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U. S. GEOLOGICAL SURVEY RADIOCARBON DATES VI*

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Dates in this list have been determined at U. S. Geological Survey radiocarbon laboratory, Washington, since our 1960 date list (USGS V). Procedures for the preparation of acetylene gas used in the counting, and the method of counting, (two days in two separate counters) remain unchanged. However, the modern standard used is no longer wood grown in the 19th century, but 95% of the activity of NBS oxalic-acid radiocarbon standard, as recommended at the 1959 Groningen Radiocarbon Conference. Measurement of the oxalic-acid standard at our laboratory indicates 6.2 ± 1% more C^{14} activity than our modern wood standard; so use of the new standard should make no appreciable difference when comparing samples computed by the old method. W. F. Libby's (1955) half-life average for C^{14}, 5568 ± 30 years, was used for the decay equation.

Pretreatment of wood, charcoal, and peat samples by boiling in acid, alkali, and acid again, is standard procedure. Ultrahigh frequency vibration cleaners are used on all shell samples. This process has proven extremely useful in removal of matrix from snail shells. In addition, shell samples are pretreated in weak acid to remove outer 20% of carbonate, a step which reduces the likelihood of contamination.

SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

A. Eastern United States

W-910. New Sharon, Maine **>38,000**

Spruce fragments from brown sandy silt, underlying blue-gray till and overlying greenish-gray till, exposed (Caldwell, 1959) on N bank of Sandy River (44° 38′ 30″ N Lat, 70° 00′ 24″ W Long), 0.6 mi NE of New Sharon, Maine. Coll. 1959 by D. W. Caldwell, Wellesley College, Wellesley, Massachusetts; subm. by R. L. Dow, Dept. of Sea and Shore Fisheries, Augusta, Maine. *Comment*: this is undoubtedly same horizon and locality as Y-689 (Yale V), dated at >30,000, and provides an excellent cross-laboratory check. Several dates on samples from beneath till now exist for localities in New England; all are outside our range of C^{14} dating.

W-883. Lewiston, New York **12,080 ± 300**

Picea mariana (id. by D. Bierhorst) from laminated silt and clay deposits of Lake Iroquois, unearthed in excavation at Lewiston in connection with Niagara Power Project of New York State Power Authority, in spoil area in SE Lewiston (43° 10′ N Lat, 79° 02′ W Long), New York. From 340 ft alt in gray silty clay, overlying till and underlying brown silty clay, obtained from

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office of C. P. Benziger, of Uhl, Hall, and Rich, Lewiston, New York. *Comment*: two runs were made on a log coll. 1958 by C. P. Benziger; subm. by E. H. Muller, Syracuse Univ. Syracuse, New York, from same locality. W-813 (USGS V) gave age of 8520 ± 300, and W-861 (USGS V), 12,660 ± 400. W-813 was believed to be incorrect due to erratic behavior of the counter. In order to verify W-861 date, another sample, coll. at same time, was requested. New date agrees with W-861; difference is considered insignificant. Because no till overlies lake beds in which wood was found, and because this locality is N of escarpment forming Niagara Falls, date of ca. 12,000 yr should date beginning of the Falls. In addition, this date, giving a minimum age for youngest till in New York, makes it unlikely that the continental ice sheet reached New York State during Valders time.

B. Central United States

W-917. Danville, Illinois **>40,000**

Wood from silt in a diversion drainage ditch dug for a strip mine in SE ¼ NE ¼ sec. 2, T 19 N, R 12 W (40° 09′ N Lat, 87° 40′ W Long), NW of Danville, Illinois. The section, originally described by Eveland (1952), consists of a series of tills interbedded with silt, sand, or gravel deposits. Recent erosion along ditch has exposed additional phenomena, and a revised, more detailed description and interpretation has been published by Ekblaw and Willman (1955). W-256 (USGS III), >37,000, was from this section from a till designated as of Ilinoian age by Eveland. Sample (W-917) comes from a silt, higher in the section (unit IX of Ekblaw and Willman). Wood occurs in this till and in the silts above and below the till. Coll. 1959 by Ekblaw and Willman, Illinois State Geol. Survey. *Comment*: this till was interpreted as Farmdale till by Ekblaw and Willman. They now state "although the previous date (>37,000) makes a Farmdale age doubtful, it appears now that the till could be Wisconsin but pre-Farmdale in age. Wood from the silt above the till could be considerably younger than till and is at least a possibility for a Farmdale age" (W. B. Willman, written commun., 1959). Date allows placement of this silt and till in Altonian substage of Frye and Willman (1960), which is of Wisconsin, pre-Farmdale age.

