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ARIZONA RADIOCARBON DATES V*

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INTRODUCTION

With few exceptions the C^{14} measurements reported here were made in this laboratory between October 1, 1962 and November 1, 1963. Sample descriptions are classified as follows:

I. Geochemical Samples.
II. Geologic-Paleoclimatic samples.
III. Early man-alluvial stratigraphy samples.
IV. Archaeologic samples.

The geochemical samples include more results on the tree ring series which were previously reported (Arizona IV). In addition, a number of bristlecone pine samples have been measured but will not be reported until an accurate tree ring chronology is available. A number of modern aquatic plants growing within a sink in Plio-Pleistocene limestone, Montezuma Well, were also measured to establish the initial C^{14} content within a limnocrene environment. The amazingly low C^{14} content of these plants further emphasizes the necessity for the careful evaluation of the initial C^{14} content of samples. Other geochemical samples consist primarily of materials chosen to evaluate the biospheric uptake of nuclear technology-produced C^{14}.

The second group of samples consists of organic material and carbonates chosen to evaluate the paleoclimatology of lakes and playas. The large number of playa samples from SE Arizona and SW New Mexico have been studied by one of the authors, A. Long, in connection with his doctoral research. The second author, V. Haynes, has been particularly concerned with research on the antiquity of man in North America and in the use of C^{14} to evaluate the stratigraphy of alluvial sites. The fourth group of samples includes, in addition to North American archaeologic samples, a number of Egyptian samples which add to the evidence for a serious discrepancy between the C^{14} chronology and the Egyptian archaeologic chronology.

Increasing attention has been given this year to the problem of sample pretreatment. The following is our present pretreatment technique: After decantation and hand-picking to remove roots, all non-carbonate samples are treated with 5% NaOH to extract humic acids and soluble lignins. If these fractions are found to represent a major proportion of the total sample they are precipitated in acid solution and converted to CO_2 in the standard way. If the carbonaceous residue from the NaOH treatment is of sufficient size for dating, it is leached with 6N HCl to remove all carbonates, checked again for root contamination, and converted to CO_2 in the standard way. In most cases, the insoluble C is the fraction desired for dating. The humate-lignin fraction is dated only if the other is unsuitable. In some cases both fractions are dated and reported.

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A special nitration method of pretreating samples of finely divided charcoal to remove contamination by fine vegetable matter has been developed and successfully tested, and is reported with geochemical samples (A-486).

Carbonate samples are hydrolysed in the standard way with phosphoric acid after the leaching of surface contaminants.

Standard deviations are computed from random counting errors only. In the opinion of the authors, the problem of the evaluation of the intial C^{14} content of samples is too complex, at present, to warrant the use of anything but this measure of precision.

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Gerald A. Cole, Life Science Center, Arizona State University, is studying the limnology of Montezuma Well and has cooperated with us in our study of samples from this locality. In this connection, we would also like to acknowledge the cooperation of the National Park Service.

Donald Grey, Catheryn MacDonald, Jack Allen and Fred Cagle assisted in laboratory analyses. Joyce Watson assisted in manuscript preparation.

SAMPLE DESCRIPTIONS

I. GEOCHEMICAL SAMPLES

Sequoia No. 3 series, California

Wood, *Sequoia gigantea*, from Giant Forest, Sequoia Natl. Park (36° 35′ N Lat, 118° 48′ W Long). Coll. 1959 by H. N. Michael, Univ. of Pennsylvania; subm. by M. A. Stokes. *Comment*: tree began growth ca. 215 B.C. and was cut in A.D. 1950. These samples were from the 10 B.C. to 50 B.C. age span.

	δC^{14},‰	δC^{13},‰	Δ,‰
A-255:7. Tree rings—Whole wood	-24 ± 5	—	—

Sample ground to approx. 40 mesh but not pretreated chemically.

A-255:10. Tree rings—Cellulose	-8 ± 5	—	—
A-255:11. Tree rings—Lignin	-8 ± 5	—	—

Comment: the average of the three samples is 13 ± 5‰. The average δC^{13} for four other analyses of Sequoia No. 3 is –20.2‰ (Arizona IV). These four samples for C^{13} analyses were first leached in hot NaOH followed by HCl. The value of δC^{13} obtained from these samples is not necessarily identical to the value for untreated wood, cellulose and lignin. Therefore no attempt was made to estimate Δ. Another sample will be analyzed to see if the δC^{14} difference between cellulose-lignin and whole wood is real.

Sequoia D-21 series, California

Wood, *Sequoia gigantea*, from Converse Mill Site, Sequoia Natl. Forest (36° 48′ N Lat, 118° 58′ W Long). Coll. 1918 by A. E. Douglass; subm. 1962 by M. A. Stokes. *Comment*: tree began growth in 1305 B.C. and was cut in logging operations ca. A.D. 1890 to A.D. 1910.

	δC^{14},‰	δC^{13},‰	Δ,‰
A-476. Tree rings	56 ± 6	–20.2	46 ± 6
1033 B.C. to 990 B.C.			
A-477. Tree rings	33 ± 5	–20.2	23 ± 6
834 B.C. to 772 B.C.			

Comment: δC^{13} value is the average of two determinations for Sequoia D-21.

