La Brea Tar Pits: A Critique of Animal Entrapment Theories

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Abstract

New evidence acquired from an ongoing excavation project at Rancho La Brea has led to a major re-evaluation of how the fossils were deposited. The traditional idea that animals were trapped in continuously active, open pools of tar has been discarded, and new theories of entrapment and deposition emerged. Although more realistic in some ways than the old theory, the alternatives suffer from the same inability to provide a defendable, gradualistic explanation. This critique represents a preparatory stage in the development of a theory that discards the principle of animal entrapments and advances the concept of a diluvial process in the formation of the tar pit fossil beds.

Introduction

Dr. John C. Merriam, a vertebrate paleontologist at the University of Berkeley, first heard of the fossils of Rancho La Brea in 1905 from Union Oil geologist William W. Orcutt. After viewing the fossils and visiting the source beds, Merriam wrote an article in 1906 about a pool of tar that deceived, trapped, and swallowed up its victims. Two years later, he wrote an expanded treatment of the subject for a popular magazine. The editor's introduction to the article had the following words:

> This sticky pool of water and tar has been a Death Trap of the Ages. Here, for centuries, evidently, the enormous ground-sloth and other clumsily moving creatures of his kind came for water, only to be held relentlessly; herds of bison and horses were entombed, extinct forms with whose bones mingle those of the mammoth and the camel. To this helpless prey, snared for them in this bird-lime bed, came the lords of the era, the huge sabre-tooth tiger and monster wolf, the largest of the dog family. Trapped in their turn, they, too, fed the black maw of the asphalt pool and the death trap baited itself anew (Merriam, 1908).

Although the above description paints a vivid picture of the struggle for survival among the tar pits, it is unfortunately marred by the use of misleading evidence. The "death trap" pictured in the article was actually a water-filled quarry dug out by a defunct asphalt mining enterprise (Figure 1).

About two hundred yards northwest of the quarry was a real tar pit excavated in 1906 by the University of California. Six years later, three more pits were excavated in the same vicinity (Stoner, 1913). In 1913, the County of Los Angeles began a two-year, trial-and-error search for more fossil pits. They dug 96 test holes, of which more than half turned out to be unproductive. (The test holes were called "pits," which makes discussion of the subject confusing. A "pit" in the sense of a test hole may, or may not, be synonymous with an actual fossil pit.) Only 16 test holes turned

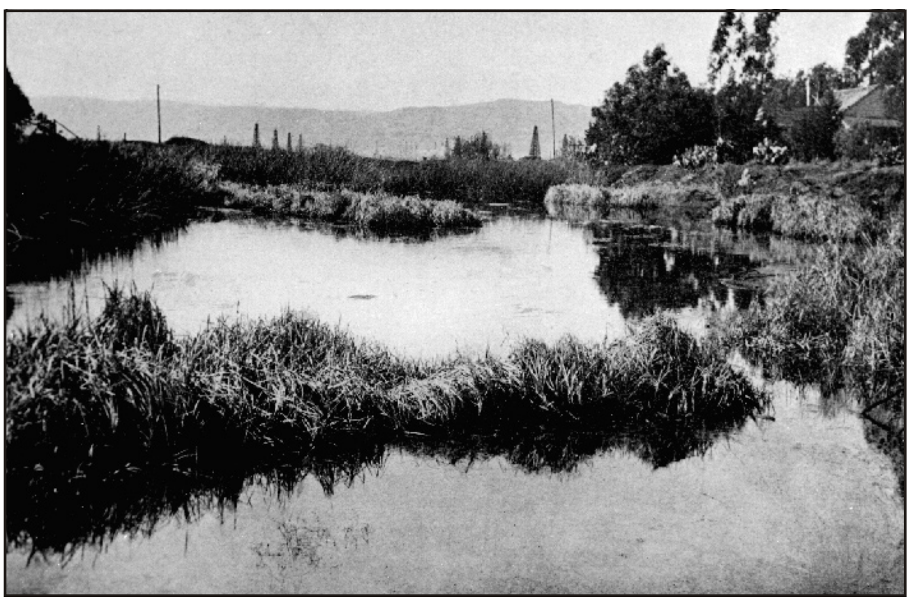

Figure 1. Asphalt quarry now filled in with water. It was misidentified as the "death trap of the ages" (Merriam, 1908).

