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NOTICE TO READERS AND CONTRIBUTORS

Since its inception, the basic purpose of Radiocarbon has been the publication of compilations of $^{14}$C dates produced by various laboratories. These lists are extremely useful for the dissemination of basic $^{14}$C information.

In recent years, Radiocarbon has also been publishing technical and interpretative articles on all aspects of $^{14}$C, especially in the Proceedings issues. The editors and readers agree that this expansion is broadening the scope of the Journal.

Another section is added to our regular issues, "Notes and Comments". Authors are invited to extend discussions or raise pertinent questions to the results of scientific investigations that have appeared on our pages. The section includes short, technical notes to relay information concerning innovative sample preparation procedures. Laboratories may also seek assistance in technical aspects of radiocarbon dating. Book reviews will also be included for special editions.

Manuscripts of radiocarbon papers should follow the recommendations in Suggestions to Authors.* All copy (including the bibliography) must be typewritten in double space. Our deadline schedule is:

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General or technical articles should follow the recommendations above and the editorial style of the American Journal of Science or the Proceedings of the Eleventh International Radiocarbon Conference. Date lists should follow the format shown in the most recent issue of RADIOCARBON. More detailed instructions are available upon request. Separate mailings have been discontinued.

Half life of $^{14}$C. In accordance with the decision of the Fifth Radiocarbon Dating Conference, Cambridge, 1962, all dates published in this volume (as in previous volumes) are based on the Libby value, $5570 \pm 30$ yr, for the half life. This decision was reaffirmed at the 11th International Radiocarbon Conference in Seattle, Washington, 1982. Because of various uncertainties, when $^{14}$C measurements are expressed as dates in years BP the accuracy of the dates is limited, and refinements that take some but not all uncertainties into account may be misleading. The mean of three recent determinations of the half life, $5730 \pm 40$ yr, (Nature, v 195, no. 4845, p 984, 1962), is regarded as the best value presently available. Published dates in years BP, can be converted to this basis by multiplying them by 1.03.

AD/BC Dates. In accordance with the decision of the Ninth International Radiocarbon Conference, Los Angeles and San Diego, 1976, the designation of AD/BC, obtained by subtracting AD 1950 from conventional BP determinations is discontinued in Radiocarbon. Authors or submitters may include calendar estimates as a comment, and report these estimates as AD/BC, citing the specific calibration curve used to obtain the estimate.

Meaning of $\delta^{13}$C. In Volume 3, 1961, we endorsed the notation $\Delta$ (Lamont VIII, 1961) for geochemical measurements of $^{14}$C activity, corrected for isotopic fractionation in samples and in the NBS oxalic-acid standard. The value of $\delta^{13}$C that entered the calculation of $\Delta$ was defined by reference to Lamont VI, 1959, and was corrected for age. This fact has been lost sight of, by editors as well as by authors, and recent papers have used $\delta^{13}$C as the observed deviation from the standard. At the New Zealand Radiocarbon Dating Conference it was recommended to use $\delta^{13}$C only for age-corrected samples. Without an age correction, the value should then be reported as percent of modern relative to 0.95 NBS oxalic acid (Proceedings 8th Conference on Radiocarbon Dating, Wellington, New Zealand, 1972). The Ninth International Radiocarbon Conference, Los Angeles and San Diego, 1976, recommended that the reference standard, 0.95 times NBS oxalic acid activity, be normalized to $\delta^{13}$C = $-19\%$.

In several fields, however, age corrections are not possible. $\delta^{13}$C and $\Delta$, uncorrected for age, have been used extensively in oceanography, and are an integral part of models and theories. For the present, therefore, we continue the editorial policy of using $\Delta$ notations for samples not corrected for age.

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ZERO BP PLUS 34: 25 YEARS OF RADIOCARBON

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Very incautiously, after printing 25 volumes of Radiocarbon, the editors have authorized some personal reminiscence. Like all “Quaternary scientists”—no better collective name is available for our strange profession—I have been engaged in historiography, writing about history, for many years. In 1946, when natural radiocarbon was discovered, my subject, the sedimentary history of lakes, was only one of several kinds of historical record that needed, and soon received, a new reading. At the time, not all custodians of other kinds of record were ready to agree that new readings were conceivable, let alone necessary. The record of their persuasion—some of which has been written by Greg Marlowe (1980) in “W F Libby and the Archaeologists”—is part of the history of historiography. To the bibliography of this dangerously abstract subject I venture to add some minor footnotes. They come, not from historical research like Marlowe’s, but from a leaky, selective memory.

Radiocarbon was founded 25 years ago, as the Radiocarbon Supplement of the American Journal of Science. The editors of the parent journal, founded in 1818 by Benjamin Silliman, are also its publishers. I take this opportunity to scotch the rumor that AJS was a house organ of the Yale Department of Geology. The fact is that several members of other Yale departments, including Biology (then Zoology) and Chemistry, were also members of the board. As an independent proprietary journal, beholden to no professional organization or firm, AJS had the authority to publish anything in earth science that it could afford. Once launched, the Supplement was aided in becoming a separate journal by a grant, GN 396, from the National Science Foundation, under a publications-assistance program that was dissolved shortly thereafter. When the AJS board received our proposal, which had been prompted by encouraging memos from Hilde Levi, chairman of an international association of working laboratories, it acted with vision, and with sufficient dispatch to forestall a competing proposal from another journal. It is not fair to say that the board had no choice, for the founding editors—Richard Foster Flint, G Evelyn Hutchinson, and I—could easily have been outvoted. My recollection that Flint saw to it that we were not is not wholly wrong, but the record shows that Hutchinson chaired the crucial meeting on November 21, 1957.

So much for the facts; readers of Radiocarbon will surely be more interested in the background. The background of $^{14}$C measurements con-
sists mainly of cosmic radiation, and is sternly suppressed by anti-coincidence devices under several inches of lead. Having now, contrary to my instincts and training, to de-suppress it, I am conscious that my training was uninfluenced by radiation of any sort. In fact, my shallow experience with analytical chemistry was slender preparation for the turn in my career that began in the zero year, an 1950. Before attempting to grapple with Willard Libby’s discovery and its early sequelae, I should mention some later events, less physical than political, in the background of Radiocarbon.

Although Libby’s discovery was announced in Physical Review (Libby, 1946), nearly all the early papers, from Chicago and from all other laboratories, were published in Science. The procession began with the confirmation of Grosse’s 1934 prediction (Grosse & Libby, 1947) and included the first measurements from Chicago and numerous others (Libby, Anderson, & Arnold, 1949; Arnold & Libby, 1949, 1951; Kulp, Feely, & Tryon, 1951; Blau, Deevey, & Gross, 1954; Suess, 1954). Chicago V (Libby, 1954), the last date list from Chicago, was published as a dozen or more laboratories were tooling up. By 1957, as their output proliferated beyond his endurance, the editor of Science, Graham DuShane, foresaw a takeover. His letter accepting Yale III complained, with some justice, that Science was not an “archive” for any branch of science.

In responding to DuShane’s challenge, though, Flint, Hutchinson, and I were less concerned with creating an archive than with insuring editorial control over original publication of measurements. By 1957 many dates, including some that were certainly wrong, were being widely quoted by journalists and others. Not only did the numbers lack precision or attribution, many contained “corrections,” often expressing nothing but historians’ misunderstanding of that unfamiliar, insulting, and badly named concept, “standard error.” Besides, by 1957, new estimates of the half-life of $^{14}$C threatened utter chaos in the literature. Flint’s tidy mind rebelled at the prospect that every published repetition of a measurement would inflate its age by three per cent per citation. Value is sometimes created by that route in economics; suppose the next editor of Science were to be an economist?

The cosmic background of Libby’s discovery, then, was forecast by A V Grosse in 1934, the year in which Harold Urey won his Nobel prize. Carbon-$^{14}$ was identified by Ruben and Kamen in 1940. Libby’s great contribution, appropriately shared with Grosse in 1947, was to detect and measure the isotope “in nature” — an elastic concept stretched to embrace sewer gas from the city of Baltimore. This curious choice was dictated by the fact that methane, a gas, could be isotopically enriched by thermal diffusion, a technique with which graduates of the Manhattan District had some experience. Just when Libby hit on the notion of “modern wood,” and selected some 20 pieces big enough (and therefore old enough) to mask the Suess (industrial carbon) effect, I do not know. When I

1 Libby’s legendary luck, which brought the Nobel award in 1960, was only incidentally displayed by the choice of modern tree-rings that were formed before much fossil carbon had been added to the atmosphere. The modern-wood assay, later revised
visited Chicago's Institute for Nuclear Studies in 1949, Ernest Anderson's thesis had been defended and Anderson was chasing neutrinos; James Arnold was talking about meteorites; my pollen-dated peat samples from Connecticut and elsewhere were being processed; and the three-story diffusion column stood idle in a stairwell.

Yale's Geochronometric Laboratory was established in 1951, with the aid of a grant from The Rockefeller Foundation. The background I know about began there, at 77 Prospect Street, in the basement of a disused fraternity house where some mysterious emanations were first attributed (by Hans Suess) to residual Potassium-40 on the bar-room floor. Several coats of strippable paint failed to abolish this prototypic Suess effect. By 1954, when atmospheric weapons-testing was declassified, we knew that we had been measuring Carbon-14 all along. Unfortunately the accuracy depended on the time of exposure of the Libby slurry (solid carbon in water with 0.5% of egg albumen) to the enriched New Haven atmosphere. Abandoning solid carbon and screen-wall counters to history's scrap-heap, we converted first to acetylene (holding it long enough to be scooped by several laboratories on the total synthesis of benzene from the sample gas) and then to gaseous carbon dioxide. This de Vriesian substance we imported from Groningen, along with G W Barendsen, who replaced Monte Blau as our premier geochronometer. Barendsen's novel, and prophetic, contribution was to prove the feasibility of scintillation-counting of $^{14}$C. But liquid carbon dioxide was a weak source of beta-rays, even under 15 atmospheres' pressure, and Minze Stuiver returned the lab to de Vries' original procedure. Soon thereafter—we are now up to 1963 in this condensed review—the re-named Radiocarbon Laboratory moved to the Kline Geology Laboratory ("Flint's Fort"), with Stuiver as Senior Research Associate and Director.

Going back to 1951, the Rockefeller Foundation grant that made all this possible was not negotiated by a non-tenured assistant professor of biology. Yale owes it to the prescience of two remarkable administrators.

upward for counting efficiencies, was 12.5 dpm per gram (Libby, Anderson, & Arnold, 1949). Three sea-shell measurements, best interpreted as "probably contaminated," gave values ranging from 6.4 to 19.2% above the terrestrial assay. Libby ignored all three, choosing for the marine biosphere the theoretical value of 1.05 times modern wood, obtained by doubling the $^{14}$C difference between wood and shell. Agreement of the specific activity of the biosphere with that calculated from the cosmic-ray neutron flux was therefore due, as Libby suggested (1952, p 29), "in some part to cancellation of errors." Projecting the modern-wood assay backward in time, and using a half-life, $5720 \pm 47$ years, which was not accepted until several years later, Arnold and Libby (1949) successfully dated several wood samples from ancient Egypt. Had they used the shorter, 5568-year half-life, Sneferu's tomb (C-12; Chicago 1) would have appeared "too young" by 240 years—unless the sample count was referred to a higher modern assay, as it was in Chicago 1, where it is 227 years "too old." But among the errors that kept the results "within statistics" (give or take half a millennium) was a bigger one, the third-millennium BC enrichment of the biosphere's radiocarbon by 3 to 9%. From his tomb, the Pharaoh evidently conspired with Libby to select the smaller figure, thereby predicting both his true age and (within ten years of 5730) the correct half-life of $^{14}$C.

Editor's Note: Evidently radon—this is a decay product in the uranium series and cannot be from $^{6}$K. MS.

The ingredient reminds one of Libby's assurance, given orally to Hutchinson, that the new technology was "about as difficult as an appendectomy, or baking a really good cake."
A Whitney Griswold is the only university president, as W C DeVane is the only college dean, for whom an assistant professor—this one at any rate—could ever substitute unreserved admiration for native, faculty-type skepticism. Once established, though, if the Laboratory were not to be a new department or research institute—units for which that dean and that president had reciprocal, well-grounded distaste—its policies and operations needed the guidance of a faculty committee. Libby’s dating project had been guided by a joint committee of the American Anthropological Association and the Geological Society of America (Johnson, 1951). Yale’s counterpart was an interdepartmental Advisory Board, which began to hold monthly meetings in 1951.

On this Board Flint, the chairman, represented Geology and the GSA committee; Hutchinson, vice chairman, was officially in Zoology. Other members of the Board, to which I as Director was responsible, were Wendell Bennett (Anthropology), George Kubler (History of Art), C G Montgomery (Physics), and Henry Thomas (Chemistry). On their deaths, at shatteringly early ages, Bennett was replaced by Irving Rouse and Montgomery’s place was taken by Henry Kraybill. When organized for educational purposes, such diversified faculty groups are commonplace, but ours was a research project. Rarely, I think, has so complex a project been conducted by a committee with so much collegiality and profound, if irreverent, scholarship.

What this research was about was clear to the Board, but difficult to describe to others. Only incidentally, in its early years, was it concerned with dating samples of interest to geology, archaeology, or (preferably) both, such as were left by the Upper Paleolithic cultures of the late Pleistocene. Before dating could be routine, we faced a clutch of “methodological problems,” nearly all of which turned out to be facets of the same problem, the specific radioactivity of “modern” carbon. In a word, the problem was biogeochemical, but “bio-”, “geo-”, and “-chemical” stood for separate cultural traditions, not yet known to be united by historiography. Sometimes, as in the case of lake marl surrounding certain Magdalenian artifacts near Hamburg, the problem was exposed by discordant dates based on different materials. Just as often, it was exposed by pure ratiocination, otherwise known as “borrowing trouble”—the kind of trouble that arises when the errors fail to cancel.

The chief ratiocinator in all this was Hutchinson, whose knowledge of the biosphere’s chemical history was unrivaled. I pause here to note that from here (1951) onward I am writing of a large and increasingly visible corps of Quaternary scientists, for whom Radiocarbon became a journal of record in 1959. Most of the practicing biogeochemists among them came together at three international conferences, at Copenhagen in 1954, at Andover in 1955, and at Cambridge in 1957. Before 1950, however, there was a smaller group, a true “invisible college,” about which I know nothing at first hand. Described as a “floating seminar on cosmochemistry,” it seems to have met whenever and wherever Hutchinson and Urey happened to attend the same scientific meeting. Among its other
American members were William Rubey and Lloyd Berkner. From conversations with Hilde Levi, I know that her professor, Niels Bohr—a biologist before he turned to physics—was at least an occasional participant. From a meeting of this group, probably at the National Academy of Sciences in 1946 or 1947, Hutchinson brought word of what promised to be, and was, the most productive discovery of modern times. But again, I can’t say when Libby became a member. Much later, in 1957, he told me that his own invisible college was founded at Berkeley by G N Lewis.

So our problems came to focus on the modern assay, of carbonates in particular. For sea-shells, we could confirm neither Libby’s theoretical value, 1.05 times modern wood, nor the higher values that probably contained some stray radiation from the Institute for Nuclear Studies. Either the surface ocean was made of upwelled, 400-year-old sea water, or fossil fuels had been added to the ocean since the Neolithic. Kubler and Rouse assured us that very few coal-fired pottery kilns existed outside the Pueblo archaeological area. But if most of the world’s industrial carbon has suffered a sea-change, why is there still so much of it in today’s atmosphere? And if that increment is not all industrial, as Hutchinson had been arguing, contra Conway, for several years, how much of it could be “truly modern,” perhaps evaded to the air from a warmer ocean? Could it be derived from decreased agricultural production, or from the oxidation of humus in soil?

Suess, awaiting the construction of his new laboratory by the U S Geological Survey, was a vigorous participant in these discussions. Returning to the laboratory after one luncheon meeting of the Board, he and Blau shaved some of the last ten years’ growth from our reference standard, a piece of black oak hewn from Flint’s woodlot by a willing graduate student. Splitting the green wood with some difficulty, they prepared another sample from the center, laid down about 1900. Unfortunately, after reduction to solid carbon, both samples picked up some of the mysterious emanations from Eniwetok, and the experiment had to be repeated when Suess reached Washington (Suess, 1955). As 1950 wood contained 2% less radiocarbon than 1890 wood, industrial carbon is indeed present, in amounts that oceanographers and others find worrisome (Broecker, Peng, & Engh, 1980). Meanwhile, the Board took notice of another quirk of the modern assay, reflecting the predilection of freshwater algae and pondweeds for carbon redissolved, as bicarbonate, from ancient limestone (Deevey et al, 1954). A little later, when Stuiver came from Groningen, bringing a model that implicated sunspots as the source of de Vries’ puzzling fluctuations of $^{14}$C in older tree-rings, we were ready to believe that physics and chemistry were at last one subject, that biology had captured both, and that geology and history were different names for the field of their interaction.

