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U S GEOLOGICAL SURVEY, RESTON, VIRGINIA, RADIOCARBON DATES XIV

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This list contains the results of some measurements made between 1966 and 1975, and includes some earlier unpublished dates. Samples are counted in the form of acetylene gas, as previously, and ages computed on the basis of the Libby half-life, 5568 ± 30 years. The dates have not been corrected for fractionation by making a ^{13}C measurement. The error listed, always larger than the one-sigma statistical counting error commonly used, takes into account possible fractionation in the laboratory and in nature and variability experienced with replicate samples. We thank Linda Wilt for helping in the preparation of the manuscript and Charles Oman for his technical assistance.

Unless otherwise stated, collectors of all samples are members of the U S Geological Survey.

A. Eastern United States

Louisville series, Kentucky and Indiana

Wood samples coll and subm 1972 by R C Kepferle.

W-2905. **2840 ± 250**

Carbonized tree limb, N bank Ohio R, 270m below mouth of Silver Creek (38° 17′ 16″ N, 85° 47′ 41″ W), Floyd Co, Indiana. *Comment* (RCK): inclined beds containing sample may have slumped to sampled position along bank of Ohio. Massive till-like deposit between inclined beds and horizontally bedded New Albany Shale (Devonian) bedrock may be the gouge along sole of slump. Thus, exposure is not evidence of glaciation. Beech, hickory, and walnut fruits assoc with sampled wood indicate deciduous forest that has more similarities to present flora than does conifer assoc of W-2907 (Kepferle, 1974a).

W-2907. **19,450 ± 700**

Knotty conifer wood lying sub-parallel to horizontally bedded sediments, in gully draining loess pit E of Illinois Central tracks from Johnsontown (38° 06′ 59″ N, 85° 51′ 03″ W), Jefferson Co, Kentucky. *Comment* (RCK): precludes any designation except Wisconsin age for overlying loess, contrary to Browne and McDonald (1960, p 171), and in support of Ray (1974), who finds no evidence for sediments of Illinoian age in area, and reported a similar age for nearby deposits, 18,530 ± 500, W-520 (R, 1960, v 2, p 147), (Kepferle, 1974b).

B. Central United States

W-2426. Iowa Point, Kansas **18,200 ± 500**

Wood *(Picea)* from dolomitic loess, at base of Peoria Loess, overlain by Brady soil zone and Bignell Loess, underlain by "Gilman Canyon

Loess" (Frye & Leonard, 1949; 1952; Frye *et al*, 1949), Iowa Point limestone quarry #2, Doniphan Co (39° 55′ 15″ N, 95° 13′ 45″ W). Coll and subm 1969 by Fred Caspall, Western Illinois Univ, Macomb, Illinois. *Comment* (FC): first date from base of Peoria Loess in NE Kansas. Stratigraphic relationships suggest date of 16,000 to 20,000 BP for initial deposition of loess. Age agrees and dates probability of boreal forest in NE Kansas prior to and possibly during deposition of Peoria Loess.

Camel Rock series, New Mexico

Charcoal coll after discovery of Clovis biface or preforms in arroyo floor below Pueblo occupation site, dated at AD 1175 to 1250. Two charcoal samples from exposures on N wall of arroyo, 0.5km W of US Hwy 64, in 3rd major arroyo N of Camel Rock (35° 40′ N, 105° 55′ W), Santa Fe Co. Coll 1973 and subm by H Warren, Mus New Mexico, Santa Fe, and G O Bachman.

W-2943. **2810 ± 250**

Depth 3m below top of "high terrace".

W-2942. **2600 ± 250**

Depth 4.5m below top of "high terrace".

General Comment (GOB & HW): we speculate that charcoal horizon was occupational level from which Clovis artifacts had weathered. Dates are consistent with Archaic cultural material.

W-2899. Cat Tail Creek, North Dakota **6850 ± 250**

Wood fragments from sand interval in valley fill, 7.5m deep in test hole, Cat Tail Creek valley (46° 08′ N, 100° 35′ W), Emmons Co. Coll 1972 and subm by C A Armstrong. *Comment* (CAA): apparently small stream has not eroded laterally to any great extent during last few thousand yr.

North Redwood series, Minnesota

Wood from roadcut, W side of Hwy 19, near North Redwood, in Minnesota R Valley (44° 40′ N, 94° 55′ W). Coll 1970 and subm by H E Wright, Univ Minnesota, Minneapolis.

W-2722. **>41,000**

Wood from sand beneath Wadena-lobe "Granite Falls" till, which underlies Des Moines lobe "New Ulm" till.

W-2723. **>41,000**

Wood from base of clay deposit beneath sand containing W-2722.

General Comment (HEW): dates indicate that till may be pre-Wisconsin or early Wisconsin, although a main Wisconsin correlation is not completely ruled out.

C. Western United States

W-2608. Flathead Lake, Montana >43,000

Lignite, depth 165m, in soil overlying Bull Lake Till I and overlain by Pinedale Till, Mission moraine, Flathead Lake (47° 26′ 10″ N, 114° 11′ 00″ W). Coll 1970 and subm by D G Smith, Univ Calgary, Calgary 44, Alberta, Canada. *Comment* (DGS): suggests that sample may be early Bull Lake. This is only date available for end moraines that mark S limit of Cordilleran ice lobes in Rocky Mtn trench.

Gallatin Natl Forest series, Montana

Organic samples from Jarrett (24SW651) archaeol site, N terrace Main Boulder R, 8km W and 40km S of McLeod, Gallatin Natl Forest (45° 21′ N, 110° 13′ W). Coll 1972 and subm by L B Davis, Montana State Univ, Bozeman.

W-2886. 320 ± 200

Charcoal from hearth, depth 40 to 60cm. *Comment* (LBD): sample was split and dated at 340 ± 100, RL-762, independently. Dates Old Woman's phase affiliation for intrusive hearth into Pelican Lake phase component (1000 BC to AD 200).

W-2885. 4630 ± 250

Charcoal and ash, roasting pit, depth 155cm. *Comment* (LBD): dates roasting pit assoc with large side-notched dart points attributable to complex at Mummy Cave, and Early Middle Prehistoric period manifestation for which a local chronology remains to be firmly established; complex tentatively dated 5500 to 3500 BC.

Snake River series, Idaho

Shells, freshwater sp, from borrow pit, excavated in Michaud Gravel (Trimble & Carr, 1961), alt 1326 to 1329m, 0.8km E of Schiller (42° 53′ N, 112° 39′ W). Coll 1969 and subm by H E Malde.

W-2512. >29,000

Whole clam shells.

W-2514. >33,000

Snail shells.

General Comment (HEM): Michaud Gravel forms delta possibly deposited during maximum discharge of Bonneville flood. The next younger deposit, Aberdeen terrace that was incised in Michaud Gravel as flood waned, yielded shells dated 29,700 ± 1000, W-731 (R, 1960, v 2, p 159) (Malde, 1968, p 10).

W-2408. Soap Lake, Washington 320 ± 200

Sagebrush, rooted in lake bottom at depth 2.3m below present lake surface, N end Soap Lake, Grant Co (47° 23′ N, 119° 30′ W). Coll 1968

by Janet Low, Diane Egan, and P B Egan; subm by W T Edmondson. *Comment* (WTE): date suggests that lake has risen at least 4.5m in the few centuries since plants were killed by rising lake water.

W-2452. **280 ± 200**

Complete re-run of W-2408.

Puget Lowland series, Washington

Peat interbedded in nonglacial detrital sediments, Auburn borrow pit, Puget Lowlands (47° 10′ N, 122° 15′ W). Coll 1973 by Kurt Othberg, Western Washington State Coll, Bellingham, Washington; subm by S Grommé.

W-3011. **>45,000**

Uppermost 5cm.

W-3012. **>45,000**

Lowermost 5cm.

General Comments (KO): dates assoc with exposure of silt in which measured paleomagnetic polarities are reversed (Othberg, 1973), and place nonglacial sediments and paleomagnetic reversal at >45,000 yr BP. Reversal may be pre-Wisconsin. However, there is no indication that these sediments are older than those of Brunhes Normal Magnetic Epoch. (SG): reversed magnetized silts are too old to represent proposed Laschamp geomagnetic polarity event, but very likely represent Blake polarity event at roughly 110,000 yr.

Port Angeles series, Washington

Wood from glacial deposits, Port Angeles area. Coll and subm 1955 and 1957 by P D Snavely, Jr.