W-882. Harrison County, Iowa **11,600 ± 200**

Spruce log (id. by D. W. Bensend, Iowa State Univ.) from alluvium at depth 28.4 to 29.4 ft in W bank of Willow Drainage ditch, 100 ft N of tributary entering from W, in SW ¼ sec. 11, T 80 N, R 43 W (41° 45′ N Lat, 95° 47′ W Long), Harrison County, Iowa. This is one of several dated-wood samples from Thompson Creek and Willow River watersheds (see Thompson Creek series, USGS V, p. 144-145). Alluvial fill represents a complex sequence of erosion, deposition and accumulation of organic matter. Deposits have been divided tentatively into 5 beds. Sample comes from 15 in. above base of bed 2, second from the bottom. Coll. 1959 by R. B. Daniels, U. S. Dept. of Agriculture, North Carolina State College, Raleigh. *Comment*: W-700 (USGS V), from top of basal bed 1 in Thompson Creek watershed, dated 11,120 ± 440. Either top of bed 1 in Thompson Creek area is younger than base of bed 2 in Willow

River area, or this detrital log was redeposited from underlying bed 1 (Daniels, and others, in preparation).

W-908. Big Bone Lick, Kentucky **<250**

Wood from blue clay in trench cut into bank of Gum Branch at junction with Big Bone Creek, near Big Bone Lick Salt Spring (38° 53′ N Lat, 84° 45′ W Long), Rising Sun and Union Quadrangles, Ohio-Kentucky. Section consists of dense blue clay underlying a Cary (?) terrace fill and a Recent terrace fill. Blue clay contains bones of bison, musk-ox reindeer and elephant (Jillson, 1936; Cooper, 1931). Coll. 1959 by F. C. Whitmore, Jr., U. S. Geol. Survey, Washington, D. C., and C. B. Schultz, Univ. of Nebraska State Museum, Lincoln. *Comment*: wood does not date the blue clay, but must have been deposited at a later date during recent scour by the stream.

W-919. Coopers Canyon, Nebraska **10,850 ± 300**

Mollusks from white cross-laminated sand exposed along W side of gully cutting into railroad embankment, and E side of Coopers Canyon in NW ¼ NW ¼ sec. 14, T 15 N, R 11 W (41° 17′ N Lat, 98° 34′ W Long), Howard County, Nebraska. Sample from upper 10 in. of sand, which underlies silt and a humic gley horizon. Humic gley soil and underlying silt had been considered by Scott (Miller and Scott, 1955) to be parts of the Sappa formation of late Kansan or Yarmouth age, and the underlying sand to be the Grand Island formation of Kansan age. Coll. 1959 and carefully cleaned by R. D. Miller, U. S. Geol. Survey, Denver, Colorado. *Comment*: W-752 (USGS V) 10,500 ± 250, was sample consisting of mollusks coll. by J. C. Brice, U. S. Geol. Survey, Lincoln, Nebraska, from beneath gley soil at Coopers Canyon. This sample was run to confirm the date on Brice's sample.

W-900. Grand Forks, North Dakota **10,080 ± 280**

Wood from N-flowing drainage ditch at jet airbase, 1.8 mi N of U. S. Highway 2, in NW ¼ sec. 31, T 152 N, R 52 W (47° 50′ N Lat, 97° 20′ W Long), 15 mi W of Grand Forks, North Dakota. Section from top to base consists of: soil, 1.8 ft; yellow sandy clay of glacial Lake Agassiz, 1.6 ft; tan crossbedded sand with a few pebbles, 6.5 ft; fossil wood (sample from here) in horizontal position in sand, branches up to 3 in. in diameter, 1.0 ft; gray, unoxidized sand at ditch level, 1.0 + ft. (Till probably underlies sand at shallow depth). Sample run as check on W-723 (USGS V), 10,960 ± 300, taken from E-flowing drainage ditch 0.5 mi S of this locality, at about the same stratigraphic horizon. The problem, discussed by Lemke and Colton (1958), is whether the ice sheet entered North Dakota in Valders time. The till inferred to underlie the fossil wood is believed to have been deposited by the ice lobe that formed the Edinburg and Holt moraines, and represents the last ice advance into North Dakota. This date, as well as from W-723, provides a minimum age for this till but does not preclude a Valders age. Coll. 1959 by R. W. Lemke, U. S. Geol. Survey, Denver, Colorado. *Comment*: if the wood gave a Two Creeks age or older (11,300 or more), last advance would have to be a pre-Two Creeks event. Because no till overlies the wood, the possibility of

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Valders age till in North Dakota would be precluded, but with the present data, no conclusions of that nature can be made.

W-901. Waukesha, Wisconsin **30,800 ± 1000**

Spruce log (id. by B. F. Kukachka, Forest Products Laboratory, Madison) from depth of 60 ft in gravelly-sand outwash exposed in Johnson Sand and Gravel Co. pit in NW ¼ SW ¼ sec. 36, T 7 N, R 19 E (43° 03′ N Lat, 88° 12′ W Long), 1 mi NE of Waukesha, Wisconsin. The log, 4 to 6 in. in diameter and 2 ft long, is one of many occurring in the pit. Site was mapped by Alden (1918) as ground moraine of Lake Michigan lobe, now regarded as of Cary age. Typical Cary stony till up to 40 ft thick lies unconformably on top of outwash, which is locally contorted. Folds seem in part to be due to overriding and in part to slump by melting of buried ice blocks. Coll. 1960 by E. R. Nelson, Public Museum, Milwaukee, Wisconsin; subm. by R. F. Black, Univ. of Wisconsin, Madison. *Comment*: local topography is similar to that studied by Black near Lake Geneva in Walworth County (sample W-638, USGS V, from Lake Geneva dated 31,800 ± 1200) in SE Wisconsin, where overriding of buried outwash by Cary ice is well established. Abundant large logs, which are obviously transported but not compressed like those in till, are supposed by Black to be part of a forest destroyed by stream action as the outwash was laid down, presumably during the deglaciation of SE Wisconsin just after Rockian advance (of Black) of some 30,000 B.P.