From Lascaux to the pharoahs and Teotihuacan; from the Glacier Peak eruption to Ilopango and Tambora; from tundra to rain forest, from ground sloths to goats; from neutrons to sunspots, precessions, and magnetic reversals; has any branch of historical science, any sector of
the atmosphere–hydrosphere–lithosphere–biosphere–cryosphere system remained untouched by some application of Libby's momentous discovery? In 1984, the 34th year since "BP" came to mean "Bill's Practice," it seems unlikely. But when comparable new discoveries are made, we can expect to find an abstract in a future issue of *Radiocarbon*.

**References**


**BOMB \(^{14}C\) IN THE OCEAN SURFACE 1966-1981**

REIDAR NYDAL, STEINAR GULLIKSEN, KNUT LÖVSETH, and FRED H SKOGSETH

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**ABSTRACT.** Bomb \(^{14}C\) has been used as a tracer for \(CO_2\) in ocean surface water to study \(CO_2\) exchange between atmosphere and ocean. Using ordinary cargo ships for sampling, we have been able to cover some parts of the Atlantic, Pacific, and Indian Oceans for certain periods. A total number of 520 samples from 89 locations were measured during the last 15 years. The data are presented both in tables and graphs. A maximum \(^{14}C\) concentration \((\Delta^{14}C)\) of ca 20\% was observed in temperate northern latitudes, and a few per cent lower at southern latitudes. A seasonal trend in the \(^{14}C\) variation, with summer maximum and winter minimum, was observed both in downwelling and upwelling areas.

**INTRODUCTION**

The development of \(^{14}C\) in the atmosphere after nuclear testing is governed by the exchange of \(CO_2\) with the land biosphere and the ocean. The latter is regarded of major importance in the present exchange. One main purpose of tracing bomb \(^{14}C\) is also to study the exchange of \(CO_2\) between atmosphere and ocean. We realized that the exchange within the ocean was very complicated, and that cooperation among several laboratories would be necessary for many years. At this laboratory we decided only to sample the ocean surface, as this could be done quite easily from cargo ships on regular routes. The main idea was to observe the mean \(^{14}C\) variation with time in the ocean surface, with a sampling program which gradually was extended to greater parts of the Atlantic, Pacific, and lastly, the Indian Oceans.

Complete tables and graphs of all our atmospheric \(^{14}C\) data were previously presented (Nydal & Lövseth, 1983). The present paper is an attempt to make a similar presentation of all the oceanic \(^{14}C\) data, which derive from 520 surface-water samples during the last 15 years. All data are regarded as final as they have been critically analyzed, recalculated, and in some cases, supplied with minor corrections. The paper is, only to a small extent, concerned with results from other laboratories.

**SAMPLING AND LOCATION**

In reviewing all the ocean data, we found it necessary to mark the widely scattered sampling with stations generally located within one or two degrees. Some earlier station symbols had to be replaced (Nydal, Lövseth, & Skogseth, 1980) with new station numbers (fig 1). The number of samples collected at each station may vary greatly, from 1 to >50. Also, the time interval between each sample may differ from one place to another, dependent on how often the ships passed the respective locations.

The Atlantic Ocean is covered with 28 stations (01 to 28) from the Barents Sea (74°N) to the south Atlantic Ocean (35°S). Sampling with cargo ships was done at two different periods, from 1966 to 1972, and from 1976 on. Several stations (17, 20, 28) were probably established too close to the continents where water upwelling occurs. The same effect may also
have occurred at stations 10, 11, and 16 on the Atlantic Ridge, and in the divergence area of the equatorial zone (0°-15°N/S). However, comparison of the results from these stations with those in the open ocean with a strong thermocline, is very useful. The most representative stations in the latter case are 15 and 16 in the Sargasso Sea and station 25 in the Southeastern Atlantic Basin.

The Indian Ocean is covered with 14 stations (31 to 45) from 1976 to the present. It was originally started with 5 regular stations (Nydal, Løvseth, and Skogseth, 1980), but change in the course of the shipping routes caused a scattering of sampling among several locations. In contrast to the Atlantic Ocean, all stations in the Indian Ocean were situated on the deep basins with depths of >3000m.

The Pacific Ocean was covered with 39 stations (51 to 88) from 1966 to 1977. The majority of stations in both hemispheres were located within the gyral circulation system between 15° and 35° latitudinal degrees with a fairly stable surface layer. Aside from the stations along the coast of North America (52, 54, and 73) and New Zealand (87 and 88) most are far from the continents where the ocean is >3000m deep. We were only able to obtain a continuous series of samples at a few locations in a 6- to 8-year period. The interval between each sample was generally 3 to 4 months.

**TREATMENT OF SAMPLES**

The treatment of samples changed with time. From 1966 to 1976, the collected samples were stored in 200L steel drums aboard the ships during the journeys. The air was removed from the drums before filling. Further processing was performed in the laboratory 2 to 4 months later. On reaching the laboratory, the drum was opened and 1L of sea water was put aside for salinity measurement. After the contents of the drum were acidified (pH <3) with 1L of concentrated sulfuric acid, the CO₂ was flushed out with nitrogen at room temperature and absorbed in an ammonia trap. A 1- to 2-day flushing followed. After further precipitation with CaCl₂, filtration of CaCO₃, and, finally, treatment with HCl, a maximum CO₂ amount of 5 to 6L was obtained.

Towards 1975 the sampling program in the Atlantic and Pacific Oceans was gradually decreased, partly due to a shipping crisis, and partly because of the inconvenient transportation of heavy drums to the laboratory. Also, there were some objections to storing the sea water on board for long periods before processing. The discovery of a seasonal trend in the ¹⁴C concentration at some locations indicated a need for better geographically defined stations and shorter intervals between each sample.

In the revised sampling program of 1976, the removal of CO₂ from sea water was done on board immediately after collection. The flushing time with 600L of nitrogen was shortened to 1.5 hours. Four to 5L of CO₂ were still obtained. The CO₂ was absorbed in 2% NaOH (0.75L) during the flushing procedure. This solution was then received in the laboratory and directly treated with hydrochloric acid (HCl) for further CO₂ release. At the beginning of the new program, nine parallel samples (200L of sea water each) were stored on board as before in order to study the reliability
of earlier samples. Only in 1 of the 9 cases a stored sample (TR-39B) showed an important deviation (40 ± 10\%_e) from the other (TR-39A).

MEASUREMENTS AND CALCULATIONS

In the same way as for tropospheric CO\textsubscript{2} samples, ocean surface samples were measured at 2 atmospheres pressure in CO\textsubscript{2} proportional counters with effective volumes generally ranging between 1 and 2L. The \textsuperscript{14}C samples collected before 1976 were generally measured with an accuracy of 10\%_e during a counting period of 25 hours. Samples collected in the new program from 1976 on were counted with an accuracy of 5 to 7\%_e during a counting time of at least 48 hours. The \textsuperscript{14}C concentration given in the tables (Δ\textsuperscript{14}C) was, as for tropospheric CO\textsubscript{2}, (Nydal & Lövseth, 1983) calculated in per mil excess above a normal \textsuperscript{14}C level according to the formula:

\[
Δ\textsuperscript{14}C = δ\textsuperscript{14}C - 2(δ\textsuperscript{13}C + 25)\left(1 + \frac{δ\textsuperscript{14}C}{1000}\right)
\]

The Δ\textsuperscript{14}C values are given relative to the standard (NBS oxalic acid) after normalization to a fixed δ\textsuperscript{14}C ratio of −25\%_e. No correction for the decay of the NBS standard (after 1950) has been performed.

From 1965 to 1976, flushing of CO\textsubscript{2} was performed in the laboratory at room temperature for 1 to 2 days (5-6L CO\textsubscript{2}); a mean δ\textsuperscript{13}C value of +2.0 ± 1.5\%_e was then observed. When the processing was performed later on board with a higher flushing speed, the δ\textsuperscript{13}C value changed to −6.5 ± 1.5\%_e. For the latter samples the flushing procedure for each sample was kept fairly constant during longer periods, and the δ\textsuperscript{13}C values were thus relatively stable.

The ocean temperature at the sampling depth was observed with an automatic recorder, located at the inlet of the water cooling system through which the samples were collected. The accuracy in the temperature recording was generally better than 0.5\degree C.

Salinity was measured at 22.5\degree C with an Inductor Salinometer (Industria Manufacturing Engineers LTD) at the Marine Biological Station in Trondheim. The result was calculated in per mil deviation from the international Salinity Standard (Standard Sea Water P91). The accuracy (one standard deviation) in each measurement was 0.003\%_e. Salinity measurements started in 1976; earlier samples were stored in glass bottles for several years before measurement. Later samples were measured immediately after arrival. Evaporation, due to a leak, was probably the cause for some unexpected high salinity values from a few bottles, stored earlier.

COMMENTS TO TABLES

All our ocean data are listed in five tables. Tables 1 and 2 contain data for, respectively, the northern and the southern Atlantic Ocean. Table 3 covers the Indian Ocean, and Tables 4 and 5 cover, respectively, the northern and southern Pacific Ocean.

Data are listed by station, 28 stations (01 to 28) for the Atlantic, 14 stations (31 to 45) for the Indian Ocean, 39 stations (51 to 88) for the Pa-
The column provides the location (sea) of samples collected from specific zones. The second column (week no.) contains the date of collection given in number of weeks from the first week in January 1963. The third column indicates the date of collection by year, month, and day. The fourth column provides the location of each sample in latitudinal-longitudinal coordinates with an accuracy of one minute. The area covered by each station is indicated by the heading and includes the group of samples belonging to the respective station. Columns 5 to 7 give the depth of collection, salinity, and temperature of the sea water.

Columns 8 to 10 show values respectively of the uncorrected $\delta^{14}C$, $\delta^{13}C$, and the corrected $\Delta^{14}C$ values given in per mil. $\delta^{13}C$ was dependent on the flushing procedure for $CO_2$ and thus has only relative importance.

RESULTS AND DISCUSSION

According to some authors (Sverdrup, Johnson, & Fleming, 1942; Broecker, Peng, & Engh, 1980) the exchange of ocean surface water with water from intermediate layers is very complex, and far from fully understood. The mixing process in the ocean occurs both in vertical and horizontal directions and can roughly be described as follows:

In the equatorial area (0° to 15°N/S) the trade wind causes a divergence zone where water upwelling occurs. Chemical analysis of various constituents of the water may give some indication of its origin. Upwelling also occurs closer to the continents or at the border between shallow and deep water. There is generally a more stable surface layer (ca 75m) at temperate latitudes (15° to 45°N/S) where downwelling occurs. Closer to the Arctic and Antarctic areas (above 45°N/S) there is a much faster downwelling of water with low salinity, which influences the water towards lower latitudes. Antarctic water especially penetrates far into the intermediate water of the Atlantic, Pacific, and Indian Oceans.

In the present program samples are collected at 4 to 10m depth, and thus are very close to the surface. The three measured parameters, $\Delta^{14}C$, temperature, and salinity, may be dependent on local weather and the degree of mixing of the upper surface layer. All the obtained data are presented here in tables and graphs. The latter are designed as time series in dependence on latitude. The data for the Atlantic Ocean are divided into 5 graphs (figs 2-6), the Indian Ocean into 1 graph (fig 7), and the Pacific Ocean into 3 graphs (figs 8-10). Studies of the data have revealed 1) seasonal and periodic variations, and 2) latitudinal variation.

1) Seasonal and periodic variations. One of the most regular seasonal trends with a positive temperature correlation was found in the Sargasso Sea (stations 15 and 16, figs 2-3). The magnitude of the peak to bottom values (2-4%) were, however, not well-defined in the data set, and the main purpose of the revised program after 1976 was to study such variations more closely. Broecker and Peng (1980) suggested an annual cycle of between 2.6 and 3.1% at temperate latitudes. They assumed that the
variation was due to a winter thickening of the surface layer. Unfortunately, it was not possible to further study the variation in the Sargasso Sea and most of the other stations in the Atlantic Ocean were influenced by water upwelling. For some stations (31 to 38) in the Indian Ocean (fig 7) a mean seasonal variation could be of the expected magnitude, but the measurements were too scanty and irregular, and a clear temperature correlation was not observed. Towards higher latitudes (south) in the Indian Ocean, the amplitude in variations increased. Measurements in the Pacific Ocean from 1970 to 1977 were also too few to support Broecker’s hypothesis.

Seasonal variations with a positive temperature correlation were also observed in areas of water upwelling. This is especially the case for station 20 in the Atlantic Ocean outside Dakar, and at station 22 on the equator in the Guinea Basin (fig 4). The peak to bottom values at Dakar (6-10%) were higher than at the equator (4-6%).

Some of the most problematic Δ14C variations are found in the Atlantic Ocean on the coast of Argentina (station 28, fig 5), and in the Pacific Ocean near Seattle (stations 52 and 54, fig 9). In both cases, there are periodic trends with peak to bottom values up to 20%. The bottom values agree more with normal surface values at this latitude. However, the peak values coincide with abnormally low salinity, which indicates intrusion of low salinity water with high 14C concentration. The most reasonable explanation is that the samples are locally influenced by the large rivers in the area.

There has been a tendency to explain erratic variations as errors in measurement. Such errors are now largely rejected due to parallel measurements. Thus, the ocean surface and internal mixing are not so regular as we would wish for modeling.

2) Latitudinal variation. Such variation is shown in the Indian and Pacific Oceans. Sampling in the Indian Ocean mainly followed a latitudinal band 6° to 41°S from 1976 to 1981, and a mean maximum Δ14C value of 14 ± 0.5% above normal level was recorded at ca 30°S (fig 7). In close agreement with this trend is the result from the South Pacific Ocean from 1970 to 1977 (fig 10). The maximum mean value was probably slightly higher here. A very large peak (32 ± 2%) was found in 1974 at station 84 (35°S, 180°E), and a peak with reduced amplitude (20.3 ± 1.3%) was simultaneously seen at station 81 (29°S, 150°N).

Measurements in the North Pacific Ocean 1970-1975 show a latitudinal dependence with a maximum mean value of a few per cent higher (max 5%) than in the southern hemisphere (fig 8). This maximum value of 18-20% above normal seems to appear in the 20° to 30°N latitudinal band, and agrees with other results (Linick, 1980; Broecker, Peng, & Engh, 1980; Tans, 1981).

The latitudinal dependence in the Atlantic Ocean is not satisfactorily recorded for the open ocean because most stations were located along the coast of Africa where upwelling occurs. The best locations for comparison with the result from the North Pacific Ocean (figs 8-9) are probably those from the Sargasso Sea (fig 2), where the agreement is satisfactory. The re-
result from these stations (15, 16) in the period 1966 to 1970 is also in agreement with those obtained by others in the same area (Quay & Stuiver, 1980; Ostlund, Dorsey, & Brescher, 1976).

In a previous paper (Nydal & Løvseth, 1983) all the ocean data are plotted versus time in one graph. Even the scattering of the data is large; a clear trend in the ocean measurement (40°N-40°S) is visible. \( \Delta^{14}C \) in the ocean surface at mean latitude passed its maximum value \( (\Delta^{14}C \sim 14\%) \) during the years 1970-1972 and is now decreasing at an exponential rate of about the same magnitude as that of the atmosphere \( (\Delta e^{-0.06t}) \).

**ACKNOWLEDGMENTS**

Sampling in the ocean surface was made possible by the kind assistance from a number of people, whose names are mostly mentioned in previous papers. Hearty thanks are given to the staff of the Institute of Marine Research Bergen, and to the Fred Olsen and Wilhelm Wilhelmsen Shipping Companies, with captains and crews. The Fred Olsen Lines collected samples from 1966 to 1972, ably assisted by Inspector Rolf Mathiesen. Collection of samples by the Wilhelm Wilhelmsen Lines was started in 1970 and still continues. We are especially indebted to Inspectors Knut Hornburg and Knut Jørgensen for helpful assistance in organizing the work. Sincere thanks go to Jon-Arne Sneli and Jon Harry Følstad at the Marine Biological Station in Trondheim for salinity measurements and helpful discussions. Thanks also are due Ragnar Ryhage, Karolinska Institutet, Stockholm, for \( ^{13}C/^{12}C \) measurements. We are greatly indebted to many of the laboratory staff. Typing by Thea Marie Aasen is greatly appreciated. Financial support from the Norwegian Research Council for Science and the Humanities (NAVF) is gratefully acknowledged.

