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US GEOLOGICAL SURVEY RADIOCARBON DATES XII

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This list contains the results of some measurements made between 1968 and 1974. Samples were counted in the form of acetylene gas, as previously, and ages were computed on the basis of the Libby half-life, 5568 ± 30 years. The error listed, always larger than the 1σ statistical counting error commonly used, takes into account variable laboratory factors but does not include external (field or atmospheric) variations or fractionation.

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

A. Eastern United States

Cape Lookout series, North Carolina

Shell and peat samples from surficial deposits of the submerged and emerged Coastal Plain prov, Cape Lookout area, North Carolina (Mixon & Pilkey, 1976). Coll and subm 1971 by R B Mixon.

W-2600. **>38,000**

Shells from rim of large Carolina Bay, alt 2 to 3m below MSL, 1.8km ENE of Hwy 70 bridge over Salters Creek, ca 4.2km WNW of Atlantic (35° 10′ N, 76° 20′ W).

W-2601. **18,460 ± 400**

Peat bed 0.9m below surface of Carolina Bay rim, alt 3 to 4m above MSL, 3.4km WNW of Atlantic (35° 10′ N, 76° 20′ W).

General Comment (RBM): dates W-2600 and -2061 indicate that the sand-ridge complex was constructed before the last major transgression of the sea, ca 18,000 to 15,000 yr ago.

W-2611. **>40,000**

Shell bed below well-sorted sand facies of Cedar I. sand, alt ca 3m below MSL, 0.7km S of Roe School on Cedar I. (35° 00′ N, 76° 18′ W).

W-2629. **24,750 ± 700**

Peat from base of fill in depression on Cedar I. barrier, alt ca 1.2m above MSL, at rd junction 0.6km SW of Roe School site, Cedar Island Barrier (35° 00′ N, 76° 18′ W). *Comment* (RBM): sample may be contaminated by ground water containing younger organic colloids; age is minimum for small "Carolina Bays" on Cedar Island (see also W-2611).

W-2628. **>38,000**

Shell bed between Cedar I. and North Bay barriers, alt ca 2.7m below MSL, 0.4km SW of Cedar I. Ferry Landing (35° 01′ N, 76° 20′ W).

Comment (RBM): age is minimum for NE-most (youngest) barrier of Cedar I. barrier complex.

W-2612. **>45,000**

Shell bed below well-sorted sand facies of Beaufort sand, alt 2.5 to 4m below MSL, ca 0.8km S of hwy bridge over straits (34° 40′ N, 76° 35′ W). *Comment* (RBM): date indicates Beaufort sand is Pleistocene rather than Holocene, as previously thought.

W-2627. **7070 ± 250**

Shell hash below Outer Banks sand, alt MSL, S side of hwy, 0.16km SW of fort, Fort Macon State Park on Bogue Banks (34° 38′ N, 76° 40′ W). *Comment* (RBM): dates formation of Outer Barrier.

Allegheny series, Maryland and West Virginia

Peat from unglaciated uplands along the Allegheny structural front (Cameron, 1970). Coll and sub 1968 by Cornelia Cameron.

W-2253. **13,620 ± 600**

Peat coll near base of peat deposit, depth 228 to 239cm, Castleman Basin, Garrett Co (39° 34′ N, 79° 16.5′ W), Maryland. *Comment* (CC): correlates with other basal peats in area.

W-2255. **5250 ± 250**

Peat, depth 122 to 142cm, from Canaan Valley (39° 7.5′ N, 79° 27.5 W), West Virginia. *Comment* (CC): dates beginning of reed-sedge peat formation.

Hudson Highlands series, New York

Peat samples from Hudson Highlands at 366m alt, W side of Rte 9W on Military Reservation boundary, NW of West Point (41° 24′ 15″ N, 73° 59′ 30″ W), New York. Coll and subm 1968 by Cornelia Cameron.

W-2249. **8340 ± 350**

216 to 229cm

W-2251. **11,220 ± 400**

485 to 503cm

W-2252. Vails Gate, New York **8660 ± 350**

Peat from terrace in Hudson Valley at 79m alt, depression on bedrock between drift ridges at base of Hudson Highlands, depth 538 to 554cm, S of Vails Gate (27° N, 94° 4′ W), Cornwall Quad. Coll and subm 1968 by Cornelia Cameron.

B. Western United States

Mount Baker series, Washington

Series dates lahars (volcanic mudflows) that originated from avalanching of hydrothermally altered rock on Mount Baker volcano. Coll and subm 1973 by J H Hyde.

W-2934. **110 ± 200**

Wood from horizon 60cm above base of lahar, W bank of Boulder Creek, ca 100m downstream from Baker Lake Rd bridge, 9.7km SE of Mt Baker volcano (48° 43′ N, 121° 42′ W).

W-2933. **530 ± 200**

Wood buried by lahar, roadcut 0.8km up logging rd from junction with Baker Lake Rd at W end Park Creek bridge, 11.3km SE of Mt Baker (48° 44′ N, 121° 40′ W).

W-2944. **5980 ± 250**

Wood from horizon 4m above base of lahar, roadcut on Middle Fork Nooksack River valley rd, 14.5km upstream from junction with Mt Baker Hwy near mouth of Clearwater Creek, 22.5km W of Mt Baker (48° 46′ N, 122° 02′ W).

W-2971. **6650 ± 350**

Wood from horizon 2m below top of lahar, E side Park Creek valley, roadside exposure 0.8km up logging rd to Baker Hot Spring from junction with Baker Lake Rd, 11.3km SE of Mt Baker (48° 44′ N, 121° 40′ W).

W-2972. **10,350 ± 300**

Carbonized wood from horizon 3cm below top of lower lahar, W bank of Sulphur Creek, ca 1km above trail head, Baker Pass Trail, 8km S of Mt Baker (48° 42′ N, 121° 48′ W).

Mount St Helens series, Washington

Pumice layers composing 4 different sets of tephra beds whose stratigraphy, age, and trend away from Mount St Helens (MSH) are fairly well known, are potentially valuable stratigraphic markers in the NW United States and adjacent part of Canada (Mullineaux *et al,* 1975). This series provides a record of explosive eruptive activity and is part of an appraisal of volcanic hazards at MSH.

