modern sea coasts varies greatly, but is, on the whole, comparatively slight. Thus the mud of the Nile delta is not over 10 to 15 meters thick. It rests on loose sand. The delta deposits of the Rhine have a thickness of 60 meters, those of the Rhone over 100 meters. In the Po the depth average is 122 meters, though near Venice 172.5 meters were penetrated without reaching bottom. The delta deposits of the Ganges and Bramaputra rest on the older sediments and average only 20 meters in thickness. The actual delta deposits of the Mississippi range from 9.5 to 16 meters at New Orleans, increasing to 30 meters at the head of the passes.[35]

It is suggested by a co-worker that, inasmuch as deltaic sediments are mostly laid down under water, and therefore displace the water, their downward pressure is thereby so greatly reduced that little weight is left to exert pressure on the bottom. Such sediments being of very light material anyway, he says the added weight is so small that the theory of deltaic subsidence is rendered all the more untenable.

The terms of the theory of deltaic subsidence counteract this suggestion largely, however, by the postulation that, through millions of years, sediments many times deeper than the water have gradually subsided, and that, by comparison, the weight of the water is now insignificant. Besides, the claim is made that, after the delta is built up and becomes land, still the subsidence continues by the deposit of alluvium from river overflow. However, suggestions like this are helpful, because, in discussing them, added light is thrown on the subject.

"The Legerdemain of Local Upheavals." Trowbridge, strange to say, he being an advocate of the general subsidence theory, very logically rejects general subsidence as applied to the Mississippi delta. He writes as follows:[36]

> The total amount and rate of settling have not been determined. The settling is probably due to the compacting of the underlying sediments, rather than to disastrophic[37] subsidence of the delta as a whole, and to superficial drainage and decay of vegetable matter.

So many opposing views existing among these recent delta authorities, reveal a weakness in their theory, and invoke most favorable impressions of the Humphreys group, the only set of workers yet to agree on a mutual interpretation of all the basic facts.

Earthquakes in river valleys which were accompanied by some subsidence, and at least one such occurrence in a delta, have often been strongly urged as examples of subsidence caused by sedimentation. A small area just above the delta of the Indus subsided slightly on the occasion of an earthquake.

Another example was the New Madrid earthquake in the Mississippi valley in 1912, though this was some hundreds of miles above the delta. Geologists who endeavor to use such occurrences in support of the subsidence theory seem to forget that deltas and river valleys are no more subject to such phenomena than most any other part of the earth.

Hilgard, in his report to General Humphreys, criticises this theory thus:

> Much has been said of the possible effects of earthquakes which so frequently startle, for a moment, the inhabitants of the Mississippi valey; and it is more than likely that the record of such events as those of New Madrid and Reelfoot lake will be found stamped on many dislocated strata hereafter. But there is a wide difference between such effects and the legerdemain machinery of "local upheavals" which is so readily resorted to by amateurs for the explanation of any unusual phenomenon.[38]

Though there is little likelihood that this was intended as applying to Lyell, yet Lyell was perhaps the originator of the application of these particular earthquakes to the theory of delta subsidence, if not the original proponent of the theory itself. He strongly contended that delta subsidence rendered impossible the accurate estimation of the age of any delta, and for this reason he especially opposed the idea that the rivers of the world could be of the same age.

Deltaic Subsidence and the Swamp Theory of the Origin of Coal. In support of the general theory of subsidence or changes in level as applied to deltas, the theory is frequently urged that coal was formed in deltaic swamps or where marine remains are present in estuary swamps.

Not only is coal presumed to have been formed in deltas, as a consequence of their gradual subsidence, but coal formation is also pointed to as proof of the general subsidence theory of deltas. It is used both as proof and as the thing to be proven. Therefore a brief examination of the facts about coal formation and deltas is necessary, and doubly profitable. Coal theories are so closely connected with the whole subject of delta formation that *no adequate conception of the problems and principles of deltas is possible without putting those theories to the test and proving that they are false.*

The veins or seams of coal are said to be buried and carbonized remains of vegetable swamp-mud, principally of timber or other vegetation that has grown in swamps which later have become sunken, and been buried where it grew by deposition of silt; after which other growth has appeared and in its turn been sunken and buried, and so on, endlessly, the process repeating through millions of years on end. Accumulation of vegetation sufficient to produce a single vein of ordinary thickness is supposed to have required a long geologic period.