**References**


Fig 1. Sampling locations for $^{14}$C in the troposphere and ocean surface.
Fig 2. $^{14}$C variation in surface water of the North Atlantic Ocean 1965-1971
Fig. 3. $^{14}$C variation in surface water of the North Atlantic Ocean 1966-1981
Fig 4: $^{14}$C variation in surface water of the North Atlantic Ocean 1976-1981
**Fig. 5.** δ^13C variation in surface water of the South Atlantic Ocean 1966-1981

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Fig 6. $^{14}$C variation in surface water of the South Atlantic Ocean 1976-1981
Fig. 7. "14C variation in surface water of the Indian Ocean 1976-1981.
Fig. 8. 14C variation in surface water of the North Pacific Ocean 1970-1975
Fig. 9. $^{14}$C variation in surface water of the North Pacific Ocean 1966-1973
Fig 10. $^{14}$C variation in surface water of the South Pacific Ocean 1970-1977
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**Station 11, 35°-38°N, 29°-32°W**

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Station 12, 38°–39°N, 22°–23°W

| SV-56  | 257  | 671207             | 32°30'N, 13°30'W | 9       | 36.91   | 19      | 218             | 0.3             | 156 ± 11 |
| SV-83  | 294  | 680824             | 34°00'N, 13°00'W | 9       | 36.95   | 24      | 221             | 2.8             | 154 ± 6  |

Station 13, 32°–34°N, 13°–14°W

| TR-126 | 870  | 790098             | 35°26'N, 18°00'E | 9.9     | 36.54   | 17.9    | 149             | -6.2            | 106 ± 7  |
| TB-172 | 931  | 801109             | 34°00'N, 24°00'E | 9.0     | 36.95   | 23.0    | 161             | -1.7            | 107 ± 8  |
| TB-196 | 977  | 810921             | 34°00'N, 24°10'E | 9.6     | 36.88   | 25.1    | 150             | -3.8            | 102 ± 5  |
| TB-205 | 990  | 811226             | 33°50'N, 19°40'E | 8.5     | 36.14   | 16.0    | 121             | -9.1            | 86 ± 7   |
| TB-216 | 1003 | 820403             | 35°13'N, 18°30'W | 10.0    | 37.92   | 15.0    | 144             | -2.7            | 93 ± 5   |

Station 14, 34°–36°N, 18°–24°E

| SV-16  | 183  | 660704             | 27°35'N, 50°30'W | 8.5     | 36.97   | 28      | 182             | -0.1            | 123 ± 9  |
| SV-35  | 215  | 670216             | 25°00'N, 50°00'W | 7.5     | 36.97   | 23      | 240             | 3.1             | 170 ± 9  |
| SV-42  | 229  | 670527             | 27°00'N, 51°00'W | 5.5     | 37.03   | 21      | 196             | 0.4             | 141 ± 10 |
| SV-51  | 244  | 670905             | 27°49'N, 52°01'W | 7       | 37.14   | 27      | 223             | 2.0             | 157 ± 11 |
| SV-61  | 258  | 671216             | 26°54'N, 47°43'W | 6       | 31.23   | 24      | 226             | -0.5            | 166 ± 11 |
| SV-71  | 272  | 680321             | 27°20'N, 50°35'W | 6.5     | 37.03   | 21      | 206             | 2.5             | 141 ± 10 |
| SV-79  | 287  | 680630             | 27°20'N, 50°42'W | 8       | 36.88   | 27      | 237             | 2.7             | 169 ± 8  |
| SV-110 | 346  | 690822             | 27°40'N, 52°10'W | 8.5     | 37.07   | 28      | 288             | 1.3             | 222 ± 7  |
| SV-126*| 375  | 700311             | 26°40'N, 49°08'W | 8       | 36.92   | 22      | 259             | 1.6             | 193 ± 9  |
| SV-145 | 401  | 700912             | 27°22'N, 50°58'W | 7.5     | 37.11   | 28      | 267             | 1.9             | 200 ± 9  |
| TO-6   | 733  | 770121             | 28°20'N, 49°53'W | 7       | 36.96   | 23.8    | 207             | -2.2            | 153 ± 8  |
| TO-14  | 755  | 770624             | 28°24'N, 50°00'W | 7.5     | 36.95   | 27.2    | 206             | -5.3            | 158 ± 8  |

Station 15, 25°–28°N, 49°–52°W

<p>| SV-24  | 199  | 661024             | 31°27'N, 39°00'W | 37.19   | 201     | 1.1     | 138 ± 9 |
| SV-87  | 301  | 681006             | 27°05'N, 43°45'W | 47.4    | 262     | 2.0†    | 194 ± 11 |
| SV-94  | 317  | 690126             | 27°35'N, 45°05'W | 46.0    | 264     | 2.0†    | 196 ± 12 |
| SV-101 | 332  | 690520             | 27°08'N, 43°02'W | 37.19   | 290     | 2.0†    | 222 ± 12 |</p>
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[Note: The table represents data from Station 17, 28°-30°N, 15°-18°W.]
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**Station 17 (continued)**

**Station 18, 24°2–25°N, 17°W**

| SV-29  | 208  | 661229             | 25°06'N, 17°00'W | 9       | 35.58      | 20             | 230             | -1.0            | 171 ± 9         |
| SV-39  | 220  | 670323             | 24°42'N, 17°12'W | 9       | 36.69      | 20             | 152             | 0.4             | 94 ± 8          |

**Station 19, 17°–18°N, 20°–22°W**

| SV-13  | 182  | 660701             | 17°20'N, 21°50'W | 9       | 36.24      | 75             | 0.2             | 21 ± 8          |
| SV-19  | 195  | 660921             | 17°50'N, 21°05'W | 9       | 35.88      | 28             | 121             | 1.3             | 62 ± 9          |
| SV-46  | 233  | 670621             | 17°08'N, 21°56'W | 8.5     | 35.88      | 23             | 72              | 1.4             | 15 ± 9          |
| SV-54  | 245  | 670912             | 16°40'N, 21°55'W | 7.5     | 27         | 168            | 0.0             | 110 ± 10        |
| SV-57  | 257  | 671204             | 17°30'N, 21°20'W | 9       | 25         | 183            | 0.0             | 124 ± 8         |
| SV-66  | 271  | 680315             | 17°00'N, 21°55'W | 9       | 36.08      | 21             | 140             | -0.3            | 84 ± 8          |
| SV-74  | 282  | 680529             | 17°30'N, 21°00'W | 6       | 37.04      | 22             | 214             | 0.2             | 154 ± 8         |
| SV-82  | 294  | 680820             | 17°00'N, 22°00'W | 9       | 36.14      | 25             | 133             | 1.2             | 75 ± 8          |
| SV-91  | 313  | 681229             | 17°00'N, 21°50'W | 9       | 23         | 202            | 1.6             | 138 ± 9         |
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<td>‡Mean value δ¹³C = -6.5 ± 1.5‰.</td>
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<td>¶Mean value δ¹³C = 1.6 ± 1.4‰.</td>
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TABLE 2. Carbon 14 in the Surface of the South Atlantic Ocean

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Station 24

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**Station 25, 14°–15°S, 01°–02°E**

**Station 26, 25°–27°S, 10°–12°E**
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*Leak in the drum.
†Mean value $\delta^{13}C = 2.0 \pm 1.5\%o$.
‡Mean value $\delta^{13}C = -6.5 \pm 1.5\%o$.
§Mean value $\delta^{13}C = 2.1 \pm 1.1\%o$. 
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**Station 31, 7°S, 67°-69°E**

**Station 32, 6°-7°S, 77°-78°E**

**Station 33**

**Station 34, 15°-18°S, 84°-89°E**

**Station 35, 18°S, 91°-94°E**
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**Station 40, 34°–36°S, 63°–65°E**

**Station 41, 32°–34°S, 107°–108°E**

**Station 42, 40°S, 31°–36°E**

**Station 43, 37°–41°S, 65°–68°E**

**Station 44, 37°–39°S, 105°–108°E**

**Station 45**

Mean value δ¹³C = −6.5 ± 1.5‰.
<table>
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<th>Location</th>
<th>Depth m</th>
<th>Salinity ( \delta^{14}C )</th>
<th>Temp ( ^{\circ}C )</th>
<th>( \delta^{18}C )</th>
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**Station 51**

**Station 52. 44°–46°N, 124°–125°W**

**Station 53**

**Station 54. 39°–42°N, 124°W**

**Station 55. 40°–42°N, 160°E**

**Station 56. 37°–40°N, 179°–180°W**

**Station 57**
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* Leak in the drum.
† Mean value δ¹³C = 1.2 ± 0.8‰.
‡ Mean value δ¹³C = 1.6 ± 0.9‰.
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#### Station 80, 26°–29°S, 120°W

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#### Station 82, 33°–36°S, 170°W

#### Station 83, 37°S, 160°E

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<td>128 ± 8</td>
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<th>Sample</th>
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<th>Date of Collection</th>
<th>Location</th>
<th>Depth m</th>
<th>Salin %</th>
<th>Temp °C</th>
<th>δ¹⁸O C %</th>
<th>δ²⁰N C %</th>
<th>Δ¹³C %</th>
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<tbody>
<tr>
<td>SV-279</td>
<td>680</td>
<td>760115</td>
<td>36°39'S, 160°00'E</td>
<td>7</td>
<td>35.58</td>
<td>22</td>
<td>186</td>
<td>5.1</td>
<td>117 ± 11</td>
</tr>
<tr>
<td>SV-283</td>
<td>699</td>
<td>760526</td>
<td>36°44'S, 160°00'E</td>
<td>7</td>
<td>35.45</td>
<td>19</td>
<td>194</td>
<td>-6.2</td>
<td>149 ± 10</td>
</tr>
</tbody>
</table>
Station 84, 35°-38°S, 179°-180°E

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<th>Lat.</th>
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<th>Temp</th>
<th>Salinity</th>
<th>Diss.</th>
<th>Age</th>
<th>U-14C</th>
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<tr>
<td>SV-188</td>
<td>710808</td>
<td>5.5</td>
<td>38.52</td>
<td>15</td>
<td>200</td>
<td>1.5</td>
<td>137 ± 8</td>
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<td></td>
</tr>
<tr>
<td>SV-233</td>
<td>730415</td>
<td>7</td>
<td>35.53</td>
<td>19</td>
<td>191</td>
<td>19.0</td>
<td>91 ± 13</td>
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<td></td>
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<tr>
<td>SV-249</td>
<td>740101</td>
<td>7</td>
<td>35.67</td>
<td>20</td>
<td>173</td>
<td>1.2</td>
<td>113 ± 10</td>
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<td></td>
</tr>
<tr>
<td>SV-261</td>
<td>740605</td>
<td>7</td>
<td>35.50</td>
<td>18</td>
<td>449</td>
<td>~20</td>
<td>319 ± 20</td>
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<td></td>
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<tr>
<td>SV-265</td>
<td>741024</td>
<td>7</td>
<td>35.46</td>
<td>17</td>
<td>202</td>
<td>17.8</td>
<td>103 ± 10</td>
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<td></td>
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<td>SV-269</td>
<td>750160</td>
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<td>35.39</td>
<td>21</td>
<td>216</td>
<td>27.1</td>
<td>96 ± 14</td>
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<tr>
<td>SV-277</td>
<td>750824</td>
<td>7</td>
<td>35.71</td>
<td>16</td>
<td>148</td>
<td>3.2</td>
<td>84 ± 7</td>
<td></td>
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<td>SV-284</td>
<td>760613</td>
<td>7</td>
<td>35.46</td>
<td>17</td>
<td>176</td>
<td>-3.8</td>
<td>127 ± 10</td>
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Station 85

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<th>Salinity</th>
<th>Diss.</th>
<th>Age</th>
<th>U-14C</th>
</tr>
</thead>
<tbody>
<tr>
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<td>751005</td>
<td>41°27'S, 150°00'E</td>
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<td>35.53</td>
<td>14</td>
<td>149</td>
<td>3.7</td>
<td>84 ± 9</td>
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</tr>
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</table>

Station 86, 39°-41°S, 150°-154°W

<table>
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<th>Lat.</th>
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<th>Temp</th>
<th>Salinity</th>
<th>Diss.</th>
<th>Age</th>
<th>U-14C</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV-281</td>
<td>760227</td>
<td>39°41'S, 150°00'W</td>
<td>7</td>
<td>35.41</td>
<td>20</td>
<td>215</td>
<td>1.1</td>
<td>153 ± 8</td>
<td></td>
</tr>
<tr>
<td>TO-11</td>
<td>770605</td>
<td>40°47'S, 154°00'W</td>
<td>7.5</td>
<td>34.55</td>
<td>15.7</td>
<td>192</td>
<td>-2.9</td>
<td>140 ± 7</td>
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Station 87, 40°-43°S, 174°-180°E

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<th>Lon.</th>
<th>Temp</th>
<th>Salinity</th>
<th>Diss.</th>
<th>Age</th>
<th>U-14C</th>
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<tbody>
<tr>
<td>SV-234</td>
<td>730524</td>
<td>42°50'S, 174°25'E</td>
<td>6</td>
<td>34.69</td>
<td>12</td>
<td>157</td>
<td>9.5</td>
<td>80 ± 8</td>
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<tr>
<td>SV-242*</td>
<td>731013</td>
<td>41°36'S, 179°17'E</td>
<td>7</td>
<td>34.26</td>
<td>15</td>
<td>195</td>
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<td>132 ± 8</td>
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</tr>
<tr>
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<td>760225</td>
<td>39°59'S, 180°00'E</td>
<td>7</td>
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<td>19</td>
<td>162</td>
<td>4.9</td>
<td>92 ± 10</td>
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Station 88, 46°-47°S, 169°-171°E

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<th>Station</th>
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<th>Lat.</th>
<th>Lon.</th>
<th>Temp</th>
<th>Salinity</th>
<th>Diss.</th>
<th>Age</th>
<th>U-14C</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV-241</td>
<td>730923</td>
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<td>7</td>
<td>37.26</td>
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<td>150</td>
<td>-0.4</td>
<td>94 ± 10</td>
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<tr>
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<td>46°40'S, 169°30'E</td>
<td>7</td>
<td>34.10</td>
<td>14</td>
<td>161</td>
<td>2.2</td>
<td>99 ± 8</td>
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</tr>
<tr>
<td>SV-262</td>
<td>740801</td>
<td>46°23'S, 171°25'E</td>
<td>7</td>
<td>34.25</td>
<td>8</td>
<td>150</td>
<td>11.1</td>
<td>69 ± 10</td>
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</tr>
<tr>
<td>SV-266</td>
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<td>7</td>
<td>34.82</td>
<td>12</td>
<td>150</td>
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<td>86 ± 9</td>
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</tr>
<tr>
<td>SV-270</td>
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<td>7</td>
<td>34.01</td>
<td>14</td>
<td>149</td>
<td>9.1</td>
<td>72 ± 8</td>
<td></td>
</tr>
</tbody>
</table>

* Leak in the drum.
CONSENSUS $\delta^{13}C$ VALUES

RICHARD BURLEIGH, KEITH MATTHEWS, and
MORVEN LEESE

Research Laboratory, The British Museum, London WC1B 3DG, England

ABSTRACT. Selected stable carbon isotope measurements published in Radiocarbon over a 12-year period have been abstracted, plotted, and summarized, to give more reliable estimates of the mean value and range of $\delta^{13}C$ for five classes of natural material (human bone collagen, non-human animal bone collagen, plant materials, wood, and charcoal), and to provide a firmer base line for stable carbon isotope dietary and environmental studies.

ACKNOWLEDGMENT

We are grateful to Juan Carlos Lerman for encouragement.

INTRODUCTION

Following Craig (1958; 1954; 1957) most radiocarbon laboratories make corrections to their $^{14}C$ age measurements on the basis of the small variations in stable carbon isotope ratio ($^{13}C/^{12}C$) shown by the materials used as samples for radiocarbon dating (Olsson and Osadebe, 1974). Not all laboratories have made these corrections to their published $^{14}C$ measurements from the beginning, some still do not do so, and others do not publish their $^{13}C$ measurements, but there is now a large amount of data recorded in Radiocarbon for a wide range of natural materials of which very little further use has been made (Lerman, 1973). With increasing interest in the relevance of stable carbon isotope measurements ($C_4$ effects) to the study of ancient diets, prehistoric economies, environmental (vegetational and climatic) change, and the evolution and taxonomy of higher plants, this bank of published data has acquired a new value and importance (see, for example, Brown, 1977; Brown and Smith, 1972; Burleigh and Brothwell, 1978; DeNiro and Epstein, 1978a, b; Lerman and Troughton, 1975; Martinez, Ambel, and Parrondo, 1982; Mazany, Lerman, and Long, 1980; Nambudiri et al, 1978; Tauber, 1981; van der Merwe and Vogel, 1978; van der Merwe, Roosevelt, and Vogel, 1981; von Schirnding, van der Merwe, and Vogel, 1982). Here we present a summary of an analysis that we have carried out of these data, which we believe will be of value in providing a base line for these new areas of study.

