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12. V. L. Ginzburg and I. M. Frank, *Zhur. Eksptl'. i Teoret. Fiz.* **16**, 15 (1946); *J. Phys. U.S.S.R.* **9**, 353 (1945).
13. G. M. Garibyan, *Zhur. Eksptl'. i Teoret. Fiz.* **33**, 1403 (1957).
14. V. E. Pafomov, *ibid.* **37**, 1853 (1959).
15. A. E. Chudakov, unpublished.
16. In the book by Jelley [*Cerenkov Radiation and Its Applications* (Pergamon, New York and London, 1958)], with which I had the opportunity of becoming acquainted after this article had been written, there is mention of the fact that in 1958 the author, together with Elliot and Goldsmith, observed a radiation emitted by 1.5-Mev protons incident on a polished aluminum target. On the basis of the data on the intensity and polarization, the investigators concluded that the glow was transition radiation. This observation has now been published as an article [P. Goldsmith and J. V. Jelley, *Phil. Mag.* **4**, 836 (1959)].
17. V. E. Pafomov, thesis, Physical Institute of the U.S.S.R. Academy of Sciences, Moscow (1957); *Zhur. Eksptl'. i Teoret. Fiz.* **32**, 366 (1957); *ibid.* **37**, 1853 (1959).
18. V. L. Ginzburg and I. M. Frank, *Doklady Akad. Nauk S.S.S.R.* **56**, 583 (1947).
19. Apparently Eq. 6 may be put down in a form similar to Eq. 5a. The difference consists only in that the sign in the denominator of the right-hand member of Eq. 5 should be changed.
20. I. M. Frank, *Usepekhi Fiz. Nauk* **30**, 149 (1946).
21. For the Vavilov-Cherenkov radiation in an isotropic medium, this point regarding the threshold is elementary, since the latter is determined simply by the maximum value assumed by the refraction index in the given medium. Of importance for further consideration is the fact that for a frequency corresponding to n_{max}, the phase and group velocities are equal (see Eq. 10), it being evident for n_{max} that $dn/dw = 0$. Hence, the fact that the threshold velocity of motion is equal to the phase velocity means that it is also equal to the group velocity of light.
22. The magnitude determined by Eq. 10 has the meaning of the group velocity of light only when there is no strong absorption—that is, in those regions of the spectrum for which the medium is transparent. The part of the curve $\kappa(\omega)$ corresponding to the region of anomalous dispersion, in which there is unquestionable dispersion, is shown in Fig. 1 by a dotted line. The peculiarities of radiation for frequencies getting into this region call for special consideration.
23. This is related to the fact that in an anisotropic medium the direction of the group velocity does not coincide with the direction of the phase velocity. This question is treated in the next section.
24. The analysis given in Fig. 2 is similar in many ways to the example given in L. I. Mandelshtam's lectures on the refraction of light by a medium with a negative group velocity [L. I. Mandelshtam, *Collected Works*, vol. 5, p. 463].
25. Some of the problems connected with plasma were dealt with in I. E. Tamm's Nobel lecture [*Science* **131**, 206 (1960)].
26. V. L. Ginzburg, *Zhur. Eksptl'. i Teoret. Fiz.* **10**, 608 (1940); *J. Phys. U.S.S.R.* **3**, 101 (1940).
27. Strictly speaking, such an analysis presupposes that there is a superposition of monochromatic waves. Each point of the trajectory should, therefore, be regarded as a source of such waves emitted for an infinitely long time. Actually, it is only the summation of waves of various frequency that produces a light impulse when the particle passes through a given point. Hence, there exists, of course, not one but an unlimited multitude of wave surfaces for a given frequency. The one that is generally plotted is singled out only by its passage through the instantaneous position of the particle (which we shall term the wave cone).
28. K. A. Barsukov and A. A. Kolomensky, *Zhur. Tekh. Fiz.* **29**, 954 (1959).

Significance of Carbon-14 Dates for Rancho La Brea

Tests analyzed in the light of early field notes emphasize the complexity of dating the several traps.