W-903. Elkhorn, Wisconsin **29,000 ± 900**

Spruce log (id. by B. F. Kukachka, Forest Products Laboratory, Madison) imbedded in outwash gravel at depth of 40 ft in gravel pit in NW ¼ SE ¼ sec. 1, T 3 N, R 16 E (42° 45′ N Lat, 88° 33′ W Long), 5 mi N of Elkhorn, Wisconsin. Occurrence is similar to W-901, this date list, (see also W-747, USGS V, Hammond, Wis., 29,000 ± 1000, and Y-572, Yale IV, 30,650 ± 1640). Gravel here is also contorted and overlain by thin till. Area is mapped as terminal moraine of Lake Michigan lobe (Alden, 1918); till is considered Cary in age (late Woodfordian of Frye and Willman, 1960) by the collector, R. F. Black, Univ. of Wisconsin. *Comment*: according to Black (written commun.) this outwash represents the retreat phase that followed the Rockian advance. Frye and Willman (1960) would correlate it with Winnebago drift of Shaffer (1956), a rock-stratigraphic unit within their Altonian substage. Leighton (1960) used similar dates from Wisconsin to date the Farmdale glacial drift of the Farmdale substage.

C. Western United States

W-892. Searles Lake, California **12,390 ± 400**

Carbonaceous mud from core hole S-35, 0.25 mi W of NE corner of sec. 2, T 26 S, R 43 E (35° 42′ 30″ N Lat, 117° 19′ 00″ W Long), Searles Lake, California (Gale, 1914). Sample taken from base of Overburden Mud deposited after lake had desiccated to form the Upper Salt. Overburden Mud extends from 0 to 22.7 ft in this core and sample was taken from bottom 0.7 ft. None of the ca. 30 dated samples from Searles Lake (Flint and Gale, 1958) are from Overburden Mud. This segment of core varies in lithology from mud

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with scattered pirssonite crystals, to muddy halite near the base. Sample consisted of organic portion of upper half. Coll. 1958 by F. J. Dluzak, American Potash and Chemical Corp., Trona, California; subm. by G. I. Smith, U. S. Geol. Survey, Menlo Park, California. *Comment*: stratigraphically older samples elsewhere in the lake sediment have been dated as younger than the 12,390 yr of this sample. It is unlikely that this is the age of Overburden Mud. It is possible that sample consisted of some carbonaceous matter reworked from older lake sediments exposed around the edges. Additional dating will help clarify the anomaly.

W-898. Thatcher, Idaho **33,700 ± 1000**

Shells of freshwater mollusks taken from calcareous silt and clay from oldest exposed sediments of Lake Thatcher, exposed in road cut in center SW ¼ NE ¼ sec. 35, T 11 S, R 40 E (42° 26′ N Lat, 111° 45′ W Long), 1.5 mi NW of Thatcher, Idaho. Sample is 99% *Valvata* spp., remainder being *Carinifex* and *Pisidum* (id. by R. C. Bright). Lake Thatcher was formed by lava-damming of Bear River (Bright, 1960). Lake rose to 5484 ft alt and overflowed into Bonneville Basin to the S. This sample came from 4935 ± 5 ft alt. Coll. 1959 by R. C. Bright, Univ. of Minnesota, Minneapolis. *Comment*: two previous samples from Lake Thatcher sediments were from higher in section. W-704 (USGS V), 32,500 ± 1000 yr was from 5290 ± 5 ft alt; W-855 (USGS V), 27,500 ± 1000 yr from 5170 ± 5 ft alt.

W-899. Preston, Idaho **13,900 ± 400**

Shells of freshwater mollusks from cross-laminated sand within a series of sediments believed associated with Provo level of Lake Bonneville in N Cache Valley, Idaho. Section is exposed in road-cut, in NE ¼ NW ¼ NE ¼ sec. 28, T 15 S, R 39 E (42° 06′ N Lat, 111° 54′ W Long), 1.3 mi W of Preston, Idaho. Sample alt, 4702 ± 5 ft, ca. 10 ft below top of cut. Sample is 85% *Valvata utahensis* and *Stagnicola* spp.; remainder *Succinea*, *Gyraulus*, hydrobiids, and *Pisidium* (id. by R. C. Bright). Coll. 1959 by R. C. Bright, Univ. of Minnesota, Minneapolis. *Comment*: all attempts to date the various stands of Lake Bonneville have been handicapped by lack of really good datable carbon from a definite stand or shoreline. Ages of the Provo-level samples range from ca. 11,600 to 40,000 yr. This large range is probably due to the reoccupation of the shorelines at various times, but it may reflect the unsatisfactory nature of materials dated.