The kinds of vegetation, so far as identified, that have been converted into coal, in supposed estuarian swamps, are the same, generally speaking, as those found in coal fields of supposed deltaic swamps. This means, if this coal-origin theory be true, that the plants which grew in brackish, or saline environment, *are the same kind as plants which grew in fresh water swamps.* Yet today with few exceptions, plants grow only in either one or the other of these two opposing environments, *but not in both. The same is true of fish life.*

Of course, in an ocean delta all degrees of salinity may be found, depending on whether river or ocean water locally predominates. These conditions might change from time to time. But in a coal-mining area, such fluctuations seldom, if ever, occur. At times, fossil deposits known to have come from the deepest parts of the ocean are found interlayered with coal. Frequently coal is interlayered with coarse gravel, and often with coarser conglomerate. Even large rocks, called "erratics," sometimes appear.

Yet no delta in the world today contains any sediment coarser than sand. It should be apparent that all of these conditions not only point away from the deltaic and swamp theory of the origin of coal, but especially oppose the estuarian origin of coal formation.

Sometimes, protruding up through many layers of sediment (representing, so they say, as many geological ages) tall trees, petrified or carbonized, have been found, some in upright position, but most of them oddly slanting.[39] Such trees may appear with tops that have not suffered from weather, wear, or decay, any more than their root ends, before being transformed into their present state. Because of this phenomenon, geologists hesitate about assigning to the layers of these particular formations the millions of years they habitually assign to layers elsewhere exactly the same except for the position of the fossil trees.

In a supposed coal-bearing swamp thus silted up many feet deep, always deeply enough to bury standing trees, why should not large numbers of trees be found in a standing position? Why are they practically all prone as though having drifted to the location? (And bear in mind that this discussion omits consideration of the coal beds themselves.) These questions are still unanswered.

A single coal deposit consisting of many seams, one above another, contains almost exactly the same kinds of plants throughout, *even to the outer edges.* But in the natural swamp forest today, the kinds of plants vary from time to time, not only as to kind, but as to location in the swamp, and may change almost completely within a man's lifetime. Moreover, as to location, they may differ in kind from place to place in the area, especially from the center toward the outer edges.

This leads to the next question: How could a swamp subside at the exact rate necessary for the growth of almost identically the same kinds of plants throughout the entire area of the swamp, and do this while it was passing through changes constantly for millions of years? And how could a single standing tree be found extending up through them all?

Of the few instances where coal and peat have been found beneath deltas, Lyell and others have made the most in an effort to bolster up their theory.[40] But they ignore the fact that coal and peat are found also, and much more abundantly, under the rivers themselves farther upstream, and under other rivers and even in far distant hills and mountains, having no relation either to rivers or deltas.

Furthermore, the apparent insincerity of the claim that coal is a deltaic swamp product, or the product of any other kind of swamp, is revealed by the fact that there appears to be no record of any modern delta or swamp having produced coal, *or ever having even been prospected for coal.* Why should not *at least a few such swamps* be still in process, with many rich beds of coal beneath as the finished product?

In concluding this discussion on coal and deltas, a sample statement is in order from those who aver the delta-swamp theory, to illustrate the attitude which they take (but also to show their agreement with the writer on the recent age of two great deltas):

> The Ganges annually carries across its delta to the sea sufficient sediment to cover one square mile 221 feet deep; the Mississippi annually discharges into the Gulf of Mexico sufficient to cover one square mile 268 feet deep. Apply these figures to the hypothetical case, and assuming that one half of the discharge goes to make forest beds by which the delta is built outward, it is seen that the Ganges would completely reclaim this area in 4,524 years and the Mississippi in 3,730 years. These, however, are two of the greatest rivers. But even if the Carboniferous rivers [the supposed Carboniferous geologic age], discharging across the region of the Appalachian coal fields, delivered but one tenth part of the detritus borne to the sea by the Ganges and the Mississippi, it is seen that the transgressive effect of the supposed subsidence would be completely nullified in periods of 45,240 and 37,300 years.[41]

In other words, Dr. Barrell is so sure that subsidence exactly keeps pace with deposit that he depends upon subsidence to be in exact proportion to the deposit. This is the essence of the doctrine as applied to coal formation. Hence, he infers that, if the supposed carboniferous-age rivers maintaining the great Appalachian coal-making swamps were only one tenth of the size of the two large rivers which he names, those ancient deltas would require just ten times as long to subside an equal amount, thus exactly keeping pace with deposit. But the whole theory has been shown to be untenable by abundant data.

For these and many other reasons, the idea that coal is a delta product and therefore affords proof for the subsidence theory is rejected. European geologists, as a rule, do not hold the swamp theory of coal-formation.