Hildegarde Howard

Carbon-14 datings are at last available on well-documented material from the Rancho La Brea fossil deposits of Los Angeles, California. These important deposits, first scientifically investigated in 1906, yielded tens of thousands of bones of extinct animals, as well as remains of insects and plants, and afforded a remarkable representation of the Pleistocene life of the Los Angeles Basin area. Although there has never been any doubt that these deposits were accumulated in Pleistocene time, there has been some change in thinking regarding the part of the Pleistocene represented (*1*) and its equivalent in terms of calendar years. Several years back, when I had occasion to conduct school groups through the exhibit of Rancho La Brea fossils at the Los Angeles County Museum, the expression "approximately 50,000 years old" was used in referring to the fossils. It has for some time been agreed that, geologically speaking, the deposits are of late Pleistocene age (*2*). Carbon-14 dating has revealed that some "late Pleistocene" glacial deposits are only 11,000 to 12,000 years old (*3*). Cave deposits containing remains of ground sloths identical with those found at Rancho La Brea have been given an age of 10,000 to 11,000 years (*4*). It has become a matter of considerable significance, therefore, to procure radiocarbon datings for the most prolific of all late Pleistocene deposits—Rancho La Brea.

In 1949, tests were made at California Institute of Technology by David L. Douglas (then a research fellow in chemistry) in the course of experimentation with the use of ionization chambers for measurement of low-level carbon-14. As Douglas did not consider his method to be perfected, and the pit source of the wood tested was unknown, his results were not noted in paleontological literature; they were, however, later recorded by Douglas (*5*) in an article explaining his method.

Tests have now been made on documented material, and by two laboratories: the Geochronometric Laboratory of Yale University, directed by Edward S. Deevey, and the Radiocarbon Laboratory developed by Hans E. Suess at the Scripps Institution of Oceanography of the University of California, La Jolla. Both laboratories tested sections from

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the same tree specimen from the Los Angeles County Museum excavation known as pit 3, with results as nearly identical as could be expected, even from separate tests at a single laboratory. The Scripps laboratory then tested a section of a wooden artifact taken from the large excavation known as pit 61–67.

The date for the tree from pit 3 was estimated to be about 14,500 years B.P. (before the present); the date for the artifact from pit 61-67 about 4450 B.P. Douglas's experiments gave a date for the undocumented wood of about 16,-350 ± 2000 years. In order that the significance of these datings may be understood, certain details connected with the excavations should be explained. The following information was largely obtained by careful study of the day-by-day field notes kept by L. E. Wyman, who was in charge of the Los Angeles County Museum excavations of 1913–15.

Early Excavations

The area in which the Rancho La Brea deposits occur comprises approximately 23 acres located on busy Wilshire Boulevard in Los Angeles. It is developed today as a scientific monument known as Hancock Park. The most extensive excavations for fossils were made by the Los Angeles County Museum in 1913–15. In connection with these excavations, 96 "pit numbers" were recorded. The majority of these numbers apply to mere test holes that yielded no fossils. Some of the other excavations, although separately numbered, were in reality made in groups around one spot. For example, eight test holes were dug in one area at the east end of the park where bones were found in profusion but in a very poor state of preservation; it was hoped that one test hole would strike a spot where preservation was good. Another group of four holes centered around a previous, rich, University of California site. The total number of separate bone-bearing "pits" represented by the museum's early excavations is actually only about 24; of these, six showed comparatively recent activity. Pits 3 and 61–67 were among the ten best fossiliferous deposits excavated by the museum.

No bones were recovered from open, liquid tar lakes. All but one of the excavations were made in solid ground (*6*). Bones were entombed in a matrix of tar-soaked sand and were usually not encountered above a depth of 2 to 4 feet. A capping of hardened asphaltum was usually found above this level, and the presence of such hard material on the surface often suggested the spot for the test hole. In some instances, small recent vents of liquid tar occurred in or beside the capping. The method of formation of the tar deposits and the part played by the activity of oil and gas in mixing the entombed materials has been described by Stock (*7*). Because of this activity, stratification as usually understood was nonexistent. Nevertheless, a grid system of 3-foot squares was worked out for the excavations, and grid and depth data were recorded for nearly all specimens. These records serve to provide general information regarding deposition and to suggest areas of irregular activity. They should not, however, be accorded the same degree of significance as data concerning true stratification.