Montezuma Well series, Arizona

Organic material from core in sediment, modern aquatic plants, and CO_2 evolved from water from Montezuma Well, Montezuma Castle Natl. Monument, ca. 10 mi. N of Camp Verde, Yavapai Co. (34° 39′ N Lat, 110° 45′ Long). Coll. 1961-1963 by G. A. Cole, P. S. Martin and R. H. Hevly; subm. 1963 by P. S. Martin and R. H. Hevly, Geochronology Labs., Univ. of Arizona, Tucson. *Comment*: Montezuma Well, elevation 3600 ft, is a unique limnocrene habitat in arid region of sub-Mogollon Arizona (Cole, 1963). It is a sink in Plio-Pleistocene fresh water limestone, with diam of ca. 400 ft and depth of 130 ft including 55 ft from the bottom to water level. Water enters through at least three deep fissures, 125 ft below water surface, at rate of ca. 5600 m^3/day. An outlet through the rim wall maintains water at a level approaching constancy. A modified ancient Indian irrigation ditch carries the water away; other old ditches may still be observed at slightly higher levels.

Chemically, Well is hard carbonate water, with calcium the principal cation. Major anions are carbonate, chloride, and sulfate in that order, while cations are calcium, sodium, magnesium and potassium in sequence. The sum of the principal ions is about 840 mg/1.

pH ranges from 6.2 at night and on some cloudy days to 6.9 on bright sunny days; there is no residual acidity. Total alkalinity, which is due entirely to bicarbonate, varies from 560 to 600 mg/1. These data, implying a theoretical free CO_2 content ranging roughly from 150 to 700 mg/1, indicate charging from a subsurface reservoir.

A-395. Organic Material from Core **7.07 ± 0.60% modern**

Remains of *Potamogeton illinoensis* Morong, an aquatic flowering plant, in core coll. under 55 ft of water, 26.5 to 41.5 cm below surface of sediments. *Comment*: apparent C^{14} age of 21,300 ± 750 yr B.P. cannot be accepted because modern aquatic plants in the Well contain similar amounts of C^{14}.

A-438. Modern Aquatic Plant **11.61 ± 0.57% modern**

Chara sp. (Charophyceae) growing in 1 to 2 ft of water; submerged at time of collection March 24, 1963, but lowered water table during summer months may expose them. *Comment*: apparent C^{14} age of these modern aquatic plants is 17,300 ± 400 yr B.P.

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A-439. Modern Aquatic Plant **4.72 ± 0.20% modern**

Potamogeton illinoensis rooted on bottom at depth of 25 ft, but uppermost leaves reach water surface. Coll. March 24, 1963. *Comment*: apparent C^{14} age of these modern aquatic plants is 24,750 ± 400 yr B.P.

A-440. Water **6.46 ± 0.42% modern**

CO_2 extracted from Montezuma Well water sample. *Comment*: apparent C^{14} age of the well water is 21,420 ± 220 yr B.P.

Comment: results illustrate the effect of the utilization of old carbon by submerged aquatic plants. Apparent age of 22,000 ± 600 yr for organic substances associated with the pollen record is not meaningful. Actual age of the organic material in the core at the 26.5 to 41.5 cm level could be 4000 B.P. or less.

Tucson Sewage series

Sludge, dried primary and digested sewage effluent samples from Tucson City Sewerage Disposal Plant on Casa Grande Highway (32° 18′ N Lat, 110° 57′ W Long). Samples coll. and subm. 1962 to 1963 by E. J. Trueblood of Tucson City Sewerage Div., P. O. Box 5077, and F. Cagle, Geochronology Labs., University of Arizona.

A-390. Dried Digested Sludge **102.6 ± 0.8% modern**

Composite sludge from months of May, June, July 1962.

A-391. Thickened Primary Sludge (volatiles) **103.3 ± 0.8% modern**

Primary sludge sample coll. Sept. 10, 1962. Heated to 300° C to drive off volatiles which were then collected, purified and counted. *Comment*: 7.0 L of CO_2 were obtained from 10.69 g of sample.

A-392. Thickened Primary Sludge (nonvolatiles) **79.4 ± 1.1% modern**

Sample obtained by burning A-391 after first collecting volatiles at 300° C. *Comment*: 2.3 L of CO_2 were obtained. Composite of A-391 and A-392 representing the weighted average of the volatile and nonvolatile components yields 97.5% modern.

A-394. Dried Digested Sludge **100.0 ± 2.1% modern**

Composite sludge from month of Aug. 1962.

A-402. Thickened Primary Sludge **100.6 ± 0.8% modern**

Primary sludge coll. Oct. 23, 1962.

A-403. Dried Digested Sludge **105.2 ± 0.7% modern**

Composite sludge for the month of Sept. 1962.

A-407A. Thickened Primary Sludge (volatiles) **106.8 ± 0.9% modern**

A-407B. Thickened Primary Sludge (nonvolatiles) **94.3 ± 2.1% modern**

Volatile and nonvolatile fractions obtained as for A-391, 392, from sludge

coll. Nov. 29, 1962. *Comment*: weighted average of 1.53 L of nonvolatiles and 3.3 L of volatiles yields 103.9% modern.

A-408. Dried Digested Sludge **98.0 ± 0.7% modern**

Composite sludge sample for the month of Oct. 1962.

A-454. Sewage Effluent **115.1 ± 2.5% modern**

Dissolved CO_2 and bicarbonate released by acidification and agitation, coll. at entrance to holding ponds May 2, 1963. Water temp 23.8° C. *Comment*: effluent has picked up C^{14} from atmosphere upon aeration but it still lags behind the atmospheric C^{14} resulting from nuclear technology.