Lava Flows as a Factor in Surface Depression. There are many hundreds of square miles of lava flows in the world, some of them many thousands of feet thick. The lava habitually sought out and flowed down valleys, often over sedimentary deposits of great thickness. But although lava is a great deal heavier than sediments of any kind, especially deltaic material, in no case did it cause subsidence, at least not enough to be reported by geologists.

Why do we not have huge geosynclines of lava layers? The fact is that geologists, in view of their firmly held crustal depression theory, have long marvelled that lava has not depressed the crust of the earth.

As an explanation of this paradox, leading authorities offer the argument that since the lava flow is the result of expansion from beneath, there is no actual addition of load to the earth's crust. This may be granted, but it would seem that the very expansion of the underlying material would render it all the more susceptible to the compression demanded by this theory of depression.

The question still persists. Why may ordinary sediments depress the earth's surface, and yet lava, which is many times heavier, even though

it buries these sediments by many thousands of feet, fail to add weight sufficient to cause such depressions?

Again, lava has been known in many instances to flow with great thickness farther than the length of any river delta in the world. In these cases, the transported lava did not represent any expansion of the underlying material, but was an actual addition to the weight upon the crust where it accumulated. Yet no subsidence from this cause has ever been reported.

Thus the contention that crustal subsidence is the result of transfer of sediments from one part of the earth to another, in which river flow is dintinguished from lava flow, is without foundation. This subject is given a typical geological discussion by Dr. Charles M. Nevin,[42] who takes the usual viewpoint, but who admits there must be something wrong somewhere.

If overloading is the cause of subsidence, then it stands to reason that a condition the reverse of overloading would give a result the reverse of depression, namely, elevation. All geologists admit that the large valleys were formed by erosion. The amount of material eroded out must have been many times greater in weight than that composing deltas. Yet, admitedly, in no case has appreciable elevation resulted from loss of load, another enigma to uniformitarians. Nevins admits this also.

These same geologists who contend so strongly for depression of the crust of the earth by deltaic overloading, admit that many individual mountains standing apart exist as separate units "by reason of rigidity of the earth's crust" to use Nevin's words. Would it not seem rather queer, then, that a few feet of vegetable swamp mud, *nature's lightest sediment*, should be so potent?

Summary of Delta Subsidence. Seven lines of evidence have been introduced which apparently disprove the theory that delta sediments depress the crust of the earth:

1. The argument drawn from the slight slope towards the Gulf of some of the upper terraces in central Louisiana is nullified by the fact that these are not river terraces, but ocean terraces having no relation to the delta as such, but maintaining in general a constant level all over the world. Other reasonable causes are assigned for occasional irregular local tilting. Even if they were river terraces they are too distant to be depended upon as guides in delta subsidence. Such isolated cases would require multiplying a hundredfold to provide evidence for the 30,000 to 40,000 feet as claimed.

2. The true principles of geo-physics would require greater subsidence at the center of gravity in the delta as a whole than at other points, whereas actually deltas are found to settle most rapidly at any point where fresh sediments at the time are being deposited.

3. Though recent geological opinion affirms that the Mississippi delta lies in a deep trough, or geo-syncline, yet the Blue Clay that has been shown to underlie the whole delta, in no instance dips to accommodate such a geo-syncline. Moreover, the drilling of many oil wells throughout the whole region reveals no strata that indicate such a structure.

4. Earthquakes, as a cause of subsidence, are ruled out, being no more frequent in river deltas and alluvial lands than elsewhere; one case only having been reported, that of the Indus.

5. Every attempt to prove that coal formation demands conditions afforded by the theoretically subsiding modern delta or estuary is apparently frustrated by numerous facts regarding coal that disprove the swamp-coal theory, and the subsidence theory as well.

6. Lava flows apparently block the general theory of local flexibility of the earth's crust. Though much heavier than delta sediments, lava flows do not depress even the sediments, much less the crust of the earth.

7. Conversely, no erosion has been enormous enough to relieve the internal pressure sufficiently for the crust to rise; and large outlying mountains are admittedly dependent for their existence on the rigidity of the earth's crust.

In view of the foregoing facts, the theory of general subsidence will be disregarded in the present paper in calculating the age of the delta of the Mississippi river or the age of the delta of any other river.

The Age of the Mississippi Delta

Having thus made clear the main issues in the controversy, the way is now open to deal directly with the mathematics of the age of the Mississippi delta.