W-2410. **>40,000**

Seacliff, W of mouth, McDonald Creek (48° 07′ 00″ N, 123° 14′ 30″ W), near Carlsburg.

W-2409. **>42,000**

Roadcut, SW end, Ediz Hook (48° 07′ 30″ N, 123° 28′ 00″ W).

W-391. **>38,000**

Quarry, SE end, Ediz Hook, E side of rd (48° 07′ 32″ N, 123° 28′ 15″ W).

General Comment (PDS): dates are too old for Vashon Drift; wood was reworked from older Pleistocene unit.

W-2474. Chesaw, Washington **9000 ± 900**

Wood in coarse sand, depth 1.5m in well excavation, home of John Thorpe, Chesaw (48° 58′ N, 119° 05′ W). Coll 1969 by John Thorpe and Madilane Perry; subm by R Fryxell, Washington State Univ, Pullman.

Comment (RF): unit dated is overlain by blue clay and soil; provides limiting date for deglaciation of area.

W-2425. Underwood Heights, Washington >40,000

Wood from diamicton (possibly a lahar), Columbia R, alt 105m, Underwood Heights (45° 45′ N, 121° 30′ W). Coll 1968 and subm by R Fryxell, Washington State Univ.

Marmes Rockshelter series, Washington

Shells and charcoal from Marmes Rockshelter site, Palouse area (46° 50′ N, 118° 20′ W). Coll 1968 by R Fryxell, and M Rubin; subm by R Fryxell. Stratigraphy (Fryxell & Cook, 1964) contains unique sequence of human remains, artifacts, fossil animal bones, as well as geol record for much of Holocene.

W-2213. 7980 ± 300

Freshwater mussel shells from fossil stream bank midden site. Sample lies on surface of bank buried by ashfall at Mazama.

W-2207. 9010 ± 300

Shells, Unit I-II.

W-2208. 8700 ± 300

Charcoal, Unit I-II.

W-2209. 9820 ± 300

Mussel shells, just above contact of gravels and shells with flood plain silt. *Comment* (RF): gives upper limiting date on Marmes level. *Comment* (MR): compares well with age of 9970 ± 110, Y-2481 (Minze Stuiver, written commun, 11/5/68) for same sample.

W-2210. 9540 ± 300

Shells from lens of shell midden, Unit III. *Comment* (MR): agrees with date of 9200 ± 110, Y-2482 (Minze Stuiver, written commun, 11/5/68) for same sample.

W-2212. 9840 ± 300

Charcoal, 3rd, 4th and 5th A horizon.

W-2218. 10,130 ± 300

Charcoal, 3rd and 4th A horizon.

General Comment (RF): dates 1st human occupation of Marmes rockshelter ca 10,000 yr BP. Deposits overlying Marmes layers, which contain bones and artifacts, date between 8000 and 10,000 yr BP.

W-2777. Newberry Craters, Oregon 1390 ± 200

Charcoal from pumice layer, exposed in roadcut, Newberry Craters (43° 45′ N, 121° 15′ W). Coll and subm 1972 by Irving Friedman. *Comment* (IF): pumice layer underlies "Big Obsidian" flow and overlies

pumice dated at 1720 ± 250, W-2168 (R, 1978, v 20, p 143); age is minimum for flow. Date consistent with that of 1270 ± 60, Tx-245 (R, 1966, v 8, p 459) from charcoal sampled nearby.

W-390. Neskowin, Oregon **1730 ± 160**

Spruce stumps, just below MSL, S of Proposal Rock, Neskowin (45° 05′ N, 124° 00′ W). Coll and subm 1955 by P D Snavely, Jr. *Comment* (PDS): stumps are part of drowned forest along Oregon coast. Because area does not appear to be one of local subsidence or landslides, drowning was probably due to eustatic rise in sea level.

W-1916. Newport, Oregon **2770 ± 350**

Shell fragments in pebbly gravel, capping 30m terrace at Jump-Off-Joe, Newport (44° 38′ 46″ N, 124° 03′ 40″ W), coastal Oregon. Coll 1966 and subm by P D Snavely, Jr. *Comment* (PDS): shells are 7.5m above wood dated at >38,000, W-646 (R, 1960, v 2, p 161). Age of 2770 ± 350 is much too young for 30m marine terrace. Basalt pebbles and shell material probably are from Holocene beach gravels which were used to surface an old wagon rd on terrace. Gravels were buried by eolian sands and now appear to be in stratigraphic sequence at Jump-Off-Joe.

W-2926. Port Orford, Oregon **1370 ± 250**

Shells, depth 5.1cm in box core, water depth 26m, 3.2 km S of Port Orford (42° 50′ N, 124° 25′ W). Coll 1971 and subm by H E Clifton. *Comment* (HEC): date clearly confirms that deposit is not relict, but a relatively recent storm deposit.

W-2981. Minaret Summit, California **1040 ± 250**

Partially charred wood, base of pumice lapilli bed, underlain by till, E wall pumice quarry, end of dirt rd, S from Devils Postpile rd at Minaret Summit (37° 39′ 05″ N, 119° 03′ 20″ W). Coll 1973 by R Koeppen and R A Bailey; subm by R A Bailey. *Comment*: this date and 920 ± 80, UCLA-908 (R, 1966, v 8, p 494) relate to age of basal tephra layers from Inyo crater (Wood, 1977).

W-1431. Inyo Crater, California **650 ± 200**

Wood, projecting into S crater from NE wall, underlain by pumice, Inyo Crater Lakes (37° 40′ N, 119° 05′ W). Coll 1961 by E C Rockwell; subm by C D Rinehart. *Comment* (CDR): pumice represents youngest extrusive material in area (Rinehart & Huber, 1965; Wood, 1977).

W-2624. Lopez Canyon, California **<200**

Wood from rubble exposed in exploratory trench across buried fault scarp that predates February 9, 1971, California faulting in Lopez Canyon (34° 17′ 47″ N, 118° 23′ 58″ W). Coll and subm 1971 by M G Bonilla. *Comment* (MGB): age is approx for formation of pre-1971 scarp (Bonilla, 1973).

San Francisco series, California

Two organic samples nearby and adjacent to bones of human skeleton found during excavation for Civic Center Sta of San Francisco Bay Area Rapid Transit Dist (BART), San Francisco (37° 46.8′ N, 122° 24.45′ W). First remains found by workmen, 1969; remainder dug out by Winfield Henn and Michael Mannion, of Treganza Anthropol Mus San Francisco State Coll, San Francisco; subm by Julius Schlocker.

W-2733. **2070 ± 250**

Peat, 90m W of and 2.7m above skeleton at base of dune deposit. *Comment* (JS): peat formed from plant debris in marsh near sea-level near shore of San Francisco Bay. Marsh was subsequently buried by at least 14.6m dune sand. Site is near pre-1850 shoreline; later filling by man moved shore 2.4km E. Data gives rate of subsidence and/or compaction of ca 0.25cm/yr.

W-2463. **4900 ± 250**

Organic clay clinging to hip bone of skeleton, alt 7.8m below MSL, depth 21.9m, N side of Market St, 36.9m S of centerline of Fulton St. *Comment* (JS): oldest date for human occupation in Bay area (Henn *et al,* 1972).

W-2764. Point Ano Nuevo, California **>43,000**

Shells *(Macoma inquinata)* from lowest exposed terrace, 0.8km NE of Ano Nuevo Point (37° 10′ N, 122° 25′ W), near Santa Cruz. Coll 1970 and subm by W O Addicott. *Comment* (WOA): same sample gave Th/U age of 16,000 ± 2000 yr (Bradley & Addicott, 1968). However, studies seem to confirm an older age.

W-2412. San Nicolas I., California **2070 ± 200**

Abalone shells *(Haliotis cracherodii)* from unexposed middle part of black sooty shell layer, atop wind-eroded dune, 52.5m W of Triangulation Sta, North Head 2, alt 168m, San Nicolas I. (33° 15′ N, 119° 30′ W). Coll 1957 and subm by J G Vedder. *Comment* (JGV): date is maximum for vegetation development on Holocene deposits on I.

Borrego Mountain series, California

Shells, N wall of Trench #2 across the 1968 Coyote Creek fault surface rupture (33° 06′ N, 116° 03′ W). Coll 1971 and subm by M M Clark.

W-2602. **5620 ± 300**

Shells from shelly bed, 1m below surface on upthrown (W) side of this dominantly strike-slip fault. Same bed could not be found across fault and is presumably deeper in sec.

W-2604. **5410 ± 300**

Shells from deepest bed exposed on downthrown side of fault. This bed is 1.9m deeper than bed of W-2602.