Comment: the six month average for sludge samples from June to Nov. 1962 is 102 ± 2% modern. Definite evidence for an increase during this time was not observed, although the average C^{14} content of atmospheric samples increased from about 135% to 140% modern during this period (I. Olsson, Upsala Univ., personal communication, April 23, 1963). Thus Tucson's Digested Sewerage Sludge is lagging significantly behind the C^{14} content of the atmosphere (Broecker and Walton, 1959). The sludge can be separated into two components, an older nonvolatile fraction and a younger volatile fraction with the volatile fraction averaging about 3.5 times larger, by volume of CO_2, than the nonvolatile fraction. The sludge may have equilibrated in part with older ground water (see A-424, this paper). It also contains a mixture of older cellulose from paper products and dead petroleum products, which must reduce the C^{14} content of vegetable and animal products that have been contaminated by nuclear technology.

Tucson Alfalfa series

Alfalfa samples grown in Univ. of Arizona farm plot on Campbell avenue, Tucson, from Sept. 12 to Oct. 27, 1962 (32° 15′ N Lat, 110° 55′ W Long). Coll. and subm. Oct. 27 by M. A. Massengale.

	δC^{14},‰	δC^{13},‰	Δ,‰
A-400. Alfalfa Leaves	362 ± 7	—	—
A-401. Alfalfa Stems	358 ± 6	—	—

Medicago sativa moapa variety, designated as sample I-M-3 by M. A. Massengale.

A-409. Alfalfa	365 ± 5	—	—

Medicago sativa African variety, designated as sample 1-A-3 by M. A. Massengale. Total plant including leaves and stem.

Comment: there is no significant difference between leaves and stem or between the two varieties. The average δC^{14} is 362 ± 4‰.

	δC^{14},‰	δC^{13},‰	Δ,‰
A-446. Tucson, Arizona	**508 ± 9**	**–22.4**	**500 ± 9**

Leaves from mulberry tree growing in residential area on outskirts of Tucson (32° 14′ N Lat, 110° 53′ W Long). Coll. April 7, 1963 and subm. by P. E. Damon. *Comment*: these leaves are from the same tree as L-253 (Lamont VIII) coll. April 4, 1959 (Δ = 187 ± 8‰), and A-329 (Arizona IV) coll. May 20, 1962 (Δ = 303 ± 6‰).

A-486. Artificial Mixture **<0.55% modern**

Dead charcoal (A-482) weighing 8.181 g was mixed with 0.466 g of post-bomb (Aug. 1963) grass roots. Sample, consisting of 94.61% charcoal and 5.39% roots, was ground, boiled in 15% NaOH for 1 hr, washed and filtered; to the residue 200 ml 6N HCl and 150 ml clorox were added slowly with stirring and boiled for 20 min; sample was again filtered and washed with distilled water; to residue, 400 ml of 50/50 HNO_3 and H_2SO_4 were added with stirring for 10 min; sample was then filtered and washed with distilled water, and dried; following this, sample was leached with nine 200 ml portions of acetone, dried in air with aspirator and washed with distilled water; lastly it was oven-dried. *Comment*: this analysis demonstrates that 5.39% of C^{14}-enriched roots can be removed from charcoal, leaving no detectible C^{14} that could affect the dating.

A-424. Tucson, Arizona **51.3 ± 1.6 modern**

Tap water from Geol. Bldg., Univ. of Arizona (32° 15′ N Lat, 110° 55′ W Long). Coll. Jan. 23, 1963 and subm. by F. C. Cagle.

II. GEOLOGY-PALEOCLIMATOLOGY

A-388. Chuska Mountains, New Mexico **19,400 ± 1800 17,450 B.C.**

Organic material from core No. 6101, 160 to 180 cm depth, in Dead Man Lake (36° 15′ N Lat, 108° 55′ W Long), Chuska Mts., San Juan Co. Pollen pattern in this core is similar to that in No. 5826e, which shows at this level an *Artemisia-Picea-Pinus* assemblage interpreted as a record of alpine vegetation during last glacio-pluvial phase. Core coll. 1961 by H. E. Wright, Jr., Univ. of Minnesota, Minneapolis (Bent and Wright, 1963). *Comment*: large standard deviation due to small CO_2 yield when burned. Other samples from Dead Man Lake core No. 5826e as follows: A-268, 312-318 cm, 24,700 ± 3900, Arizona IV; A-213, 725-735 cm, 28,000, Arizona III. Core No. 5825a, nearby: L-515A, 9-12 cm, 3900 ± 300.

A-482. Bodega Bay, California **>42,500**

Wood from near sealevel, part of a forest, now ca. 40 ft below land surface in reactor pit excavations (38° 18′ N Lat, 123° 3′ W Long), Bodega Head, California. Coll. 1963 by Lu Waters, Cotati, California; subm. 1963 by Pierre St. Amond, China Lake, California.

A-451. China Lake Pelecypod shell **28,500 ± 4300 26,550 B.C.**

Shell of *Anodonta oregonensis* in drill core from 24.5 ft below surface of China dry lake, 10 ft N of core MD-1 (Smith and Pratt, 1957), (35° 43′ N Lat, 117° 38′ W Long), China Lake, California. Coll. 1963 by R. Von Huene, U. S. Naval Ordinance Test Station; subm. by P. S. Martin, Geochronology Labs., Univ. of Arizona. *Comment*: a 200-grain pollen count from mud enclosing the shell yielded 38% sedge, 9% cattail and other pollen of shallow-water aquatic plants.