Sir Charles Lyell's Estimate. Sir Charles Lyell's own account of his calculations on the delta's depth and age follows in part:[43]

> When I visited New Orleans in February, 1846, I found that Dr. Riddell had made numerous experiments to ascertain the proportion of the sediment contained in the waters of the Mississippi; and he concluded that the mean annual amount of solid matter was to the water as 1/1245 in weight, or about 1/3000 in volume. From the observations of the same gentleman, and those of Dr. Carpenter and those of Mr. Forshey, our eminent engineer, the average width, depth, and velocity of the Mississippi, and thence the mean annual discharge of water, were deduced. I assumed 528 feet, or a tenth of a mile, as the probable thickness of the de-

> posit of mud and sand in the delta; founding my conjecture chiefly on the depth of the Gulf between the southern point of Florida and Belize (a city on the lower delta), which equals an average of 100 fathoms, and partly on some borings 600 feet deep in the delta at New Orleans, in which the bottom of the alluvial matter had not been reached. The area of the delta being 13,600 square miles, and the quantity of solid matter annually brought down by the river being 3,702,758,400 cubic feet, it must have taken 67,000 years for the formation of the whole, and if the alluvial matter of the flood-plain above the delta be 264 feet deep, or half that of the delta, it might have required 33,500 years more for its accumulation, even if its area be estimated as only half that of the delta, whereas it is in fact, larger.[44]

Lyell later accepted a slightly higher annual water discharge from Mr. Forshey, the engineer, which, as Lyell said, "would diminish by one eleventh the number of years required to accomplish the task alluded to." This reduces his estimate of the age of the delta to 60,910 years.

The writer questions Lyell's assumption of 528 feet as the depth of the delta, because, **first:** In the log of the well at New Orleans, at this depth there occurred no change in fossils or other materials from those immediately preceding, and there was nothing at 528 feet to mark the termination of a stratum. On the other hand, the sediment at that depth was decidedly different from that above the 41-foot level, *which did very definitely mark a geologic horizon* both in fossils and in the character of inorganic materials.

Second: the method followed by Lyell involves a great inconsistency. In selecting an average depth, he takes the average depth from the delta to the tip of Florida, which takes in the deepest part of the Gulf, running to 946 feet,* and takes no account of the shallow waters that lie along the shore on the site of the delta. Why should he do that? Besides, the bottom of the formation not having been reached at the bottom of the well at New Orleans, the choice of even the bottom would have been illogical.

Much more accurate and reasonable appears to have been the method of Humphreys in plotting on his map (published in his Professional Paper 13, already referred to) the contours of the whole Gulf, and then choosing the depth along the coast on each side of the delta corresponding in distance with the delta from the general shore line. This Humphreys found to be approximately 40 feet for the middle part, but 100 feet for the outer edge.

Third: Lyell's position that the delta could not start till the river had filled up its flood-plains is seemingly not tenable, as the river is still filling up its flood-plains though it has built its delta; and this is true of all rivers with flood-plains and deltas. Therefore his call for a separate period for that purpose, though seemingly plausible, cannot be granted.

Hilgard on the Depth of the Delta. Lyell had not only challenged in Humphrey's former report the statement that "the river is flowing through the delta region in a channel belonging to a geological epoch antecedent to the present," but also had suggested that the log of the New Orleans well be examined by a competent geological observer, not having made such examination himself, apparently having seen only the written account of the log drawn up by non-geologists of the local Academy of Science. General Humphreys, therefore, appointed Professor Hilgard, state geologist of Louisiana, to make the investigation.

But the Civil war interfered and Hilgard's report was not published till 1868. From that report is taken the following statement: "The annual, or in a sense the rather mensual floods of the river ought to cause a much more frequent alteration and change in the character of the deposits than is actually found, especially in the lower portion of the profile."[45] He further reports that an occasional fragment of decomposed or partly lignitized wood is found in the deposits below 41 feet, but that the true river sediments above that depth besides having the larger fragments, are permeated with fine crumbs or grindings of wood, by the wear of the river.

Thus Hilgard points out that the *extreme thickness of the layers below the 41-foot level is incompatable with river action,* and that this view is further supported by the difference in wood fragments, none ground fine by river action appearing below the 41-foot level. In this connection he says:

> Sir Charles Lyell still inclines in a measure to the opinion that the strata penetrated in the New Orleans well may be delta deposits. This supposition, however, appears to be incompatible, not only with what we already know of the general geology and geological history of the lower Mississippi valley (as shown in former papers), but with the character of the strata themselves. *They are altogether too prevalently of a marine character, so far as examined.*[46]

The same opinion is given by Trowbridge.[47] He and others admit that the layers beneath the 41-foot level are to a large extent contemporaneous with the shellfish living today in the Gulf.

