THE CARSON-CITY ICHNOLITES.

THE fossil footprints upon the layers of sandstone in the quarry at Carson City, in the state of Nevada, have excited much interest and discussion, not only by reason of the number and grouping of animals represented, but especially because some of the tracks have a rough resemblance to such footprints as a man of great size might make in walking upon soft mud. Elaborate reports and memoirs have already appeared,[1] regarding these tracks; and in California and Nevada there has been, and continues to be, a great difference of opinion as to the origin of the tracks which resemble the imprints of human feet. These tracks occur in a light, gray-colored, coarse sandstone formation, of the mammalian age of the tertiary, lying in nearly horizontal beds, with thin partings or layers of clay at intervals. The section at one point directly above one of the series of tracks is as follows: —

Sandy clay	18 inches.
Sandstone	4 feet.
Clay	½ inch.
Sandstone	16 feet.
Fine clay	2 feet 2 inches.
Coarse sandstone	10 "
Sandy clay, with tracks	3 "
Sandstone	18 to 24 "
Clay layer, with tracks	1 to 2 "
Sandstone below the quarry floor,	38 feet.

The tracks represent at least ten different animals, as follows: Elephas, or the mammoth; elk, or American reindeer; Bos, or buffalo; horse; wolf; tiger; peccary; Mylodon, or a giant sloth; the so-called 'Homo Nevadensis;' birds.

Bones and teeth of the elephant and of the horse have also been found in the sandstone beds above the ichnolites. There are also casts of shells of Anodonta, and an abundance of casts of reeds and aquatic plants, directly overlying the layers of silt or mud on which the tracks are found.

The sequence of events is plainly recorded in these beds. The floor of the quarry marks the close of a period of strong currents of water, depositing sand. A period of quiescence ensued, with the deposition of a fine clay or silt. This was drained of water, and became firm enough for animals to walk upon it and leave their tracks. This layer is separated from a second clayey layer by about eighteen inches of sand, marking an overflow and a second period of quiescence and drying-up. The tracks are most numerous and distinct upon this second layer. Immediately over it we find several inches in thickness of fine clayey sediment, penetrated by aquatic plants, with the remains of fresh-water shells, indicating the existence of a shallow lake or lagoon for a considerable period. The overlying coarse sandstones show the influx of strong currents, bearing the sand and the bones of animals from some point beyond, and higher than the tracks.

It is probable that these deposits were formed near the mouth of a comparatively large stream, subject to floods, and flowing into a shallow lake. Such conditions are not unlike those we now find all along the eastern base of the Sierra Nevada, where mountain torrents pour out into elevated valleys without outlet, and form broad lakes, which vary greatly in their extent at different seasons of the year. During the season of the melting of the snows, the lakes cover a much greater area than in the dry season, when the rivers cease to flow, and the lake-water disappears by evaporation. Large areas of the shores of such lakes then become exposed, and are gradually dried. If, as in the case of the deposits under consideration, the upper clayey sediments are underlaid by coarse sandstone, the clay layer is rapidly dried by under-draining, and affords a firm footing for animals in search of water. This need of water may account for the number of animals which crowded together at this place. It is possible, also, that a warm spring existed there, as at the present time, drawing animals toward it from the surrounding deserts.

The sandstone surface is distinctly marked by raindrop pits and by ripple or wave marks.

Tracks of the mammoth or elephant.

These appear as a series of circular depressions from three to six inches in depth, and averaging twenty inches in diameter. The most important series is forty feet long, and has ten distinct footprints. Most of these have a raised margin or border of clay in ridges, due to the great pressure and squeezing of the clay.

[1] Footprints found at the Carson state prison. By H. W. HARKNESS, M.D. *Proc. Cal. acad. sc.*, Aug. 7, 1882.

On certain remarkable tracks found in the rocks of Carson quarry. By JOSEPH LECONTE. *Proc. Cal. acad. sc.*, Aug. 27, 1882.

Prehistoric footprints in the sandstone quarry of the Nevada state prison. Description by CHARLES DRAYTON GIBBES, C.E., Sept. 4, 1882, to accompany diagrams of footprints.