W-2874. **460 ± 200**

Charcoal from deposit that contains breadcrusted volcanic bombs and that overlies ca 3m of fluvial deposits, bank of N Fork Toutle R at Spirit Lake Lodge (46° 15′ N, 122° 10′ W). Coll and subm 1972 by D R Crandell. *Comment* (DRC): deposit was previously regarded as that of a hot lahar ca 330 yr old (Mullineaux & Crandell, 1962). The similarity in age of the sample to that of the underlying tephra set W, which has been dated at ca 450 yr by radiocarbon and tree rings, suggests that both deposits were formed during the same eruptive period.

W-2989. **510 ± 200**

Charcoal from unweathered pyroclastic flow deposit which overlies a succession of weathered tephra deposits, quarry on SE slope of Goat Mt, 8.9km SW of MSH (46° 10′ N, 122° 16′ W). Coll and subm 1973 by D R

Crandell. *Comment* (DRC): dates a pyroclastic flow that occurred during an eruptive period at MSH between 600 and 450 yr ago.

W-2993. **1150 ± 200**

Charcoal from lithic tephra at base of set W, roadcut along USFS Rd 100, ca 0.5km from State Hwy 504, ca 6km NE of the top of MSH (46° 14′ N, 122° 09′ W). Coll and subm 1973 by D R Mullineaux.

W-2990. **1620 ± 200**

Charcoal at base of cindery ash that overlies scoria in upper part of Set B, roadcut along State Hwy 504, ca 5km N of top of MSH (46° 16′ N, 122° 11′ W). Coll and subm 1973 by D R Mullineaux. *Comment* (DRM): sample is from above basaltic tephra Layer U. With Sample W-2527 (Pine Creek series), which came from below the layer, it dates Layer U, which overlies tephra Layer I (see W-2863 and -2871).

W-2863. **1890 ± 250**

Peat from 2cm below pumice Layer I, small peat bog in meadow, 0.2km W USFS Rd N920.2, ca 24km E of MSH (46° 13′ N, 121° 56′ W). Coll 1972 and subm by D R Mullineaux.

W-2925. **1850 ± 250**

Complete rerun of Sample W-2863 to check date.

W-2871. **2130 ± 250**

Peat from 2cm above pumice Layer I, same location as W-2863.

W-2924. **1780 ± 250**

Complete rerun of W-2871 to check date.

General Comment (DRM): W-2863 and -2871 date Layer I closely, and match the stratigraphic sequence well.

W-2977. **2060 ± 200**

Charcoal from pyroclastic flow above tephra Set W and below andesite flow, N valley wall of S Fork Toutle R on W flank of MSH (46° 13′ N, 122° 15′ W). Coll and subm 1973 by D R Crandell.

W-2978. **2100 ± 200**

Charcoal from pyroclastic-flow deposit below tephra Set W and above tephra Set B, W valley wall of Studebaker Creek on NW flank of MSH (46° 13′ N, 122° 14′ W). Coll 1972 and subm by D R Crandell.

W-2277. **1860 ± 250**

Charcoal from roots of a tree covered by a pahoehoe flow in small side passage in Lake Cave, ca 11km S of summit of MSH (46° 05.8′ N, 122° 12.9′ W). Coll 1968 by J H Hyde; subm 1969 by D R Crandell. *Comment* (JHH): pahoehoe flow is one of earliest assoc with growth of "modern" cone of MSH (as opposed to "old" MSH represented by Swift Creek assemblage). Date agrees with dates from other parts of lava flow

and indicates that flow was emplaced in a relatively short interval of time.

General Comment (DRC): samples date pyroclastic flows formed during an explosive eruptive period at MSH 2200 to 2000 yr ago. The pyroclastic-flow deposits underlie andesite and basalt lava flows, and overlie a succession of pyroclastic-flow deposits of "old" MSH.

W-2872. **2220 ± 250**

Charcoal from tephra Set B, roadcut in valley of Castle Creek, ca 4.8km NW of base of MSH (46° 15′ N, 122° 15′ W). Coll and subm 1972 by D R Crandell. *Comment* (DRC): shows that mafic volcanism of the modern volcano began before ca 2200 yr ago.

W-2923. **2200 ± 250**

Complete rerun of W-2872 to check date.

W-2439. **2780 ± 200**

Wood from between Layers P and I, Bench Lake area, Mt Rainier Natl Park (46° 46′ N, 121° 42′ W). Coll and subm 1969 by D R Mullineaux.

W-2440. **2780 ± 250**

Wood from between Layers K and Y, same location as W-2439.

General Comment (DRM): W-2439 and -2440 are from above and below a series of 5 or more thin white ash deposits from MSH that directly overlie ash Layer Y. Dates suggest that MSH eruptions were closely spaced in time; from the stratigraphy, I would have expected the date for W-2440 to be closer to a previous date from Layer Y, 2980 ± 250 (W-1118: R, 1964, v 6, p 56) than to date for W-2439.

W-2873. **2840 ± 250**

Charcoal from a pyroclastic-flow in main fill of valley overlain by deposit containing W-2872, borrow pit on W side of valley of Castle Creek ca 4.8km NW of base of MSH (46° 15′ N, 122° 15′ W). Coll and subm 1972 by D R Crandell. *Comment* (DRC): main fill is believed to have accumulated during final period of activity of an old dacitic MSH eruptive center. That period lasted from ca 3000 to 2500 yr ago and is also represented by youngest part of Pine Creek valley-fill assemblage SE of MSH and by tephra Set P (Crandell and Mullineaux, 1973).

W-2875. **2900 ± 250**

Carbonized wood from soil zone between lahar assemblages, gravel pit in N Fork Toutle R valley at mouth of Alder Creek, 35.4km from MSH (46° 21′ N, 122° 33′ W). Coll and subm 1972 by D R Crandell. *Comment* (DRC): dates limit soil development episode between periods of eruptive activity and lahar formation at MSH.

W-2980. **2910 ± 200**

Charcoal from a pumiceous pyroclastic-flow deposit B that is younger than tephra Set GB and older than a lithic pyroclastic flow Deposit A, roadcut in Coldspring Creek valley at W base of MSH (46° 12′ N, 122° 15′ W). Coll and subm 1973 by D R Crandell. *Comment* (DRC): dates pyroclastic flow that occurred during an explosive eruptive period at MSH 3000 to 2500 yr ago. Eruptive deposits of this period were previously recognized on N and SE flanks of volcano, but this is 1st one recognized on the W side.

W-2552. **3180 ± 700**

Wood from sand layer overlying ash layer B and underlying ash layer M, valley wall of Ohanapecosh R, S of Indian Bar, Mt Rainier Natl Park (46° 49′ N, 121° 39′ W). Coll 1967 and subm by D R Mullineaux. *Comment* (DRM): date is younger than expected; stratigraphic position is below another sample, ca 3500 yr old (W-1752, R, 1967, v 9, p 520). Sample was too decomposed to be id and may have been part of a root.