Pit 3

Pit 3 was excavated by the museum from July 1913 through August 1914. It was one of the simpler deposits, fairly symmetrical in shape, possibly having accumulated in an old gully. It was approximately 15 feet in diameter at its upper levels, sloping to dimensions of only 2½ by 3½ feet at its maximum depth of 27 feet. On one sloping bank, a tree 8 feet tall was found upright, rooted in the clay that lay beneath the asphalt. The tip of the largest branch was first encountered at a depth of 4 feet. As the branch was uncovered by excavation, its connection with the main trunk was revealed. Both branch and trunk had a diameter of approximately 10 inches. Bones of the typical Pleistocene La Brea fauna were packed solidly around the branch and the trunk. The following quotation is from the field notes of 15 December 1913, the date on which the tree was removed from the pit: "Tree was rooted in a stiff clay, at 12 feet. Many roots, some of them large ones, penetrated the adjacent wall almost horizontally, others projected into a mass of clayey matrix, well-boned. Directly underneath the trunk the earth was loose and bones lacking. The whole aspect of things indicated that the tree had grown on the bank of a gully, or possibly at the edge of a bone deposit that had been completely covered with a heavy deposit of clay; and when the tree was well grown it was submerged by a vent breaking through underneath its branches." The wood of this tree has been identified as cypress.

The samples of the tree that were tested at the Yale laboratory were from the trunk and were accompanied by the following notes: "1. (Yale no. Y-354) 2-inch core bored in center of trunk, 33 inches from bottom of tree. Outside of wood penetrated by tar for approximately 1/16 inch; solid wood for 3½ to 4 inches; centermost part of core rotted, tar-soaked wood (center of tree apparently rotted, or tunneled by insects). 2. (Yale no. Y-355) 2-inch core bored 11½ inches above sample no. 1; details as in sample no. 1." The unrotted wood from each sample was used for testing; part of each sample was washed in xylol to remove the tar. The results were as follows (*8*): Samples from which tar was not removed, No. 1, 14,500 ± 210 years; No. 2, 14,110 ± 420 years. Samples from which tar was removed, No. 1, 15,390 ± 230 years; No. 2, 13,890 ± 280 years.

A section from the root of the same tree was sent to the La Jolla Laboratory, where it was tested with the technical assistance of George S. Bien and Paula Sandoval. The tar was extracted from this entire sample. The date obtained for the wood (sample No. LJ 55) was 14,400 ± 300; the extracted tar (sample No. LJ 89) tested essentially "dead"—that is, older than 28,000 years.

The dating of the tree from pit 3 undoubtedly could apply as well to the fossil bones of the extinct animals, such as ground sloth, horse, lion, mastodon, wolf, and saber-toothed cat, found to a depth of approximately 12 feet around the tree. It is possible, however, that earlier dates might apply to the bones found at the 18- to 27-foot levels. The presence of oxidized asphaltum and clay at the 15-foot level suggests a period of quiescence between the entrapment of the animals represented in the lower beds and those represented in the upper.

Pit 61–67

The museum's excavations of pits 61 and 67 were carried on concurrently, in the fall of 1914 through the spring of 1915. Both were started at the edge of an old artificial pond whose bed was then dry. Fossiliferous matrix was found under the pond bottom from a depth of about 6 feet below the surrounding surface to as much as 20 feet in some places. About midway through the

period of excavation it was observed that the two "pits" would join. The one to the west (started as pit 61) seemed to be a series of connected pockets, varying in cubic contents from 1 to 10 yards, connecting in turn (to the east) with a fairly continuous deposit some 15 feet in diameter which formed the major portion of the excavation originally called pit 67. Adjacent to and southeast of this major section of pit 67, the matrix was fossiliferous but broken by blocks of hardened asphalt that may, according to the field notes, have caved in from the banks in past times. At least 13 of the approximately 17 artifacts recovered from pit 61–67, and a great variety of shells, were found in a strip about 30 feet long by 3 to 6 feet wide, at depths of 11 to 18 feet, in this latter portion of pit 67 and its extension into pit 61. In recording the occurrence of the artifacts and shells, the field notes include the following comment under date of 26 April 1915: "There is in this a suggestion that an Indian camp was once located very close to this spot."

The artifacts are listed and discussed by Woodward (*9*). He found that the bulk of them correspond to artifacts known from Indian sites in southern California dating into the historical period. Four of them (all wooden), however, suggested an earlier culture, not previously recognized in southern California. These consist of a bunt foreshaft for an atlatl dart and three atlatl dart foreshafts. It was a section of one of the latter that was tested at the La Jolla Laboratory as sample No. LJ 121 and dated 4450 ± 200 years B.P.