*Note by Clifford L. Burdick: Allen says the deepest part of the gulf is 916 feet (measuring, I assume, on a straight line from the delta of the river to the southern tip of Mexico). Actually, it is nearer to 7,000 feet.

Many authorities place these shells back in the Pliocene; but Hilgard, in his table, comparing the shells found below 41 feet at New Orleans with those thought to be of the Pliocene and post-Pliocene on the coast of South Carolina, and comparing these both with those now living in the Gulf, says that for the most part these shells are apparently of one series.

He makes the astonishing statement:[48] "Moreover, not only the leading shells of the New Orleans strata, but the *entire list*, excepting the new species, might be picked up in an hour's time on the beach of any of the islands of the Mississippi Sound." One would conclude that the situation shown by this testimony does not lend consistency to the theory of the geologic ages.

In Hilgard's log, in this same report, no shells are listed till a depth of 41 feet and 8 inches is reached, and then he mentions "a few shell fragments." At 41 to 42 feet, he says he found,

> coarse rounded sand, with numerous shells, mostly broken, quite hard *Mactra lateralis, M. Sayi, Arca transversa, Cardium magnum, Tellina flexuosa, T. tenta, Lucina costata, Venus crebraria, Astarte lunulata, Pandora trilineata, Oliva literata, Natica pusilla, N. campeaehensis, Acus dislocation, Marginella limatula, Bullina cassaliculata.*

Continuing in his report, he described the findings at 543½ to 546 feet, as follows:

> Coarse white beach sand, with numerous shells, *Mactra lateralis, Area transversa, A. ponderosa, Lucina costata, L. multilineata, Pholas costata, Artemis concentrica, Cardium N. sp.* [same as at 43 to 56, and at 235 feet]. *Bullina canaliculata, Olive mutica, Pleurotoma carinum, Buccinum acutum, Natica pusilla, Dentalium sp.*

Notice the similarities between shells found at a depth of from 543 to 546 feet with those at from 41 to 42 feet. One naturally is led to wonder why Lyell, who chose 528 feet as the average depth of the delta, could not just as well have chosen 41 feet, *and better, because it marked the only distinct transition in the whole log.*

Hilgard's report especially shows the changes in the minerals composing the sands and clays below 41 feet to be far too extreme and abrupt to have been laid down from a river channel, where the grains would be mixed and remixed continuously as they were carried along by the river, producing a more homogeneous deposit.

These abrupt extremes tend to show that the sediments have been brought in large quantities at a time and from different directions, as by oversweeping continental waters. There is abruptness also in the changes in nature of the sands, much of which is too coarse and too sharp for river sedimentation in that delta. There is nothing like it in the present Mississippi delta.

Humphreys on the Age of the Delta. Only the small lower end of the delta has a depth of 100 feet, and this lessens gradually all the way up to the other end. At New Orleans, about half way up to the head, the depth is 41 feet. Therefore, Humphreys chose 40 feet as the average depth of the delta.

Humphreys, with his background of thorough knowledge and vast data, offered several corrections to Lyell's estimate of the amount of sediment carried annually in the waters of the river. He found that more sediment is carried than Lyell has allowed, and especially that large amounts of solid matter are being constantly rolled along on the bottom of the river-bed, of which Lyell had taken no account.

Humphreys also brought more accurately into calculation the bayous, the outlets, and the subsidiary rivers, as well as the delta itself. He made different estimates from different conditions, using alternative sets of figures, in one set taking into account rivers and territory not included in the other, thus providing a scientific countercheck on each estimate. He had all territories and rivers involved carefully platted on maps and charts by the engineers in his department. In a letter to Lyell, he said:

> Now, using the red curves of No. 1, and adopting 40 feet as the mean depth of the alluvium inside of the 10-fathom curve, we have 4,900 years as the age of the delta. [The Tansus river bottom is included in this computation, and in the one following.]
>
> Using the red curves of No. 2 and the mean thickness of 40 feet for the alluvium inside the 10-fathom curve, we have 5,400 years for the age of the delta.
>
> The first agrees better than the second with the age computed (4,400 years) from measurements upon the progress of the river into the Gulf, which afforded a means of determining the age of the delta independently of any knowledge of the quantity of earthy matter held in suspension by the river water or that moved along the bottom of the river.[49]