DATA ANALYZED

The analysis is based on stable carbon isotope ($\delta^{13}C$) measurements published in Radiocarbon, volumes 12-23 inclusive (1970-1981), that is, including all the volumes completed when this work was begun, but excluding older data published before 1970. Further major exclusions were: peat because of its inhomogeneity; molluscan shell because of the diversity of species and localities; soft tissues of modern humans associated with bomb-carbon studies (Lyon and Baxter, 1978); and 702 tree-ring measurements (395 measurements of Pinus aristata, mean value and standard deviation $-22.0 \pm 2.0\%$, and 307 measurements of Quercus sp, mean value and standard deviation $-25.6 \pm 1.3\%$) because some of these were known to reflect fractionation within the laboratory (Suess, 1978, p 4). Measure-
ments that were not made relative to the PDB standard were also excluded. Five main categories were established: human bone collagen; non-human animal bone collagen (excluding fish and other aquatic vertebrates); plant materials other than wood and charcoal; wood; and charcoal. Other information relating to each measurement, but subsidiary to the main purpose of the analysis was also recorded (identification to species where available, sample age, laboratory number). The total number of measurements included was 3249.

Most probably the accuracy of measurements made specifically for stable isotope investigations such as those noted in the Introduction above, will be higher than that of measurements originally made for the purpose of correcting ¹⁴C ages. An error of 1.0‰ in $\delta^{13}C$ is equivalent to an error of 16 radiocarbon years independent of absolute sample age, which is small in relation to some of the other sources of error to which radiocarbon dates are subject and (other than by high-precision laboratories) can generally be tolerated. Conversely, a direct $C_4$ contribution to the diets of humans probably cannot be estimated to within much better than ±10‰ from even the most precise $\delta^{13}C$ measurements because of other sources of dietary uncertainty and the variations inherent between individuals, although for most archaeological purposes such an accuracy would be quite sufficient. On average, the data recovered from Radiocarbon should provide reasonably good estimates of the means and the ranges characteristic of the five main categories of material given above. Although the approximate ranges within which the $\delta^{13}C$ values of these materials normally lie is known (Olsson and Osadebe, 1974; van der Merwe and Vogel, 1978), the potential value of the published data in establishing the more accurate estimates necessary for comparative purposes has up till now been largely neglected.

**METHODS**

Measurements of $\delta^{13}C$ and relevant subsidiary information for the five categories of material indicated above were recovered from the selected volumes of Radiocarbon by a visual search, recorded, and stored on disc in a Hewlett Packard 1000 computer ready for subsequent retrieval, tabulation, plotting, and statistical analysis. Desired sets of measurements for particular materials from given (broad) geographic regions could then be recovered and if appropriate amalgamated with comparable data for the same materials from other regions, to give as many values as possible within each main category.

**RESULTS**

The $\delta^{13}C$ measurements were retrieved in both printed and plotted form by regions and, within regions, by materials as shown in tables 1-5. Other ways of primary retrieval were also possible, for example, by age, by materials, or by laboratories, but were not used for the main analysis. Subsequently, these data were combined using visual matching of overlaid plots, to give the overall mean values and ranges listed in table 6. Specimen plots for human and animal bone collagen, antler collagen,
### Table 1

<table>
<thead>
<tr>
<th>Region</th>
<th>Number (n)</th>
<th>Mean (m)</th>
<th>SD (±)</th>
<th>Range (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>98</td>
<td>-19.5</td>
<td>1.6</td>
<td>-17.2 to -24.6</td>
</tr>
<tr>
<td>N America</td>
<td>2</td>
<td>-21.5</td>
<td>0.6</td>
<td>-21.1 to -21.9</td>
</tr>
<tr>
<td>S America</td>
<td>2</td>
<td>-15.5</td>
<td>1.3</td>
<td>-14.5 to -16.4</td>
</tr>
<tr>
<td>N Africa</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>S Africa</td>
<td>6</td>
<td>-11.4</td>
<td>2.4</td>
<td>-8.0 to -12.9</td>
</tr>
<tr>
<td>Asia</td>
<td>5</td>
<td>-19.5</td>
<td>0.5</td>
<td>-18.7 to -20.0</td>
</tr>
<tr>
<td>Australasia</td>
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<td>-26.0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
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### Table 2

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<th>Range (r)</th>
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<td>2.5</td>
<td>-13.9 to -24.1</td>
</tr>
<tr>
<td>S America</td>
<td>1</td>
<td>-19.4</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>N Africa</td>
<td>2</td>
<td>-19.2</td>
<td>2.8</td>
<td>-17.2 to -21.1</td>
</tr>
<tr>
<td>S Africa</td>
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<td>-17.3</td>
<td>4.5</td>
<td>-11.8 to -24.9</td>
</tr>
<tr>
<td>Asia</td>
<td>3</td>
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<td>1.8</td>
<td>-19.0 to -22.2</td>
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<tr>
<td>Australasia</td>
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<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
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<td>-11.8 to -32.8</td>
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</table>

### Table 3

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<td>6.1</td>
<td>-8.7 to -22.5</td>
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<td>6.2</td>
<td>-9.8 to -27.3</td>
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<td>-21.0</td>
<td>6.0</td>
<td>-9.2 to -30.8</td>
</tr>
<tr>
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<td>0.7</td>
<td>-22.8 to -25.4</td>
</tr>
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<td>0.6</td>
<td>-21.9 to -24.1</td>
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<td>-8.7 to -33.2</td>
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### Table 4

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<th>Range (r)</th>
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<td>-13.3 to -31.4</td>
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<tr>
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<td>-12.5 to -30.2</td>
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<td>-24.2</td>
<td>1.6</td>
<td>-22.1 to -26.7</td>
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<tr>
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<td>3.4</td>
<td>-10.1 to -27.8</td>
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<td>Asia</td>
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<td>-23.7</td>
<td>4.1</td>
<td>-20.7 to -30.8</td>
</tr>
<tr>
<td>Australasia</td>
<td>14</td>
<td>-25.0</td>
<td>0.6</td>
<td>-24.1 to -25.9</td>
</tr>
<tr>
<td>Total</td>
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<td>-25.2</td>
<td>2.3</td>
<td>-10.1 to -31.4</td>
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</table>
Different natural materials have their own characteristic δ¹³C values so that the spread of measurements observed for a given material such as wood or bone collagen is not simply random. The data listed in tables 1-6 cover the full range of measurements recorded for the five categories of material considered in the analysis, and a comparison of the figures given in the tables (ranges, means, and standard deviations) with the data plotted in figures 1-6 gives a good idea of the respective distributions. As the number of observations is quite large, judicious removal of outliers does not significantly alter mean values, but reduces the standard deviation of the mean (cf., for example, values for animal bone collagen and plant materials in table 6, with values of −21.7 ± 1.8‰ and −25.0 ± 1.8‰ when the limits for these materials are reduced to −26 to −16‰ and −30 to −20‰ by the removal of 54 and 69 measurements, respectively). As some at least of the outlying measurements probably arise from a combination of systematic natural variations (C₄ effects, for example), laboratory errors, and perhaps misidentification of materials (there are, for instance, no C₄ trees, yet some values for what was stated to be wood or wood charcoal lay in the C₄ range), discriminate removal of some values does appear to be justified. Practically speaking, the result is more useful as well as being more reliable. Independently of this, some of the data, when plotted, were found to be slightly skewed towards more negative values in a way suggestive of fractionation, but whether this reflects a natural process or arises within laboratories cannot be determined.

### Table 5

<table>
<thead>
<tr>
<th>Region</th>
<th>Number (n)</th>
<th>Mean (m)</th>
<th>SD (±)</th>
<th>Range (r)</th>
</tr>
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<td>−17.7 to −30.8</td>
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<td>N America</td>
<td>217</td>
<td>−25.2</td>
<td>2.4</td>
<td>−11.8 to −29.0</td>
</tr>
<tr>
<td>S America</td>
<td>24</td>
<td>−24.4</td>
<td>2.5</td>
<td>−17.9 to −28.6</td>
</tr>
<tr>
<td>N Africa</td>
<td>18</td>
<td>−25.0</td>
<td>2.0</td>
<td>−21.9 to −27.4</td>
</tr>
<tr>
<td>S Africa</td>
<td>141</td>
<td>−25.5</td>
<td>2.8</td>
<td>−10.5 to −29.0</td>
</tr>
<tr>
<td>Asia</td>
<td>31</td>
<td>−25.1</td>
<td>1.7</td>
<td>−18.6 to −27.1</td>
</tr>
<tr>
<td>Australasia</td>
<td>5</td>
<td>−22.1</td>
<td>0.8</td>
<td>−20.9 to −22.8</td>
</tr>
<tr>
<td>Total</td>
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<td>−24.7</td>
<td>1.8</td>
<td>−10.5 to −30.8</td>
</tr>
</tbody>
</table>

### Table 6

<table>
<thead>
<tr>
<th>Material</th>
<th>Number (n')</th>
<th>Mean (m')</th>
<th>SD (±)</th>
<th>Range (r')</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human bone (collagen)*</td>
<td>105</td>
<td>−19.5</td>
<td>1.5</td>
<td>−17.2 to −24.6</td>
</tr>
<tr>
<td>Non-human animal bone (collagen)</td>
<td>292</td>
<td>−21.2</td>
<td>2.7</td>
<td>−11.8 to −32.8</td>
</tr>
<tr>
<td>Plant materials*</td>
<td>2735</td>
<td>−25.0</td>
<td>2.2</td>
<td>−17.2 to −33.2</td>
</tr>
</tbody>
</table>

* Less values showing probable C₄ effect (see text)
Richard Burleigh, Keith Matthews, and Morven Leese

The justification for combining data for materials from different geographic regions is that the $\delta^{13}C$ values characteristic of each material are age independent and phylogenetically determined (ie, fundamentally via photosynthesis of green plants), geographic and environmental factors being of small secondary importance (and the CAM pathway of desert suc-

Fig 1. European human bone collagen (98 values)

Fig 2. All human bone collagen (114 values) including those showing $C_4$ effects

Fig 3. European animal bone collagen (245 values)
Consensus δ¹³C Values

...culents, though regulated by the environment, was regarded as numerically unimportant in this analysis). Thus, although the data analyzed are
biased by being predominantly European, and additional bias may result
from publication of many dates without δ¹³C values in the volumes of
Radiocarbon searched (and perhaps from the exclusion of measurements
made before 1970), the results themselves should not be influenced by this.

Fig 4. Antler collagen (British Isles; 70 values)

Fig 5. All plant material including wood and charcoal (2843 values; marked bi-
modality of C₃ and C₄ pathways suppressed by scale)

Fig 6. All wood (1155 values)
CONCLUSIONS

The results obtained (table 6) for plant remains, wood, and charcoal are in close agreement with previous approximations of typical $\delta^{13}C$ values for these materials. The results for bone collagen, and in particular, for human bone collagen, are now much better defined than hitherto. Rigorous selection and analysis of the published data upon which these values are based have given them greater reliance than previous estimates of the range of values found in bone collagen. We believe that these values, and in particular, those for human bone collagen, will provide the most useful base line currently available for stable carbon isotope studies of prehistoric diet (and that these values will be vindicated in turn by these specialized studies).

Two final points that emerge are, first, the evident need for careful specific identification of all the materials used for stable carbon isotope analysis and $^{14}C$ dating (and by inference, the desideratum of confining any one measurement to a single species and, if possible, to a single individual), and, second, the need for an interlaboratory ($C_3$) bone collagen standard for stable carbon isotope studies (Erle Nelson, Simon Fraser Univ, pers commun).

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Olsson, I U and Osadebe, F A N, 1974, Carbon isotope variations and fractionation corrections in $^{14}C$ dating: Boreas, v 3, p 139-146.
SELECTIVE LEACHING OF SHELLS FOR ¹⁴C DATING

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ABSTRACT. Although acid leaching of shell carbonates prior to ¹⁴C assay is usually desirable, under some circumstances it can worsen contamination by preferentially dissolving unaltered shell and thus increasing the proportion of secondary carbonate. The risk can be eliminated by monitoring the progress of leaching with the help of microscopy and x-ray diffraction.

Interest in the late Quaternary evolution of marine and lake shorelines continues to grow among palaeoclimatologists, archaeologists, and students of recent crustal deformation. As mollusk shells are commonest organic material found in strandline deposits their suitability for ¹⁴C dating is an important issue.

Granted that contamination by modern carbon is not always readily detected, careful sample selection and pretreatment can at least minimize the area of doubt by confining the material used for dating to carbonate which gives no indication of secondary contamination. A judicious combination of mechanical cleaning and acid leaching is, in our experience, often successful in removing secondary carbonate and recrystallized shell (Vita-Finzi, 1980). This note draws attention to the need for monitoring the progress of leaching. Samples are often leached until a certain proportion by weight has been removed, on the assumption that contamination is concentrated in the outer parts of the shell and leaching will consequently deal with it. The assumption is not always justified and leaching can make things worse than they originally were.

The commonest sources of shell contamination by younger carbonate stem from replacement of the original shell material by carbonate (usually calcite) and deposition of secondary carbonate coatings or infillings. Its recognition is, of course, not always easy. An existing cavity (such as a tubule) in an aragonitic shell may thus be filled by micritic aragonite and, as Chappell and Polach (1972) have shown, recrystallization can operate in a closed system mode and need not incorporate extraneous carbon. This paper is concerned only with secondary carbonate because it is generally easy to identify by a variety of techniques.

The first stage in the screening of shell samples for ¹⁴C analysis is usually to inspect representative specimens under the light microscope. When the offending cement is on the outside of the unaltered material, the effects of leaching are readily traced by taking peels or thin-sections before and after abrasion and leaching (Vita-Finzi, 1980). Difficulties arise when the section does not intersect all the voids in which secondary carbonate is present, a distinct possibility in the case of lenticular chambers present in some oyster shells (Moore, 1971), as the acid is unlikely to reach the contaminant and the observer is none the wiser. Even if the crack is exposed it is essential to ensure that leaching has removed the infilling rather than the shell (pl 1).
Where the contact between the secondary carbonate and the unaltered shell is not well defined, the success of any pretreatment may need to be checked by scanning electron microscopy, as neither thin sections nor peels lend themselves to high-power inspection in ordinary light. Walker (1979; see also Vita-Finzi, 1980) has illustrated in a specimen of *Oliva* a sharp boundary between neomorphic calcite enclosing relic aragonite lamellae and a zone where the aragonite crossed-lamellar structure has only undergone etching. Plate 2 shows how the SEM can be used to establish the extent of contamination. In the example illustrated the secondary carbonate is confined to the surface and can thus be removed by abrasion and leaching.

X-ray diffraction permits the amount of contaminant to be assessed with ease in the case of shells originally composed of aragonite if (as is usually the case) the cement is calcitic. As only a few mg of samples are required for each analysis, and as the assay is performed easily and quickly, the progress of leaching can be monitored by repeated determinations on the critical part of the shell section (Vita-Finzi, 1980) or on homogenized subsamples representative of the shell as a whole. The latter approach is illustrated in the experiment discussed below.

The material in question comprised bivalve shells of *Dreissena* sp (ca 2cm long) from shoreline sediments of palaeo-lake Konya in south-central Turkey, *14C*-dated to ca 20,000 yr BP (for details, see Roberts, 1983). Some of these shells were coated with a secondary calcite cement which had been laid down within and between the shells by percolating meteoric water. If dated along with the shells, the calcite cement would thus have reduced the *14C* age of the sample. Because the unaltered shells consisted of aragonite, it was possible to distinguish them from the secondary (calcite) carbonate by XRD and hence to measure contamination for shell samples subject to different degrees of acid leaching.