General Comment (MMC): data indicate at least 1.9m vertical separation caused by fault movement at this place during last 5400 yr (Clark *et al,* 1972). Parallel trench across fault, excavated 1977 ca 25m NW by R V Sharp and M G Bonilla, shows 3 to 4m vertical fault separation of bed that is possibly same as that of W-2602.

Santa Cruz series, California

Organic sediment samples from drill holes in sag ponds in valley controlled by San Andreas fault, N of Pajaro Gap, Santa Cruz Co (36° 55′ N, 121° 45′ W). Coll and subm 1971 by A M Sarna-Wojcicki.

W-2784. **680 ± 200**
Organic mud, depth 1.1m.

W-2782. **900 ± 200**
Organic mud, depth 1.3m.

W-2811. **3410 ± 250**
Organic clay, depth 2.2m.

W-2812. **3415 ± 250**
Organic clay, depth 2.3m.

W-2789. **3860 ± 500**
Organic clay, depth 4.4m.

W-2787. **3200 ± 500**
Organic clay, depth 4.5m.

W-2785. **3470 ± 500**
Organic mud, depth 5.0m.

W-2786. **3850 ± 500**
Organic mud, depth 5.1m.

General Comment (AMS): lower dates indicate rapid alluviation over short period of time, on the order of 100 to several hundred yr, followed by long period of nondeposition or erosion, lasting until ca 1000 to 1500 yr BP, followed by period of slower alluviation until present. Periods of alluviation may represent deformation of thalweg of valley by prehistoric seismic events, with formation of sag, which was then rapidly filled by alluvium.

W-2457. San Benito, California **1740 ± 250**

Organic clay, sag pond, depth 1.6 to 1.9m, San Benito Co (36° 30′ N, 120° 50′ W). Coll and subm 1969 by Andrei M Sarna-Wojcicki. *Comment* (AMS): age falls within estimate obtained from erosion-deposition rates.

W-2461. Orchard Peak, California **13,060 ± 400**

Plant material, sag pond, depth 7.5 to 8.4m, 13.5m E of earth dam, Twisslemann's Ranch, Orchard Peak quad, S of Cholame Valley (35° 45′

N, 120° 15′ W). Coll and subm 1969 by Andrei M Sarna-Wojcicki. *Comment* (AMS): dates sag pond depression that was completely filled by sediment and more recently re-excavated by erosion.

W-2616. Glendale, Nevada >45,000

Carbonaceous mudstone, near top of exposed lacustrine sequence of gypsiferous and limy mudstone containing brimstone deposits, off Hwy I-15 overpass across Union Pacific RR track, SW of Glendale (36° 39′ 10″ N, 114° 34′ 45″ W), N end of North Muddy Mts. Date will help to determine origin of sulfur deposits. Coll 1968 and subm by F G Poole. *Comment* (FGP): unit sampled also contains abundant plant fragments and some snails.

Oak City, series, Utah

Marl and shell samples from Oak City area, Millard Co. Subm by D J Varnes and Richard Van Horn.

W-2968. 5770 ± 250

Clam shells in silty alluvium, bank of Sevier R (39° 25′ 42″ N, 112° 27′ 03″ W). Coll 1973 by D J Varnes. *Comment* (DJV): indicates that alluvium is post-Lake Bonneville, although it is lithologically identical with known pre-Lake Bonneville alluvium.

W-931. 12,560 ± 400

Light-gray silty marl containing fragments of black pumiceous ash, alt 1527m, overlain by Bonneville bench, underlain by 1.5m gravel overlying sand and clay lake deposits, Gilbert's Leamington sec, at mouth of valley cut through Canyon Range by Sevier R, at foot of quartzite ridge, N of Sevier R (39° 32′ 47″ N, 112° 15′ 29″ W). Coll 1957 by D J Varnes. *Comment* (DJV): although very thin, this marl is probably equivalent to Gilbert's "White Marl" and is within Bonneville Formation of Lake Bonneville Group.

W-2378. 13,060 ± 350

Gastropod shells with fragments of pelecypod shells, 15.2km NE of Delta towards Lynndyl (39° 25′ 50″ N, 112° 26′ 53″ W). Coll 1969 by D J Varnes and Richard Van Horn. *Comment* (DJV): material is believed to be lacustrine and to have been deposited during last rise of Lake Bonneville above 1425m.

W-2969. 16,510 ± 350

Gastropods from gravelly sand, Big Gully (39° 26′ 43″ N, 112° 23′ 59″ W). Coll 1973 by D J Varnes. *Comment* (DJV): youngest date yet obtained from sec at Big Gully. Sample was coll ca 1m above "White Marl" horizon, which has many dates in the range 17,000 to 18,000, (Broecker & Kaufman, 1965).

W-924. **18,200 ± 500**

Light gray marl at base of Lake Bonneville Group enclosing a bed of black volcanic ash, lower Sevier R Delta (39° 24′ 31″ N, 112° 27′ 52″ W). Coll 1957 by D J Varnes.

W-946. **15,900 ± 400**

Complete re-run of W-924. *Comment* (DJV): dates for material at base of Lake Bonneville Group are much too young and indicate exchange of carbon isotopes, possibly by ground water.

W-2967. **19,910 ± 600**

Gastropods from silty sand, 0.6m below base of upper Alpine blocky clay (39° 30′ 55″ N, 112° 20′ 56″ W). Coll 1973 by D J Varnes and J C Liddicoat, Univ California, Santa Cruz. *Comment* (DJV): date appears too young, being separated from an overlying basaltic ash, dated at 18,200, W-924, by an unconformity and 11.4m fine-grained lacustrine deposits. Isotope exchange by ground water is possible. Similar gastropod material was dated by U-Th method at 40,000, L-1005C (W S Broecker, written commun, 6/27/66).

W-2966. **20,140 ± 400**

Gastropods from gravel at base of Lake Bonneville Group, bank Sevier R (39° 24′ 50″ N, 112° 27′ 01″ W). Coll 1973 by D J Varnes. *Comment* (DJV): previously obtained material on bank near this horizon ranges from 14,000 to 18,200 (W-946, -924: this list; L-711B, -774F: Kaufman & Broecker, 1965), but on opposite bank dates >32,000 (L-711A: Kaufman & Broecker, 1965) by ^{14}C, and 140,000 (L-1005A: W S Broecker, written commun, 6/27/66) and 108,000 ± 23,000 (L-711A: Kaufman & Broecker, 1965) by U-Th. This analysis confirms exchange of carbon isotopes by ground water contamination.

W-923. **20,000 ± 500**

White marl from middle of highest white marl bed overlying volcanic ash, in marl pit near rd from Oak City to Lynndyl (39° 25′ 47″ N, 112° 20′ 03″ W). Coll 1949 by Richard Van Horn. *Comment* (DJV): probably equivalent to Gilbert's "White Marl" in Bonneville Formation of Lake Bonneville Group.

W-927. **>35,000**

Light-gray silty, clayey marl, near top of sec of Alpine Formation, Lake Bonneville Group, at Big Gully (39° 26′ 49″ N, 112° 24′ 05″ W). Coll 1949 by Richard Van Horn. *Comment* (DJV): date agrees with stratigraphic assignment.

W-2553. Fountain Creek, Colorado **<200**

Wood, possibly at contact of Pierre Shale and Verdos Alluvium, Fountain Creek, Colorado Springs, El Paso Co (38° 47′ 49″ N, 104° 49′

15″ W). Coll 1970 by Joseph Alley; subm by G R Scott. *Comment* (GRS): apparently this was from modern channel cut into Verdos Alluvium.

Ophir Valley series, Colorado

Well-preserved wood, lying on bedding planes in goethite deposit built up by precipitation from springs and seeps, dated as part of study of geochemical kinetics of iron spring deposit (Hanshaw & Spiker, 1972), Ophir Valley, San Juan Mts, San Miguel Co. Coll and subm 1971 by B B Hanshaw and E Spiker.

W-2414. **2990 ± 250**
5m above base of deposit.

W-2711. **4880 ± 250**

W-2716. **5730 ± 250**

W-2712. **5970 ± 250**
6.1m below W-2711.

W-2713. **6310 ± 250**
0.5m below W-2712.

W-2714. **6300 ± 250**
0.3m below W-2713.

W-2710. **7100 ± 250**

W-2717. **7240 ± 250**
1.8m below W-2716.

W-2420. **8250 ± 300**
7.3m below top of deposit, 10m above base.