This next method referred to (the result being 4,400 years) is very much simpler than the other, and supplies a countercheck. Humphreys *averaged the yearly rate of advance of all of the mouths of the river into the Gulf*, and then *divided that rate per year into the total number of miles up to the head of the delta to get the age of the delta.* He said:

> It is assumed that the rate of progress has been uniform to the present day . . . and

> there are some considerations connected with the manner in which the river pushes the bar into the Gulf each year, which tend to establish the correctness of that position . . . the number of years which have elapsed since the river began to advance into the Gulf can be computed. The present rate of progress of the mouth of the river may be obtained *by a careful comparison with the progress of all of the mouths of the river,* as shown on the maps of Captain Talcott, U. S. Engineers, 1838 and the U. S. Coast Survey in 1851—the only maps that admit of such a comparison. They give 262 feet for the mean yearly advance of all the passes (mouths).[50]

Therefore, the 262 feet, divided into the total distance to the head of the delta, (1,152,800 feet) gives 4,400 years as the age of the delta.

The writer might be inclined to add two or three feet to the 40, because possibly New Orleans might not be quite far enough down the river to represent the cite of average depth. Two more feet would make it 4620 years.

Still another estimate based on Lyell's figures of annual discharge of sediment and area of delta, by which he produced 60,900 years, is offered by the writer, discarding Lyell's depth figure of 528 feet, and using Humphreys' more reasonable figure of 40 feet for the depth of the delta. This 40 feet is about 7½% of 528 feet, and the result would be 7½% of Lyell's age estimate of 60,900 years, or 4,567 years. This is not too far from Humphreys' 4,400 years, and almost equal to his other estimates, and the two additional feet in depth would make it remarkably close.

Is This the Total Age of the River? Humphreys said:

> The age of the delta has been estimated at 4,400 years, upon the assumption that the river was of equal magnitude during the whole of the period of its delta-forming condition. This assumption implies that the river was suddenly brought into existence with its present condition, or was suddenly converted into that condition. The rapid, simultaneous upheaval of the whole basin of the river would have brought that river suddenly into existence with very much the same characteristics that it now possesses; but geologists do not admit the possibility of such a rapid upheaval.[51]

Humphreys then defeats the geologists' theory of supposed very slow uplift. He had previously cited the constant presence of the pre-river "Blue Clay" at the river's low water mark; now he says that no such alluvium is found higher than the high water mark in the present river. Therefore, he asserts, no delta was uplifted, as in such case its remains would have been cut into, with remnants left. This sound conclusion gives expert confirmation to other evidence submitted against the theory of general upheaval and subsidence.

He then postulates the condition of the possible river before it was delta-forming, saying that it must have been a clear river with no floods and therefore no sediments. He proposed the possibility that the 300-foot gorge between St. Louis and Cairo could for a time have impounded the river behind it while it was being cut down, thus depleting the water of its sediments. He reasoned that the 300-foot fall to the Gulf from the bottom of this cut would not be sufficient to cause a muddy stream.

As to the length of time involved, that would depend upon the hardness of the material in the cut and the depth of the water that was doing the work. From modern and recent detailed observation, geologists are in possession of very surprising data as to the rapid cutting power of water.[52] It is likely that this particular formation is only soft sandstone and shales, with possibly parts consisting of unhardened materials. Postulating the Genesis flood, and that this cut was made during the run-off of the waters before much hardening of materials in those strata had taken place, a comparatively short time only was necessary to make this cut.

A Survey of the Evidence

After about a century of diligent geological study of the Mississippi river and its delta, much of it devoted to various features bearing on the age of the river, reasonable conclusions based on acceptable facts now seem to be justified. Sir Charles Lyell had estimated its age at 60,900 years.

But General Humphreys, who, with his staff of engineers and geologists, had charge of the delta for twenty-five years, and Hilgard, studying it until thirty-five years later, accumulated vast data which have apparently never been superseded by subsequent discoveries. Their basic evidence appears to prove that the river has been in existence only 4,400 to 5,000 years. Facts developed since then seem only to strengthen this conclusion.

The main features may be stated briefly as follows:

1. *The Pre-River Formation.* Recent oil geologists find the deepest layers to consist of fine land sediments apparently deposited far from land but somewhat interlayered with ocean sediments, a phenomenon totally unknown to present geological processes, though fitting remarkably well with Deluge mud settling in deep waters during that postulated catastrophe.

Tending to show the erratic and at times extremely violent nature of those waters thus in

commotion, there is that great layer of gravel some 3,000 feet beneath the whole region of the north Gulf coast, underlying the delta and well out into the Gulf. Another witness to that overspreading torrent is the bed of gravel and clay nearer the surface, also spread out as widely, far wider than any river could spread it, into which the river has cut its channel for hundreds of miles.