Willcox playa series, Arizona

$CaCO_3$ coll. on or near surface E of present playa (32° N Lat, 110° W

Long), and 5 to 10 mi S of town of Willcox. Material dated with purpose of establishing water level chronology for the pluvial lake Cochise, of which Willcox playa is a remnant. All samples washed in dilute HCl before hydrolysis. Coll. 1962, and subm. by Austin Long. *Comment*: although Lake Cochise undoubtedly had hard water, and the problem of initial C^{14} content is a real one (Oana & Deevey, 1960; Broecker & Walton, 1959; Montezuma Well series, this date list), the results are reported in terms of yr B.P. with the understanding that the numbers are maximum ages. Nevertheless, the results indicate lake levels responding to known climatic fluctuation during the Late Pleistocene. All elevations given in ft.

Table shows tufa collected on surface:

No.	Location	Altitude, ft	Uncorrected date
A-311	NE ¼, sec. 14 T15S, R25E	4180	7350 ± 130
A-339	SE ¼, sec. 24 T14S, R25E	4220	10,400 ± 100
A-335	NE ¼, sec. 12 T16S, R25E	4212	11,100 ± 100
A-315	SE ¼, sec. 13 T15S, R25E	4220	11,150 ± 180
A-314	NE ¼, sec. 14 T15S, R25E	4190	11,300 ± 180
A-313	SE ¼, sec. 14 T15S, R25E	4200	11,470 ± 180
A-361	NW ¼, sec. 2 T14S, R24E	4175	12,890 ± 420
A-338	NW ¼, sec. 12 T16S, R25E	4173	13,600 ± 450
A-310	SW ¼, sec. 14 T15S, R25E	4175	17,600 ± 1200
A-312	NE ¼, sec. 14 T15S, R25E	4200	18,300 ± 900
A-337	NW ¼, sec. 12 T16S, R25E	4177	20,400 ± 370
A-309	NW ¼, sec. 36 T14S, R25E	4180	20,500 ± 370
A-336	NE ¼, sec. 12 T16S, R25E	4190	21,500 ± 370
A-319	NE ¼, sec. 13 T16S, R25E	4241	21,600 ± 1800
A-305	NE ¼, sec. 11 T14S, R25E	4225	22,600 ± 2600

The following two samples were coll. from sand dunes and are presumed to be caliche formed by dissolution and re-deposition of loess, probably derived from the dried playa surface.

A-291. Caliche **40.6 ± .4% modern (7160 yr)**

Large stabilized dune, NE ¼, sec. 14, T14S, R25E, alt 4200 ft.

A-304. Caliche **63.4 ± 3.8% modern (3660 yr)**

Apparently young active dune, SW ¼, sec. 10, T14S, R25E, alt 4175 ft.

Two samples from limestone deposit, especially well exposed in a quarry E of the playa (32° 08′ N Lat, 109° 45′ W Long).

A-318. Quarry limestone **17,900 ± 270**

Top of lime layer 2 ft below surface of ground.

A-360. Quarry limestone **27,600 ± 900**

Bottom of lime layer 10 ft below surface of ground.

A-316A. Limestone, Carbonate fraction **13,700 ± 150**

Limestone outcropping, alt 4190 ft, thought to be equivalent to lime in quarry; in light of data, it may be a more recent deposit.

A-316B. Limestone, organic fraction **19,100 $^{+3500}_{-6800}$**

Unidentified organic material from A-316, possibly younger but probably deposited contemporaneously with it.

A-458. Quarry limestone, organic fraction **10,690 ± 650**

Organic material from specimen coll. near A-360. Apparently represents post-carbonate deposition of soil humus.

A-355. Playas Lake, New Mexico **3190 ± 160**

Carbonate deposited at or near margin of intermittent lake (31° 55′ N Lat, 180° 35′ W Long). Material probably recently formed, and still forming today at places nearer the center of the basin. Coll. 1962 and subm. by A. Long. *Comment*: if carbonate age is calculated on basis of continuous, uniform rate of carbonate accumulation until present, it is 7300 B.P. (see A-250, p. 299, Arizona IV).

San Agustin Plains series

Carbonate samples related to the final shrinking of the extinct lake, deposits of which were described by Clisby and Foreman (1958), with C^{14} dates as published by the Yale lab. (Yale VII). Tufa deposits are most prominent on each of a series of terraces, and diminish or disappear between terraces. Coll. 1962 and subm. by A. Long.

A-393. Tufa, 6800 ft **10,500 ± 130**

Tufa just beneath wave-cut cliffs in NW ¼, sec. 16, T5S, R14W, alt 6800 ft (33° 52′ N Lat, 108° 16′ W Long).

A-404. Tufa, 6850 ft **10,680 ± 170**

Tufa on lowest major terrace on SW "shore" (33° 43′ N Lat, 108° 18′ W Long) SW ¼, sec. 3, T7S, R14W, alt 6850 ft.

A-405. Tufa, 7000 ft **13,500 ± 650**

Tufa on highest major terrace (alt 7000 ft) 1.8 mi SW of A-404 (33° 42′ N Lat, 108° 19′ W Long) NW ¼, sec. 14, T7S, R14W.

A-406. Lime crust, 7300 ft **1.6% modern**

Calcareous crust on basalt cobbles coll. on continental divide just NW of San Agustin Plains (33° 57′ N Lat, 108° 30′ W Long), alt 7300 ft.

Lordsburg series, New Mexico

Carbonate samples from near Lordsburg Playa, Grant Co., New Mexico. Coll. 1962 and subm. by A. Long.