General Comment (BBH & ES): ages of wood from different stratigraphic levels indicate that rates of accumulation are between 0.6 and 1.6mm/yr, average being 0.9mm/yr. Markers placed in seeps developed 2mm crust of goethite in 2yr, showing that deposit is still growing at same rate. Apparently, deposit began to develop soon after retreat of most recent mt glaciers.

Teton Park series, Wyoming

Shell and organic samples from Teton Park, Teton Co (Love *et al,* 1965; Love & Taylor, 1962). Coll 1963 and 1969 and subm by J D Love.

W-2428. **370 ± 200**
Charred wood fragments in soil horizon overlain and underlain by till, W base South Park Cemetery Hill (43° 22′ 30″ N, 110° 45′ W). *Comment* (JDL): young age is probably result of slump or solifluction that put till over young soil.

W-2429. **1570 ± 200**

Charcoal fragments in light-brown silt, roadcut S side of Gros Ventre USFS rd, 60m W of junction of Sohare oil well rd (43° 30′ N, 110° 15′ W). *Comment* (JDL): age is minimum for Dibble Racetrack terrace, maximum for 24m post-terrace downcutting by Gros Ventre R, and minimum for major landslide directly overlain by charcoal layer (Bailey, 1971, p 90).

W-2432. **4120 ± 200**

Shells *(Helix)* embedded in organic dark-gray silt, roadcut, N side USFS Gros Ventre R rd, N of Lower Slide Lake scenic turnout (43° 37′ 30″ N, 110° 30′ W). *Comment* (JDL): represents land snail unit indicating lake margin had filled up, (Bailey, 1971, p 67, fig 45).

W-2458. **3790 ± 250**

Organic silt and charcoal, 1.5m above base of deposit, 2.7m below W-2432. *Comment* (JDL): represents lacustrine environment.

General Comment (JDL): dates are minimum for landslide resulting in lake where sediment accumulated. Slightly subdued features of slide would be expected in slide of this age. Ages also indicate how rapidly Gros Ventre R excavated 45m of valley in post-lake time.

W-2479. **5000 ± 650**

Snail shells embedded in loess, from roadcut, E side of Fish and Wildlife Service dugway rd in National Elk Refuge (43° 30′ N, 110° 37′ 30″ W). *Comment* (JDL): age is much younger than expected. Either age or stratigraphic correlation with widespread 15,000 yr old loess is invalid. Suggest recollection and redating.

W-1556. **14,800 ± 400**

Shells, from upper of 2 shell beds, N of Jackson (43° 32′ 32″ N, 110° 42′ 35″ W). *Comment* (JDL): date is maximum for folding and faulting in upper loess, (Love *et al,* 1965, p 40).

W-1558. **>33,000**

Shells, from lower shell bed, 20m below W-1556. *Comment* (JDL): this is from same location as W-1556, but from below old till, (Love *et al,* 1965, p 40).

W-1560. **19,100 ± 600**

Shells in loess from upthrown block of large Holocene fault system, N of Jackson (43° 32′ 40″ N, 110° 44′ 25″ W). *Comment* (JDL): age of offset loess dates fault movement which, here, is 60m in post-loess time (Love *et al,* 1965, p 40).

W-2453. **>45,000**

Carbon chunks intermixed with pumice fragments and sand, upper part of 15m hwy cut, 60m S of target range turnoff (43° 22′ 30″ N, 110°

37′ 30″ W). *Comment* (JDL): infinite age indicates that Bailey Creek slide, placer gold accumulation to 120m thickness, and destruction of slide lake, all took place >45,000 yr ago. Date is valuable for chronology of later events along Snake R, especially cutting of terraces and stabilization of old lake-triggered slides.

W-1684. Pelican Valley, Wyoming **7550 ± 350**

Wood in Pelican Valley lacustrine sequence, Yellowstone Natl Park (44° 36′ N, 110° 14′ 50″ W). Coll and subm 1965 by J D Love. *Comment* (JDL): sequence overlies youngest glacial deposit in area, is at least 60m thick, widespread, and is involved in tectonics that destroyed at least half of ancestral Yellowstone Lake.

W-2928. Rainbow Springs, Wyoming **>45,000**

Oil that bubbled up in probe hole 1.2m deep in oily swamp, originating from bluish-gray tuffaceous lacustrine claystone containing oil-secreting alga *Botryococcus* and Pleistocene or Holocene diatoms and pollen, Rainbow Springs (Love & Good, 1970). Coll and subm 1963 by J D Love.

Yellowstone Natl Park series, Wyoming

Series is part of study of surficial geol history of Yellowstone Natl Park area (Richmond 1975; 1976; 1977; Pierce *et al*, 1976).

W-2766. **540 ± 250**

Wood from landslide-dammed lake silt, 3m above river level in Grand Canyon of Yellowstone R (44° 45′ 48″ N, 110° 23′ 35″ W), Tower Junction quad. Coll and subm 1971 by G M Richmond. *Comment* (GMR): dates large blockslide of Eocene rock that dammed canyon at N end Sevenmile Hole.

W-2735. **2430 ± 250**

Wood from lake silt in escarpment of 12m terrace, W side Grand Canyon of Yellowstone R at site of 1971 landslide, 8 km below Lower Falls and ca 1.6km upstream from foot of Sevenmile Hole Trail (44° 44′ 25″ N, 110° 25′ 19″ W), Canyon Village quad. Coll and subm 1971 by G M Richmond. *Comment* (GMR): approx dates large post-Pinedale landslide of hydrothermally altered rhyolite that blocked Yellowstone R and formed lake in canyon.

W-2487. **2850 ± 600**

Wood from base of peat lobe on slope adjacent to meadow along small tributary to Raven Creek, 2.4km SE from top of Pelican Cone (44° 38′ 10″ N, 110° 10′ W), Pelican Cone quad. Coll 1967 and subm by G M Richmond.

W-2581. **3480 ± 300**

Complete re-run of W-2487. *Comment* (GMR): minimum age for movement of peat lobe on slope.

W-2734. **3500 ± 250**

Peaty organic material, 2 to 7cm thick, beneath colluvium overlain by forest fire debris and surface dune sand. Deposit rests on Squaw Lake hydrothermal explosion debris in bluff on Yellowstone Lake, 0.2km E of Squaw Lake picnic area (44° 33′ 15″ N, 114° 15′ 00″ W), Canyon Village quad (Richmond, 1973b). Coll and subm 1971 by G M Richmond.

W-2497. **4950 ± 400**

Humic silt, on gravel of 5m stream terrace along Pelican Creek, ca 90m upstream from horse bridge (44° 34′ 30″ N, 110° 15′ 30″ W), Canyon Village quad. Coll 1967 and subm by G M Richmond.

W-2580. **5900 ± 300**

Willow twigs from boggy sand layer beneath gravel of 5m stream terrace at same locality as W-2497. Coll 1967 and subm by G M Richmond. *Comment* (GMR): overlying gravel is probably related to lake terrace 12 to 14m above Yellowstone Lake. This date and 4950 ± 400 from W-2497 bracket age of gravel.

W-2765. **5750 ± 300**

Charcoal from base of thick colluvium, exposed in gully, N slope Conant Basin, Teton Natl Forest, S of Yellowstone Natl Park (44° 02′ N, 110° 54′ W), Grassy Lake Reservoir quad. Coll 1968 and subm by G M Richmond.

W-3190. **7530 ± 250**

Wood from dark peaty deposit 30cm thick, beneath 7.3m pebbly lake sand with diatomaceous silt layers, in bluff of Yellowstone Lake, mouth of Solution Creek (44° 24′ 20″ N, 110° 30′ W), Frank Island quad. Coll 1974 and subm by G M Richmond.

W-3187. **7890 ± 250**

Charcoal from brownish sandy peat 15cm thick, same locality as W-3190, but 1m below. Coll 1974 and subm by G M Richmond.

W-2486. **8000 ± 500**

Peaty silt, overlain by hydrothermal explosion debris from crater at Turbid Lake, at right angle bend of Sedge Creek, 1.6km NE of Turbid Lake (44° 34′ N, 110° 15′ W), Pelican Cone quad. Coll 1967 and subm by G M Richmond. *Comment* (GMR): charcoal beneath explosion debris, 1.6km to SW, was dated at 8310 ± 300, W-1944 (R, 1969, v 11, p 217). Approx date for instantaneous explosion.