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up pits with large quantities of bones. With the exception of Pit 91, these pits were emptied of their contents, packed in wooden crates, and transported to the Museum of History, Science, and Art. The main part of the bone mass of Pit 91 was left intact as a showcase for future public display.

The Re-opening of Pit 91

After a fifty-four year hiatus, excavation work at Pit 91 was re-activated on June 13, 1969. It continues on a seasonal basis to the present day. More methodical than the early excavations of 1906 through 1915, the renewed excavation is a painstaking centimeter-by-centimeter search for fossils of all kinds, from large bones to microscopic-sized organisms such as pollen and diatoms. Identification, position, and orientation of all items found are meticulously noted and illustrated with diagrams and sketches.

The wealth of information thus acquired was by no means a confirmation of old ideas. On the contrary, some discoveries did not fit within the rubric of continuously active, deep tar pools. At a little over six feet below the surface of the ground, excavators found an ancient streambed that ran from an east-to-west direction, curving towards the south wall. They also found levels of sedimentation, which pointed toward the fluid dynamics of water as a formative factor in Pit 91.

> The fossil remains were frequently admixed with gravel lenses, cobbles, and pebble clasts of fluviatile origin. Freshwater limestone lenses, mollusks, and hardened asphaltum deposits were interbedded with bone-bearing sediment in several of the pits. . . . Both the molluscan faunas and the limestone strata indicate intervals during which separate tar seeps were submerged, possibly by ephemeral lakes or ponds, or meandering stream channels (Woodard and Marcus, 1973, p. 56).

The geological history of the fossil deposits, as revealed by the renewed excavation, appeared to be more complex than previously imagined, and the tar pool entrapment theory was clearly in trouble. Weaknesses that had previously been overlooked were now coming under close scrutiny. One flaw in particular was the small size of some of the pits. Woodard and Marcus (1973, p. 63) acknowledged that "many bone pockets, although containing numerous disarticulated skeletal remains, were too small to have served as asphaltic traps."

Pit 36, for example, was four feet long by two feet wide by eleven feet deep. Considering the preponderance of carnivores in Rancho La Brea censuses, Pit 36 unquestionably lacked the space for entrapment episodes requiring as many as six carnivores pouncing on a single herbivore. Another undersize hole was Pit 16. Only four feet wide, this pit was a near circular hole that went down 24 feet before it contracted three more feet into a small tar vent. Compare these pit sizes to a typical victim such as the saber-tooth cat with a head and body length of five and a half feet, or the mastodon, which had a length of twelve feet. Pit 37 was merely a "narrow chimney" only eight feet deep. Inside were the bones of badger, deer, coyote, and a large number of birds, over 90% of which were the predacious types such as vultures, hawks, and owls (Howard, 1962). While the average size of a tar pit was 15 feet in diameter at the surface (the largest one having a semi-commodious measurement of 25 x 15 feet at the surface), the smaller pits with diameters of five feet or less present a serious challenge to animal entrapment scenario writers.

By the early 1970's, paleontologists had reached a consensus that the animal entrapment theory had to be either modified or discarded. Consequently, two alternative theories were formulated. One was the tar puddle entrapment theory, and the other was the fluvial transport theory.

The Tar Puddle Entrapment Theory

The fossil pits of Rancho La Brea are located at Hancock Park. Within the park, visitors can see tar seeps forming puddles about two to four feet in diameter. If on a slope, the seep can spread farther, perhaps as much as 15 feet or more. When tar seeps reach an advanced stage of development, they look like volcanoes about three to four inches high with a circumference equivalent to an automotive tire (Figures 2 and 3). Bubbling from the center of these mounds are flows of tar that move at a sluggish, almost imperceptible rate. These larger seeps are called tar springs, and some of them can be fairly extensive in the puddles they generate. One geologist observed a puddle with a diameter of 30 feet (Merriam, 1911).