The source of this gravel is thought to be the glacial region of the north, the size of the gravel decreasing as the Gulf is approached. All of this, including the ice and water as the source of the gravel and the clay, is well in line with Deluge Geology.

Upon this bed of gravel and clay was deposited a great mantle of wind-blow material, a feature of almost world-wide occurrence. And this, too, coming as it did late in the Deluge period, and possible only in a world barren of vegetation and subject to extremes of temperature which could produce the wind, is acceptable to the catastrophic theory.

The original investigation of the pre-river foundation of the Mississippi apparently demonstrated that this wind-blown material fell into the supposed pre-river estuary and settled without being extensively transported. Still above this came the "Yellow Loam," a fine loamy clay brought in by supposed *estuarian* waters, and still prior to the birth of the river. All of these layers were called the "antecedent bed" of the river which subsequently appeared and cut down through them all and into the layer of gravel and clay.

2. *The Deposits Impossible by River, Estuary, or Normal Ocean.* No river of the gradient of the Mississippi could have transported or deposited such underlying strata as the gravel. The lack of speed and power to transport and spread out such material, much less distribute it so evenly over such a wide area, appears to rule out river action. But very much less could such deposition have been accomplished by an estuary, not only because of a lack of sufficient gradient, but because of the constant buffeting of tides with river flow.

The ocean in normal behavior is also out of the question. The finer materials, especially the loess, apparently fell from the atmosphere into standing water periodically in commotion and at rest but not of a river.

3. *Only Oversweeping Ocean Capable of Forming the Deposits.* Waters not now acting anywhere in the world are demanded, waters covering the whole region, at varying depths and at various speeds. The extremes between coarse gravel layers and the finest clay, sand, etc., all equally spread out, seem to demand these variations and this agency.

The beds of gravel mingled with clay do not so much represent gravel alone carried along by the torrential waters as they do the whole being forced along *as a single viscous mass* by deep waters oversweeping these wide areas in great force. This type of deposit is common throughout the world and diligent study should be given it. The heavy material pushed bodily along the bottom of all deep and rapid streams is a feeble example, the best that nature now affords in operation at present.

For nearly a century certain geologists have freely granted that, should the earth be suddenly disturbed in its rotation, the crust would convulse and the waters would produce just such a debacle as Deluge Geology postulates.

4. *The Size of the Delta.* There was no marked difference between Lyell and Humphreys as to the size of the delta, the main point at issue being the depth. But later geologists, ignoring the findings of these early workers, have gone to extremes in both. Some, while still retaining Humphreys' shallow depth averaging about 40 feet, would spread it out all over the southern Mississippi valley and north Gulf coastal plain. They claim an area of 200,000 square miles instead of the 12,600 to 13,500 of Lyell and Humphreys.

Others would retain the small area, or even narrow it down still more, but make a vertiable "bottomless pit" syncline of it, 30,000 to 40,000 feet deep. But for such sink-hole no proof whatever is offered, and in fact, oil-well logs bear out Humphreys' figures as to the depth and as to the utter lack of any such syncline.

5. *The Theory of Changes in Level.* The most potent obstacle to any dependable basis for the depth and therefore the age of the delta has been the theory of subsidence and upheaval, especially the theory of general subsidence by the weights of deltaic sediments. But the identical "Blue Clay" found at the water's edge up-river was found 40 feet deep at New Orleans and on the Gulf bottom on each side of the delta, and this fact seems to defeat that theory.

Again, if the theory were true, the delta *as a whole* would subside, *and the subsidence would be greatest at the center of gravity of the delta as a whole.* Instead, the most rapid subsidence is wherever the most rapid deposit of fresh sediments happens to be going on.

The theory of the swampy origin of coal is urged by those who hold the general subsidence theory, *and they point to this theory of the origin of coal as proof of the general subsidence of the deltas.* But this theory of coal is very vulnerable and easily disproven and is not held by European geologists generally.

Lava flows, though often thousands of feet thicker and much heavier than delta sediments, do not depress the crust of the earth, and do not

even depress sedimentary layers. Conversely, the most deeply eroded areas on earth have never been known to rise on account of that erosion.

For all of these reasons the general theory of subsidence is rejected in estimating the age of deltas.