W-2748. **8820 ± 300**

Wood, depth 71 to 79cm below top of sandy bog deposit overlying Pinedale Till and outwash in bluff of Yellowstone R, upstream from Yellowstone Lake and immediately downstream from confluence of Monument Creek (44° 14′ 05″ N, 110° 08′ W), Two Ocean Pass quad. Coll 1970 and subm by G M Richmond.

W-2738. **10,720 ± 350**

Charcoal, 1.34km above ash from Glacier Peak, 2.4m above lake level, in bluff of Yellowstone Lake immediately E of Squaw Lake picnic area, N end of lake (44° 33′ 10″ N, 110° 19′ 20″ W), Canyon Village quad. Coll 1970 and subm by G M Richmond.

W-2736. **10,900 ± 350**

Carbonized wood from mudflow unit, overlying Pinedale Till and recessional gravel, and overlain by lake silt, same location as W-2735. *Comment* (GMR): postdates Pinedale deglaciation of this part of Grand Canyon of Yellowstone R and predates landslide assoc with overlying lake beds from which W-2735 was coll.

W-2767. **11,600 ± 350**

Twigs and peat, depth 310 to 315cm below surface at base of sandy bog deposit overlying Pinedale Till and outwash gravel, same location as W-2748. Coll 1970 and subm by G M Richmond. *Comment* (GMR): date is minimum for deglaciation and end of outwash deposition along Yellowstone R above Yellowstone Lake.

W-2894. **13,650 ± 600**

Thin organic-rich lake silt, at base of finely laminated lake sand, overlying varved silt. Organic silt, 10m to E, is overlain and folded into distal deposit of hydrothermal explosion breccia from craters in Mary Bay, "Squaw Point" on Yellowstone Lake at Squaw Lake picnic area (44° 33′ 10″ N, 110° 19′ 30″ W) Canyon Village quad. Coll and subm 1972 by G M Richmond. *Comment* (GMR): organic silt and explosion breccia underlie ash from Glacier Peak (ca 12,000 yr BP). Dates hydrothermal explosions in Mary Bay and approx end of deposition of varved silts.

W-2739. **14,130 ± 375**

Thin lenticular bryophyte mattes from lake silt, same locality as W-3190. Coll 1970 and subm by G M Richmond. *Comment* (GMR): dates opening of this part of Yellowstone Lake during recession of Pinedale glacier.

W-3183. **14,490 ± 350**

Re-run of W-2739. Recoll 1974 and subm by G M Richmond.

W-2895. **17,460 ± 500**

Black humic clay lenses, 5cm thick, disconformably overlying involuted reddish-brown clayey loess, and overlain by brown loess and solifluction layer of basalt blocks, 0.8km E of Warm R Bridge, along forest rd E of Warm R Campground, 7.2km W of Yellowstone Natl Park (44° 15′ 55″ N, 111° 16′ 30″ W), Hatchery Butte quad, Idaho. Coll and subm 1972 by G M Richmond. *Comment* (GMR): locality is beyond outer limit of Pinedale glaciers.

W-2896. **17,480 ± 500**

Dark organic silt, 50cm thick in uppermost part of loess, overlain by 45cm reddish-brown soluflucted loess beneath 1m slabby black vitrophyric tuff fragments in sandy matrix, cut on W side Fish Creek Rd at rd level, 0.4km S of junction of Fish Creek Rd with Snow Creek Rd near Horsefly Spring, 5.6km W of Yellowstone Natl Park (44° 10′ 50″ N, 111° 10′ 05″ W), Warm River Butte quad, Idaho. Coll and subm 1972 by G M Richmond. *Comment* (GMR): locality is beyond outer limit of Pinedale glaciers.

W-2582. **>29,000**

Humic lake sediments with thin bryophyte mattes, in lower part of sediments dipping gently N, same locality as, and disconformably overlying W-2739, -3183, -3187, and -3190. Coll and subm 1968 by G M Richmond. *Comment* (GMR): though no till is present, deposit is believed to pre-date Pinedale Glaciation. *Comment* (MR): although sample gave finite age of ca 29,000 yr, we believe that material is contaminated by an indeterminate amount of modern carbon that cannot be removed. Therefore minimum age is quoted. See discussion by Pierce *et al* (1976).

W-2955. **>40,000**

Laminated silty clay containing thin lenticular bryophyte mattes gently dipping downstream, disconformably overlain by sand and gravel deposited during stagnation of Pinedale glacier, E bluff Solution Creek, ca 1.7km above its entrance into W thumb Yellowstone Lake (44° 23′ 40″ N, 110° 30′ W), Frank Island quad (Richmond & Waldrop, 1975). Coll and subm 1973 by G M Richmond. *Comment* (GMR): W-2955, and -2012, >38,000 (R, 1969, v 11, p 218) were derived from same bryophyte matte horizon. Dated horizon dips 3° N and disappears downstream beneath successively younger similarly dipping beds that extend to locality dated by W-2582.

W-2197. **>42,000**

Wood in lake silt, S side Beaverdam Creek, near junction with Rocky Creek (44° 20′ N, 110° 10′ W), Eagle Peak quad (Richmond & Pierce, 1972; Richmond, 1974; Richmond, 1973b). Coll 1967 and subm by G M Richmond. *Comment* (GMR): wood is from lake silt that grades up through sand into 12m gravel overlain by peaty sand, dated by ^{14}C enrichment method as 68,300 ± 2200 (Grootes, 1977), higher lake silt, proglacial gravel and Pinedale Till.

W-2411. **>45,000**

Organic layer in laminated silt along Trappers Creek, overlain by 6m gravel, underlain by 12m gravel and by older till, lake sediments, and gravel (45° 1.62′ N, 110° 5.88′ W), Eagle Peak quad. Coll 1966 by K L Pierce; subm by G M Richmond.

W-2264. **>42,000**

Wood and plant debris from laminated clayey silt deposit lying disconformably beneath gray Pinedale Till, containing small pebbles of obsidian, S side Teton Natl Forest, immediately S of Yellowstone Natl Park (44° 07′ 30″ N, 110° 49′ W), Grassy Lake Reservoir quad (Richmond, 1973a; Richmond & Waldrop, 1975). Coll and subm 1968 by G M Richmond. *Comment* (GMR): laminated silt grades downward into lake sand, underlain to W by older pink till that contains no obsidian.

W-2780. Cub Creek, Yellowstone Natl Park, Wyoming **14,360 ± 400**

Organic silt from piston core, depth 7.0 to 7.3m, alt 2485m, 3.2km E of Yellowstone Lake on rd to E entrance of Yellowstone Natl Park (44° 30′ N, 110° 15′ W). Coll 1970 and subm by H E Wright, Jr, Univ Minnesota, Minneapolis. *Comment* (HEW): material dated is in herb pollen zone, indicating late glacial alpine vegetation before spread of sub-alpine forests; it is combination of 8cm directly above volcanic ash and 16cm directly below. Date gives reasonable minimal time for withdrawal of Pinedale ice from this part of Yellowstone Plateau. This and other ash dates, as well as pollen stratigraphy, are discussed by Waddington and Wright, Jr (1974).

D. Mexico

La Malinche series, Mexico

Series is part of study of volcanic ash and lapilli at Valsequillo archaeol sites, Puebla, Mexico. Area is surrounded by 3 major volcanoes: Popocatepetl, Iztaccihuatl, and La Malinche (LM). Chronology of volcanic ejecta in basin deposits that contain archaeol sites is useful in studies of regional archaeol, paleontol, and geol.

The S and W flanks of L M, alt 4450m, N of Puebla are mantled by surficial deposits that include at least 10 layers of volcanic ash and pumice lapilli. These are intercalated with buried soils, alluvial fan material and mudflows. See also Heine (1971). Field relations indicate that layers of ash and pumice represent airfalls (locally ash flows) from explosive eruptions indigenous to LM. The latest ash, a blanket of lithic volcanic sand 6m thick, overlies fossil soil developed on moraine that extends along W flank of mt at 3800m alt (just below treeline—3900 to 3950m); ash is, in turn, succeeded by small moraine at 4100m alt on NW side. Thus, all but 1 of the id volcanic layers are older than 2 episodes of glaciation, and all volcanic layers that contain pumice are older than any recognized glaciation. Older of the moraines on LM is regarded as late Pleistocene on basis of its geomorphic similarity to an upper Pleistocene moraine in Iztaccihuatl (White, 1962), and younger moraine is probably early Holocene.