W-902. Cascade, Montana **7460 ± 250**

Snail shells from undercut bank of Missouri River, 2 mi NE of Cascade, SE ¼ NE ¼ sec. 24, T 18 N, R 1 E (47° 20′ N Lat, 111° 53′ W Long), Montana. From buried soil horizon that may be Hypsithermal in age, with wide regional distribution. Soil, at depth 6 ft is overlain by ash (Galata ash of Horberg and Robie, 1955). Date gives age of buried soil, as well as a maximum age for ash. Underlying sample horizon are beds of clay, silt and sand. At 10 ft, in silt, a nearly complete bison skeleton was coll. and identified as *Bison antiquus*, Leidy. Clam shells from bison horizon were dated as 8800 ± 300, W-594, (USGS V). Coll. 1958 and subm. by R. W. Lemke, U. S. Geol.

Survey, Denver, Colorado. *Comment*: shells were vibrated by an ultrasonic cleaner that removed adhering matrix.

W-918. Gallatin County, Montana **600 ± 250**

Charred wood from E wall of arroyo, in NE 1/4 NE 1/4 sec. 16, T 3 N, R 3 E (46° 01′ N Lat, 111° 22′ W Long), Clarkston Valley, Gallatin County, Montana. Charred wood is from stratum of silt a few in. thick, containing many large pieces of wood, ranging from unaltered through surficially charred, and the articulated backbone and ribs (but not head or limbs) of *Bison bison* (id. by G. E. Lewis, USGS, Denver). Stratum is 8 ft below surface of Quaternary alluvium and colluvium at least 20 ft thick. Surface has been stable long enough to develop thin soil and continuous grass cover. Coll. 1957 by G. D. Robinson, U. S. Geol. Survey, Denver, Colorado. *Comment*: locality is at head of latest arroyo cutting, probably dating from the 1870s. Wood, obviously from an occupation site, helps date time of alluviation of Clarkston Valley.

W-921. Toledo, Oregon **>40,000**

Wood embedded in silt and clay exposed in road cut along E side of Olallie Creek, 600 ft W, 2150 ft S, NE corner sec. 17, T 11 S, R 10 W (44° 38′ N Lat, 123° 52′ W Long), Toledo quadrangle, Oregon. Exposed Pleistocene sequence consists of 90 ft of poorly consolidated clay, silt, and sand, with thin gravel beds. Wood is abundant in lower part of section; this sample from 65 ft depth. Coll. 1958 by P. D. Snavely, Jr., U. S. Geol. Survey, Menlo Park, California. *Comment*: these sediments were believed to have been deposited in an embayment that formed in the vicinity of Toledo, Oregon, during a post-Wisconsin rise of sealevel.

W-922. Nisqually River, Washington **1640 ± 250**

Wood from a duff zone at top of a yellow pumice exposed by excavation of W approach to new Nisqually River bridge, 150 ft SW from bridge and directly beneath highest ridge of Nisqually Glacier moraine (1840 of Sigafoos and Hendricks, in press) in Mount Rainier National Park (46° 47′ N Lat, 121° 45′ W Long), Washington. Section consists of surface till of 1840 moraine, a series of pumice layers (the sample horizon from above the uppermost pumice, a good stratigraphic marker), overlying till. Crandell and Waldron (1956) described a measured section of recent pyroclastics from Mount Rainier that is similar to that on Nisqually side of mountain. Coll. 1959 by R. D. Miller, U. S. Geol. Survey, Denver, Colorado. *Comment*: date gives minimum age for coarse yellow pumice widespread in the Mount Rainier region.

Mount Rainier series, Washington

Wood exposed on E wall of Kautz Creek during 1948 flood, ca. 0.75 mi upstream from Wonderland Trail crossing in the NE 1/4 NW 1/4 sec. 21, T 15 N, R 8 E (46° 47′ N Lat, 121° 48′ W Long), Mount Rainier National Park, Washington. Strong flood of 1948 cut channel 60 ft deep, exhuming a section consisting of (from top to base): flood deposits, 20 ft; buried forest 0 to 3 ft (sample W-926 from here); mudflow deposits, 33 ft; pumice slurry flood deposit, 3 to 15 ft; pumice ash fall, 1.5 to 2 ft; immature soil zone, 0.5 ft (W-

925 from here); mudflow deposits, less than 12 ft. W-925 was stump rooted in mudflow at base of section. Tree was killed by a 2-ft fall of lapilli from Mount Rainier or by a flood of pumice slurry and boulders that immediately followed ash fall and buried roots of tree to a depth of more than 10 ft. Still later it was buried under additional 50 ft of deposits. During this accumulation, there was a period of non-deposition, allowing a forest to grow. W-926 was from log, 10 in. in diameter, taken from this buried forest. Samples date last main eruption from Mount Rainier. Coll. 1960 by A. C. Waters, Johns Hopkins Univ., Baltimore, Maryland. *Comment*: two samples may have different ages; if so, this small difference is not detectable by C^{14} method.

W-925. Mount Rainier stump **350 ± 250**

Stump exposed at water level.

W-926. Mount Rainier log **350 ± 250**

Log taken from bluff 37 ft above stream bed.