For small creatures such as birds, rabbits, snakes, and insects, tar puddles are dangerous traps (Figure 4). Even large animals, such as cows and horses, have reportedly been stuck in puddles only two or three inches deep. These modern episodes have led some scientists to formulate the tar puddle entrapment theory. According to Akersten, Shaw, and Jefferson (1983),

> . . . very shallow puddles of asphalt, more nearly analogous to flypaper than to quicksand, were often concealed by floating leaves and dust. Occasionally, an incautious herbivore became entrapped and, in turn, lured a number of carnivores to their fates. The carcasses decayed; individual bones rotted free, became saturated with asphalt, and settled at least partway into the mire.

During the warmer months of the year, tar seeped up through the permeable sands of dry streambeds, creating puddles that were highly viscous and hazardous to unwary

Figure 2. Tar spring seeping into asphalt quarry now filled with water. Photograph taken by the author in May 2002.

creatures. With the onset of winter, the tar seeps became dormant and the puddles started to solidify. During rainstorms, water filled the streambeds and spread a thin layer of sand over the inactive seeps. With the return of warm weather, the streams dried up and the tar seeps once again began to flow, creating new traps. The fact that bones were found in pit-like formations is due to the tar vents saturating and preserving the bones within their reach, while the remaining bones beyond the margin disappeared through the attritional effects of weather and decay. Over time the annual buildup of tar seeps and bone material grew simultaneously higher along with the surrounding level of the alluvial terrain. A good summary of the key ideas of this theory is provided by Harris and Jefferson (1985, p. 10):

> Animals and plants were captured in shallow surface sheets of viscous asphalt rather than in large pools or "pits," but over time such asphalt layers built up into large conical bodies through continued deposition. The preservation of the bones and plant materials was aided by their subsequent burial in sediments of the alluvial plain.

Figure 4. A tar puddle in which two birds had been caught. The smaller bird to the right is a meadowlark. The bird in the center is unidentified (Merriam, 1911).

Figure 3. Close up of same tar spring near asphalt quarry. Dark cavity in the center of spring shows where a bubble had burst. Photograph taken by the author in May 2002.

Although generally accepted by the scientific establishment, there are no observational or experimental data that show that tar puddles have the viscosity to capture large animals, including such megafauna as elephants and bison. Even local anecdotes about horses and cows standing trapped in tar puddles, whether true or not, cannot properly be called scientific proof if they lack such routine items of information as time, place, and names of witnesses. Considering the lack of solid evidence, the tar puddle theory does not merit further discussion.

The Fluvial Transport Theory

The fluvial transport theory is a modification of the deep tar pool entrapment concept. As formulated by Woodard and Marcus (1973, p. 63), the fluvial transport theory postulates "localized fluviatile concentrations of bones in stream channels or ponds."

> Some of the larger fossil concentrations probably represent actual sites of animal entrapment and burial. Many bone deposits appear to represent concentration under fluviatile conditions after the bones had lain on the surface for some time. This is supported from the character of the enclosing sediments, size of the fossil pockets, and the abraded and weathered nature of the bones (Woodard and Marcus, 1973, p. 68).

To support their theory, the two authors drew upon the core sample data collected during a search for undiscovered fossil pits in 1945. A total of 87 test holes were drilled all around Hancock Park. The test holes revealed four distinct sedimentary layers. The uppermost layer consisted of

6.5 to greater than 17 feet of flood-plain deposits of sand, clay, gravel, and asphalt. Rounded gravel and cobble sized clasts were an indication of "fluvatile disintegration" (Woodard and Marcus, 1973, p. 60) of granitic rocks.

The second layer consisted of asphaltic sand varying in thickness from less than 3.5 and up to 7.6 feet. The authors believed that the second layer represented a period when bones were possibly being deposited by animal entrapments.