Sequence of ash and pumice lapilli on LM is divided into 2 parts separated by minor unconformity. None of these volcanic layers has yet been id in beds of ash and pumice at Valsequillo, and probably the layers

equivalent to those at Valsequillo are still deeply buried on LM. Organic sediment and charcoal samples coll 1966 and 1968 and subm by H E Malde.

W-1912. **5750 ± 280**

Humus soil, 40cm thick, on pumice near treeline, buried by airfall of lithic volcanic sand equivalent to that of W-1909, NW flank LM, alt 3850m, 0.5km WSW of Cerro Chi Chi (19° 15′ N, 98° 03′ W).

W-1923. **7450 ± 250**

Humus soil, 35cm thick, on pumice 500m below treeline, buried by airfall of lithic volcanic sand equivalent to that of W-1909, W flank LM, alt 3420, near spring in Barranca Apache, 3km E of Tlaloca (19° 14′ N, 98° 04′ W).

W-1909. **8240 ± 300**

Humus soil, 40cm thick, on moraine, buried by airfall of lithic volcanic sand, W flank LM, alt 3800m, head of Barranca Apache, 4km E of Tlaloca, 1.6km SW of W-1912 (19° 14′ N, 98° 03′ W).

General Comment (HEM): development of this soil ended as consequence of sudden burial by lithic volcanic sand. Date is maximum (ca 5700 BP) for younger moraine on LM, not covered by sand, alt 4100m. Because soil must have begun to form when ice that built older moraine retreated, age of this soil closely approximates end of this glacial advance (ca 8200 BP) although glacial maximum was necessarily somewhat older. This is consistent with known regional glacial history (White, 1962). As applied to age of Valsequillo S of Puebla, date for this soil is minimum for any LM pumice deposits that may be id as airfalls in Valsequillo because all pumice eruptions from LM are stratigraphically below this soil.

W-1908. **23,940 ± 1000**

Humus soil 75cm thick, buried conformably by 50cm unsorted stony debris, then by 7cm laminated pumice lapilli, and by massive ash flow at least 8m thick, W flank LM, Barranca Angostura, alt 2700m, 2.2km SW of Tlaloca (19° 13′ N, 98° 06′ W).

W-1911. **25,920 ± 1000**

Humus soil 1.5m thick, buried conformably by lm unsorted stony debris, then by 10cm laminated pumice lapilli, and by massive ash flow at least 18m thick, W flank LM, Barranca San Jose Xotanacatla, alt 2450m, 6km ENE of San Cosme Mazatecoxco (19° 12′ N, 98° 08′ W).

W-2570. **24,300 ± 1000**

Charcoal, lower part of humus soil, same location and horizon as W-1911.

W-2571. **26,100 ± 600**

Soil humates, extracted from soil in lab of Vance Haynes (SMU), same location and horizon as W-1911.

General Comment (HEM): dates indicate soil is ca 25,000 yr old. Development of this soil must have ended as consequence of sudden burial by overlying stony debris, possibly an airfall of lithic fragments resulting from nonmagnetic explosion of LM, followed by laminated lapilli and ash flow. If volcanic layer equivalent to this ashflow is missing at Valsequillo because Valsequillo deposits are older, dates imply that Valsequillo archaeol site provides earliest known signs of man in New World.

W-1927. **8110 ± 300**

Charcoal in soil 50cm thick correlated with soil of W-1911, buried conformably by 10cm laminated pumice lapilli and by massive ashflow at least 18m thick (layer of stony debris found at other exposures between soil and laminated lapilli is lacking here), W flank LM, Barranca San José Xotanacatla, alt 2500m, 7.5km ENE of San Cosme Mazatecoxco (19° 12′ N, 98° 07′ W). *Comment* (HEM): because other dates for this soil substantially agree (W-1911, -1908 -2570, -2571), and indicate age 3 times as old as this charcoal, charcoal is probably not indigenous but represents carbonized roots of plants that grew more recently.

W-1913. **17,350 ± 550**

Humus soil, 15cm thick, below 2.5m pumice that unconformably underlies W-1911, same location as W-1911. *Comment* (HEM): date is discounted because sample was below W-1911 but is dated as younger. Sample is evidently contaminated.

W-1925. **17,650 ± 550**

Humus soil, 45cm thick, developed on stony layer and overlain by 20cm lithic volcanic sand and then by 1.5m pumice, W flank LM, Barranca Angostura, alt 3000m, 1.5km SE of Tlaloca (19° 13′ N, 98° 05′ W). *Comment* (HEM): significance of date in chronology of volcanic deposits on LM is uncertain, pending petrographic study of overlying sand and pumice.

Valsequillo barranca series, Mexico

Barrancas (deep arroyos) that debouch along embayed N shore Valsequillo Reservoir are partly filled with compact, gravelly alluvium, now dissected. This alluvial fill is at grade with alluvial formation ca 30m thick (known locally as Valsequillo gravel) widely exposed around reservoir, although barranca deposits and typical Valsqeuillo at reservoir are nowhere in contact. On basis of unpub geol mapping by Malde, 1964-1966, and on incomplete petrographic study by V Steen-McIntyre of several intercalated beds of volcanic ash and lapilli, barranca alluvium and Valsequillo appear correlative. Barranca deposits probably represent alluvium that filled tributaries of large valley where typical Valsequillo was deposited concurrently. Radiocarbon analyses from barranca deposits, therefore, are believed to apply to Valsequillo, which has not yet yielded material suitable for direct radiocarbon dating. Selected bone samples from these alluvial gravels were also dated by uranium-series method

(Szabo *et al,* 1969). However, archaeologically, several uranium-series dates are much too old. Samples of freshwater clams, freshwater snails, and land snails from alluvium, Puebla, Mexico. Coll 1966 by J Reynolds and C E Ray, US Natl Mus, Washington, D C; subm by H E Malde.

W-1974. **Modern**

Living snails, *Holospira,* Barranca de Caulapan, 425m S of rd to Valsequillo Presa, 8km on rd ESE from San Francisco Totimehuacan (18° 57′ N, 98° 08′ W). Coll 1964 by H E Malde. *Comment* (HEM): control sample for modern standard.

W-1896. **9150 ± 500**

Shells, 23m above W-1898, Barranca de Caulapan. *Comment* (HEM): dates upper limit for alluvium.

W-1895. **21,850 ± 850**

Shells, 10m above W-1898, Barranca de Caulapan, 8m above W-1975. *Comment* (HEM): from same bed immediately adjacent to sample, C Irwin-Williams and J Armenta found *in situ* a chert flake, possibly an artifact, which may be oldest directly dated record of man in New World.

W-1975. **>29,000**

Shells from gravelly sand in gravel above base of compact alluvial fill, 2m above W-1898, Barranca de Caulapan.

W-2189. **30,600 ± 1000**

Shells from gravelly sand near base of compact alluvial fill, 50m upstream from W-1898, Barranca de Caulapan.

W-1898. **>35,000**

Shells, at base alluvial fill, Barranca de Caulapan.

General Comment (HEM): alluvial fill rises to form well-defined terrace at grade with surface of Valsequillo deposits preserved in isolated outcroppings where barranca joins reservoir. Dates indicate alluvium began to accumulate at least 35,000 yr ago, changed from gravel to fine-grained material ca 20,000 yr ago, and culminated ca 9000 yr ago.

W-1899. **>35,000**

Shells, at base of alluvium, 8m above Rio Atepitzingo, 10m N of bridge, 1500 ESE of San Francisco Totimehuacan (18° 58′ N, 98° 10′ W). *Comment* (HEM): indicates assoc fossils and possible artifacts (Aveleyra, 1962, p 44) are at least as old as late Pleistocene. Unpub mapping and drilling by H E Malde demonstrates that alluvium at Rio Atepitzingo connects in subsurface with that along Rio Alsesca upstream from village of Totimehuacan.

W-1901. **>35,000**

Shells, near base of alluvial fill, Barranca de Xochiac, 1250m E of San Pedro Zacachimalpa (18° 56′ N, 98° 09′ W). *Comment* (HEM): sug-

gests all fossils and possible artifacts near base of alluvium are at least as old as late Pleistocene (Armenta, 1959; Lorenzo, 1960).

W-1897. **20,780 ± 800**

Shells, 2 to 3m below top of well-exposed alluvium at least 8m thick, 45km ESE of Puebla, W edge Santa Isabel Tlanepantla, 300m upstream from cemetery (18° 51′ N, 97° 54′ W). *Comment* (HEM): suggests local fauna from Barranca de Santa Isabel Tlanepantla is closely contemporaneous with local faunas from Valsequillo barrancas. Date helps estimate age of inferred widespread fauna in this prov of Mexico.