W-914. Pinedale, Wyoming **11,330 ± 320**

Organic matter taken from near base of core obtained from an unnamed lake on top of left lateral moraine of Green River lobe, Pinedale in age, in NW ¼ sec. 9, T 36 N, R 110 W (43° 06′ N Lat, 110° 00′ W Long), 18 mi N of Pinedale, Fremont County, Wyoming. Sediment consists of dark, yellow-brown copropelic clay. Dated sample taken from 310 to 315 cm below top of core, coincident with a *Betula* maximum, below a *Pinus* minimum, and below a *Picea* maximum. Pollen analysis by R. C. Bright. Coll. 1959 by H. E. Wright, Jr. and R. C. Bright, Univ. of Minnesota, Minneapolis. *Comment*: two related samples are shells coll. from knob-and-kettle outwash of Pinedale age, 3 mi SE of Jackson Lake, Wyoming. W-392 and W-393 (USGS IV) dated 9580 ± 250 and 8800 ± 250 respectively.

D. Alaska

Sullivan Creek series, Alaska

Wood recovered from frozen silty sediments of late Pleistocene and Recent age exposed in mining excavations near Sullivan Creek, Tofty placer-mining district (65° 10′ 45″ N Lat, 150° 20′ 15″ W Long), central Alaska. Stratigraphic section is as follows: (A) massive, structureless silt, probably loess, 5 to 10 ft thick; (B) discontinuous lenses of fresh peat, large and uncompressed logs, 0 to 5 ft thick; (C) stratified organic silt, largely reworked loess, 10 to 30 ft thick; (D) pond sediments or fine fluvial gravel containing abundant bones of mammoth, bison, horse, ground squirrel, lemming and other microtine rodents, 0 to 7 ft thick, resting unconformably on underlying unit; (E) organic silt, stratified, but stratification extremely distorted, probably as consequence of having thawed out during deposition of overlying unit. Soil profile in upper 1 to 5 ft. Total thickness 10 to 20 ft; (F) pebble gravel overlying bedrock. Coll. 1956 by D. M. Hopkins, U. S. Geol. Survey, Menlo Park, California.

W-891. Wood from unit D **2520 ± 200**

This appears to be much too young because beaver-gnawed wood from unit B has been dated as 6820 ± 200 (W-810, USGS V).

W-895. Wood from unit F **>39,000**

W-896. Omega Creek, Alaska **4100 ± 200**

Wood recovered from abandoned mining pit of Montana Mining Co. in Omega Creek opposite mouth of Montana Creek, Eureka placer-mining district (65° 10′ 45″ N Lat, 150° 20′ 15″ W Long, central Alaska. Wood embedded in iron-stained but fresh gravel, 9 ft thick, overlain by gravelly peaty silt, 4 ft thick, and underlain by sequence of peat, silt, and gravel, 12 ft thick. Coll. 1956 by D. M. Hopkins, U. S. Geol. Survey, Menlo Park, California. *Comment*: age indicates specimen came from bed ca. correlative with units A and B at Sullivan Creek (see W-891, W-895).

E. Miscellaneous

Waipahu series, Oahu

Two samples of oyster shells were analyzed to date the 25-ft (Waimanalo) stand of sea in Hawaii. Stand is considered definitely eustatic and most probably formed during interglacial or interstadial period. A 25-ft stand is recognized in many parts of the world; in Europe it is termed by some Late Monastirian. Section consists of alluvium to the surface of an embankment at alt 20 ft with a bed of oyster shells 1 ft thick at 13 ft. Coll. 1959 by J. F. Mink; subm. by K. J. Murata, U. S. Geol. Survey, Hawaiian Volcano Observatory and Washington, D. C.

W-886. Waipahu 1 **>38,000**

Shells, densely packed but not cemented. Loose silty marl mixed with shells. Sample came from upper part of oyster bed at 14 ft above sealevel. Obtained from embankment at end of Awanui Street in Wailani Tract, Waipahu (21° 23′ 13″ N Lat, 158° 00′ 06″ W Long), Oahu, Hawaiian Islands.

W-885. Waipahu 2 **>38,000**

Oysters from continuation of bed from which W-886 was taken. From embankment at end of Maikai Street in Wailani Tract, ca. 500 ft S of W-886 (21° 23′ 10″ N Lat, 158° 00′ 02″ W Long), Oahu. *Comment*: activity of both samples was equivalent to age of 39,000 yr. However, as these were shells, definite possibility exists that enough modern carbon was added from atmosphere or ground water to make them look this young. They may actually be much older.

Pahala ash series, Hawaii

Pahala ash is considered only good marker bed in Hawaii. Much of the geology on the island of Hawaii is dated as pre-Pahala ash or post-Pahala ash, with age of ash itself known only as late Pleistocene. These two samples of carbonaceous ash, therefore, are extremely important to the geology of ca. 4000 square mi. The two dates, bracketing deposition of most of ash, show that fall occurred from climax of late Wisconsin glacial stage to its final retreat. Coll. 1959 by G. D. Fraser, U. S. Geol. Survey, Hawaiian Volcano Observatory, Hawaii National Park, Hawaii; subm. by K. J. Murata, U. S. Geol. Survey, Washington, D. C.