W-2867. **5860 ± 300**

Charcoal from within pumice layer GB, above at least part of pumice Set J, below the Mazama ash, along logging rd 847, 8km W of MSH (46° 11′ N, 122° 16′ W). Coll 1972 and subm by D R Mullineaux. *Comment* (DRM): date is anomalous because Layer GB is overlain by Mazama ash (6600 yr) in many places. Possibly "GB" contains more than 1 bed.

W-2702. **8430 ± 300**

Charcoal from middle of tephra set J, along USFS Rd N92G, 6.4km NE of MSH (46° 14′ N, 122° 07′ W). Coll and subm 1971 by D R Mullineaux. *Comment* (DRM): although part of Set J may be nearly 12,000 yr old, W-2702 age indicates that the only NE-trending thick and coarse pumice layers were erupted during a short period ca 8400 to 8300 yr ago (see W-2587, Swift Creek series).

W-2991. **8900 ± 300**

Charcoal at top of Set J, logging roadcut, ca 10km ESE of top of MSH (46° 09.5′ N, 122° 04′ W). Coll and subm 1973 by D R Mullineaux. *Comment* (DRM): date suggests that all the coarse thick pumice to the SE is older than the oldest coarse thick bed in Set J NE of the volcano, dated at ca 8400 yr old.

W-2832. **11,700 ± 400**

Charcoal at base of tephra Set J, roadcut along logging Rd 822, ca 9.6km ESE of MSH (46° 10′ N, 122° 04′ W). Coll and subm 1972 by D R Mullineaux.

W-2868. **12,110 ± 375**

Charcoal from horizon between 2 pre-J pyroclastic flows, along logging Rd 140, ca 1km from USFS Rd N92, ca 8km E of MSH (46° 12′ N, 122° 05′ W). Coll 1972 and subm by D R Mullineaux.

W-2870. **11,550 ± 400**

Charcoal from base of lowest pre-J pyroclastic flow and above W-2866, same location. Coll 1972 and subm by D R Mullineaux.

W-2866. **11,900 ± 300**

Charcoal in soil zone at top of tephra Set S, below pre-J pyroclastic flow, same location. Coll 1972 and subm by D R Mullineaux.

General Comment (DRM): these 3 samples (W-2866, -2870, -2868) date various parts of sequence of lithic pyroclastic flows and lahars between Sets S and J. Because of oxidation zones, I expected lengthier representation between oldest and youngest flows in this group.

W-2678. **9600 ± 300**

Fragments of charcoal from lower part of a pumiceous ash, and from upper part of soil profile in colluvium underlying ash, roadcut on USFS Rd 111 at Jumbo Creek, 32km NE of MSH (46° 20′ N, 121° 47′ W). Coll and subm 1971 by D R Mullineaux. *Comment* (DRM): sample consisted of bits of carbonized vegetation from within and under pumice Set S and was expected to date older limit for that set. Date is anomalously young, because Set S directly underlies deposits dated from 11,500 to 12,000 yr. Contamination of sampled zone by younger but carbonized root material may be responsible.

W-2551. **17,270 ± 1000**

Organic material in basal part of thick pumice Deposit P, roadcut along hwy, Skamania Co. Coll 1970 by Meyer Rubin, D R Mullineaux and J H Hyde; subm by D R Mullineaux. *Comment* (DRM): date appears to be too young; its stratigraphic position is below and separated by interval of soil from horizon dated between 20,350 and 18,560 yr old. (See W-2540 and W-2413, Swift Creek series.) Dated sample may have included some material carried downward by ground water.

W-2574. **>29,000**

Peat and organic silt, 1st 10cm below pyroclastic layer Unit 2, Fargher Lake (45° 53.5′ N, 122° 30.5′ W). Coll and subm 1970 by J H Hyde and D R Mullineaux. *Comment* (DRM): dates upper limit for a widespread, fairly distinctive pumice deposit extending S and SW from MSH.

Pine Creek series, Mount St Helens, Washington

The Pine Creek volcanic assemblage consists of deposits of hot pyroclasic flows and lahars interbedded with alluvium and tephra. Tephra deposits are divided into several groups, each consisting of several layers

that contain similar mineral suites. Pine Creek assemblage was deposited after eruption of tephra Set S (see Swift Creek series) and before eruption of Set B.

General Comment (DRC & DRM): dates indicate that oldest Pine Creek eruptive episode occurred before ca 12,000 yr ago and youngest, between 3000 and ca 2500 yr ago (Crandell & Mullineaux, 1973).

W-2527. **1740 ± 250**

Charcoal from within tephra Set B, roadcut along USFS Rd N826A, 6.4km SE of MSH volcano (46° 08′ N, 122° 09′ W). Coll and subm 1970 by J H Hyde.

W-2529. **2580 ± 250**

Charcoal from pyroclastic-flow deposit, same location as W-2527. Coll and subm 1970 by J H Hyde and D R Crandell. *Comment* (JHH): dates a pyroclastic flow resulting from an explosive volcanic eruption. This sample and W-2527 bracket several pyroclastic layers and a soil-forming horizon.

W-2541. **2670 ± 250**

Charcoal from pyroclastic-flow deposit, W valley wall Pine Creek, 12.9km SE of summit of MSH (46° 06′ N, 122° 05′ W). Coll and subm 1970 by D R Crandell.

W-2542. **2850 ± 250**

Charcoal from pyroclastic flow deposit, E bank of Pine Creek, 14.5km SE of summit of MSH (46° 06′ N, 122° 04′ W). Coll and subm 1970 by D R Crandell.

W-2675. **2960 ± 250**

Charcoal from base of tephra Set P, roadcut in Smith Creek Valley, 9.7km E of MSH summit, along USFS Rd N92, 1.3km S of Ape Canyon Creek (46° 12′ N, 122° 04′ W). Coll and subm 1971 by D R Mullineaux.

W-2829. **2930 ± 250**

Charcoal from base of tephra Set P, same location as W-2675.

W-2549. **3350 ± 250**

Charcoal from within tephra Set Y, outcrop along E side of USFS Rd N92, NE of MSH. Coll and subm 1970 by D R Mullineaux. *Comment* (DRM): dates a *nuée ardente* from MSH, and with a sample dated 3510 ± 230 (W-1752, R, 1967, v 9, p 520) provides brackets for eruption of 2 largest pumice layers of tephra Set Y from that volcano.