6. *The Depth of the Delta.* Having disposed of the theory of general subsidence as applied to deltas, the many simple facts of the delta of the Mississippi adjust themselves easily as to its depth. At New Orleans it is 40 feet deep, and 100 feet at its outer edge, and this is well in agreement with official topographical surveys of the Gulf bottom on each side of the delta, and with the "Blue Clay" in the river at corresponding depths. Considering these facts it is difficult not to accept the 40 foot *average* depth chosen by the Humphreys group. (The author would perhaps deepen this estimate two or three feet, inasmuch as New Orleans is apparently not quite far enough south to represent the place of average depth. But this would not greatly lengthen the age of the delta.)

7. *Age Estimates.* Except in the matter of his chosen depth of 528 feet, Lyell's final estimate of 60,910 years was otherwise based on fairly acceptable data. With the 40-foot depth instead of his 528-foot depth, the age of the delta by his calculations is well within range of that of the Humphreys group. The two methods used by Humphreys form a balancing check on each other that lends confidence to the results.

Conclusions

That the age of the Mississippi river is within the general range of 4,500 to 5,000 years, in view of all of the facts and principles thus far brought out, now seems beyond much doubt. How it could be substantially increased or decreased is difficult to see. Suppose it were doubled, or quadrupled, such a period would still not be a start toward the immense ages required by the uniformitarians.

Even Lyell's estimate, though satisfying the requirements of the geologic age theories of his day, would have to be multiplied several fold for the standard doctrines of today, which demand millions of years instead of thousands. Therefore, any changes in the estimates which would lend any comfort to the evolutionary theorists are almost unthinkable.

The question at once presents itself as to how a great river system like the Mississippi *could thus suddenly come into being except by a geological revolution practically continent-wide.* Since there is no sign of any other river system having previously occupied that vast area, or any part of it, such a cataclysm seems to be demanded, a complete and profound reworking of the crust of the earth to great depths. Furthermore, it is a river system eroded on a surface which was itself the obvious result mostly of water action but *vastly different from river action or any other geological work by water action known today.*

A mere glance at the size, depth and character of the other deltas of the world should impress anyone that they may well be virtually the same age as the Mississippi delta. All of the facts and principles developed in this present study will be of vital application to the other deltas and rivers, and these remarkable results for the Mississippi delta form the basis for age estimates of other rivers of the world.

Labors on several other natural chronometers involving geological processes, besides the growth of river deltas, are apparently developing, each with considerable capacity for accuracy, and they will be of utmost value in correlating and counterchecking. Altogether, there appears to be some promise of satisfying all reasonable doubts *not only that the Flood of Noah was universal,* but *that it occurred well within the range of dates set by sacred writings and archaeological evidences.*

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BOUNDARIES OF THE MIN: AN ANALYSIS OF THE MOSAIC LISTS OF CLEAN AND UNCLEAN ANIMALS*

ARTHUR J. JONES**

The Mosaic food lists are analyzed in detail and exhaustive lists of the genera covered by each Hebrew name are presented. The author shows that the ***min*** *generally lie at the family level (superfamily,* ***family,*** *subfamily) in current classification systems. An annotated bibliography is provided.*

Introduction

It was concluded in the first article ["A General Analysis of the Biblical Kind (Min)," CRS *Quarterly*, 9(1):53-57 (June, 1972)] that the Mosaic lists of clean and unclean animals do permit an analysis of the boundaries of the *min* ("kind").

The present article contains continued analysis of the lists in detail in order to determine where, in the modern hierarchy of biological categories (phylum, class, order, family, genus, species), the *min* would generally lie. I have endeavored to list under each Hebrew name all the species which would have been denoted.

I encountered considerable difficulty in this task because I initially did not know where to obtain certain information. In order to enable others to investigate this subject more readily I have appended a bibliography of all the literature which provided relevant information.

*Second in a series of articles dedicated to the memory of Dr. Jacobus Johannes Duyvené de Wit (1909-1965), late Professor of Zoology at the University of the Orange Free State, Bloemfontein, South Africa.

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Annotated Animal Lists

The size of the animal is indicated in parentheses. In the case of the clean *behemah* this is shoulder height/horn length. In all other cases the total (head to tail) length is given. If a second figure is given this is the *standard length* (which excludes the tail). All measurements are given in centimeters.

OUTLINE OF ANIMALS OF THE MOSAIC FOOD LISTS

1. *Behemah*

1.1. *Clean behemah*

1.1.1. *Domestic behemah* (Dt. 14:4).

a. *shor*—domestic cattle: ox, *Bos taurus* (100-140/variable); zebu, *Bos indicus*; buffalo, *Bubalus Bubalis* (170/150).