W-905. Kaone fault scarp, bottom **17,360 ± 650**

Carbonaceous ash from top of the lower bed of Pahala ash exposed on SE end of seaward-facing Kaone fault scarp (19° 20′ N Lat, 155° 20′ W Long), S slope of Kilauea Volcano, Hawaii. Section (Stearns and Macdonald, 1946) consists of 26 ft of upper part of Pahala ash, overlying 5 ft of pahoehoe basalt, 7 ft of lower part of Pahala ash and basalt. Carbon came from contact of lower part of Pahala ash with overlying pahoehoe. Tree molds in basalt have diameters of 10 in., proving more vegetation existed in Pahala time than at present in this desert area. This substantiates a pluvial climate here during glacial Wisconsin stage.

W-907. Maniania Pali, top **10,140 ± 300**

Carbonaceous volcanic ash exposed in sea cliff at Maniania Pali (19° 03′ N Lat, 155° 35′ W Long), S of Honuapo, Hawaii. Pahala ash just S is 25 ft thick (Stearns and Clark, 1930), 3 ft of ash overlain and underlain by basalt. Sample came from top of ash at its contact with overlying basalt.

W-913. Thjorsarbru, Iceland **8170 ± 300**

Peat lens, 30 cm thick, overlain by oldest Thjorsa lava flow, from Thjorsarbru, W bank of river (63° 55′ N Lat, 20° 39′ W Long), Arnessysla, S Iceland. Sample was taken from top of lens, within 5 cm of contact with the lava. Overlying lava flow is 130 km long, covering area of 800 square km; possibly greatest postglacial lava flow on the Earth. Coll. 1959 by G. Kjartansson, Museum of National History, Reykjavik, Iceland. *Comment*: W-482, 8065 ± 400 (USGS IV) was peat sample from same locality, probably from same horizon.

W-909. Stokkseyri, Iceland **1910 ± 250**

Bottom layer of peat overlying oldest Thjorsa lava flow, from beach at Stokkseyri (63° 50′ N Lat, 21° 06′ W Long), Arnessysla, S Iceland. Sample taken from ca. 1 m below mean sealevel. Since the peat contains only freshwater diatoms, sample antedates rise of sealevel that inundated the peat. Coll. 1954 by G. Kjartansson, Museum of Natural History, Reykjavik, Iceland. *Comment*: although peat overlies Old Thjorsa lava, date is not believed to give a close bracket (with W-913) to time of the flow. Rather, it is believed that a low-water table in the permeable lava prevented formation of peat until sealevel rose sufficiently.

W-911. Hnubbafossar, Iceland **5290 ± 250**

Plant remains, mostly of moss (*Amblystegium fluviatile*), contained in laminated clay as tough and coherent but very thin sheets. From Hnubbafossar (64° 08′ N Lat, 18° 58′ W Long), N bank of Tungnaa, central highlands of Iceland. Coll. 1959 by G. Kjartansson, Museum of National History, Reykjavik, Iceland. *Comment*: clay, containing organic matter, was deposited by glacial river Tungnaa in a short-lived lake dammed against edge of youngest Thjorsa lava flow. Clay is rhythmically laminated. Sample was taken near base of clay overlying next-to-youngest Thjorsa lava flow.

W-912. Lake Thingvallavatn, Iceland **9130 ± 260**

Carbonized plant stems from E bank of Efra-Sog River, outflow of Lake Thingvallavatn (64° 08′ N Lat, 21° 02′ W Long), Iceland. Plant remains are contained in surface layer of soil developed on eolian deposits, overlain by Thingvallahraun lava flow. Coll. 1957 by G. Kjartansson, Museum of Natural History, Reykjavik, Iceland. *Comment*: at contact, soil is blackened by carbonization of its organic matter by heat of lava. Thus sample precisely dates eruption of Thingvallahraun.

Saudi Arabian ground-water series

A series of samples consisting of bicarbonate and CO_2 extracted from deep water samples from Saudi Arabia was analyzed for C^{14} content to determine time since their precipitation as rainfall. Waters came from aquifers, at depths below well-head greater than 1200 ft. Distances from outcrop of aquifers to wells range from 24 to 250 km.

Water was coll. in large drums without air contamination. Shortly after collection, it was introduced into a solution of barium hydroxide for precipitation of CO_2 and bicarbonate. Precipitate was filtered and washed, and treated as a normal carbonate for C^{14} analysis. Ages of samples were computed on basis that initial C^{14} content was the same as that of contemporary wood, or more exactly 95% of the NBS oxalic-acid C^{14} standard. No C^{14} measurements were made here on shallow well water, to determine whether carbon in the water begins with a deficiency of C^{14} due to uptake of old carbon from limestone. Studies of this nature have been made in till plains of Germany by Brinkman, Munnich and Vogel (1959). Their age computations on deeper waters are based on an initial C^{14} content of 80 to 85% of modern wood. This subtracts ca. 2000 yr from their apparent dates. In Saudi Arabia, it is believed that infrequent and usually torrential rainfall adds water directly to sandstones and dunes above sandstones, without uptake of "dead" carbonate.