W-2677. **3900 ± 250**

Charcoal from base of tephra Set Y, same location as W-2675. *Comment* (DRM): dates onset of eruption of group of Layer Y pumices.

Swift Creek series, Mount St Helens, Washington

The Swift Creek volcanic assemblage consists of deposits of pyroclastic flows, lahars, and alluvium subdivided and correlated by means of

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3 principal sets of tephra deposits. Tephra deposits were erupted before, during, and after assemblage was formed and are distinguished by different heavy-mineral suites (Hyde, 1975).

W-2587. **8300 ± 350**

Charcoal from within upper part of tephra set J, 6.4km NE of summit of MSH, along USFS Rd N926 (46° 14′ N, 122° 07′ W). Coll and subm 1970 by D R Mullineaux. *Comment* (DRM): dates topmost pumice layer of 2 presently recognized in Group J.

W-2655. **11,800 ± 300**

Wood from lahar below tephra Set J, W bank Muddy R, Skamania Co. Coll and subm 1971 by D R Crandell. *Comment* (DRC): dates upper age of a postglacial eruptive episode at MSH during which many hot pyroclastic flows and lahars formed thick fills in valleys on SE side of volcano (Crandell & Mullineaux, 1973). Also dates older limit for tephra Set J.

W-2441. **11,880 ± 350**

Charcoal from ash beneath tephra Set J, roadcut on USFS Rd N92, 8km NE of MSH (46° 14′ N, 122° 07′ W). Coll and subm 1969 by J H Hyde and D R Mullineaux. *Comment* (JHH): date agrees with stratigraphic data. Pyroclastic Layer J is widespread in MSH area, and may have wide distribution to E and S of volcano.

W-2983. **13,130 ± 350**

Charcoal from pyroclastic flow below upper bed of tephra Set S, outcrop at E end of high bridge over Swift Creek, ca 13km S of top of MSH (46° 05.5 N, 122° 12′ W). Coll and subm 1973 by D R Mullineaux.

W-2413. **18,560 ± 550**

Charcoal from pyroclastic-flow deposit beneath tephra Set S, gravel pit beside rd, Lewis R valley, ca 16km S of MSH (46° 03′ N, 122° 12′ W). Coll and subm 1969 by J H Hyde and D R Mullineaux. *Comment* (JHH): date agrees with known geol relationships. Dated deposit may help establish late Wisconsin glacial chronology in area.

W-2540. **20,350 ± 500**

Charcoal from pyroclastic flow below upper bed of tephra Set S, S side of Lewis R near Swift Dam, ca 16km S of MSH (46° 03′ N, 122° 12′ W). Coll and subm 1970 by J H Hyde.

General Comment (JHH): this date, with W-2413, dates 2 episodes of explosive volcanism and brackets a pyroclastic layer and a soil-forming horizon.

W-2653. **36,000 ± 2000**

Wood from lahar, along stream bed of Lewis R, ca 16km S of MSH (46° 03′ N, 122° 12′ W). Coll and subm 1971 by D R Crandell. *Comment* (DRC): date indicates age of a lahar in the Lewis R valley which formed

during oldest known eruptive episode of MSH volcano. The lahar contains pumice mineralogically similar to tephra beds from which W-2661 was obtained.

W-2661. **37,600 ± 1000**

Charcoal from upper part of lowest layer of unnamed tephra set, quarry in Smith Creek-Muddy R valley, ca 11km E of MSH summit (46° 11′ N, 122° 03′ W). Coll and subm 1971 by D R Mullineaux. *Comment* (DRM): dates oldest known coarse and thick pumice deposit of MSH.

W-2976. **36,000 ± 2000**

Charcoal from lower part of coarse pumice lapilli bed, quarry in Smith Creek-Muddy R valley, 11.3km E of MSH (46° 11′ N, 122° 03′ W). Coll and subm 1971 by D R Mullineaux.

W-2421. **>35,000**

Wood exposed at upper surface of block and ash-flow unit, streambed Lewis R, 16km S of MSH (46° 03′ N, 122° 12′ W). Coll 1969 by J H Hyde and D R Mullineaux; subm by J H Hyde.

Kalama River Valley series, Mount St Helens, Washington

Volcanic rocks and unconsolidated geol deposits in upper Kalama R valley were studied to determine the kind of catastrophic geol events that might accompany a future eruption of MSH (Hyde, 1970).

W-2403. **610 ± 200**

Charcoal from horizon 1.8m below top of lower nuée ardente deposit, gravel pit beside rd, Kalama R valley ca 11.3km SW of MSH (46° 08′ N, 122° 19′ W). Coll and subm 1969 by J H Hyde and D R Mullineaux. *Comment* (JHH): indicates that pyroclastic-flow deposits were emplaced between 610 ± 200 yr and ca 300 yr, the age of the oldest tree found growing on the surface of the youngest deposit. Sample horizon directly overlies the basalt flow of Merrill Lake.

W-2436. **2200 ± 200**

Charcoal from horizon, within a mudflow sequence, near base of white pumice bed, roadcut, Kalama R valley, ca 35.4km SW of MSH volcano (46° 06′ N, 122° 36′ W). Coll and subm 1969 by J H Hyde and D R Mullineaux. *Comment* (JHH): indicates deposits probably formed during same period of volcanism as the Silver Lake Lahar assemblage in the Toutle R valley on NW side of volcano.

Mount Rainier National Park series, Washington

Twenty-two layers of tephra-volcanic ash and coarser airfall pyroclastic debris that blanket much of Mount Rainier Natl Park were extensively studied to document the recent eruptive history of Mount Rainier volcano (MR) (Mullineaux, 1974). This series reports the effort to date some of these tephra layers with wood samples from sediments separating layers. Coll and subm 1969 by D R Mullineaux.

W-2437. **5770 ± 250**

Wood overlying tephra Layer D and underlying tephra Layer N, Mount Rainier Natl Park, 0.8km SE of junction of Hwys 410 and 143 at Cayuse Pass (46° 52′ N, 121° 32′ W).

W-2424. **6380 ± 250**

Carbonized wood fragments from between pumice Layers L and D, Cowlitz Park, Mount Rainier Natl Park (46° 49′ N, 121° 38.5′ W).

W-2423. **6440 ± 250**

Wood from between Layers A and L. Same location as W-2437.

W-2422. **6730 ± 250**

Wood from between Layers O and A, same location as W-2437.