Contaminated *Dreissena* shells were broken into fragments 0.5 to 2mm in diameter, homogenized, and divided into subsamples, each weighing 0.4gm. Apart from a few which were left unleached, subsamples were leached in 2 to 10% HCl, the resulting weight loss ranging between 14.8% and 86.6%. After washing, drying, and re-weighing, they were ground to a powder for ca 2 minutes in a mortar and pestle. The ground subsamples were each analyzed by XRD, using Cu–Kα radiation over 2θ angles between 20° and 31°. This range incorporates the first-order peaks of both aragonite (26.24°) and calcite (29.49°). From the resulting chart traces, the heights of the aragonite and calcite peaks were calculated, duplicate traces being obtained whenever possible. The peak heights provide values for the proportion of calcite in each subsample, and therefore also for the percentage of secondary contamination. In the ratio used (R, of Milliman, 1974), a value of 1.0 indicates 100% aragonite and zero contamination, and lower values represent increasing per cent of calcite and of contamination, 0.0 indicating 100% calcite. The maximum accuracy of peak intensity analysis is ca ±1%.
Calcite crystals partially filling cavity in Ostrea sp (sample C814). Note how leaching has removed foliated shell in lower right but spared the infill. Scale bar measures 1 mm.
Scanning electron micrograph of cross-lamellar aragonite in *Pondylus gaederopus* (sample G82/601). Secondary carbonate is absent from the tube (lower right) and confined to the surface (eg. lower center). Scale bar measures 10 µm.
As leaching is designed to reduce contamination, it should be positively correlated with the aragonite/calcite ratio. The *Dreissena* shells analyzed gave a weak negative correlation of –0.63 between percent weight loss by acid leaching and this ratio (fig 1). Unleached samples had R1 values ca 0.7, and these fell to 0.6 at ca 80% leach. In other words, the secondary calcite cement was more resistant to acid than the original shells, and leaching increased the proportion of contamination. For samples such as these, pretreatment should consist of mechanical cleaning and leaching of individual shells after hand sorting. The operation is tedious but is rewarded by confidence in the 14C date.

ACKNOWLEDGMENT

We thank Mrs N Nicholas for help with the SEM.

REFERENCES


BRITISH MUSEUM NATURAL RADIOCARBON MEASUREMENTS XVII

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Research Laboratory, The British Museum, London WC1B 3DG, England

The following list consists of dates for archaeologic and geologic samples mostly measured from June 1982 to June 1983. The dates were obtained by liquid scintillation counting of benzene using the laboratory procedures outlined in previous lists (see, eg, BM-VIII, R, 1976, v 18, p 16). Dates are expressed in radiocarbon years relative to AD 1950 based on the Libby half-life for $^{14}C$ of 5570 yr, and are corrected for isotopic fractionation ($\delta^{13}C$ values are relative to PDB). No corrections have been made for natural $^{14}C$ variations. The modern reference standard is NBS oxalic acid (SRM 4990). Errors quoted with dates are based on counting statistics alone and are equivalent to ± 1 standard deviation (± 1σ). Descriptions, comments, and references to publications are based on information supplied by submitters.

ARCHAEOLOGIC SAMPLES

Algeria

Cherchel series

Samples from Forum site at Cherchel (36° 40' N, 1° 40' W) dated to establish chronology for Islamic period of site. Coll 1981 and subm by T W Potter, Dept Prehist and Romano-British Antiquities, British Mus.

$\delta^{13}C = \text{relative to PDB}$

BM-2129. Cherchel
Charcoal, ref 408 OX, from floor of bldg overlying forum ambulatory.

$1080 \pm 130$

BM-2130. Cherchel
Charcoal, ref 416 PF, from floor of bldg overlying forum ambulatory.

$460 \pm 50$

BM-2132. Cherchel
Charcoal, ref 409 OY, from Islamic refuse pit.

$65 \pm 40$

BM-2133. Cherchel
Charcoal, ref 501, from floor plaster.

$45 \pm 35$

BM-2134. Cherchel
Charcoal, ref 502, from floor plaster.

Modern

$\delta^{13}C = \text{relative to PDB}$

General Comment (TWP): result for BM-2134, which is stratified below BM-2133, seems anomalous; BM-2130 is later than expected. Other dates

British Isles

**Freshwater shell series**


**BM-1801. Carbonate**

*Unio tumidus* from R Thames at Culham, Oxfordshire (pair of united valves).

125 ± 5% modern  
$\delta^{13}C = -10.9\%_o$

**BM-1802. Protein**

*Unio tumidus* from R Thames at Culham (same shell as BM-1801, above).

178 ± 5% modern  
$\delta^{13}C = -31.0\%_o$

**BM-2072. Carbonate**

*Unio tumidus* from R Thames at Pangbourne, Berkshire, (3 pairs of united valves).

1525 ± 30  
$\delta^{13}C = -9.9\%_o$

**BM-2073. Protein**

*Unio tumidus* from R Thames at Pangbourne (same shells as BM-2072, above).

750 ± 180  
$\delta^{13}C = -30.6\%_o$

**BM-2135. Carbonate**

*Margaritifera auricularia* from R Saône, France (1 valve of united pair).

1480 ± 50  
$\delta^{13}C = -9.6\%_o$

**BM-2136. Protein**

*Margaritifera auricularia* from R Saône (same shell as BM-2135, above).

730 ± 180  
$\delta^{13}C = -28.5\%_o$

General Comment (RB): dead carbon contribution cannot be estimated
from respective measurements of *Unio tumidus* coll 1968 (BM-1801, -1802) because of bomb carbon effect, and results for shells of this sp coll 1923 (BM-2072, -2073) are inexplicably old, as are those for *Margaritifera auricularia* recorded as coll 1969 (BM-2135, -2136). Absence of bomb carbon from protein fraction of this shell (BM-2136) indicates that it was not live-coll specimen. Further, definitely live-coll, shells of this sp, of known pre-bomb age, must be analyzed to resolve this and help provide appropriate dead carbon blanks for measurements of fossil shells of this sp (Preece et al, in press).

**Northampton series**

Animal bone (collagen) and wood from stratified sequence of deposits exposed by gravel extraction at Earl’s Barton, near Northampton, Northamptonshire, England (52° 15′ N, 0° 55′ W, Natl Grid Ref SP 870625). Coll 1982 and subm by A Currant and C B Stringer, Dept Palaeontol, British Mus (Nat Hist).

**BM-2026. Northampton**

\[3400 \pm 50\]

\[\delta^{13}C = -23.5\%\]

Mandible of *Bos primigenius* from undisturbed peat layer underlying modern soil.

**BM-2027. Northampton**

\[5230 \pm 45\]

\[\delta^{13}C = -24.6\%\]

Wood (cellulose fraction) from base of peat underlying modern soil and overlying Devensian fluvio-glacial gravels.

**BM-2074. Northampton**

\[23,880 \pm 770\]

\[\delta^{13}C = -20.9\%\]

Fragment (distal epiphysis) of left humerus of woolly rhinoceros (*Coelodonta antiquitatis*) from Devensian gravels underlying peat and modern soil.

**BM-2074C. Northampton**

\[25,500 \pm 650\]

\[\delta^{13}C = -21.0\%\]

Repeat measurement of BM-2074, above, using fresh sample of collagen (total amino acids) separated at Oxford Radiocarbon Accelerator Lab (R Gillespie, pers commun).

**General Comment** (RB, CA, & CBS): BM-2026, -2074 add usefully to series of dates for Late Pleistocene/Early Holocene mammalian extinctions (R, 1982, v 24, p 236-238, 262-264). Fragmentary human parietal and post-cranial bones from silt lens within gravel are of modern type and though not directly dated probably relate to later prehistoric/early historic activity on site.

**Brixworth series**

Samples from All Saints Church, Brixworth, Northamptonshire, England (52° 20′ N, 0° 55′ W, Natl Grid Ref SP 745708). Coll 1982 and subm by D Parsons, Univ Leicester.
**BM-2047. Brixworth**  
Collagen from human bone, ref 3002, from burial in NE angle of foundations. $\delta^{13}C = -20.2\%$

**BM-2047A. Brixworth**  
Repeat measurement of BM-2047, above. $\delta^{13}C = -19.7\%$

**BM-2048. Brixworth**  
Collagen from human bone, ref 3005, from burial in cist of rough hewn slabs cut into mortar floor. $\delta^{13}C = -18.7\%$

**BM-2154. Brixworth**  
Charcoal, ref 900, from ditch primary fill. $\delta^{13}C = -24.7\%$

**BM-2155. Brixworth**  
Charcoal, ref 364C. $\delta^{13}C = -24.3\%$

*General Comment (JA):* dates relate also to experimental work on dating of carbonate materials (mortars) which will be pub elsewhere.

**Harrow Hill series**

Charcoal and red deer antler from Neolithic flint mine shafts at Harrow Hill, near Worthing, Sussex, England (50° 50' N, 0° 30' W, Natl Grid Ref TQ 080100). Coll 1982 and subm by G de G Sieveking, Dept Prehist and Romano-British Antiquities, British Mus.

**BM-2071. Harrow Hill**  
Charcoal, ref HH19 (*Corylus* sp, id by Rowena Gale, Royal Botanic Gardens, Kew), in Shaft 13c, 5cm above base of shaft. $\delta^{13}C = -26.7\%$

**BM-2075. Harrow Hill**  
Charcoal, ref HH19; repeat measurement of BM-2071, above, using fresh material. $\delta^{13}C = -26.4\%$

**BM-2097. Harrow Hill**  
Charcoal, ref HH43, from fill of Shaft 13a. $\delta^{13}C = -25.2\%$

**BM-2098. Harrow Hill**  
Charcoal, ref HH28, from fill of Shaft 13g. $\delta^{13}C = -25.7\%$

**BM-2099. Harrow Hill**  
Red deer antler (collagen), ref HH27, 5cm above floor, on crawling floor to Gallery 13 I. $\delta^{13}C = -23.1\%$

**BM-2124. Harrow Hill**  
Charcoal, ref HH84, from fill of Shaft 13c, 1.5m above base of shaft, assoc with Mollusca (Kerney, in press). $\delta^{13}C = -24.9\%$
General Comment (GdeGS): dates for these samples from freshly excavated mine confirm previous earlier dating (ca 2700-3000 bc) for S Downs group of flint mines (R, 1969, v 11, p 285-286) relative to Grime’s Graves (ca 2000 bc) and other groups (ca 2500 bc).

3090 ± 60
$\delta^{13}C = -25.0\%_o$

BM-2088. Witton

Charcoal sample from pit fill at Witton, Norfolk, England (52° 50’ N, 1° 30’ E, Natl Grid Ref TG 334319) assoc with late Beaker and plain wares (Lawson, in press). Coll 1981 by J Owles and subm by A J Lawson, Norfolk Archaeol Unit. Fractionation correction estimated. Comment (AJL): sample was from apparently sealed context, although some animal disturbance was noted; no other contemporary activity has been identified in area. Assoc of plain wares and late Beaker sherds is not surprising but date is later than expected for both types. Date is comparable with that for Billingborough Fen (BM-1410, 3150 ± 60: R, 1981, v 23, p 15) which has well-defined Bucket Urn ceramic component which might be considered to be stylistically later than Witton plain wares.

1760 ± 70
$\delta^{13}C = -25.8\%_o$

BM-2091. Haddenham


Burghfield Quarry

Wood, id as oak, ref 40.82, from outer edge of ‘logboat’ coffin (Ashbee, 1960) under ‘yellow silt’ floodplain deposit of lower Kennet Valley, discovered during gravel extraction at Burghfield Quarry, Burghfield, near Reading, Berkshire (51° 25’ N, 1° 0’ W, Natl Grid Ref SU 705710). Coll 1982 by C L Cram and P Worsley and subm by C L Cram, Reading Mus. Measured to obtain youngest date for tree and terminus ante quem for burial.

1500 ± 60
$\delta^{13}C = -23.6\%_o$

1750 ± 50
$\delta^{13}C = -23.6\%_o$

BM-2096A. Burghfield Quarry

Repeat measurement of BM-2096, above. Comment (RB): result shows burial is later than expected (ca 1500 bc), but indicates late survival of this burial practice.

2610 ± 60
$\delta^{13}C = -23.3\%_o$

BM-2123. Flag Fen

Cellulose extracted from sapwood sample from artificial wooden platform at Flag Fen, near Fengate, Peterborough, England (52° 30’ N, 0° 10’ W, Natl Grid Ref TL 212989). Coll 1982 and subm by F Pryor, Fenland Archaeol Associates. Comment (FP): site is unique in England and was
possibly used for defense. Date indicates use of site during Ewart Park phase of Late Bronze age, but will have to be used in conjunction with tree-ring studies to give fuller picture of times of use and construction. For dates from nearby site of Fengate see: R, 1975, v 17, p 229; R, 1977, v 19, p 405-406; Pryor (1980).

**BM-2137. Devil's Dyke**

Charcoal (*Prunus* sp, *Rosaceae*, subfamily Pomoideae, *Fraxinus* sp, *Corylus* sp, *Acer* sp) id by Rowena Gale, Royal Botanic Gardens, Kew, from Pit 1, Layer 135-150cm, at Devil's Dyke, near Brighton, Sussex, England (50° 50' N, 0° 10' W, Natl Grid Ref TQ 266103). Coll 1982 by Caroline Ellis, M P Kerney and R B G Williams and subm by M P Kerney. Molluscan diagram prepared from sec shows Postglacial biozone d2 (woodland) succeeded by biozones e and f (grassland; Kerney, 1977); charcoal and assc pottery from near base of zone e. Charcoal-rich layer also corresponds with first appearance of *Monacha cartusiana* (Müller), molluscan “weed” sp probably introduced to Britain by prehistoric farmers. Comment (MPK & CE): date is somewhat later than expected for primary forest clearance of adjacent downland, but it should be noted that charcoal horizon lies ca 25cm above clearance episode proper (base of molluscan biozone e), and plant taxa represented by charcoals suggest some secondary regeneration. Base of biozone f, which broadly coincides with period of Roman occupation in chalklands of S Britain, lies at convincingly higher level in sec (Ellis, 1983). Though comprising only undiagnostic wall-scherds, hand-made, flint-gritted pottery from charcoal-rich layer is more typical of earlier part of 1st millennium bc (fide Valery Rigby and I A Kinnes, Dept Prehist and Romano-British Antiquity, British Mus).

**BM-2150. Devizes Castle**

Cellulose from sample of oak corbel from ceiling in Devizes Castle, now Devizes Mus, Devizes, Wiltshire, England (51° 20' N, 2° 0' W, Natl Grid Ref SU 010625) measured to date carving. Sample was heavily contaminated with creosote but this was removed by cellulose extraction. Coll 1983 by Res Lab, British Mus, and subm by G Zannecki, Univ London. Comment (JA): sample dated composed material from ca 65 annual rings, but date is clearly distinguishable from earliest possible hist date ca AD 1150 and lies close to alternative dating proposed for restoration of castle in ca AD 1500, following Stuiver (1982).

*British Middle and Late Devensian sites*

Animal bone (collagen fraction) from stratified cave and rock-shelter sequences (Bramwell, 1973; McBurney, 1959) measured to provide dates for assoc archaeol and environmental record. Extension in collaboration with A J Stuart of program for investigation of Late Pleistocene/Early Holocene mammalian extinctions (R, 1982, v 24, p 236-238, 262-264).
**BM-2102. Bridged Pot**

Fragments of shaft of limb bone of large mammal, id by K Scott and A J Stuart, from Layer B, angular limestone clasts in red clay/silt matrix, in Bridged Pot, rock shelter at head of Ebbor Gorge, near Wookey Hole, Mendip, Somerset, England (51° 10' N, 2° 40' W, Natl Grid Ref ST 526487). Coll 1958 by C B M McBurney and subm 1982 by A J Stuart, Dept Zool, Univ Cambridge. Comment (AJS): date is later than expected (10,000-11,000 bp) from fauna, which includes reindeer, arctic lemming, and pika.

**Picken’s Hole series**


**BM-2117. Picken’s Hole**

Fragment of shaft of limb bone of large mammal, ref M30.2/605, Sample C, from Layer 3. Expected date ca 34,000 bp. Comment (AJS): date in broad agreement, though substantially younger than previous date for Layer C, BM-654: 34,265 \(\pm 2600\) \(+2600\) \(-1950\). Fauna, of Middle Devensian type includes spotted hyena, reindeer, horse, woolly rhinoceros, and mammoth (Stuart & Scott, ms in preparation). Further samples will be measured.

**BM-2118. Picken’s Hole**

Distal metacarpal of reindeer (*Rangifer tarandus*) ref M 30.2/57, Sample B, from Layer 5. Expected age ca 40,000 bp. Comment (AJS): date much younger than expected (> 40,000 bp). Bone labeled as from Layer 5, but obtained from trial trench where stratification indistinct; presumably comes from overlying deposit of late Glacial age. Date is acceptable for reindeer. Previous dates for Layer 5, BM-655A, -655B: 26,650 \(+1700\) \(-1400\) and 27,000 \(+1850\) \(-1500\), are anomalously young. Further samples will be measured.

**Ossom’s Cave series**


**BM-2126. Ossom’s Cave**

Fragment of shaft of humerus of large bovid, ref Sample C, from
Layer D, Sq V/VI. Expected age: ≥ 11,000 bp. Comment (AJS): date indicates considerable age difference between Layers D and C.