Samples coll. in 1959 and 1960 by the Arabian-American Oil Co.; subm. by Glen Brown, U. S. Geol. Survey, Washington, D. C. *Comment*: ages for deep artesian waters at Buraida, Riyadh, Khurais, and Abqaiq range from 20,400 to 24,630 yr. This is in fair agreement with a maximum estimate of 18,500 yr, the calculated time (based on gradient and permeability) for water to move from outcrop to Abqaiq; the most distant well-head. Climax of Wisconsin glacial stage occurred at this time, and high rainfall during this pluvial period must have charged the aquifers. Ages of greater than 33,000 for the water samples from the western Rub al Khali may be due to old carbonate taken up from carbonate rocks in Yemen highlands and calcareous loess E of the highlands; or the water there may actually have fallen during an earlier glacial age.

W-904. Buraida **20,400 ± 500**

Water from town well of Buraida (26° 20′ N Lat, 43° 58′ E Long), Saudi Arabia, depth 1250 ft, from a flowing artesian well in Nubian-type sandstone of Cambrian and Ordovician ages. Minimum distance to outcrop, 24 km; water, 100°F.

W-889. Riyadh **24,630 ± 500**

Water from water well 180, 300 ft WSW of Shamasi powerhouse, Riyadh (24° 35′ N Lat, 46° 45′ E Long), Saudi Arabia, depth 3647 to 3974 ft from artesian well in Nubian-type sandstone of Triassic or Jurassic age. Distance to outcrop, 60 km.

W-897. Khurais **20,760 ± 500**

Water from water well 8, in Khurais (25° 29′ N Lat, 47° 58′ E Long), Saudi Arabia, depth 1490 to 1693 ft, from artesian well in Nubian-type sandstone of Cretaceous age. Distance to outcrop, 70 km; water 80°F.

W-894 Abqaiq **22,500 ± 500**

Water from water well 32, in Abqaiq (25° 58′ N Lat, 49° 40′ E Long), Saudi Arabia, depth 3003 to 3402 ft, from artesian well in same aquifer as W-897. Distance to outcrop, 250 km; water, 134°F.

W-888. Quad T-4, ST-7WW **>33,000**

Water from well ST-7WW in quad T-4 (17° 30′ N Lat, 47° 08′ E Long), depth 1617 to 3035 ft, from pumped well from a sandstone aquifer, with some calcareous beds, of Jurassic and Cretaceous age. Distance to outcrop, 75 km; water, 100°F.

W-887. Quad 0-5, ST-13WW **>33,000**

Water from well ST-13WW in quad 0-5 (18° 20′ N Lat, 47° 08′ E Long), depth 3435 to 3506 ft, from pumped well from sandstone aquifer with some calcareous beds, of Permian age. Distance to outcrop, 200 km; water, 98°F.

II. ARCHAEOLOGIC SAMPLES

W-915. Fell's Cave, Chile **10,720 ± 300**

Charcoal from fire pit from oldest occupation layer of Fell's Cave, a shelter at North Arm Station (52° 04′ S Lat, 69° 07′ W Long), Chile, near Strait of Magellan. Shelter was formed by Rio Chico undercutting volcanic rock, leaving basal deposit of sand and clay, now 19.5 ft above stream. Hunters of the giant sloth and native horse camped on this fresh floor, building fires in depressions. Small shrubs were used for fuel, judging from some pieces of charcoal which retained their form. Area is treeless today and may have been then. A roof rock-fall interrupted the occupation, as the articulated foreleg, neck and skull of a horse were found directly beneath the slabs. Subsequent reoccupation was by people with different hunting equipment, after extinction of horse and sloth. Coll. 1959 by J. B. Bird, American Museum of Natural History, New York; subm. by Clifford Evans, U. S. National Museum, Washington, D. C. *Comment*: two related samples from Patagonia are the Mylodon Cave sloth dung (C-484, 10,832 ± 400, Chicago I), and Palli Aike Cave, burned bone (C-485, 8639 ± 450, Chicago I). Details of find, with its relation to changes in sealevel, recession of glacial Lake Laguna Blanca, and volcanic activity, were given by Bird (1938).

W-916. Tell Gat, Israel **4410 ± 250**

Carbonized grains of wheat, uncovered during excavations at Tell Sheikh Ahmed el Ureini, known as Tell Gat (31° 38′ N Lat, 34° 48′ E Long), Israel. Grains coll. by Israel Dept. of Antiquities, during its 1957 campaign, from debris of large building in Stratum IV. Subm. by Immanuel Ben-Dor, Emory Univ., Atlanta, Georgia. *Comment*: debris showed clear signs of conflagration, and judging from other material coll. at the same level, should belong to Early Bronze I age, 3100-2900 B.C. era. Grains were probably contained in large pottery jar, which had been crushed by destruction of building, as they were found accumulated in one spot. Jar was completely recovered. Level 131.00, locus 4001, no. 509, room 61.

References

Date lists:

Chicago I. Arnold and Libby, 1951
USGS III. Rubin and Suess, 1956
USGS IV. Rubin and Alexander, 1958
USGS V. Rubin and Alexander, 1960
Yale IV. Deevey, Gralenski, and Hoffren, 1959
Yale V. Stuiver, Deevey, and Gralenski, 1960

Alden, W. C., 1918, Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 106, 356 p.