General Comment (DRM): samples separate successive major pyroclastic layers O (Mt Mazama ash), A, L, D, and N, respectively, in pyroclastic sequence at Mount Rainier. The 1st 3 dates show that MR erupted layers A, L, D, N intermittently during ca 1000-yr-period rather than during 1 short eruptive episode. Date for W-2422, above Mazama ash, agrees well with 6600- to 6700-yr age commonly cited for Mt Mazama eruption.

Lassen Volcanic National Park series, California

Charcoal from pyroclastic-flow in Chaos Crags-Lassen Peak area. Coll and subm 1968 by D R Crandell and D R Mullineaux.

General Comment (DRC): eruptive episode dated by these pyroclastic flows culminated with extrusion of Chaos Crags dacite plug-domes N of Lassen Peak (Crandell *et al*, 1974).

W-2228. **1000 ± 300**

Charcoal embedded in 2 ash layers believed to be parts of 1 general eruptive episode, Lassen Volcanic Natl Park, between Chaos Crags and Lassen Peak (40° 30.4′ N, 121° 30.5′ W).

W-2235. **1000 ± 300**

Charcoal from lahar that overlies a partly oxidized lahar, believed to be correlative with W-2259, roadcut on S side State Hwy 44 ca 0.24km W of Lassen Park boundary, Lassen Volcanic Natl Park (40° 32′ N, 121° 35′ W).

W-2261. **1010 ± 250**

Charcoal from log embedded in lowest of 4 pyroclastic flows exposed in W bank of Lost Creek (46° 32.5′ N, 121° 29′ W).

W-2257. **1200 ± 300**

Charcoal from log enclosed in pyroclastic flow in S bank of E fork of Manzanita Creek (40° 31′ N, 121° 32′ W).

W-2232. **4600 ± 600**

Peat from top 8cm of peat deposit, W bank of Lost Creek 0.18km downstream from Lassen Park Rd bridge, Lassen Volcanic Natl Park (46° 32.5′ N, 121° 29′ W).

W-2231. **5400 ± 600**

Peat from bottom 5cm of same deposit as W-2232, same location.

General Comment (DRC): W-2231 and -2232 dates period of volcanic dormancy represented by a thick peat accumulation on a valley floor adjacent to Lassen volcano. The upper sample (W-2232) approximately dates a volcanic ash layer that represents renewed volcanic activity.

W-2230. **<200**

Wood enclosed in lahar, W bank of Lost Creek near "Hot Rock," Lassen Volcanic Natl Park (40° 32′ N, 121° 29′ W).

W-2259. **>32,000**

Charcoal from partly oxidized lahar sampled from a streambank of Manzanita Creek (40° 32′ N, 121° 35′ W). *Comment* (DRC): dates a pyroclastic flow representing an early eruption of Lassen Volcano which predates last major glaciation and Lassen Park plug-dome. Its source vent has not been positively id.

W-2814. Mount Shasta, California **9230 ± 300**

Charcoal at base of pyroclastic flows, roadcut on E side of Interstate Hwy 5 near W base of Black Butte (41° 22′ N, 122° 23′ W). Coll and subm 1972 by D R Crandell. *Comment* (DRC): dates deposit of a hot pyroclastic flow, probably formed during building of Shastina, a post-glacial parasitic cone on W side of Mount Shasta volcano. Above this deposit are other pyroclastic-flow deposits, formed during eruption of Shastina's summit plug of hornblende andesite (Crandell, 1973).

Coyote Creek Fault series, Borrego Mountain area, California

Shell and charcoal samples from surface and subsurface strata offset by Coyote Creek fault. Deformation is inferred from vertical displacement of flat-lying sediments deposited in Holocene Lake Cahuilla, which covered parts of the fault until at least 800 yr ago (Clark *et al,* 1972). Coll and subm 1969 by M M Clark.

W-2448. **1230 ± 250**

Gastropod shells from shell-rich deposit, 150mm-thick, of Holocene Lake Cahuilla ca 1m below surface, ca 1km from Holocene shoreline (33° 59.1′ N, 116° 3.21′ W), alt ca +1 to 2m. *Comment* (MMC): this date, combined with those of W-2456 and -2468, below, plus displacement along this same fault plane during Borrego Mt earthquake of April 9, 1968, yields a linear tectonic displacement rate at this site of 5×10^{-4}m/yr over the last 3000 yr, and a recurrence interval for 1968-type earthquake of 100 to 300 yr (Clark and Grantz, 1971).

W-2454. **1650 ± 250**

Shells from strata 2.4m below surface and ca 1.2km from shoreline, collection from wall of trench excavated across a fracture that formed during 1968 Borrego Mt earthquake (33° 5.74′ N, 116° 3.17′ W), alt ca 1 to 2m. *Comment* (MMC): fracture did not previously break these strata, despite connection and proximity (ca 100m) to main Coyote Creek trace and connection with fracture described under W-2448, both of which broke repeatedly during the same period. This demonstrates that some fracturing does not repeat at the same location during every episode of faulting. It also indicates lacustrine conditions 1650 ± 250 yr ago at this site.

W-2455. **1370 ± 250**

Shells from 1m below present ground surface in same trench as in W-2454. Coll level is 30cm below distinctive layer dated by W-2448. *Comment* (MMC): strata exposed in this trench and in nearby (ca 300m away) trench of W-2448, along with dates obtained from them, suggest, but do not prove, continuous lacustrine conditions at these 2 sites from 1650 ± 250 yr ago (W-2454) until Lake Cahuilla disappeared; see W-2456, below.

W-2456. **860 ± 200**

Pelecypod shells from surface exposure of distinctive youngest deposit of former Lake Cahuilla next to 1968 rupture of Coyote Creek fault (33° 5.36′ N, 116° 2.94′ W). This laterally extensive stratum is as much as 0.3m thick at coll site. At trench described under W-2448, base of same stratum was offset vertically 56cm by faulting. *Comment* (MMC): date is somewhat older than youngest ages given by others for Lake Cahuilla (ca 300 yr, eg, Hubbs *et al*, 1960, 1963, 1965).

W-2468. **3080 ± 600**

Gastropod shells from 1.5m below surface in walls of same trench as in W-2448, from lacustrine sediments ca 0.1m below base of layer, offset vertically ca 1.7m by faulting; see W-2448. *Comment* (MMC): strata exposed in trench indicate lacustrine conditions during much of period from at least 3080 ± 600 yr until lake disappeared. But brief lowerings of lake, if not accompanied by significant subaerial erosion or deposition, would be difficult to detect in this exposure.