The third layer was 4.3 to 8 feet of clay that was frequently sandy towards the base. Like the first layer, the third layer was the result of "fluvatile deposition, probably in a flood-plain environment." '

The fourth layer consisted of bituminous sand that went down to a depth of 66 feet. Unlike the second layer of tar and sand mentioned above, the fourth layer does not represent a period of animal entrapping activity. According to mainstream scientific thinking, the fourth layer is a transitional phase in the geology of Southern California. Ocean water receded from the continent, and the basin of Los Angeles became a dry land environment with bodies of freshwater. It was towards the end of this period that land animals began migrating into the area.

According to Woodard and Marcus, the four sedimentary levels described above were observed inside the tar pits as well. To prove their point, they refer to the field notes for the excavations of Pits 3, 4, 13, and 81. Since their stratigraphical analyses of these four pits are basically similar, we shall focus on Pit 3 to illustrate their argument.

The Excavation of Pit 3

Pit 3 began on July 16, 1913 as an exploratory trench from the bank of a man-made pond. The excavators proceeded toward a spot where a fresh puddle of tar was spreading from a tar vent. When they had reached the puddle, they broke away six inches of asphalt outcropping and found a quantity of mainly coyote bones as well as many from birds and rodents. Most of these bones were so decayed that they had to be thrown away. The excavators widened the hole and saw that the fossil pit had a diameter of about 15 feet. They found an abundance of wolf and saber-tooth cat skulls, as well as a small number of herbivore skulls such as sloth and bison. The disproportionate number of carnivores was typical throughout the pit. As they proceeded downward, they found that the pit had a conical shape. The above comments apply to the pit as a whole. The following is a summary of what was found at various levels.

At a depth of four-and-a-half feet below the surface of the ground, excavators found the trunk of a cypress tree about ten inches in diameter. The wood was so fresh, that it appeared that the tree had been buried alive. The top of the trunk was missing, either having been burned or rotted

Figure 5. Cypress tree taken from Pit 3. When found, it was heavily saturated with water and tar (Wyman, 1926).

off. As they dug down, they found that the trunk had a large branch that projected horizontally across the pit (Figure 5). Around the branch and trunk was a mass of bones so tightly packed and interlocked that it was difficult to squeeze fingers into the narrow cavities to remove them.

At the seven-and-a-half-foot level, the matrix of tar and sand was described as "the very best preservative sort, as many of the bones coming out now are in a high state of preservation."

At the nine-foot level, the matrix was described as "mostly of a rather coarse sand well tar-soaked, in places with some small gravel and twigs, apparently drift material." Saber-tooth cat bones were far exceeding the wolf bones. There were occasional herbivores such as sloths and mastodons. Along the south wall was a deposit of tarry sand that was virtually barren of bones. The surface contact between the barren sand and the mixture of sand and fossils was sharply defined.

At the ten-foot level, excavators were finding more small gravel, twigs, and leaves. Again these were recognized as "drift material," which meant that floods had transported them from somewhere else and buried them in the pit. The leaves and twigs were saturated with water. It was soon discovered that water-soaked plant material had a spoiling effect on the quality of fossil preservation. Any bones close to wood were mushy, crumbly, and badly decayed.

At the twelve-foot level, the matrix changed from bituminous sand to a mixture of clay and a substance that looked like asphalt with a reddish-brown color. Here excavators found the cypress tree rooted in stiff clay. Many of the larger roots penetrated almost horizontally into the wall of clay. It appeared that the tree had either grown on the bank of a buried gully, or the edge of the bone deposit had been completely covered by a heavy deposit of clay. The total height of the tree trunk was about eight feet. It had two large branches, one eight feet long and the other eleven feet long. These branches had been broken off at the ends. [Some of these details were not in the field notes but were provided by (Davidson, 1914)]. In order to remove the trunk, excavators had to cut off numerous roots. Lifting the tree out of the pit was a difficult operation requiring a team of twelve men, for it was heavily saturated with water and tar (Figure 5).