Arnold, J. R., and Libby, W. F., 1951, Radiocarbon dates: Science, v. 113, p. 111-120.

Bird, Junius, 1938, Antiquity and migrations of the early inhabitants of Patagonia: Geog. Rev., v. 38, no. 2, p. 250-275.

Bright, R. C., 1960, Geology of the Cleveland area, southeastern Idaho: Masters Thesis, Dept. of Geology, Univ. of Utah, Salt Lake City, Utah, 262 p. 7 plates, 2 tables.

Brinkman, R., Munnich, K. O., and Vogel, J. C., 1959, C^{14}-Altersbestimmung von grundwasser: Naturwissenschaften, v. 46, heft 1, p. 10.

Caldwell, D. W., 1959, Glacial lake and glacial marine clays of the Farmington area, Maine: Maine Geol. Survey, Spec. Geol. Study, ser. 3, 48 p., 3 folded pls.

Cooper, C. L., 1931, The Pleistocene fauna of Kentucky: Kentucky Geol. Survey, ser. VI, no. 36, p. 435-447.

Crandell, D. R., and Waldron, H. H., 1956, A recent volcanic mudflow of exceptional dimensions from Mt. Rainier, Washington: Am. Jour. Sci., v. 254, p. 349-362.

Daniels, R. B., Rubin, Meyer, and Simonson, G. H., [in preparation], Alluvial chronology of the Thompson Creek watershed, Harrison County, Iowa.

Deevey, E. S., Gralenski, L. J., and Hoffren, Väinö, 1959, Yale natural radiocarbon measurements IV: Am. Jour. Sci. Radioc. Supp., v. 1, p. 144-172.

Ekblaw, G. E., and Willman, H. B., 1955, Farmdale drift near Danville, Illinois: Illinois State Acad. Sci. Trans., v. 47, p. 129-138.

Eveland, H. E., 1952, Pleistocene geology of the Danville region, Illinois: Illinois State Geol. Survey Rept. Inv. 159, 32 p.

Flint, R. F., and Gale, W. A., 1958, Stratigraphy and radiocarbon dates at Searles Lake, California: Am. Jour. Sci., v. 256, p. 689-714.

Frye, J. C., and Willman, H. B., 1960, Classification of the Wisconsinan stage in the Lake Michigan glacial lobe: Illinois State Geol. Survey Circ. 285, 16 p.

Gale, H. S., 1914, Salines in the Owens, Searles, and Panamint basins, southeastern Calif.: U. S. Geol. Survey Bull. 580-L, p. 251-323.

Horberg, Leland, and Robie, R. A., 1955, Postglacial volcanic ash in the Rocky Mountain piedmont, Montana and Alberta: Geol. Soc. America Bull., v. 66, no. 8, p. 949-955.

Jillson, Willard R., 1936, Big Bone Lick: Louisville, Kentucky, Standard Printing Co., 164 p.

Leighton, M. M., 1960, The classification of the Wisconsin glacial stage of north central United States: Jour. Geology, v. 68, no. 5, p. 529-552.

Lemke, R. W., and Colton, R. B., 1958, Summary of the Pleistocene geology of North Dakota: Midwestern Friends of the Pleistocene Guidebook, 9th Ann. Field Conf., North Dakota Geol. Survey, Misc. ser. no. 10, p. 41-57.

Libby, W. F., 1955, Radiocarbon dating: 2nd ed., Chicago, Illinois, Univ. Chicago Press,

175 p.
Miller, R. D., and Scott, G. R., 1955, Sequence of alluviation along the Loup River, Valley County area, Nebraska: Geol. Soc. America Bull., v. 66, p. 1431-1448.
Rubin, Meyer, and Alexander, Corrinne, 1958, U. S. Geological Survey radiocarbon dates IV: Science, v. 127, p. 1476-1487.
———— 1960, U. S. Geological Survey radiocarbon dates V: Am. Jour. Sci. Radioc. Supp., v. 2, p. 129-185.
Rubin, Meyer, and Suess, Hans E., 1956, U. S. Geological Survey radiocarbon dates III: Science, v. 123, p. 442-448.
Shaffer, P. R., 1956, Farmdale drift in northwestern Illinois: Illinois State Geol. Survey Rept. Inv. 198, 25 p.
Sigafoos, R. S., and Hendricks, E. L., The modern history of Nisqually glacier, Washington: U. S. Geol. Survey Prof. Paper 387-A, [in press].
Stearns, H. T., and Clark, W. O., 1930, Geology and water resources of the Kau district, Hawaii: U. S. Geol. Survey Water-Supply Paper 616, p. 29-191.
Stearns, H. T., and Macdonald, G. A., 1946, Geology and ground-water resources of the Island of Hawaii: Hawaii Div. Hydrography Bull. 9, 363 p.
Stuiver, Minze, Deevey, Edward S., and Gralenski, L. J., 1960, Yale natural radiocarbon measurements V: Am. Jour. Sci. Radioc. Supp., v. 2, p. 49-61.