W-2469. **2450 ± 250**

Shells exposed in wall of a wash that crosses 1968 break of Coyote Creek fault (33° 1.36′ N, 115° 59.36′ W), alt ca −5m. *Comment* (MMC): site lies ca 2km from Holocene shoreline that traverses base of Fish Creek Mts. Sample came from a layer that filled a shallow channel along the fault cut into underlying lacustrine layer. Sampled layer was in turn channeled by post-Lake Cahuilla erosion. This channel cutting was very likely related to episodes of faulting when lake was not present; hence,

exposure records faulting along 1968 break at least 2450 ± 250 yr ago when lake surface probably was lower than —5m.

San Jacinto Valley series, California

Wood from 3 depths in a well in San Jacinto Valley graben (33° 46′ N, 116° 59′ W). Coll 1971 by Eastern Municipal Water Dist and Metropolitan Water Dist. of Southern California; subm by B E Lofgren.

General Comment (BEL): dates rates of deposition that suggest downfaulting averaged ca 2.1 mm/yr from 42,000 to 15,270 yr BP and has increased since 15,270 yr BP, to ca 5.8 mm/yr; see Lofgren and Rubin (1975).

W-2729. Depth, 89m **15,270 ± 450**

W-2827. Depth, 98m **21,260 ± 650**

W-2828. Depth, 146m **42,000 ± 1500**

Yellowstone Lake series, Wyoming

Peat and organic silt in core from N edge of fen ca 4.6m above Yellowstone Lake, ca 2.4km W of Trail Creek Cabin, SE arm of Yellowstone Lake, Yellowstone Natl Park (44° 17′ 30″ N, 110° 15′ 30″ W). Coll 1966 and subm by R G Baker, Center for Climatic Research, Univ Wisconsin, Madison.

General Comment (RGB): samples date climatic fluctuation during postglacial period (Baker, 1969).

W-2280. **2470 ± 250**

Peat, depth 240 to 260cm. *Comment* (RGB): sample was 30cm above a small rise in spruce pollen that suggests cooling trend, and sharp rise in sedge pollen and *Carex* seeds that marks change from small pond to fen conditions.

W-2281. **5390 ± 250**

Peaty mud, depth 442 to 460cm. *Comment* (RGB): date marks onset of slightly cooler conditions following Altithermal.

W-2284. **9240 ± 300**

Organic silt, depth 500 to 541cm. *Comment* (RGB): dates beginning of apparent hiatus during Altithermal time at this site.

W-2285. **11,550 ± 350**

Organic silt, depth 700 to 724cm. *Comment* (RGB): sample was 60cm above boundary separating lower tundra and parkland vegetation zone from upper zone of forest vegetation.

W-2286. Lilypad Pond, Wyoming **5590 ± 250**

Peat in core, depth 276 to 301cm, from N edge of pond ca 12m above Yellowstone Lake, ca 1.6km W of Trail Creek Cabin, SE arm of Yellowstone Lake, Yellowstone Natl Park (44° 17′ 30″ N, 110° 15′ W). Coll 1967 and subm by R G Baker. *Comment* (RGB): peat formation at

fen margin probably began in response to wetter conditions after Altithermal. Date, 5390 ± 250, W-2281, this list, from 4.6m lagoon supports suggestion.

C. Alaska

Bootlegger Cove Clay series, Anchorage, Alaska

Samples dating Bootlegger Cove Clay (BCC), overlying Elmendorf moraine (EM) and underlying brown sand, Knik Arm, Anchorage. Coll and subm 1969 by H R Schmoll and Ernest Dobrovolny.

General Comment (HRS & ED): series indicates that BCC was deposited ca 14,000 yr ago. BCC seems to represent a marine transgression following maximum development of Wisconsin glaciation, rather than interstadial event of middle Wisconsin age or an older glacial or interglacial event (see Schmoll *et al,* 1972).

W-2369. **14,900 ± 350**

Mollusk shells from BCC in sea bluff on S shore of Knik Arm, ca 1.7km ESE of Pt Woronzof (61° 11′ 58″ N, 149° 59′ 00″ W).

W-2367. **14,300 ± 350**

Mollusk shells from BCC in sea bluff on N shore of Knik Arm, ca 1km NE of Pt MacKenzie (61° 14′ 45″ N, 149° 58′ 17″ W).

W-2389. **13,750 ± 500**

Mollusk shells from BCC in sea bluff on NW shore of Knik Arm, 4.5km NE of Pt MacKenzie (61° 15′ 52″ N, 149° 55′ 18″ W).

General Comment (HRS & ED): BCC dates confirm correlation of shell zone within BCC exposed on both sides of Knik Arm and indicate that deposition took place over ca 1000 yr. Dates are also maximum for EM, which overlies this zone ca 3.2km to NE.

W-2375. **11,690 ± 300**

Wood beneath colluvium overlying EM, stratigraphically overlying BCC, NW shore of Knik Arm, ca 4.35km NE of Pt MacKenzie (61° 15′ 51″ N, 149° 55′ 27″ W). *Comment* (HRS & ED): date is minimum for EM and confirms approx correlation with adjacent Anchorage outwash deposits.

W-2366. **>40,000**

Organic fragments within 5cm zone in brown sand unit in sea bluff along N shore of Knik Arm, ca 18.8m NE of Pt MacKenzie (61° 23′ 32″ N, 149° 50′ 21″ W). *Comment* (HRS & ED): date confirms interpretation of Karlstrom (1964) that the part of this sec exposed beneath modern beach stratigraphically underlies main BCC exposure in bluff behind modern beach. However, clay/silt with scattered shells overlying this sample, does not correlate with main body of BCC.

Gastineau Channel series, near Juneau, Alaska

This series is part of a geol study of the Gastineau Channel formation, a sequence of heterogeneous glaciomarine deposits of late Pleistocene and early Holocene age, consisting of pebbles and larger clasts dispersed through a fine-grained matrix of silt and sand (Miller, 1973).

W-2396. **11,920 ± 1000**

Mollusks from stony diamicton overlying bedrock 122m above MSL, along S slope of Salmon Creek, ca 1.5m above RR track and trail to Salmon Creek Reservoir in floor of gully crossed by trestle (58° 20′ 00″ N, 134° 26′ 53″ W). Coll 1969 by Ernest Dobrovolny and H R Schmoll; subm by R D Miller. *Comment* (RDM): slightly younger than expected. Samples from interlayered diamicton-deltaic gravel at only 46m or less above MSL showed ages in 12,800 yr range (W-1830, -1831: R, 1969, v 11, p 222-223).