Although scattered fossils were found near the artifacts, the contemporaneity of artifacts and fossils has always been questioned. In the first place, the whole south portion of the excavation was subject to such frequent crumbling and caving-in that one is inclined to question the validity of grid and depth notations for materials from this area. Furthermore, the irregularity of the matrix in this southeast portion and the occurrence of numerous pockets throughout the entire pit 61–67 deposit suggest that this area was extremely unstable over a long period of time and that there was probably considerable intermittent activity.

The appearance of new surface vents of tar is, even today, characteristic of the entire Hancock Park area. These vents represent chimneys formed by gas pressure from subterranean petroleum deposits. As they enlarge, they can become channels for conveying surface materials downward as well as for bringing tar upward. In some of the excavated deposits, "chimney" accumulations could be detected from the character of the matrix. It is, therefore, possible that vents occurred beside or through the ancient pit 61–67 deposit at a somewhat later time. The presence of large chunks of hard material intermingled with softer matrix in the southeast section suggests, further, that a fracture of some extent may have existed, causing the edges of the banks to crumble and fall as they were undermined by fresh tar or weakened by heavy rains. These observations, together with the comparatively recent date now recorded for one of the artifacts, substantiate our previous contention that the artifacts and fossils in pit 61–67 were not contemporaneous. Obviously the artifacts were not of Pleistocene age; the condition of the pit seems adequately to explain their association with fossil bones without assuming that the animals represented existed up to 4500 years ago.

From this brief discussion of two of the Rancho La Brea deposits, which have been sampled for carbon-14 dating, it will be obvious that age determination for the complete La Brea section is far from complete. It is quite possible that other samples from greater depth in pit 3, and samples of nonhuman origin in pit 61–67, will yield dates different from those yielded by the samples already tested. It is also of particular importance to obtain knowledge of the relative ages of the several other active Pleistocene pits. Wood from three of the most important of these is on deposit at the Scripps laboratory, and results are eagerly anticipated (*10*).

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1. See C. Stock, *Los Angeles County Museum Sci. Ser. No. 1* (1930), pp. 16–20; *ibid., No. 11* (1946), pp. 13–16; and *ibid., No. 13* (1949), pp. 15–17.
2. C. Stock, *ibid., No. 13* (1949), p. 17, Fig. 5.
3. W. F. Libby, *Radiocarbon Dating* (Univ. of Chicago Press, Chicago, Ill., 1952), p. 88 (dating of wood and peat samples taken under glacial drift in Wisconsin).
4. ———, *ibid.*, p. 85 (dating of samples from Gypsum Cave, Nevada).
5. D. L. Douglas, *Gen. Elec. Rev.* **55**, 16 (1952).
6. One test was made in the center of the large tar and water lake on Wilshire Blvd., but the lake was drained first, and the hole was dug in bottom sediments. The fossils obtained were in a poor state of preservation.
7. C. Stock, *Los Angeles County Museum Sci. Ser. No. 13* (1949), pp. 18–20, 24; *ibid., No. 15* (reprint ed., 1953); *ibid., No. 20* (reprint eds. 1956, 1958).
8. E. S. Deevey, L. J. Gralenski, V. Hoffren, *Am. J. Sci. Radiocarbon Suppl.* **1**, 151 (1959).
9. A. Woodward, *Bull. Southern Calif. Acad. Sci.* **36**, 41 (1937).

10. I wish to thank Edward S. Deevey and Hans E. Suess and their associates for aiding the Los Angeles County Museum in these important tests. I am also very grateful to Carl L. Hubbs of the Scripps Institution of Oceanography, through whom the arrangements were made for the tests at the La Jolla Laboratory.

Edward Chace Tolman: A Life of Scientific and Social Purpose

The era of the grand system-builders of American psychology draws to a close with the death of Edward Chace Tolman in Berkeley, California, on 19 November 1959.

Edward Tolman was born in Newton, Massachusetts, in 1886. He graduated from the Massachusetts Institute of Technology in 1911 with a B.S. in electrochemistry. Pursuing his combined interests in science and the philosophy of human conduct, he entered into graduate study in the joint department of philosophy and psychology at Harvard. After receiving his Ph.D. in 1915 and after a brief period of teaching at Northwestern University, Tolman came in 1918 to the University of California in Berkeley, where he remained for the rest of his career. It was here that he began the experimental and theoretical work that was to continue for four decades. It is fitting that his pioneering work started when he moved West. For the characteristics of the West that he came to love—its open expansiveness, its free and stimulating spirit—also became the characteristics of his system-building.