At the thirteen-foot level, the slanting-in of the west wall was decreasing the amount of available space for the digging crew to work in. This was the beginning of the contraction of the pit, which at deeper levels would taper down to a small hole.

At the fifteen-foot level, the matrix changed more into clay with numerous pockets of tarry sand. Excavators found a log four feet long standing upright upon the crotch of an inverted tree stump. Underneath the tree trunk, excavators found great quantities of bones. The matrix here was gravel impregnated with tar.

At the eighteen-foot level, the matrix became asphalt with fewer bones than in the softer tar-soaked sand.

At the twenty-foot level, the whole pit was clogged with areas of asphalt, which made digging very hard.

At the twenty-one-foot level, fewer bones were found. The whole floor of the pit was contracting at an ever-increasing rate as the excavators dug deeper. More than half the floor was oxidized asphaltum, or semi-hardened tar, which was very hard to dig through.

At the twenty-three-foot level, the floor of the pit was only four feet across. Bones at this depth were still being removed.

At the twenty-five-foot level, a sloth pelvis completely filled the small hole. Underneath the pelvis was a bison skull – the last bone to be removed from the pit.

At the twenty-seven-foot level, the pit had tapered down to a narrow chimney several inches wide and continued downward to a petroleum deposit one to three thousand feet below the surface of the earth. At this level, the excavation for Pit 3 was terminated on August 18, 1913.

Stratigraphical Analysis of Pit 3

Woodard and Marcus (1973, p. 64) identified six phases in Pit 3. These phases are listed below in the order in which they appear stratigraphically from the uppermost layer to the lowermost:

- Phase VI: This phase is the last and most recent of the layers to have been deposited. It consists of "sediments of probable flood-plain origin" from the surface level of the ground to a depth of 2.4 meters (8 feet).
- Phase V: At the 2.4-meter level, excavators encountered "richly fossiliferous asphaltic sand."
- Phase IV: At the 3.6-meter level (12 feet), the strata changed to stiff clay. Separating the second layer from the third layer was a boundary layer consisting of hard asphaltum, oxidized a dark reddish-brown color. According to the authors, this layer represents a period when tar vents were inactive.
- Phase III: At the 4.5-meter level (15 feet), excavators encountered another boundary of hardened reddish-brown asphaltum, below which was a layer of grey clay enclosing pockets of fossils in bituminous sand.
- Phase II: At the 5.4-meter level (18 feet), a layer of asphaltic grey clay with pockets of gravel and limestone was found. At this interval the fossil-bearing bituminous sand was being replaced by barren clay.
- Phase I: This phase is the earliest of the layers to be deposited at the site of Pit 3. It consisted of "asphaltic sand" that began at the 6.3-meter level (21 feet). This sediment continued unchanged to the point where the excavation ended at 8.1 meters (27 feet).

These stratigraphical phases can be related to the four-level core sample data of 1945, if one combines Phases II, III, and IV into a single level. As described by Woodard and Marcus, these phases appear to indicate that the deposition of the contents of Pit 3 corresponded to the deposition of equivalent sedimentary layers of the surrounding terrain.

To fix the time spans for both animal entrapment and fluvial deposition, the authors rely on carbon-14 dating of various bone specimens. Table I shows the results for samples from Pit 3. Assuming that the carbon-14 dates are accurate, the recent period of fluviatile deposition is almost 13,000 years long; the period of animal entrapments was less than 2,000 years long; and the older period of fluvatile deposition was 7,000 years long. (Woodard and Marcus explain the anomalous specimen at twenty-six feet as being the result of either contamination of the sample or the shifting of bones inside the pit.)

To support their argument that at least two layers in Pit 3 were deposited by fluviatile conditions, the authors refer to a significant discovery from the renewed excavation of Pit 91. What excavators were amazed to find was that the onset of tar seeps came *after* the bones were deposited. A saturation zone emanating from a tar vent permeated into the bone mass. The saturation gradually decreased the fur-

Table I. Sample results from Pit 3.