W-2721. **>39,000**

Peat from stony diamicton, at 114m above MSL in steep bluff on NE side of Montana Creek (58° 25′ 55″ N, 134° 37′ 52″ W). Coll 1971 by R D Miller and Christopher Kenah; subm by R D Miller. *Comment* (RDM): predates marine transgression that deposited Gastineau Channel formation.

W-2719. **2080 ± 250**

Peat from base of 0.6m peat sec overlying till, from excavation site for dam, SE shore of Cropley Lake, Douglas I. (58° 16′ 00″ N, 134° 31′ 24″ W). Coll 1971 by R D Miller and Christopher Kenah; subm by R D Miller. *Comment* (RDM): date is younger than expected. Overlying till is thought to be early Fraser age or older and is believed to predate glaciomarine deposits at lower alts dated at maximum age of 12,000 in this area, but may be contemporaneous.

W-2720. **<200**

Wood from log in alluvium, SE embankment of Gold Creek adjacent to E margin of Evergreen Bowl (58° 18′ 22″ N, 134° 24′ 41″ W), Juneau. Coll 1971 by R D Miller and Christopher Kenah; subm by R D Miller. *Comment* (RDM): sample may date a large rock avalanche that fell from slopes of Mt Juneau.

W-2380. **2740 ± 200**

Peat overlying beach gravel in W wall of gravel pit 34m above MSL, Douglas I, near Eagle Creek (58° 18′ 37″ N, 134° 27′ 22″ W). Coll 1968 and subm by R D Miller. *Comment* (RDM): significance of age uncertain. Peat samples along Douglas I. on emerged beach surface resulted in older age at lower alt, 5730 ± 350 at 23m alt. (W-1949, R, 1970, v 12, p 328). Thus, date seems too young, probably formed after rebound under fresh-water conditions.

W-2394. **10,760 ± 500**

Mollusks from stony diamicton, in floor of gravel pit at 24m above MSL, underlying deltaic gravel, same location as W-2380. Coll 1969 by Ernest Dobrovolny and H R Scholl; subm by R D Miller. *Comment* (RDM): date supports idea that deltas formed at slightly different rates during rather rapid rebound after removal of glacial ice in area.

W-2395. **9150 ± 800**

Mollusks from stony diamicton overlying deltaic gravel, in wall of gravel pit at 32m above MSL. Coll 1969 by Ernest Dobrovolny and H R Schmoll; subm by R D Miller. *Comment* (RDM): dates accumulation of diamicton over deltaic gravels, perhaps owing to slowing of isostatic rebound allowing eustatic rise to equal and overtake it.

W-2392. **9800 ± 300**

Mollusks from gravelly diamicton, 21m above MLLW, E side of Cove Creek, Douglas I. (58° 19′ 22″ N, 134° 36′ 52″ W). Coll 1969 by Ernest Dobrovolny and H R Schmoll; subm by R D Miller. *Comment* (RDM): age is in correct range for late glaciomarine deposition in Juneau area. Represents late phase nearshore shallow-water deposit near mouth of stream carrying coarse debris into ice-free marine environment.

W-2258. **8280 ± 350**

Basal peat at 32m above MSL, overlying beach gravel that in turn overlies shelly diamicton, from SW shore of Auke Lake, near Auke Bay, NW of Juneau (58° 23′ 07″ N, 134° 37′ 54″ W). Coll and subm 1968 by R D Miller. *Comment* (RDM): dates interval between marine deposition and peat formation.

W-2263. **10,630 ± 500**

Mollusks from sandy diamicton, 30m above MSL, overlain by beach gravel, same location as W-2258. Coll and subm 1968 by R D Miller. *Comment* (RDM): age seems to fit near-sea-level diamicton, 10,640 ± 300 (W-1827, R, 1969, v 11, p 222), sampled nearby. Stones in deposit along with complete and articulated shells indicate ice-free conditions but rafting.

W-2393. **9700 ± 800**

Mollusks from sandy diamicton, underlying deltaic deposit on N side of Kowee Creek, N of Douglas Island Bridge between Douglas I. and Juneau (58° 17′ 55″ N, 134° 26′ 03″ W). Coll 1969 by Ernest Dobrovolny and H R Schmoll; subm by R D Miller. *Comment* (RDM): age is younger than anticipated but supports idea that deltas formed at slightly different rates during rather rapid rebound after removal of glacial ice in area.

W-2260. **9070 ± 350**

Wood from black humic zone in embankment on NW side of Lemon Creek near jail site, Juneau area (58° 21′ 46″ N, 134° 28′ 54″ W). Humic

zone overlies diamicton and underlying deltaic sand and gravel. Coll and subm 1968 by R D Miller. *Comment* (RDM): wood probably tidal drift, suggesting date for change in depositional environment.

W-2384. **7150 ± 300**

Peat and woody stems 14m above MLLW, along Glacier Hwy embankment, N side of rd, Juneau area (58° 21′ 37″ N, 134° 32′ 5″ W). *Comment* (RDM): date is one of oldest from basal peat near modern sea level, and indicates near-sea-level stabilization of land after retreat of late Wisconsin ice sheet in Juneau area.

Mendenhall Glacier series, Alaska

Wood from deposits of Mendenhall Glacier near Juneau. Coll 1968 and subm by R D Miller.

General Comment (RDM): age suggests ice advance started near beginning of climatic change, signaling Neoglacial advance.

W-2377. **2780 ± 200**

Wood from loose glacial debris below active ice front of grounded part of Mendenhall Glacier (58° 26′ 13″ N, 134° 33′ 44″ W), Juneau area. *Comment* (RDM): age suggests wood material was overridden and carried to deposition site from growth site.

W-2379. **2800 ± 200**

Wood from lateral moraine on W side of Mendenhall Lake and below Mendenhall Glacier Trail (58° 26′ 06″ N, 134° 33′ 47″ W), Juneau area.

W-2250. Amchitka Island **>38,000**

Carbonized tree trunk (*Gymnosperm*) from tilted sedimentary rock ca 1.8m above present beach level, South Bight, Amchitka I. of Rat Is. rocks (51° 26′ N, 179° 15′ E), Aleutian Is. Coll 1966 by H T Shacklette and R H Morris; subm by H T Shacklette. *Comment* (HTS): tree trunk is in beach deposit of drift wood and indicates sea level.