**BM-2127. Ossom's Cave**

Fragment of shaft of limb bone (*cf* reindeer, *Rangifer tarandus*), ref Sample B, from Layer C, Sq V, red clay layer. Expected age: 10,000-11,000 bp. Comment (AJS): date in broad agreement, but older than, previous date from Layer C, 10,590 ± 70 (GrN-7400, unpub). Fauna includes reindeer, arctic and Norway lemmings and ptarmigan, in assoc with Upper Palaeolithic industry (Bramwell *et al*, ms in preparation). Further samples will be measured.

**France**

**Choisy-au-Bac series**


**BM-2050. Choisy-au-Bac**

Charcoal, ref E 48, from debris of rampart, assoc with final occupation, Phase IIc.

**BM-2051. Choisy-au-Bac**

Charcoal, ref W7, from Structure 40, Phase III.

**BM-2052. Choisy-au-Bac**

Charcoal, ref ZB13, from S corner of rampart, corresponding with final debris, Phase IIc.

**BM-2053. Choisy-au-Bac**

Charcoal, ref H50, destruction of wooden framework of rampart, Phase IIc.

**BM-2054. Choisy-au-Bac**

Charcoal, ref C43, rampart debris, Phase IIc.

**BM-2055. Choisy-au-Bac**

Wood charcoal, ref E45, from House no. 15, Phase IIc.

**BM-2056. Choisy-au-Bac**

Charcoal, ref K49, from House no. 15, Phase IIc.

**BM-2057. Choisy-au-Bac**

Collagen from bone fragments, ref W4, from Structure 40, Phase III.
BM-2058. Choisy-au-Bac

Collagen from bone fragments, ref Q56, House no. 6, Phase Ib.

General Comment (SN): samples refer to sequence of 10 occupation levels separated by alluvial deposits and spanning LBA/EIA transition. Samples come mainly from Phases II and III, which account for 7 of levels (Agache, 1982, p 268-272). Five dates with standard deviations of ± 70 and less give average date within 5th century bc, which is later than expected.

Figure of Christ series

Wood samples (*Juglans* sp) id by Rowena Gale, Royal Botanic Gardens, Kew, drilled from body and head of near life-sized figure of Christ, of French origin and claimed to date to 12th century AD. Coll 1982 by Research Lab, British Mus and subm by N Stratford, Dept Medieval and Later Antiquities, British Mus.

BM-2100. Figure of Christ

Wood drilled from same place in center of back of figure as BM-1977 (see below).

BM-2101. Figure of Christ

Wood drilled from head of figure.

General Comment (RB): for other dates for figure see BM-1977 to 1979 (R, 1983, v 25, p 47-48). Even when max age of 200 yr normally attained by walnut is allowed for, dates indicate real difference in age between detachable arms and body of figure, which is thus a composite piece.

India

Zawar series

Samples assoc with zinc mine at Zawar, Udaipur Dist, Rajasthan (24° 50' N, 73° 50' E). Coll 1982 by P Paliwal and P T Craddock and subm by P T Craddock, Research Lab, British Mus.

BM-2017. Zawar

Charcoal from contents of one retort from many forming long walls across site. Extracted by treatment with hydrofluoric acid.

BM-2065. Zawar

Charcoal from similar retort to BM-2017, above, believed to be from Zawar. Extracted by treatment with hydrofluoric acid. Fractionation correction estimated.

BM-2148. Zawar

Wood, ref LW/1982/2, from scaffold in escape route stope inside Zawar Mala mine.
1920 ± 50

BM-2149. Zawar

Wood, ref LW/1982/1, from launder in escape route inside Zawar Mala mine.

*General Comment (PTC):* BM-2017, -2065 are inexplicable. Both carbon samples were distributed throughout sintered charge sealed inside clay retorts. By 1820's site is known to have been deserted. Origins of metal production at Zawar are still uncertain. Zinc, with some lead and silver all occur in mines from which timber used for BM-2148, -2149 was taken. Zinc is known to have been smelted from 14th century, but dates suggest zinc and brass production may be much earlier here (Craddock, Gurjar, & Hegde, 1983).

**Indian Ocean**

750 ± 370

BM-2125. Giant tortoise

Collagen from bony carapace of *Geochelone abrupta* from colln of Mus Natl Hist Nat, Paris, from Madagascar (Malagasy Republic; ca 22° S, 45° E), precise loc and date of colln unknown. Subm by E N Arnold, Dept Zool, British Mus (Nat Hist) as part of investigation of hist, distribution and carbon isotope relationships of giant tortoises in Indian Ocean region (R, 1982, v 24, p 245-246). *Comment (RB):* small size of sample accounts for large error of 

**Iraq**

Tell Taya series

Samples from site at Tell Taya, near Mosul, N Iraq (36° 20' N, 42° 30' E). Coll 1973 and subm by J Reade, Dept Western Asiatic Antiquities, British Mus.

BM-2109. Tell Taya

Charcoal, ref sample III/3 (batch C 1055), from Level III, old Babylonian period.

BM-2110. Tell Taya

Charcoal, ref sample III/8 (batch C 1086), from Level VI, Ur 3 or Late Agade period.

BM-2112. Tell Taya

Charcoal, ref sample III/9 (batch C 1107), from Level VIII, Agade period.

BM-2113. Tell Taya

Charcoal, ref sample III/16 (batch C 1123), from Level VIII or IX, Agade period.

*General Comment (JER):* samples are from one area of excavation (Reade
et al, 1973) and should all be reliable. Deposit from which BM-2109 derives almost certainly dates from reign of Babylonian king, Hammurapi (1848-1806, 1792-1750, or 1728-1686 BC by three “historic” chronologies most widely used). BM-2110 should be ca 200-350 calendar yr earlier. These two determinations are clearly satisfactory. BM-2112 is stratigraphically earlier than BM-2110 (at least 50 calendar yr earlier) and determination is still satisfactory. BM-2113 must be discounted, perhaps because of very small sample size.

**Palestine**

**BM-2114.** Tell el Ajjul

Collagen from shaft of left metacarpal (epiphyses not destroyed) of domestic horse (*Equus caballus*), id by Juliet Clutton-Brock, Dept. Zool, British Mus (Nat Hist), from Burial 1474 at Tell el Ajjul, Gaza, Palestine (31° 30' N, 34° 30' E). Coll 1933-1934 by Sir Flinders Petrie and subm 1982 from British Mus (Nat Hist) colln, to provide direct date for horse skeleton dated from archaeol evidence to Hyksos period, ca 1650-1550 BC (Petrie, 1934, p 15, 16), in support of osteometric studies (Clutton-Brock, in press; Wapnish, in press). Comment (RB): direct dating evidence for early domestic equids in Middle East is sparse due to relative scarcity of well-preserved and well-stratified remains, but on firm archaeol evidence this particular skeleton cannot be earlier than Hyksos period and unexpectedly early date apparently results from incomplete removal of paraffin wax used by Petrie as preservative; hydroxyproline separated from unused epiphyses could be dated by accelerator method (Burleigh, in press).

**Papua New Guinea**

**Padad Kao series**

Charcoal from ditch intersections in rectangular system of relict agric mounds now under secondary woodland at Padad Kao, 1km SW of Waidoro village, Western Prov (9° 10' S, 143° 0' E). Coll 1981 by J R Flenley, Dept Geog, Univ Hull and subm by D R Harris, Inst Archaeol, Univ London.

**BM-2093.** Padad Kao

Charcoal, ref Pad 1, 20 to 25cm depth.

**BM-2094.** Padad Kao

Charcoal, ref Pad 1, 25 to 30cm depth.

**BM-2138.** Padad Kao

Charcoal, ref Pad 6, 45cm depth.

General Comment (DRH): recent age of site unexpected; cf date of 780 ± 70 bp (Beta Analytic Inc, unpub) for midden under similar site on nearby island of Saibai (Harris & Laba, 1982; Barham & Harris, in press).
Poland

Wierzbica series

BM-2103. Wierzbica, Zele
Charcoal, ref 1/15, from Cutting II/81, Shaft 11, 280cm depth.

BM-2104. Wierzbica, Zele
Charcoal, ref 2/5, from Cutting II/81, Shaft 9, 200cm depth.

BM-2105. Wierzbica, Zele
Charcoal, ref 3/76, from Cutting I/80, Shaft 8, 170cm depth.

BM-2107. Wierzbica, Zele
Charcoal, ref 5/10, from Cutting II/81, Shaft 11, 230cm depth.

General Comment (RB): dates relate to later occupation of site and not to Early Bronze age (ca 2000-1500 bc) or Neolithic (ca 4200-2000 bc) mining activity, for which there is clear archaeol evidence, or possible terminal Palaeolithic flint exploitation (ca 10,000-8000 bc), for which there is independent archaeol evidence (Lech, 1979; 1981).

Sardinia

BM-2139. Grotta Filiestru
Collagen from bulked post-cranial bones (ref GFM D61-65) of extinct lagomorph (Prolagus sardus) id by Marsha Levine, Dept Archaeol, Univ Cambridge, from lowest level of fill (Trench D, Layers 7-9) in limestone cave with ca 3m undisturbed occupation deposits, Grotta Filiestru, near Bonu Ighinu, commune of Mara, Sassari prov, 30km S of Sassari (40° 30' N, 8° 40' E). Coll 1980 and subm by D H Trump to provide date for P sardus and for comparison with unpub date for earliest human occupation of cave (Q-3020, 6710 ± 75; Trump, 1983). Comment (RB): result suggests P sardus abandoned Grotta Filiestru well before time of earliest evidence for human occupation, although there is evidence for its later presence (ca 5000 bp) in less frequented neighboring cave of Su Tintirriolu (Loria & Trump, 1978). Prolagus survived in Sardinia until historic period (Clutton-Brock, 1981, p 146).

Spain

BM-1988. Ferrandell Oleza
Collagen from teeth and bone sample, from Exploratory Trench
West, Level II at Beaker settlement site at Ferrandell Oleza, Old Settlement, Valldemosa, Mallorca, Baleares (39° 40' N, 2° 30' E), assoc with Beaker pottery, worked flints, and domestic animal remains. Coll 1981 and subm by W H Waldren, Donald Baden-Powell Quaternary Research Centre, Pitt Rivers Mus, Univ Oxford and Dir, Deya Archaeol Mus and Research Centre, Deya de Mallorca. Comment (RB): date is later than expected (ca 2000 bc).

**BM-2001. Olive wood**

Olive wood (Olea europaea) from heartwood of once-large, but gnarled and heavily wind-sculpted living tree on rocky outcrop on cultivation terrace at ca + 300m, near Deya de Mallorca, Mallorca, Baleares (39° 45' N, 2° 40' E). Coll 1981 and subm by R Burleigh. Measured to check age of > 1000 yr frequently claimed for some of trees, and help estimate min age of construction of stone cultivation terraces and irrigation cisterns. Comment (RB): date does not support supposition of great age for individual olive trees based on ancient appearance and large size.

175 ± 30
$\delta^{13}C = -25.6\%o$

**BM-2140. Son Matge**


2820 ± 40
$\delta^{13}C = -16.0\%o$

**BM-2064. Chinflon**

Cellulose extracted from wood sample id as Erica arborae by Rowena Gale, Royal Botanic Gardens, Kew, from 15m depth at junction of modern and earlier mineshafts (Rothenburg & Blanco Freijeiro, 1980) in mine at Chinflon, Huelva Prov (37° 40' N, 6° 40' W). Coll 1981 and subm by P T Craddock, Research Lab, British Mus. Comment (PTC): for other dates from site cf R, 1982, v 24, p 252. Excavations from top of some of ancient mines have produced evidence of Phoenician reworking. Top of this shaft cut underground has not yet been located on surface. Date shows ancient mines are much more extensive than previously thought.

2440 ± 50
$\delta^{13}C = -23.2\%o$

**Syria**

**Tell Nebi Mend series**

Samples from long sequence of stratified material from multi-period site at Tell Nebi Mend, Qadesh, 30km SW of Homs (34° 30' N, 36° 30' E). Dates from 2nd and 1st millennia can be compared with those derived from refs to site in Egyptian, Hittite, and Assyrian texts; 3rd millennium dates should help with Ebla controversy. Coll 1977-1981 and subm by P J Parr, Inst Archaeol, Univ London.
**BM-2029. Tell Nebi Mend**
Wood charcoal, ref S 109, from VII 100.16.

**BM-2030. Tell Nebi Mend**
Wood charcoal, ref S 121, from V 105.5.

**BM-2032. Tell Nebi Mend**
Wood charcoal, ref S 249, from III 206.24.

**BM-2033. Tell Nebi Mend**
Wood charcoal, ref S 251, from III 203.63.

**BM-2034. Tell Nebi Mend**
Wood charcoal, ref S 258, from V 105.42.

**BM-2035. Tell Nebi Mend**
Wood charcoal, ref S 278, from III 206.15.

**BM-2036. Tell Nebi Mend**
Charcoal, ref S 280, from VIII 600.29.

**BM-2037. Tell Nebi Mend**
Charcoal, ref S 281, from III 206.35.

**BM-2038. Tell Nebi Mend**
Charcoal, ref S 283, from V 105.7.

**BM-2039. Tell Nebi Mend**
Charcoal, ref S 285, from VIII 602.16.

**BM-2040. Tell Nebi Mend**
Charcoal, ref S 288, from III 204.17.

\[ 3310 \pm 35 \quad \delta^{13}C = -22.0\% \]

\[ 2700 \pm 40 \quad \delta^{13}C = -20.4\% \]

\[ 2925 \pm 45 \quad \delta^{13}C = -22.4\% \]

\[ 2200 \pm 50 \quad \delta^{13}C = -24.7\% \]

\[ 2415 \pm 40 \quad \delta^{13}C = -22.6\% \]

\[ 3000 \pm 35 \quad \delta^{13}C = -21.6\% \]

\[ 4220 \pm 120 \quad \delta^{13}C = -22.4\% \]

\[ 2720 \pm 230 \quad \delta^{13}C = -25.0\% \]

\[ 2390 \pm 45 \quad \delta^{13}C = -22.2\% \]

\[ 4180 \pm 90 \quad \delta^{13}C = -23.1\% \]

\[ 3140 \pm 60 \quad \delta^{13}C = -20.3\% \]

**General Comment** (PP): any comments must be tentative until stratigraphy and assoc. material have been fully studied. Ceramic chronology for this part of Syria is at present poorly known; it is hoped excavation will add to refinement of this. BM-2038 is now known to be from mixed provenance and should be disregarded. BM-2033 and -2034 appear to be several centuries too young even when calibrated and are probably contaminated. BM-2029, -2032, -2035, -2037, -2040, and possibly BM-2030 fit pottery evidence when calibrated (Clark, 1975). BM-2036 and -2039 fit estimated dates best if uncalibrated. Inconsistencies can only be resolved when further samples have been analyzed and stratigraphy of site correlated with dated hist events and textual material.
**United States**

**Indian Fort Road series**


80 ± 35

**BM-2120. Indian Fort Road**

Charcoal, ref 69 (Fagus sp) id by Joan Sheldon, Inst Archaeol, Univ London.

200 ± 30

**BM-2121. Indian Fort Road**

Charcoal, ref 57.

125 ± 40

**BM-2122. Indian Fort Road**

Charcoal, ref 60 (Quercus sp) id by Joan Sheldon.

*General Comment* (KT & DMJ): interpretation of results is complicated by difficulty of calibrating dates of period. BM-2121 seems to fit best with archaeol and documentary evidence from site.

**GEOLOGIC SAMPLES**

**Copal series**

Copal (resin) of E African origin (ca 7° S, 38° E; precise locality and date of colln unknown). Subm by P E S Whalley, Dept Entomol, British Mus (Nat Hist), to provide date for large pieces in British Mus (Nat Hist) colln having numerous insect inclusions.

10 ± 50

**BM-2115. E African copal**

δ¹³C = -26.0‰

50 ± 50

**BM-2116. E African copal**

δ¹³C = -21.5‰

*General Comment* (RB): insect inclusions in copal ca < 25,000 yr old are of little palaeontol value despite frequent near-perfect 3-dimensional preservation; copal has generally been assumed to be of “Pleistocene” age (*ie*, not less than ca 1Myr), but these results, together with others in series (R, 1982, v 24, p 256), show that entomol study of African and other copal (gum) cannot be undertaken without support of definite (min) date for pieces studied (Burleigh & Whalley, in press).