A-417. Lordsburg, caliche **28.8% modern**

Caliche 6 in. below surface (32° 18′ N Lat, 108° 50′ W Long), alt 4200 ft, coll. E margin of Playa, interbedded with clay and gravel, overlain by gravel of probable recent age. *Comment*: C^{14} content is consistent with origin during last pluvial episode (Arizona IV).

A-418. Lordsburg, carbonate **4560 ± 90**

Carbonate formed in stream bed (32° 17′ N Lat, 108° 57′ W Long),

presently covered by 1 to 3 ft soil zone which has been cut by more recent stream action. *Comment*: carbonate date provides maximum age for overlying soil and thus indicates post-altithermal down-cutting on W side of Lordsburg playa.

Avra Valley, Arizona

Carbonate fraction (Caliche) from soil (A-397) and subsoil (A-398, A-399), sec. 5, T12S, R11E, Pima Co. (32° 20′ N Lat, 110° 20′ W Long). Coll. 1960 by M. S. Yesilsoy and S. W. Buol, Chem. and Soils Dept., Univ. of Arizona, Tucson; subm. by S. W. Buol.

A-397. Avra Valley, 38 to 44 in. depth 79.6 ± 1.1% modern
$CaCO_3$ content of soil zone is 1.5% by weight.

A-398. Avra Valley, 60 to 66 in. depth 29.6 ± 0.4% modern
$CaCO_3$ content of soil zone is 9.3% by weight.

A-399. Avra Valley, 84 to 90 in. depth 0.88 ± .45% modern
$CaCO_3$ of soil zone is 9.3% by weight.

Comment: the chemical discontinuity at the 60 in. level is corroborated by petrographic analyses (Yesilsoy, 1962). Assuming an instantaneous origin for the carbonate in the 38 to 44 in. zone, and initial C^{14}/C^{12} the same as contemporary atmosphere, the age would be 1840 B.P. If the initial C^{14}/C^{12} were less than its contemporary atmosphere, the age would be still younger. Assuming continuous formation of carbonate, at constant rate, from some time in the past to the present time, with each layer deposited at 100% modern at the times of deposition, the time of first deposition of A-397 was 2300 yr ago (see A-250, Arizona IV, p. 299). Any assumption of less than 100% modern initial concentration of C^{14} would make the age even younger. Thus, we may conclude that the age of the carbonate in A-397 is $\leqslant$2300 B.P. The approximate rate of caliche formation, ca. 1 in./1000 yr, in this locality is similar to the rate in the neighboring Santa Cruz Valley (eg. see Oracle Junction Series, Arizona IV, p. 297). Thus A-398 represents carbonate accumulated over, very approximately, a 6000 yr span of time. An "average age" for the A-398 carbonate (or caliche) is 9800 B.P.

A-387. Newport Mesa, California >44,000

Marine shell, *Schizothaerus nuttallii*, from member of lakewood formation (33° 30′ N Lat, 117° 50′ W Long). Coll. 1950 by George Kanakoff, Los Angeles County Mus.; subm. by J. F. Lance, Univ. of Arizona, Tucson, and W. E. Miller, Long Beach State College, California. *Comment*: beds of Newport Mesa have long been correlated with the Palos Verdes formation of the Palos Verde Hills which contains an abundant invertebrate fauna and a few mammalian fossils in some places. The vertebrate fossils are similar to those from Rancho La Brea but could be somewhat older from a paleontological standpoint (Lance, 1948; Kanakoff and Emerson, 1959). Kulp and others (1952) have dated a specimen (L-144A) of the same species from the Palos Verdes formation of the Palos Verdes Hills area at >30,000 yr.

III. EARLY MAN-ALLUVIAL STRATIGRAPHY

A. Southwestern States

Lehner Ranch series, Arizona

Lehner site, San Pedro Valley (31° 25′ 23″ N Lat, 110° 06′ 48″ W Long), Cochise County, Arizona, Ariz:EE:12:1, is an elephant-kill site in which Clovis fluted points were found in association with charcoal, bones of nine immature mammoths, and remains of horse, bison and tapir (Haury *et al.*, 1959; Lance, 1959; Antevs, 1959).

A-378. Charcoal **10,940 ± 100 8990 B.C.**

Charcoal from sand and gravel unit (Clovis level) immediately below unit *k* and stratigraphically equivalent to unit *i* or *j* of Antevs (1959). Equivalent to pollen sample 13 of Mehringer pollen profile 2 (in preparation). Coll. and subm. 1962 by P. J. Mehringer and C. V. Haynes, Geochronology Labs. *Comment*: sample dates the base of a pollen profile which should provide an estimate of the vegetation when the San Pedro Valley was occupied by mammoth, tapir, bison, horse, and people of the Llano complex. Date falls within one standard deviation of the average of 11,260 ± 360 B.P. for six dates (A-40a, 40b, and 42; K-554; M-811; and A-378) from this level. Overlying unit *k* has been dated as 10,410 ± 190 (A-33 bis., Arizona III).

A-450a. Charcoal **2550 ± 160 600 B.C.**

Charcoal from rock-lined hearth 110 cm below present surface in alluvial sand subunit of unit *o* (Antevs, 1959) in N bank of Lehner arroyo. Corresponds to pollen samples 4 to 6 of Mehringer pollen profile 5 (in preparation). *Comment*: date establishes a late Chiricahua or early San Pedro age for the hearth and dates the vegetation indicated by the pollen samples.