Specimen Depth (ft.)	Sample Number	Carbon-14 Age	Deposition Activity
7	UCLA-1292B	12,700 BP*	Fluvatile
11	UCLA-1292E	14,400 BP	Entrapping
12	UCLA-1292C	14,500 BP	Entrapping
22	UCLA-1292J	20,500 BP	Fluvatile
22	UCLA-1292A	21,400 BP	Fluvatile
26	UCLA-1292K	19,300 BP	Fluvatile

***BP = before the present**

ther it spread, so that bones at the periphery of the zone were only partially, if at all, permeated by the tar.

This information is strong evidence for a theory that combines animal entrapments and fluvial conditions in the making of the fossil beds. Yet as the reader of my article will soon see, this same information can also be used for a theory that eliminates animal entrapments altogether.

Water-Saturated Wood

Another detail supporting the fluvial transport theory is the water-saturated wood debris found inside Pit 3. The upright cypress tree trunk (Figure 5) was so heavy with water that removing it was a difficult operation. Twigs and leaves were also drenched. These details do not represent a minor anomaly. Stumps, branches, twigs, and leaves within other pits were similarly soaked with water. In the field notes, this woody material was described as the result of "drift" or being "washed in." The abraded surfaces of the wood indicated water-driven movement over rough terrain.

Yet if the fluvial transport theory were true, we should expect to find pieces of timber lying more or less horizontally within the sediments that brought them into the pits. Some wood specimens were in horizontal positions and others were positioned vertically, crossing sedimentary boundaries. The aforementioned cypress tree trunk crossed two layers representing fluvial transport and animal entrapments. If thousands of years of deposition are represented in these two layers, it is doubtful the tree would have maintained the freshness and integrity its wood displayed. In addition to these polystrate pieces of timber, the tangled and interlocked mingling of bones and wood debris seem to point toward a single violent event rather than a gradual layering of sediments over an indefinite period of time. The strange juxtaposition of the four-foot log standing upright upon the crotch of an inverted tree stump bears witness to a flooding episode several orders of magnitude more powerful than the winter overflows of streambed channels called for by the fluvial transport theory.

Bone Concentrations in Flood-Plain Environments

After nearly thirty years, the article produced by Woodard and Marcus still stands as a landmark in the literature of the La Brea Tar Pits. Yet much of their material has lost its value in the light of recent studies of modern flood-plain environments.

One such study was conducted at a dry lake basin within the Amboseli National Park in southern Kenya. A limited number of spring-fed channels periodically flood the basin, moving and burying the scattered remains of deceased animals. The study focused on a stable population of 1000 wildebeests. Every year this herd contributes 250 carcasses to the basin floor with about a 100 of these being infants or juveniles. The smaller carcasses are normally devoured by predators and scavengers, which leaves about 150 carcasses remaining. About two-thirds of these carcasses are destroyed by weathering before they can be transported by flooding to suitable places for burial. Finally, for each carcass, only eight out of the original 152 skeletal parts are actually buried. While these numbers cannot be expected to apply to all situations, they do provide a case study for illustrative purposes. The predicted yearly input of buried bones from ten of the major herbivores at Amboseli, averaged over the whole basin area of 600 km^2, would be 0.01 bone per 1000 m^2. Since a fossiliferous deposit is assumed in these studies to be one bone per 1000 m^2, it will take one hundred years for the dry lakebed to become incrementally more fossiliferous, even if all the buried bones are preserved over time. These figures are compatible with studies made in other flood-plain environments around the world. Assumed accumulation totals cannot be much higher, without pushing animal mortality rates into the catastrophic range (Behrensmeyer, 1982).