W-1980. Puente del Negro, Mexico **4350 ± 250**

Charcoal at base of fine volcanic ash bed, E side Rio San Francisco, depth 329 cm, 200m NNE of Puente del Negro, Pueblo (19° 04′ N, 98° 12′ W), Mexico. Coll 1966 by P S Martin; subm by H E Malde. *Comment* (HEM): dates white ash marker.

W-1995. Rio Frio, Mexico **>40,000**

Carbonized wood in ash flow, exposed borrow pit, 200m SE of Rio Frio junction on Mexico City-Puebla Toll Rd, alt 2970m, (19° 20′ 55″ N, 98° 40′ 00″ W), Mexico. Coll 1966 by V Steen-McIntyre and H E Malde; subm by H E Malde. *Comment* (HEM): ash flow rests on fresh lava above pumice layers and intercalated buried soils that conform closely to existing topography. Overlying volcanic ash probably represents airfalls from Popocatepetl.

E. Pacific Islands

Jarvis Island series, Pacific Ocean

Coral samples from Jarvis I. (00° 23′ S, 160° 01′ W), Southern Line Is, Central Pacific Ocean. Coll 1968 by J I Tracey, Jr and S O Schlanger; subm by J I Tracey, Jr.

W-2315. **1810 ± 250**

Aragonite coral boulder, cemented in rubble, base of conglomerate at MLW, N coast of I.

W-2314. **2270 ± 250**

Aragonite coral cobble from top of cemented rubble, 1.5m above reef flat, MSL, N coast of I.

General Comment (JIT): dates compare with others for cemented rubble in Micronesia (Shepard *et al,* 1967; Curray *et al,* 1970). These corals are ca 2000 yr younger than corals from emergent reefs within Jarvis I. (W-2317, -2318) and are slightly younger than dolomitized lagoonal mud 2530 ± 250, W-2287 (R, 1978, v 20), (US Geol Survey, 1970; Schlanger & Tracey, 1970).

W-2317. **3980 ± 250**

Aragonite coral from microatoll in growth position, 1.2m above

W-2318. **3950 ± 250**

Aragonite coral from microatoll, 15m S of W-2317, same alt.

General Comment (JIT): date growing lagoon reefs of Jarvis that are now emergent. Age can be compared with dates of similar emergent reefs on Malden I. and on Starbuck I. (Tracey, 1972).

Starbuck Island series, Pacific Ocean

Calcium carbonate samples from present reef flats and from shell facies of emergent lagoon reefs within Starbuck I. (05° 38′ S, 155° 55′ W), Southern Line Is, Central Pacific Ocean. Reefs are formed almost entirely of articulated *Tridacna* in growth position. Coll 1968 by J I Tracey, Jr and S O Schlanger; subm by J I Tracey, Jr.

W-2381. **1230 ± 200**

Aragonite shells (*Tridacna*) *in situ* in coral microatoll on N reef flat, alt 0.3m above highest presently living coral on outer reef flat.

W-2383. **1980 ± 200**

Aragonite coral from emergent coral head, *in situ,* same locality and alt as W-2381.

General Comment (JIT): samples from slightly emergent flat on present reef.

W-2390. **1820 ± 200**

Aragonite coral (*Porites*) from large microatoll, overlying emergent shell reef, alt 1.5m above MSL, center of I.

W-2385. **2690 ± 250**

Aragonite (*Tridacna*) same location and alt as W-2390.

W-2451. **2940 ± 250**

Complete re-run of W-2385.

General Comment (JIT): same ages were expected since both shells and coral were on flat top of reef ridge.

W-2566. **2000 ± 250**

Algal reef rock (*Lithophyllum*) from present reef flat, 0.3m above MLW, same alt as living algal margin 15m seaward, N reef. *Comment* (JIT): suggests present living margin is thin veneer on older reef at same level, or possibly that margin has grown seaward 15m in 2000 yr, leaving behind relict uneroded parts of old margin.

Malden Island series, Pacific Ocean

Calcium carbonate samples formed at or just below former low

W-2329. **3550 ± 250**

Aragonite oolite crust on emergent lagoon floor 1m above MSL. *Comment* (JIT): oolite crust is much younger than emergent reefs of Malden I. but is close to ages of emergent reefs of Jarvis I. It is older, but in same range, as emergent reefs of Starbuck I., suggesting that though Malden reefs grew >27,000 to 38,000 yr ago, a resubmergence 3000 to 4000 yr ago led to ooid formation on Malden shoals.

W-2334. **>38,000**

Shells (*Tridacna*) *in situ,* encrustate reef rock, 1.3m above MSL.

W-2356. **>27,000**

Calcite and aragonite, encrustate reef rock, 0.9m above MSL.

W-2358. **>29,000**

Aragonite coral, from cemented rubbly layer overlying algal reef rock, 1.1m above MSL.

W-2359. **>32,000**

Shells (*Tridacna*) *in situ,* in coralline algal reef rock, 1m above MSL.

General Comment (JIT): emergent reefs of Malden I. are not in 1500 to 4000 yr range of most low (1 to 2m) emergent Pacific reefs. They are probably equivalent to emergent reefs or feo of Tuamotu Is, 120,000 yr range, (Veeh, 1966) but are remarkably uneroded. Reef structures are better preserved than most Holocene emergent reefs (Tracey, 1972).

Fanning Island series, Pacific Ocean

Coralline algae (*Lithophyllum*) 0.8km S of English Harbor, Fanning I. (03° 00′ N, 159° 00′ W), Line Is, Central Pacific Ocean. Coll 1968 by J I Tracey, Jr and S O Schlanger; subm by J I Tracey, Jr.

W-2568. **2200 ± 250**

Algal reef rock at beach line, midtide level, top of truncated reef flat.

W-2569. **<200**

Living algal reef rock, 15m seaward of W-2568.

General Comment (JIT): living algal margin of reef, which contains well-developed spurs and grooves, is at same level as top of adjacent truncated reef. Date of 2200 yr for truncated reef indicates that present algal margin (W-2569) is thin veneer on older reef, or possibly that present margin grew 15m seaward in 2000 yr.

W-2539. Enderbury Island, Pacific Ocean **2630 ± 250**

Aragonite shells (*Tridacna*) *in situ* in microatoll, small dry lagoon, 1m above MSL, Enderbury I. (03° 00′ S, 171° 00′ W), Phoenix Is, Central Pacific Ocean. Coll 1969 by Harold Rehder, Smithsonian Inst, Washington, D C; subm by J I Tracey, Jr. *Comment* (JIT): representative of lagoon reef ridges in dry lagoon at center of I. and indicates sea level was at least 1m higher relative to Enderbury I. 2600 yr BP.

W-2564. Vatia Bay, American Samoa Is, Pacific Ocean 250 ± 200

Coral *in situ* in large reef block containing USGS benchmark, 1m above MSL, on reef flat E side of Vatia Bay (14° 14.9′ S, 170° 40.1′ W), American Samoa, Central Pacific Ocean. Coll 1968 by J I Tracey, Jr and S O Schlanger; subm by J I Tracey, Jr. *Comment* (JIT): reef block contains large corals as much as 1m across in upright position, and was called remnant of reef from higher 1.5m stand of sea by Stearns (1944, p 1308). The block, however, is near present reef edge, and comparably large coral knolls are visible nearby at depths of 5 to 8m. Date indicates block was tossed upright upon reef by storm waves, and is not relict of eustatic sea stand.

Midway Island series, Pacific Ocean

Limestone and coral samples from reefs of Midway I., Hawaiian Is. Coll 1965 and subm by J I Tracey, Jr (Gross *et al,* 1969; Ladd *et al,* 1967; 1970). Samples were used to date emergent reefs for comparison with other Pacific Is.

W-1851. <200

Living coralline algae (*Lithophyllum*) from living reef margin, E reef (28° 15′ N, 177° 19′ W).

W-1956. 1230 ± 250

Detrital reef limestone, from emergent ledge, 0.6m above MLLW, E reef (28° 15′ N, 177° 19′ W).

W-1846. 2090 ± 200

Encrustate reef limestone, from emergent reef rock, 0.8m above MLLW, N reef (28° 17′ N, 177° 22′ W).

W-1962. 2220 ± 250

Detrital reef limestone, from truncated platform near reef edge, 0.6m above MLLW, W reef (28° 14′ N, 177° 25′ W).

W-1954. 2420 ± 300

Encrustate reef limestone, from emergent ledge near reef margin, 0.6m above MLLW, E reef (28° 15′ N, 177° 19′ W) (Stearns, 1974, p 796).