Blackwater No. 1 series, Clovis, New Mexico

The Blackwater No. 1 locality (34° 17′ N Lat, 103° 19′ W Long), Roosevelt Co., New Mexico is described by Sellards (1952, p. 29-31) and by Wendorf (1961, p. 115-117). Other C^{14} dates are 6230 ± 150 (0-170) and 6300 ± 150 (0-169) on burned and unburned bone from the "carbonaceous silt" unit; and 4950 ± 150 (0-157) on burned bone from the "jointed sand" unit (Humble I, p. 149). Coll. 1962 by Vance Haynes, Jerry Harbour and James Hester; subm. by Fred Wendorf and J. Hester, Mus. of New Mexico, Santa Fe.

A-386. Diatomite unit, Folsom occupation **10,490 ± 900 8540 B.C.**

Humic acids and lignins extracted from fossil plant remains in diatomite between carbonaceous silt above and gray sand below. *Comment*: date is comparable to Folsom dates at other sites.

A-379. Fine-grained carbonaceous matter in silt **9900 ± 320 7950 B.C.**

A-380. Humic acid and lignin fractions **10,600 ± 320**
8650 B.C.
Average: 10,250 ± 320
8300 B.C.

A transitional zone of interbedded silt and diatomite layers between silt above and diatomite below was sampled to provide a maximum age of carbonaceous silt deposition and a minimum age of diatomite deposition. *Comment*: dates are comparable to A-386 and suggest that the transitional zone is part of the diatomite unit.

A-481. Llano occupation **11,170 ± 360**
9220 B.C.

Humates and lignins from carbonized plant remains in the Clovis level. Coll. 1963 by G. A. Agogino, subm. 1963 by Agogino and C. V. Haynes. *Comment*: sample occurred as a silt-clay lens 1 in. thick, extending in and around the skull of mammoth No. 1 and indicating deposition soon after emplacement of the mammoth remains and associated Clovis artifacts. Sediments are free from contamination by roots or humic acids derived from soils, and hence the sample consists entirely of humic acids and soluble lignins extracted from the fossil plants during laboratory pretreatment. Date is consistent with dates (see A-386, 379, and 380 this date list) obtained from stratigraphically higher diatomite containing Folsom artifacts. Date also falls within time range established for Llano complex at the Lehner site (11,260 ± 360; see discussion for A-378, this date list) and at the Dent site (11,200 ± 500, I-622 Isotopes, Inc., unpub.).

A-375. McCullum Ranch, New Mexico **15,750 ± 760**
13,800 B.C.

Fine-grain free carbon from well-sorted gray sand exposed in deflated depression (blowout) on the Curtis McCullum ranch, Blackwater Draw, E New Mexico (34° 16′ N Lat, 103° 16′ 30″ W Long). Coll. 1962 by V. Haynes and J. Hester; subm. by F. Wendorf and J. Hester. The carbon was washed from the sand by decantation in distilled water. Standard pretreatment showed no humic acids. This and the absence of artifacts suggest that the free carbon is the remains of a natural fire. The carbonaceous lens occurs within friable well-sorted quartz sand and is stratigraphically equivalent to a calicum carbonate duricrust believed to represent an ancient interdunal pond. Associated with the pond unit and the basal part of the overlying gray eolian sand are fossil remains of mammoth, horse, bison, camel and sloth. The pond unit contains numerous molluscs. No evidence of human occupation was found. *Comment*: dates a relatively wet late-Wisconsin episode on the High Plains, and a contemporary fauna.

A-396. North Palo Duro Creek, Texas **6120 ± 60**
4170 B.C.

Burned bone from test excavation in alluvium at base of an exposed arroyo wall of North Palo Creek, T. Dooley ranch near Sunray, Texas (36° 15′ N Lat, 102° 45′ W Long). This horizon produced Plainview points and other artifacts representing a single period of occupation. Coll. 1959 by Keith Glasscock; subm. by F. Wendorf. *Comment*: the date is considerably younger

than the Plainview level at the type site (9800 ± 500 B.P., L-303, Lamont IV, p. 1329) and unfortunately there is insufficient data to evaluate the date on geological grounds.

B. Wyoming Alluvial Stratigraphy

Since 1959 the Pleistocene and Recent alluvial stratigraphy associated with Early Man sites in Wyoming has been investigated by V. Haynes in collaboration with archaeologists H. T. Irwin, Peabody Mus., Harvard Univ.; Cynthia Irwin-Williams, Am. Mus. of Nat. History; and G. A. Agogino, Eastern New Mexico Univ. Attention is being focused upon the Hell Gap area where the archaeologists have demonstrated a remarkably complete record of human occupation from 11,000 B.P. to the present. A consistent record of human occupation, vertebrate fossils, and C^{14} dates controlled by detailed stratigraphy is being developed and will be reported elsewhere.

A-364. Lance Creek Bison Fall **2450 ± 75**
500 B.C.

Charcoal from aboriginal hearth in middle portion of an alluvial fill and associated with numerous bison remains and triangular side-notched points. The alluvium occurs below bluffs of Tertiary rocks adjacent to Lance Creek (42° 59′ N Lat, 110° 53′ W Long), Niobrarra Co., Wyoming. Coll. and subm. 1962 by C. V. Haynes. *Comment*: the alluvium is the Kaycee formation of Leopold and Miller (1954) and the C^{14} date confirms their estimate of its age.

A-365. Rawhide Creek Site **10,180 ± 480**
8230 B.C.

Charcoal from bottom of laminated silt, overlying massive silt and sand, exposed in left bank of Rawhide Creek, Goshen Co., Wyoming (42° 33′ N Lat, 104° 30′ W Long). Coll. 1961 by G. Agogino and subm. 1962 by C. V. Haynes. *Comment*: provides maximum date for deposition of laminated silt. Underlying unit contains flint workshop debris including bifacial forms broken in the process of manufacture. Date is therefore minimal for human occupation of the site.