HARKNESS, *Proc. Cal. acad. sc.*, August, 1883. (Abstract in *New-York evening post.*)

O. C. MARSH, *Amer. journ. sc.*, No. 152 [3] xxvi., August, 1883.

The Carson footprints. Report of Professor GEORGE DAVIDSON, president of the California academy of sciences, August, 1883.

Ichnolites of the Carson quarry. W. P. BLAKE. *Trans. Conn. acad. arts and sciences*, February, 1884.

The stride of the elephant which made the tracks here represented was about five feet eight inches, and the straddle three feet five inches, measuring from outside to outside.

Tracks of man (*so called*), **or mylodon** (?)

The long and curved tracks, which have excited the greatest degree of interest from their supposed human origin, extend in several different directions, but generally in straight direct lines. The longest series has forty-four tracks, and is a hundred and twelve feet long.

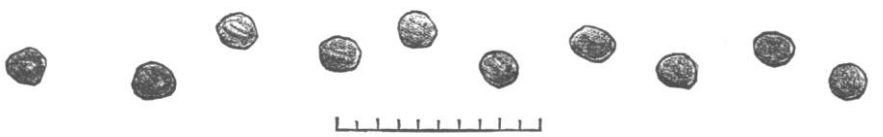

FIG. 1. — TRACKS OF THE ELEPHANT.

Another set of tracks is the most distinct of all, and is upon the upper layer of silt or clay, two feet above the general level of the quarry floor. A rubbing upon paper twenty-seven feet long, covers twelve tracks of this series, and shows the general form and the exact sequence and position of these tracks. The imprint on the paper being formed by rubbing with a graphite pad, it gives a more accurate idea of the shape of the tracks than any drawing made with hard, sharp outlines; for none of the outlines are sharply marked, but the depression gradually shades off into the generally plane surface. For this reason it is not easy to state definitely the exact size of these tracks. They may be said to be generally from nineteen to twenty-one inches in length, and from six to nine inches in breadth. The form is curved, not greatly unlike the inner curve of the human foot. The amount of depression is irregular and trough-like, deepest at the centre, as if the greatest pressure was exerted there; in this respect differing decidedly from the impress of a human foot, being without the heel and toe depressions, although some of the tracks show a more abrupt depression at the supposed heel than at the other end.

In order to explain the great size of the tracks on the theory of their human origin, and, further, to explain a peculiarity in the form of some of them, it has been asserted that sandals were worn. This peculiarity consists in a flat, tabular surface or border, extending, like a terrace, from an inch to two or three inches wide along the inner margin of the track. This is thought by some to be the impress of the sandal. The tracks having this peculiarity are shown of full size in figs. 1 to 5, attached to the memoir of Dr. Harkness. While he is fully confident that these are the imprints of sandals, he points out a very significant fact, — "that the impression is upon the same plane in each of the diagrams, and that there is no indication of toe or pad or arch in any of them" (p. 7).

A critical examination of these tracks having the partial border of a flat surface, showed that this flat margin marks a parting or dividing plane in the sediments along which the clay-like layers separated; such portions, apparently, as were not crushed and broken through, being lifted off as the foot of the animal was raised and carried forward.

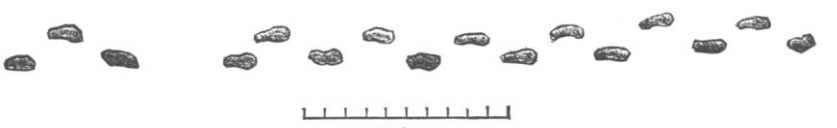

FIG. 2. — TRACKS RESEMBLING THE IMPRINT OF HUMAN FEET.
(*From the plan by Gibbes.*)

The fact that it occurs irregularly, sometimes on one side of the track for a short distance, and sometimes on the other, and irregularly at the end, and is sometimes entirely absent, goes to show that it was not produced by a flat, rigid surface. Besides, we cannot conceive of a flat sandal, such as would be required to make a *flat* imprint, permitting the central part of the track to be so greatly depressed. And in walking with sandals, the toe in leaving the

track, especially in a soft, muddy surface, tends to depress, and throw back the mud towards the centre of the track, whereas the conditions in these tracks are reversed. A longitudinal vertical section of one of these tracks would be nearly as in the diagram, the greatest depression being in the middle.