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LA JOLLA NATURAL RADIOCARBON MEASUREMENTS X

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INTRODUCTION

The following date list covers samples dated by the La Jolla (Mt Soledad) Radiocarbon Laboratory from January 1979 through August 1982. Most archaeologic, most geologic, and some geochemical samples measured during that period are included here. Results of 14C analyses of samples of tree rings, banded coral rings, and Antarctic seawater dissolved inorganic carbon measured during this period will be published elsewhere. Because of the cessation of all federal grant funding of this laboratory, this is the last date list to be published by it.

Sample preparation methods have remained the same as described by Linick (1977). Seven gas proportional counters described previously by Linick (1977; 1979) and a 0.2L copper counter were used. As previously, results reported here are based on 95% of NBS oxalic acid activity normalized to a δ13C of −19‰ (PDB). All sample activities have been normalized to a δ13C of −25‰ (PDB). Measured δ13C values are given for all samples for which the measurement was made; the mass spectrometric analyses were performed on CO2 prepared by complete recombustion of an aliquot of the acetylene counting gas sample except for the small number of cases in which CO2 was counted. Ages listed are conventional radiocarbon ages based on the 5568-year Libby 14C half-life; listed uncertainties are one sigma statistical standard errors. Conventional ages for shells and carbonate sediments must be considered to be “apparent ages” only (Linick, 1979); estimated reservoir ages must be subtracted from them for proper interpretation. Where applicable, “calibrated” dates corresponding to the probable time of origin of terrestrial plant or animal organic material are given at the end of the sample descriptions. The estimated most probable date or range of dates is given, followed in parentheses by the range of dates corresponding to the 95% confidence interval. For the AD period, both the most probable date(s) and the 95% confidence interval were determined from Stuiver (1982, fig 3). For the BC period, the most probable date(s) were determined from Suess (1979, table 1) and from unpublished measurements by the La Jolla laboratory; for the BC period, the 95% confidence interval was determined from Klein et al (1982, table 2). Δ values have been age-corrected from the year of collection or growth to 1950.

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Space Institute. Samples were prepared by S M Griffin, C S Hutto, and T L Jackson. S M Griffin, C S Hutto, and E M Druffel assisted in measuring the samples. D K Sullivan maintained the electronic equipment.

ARCHAEOLOGIC SAMPLES
United States

Most samples are from the Pacific coast. Listings are ordered from north to south.

Oregon

LJ-5646. Manzanita
Beeswax probably assoc with shipwreck at beach at Manzanita (45° 43' N, 123° 57' W). Specimen removed from center of larger sample stored since ca AD 1900 in mus colln. No known treatment of specimen. Coll ca 1900; subm by J A Woodward, Mt Hood Comm Coll, Gresham, Oregon. Comment (JAW): shipwreck thought to be from 16th, 17th, or early 18th century AD. Calibration: AD 1540, 1630 (1490 to 1650).

LJ-5267. Nehalem Bay
Wood splints from woven mat from underwater site at Nehalem Bay, Tillamook Co (45° 42' N, 123° 55' W). Found ca 2m below mean tide level, under 50cm of fine silt. From aboriginal fish weir (?) of Late Prehistoric or Historic period. Wood id by Center for Wood Anatomy Research as Western Larch (Larix occidentalis) or Douglas Fir (Pseudotsugu menziesii). Coll July 1980 and subm by J A Woodward. Comment (JAW): dating of aboriginal construction of weir is relevant to reconstruction of sea level and local environmental changes in Nehalem Bay during last 2000 yr. Calibration: AD 1470 (1420 to 1640).

LJ-5300. Nehalem Bay
Charcoal from Indian midden found below high tide level in Nehalem Bay (45° 42' N, 123° 55' W). Coll Sept 1980 and subm by J A Woodward. Dated to reconstruct environmental changes in Nehalem Bay in last 500 yr. Calibration: AD 1640 (1500 to 1670, 1740 to 1800).

LJ-5119. Gladstone

California
Fort Irwin series

Fragmented charcoal from Fort Irwin, on Drinkwater Lake, San Ber-
LJ-5499.  Fort Irwin, SBr-4446  
$\delta^{14}C = -14.5\%$

Charcoal fragments from Site SBr-4446, N shore of Drinkwater Lake, Fort Irwin (35° 29' 30" N, 116° 31' 30" W). From Unit E1-N0, 0 to 10cm depth. Site is small camp with ca 30 flakes, metates, burned animal bone; shallow deposit to ca 10cm depth. Calibration: AD 1660 (1530 to 1690, 1720 to 1810, 1920 to 1950).

LJ-5500.  Fort Irwin, SBr-4449  
$\delta^{14}C = -22.6\%$

Charcoal fragments from Drinkwater Basin, Fort Irwin (35° 29' 15" N, 116° 32' 00" W), from Unit 11, 60 to 70cm depth. Site consists of surface scatters of ca 5600m² and 300m² areas of developed midden near granitic bedrock overhangs. Based on artifact types, sample was expected to date no older than AD 450. Calibration: AD 540 (340 to 650).

1040 ± 50  
LJ-5501.  Fort Irwin, SBr-4449  
$\delta^{14}C = -22.6\%$

Charcoal fragments from Drinkwater Basin, from Unit 1, 40 to 50cm depth. *Comment* (RHN): $^{14}C$ date serves as calibration for obsidian hydration rate, for dating Anasazi contact in region, for temporal context for mt base exploration, and for diversity of artifact types. Calibration: AD 990 (880 to 1040, 1090 to 1150).

Tustin Plain series


1900 ± 50  
LJ-4810.  Tustin Plain, 34-64cm  
$\delta^{14}C = + 0.7\%$

Shells (*Chione* sp) from Loc C, Test Unit 2, 34 to 64cm depth.

2480 ± 70  
LJ-4812.  Tustin Plain, 60-70cm  
$\delta^{14}C = + 1.4\%$

Shells (*Aequipecten circularis*) from Loc AB, Test Unit 2, 60 to 70cm depth.

2640 ± 70  
LJ-4811.  Tustin Plain, 70-80cm  
$\delta^{14}C = + 1.8\%$

Shells (*Aequipecten circularis*) from Loc AD, Test Unit 2, 70 to 80cm depth.

Newland House series

Samples from Newland House site, CA-Ora-183, on bluff above Santa Ana R basin, Huntington Beach, Orange Co (33° 40' 33" N, 117° 59' 10" W). From Test Unit No. 14, Level 5, 50 to 60cm depth, in immediate assoc with cogstone. Coll Aug 1979 by Joyce Clevenger, Johann Anderson,
and Steven Goerke; subm by Constance Cameron, Anthropol Mus, California State Univ, Fullerton. Comment (CC): samples analyzed to date cogstone. First cogstone found in immediate assoc with datable material. Samples were of primary importance in delineating Orange Co chronology.

13,900 ± 500  
LJ-4999. Newland House, charcoal  
\[ \delta^{13}C = -24.9\%o \]  
Charcoal. Comment: age was far greater than expected; thus there is some question whether sample might have been contaminated with \(^{14}C\)-free asphaltic material (see Venkatesan et al, 1982).

5090 ± 100  
LJ-5002. Newland House, shell  
Whole and fragmented shell (Chione).

1230 ± 60  
LJ-4813. Upper Newport Canyon  
\[ \delta^{13}C = + 0.9\%o \]  
Shells (Chione) from Site CA-Ora-287, on crest (alt 12.3m) of small knoll at NW extremity of Upper Newport Canyon, Orange Co (33° 40' N, 117° 51' W). From Test Unit 1, 30 to 40cm level. Coll Nov 1978 and subm by Adella Schroth. Measured to determine temporal placement of site within Upper Newport series.

820 ± 90  
LJ-4867. Upper Oso Drainage  
\[ \delta^{13}C = -25.5\%o \]  
Charcoal from Site CA-Ora-727, in Upper Oso Drainage, Orange Co (33° 39’ 00” N, 117° 37’ 30” W), from 30 to 50cm depth. Coll July 1979 and subm by J L Craib, Archaeol Resource Management Corp. Comment (JLC): sample dated to further define chronol ordering of early-late period in Mission Viejo environs. Date helps analyze contemporaneous site types in terms of general settlement system. Calibration: AD 1240 (1000 to 1320, 1370 to 1380).

Sand Canyon Wash series  
Samples from Site CA-Ora-379 in Sand Canyon Wash, San Joaquin Hills, Orange Co (33° 38’ 52” N, 117° 47’ 54” W), alt 76 to 84m. Sand Canyon Wash (in N portion of San Joaquin Hills) drains from N to S until it reaches Tustin floodplain area, where it turns W to eventually join San Diego Creek, a major tributary of Upper Newport Bay. It is ca 6.4km from mouth of wash to present Upper Newport Bay. Coll Sept 1979 and subm by R D Douglas, Larry Seeman Assoc, Inc (formerly Archaeol Planning Collaborative), Newport Beach.

240 ± 40  
LJ-5117. Sand Canyon Wash, charcoal  
\[ \delta^{13}C = -26.1\%o \]  
Charcoal from Rockshelter No. 1, TT5, 40cm depth. Calibration: AD 1650 (1530 to 1690, 1730 to 1810, 1940 to 1950).

1610 ± 40  
LJ-5118. Sand Canyon Wash, shell  
\[ \delta^{13}C = + 0.9\%o \]  
Shell (Aequipecten circularis) from open midden loc at habitation site, Unit 6, 40 to 50cm depth.
Coyote Canyon series

Samples from fire hearth features at small Late Prehistoric campsite, CA-Ora-227, Coyote Canyon drainage of San Joaquin Hills region near city of Irvine, Orange Co (33° 37' 22" N, 117° 49' 50" W). Site is ca 6.5km N of Pacific Ocean and 4.8km E of Upper Newport Bay at alt 109m on S-facing slope of small tributary drainage of Coyote Canyon. Prior to excavation, site consisted of small, oval-shaped shell midden, ca 384m². Ca 5% of surface area of midden deposit was excavated before site was destroyed during expansion of Coyote Canyon Landfill Facility. Coll Aug 1979 and subm by R D Douglas.

LJ-4997. Coyote Canyon, charcoal, Unit 8 $\delta^{14}C = -25.2\%o$

Charcoal from Unit 8, Feature 4, 20cm below ground level. Calibration: AD 1650 (1500 to 1690, 1720 to 1810, 1930 to 1950).

LJ-4998. Coyote Canyon, charcoal, Unit 2 $\delta^{14}C = -25.2\%o$

Charcoal from Unit 2, Feature 1, 15cm below ground level. Comment: previous measurements for charcoal samples from fire hearth feature in Unit 2 at same site are 230 ± 70 for 10 to 20cm below ground level and 330 ± 70 for 30 to 40cm below ground level (LJ-4254 and -4255, respectively: R, 1980, v 22, p 1035). Comment (RDD): results for all charcoal at site suggest that site was occupied after AD 1500. Date is important for understanding of aboriginal cultural patterns of period just prior to European contact in coastal Southern California. Calibration: AD 1650 (1490 to 1880, 1920 to 1950).

LJ-5000. Coyote Canyon, shell, Unit 7 $\delta^{14}C = +1.2\%o$

Shell (Ostrea lurida) from Unit 7, 10 to 20cm below ground level.

LJ-5001. Coyote Canyon, shell, Unit 8 $\delta^{14}C = +1.3\%o$

Shell (Chione undatella) from Unit 8, 10 to 20cm below ground level. Comment: charcoal sample LJ-4997, above, and this shell sample came from essentially same provenience. Shell sample appears to be 650 ± 70 yr older ($^{14}C$ depletion of 8 ± 1%), somewhat larger than usual marine reservoir effect in area.

Laguna Beach series

Nine shell samples from coastal sites in and near Laguna Beach, Orange Co. Coll and subm by N M Magalousis, Chapman Coll, Orange. Comment (NMM): samples dated to establish basis for more acceptable and realistic chronology for Laguna Beach area. Some samples may qualify for National Registry status. Ages were expected to range between 3000 and 9000 BP. Only two Laguna Beach sites dated previously ("Laguna Woman" site and Site CA-Ora-370). Samples related directly to gap in recent known dates and "Laguna Woman" find. For Crescent Bay sites, aim was to date change of subsistence levels at site from period of over-extrac-
tion of food from local estuary to period of definitive decrease of shell size, types, and volume. *Comment:* ages for shells from Site Ora-370, rock shelter in Sycamore Hills area of Laguna Beach (33° 33' N, 117° 46' W), are 810 ± 50 and 1310 ± 40 (LJ-3449 and -3515, respectively: R, 1979, v 21, p 187).

**LJ-4878. Crescent Bay**

δ¹³C = + 0.7‰

Shell fragments from Site CA-Ora-596, Crescent Bay, Laguna Beach (33° 32.7' N, 117° 48.1' W). Site is coastal cliff site, first prehistoric shelter found in Laguna Beach. From Sounding 1, Loc B, Level 6, 50 to 60 cm depth. Coll Sept 1978.

**LJ-4879. Crescent Bay**

δ¹³C = + 1.2‰

Shell fragments from Site CA-Ora-596 (see LJ-4878, above). From Sounding 1, Loc C, Level 7, 70 to 80 cm depth. Coll Sept 1978.

**LJ-5292. Crescent Bay Park #1**

δ¹³C = + 2.0‰

Shells from Crescent Bay Park site, on cliff edge overlooking Pacific Ocean, Laguna Beach (33° 32.7' N, 117° 48.1' W). This is portion of village site of major importance. From Test Pit 3, Level 3, 34 cm depth. Coll July 1979.

**LJ-5293. Crescent Bay Park #2**

δ¹³C = + 1.8‰


**LJ-5294. Crescent Bay Park #3**

δ¹³C = + 1.5‰


**LJ-5295. Crescent Bay Park #4**

δ¹³C = + 1.9‰


**LJ-5296. Dolley #1**

δ¹³C = + 1.4‰

Shells from Dolley site, coastal site on cliff edge next to Pacific Ocean, South Laguna Beach (33° 30' N, 117° 45' W). From Test Pit 5, E corner of Dolley property, Level 3, 39 cm depth. Coll June 1979.

**LJ-5297. Fowlie #1**

δ¹³C = + 2.0‰

Fragmented, crumbly shells from Fowlie site, hunting site in San Joaquin Hills, ca 400m from Pacific Ocean, South Laguna Beach (33° 30' N, 117° 45' W). From Test Pit 5, Level 3, 30 to 40 cm depth. Coll June 1979.
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LJ-5298.  Fowlie #2

Shells from Fowlie site (see LJ-5297, above). From Test Pit 2, Level 1, Feature 1, 10cm depth. Coll June 1979.

San Dieguito River Valley series

Ten shell samples coll from S side of San Dieguito River Valley, E of Camino Real, city of Del Mar, San Diego Co. Coll and subm by R H Norwood. Measured to date occupation of sites by La Jolla Indian culture.

LJ-1608.  SDM-W-40 West

Shells from Site SDM-W-40 West, E of and adjacent to El Camino Real (33° 13’ 50” N, 117° 58’ 22.2” W). From Unit E104/N100, 30 to 40cm depth at W-40 West loc. Coll Aug 1978.

LJ-1609.  SDM-W-40


LJ-1610.  SDM-W-1584

Shells (Chione) from Site SDM-W-1584, “La Jolla” site on knoll overlooking Gonzalez Canyon to S (33° 13’ 37.5” N, 117° 58’ 18.1” W). From Unit E110/N100, 40 to 50cm depth. Coll Aug 1978. Expected to date probable second and later occupation of site.

LJ-1611.  SDM-W-1584

Shells (Pecten) from Site SDM-W-1584 (see LJ-1610, above). From Unit E112/N91, 80 to 90cm depth. Coll Sept 1978. Dates lower occupation of probable two-component La Jolla site.

LJ-1612.  SDM-W-1585

Shells (Chione) from Site SDM-W-1585, La Jolla site on knoll overlooking San Dieguito R to N (33° 13’ 30” N, 117° 58’ 23.8” W). From 20 to 30cm depth. Coll July 1978.

LJ-1613.  SDM-W-1585

Shells (Pecten) from Site SDM-W-1585 (see LJ-1612, above). From Unit E101/N78, 30 to 40cm depth. Coll July 1978.

LJ-1614.  SDM-W-1586

Shells (Pecten) from Site SDM-W-1586 (SDi-194), La Jolla site on high knoll overlooking San Dieguito R to N (33° 13’ 10.4” N, 117° 58’ 20.8” W). From Unit E210/N98, 20 to 30cm depth. Coll Aug 1978. Site previ-
olutely studied by Warren, True, and Endley in 1960’s. This dating permits temporal assessment of occupation studied by them.

**LJ-4616. SDM-W-1667**

Shells from Site SDM-W-1667, La Jolla site between W-1587 and W-1588 (33° 12’ 46.4” N, 117° 58’ 24.3” W). From Unit E101/N71, 30 to 40cm depth. Coll Aug 1978.