A-366. Rawhide Butte Mammoth Site **10,550 ± 350**
8600 B.C.

Charcoal on erosional contact between two silt units (42° 37′ N Lat, 104° 29′ W Long) NE foothills of Rawhide Buttes, Niobrarra Co., Wyoming. Coll. 1960 and subm. 1962 by C. V. Haynes. *Comment*: the lower silt contains the articulated remains of mammoth that were exposed in antiquity by erosion. The top portions of several articulated vertebra were charred. The C^{14} date is, therefore, that of the contact between the two units and is later than the mammoth. No artifacts were found in direct association.

A-372. Sisters' Hill site, Wyoming **9600 ± 230**
7650 B.C.

Fossil plant remains in silt of channel fill exposed at the Sister's Hill site (44° 16′ N Lat, 106° 46′ W Long), Johnson Co., Wyoming. Coll. and subm. 1962 by C. V. Haynes. *Comment*: dates alluvial deposition that postdates a deposit containing Agate Basin and Hell Gap artifacts. A composite charcoal sample from the occupational levels has been dated at 9650 ± 250 (I-221,

Isotopes IV). The indicated 50-yr difference between the two periods of alluvial deposition is believed to be too small, but the dates are in proper stratigraphic order and of the right magnitude if the statistical errors are considered.

A-431. Hell Gap, Site 2, Wyoming **13,060 ± 600**
11,100 B.C.

Disseminated charcoal in greenish-gray silty clay, forming the upper foot of graded alluvial gravel, sand and silt, Hell Gap, Site 2 (42° 24′ 35″ N Lat, 104° 38′ 25″ W Long), Goshen County, Wyoming. Coll. 1960 and subm. 1963 by C. V. Haynes. *Comment*: alluvial unit is tentatively correlated with the Ucross formation of Leopold and Miller (1954). Date is commensurate with the late Wisconsin age assigned that formation, and predates occupation of the site by makers of Hell Gap, Folsom, and Midland artifacts.

A-432. Hell Gap Site, Wyoming **1000 ± 160**
950 B.C.

Charcoal from rock-filled fire pit excavated from a buried erosion surface at the Hell Gap site, pump locality (42° 24′ 30″ N Lat, 104° 38′ 8″ W Long), Goshen County, Wyoming. Coll. 1962 and subm. 1963 by C. V. Haynes. *Comment*: no diagnostic artifacts were found in association with the hearth, but the stratigraphic position and the date confirm a late prehistoric age.

IV. ARCHAEOLOGY

Casas Grandes series, Mexico

Corn kernels, wood and charcoal from Casas Grandes Archaeological Site (30° 22′ N Lat, 107° 58′ W Long) NW Chihuahua. Subm. 1962 by C. C. Di Peso, Amerind Foundation, Inc., Dragoon, Arizona. *Comment*: a tree ring chronology has been established which covers a period of 486 yr from A.D. 851 to A.D. 1336 (Scott, 1963).

A-412. Charcoal, CG(C)6 **640 ± 30**
A.D. 1310

From Pit Oven 4-1, 200 cm below surface in fill of stone-lined pit; archaeologic site CHIH. D:9:1; associated with Diablo Phase of Tardio Period. Coll. 1958 by B. N. Wettlaufer.

A-415A. Wood, CG(D)262 **820 ± 50**
A.D. 1130

A-415B. Wood, Humus fraction **560 ± 180**
A.D. 1390

From upright wood post No. 1, Room 38-11, CHIH. D:9:1; associated with Buena Fe Phase of Medio Period. Coll. 1960 by R. C. Trujillo. *Comment*: wood was leached with hot dilute NaOH, followed by 3N HCl, and washed in distilled water. Wood and humic acid fractions were then measured separately.

A-411. Charcoal, CG(C)189 **710 ± 40**
A.D. 1240

From 1st floor ceremonial House 1, charcoal in contact with floor in burned room, CHIH: D:9:14; associated with Reyes Phase of Medio Period. Coll. 1959 by R. C. Trujillo.

A-413. Charcoal, CG(C)175 **890 ± 190**
A.D. 1060

Charcoal and charred corn kernels on floor of Room 30, CHIH: D:9:2; associated with Perros Bravos Phase of Viejo Period. Coll. 1959 by R. C. Trujillo.

A-410A. Corn Kernels, CG(P)53 **1130 ± 100**
A.D. 820

A-410B. Corn, Humus fraction **950 ± 160**
A.D. 1000

Corn kernels from under 10 cm of fill on floor of House K, CHIH: D:9:2; associated with Convento Phase of Viejo Period. Coll. 1959 by R. C. Trujillo. *Comment*: House K was overlapped by House J, also of Convento phase, which was overlapped by House S of Pilon Phase. The C^{14} chronology of these and other dates at the site agrees within experimental error with the tree-ring chronology.

Carter Ranch series, Arizona

Charcoal and humates from Site LS-199A along Hay Hollow Wash, Carter Ranch (34° 30′ N Lat, 110° 5′ W Long), ca. 9 mi SE of Snowflake, Navajo County, Arizona. Coll. 1962 by W. A. Lonacre, R. H. Hevly and James Hill; subm. by P. S. Martin, Chicago Nat. History Mus.