FIG. 3. — CROSS-SECTION OF IMPRESSION.

The breadth of the track-way, or straddle, is the next great objection to the theory of human origin. The whole breadth is from twenty-eight to thirty inches, whereas man requires, in walking, not over ten or twelve inches. If we take the ordinary stride of a man six feet high at twenty to twenty-four inches, the ratio of the breadth of space required in walking to this step is as ten or twelve to twenty or twenty-four, or 1 : 2; while in the tracks before us the ratio is as twenty-eight to twenty-seven, the step, in fact, being less than the straddle. This alone is fatal to the bipedal theory, and in favor of the quadrupedal; for upon the quadrupedal theory the length of step is fifty-six to sixty-two inches, and, the width being twenty-eight to thirty, the ratio of the width to the length is nearly as one to two.

There are also evidences of a duplication of tracks made by the hind-feet overstepping the imprints of the fore-feet. This has been particularly pointed out by Professor Davidson in his report.

The tracks of this series all have the appearance of being made by an animal with short legs, for it is evident that there was a sliding in and out of the foot, particularly in the trough-shaped impressions of the lower horizon of clay.

When first opened, these are always filled up with a compressed mass of clay and sand; and sometimes traces of a coarse, sedgy grass or vegetation are found, as if it had been pressed down under the foot into the clay.

The opinion of Professor Marsh, that these tracks were formed by one of the edentates, is best in accord with the phenomena, and appears the more reasonable when we give due weight to the fact that some of these animals are believed to have walked partly upon the side of the foot and leg, thus carrying their great claws in such a way that they left no imprint.

Elk (?)

Of the supposed elk-tracks there are thirteen in sequence, each track from four to five inches long by three and one-half wide, average step eighty inches, and breadth of track thirteen inches.

Deer.

The series referred to the deer is twelve feet one inch in length, and includes ten tracks of an animal with a sharp-pointed hoof, triangular in form, measuring two inches by two and one-half inches.

Birds.

The bird-tracks are numerous, and are generally about six inches in length and breadth, showing four toes, as in the figure.

It is well to note that the intense interest attaching to the question of the human origin of some of the tracks has greatly overshadowed the importance, geologically, of the whole series and the lessons to be learned from them. There has not been such an important discovery of fossil tracks since the unearthing of the fossil footprints in the sandstones of the Connecticut valley. These last were discovered in 1800, and served to stimulate and to foreshadow our knowledge of the forms of life between birds and lizards. The venerable Dr. Hitchcock, the author of 'Ichnology of New England,' in contemplating the evidences of the

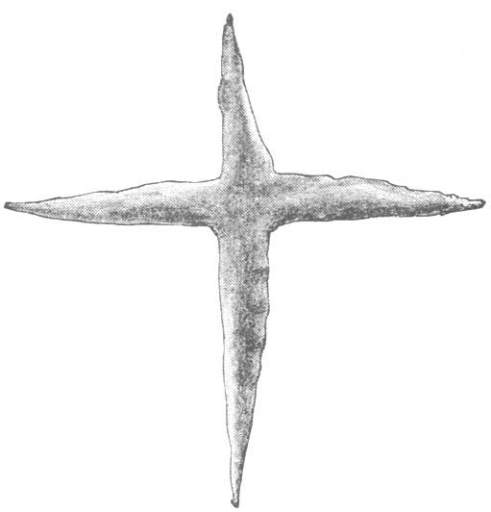

FIG. 4. — BIRD-TRACK.

so-called bird-tracks of the Connecticut valley, was led to exclaim, "Indeed, some of the tracks of these narrow-toed bipeds have such a resemblance to the feet of some lizard, that I anticipate the discovery of front teeth."