Now let us compare the above figures with the conditions of the La Brea Tar Pits. Pit 3 had nearly 50,000 skeletal parts and fragments. Since the pit had a rough conical shape of about 15 feet at the surface and a depth of about 27 feet, that works out to be approximately 1600 cubic feet, or 850 bones per cubic yard. This numerical density is comparable to bone concentrations in other pits. For example, a large quantity of bones, including 17 complete skulls of the saber-tooth cat and 40 complete skulls of the dire wolf, were contained in two cubic yards of bone material at UC Locality 2050 (Merriam, 1908). If the first fluviatile phase was 13,000 years and the second fluviatile phase was 7,000 years, the number of bones in each pit is too high when compared to bone assemblage surveys in modern flood-plain environments. Uniformitarian rates of fluvial deposition are therefore unworkable when applied to the La Brea Tar Pits.

Pits and Sedimentary Layers

The fluvial transport theory combines two processes of nature that are essentially contradictory.

1. The process of bone deposition in concentrated masses requires the existence of holes or ground surface depressions that are stable and continuously open.
2. The process of sedimentation does not create holes; instead it fills them.

If the analysis of Woodard and Marcus is correct, then both these processes had simultaneously occurred in the pits. It is worth noting here that this theory replaces an old idea that was conceived by Luther E. Wyman, the supervisor of the county excavations of 1913 through 1915. Here is what he said about the origin of the tar pits in 1926.

> During the two years' work of the Museum, however, many phenomena were encountered which seem explainable only on the theory that pits were formed by heavy "blow-outs" of gas from the oil deposit below, forming surface craters, most of which were roughly funnel-shaped, and followed by an inflow of oil which with sand filled the craters to the surrounding level. The gas pressure relieved, the craters would become quiescent, possibly crusting over, . . . (Wyman, 1926, p. 9)

There are features about Pit 3 as well as other pits that confirm Wyman's conclusion. These features include the funnel shape of the pits and the sharply defined contour against the surrounding terrain. On the other hand, we cannot easily dismiss the theory of Woodard and Marcus, for they have used the latest studies of the strata of Hancock Park and surrounding areas. They also rely on the data of Pit 91, which is far more thorough and meticulous in the recovery and analysis of fossil material than the old excavations ever were.

It should be pointed out here that the sedimentation *outside* the pits is not under dispute. The core sample studies of 1945 are compatible with both views. The issue in question is the perceived stratification *within* the pits. Wyman relied on his observations of phenomena in the vicinity of the tar pits to formulate the gas blowout theory. Woodard and Marcus relied on the field notes of 1913 through 1915 and the recent observations and field notes of Pit 91 to formulate the fluvial transport theory.

It is relevant to point out that the author of the early field notes was Wyman himself. Although he was a trained and observant scientist, carefully noting significant details, he was not always clear about what he was actually seeing. For example, the first time that Wyman makes a comment about the matrix of Pit 3 was on August 12, when excavators were down to the seven-and-a-half-foot level. He said, "Matrix is apparently of the very best preservative sort," meaning it was a mixture of tar and sand. When he made this comment, he said nothing about the thickness of this matrix. Did he mean that this type of matrix was first encountered at the seven-and-a-half-foot level, or was he applying his comment to the whole pit as dug out to that point? Even Woodard and Marcus admit that the field notes are not detailed geological records and can only be used to provide general information. Thus to ascribe distinct and precisely measured strata within the pits based on random comments within Wyman's field notes may be placing too fine an interpretation on them.

In my own survey of the field notes, I found a great many references to "tarry sand" or "good matrix of tar-soaked sand" and correspondingly very few references to "tarry clay." In fact wherever the word "clay" was joined with an adjective, it was most often the word "barren," meaning absolutely no bone material was found in it. These details lead me to believe that the predominant matrix was a mixture of tar and sand and that it was generally well distributed throughout the pits from top to bottom.