A-425a. Pithouse, charcoal **1020 ± 40**
A.D. 930

A-425b. Pithouse, humates **1170 ± 180**
A.D. 780

Comment: the archaeological estimate for age of the pithouse is A.D. 600 to 800 and probably the first half of this period; hence the C^{14} dates appear too young. This suggests that the C^{14}/C^{12} ratio may have been anomalously high at the time, as is also indicated by recent investigations of Damon and Long (1963). Sample is associated with the floor level of Hevly's pollen profile LS-199A (Hevly, 1963).

A-427. Lava Beds National Monument **1160 ± 160**
A.D. 790

House pit timber from Univ. of California Archaeol. Survey Site Sis-101 (41° 49′ 35″ N Lat, 121° 29′ 50″ W Long), lakeshore bluff about 300 yd NE of Captain Jack's stronghold, Lava Beds Natl. Monument, California. Coll. and subm. 1962 by B. K. Swartz, Jr., Univ. of Arizona. *Comment*: the wood beam is directly associated with a component of the Tule Lake Phase, estimated archaeologically to have begun ca. A.D. 1500. The C^{14} date appears to be too old, but may mean that an old log was used in pit house construction.

A-389. El Doctor Mining District, Mexico **1220 ± 65**
A.D. 730

Outer rings of small tree trunk found with stone implements and sandal made of maguey fiber in Ampliacion del Santo Palo mercury mine, in excavation 20 m below surface, covered by debris, El Doctor mining district, municipality of Cadereyta, Queretaro (20° 55′ 00″ N Lat, 99° 33′ 30″ W Long). Coll. 1962 by Eduardo Sanchez-Garcia; subm. by Carl Fries, Jr. and E. Schmitter,

Inst. de Geol. Univ. Nac. Autonoma de Mexico, Mexico, D. F. *Comment*: date apparently demonstrates that the Indians of the region mined cinnabar from underground workings in pre-Columbian times. Cinnabar was used as red paint in many murals in pre-Columbian structures in central Mexico.

Wadi Halfa series, Sudan

Wood and charcoal samples from fortresses and habitations along the banks of the Nile in the Wadi Halfa district of Sudan. Subm. 1963 by W. Y. Adams, UNESCO Programme Specialist, P. O. Box 131, Wadi Halfa, Sudan.

A-433. Semna I **3670 ± 60**
1720 B.C.

A reinforcing timber built into the wall, 100 cm above present ground level, W portal of N fortress gate, Semna West Fortress (21° 29′ N Lat, 30° 58′ E Long). Coll. 1962 by Alexander Badawy of U.C.L.A. Expedition to Nubia. *Comment*: sample from main girdle wall considered to be one of the original features of the fortress built in the reign of Sesostris (=Senusret) III. His reign has been determined by the astronomically fixed chronology as beginning 1887 B.C. and ending 1849 B.C. The timber is badly decayed and termite-ridden. The discrepancy between the expected date and C^{14} date is in the same direction but not as great as that for another Semna I sample, A-205 (Arizona IV). The difference in the C^{14} dates for A-433 and A-205 may be due, in part, to the age of the wood at the time of construction of the fortress. The fortress has been described by Dunham (1960).

A-434. Askut II **3560 ± 50**
1610 B.C.

A reinforcing timber built into inner face of N girdle wall about 50 cm above present ground level, Fortress of Askut (21° 37′ N Lat, 31° 06′ E Long). Coll. 1962 by W. Y. Adams. *Comment*: Askut Fortress is not historically recorded, but on the basis of location, layout and contents it belongs to the well-known Middle Kingdom chain of fortresses built chiefly during the reign of Sesostris III. Askut, like the other fortresses, had a substantial New Kingdom re-occupation, beginning probably in the time of Thutmose III (1501-1447 B.C.). However, the girdle wall from which the sample was taken is of Middle Kingdom construction and is presumed to be part of the original fortress structure. Wood is badly decomposed.

A-435. Mirgissa II **3460 ± 70**
1510 B.C.

Wood from horizontal timber built into top of mud-brick wall, part of outer girdle near SE corner of the upper fortress, Mirgissa (21° 48′ N Lat, 31° 10′ E Long). Coll. 1962 by W. Y. Adams. *Comment*: one end of the timber was found protruding from the eroded top of the wall, about 3 m above the present ground level. After the overlying bricks were removed a considerable portion of the timber was removed from the wall. Sample is from a point which was 1 m within the wall. Mirgissa Fortress is the only one of the Second Cataract fortresses which has a double girdle wall. Prof. Emery of the Egypt Exploration Society has suggested that the outer wall may have been added in New Kingdom times to strengthen the fortress. However, the outer girdle wall is

architecturally identical to the inner wall and it seems more probable, according to W. Y. Adams, that they were both built during the Middle Kingdom. The construction of the walls is typical of Middle Kingdom Military architecture.

A-437. Buhen III **3520 ± 70**
1570 B.C.

Wood fragments from inner Middle Kingdom fortification associated with portion of Buhen Fortress (21° 51′ N Lat, 31° 17′ E Long). Coll. 1962 by W. Y. Adams. *Comment*: the fortification walls were probably built during the reign of Sesostris II (1903-1887 B.C.).

A-436. Service Site 6-G-25 **4730 ± 50**
2780 B.C.

Charcoal from habitation refuse about 10 cm beneath surface consisting of windblown sand, about 100 m distant from nearest vegetation, Sudan Antiquities Service Site 6-G-25, Unit A-1, Level 1 (21° 55′ N Lat, 31° 18′ E Long). Coll. 1962 by Hans-Ake Nordstrom.

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