He cites Owen as saying, before fossil footprints were known, that "a single foot-mark of

a cloven hoof indicates to the observer the forms of the teeth, of all the big bones, thighs, shoulders, and of the trunk of the body, of the animal which left the mark."[1]

W. P. BLAKE.

Mill Rock, New Haven.

THE VIRULENCE OF CULTIVATED ANTHRAX VIRUS.

Experimental studies on the artificial attenuation of the infectious properties of the bacillus of Anthrax by means of cultivation. By Dr. R. KOCH, Dr. GAFFKY, and Dr. LOEFFLER.

Mittheilungen aus dem Kaiserlichen gesundheits-amte. Zweiter band. Berlin, 1884. (Extract from the publication of the imperial board of health of Germany.)

PASTEUR'S announcement that the parasites of malignant Anthrax were capable of changing their characteristics when cultivated under certain conditions, and that when thus modified they could be used for protective inoculation, aroused the greatest interest among investigators. Such a statement could not be accepted without confirmation at the hands of other observers; and none were better fitted for this task than the Royal health commission of Germany, at the head of which stands Dr. Robert Koch.

The experiments, which were instituted under his direction, have been carried on for two years, and have shown, that, although the bacilli could be rendered harmless, their protective power was not so great as was expected.

The original communication of the French *savant* was not exact in the details by which the experiments were to be carried out, and Koch had to employ much time in preliminary studies. This cannot, however, be considered as lost, since many valuable facts have been obtained by it.

According to Pasteur, if the cultivations were kept at a temperature constantly maintained between 42° and 43° C., the virulence gradually decreased until the ninth day, when it was entirely lost. By removing a specimen on any day, and allowing it to germinate at a temperature of 37° C., its activity at that stage could be perpetuated, and thus any degree of virulence that was required could be preserved. Two such cultures of different strength were used for protective inoculation, the weaker of which was called the *premier*, and the stronger the *deuxième vaccin*.

Koch commenced his investigations in the following way. A mouse was injected with blood containing spores of the bacillus, which had been kept five years, and was known to be of great virulence.

The animal was killed at the end of twenty-four hours, and a minute quantity of the spleen was taken on the point of a platinum needle which had been sterilized by heat, and sown in a glass bulb containing twenty cubic centimetres of chicken-bouillon neutralized with sodic carbonate. The bulb was then sealed, and placed at once in a constant-temperature apparatus, which was kept between 42° and 43° C.

Samples were taken daily, and tested upon animals; but, contrary to the promised result, the growth was found to be as deadly for small animals on the ninth as on the first day. Further cultivation proved, however, that, in a period varying from eighteen to twenty-nine days, the infectious property was entirely lost, although the external appearance of the bacillus was unaltered. Thus far, Pasteur's assertion was substantiated, except in regard to the length of time. A portion of this was taken, and allowed to grow at an ordinary temperature for two years; and during this time there has been no evidence of a return of virulence, nor has the form changed. These bacilli are as immovable as the active ones; their ends appear sharply truncated; they form long filaments, in which are developed oval glancing spores. Vaccination with this entirely inactive form did not give immunity against inoculation with the virulent one.

Those of a slight degree of force were next tried. At the end of twenty-four days a culture was obtained which would kill mice, but not guinea-pigs or other small animals, but still did not render them safe. This particular form Koch speaks of as 'mouse anthrax.'

It was thought that perhaps this represented the second and the inactive form, the first vaccination of Pasteur. Accordingly, a sheep was tried, but it succumbed to the malignant form as quickly as ever. It was next proposed to use three or more preventive inoculations; and, accordingly, cultures from the fifteenth day were taken as the first, from the eleventh as the second, from the ninth as the third, and from the fifth as the fourth, and these were followed by the virulent form. In this manner seven sheep, seven rabbits, and eleven guinea-pigs were tried. At the end, all the rabbits and guinea-pigs, and five of the sheep, had died.

In order to determine whether there might not be some other difference, specimens of the vaccinating-material, as furnished by Pasteur through his agent, were purchased, and proved

[1] *Proc. am. assoc. ad. sc.*, xiv. 146.