Let us now turn to the evidence of Pit 91. It is true, of course, that this ongoing excavation has been uncovering stratification levels within the bone mass. Yet this evidence cannot be regarded as wholly trustworthy. It is an unfortunate fact that Pit 91 is not an undisturbed pit. During the late 1800's, the ground had been turned over by workmen seeking commercial grade asphalt. According to Wyman's field notes of June 13, 1915, "about 2 ft. of earth that had been moved at some time (probably in the search for asphaltum long ago)." On June 28, Wyman wrote, "Soft vegetation that appears like hay show in spots down to 8-ft., evidently marking the bottom of old asphalt diggings. As traced on the wall of the pit, the floor of these old diggings was extremely irregular. This mixed earth and asphaltum moved so long ago is almost as hard as any original earth."

After the excavation of Pit 91 ended in August 1915, the hole was filled in over the course of the next several decades. This provided another complicating factor, as the following extract from the field notes of the renewed excavation shows:

> Sept 3, 1969: Today several geologists came to study the excavation trying to determine which sediments were reworked & which undisturbed.
> [List of names of four geologists provided here]
> The consensus of the above group and myself [George J. Miller] was that Unit 1 was definitely fill, that Unit 2 was probably fill, (I feel that this material could have been the result of work done in the 1800's to recover asphaltum) and that Unit 3 (including darker asphaltic sandy materials) was undisturbed. The area in which the bone showing a tool mark (not made in present excavation) was difficult to interpret. We all felt it could possibly represent reworked material, but might just as well be in place. It seems possible to me that the mark could have been made in the late 1800's work; when bone was struck, the workers moved to another area because of the hindrance. The presence of much bone was probably a nuisance to them.

Although the renewed excavation of Pit 91 has provided much valuable data, the vacillations apparent in the field notes stand as a warning not to accept Pit 91 data without due caution.

Since the competing ideas of the gas blowout theory and the fluvial transport theory both have merit, a workable solution might be to meld both ideas into a unified theory and to discard the animal entrapment idea entirely. The following is a suggested sequence of events.

1. Through the force of moving water, alternating sediments of sand and clay were spread over the basin of Los Angeles.
2. As a result of earth tremors, cracks in the ground developed, allowing gas to escape upward and create funnel-shaped blowouts through the sediments of sand and clay.
3. The bones of uncounted animals which died during this period as well as numerous uprooted trees and branches were swept up by the force of water. Some of these transported bones and vegetation were concentrated into the funnel-shaped holes that had previously released natural gas. Other bones came to rest upon the surface of the ground surrounding the holes.
4. Petroleum followed the gas, filling the boniferous holes and spilling over the bone-strewn ground. A large asphalt lake spread approximately over a square mile. This lake eventually dried into a hard crust that capped and preserved the contents inside the pits.

In my next article, I will discuss the dynamics of the water itself in the destruction of animal life in Southern California and in the concentration of the bone material into the La Brea Tar Pits.

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Book Review

Moral Darwinism: How We Became Hedonists by Benjamin Wiker
InterVarsity Press, Downers Grove, IL. 2002, 327 pages, $20

Dr. Benjamin Wiker is a Lecturer in the philosophy and history of science at Franciscan University, a Senior Fellow of the Discovery Institute, and a free-lance writer. Most people think that Darwinism began with Charles Darwin in the mid-19th century. In *Moral Darwinism*, however, Wiker traces its roots to a much earlier genesis – the Greek philosopher Epicurus.

Epicurus' philosophy was that the greatest pleasure is the absence of pain. We often think of Epicurus as a hedonist (one devoted to physical pleasure), but in fact he was an ascetic. His simple lifestyle was, for him, the best way to avoid painful experiences.

The science of Epicurus was materialistic in nature. He believed in "the simple, eternal atom" (p. 40) as the base of the physical world. Epicurus thought the universe was infinite and had no beginning. To him "the gods were a part of nature, made of atoms just like everything else in the universe" (p. 43). Epicurus' theology was based on "the subordination of the gods to nature so that they could not interfere with human affairs" (p. 45). Epicurus' theology led to a materialistic morality; he believed that no moral actions were intrinsically evil.

Epicureanism was effectively dead by about 400 A.D., having been supplanted by Christianity. The Christianization of Europe assured that the intelligent design view of the universe would prevail in Western thought for the next thousand years.