Bikini Atoll series, Pacific Ocean

Carbonate samples from Bikini Atoll, Central Pacific Ocean (Emery *et al,* 1954). Coll 1946, 1947 and subm by J I Tracey, Jr.

W-1848. <200

Living calcarous alga (*Lithophyllum*) from present reef margin (11° 37′ N, 165° 33′ E) near S end of Bikini I. *Comment* (JIT): control sample for comparison with Holocene reef limestone samples.

W-1845. **640 ± 180**

Coralline alga (*Lithophyllum*) from eroded algal reef rock 30m behind reef margin, 0.9m above MLLW (11° 37′ N, 165° 33′ E). *Comment* (JIT): limestone is part of algal margin at same alt as present living margin (W-1848) but 0.6m higher than present reef flat (Emery *et al,* 1954, pl 39; Tracey & Ladd, 1974). It possibly formed under conditions similar to present (same sea level) but died as outer parts of margin grew and cut it off from continual surf.

W-1948. **4050 ± 300**

Reef limestone, chiefly aragonitic coral, from eroded hummocky surface of reef rock at MSL (11° 36′ 25″ N, 165° 33′ 14″ E), S end of Bikini I., (Emery *et al,* 1954, p 162; Tracey & Ladd, 1974). *Comment* (JIT): dates eroded top of reef underlying Bikini I.

W-1950. **5750 ± 300**

Reef limestone of coralline algae (high Mg calcite), depth 4.6m, 2.1m below MLW, Drill Hole 3, (11° 36′ 25″ N, 165° 33′ 12″ E), SE end of Bikini I., (Emery *et al,* 1954, p 83, 255; Tracey & Ladd, 1974). *General Comment* (JIT): this date, W-1948 for reef rock at Bikini, and W-1850 at Eniwetok indicate that sea level in N Marshall Is region was within 2m of present levels 6000 yr ago, and attained present level by 4000 yr ago.

W-1850. Eniwetok Atoll, Pacific Ocean **6220 ± 200**

Aragonite coral in coral-algal reef rocks, depth 3.1m, 2.1m below MLLW, from hole drilled on rubble groin on reef flat, 60m off E coast of Engebi I. (11° 39′ 55″ N, 162° 15′ 05″ E), Eniwetok Atoll, Central Pacific Ocean (Ladd & Schlanger, 1960, p 884-889; Tracey & Ladd, 1974). Coll 1950 by H S Ladd; subm by J I Tracey, Jr. *Comment* (JIT): sample is higher but older than those reported by Thurber *et al* (1965), and suggests sea level at Eniwetok at 6000 yr BP was no more than 2m below present levels.

W-1952. Kure Island, Pacific Ocean **1480 ± 250**

Encrustate reef limestone, emergent, eroded platform at reef edge, 0.6m above MLLW, N reef of Kure I. (28° 27′ N, 178° 20′ W), Hawaiian Is, Pacific Ocean. Coll 1965 and subm by J I Tracey, Jr. *Comment* (JIT): dates emergent reef of Kure for comparison with Midway and other Pacific islands, (Gross *et al,* 1969; Stearns, 1974).

Easter Island series, Pacific Ocean

Charcoals from Rano Raraku volcano quarry (Mazière, 1968, p 138), Easter I. (27° S, 109° W). Subm by Harmon Craig, Scripps Inst Oceanog, La Jolla, California.

W-2509. **<200**

Excavated site in "stone-cutters' working place", S side quarry, depth 0.6m. Coll 1963 by Francis Mazière, SIO.

W-2511. **<200**

Charcoal from series of charcoal hearths with convex-up shape, depth 1m, at site of Thor Heyerdahl's cutting of modern tiki from quarry face. Coll by Harmon Craig on SIO Carrousel Expedition.

General Comment (HC): dates ostensibly indicate that statue carving on Easter I. may have continued until very recent times, even after legendary "Poike ditch fire" and disastrous war, dated by Heyerdahl as ca 333 yr BP. But soil from which samples were coll is completely filled with grass roots; thus dates should be regarded as lower limits (*ie* they could be older), validity of which depends on degree to which rootlets were successfully removed from samples. *Comment* (MR): all visible rootlets were removed prior to burning sample, but decomposed intruded rootlets may be significant source of young organic carbon.

F. Miscellaneous Samples

W-2575. Santa Maria Island, Azores **>30,000**

Marine bivalves from emerged encrusting algal limestone reef, along S shore of I., from Priaia to Prainha, 1.8m above MHW, Santa Maria I. (36° 57.3′ N, 25° 06.7′ W). Coll and subm 1967 by W S Newman, Queens Coll, Flushing, New York. *Comment* (WSN): date, with 29,950 ± 1200 yr (I-5666) for encrusting algal limestone is probably evidence that relative sea level prior to classical Wisconsin was higher than present.

W-2442. Monrovia, Liberia **<200**

Carbonaceous silica-rich sand, depth 0 to 1m, 5 to 7.5m above MSL, Brewerville VOA site, 12km N of Monrovia (06° 26′ 37″ N, 10° 49′ 15″ W). Coll and subm 1969 by Sam Rosenblum. *Comment* (SR): sand represents tidal-lagoon environment which suggests a ca 6m relative fall of sea level during ⩽200 yr, a rather rapid rate. Evidence for uplift and/or sea level drop as noted in Ghana, 1500km E, was reported in 1940. There terraces are as much as +36m to −18m and similar silica sand is noted near seacoast.

Coastal Liberia series

Wood and charcoal dated to establish chronology for late Pleistocene and Holocene events in coastal area of Liberia. Coll 1968-70 and subm by W L Coonrad.

W-2957. **960 ± 200**

Charcoal fragments in sparse midden zone, depth 0.9 to 1.2m, beach cut bank (06° 31′ N, 10° 57′ W). *Comment* (WLC): local subsidence causing beach erosion is apparently very recent although apparently not documented historically. Date was referred to Creighton Gabel, Boston Univ, African Studies Center, Brookline, Massachusetts. *Comment* (CG): test excavations produced abundant pottery and charcoal. Date agrees very well with 1 obtained by us at same depth, 865 ± 155 (GX-3308), indicating initial occupation of site took place in 9th or 10th century AD.

W-2953. **4210 ± 250**

Charcoal fragments found buried with earthenware pots and iron implements, depth 0.9m, cut bank on SE side of Po R behind rock outcropping at beach-river intersec (06° 30′ 25″ N, 10° 55′ 30″ W). *Comment* (WLC): age is surprisingly old, but, if accurate, is significant in indicating that both iron and pottery were produced and utilized in Liberia earlier than previously known. *Comment* (CG): site was investigated by us. Extensive recent disturbance was noted, and no pottery or iron was seen. Date is far earlier than any presently accepted for early Iron age in West Africa or any other part of continent.

W-2952. **6620 ± 250**

Wood fragments, beach at Kabiki at mouth of Cavalla R (04° 21′ 42″ N, 07° 32′ W). *Comment* (WLC): age suggests approx equivalence with Bushrod I. clay age of 6160 ± 600, W-2238 (R, 1978, v 20, p 154; Blade, 1970, p 8). Both samples eroded from offshore deposits thought to be located at MSL, indicating lower sea level along this part of African coast 6000 to 7000 yr ago.

W-2958. **8400 ± 300**

Wood fragments, coll from dredge spoil, depth −10.5 to −13.5m Monrovia Freeport harbor (06° 21′ N, 10° 48′ W). *Comment* (WLC): suggests deeply incised buried river channels crossing present coastal boundary and that beach placers possibly developed 10,000 yr ago are now located far offshore.

W-2962. **12,120 ± 350**

Wood embedded in Edina Sandstone, cropping out at back edge of modern beach (06° 30′ 40″ N, 10° 56′ 25″ W). *Comment* (WLC): appears anomalously young. The Edina SS is unconformably overlain by unconsolidated deposits dated at 6000 yr, W-2238 (R, 1978, v 20, p 154) to 10,000 yr, St-1106 (R, 1965, v 7, p 273; White, 1969).

W-2447. Kumba, Liberia **3160 ± 200**

Wood cut from log buried by stream gravels, 2100m NW of Kumba (07° 39′ 46″ N, 10° 35′ 18″ W), Liberia. Coll 1968 and subm by J F Seitz. *Comment* (JFS): dates radical change in stream regimen. Logs were deposited when streams ran on beds of weathered bedrock; later, gravel was deposited.

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