D. Miscellaneous

Lake Windermere series, England

Organic silt and clay core samples from S basin of Lake Windermere (54° 36′ N, 03° 10′ W). Coll and subm 1969 by F J H Mackereth, Freshwater Biol Assoc, United Kingdom. Lake sediments provide a record of oscillations in geomagnetic declination (Mackereth, 1971). Cores were dated to determine frequency of oscillations. Samples taken at maximum excursion of declination swings.

W-2313. Organic silt, depth 22 to 32cm **800 ± 250**

W-2269. Organic silt, depth 26 to 38cm **1140 ± 250**

W-2274. Organic silt, depth 70 to 80cm **1370 ± 250**

W-2270.	**Organic silt, depth 105 to 115cm**	**2430 ± 250**
W-2273.	**Organic silt, depth 143 to 153cm**	**3430 ± 250**
W-2268.	**Organic silt, depth 183 to 193cm**	**4530 ± 250**
W-2272.	**Organic silt, depth 215 to 225cm**	**6150 ± 250**
W-2267.	**Organic silt, depth 243 to 253cm**	**7370 ± 250**
W-2275.	**Organic clay, depth 288 to 298cm**	**10,130 ± 350**
W-2276.	**Organic clay, depth 360 to 380cm**	**13,400 ± 400**

General Comment: 1st 2 samples are not zero age because of addition of dead carbon to top layer from industrial pollution. Bottom 2 are from clay. If uncorrected ages are used in computation, average period for full wave swing is 2230 yr. Depending what tree ring correction is used, the full wave period may be as much as 2700 yr.

East China Sea series

Eustatic sea-level changes are studied using a series of brackish-water and shallow-water marine mollusks coll from dredgings on shelf in East China Sea. Area is at approx same lat as Atlantic coast of United States and was not subject to heavy glaciation during Pleistocene (Emery *et al,* 1971). Coll 1967-1968 by Hiroshi Niino; subm by K O Emery, Woods Hole Oceanog Inst, Woods Hole, Massachusetts.

W-2214. **Sta 5, *Mytilus corscum*, depth 125m** **11,050 ± 600**
(35° 29′ N, 131° 18′ E)

W-2215. **Sta 6, *Mytilus corscum*, 118m** **10,520 ± 600**
(35° 27′ N, 131° 18′ E)

W-2340. **Sta 7, *Astarte*, 194m** **>33,000**
(35° 27′ 30″ N, 130° 35′ 35″ E)

W-2342. **Sta 7, *Macoma calcarea*, 194m** **>40,000**
(35° 27′ 30″ N, 130° 35′ 35″ E)

W-2343. **Sta 13, *Macoma calcarea*, 219m** **15,740 ± 400**
(34° 40′ 00″ N, 129° 16′ 15″ E)

W-2338. **Sta 15, *Mercenaria stimpsoni*, 120m** **9880 ± 350**
(34° 15′ 15″ N, 129° 07′ 30″ E)

W-2217. **Sta 23, *Mactra chinensis*, 64m** **10,000 ± 600**
(31° 00′ N, 125° 31′ E)

W-2216. **Sta 23, *Corbicula japonica*, 64m** **27,000 ± 1000**
(31° 00′ N, 125° 31′ E)

W-2036. Sta 24, *Ostrea gigas*, 112m **15,200 ± 850**
(29° 30′ N, 126° 15′ E)

W-2220. Sta 28, *Mactra chinensis*, 62m **3000 ± 500**
(28° 29′ N, 125° 13′ E)

W-2254. Sta 28, *Anadara subcrenata*, 62m **13,260 ± 600**
(28° 29′ N, 125° 13′ E)

W-2219. Sta 28, *Corbicula japonica*, 62m **>30,000**
(28° 29′ N, 125° 13′ E)

W-2337. Sta 30, *Ostrea gigas*, 140m **12,200 ± 400**
(26° 30′ N, 123° 00′ E)

W-2341. Sta 30, *Mactra chinensis*, *Pecten albicans*, 140m **23,260 ± 600**
(26° 30′ 00″ N, 123° 00′ 00″ E)

W-2360. Sta 32, *Arca inflata*, 190m **>26,000**
(25° 44′ N, 123° 18′ E)

General Comment (KOE): samples coll from depths greater than ca 140m, maximum extent of sea-level lowering, are old, as expected. Shells of different species in samples from sta 23, 28, and 30, gave significantly different dates. Older shells may be relicts of previous regressive stage of sea. Nevertheless, most of the dates favor a minimum sea level ca 15,000 yr ago.

Atlantic Continental Shelf series

Shells (*Crassostrea virginica* [Gmelin]) from Atlantic Continental Shelf of United States. Coll 1968 by R L Wrigley, Bureau Comm Fisheries, Biol Lab, Woods Hole, Massachusetts; subm by K O Emery, WHOI.

General Comment (KOE): species live only in slightly brackish water, 0 to 3m depth, and thus date past sea level (Emery & Milliman, 1970).

W-2237. Sta 182, 67m **9600 ± 600**
Georges Bank (40° 51.5′ N, 67° 41.5′ W), Atlantic Ocean.

W-2241. Sta 308, 42m **9000 ± 600**
Near Hudson Canyon (39° 51′ N, 73° 15.7′ W), Atlantic Ocean.

W-2262. Sta 231, 69m **11,340 ± 600**
Hudson Canyon region (39° 55′ N, 72° 28′ W), Atlantic Ocean.

Lake Kivu series, Africa

Lake Kivu (01° 45′ S, 29° 06′ E) is smallest, ca 2400km^2, highest, ca 1500m, and one of deepest, ca 500m, of rift lakes in E-central Africa. Its deep water contains ca 50km^3 of methane (STP). Two mixtures of carbon dioxide and methane from deep water were dated to determine

source of methane. Coll and subm 1972 by W G Deuser, WHOI. *Comment* (WGD): decomposing plankton and other organic matter cannot be a main source of methane. Most of the methane was formed by bacteria utilizing carbon dioxide and hydrogen of volcanic origin (Deuser *et al,* 1973).

W-2742. **22,000 ± 4000**

Methane (40%) and CO_2 (60%) from depth 415m.

$\delta^{13}C = -19.3‰$

W-2743. **20,500 ± 2000**

Methane (35%) and CO_2 (65%) from depth 395m.

$\delta^{13}C = -16.5‰$

W-2239. Chaim mine, Saudi Arabia **950 ± 300**

Charcoal from stope in an ancient gold mine, Ishmas area, S Hijas Prov, ca 70km E of Rhyanah (20° 55′ N, 43° 44′ E). Coll and subm by T H Kiilsgaard. *Comment* (THK): date agrees well with previous estimates of age of mine.

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