6490 ± 110
\[ \delta^{13}C = + 1.5\% \]

**LJ-4615. SDM-W-1588**

Shells (Chione) from Site SDM-W-1588, La Jolla site on highest knoll between El Camino Real and McGonigle Canyon, on S side of San Dieguito R at Zanja Marker (33° 12’ 32.7” N, 117° 58’ 26” W). From Unit E106/N205, 70 to 80cm depth. Coll Sept 1978.

7720 ± 100
\[ \delta^{13}C = + 0.8\% \]

**LJ-4607. SDM-W-1558**

Shells (Chione, Pecten) from Site SDM-W-1588 (see LJ-4615, above). From Unit E111/N210, 80 to 90cm depth. Coll Aug 1978.

8290 ± 100
\[ \delta^{13}C = + 2.0\% \]

**LJ-5270. Merriam Mts**

Charcoal flecks from Site SDM-W-1934 (SDi-5951), immediately N of Deer Springs Rd, ca 1200m E of its junction with US Hwy 395, in Merriam Mts, E of Vista and NW of Escondido, San Diego Co (33° 12’ N, 117° 08’ W). From Unit B, 20 to 30cm depth. Site attributed to Luiseño inhabitants of Late Prehistoric period. Animal bone fragments and Tizon Brown Ware potsherds found in upper 20cm of unit. Coll June 1979; subm by C R Lorenz, Advance Planning and Research Assocs, San Diego. Calibration: AD 1520, 1610 (1440 to 1660).

330 ± 60
\[ \delta^{13}C = -25.2\% \]

**LJ-4880. Fire Mt Ridge**

Six shells (Chione) from Site SDM-W-2115, on S slope of Fire Mt Ridge System at alt 67 to 79m in Oceanside, San Diego Co (33° 11’ 30” N, 117° 19’ 58” W). From Unit E93/N20 of shell midden site with small amount of lithics, dimensions 90m N-S by 75m E-W, 40 to 50cm depth. Coll June 1979 and subm by Carol Walker, Regional Environmental Consultants. Dated to place site in regional chronology.

1470 ± 70
\[ \delta^{13}C = + 1.4\% \]

**Grapevine Canyon series**

Two charcoal samples from Huffman site, SDi-1009, in Grapevine Canyon, S of Ranchita, San Diego Co (33° 11’ N, 116° 31’ W). Samples are occupational debris from Test Unit 4 of disturbed campsite with milling and cupule features, suggesting some religious significance. Coll Apr 1979 and subm by H K Polan, Archaeol Consulting and Technol, Inc, El Cajon.

**LJ-4753. Grapevine Canyon, 40-50cm**

Charcoal from 40 to 50cm below surface. Calibration: AD 1330, 1350, 1390 (1260 to 1470).

580 ± 90
\[ \delta^{13}C = -23.0\% \]
La Jolla Natural Radiocarbon Measurements X

LJ-4754. Grapevine Canyon, 50-60cm
Charcoal from 50 to 60cm below surface. Calibration: AD 1240 (1040 to 1290).

Shadow Ridge series

LJ-5112. Shadow Ridge #1
Charcoal from Test Unit W78/S10, 30 to 40cm level. Calibration: AD 1320, 1360, 1390 (1280 to 1430).

LJ-5113. Shadow Ridge #2
Charcoal from Test Unit W78/S10, 40 to 50cm level. Calibration: AD 1420 (1300 to 1470).

LJ-5114. Shadow Ridge #3
Charcoal from Test Unit W107/S46, 30 to 40cm level. Calibration: AD 1460 (1420 to 1640).

LJ-5115. Shadow Ridge #4
Charcoal from Test Unit W107/S46, 40 to 50cm level. Calibration: AD 1420 (1300 to 1440).

LJ-5427. Carlsbad
Fragmented shell from Site SDM-W-133, above Agua Hedionda Lagoon at end of Skyline Rd, Carlsbad, San Diego Co (33° 09' 11" N, 117° 19' 04" W). From Unit E1025/N845, 10 to 20cm below ground surface. Coll Feb 1981 and subm by S M Hector, Regional Environmental Consultants. Comment (SMH): pottery fragments were found at site, and age helps date introduction of ceramics into Luiseno Indian territory from S. Possible multiple occupations of site.

La Costa series
Four shell samples from Site SDM-W-110, shell midden immediately E of El Camino Real between Palomar Airport Rd and La Costa Ave/Alga Rd, near La Costa, San Diego Co (33° 06' 03" N, 117° 16' 00" W). Site may be multi-component, representing Early Milling and Late Prehistoric occupations.

LJ-5299. SDM-W-110
Shell from Unit E350/N400, 50 to 60cm depth. Coll July 1980 and subm by Carol Walker.
LJ-5483. SDM-W-110
Shell from Unit E322/N422, 50 to 60cm depth. Coll Jan 1981 and subm by S M Hector and Carol Walker.

LJ-5484. SDM-W-110
Shell from Unit E318/N439, 40 to 50cm depth. Coll Jan 1981 and subm by S M Hector and Carol Walker.

LJ-5485. SDM-W-110
Shell from Unit E312/N458, 30 to 40cm depth. Coll Jan 1981 and subm by S M Hector and Carol Walker.

El Camino Real/Encinitas Blvd series

LJ-4569. SDM-W-1805, 10-20cm
Charcoal from Site SDM-W-1805, ca 760m NW of intersection of El Camino Real and Encinitas Blvd in rd cut that runs E-W along boundary of Secs 11 and 14, San Diego Co (ca 33° 03' 02.2" N, 117° 15' 51.9" W). From Unit 1, 10 to 20cm depth. This sample and LJ-4570, below, dated to determine duration of site occupation. Calibration: AD 640 (530 to 720, 750 to 770).

LJ-4570. SDM-W-1805, 50-60cm
Charcoal from Site SDM-W-1805 (see LJ-4569, above). From Unit 1, 50 to 60cm depth, from ca 170cm away from LJ-4569, above. Comment: age slightly less than that for shallower sample from site. Calibration: AD 780 (660 to 980).

LJ-4567. SDM-W-638
Charcoal from Site SDM-W-638, atop low knoll ca 520m WNW of intersection of El Camino Real and Encinitas Blvd, San Diego Co (ca 33° 02' 49" N, 117° 15' 49.9" W). Sample B from Feature II. Charcoal assoc with exposed roasting pit in which diagnostic artifacts were absent. Sample appeared to contain significant amount of lighter material, some of which was removed during lab pretreatment. Calibration: AD 1070, 1130, 1160 (1000 to 1260).

Fairbanks Ranch series
Ten shell samples from Fairbanks Ranch, Lower San Dieguito Valley, San Diego Co (ca 33° 00' N, 117° 11' W). Site is highly disturbed, relatively large Early Milling site in lemon and orange orchards. Mean depth of deposits is 40 to 50cm, with shell relatively scarce and predominantly

**LJ-5160. SDM-W-1356; 21-2; 180**

Whole and fragmented shells (Chione) with eroded surfaces, from 10 to 20cm depth of Site W-1356 (33° 00' 32" N, 117° 10' 44" W). Site is relatively small, shallow (ca 30cm) satellite camp of Early Milling occupation, possibly contemporaneous with Site SDM-W-593, below. At SDM-W-1356, shell is scarce and entirely Chione.

**LJ-5161. SDI-150C; 4-1,2,3; 475,479,481**

Very eroded, fragmented shells (Chione) from 0 to 30cm depth at site SDI-150C (33° 00' 16" N, 117° 10' 56" W). Site is a lightly disturbed, relatively large Early Milling deposit, ca 40cm in depth. *Comment* (RHN): specimens provide only opportunity to date substantial Early Milling occupation in which very little shell is present, representing either temporal or functional difference.

**LJ-5028. SDM-W-593A; 32-4; 1968**

Eroded and fragmented shells (Chione, some Pecten) from 30 to 40cm depth in Site W-593A (33° 00' 14" N, 117° 11' 22" W). Site has deposit ca 40cm in depth and is in lemon grove.

**LJ-5030. SDM-W-593A; 3-4; 1774**

Eroded shell fragments (Chione) from 30 to 40cm depth in Site W-593A (see LJ-5028, above). Site apparently represents base camp of relatively large size, surrounded by smaller, non-datable sites. *Comment* (RHN): obsidian was recovered from 10 to 20cm level of this unit; hydration measurement is 5.2µ, with possible age of 5426 yr BP.

**LJ-5029. SDM-W-593B; 42-4; 2131**

Eroded shell (Chione) from 30 to 40cm depth in Site W-593B (33° 00' 13" N, 117° 11' 23" W). *Comment* (RHN): specimens were obtained from shell lens and were directly assoc with obsidian giving hydration measurements of 5.9µ, 8.2µ, and 5.3µ, corresponding to possible absolute age range of 5045 to 7086 yr BP.

**LJ-5155. SDM-W-593B; 16-3; 14**

Relatively large shell fragments (Chione) from lens at 20 to 30cm depth at Site W-593B (33° 00' 13" N, 117° 11' 23" W).

**LJ-5156. SDM-W-593C; 26-3; 14**

Relatively small, eroded shell specimens (Chione) from 20 to 30cm depth at Site W-593C (33° 00' 11" N, 117° 11' 24" W).
86

T W Linick

LJ-5157. SDM-W-593C; 58-3; 2237

6520 ± 70

Eroded shells (Chione, some Pecten) from 20 to 30cm depth at Site W-593C (see LJ-5156, above).

LJ-5158. SDM-W-596; 26-5; 704

7110 ± 70

Whole shells (mixed Pecten, Chione) from lens at 40 to 50cm depth at Site W-596 (32° 59' 59" N, 117° 10' 46" W). Relatively abundant Pecten and Chione shells were found at site. Age helps date subsistence change (from Pecten to Chione). Site is anomaly in immediate area and may represent different occupation or function.

LJ-5159. SDM-W-596; 38-7; 875

7230 ± 80

Fragmented shells (mixed Chione, Pecten) from lens at 60 to 70cm depth at Site W-596 (see LJ-5158, above). Date places lower, relatively undisturbed portion of site in temporal perspective at period when diversity of shell sp was exploited.

San Clemente Island series

Sixteen samples from San Clemente I., Southern California coastal island were coll and subm by L M Axford and assocs, Mesa Coll, San Diego. Samples measured to date human habitation on island and to contribute to S coastal chronology. Series previously reported in Linick (1979; 1980).

LJ-4172. SCLI/RC-10, charcoal

4500 ± 400


LJ-5411. SCLI/RC-19, shell

3520 ± 320

δ13C = 0.0‰

Marine shell from Site SCLI-36 (T-36) (33° 00' 08" N, 118° 34' 16" W). From center of site, from post hole ca 36cm deep. Coll Nov 1975 by L M Axford and Roxie Phillips.

LJ-4220. SCLI/RC-11, shell

300 ± 400

δ13C = + 2.8‰

Small piece of abalone shell from Site SCLI-1167, at S end of earthen dam in valley NW of national forest on main island rd (32° 58' 01.453" N, 118° 32' 27.240" W). Taken at depth 10 to 23cm. Coll Dec 1977 and subm by L M Axford and R M Carlson. Comment: age for charcoal sample

**LJ-5303. SCLI/RC-22, charcoal/seeds/ash/soil**

<table>
<thead>
<tr>
<th>2540 ± 210</th>
<th>Est ( \delta^{13}C = -25.0% )</th>
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**LJ-5037. SCLI/RC-22, shell**

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<tr>
<th>2730 ± 90</th>
<th>( \delta^{13}C = + 1.2% )</th>
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Shell from same provenience as LJ-5303, above. Coll May 1979 and subm by L M Axford.

**LJ-4646. SCLI/RC-16, charcoal**

<table>
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<tr>
<th>1840 ± 60</th>
<th>Est ( \delta^{13}C = -25.0% )</th>
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**LJ-4673. SCLI/RC-17, shell**

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<tr>
<th>960 ± 60</th>
<th>( \delta^{13}C = + 1.5% )</th>
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Five black abalone shells, each ca 3.8 to 8.9cm long, from Site SCLI-1360 (32° 56’ 47.87” N, 118° 29’ 49.12” W). From collapsed rock shelter. Coll Nov 1978 and subm by L M Axford and T Boone.

**LJ-4647. SCLI/RC-18, charcoal**

<table>
<thead>
<tr>
<th>1770 ± 60</th>
<th>( \delta^{13}C = -24.1% )</th>
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**LJ-4672. SCLI/RC-17, shell**

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<tr>
<th>850 ± 50</th>
<th>( \delta^{13}C = + 2.8% )</th>
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**LJ-5643. SCLI/RC-23, charcoal**

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<tr>
<th>500 ± 70</th>
<th>Est ( \delta^{13}C = -25.0% )</th>
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**LJ-5640. SCLI/RC-24, shell**

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<tr>
<th>1000 ± 60</th>
<th>( \delta^{13}C = 0.0% )</th>
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**LJ-5641. SCLI/RC-25, charcoal**


**LJ-5639. SCLI/RC-25, shell**

Shells (black abalone, owl limpet, and tegula sea snail) from same provenience as LJ-5641, above). Coll May 1977 by L M Axford and L D Lindmark; subm by L M Axford. Comment: even after subtracting marine reservoir age, shell age is much greater than that of LJ-5641 charcoal.

**LJ-5302. SCLI/RC-20, charcoal**


**LJ-5306. SCLI/RC-20, shell**

Green abalone shell from same provenience as LJ-5302, above. Coll Apr 1979 and subm by L M Axford and T Boone. Comment: even after subtracting marine reservoir age, shell age is much greater than that of LJ-5302 charcoal.

**LJ-5304. SCLI/RC-21, charcoal**


**Del Mar series**

Three shell samples taken to establish date for coastal shellfish exploitation sites in vicinity of Del Mar, San Diego Co. Subm by S M Hector.

**LJ-5665. SDM-W-25A**

Shells (Chione, Pecten) from Site SDM-W-25A, adjacent to San Dieguito Lagoon, Del Mar (32° 57' 30" N, 117° 14' 45" W), from 0 to 10cm depth. Coll May 1982 by S M Hector.

**LJ-5668. SDM-W-2302**

Shells (Pecten) from Site SDM-W-2302, adjacent to San Dieguito Lagoon, Del Mar (32° 57' 15" N, 117° 14' 30" W). From 0 to 10cm depth. Coll May 1982 by S M Hector.

**LJ-5667. SDM-W-1291A**

Shells (mainly Pecten, some Chione) from Site SDM-W-1291A, N of
Carroll Canyon, Del Mar (32° 56' 30" N, 117° 14' 30" W), from 70 to 100cm depth. Coll Oct 1980 by R H Norwood.

**Rancho Peñasquitos series**

Two charcoal samples from Rancho Peñasquitos area, San Diego Co, Coll July 1980 and subm by R H Norwood.

**LJ-5266. Rancho Peñasquitos, SDM-W-1339A**

Charcoal removed from bulk soil sample excavated at Site SDM-W-1339A, 100m S of intersection of Rancho Peñasquitos Blvd and Carmel Mt Rd, San Diego Co (32° 56' 20" N, 117° 07' 20" W), from 20 to 40cm depth. Site consists of portion of large Late Prehistoric village. Deposit is relatively shallow (ca 50cm) and may also have Early Milling component. *Comment* (RHN): only absolute date for occupation; it helps evaluate obsidian hydration results. Calibration: AD 1660 (1520 to 1880, 1910 to 1950).

**LJ-5265. Rancho Peñasquitos, SDM-W-1337**

Charcoal removed from large bulk soil sample excavated at Site SDM-W-1337, in canyon between Rancho Peñasquitos Blvd and Peñasquitos Canyon, San Diego Co (32° 56' 25" N, 117° 07' 25" W), from 20 to 40cm depth in deposit up to 100cm deep. Site consists of small Late Prehistoric campsite with developed midden of ca 600m² area. Ceramics and small desert side-notched points were present. *Comment* (RHN): only date for occupation. Date permits assessment of contemporaneous occupation of this site and SDM-W-1339 (see LJ-5266, above) to N. Calibration: AD 1640 (1520 to 1670, 1740 to 1800).

**LJ-5291. Sorrento Valley**

Carbonate from burned human rib bones from Bailey property, Site SDM-W-654, Roselle St, Sorrento Valley, San Diego Co (32° 54' 6" N, 117° 13' 9" W), Coll May 1980 and subm by R A Tyson, San Diego Mus of Man, San Diego. *Comment* (RAT): rib bones are from secondary burial which was being washed out of side of creek bed. There were parts of two individuals in burial—adult and adolescent. Both skeletons show signs of breaking and burning. Some bones were split and broken before they were burned. Soil contains shell and flakes, but no pottery. Soil is dark and contains small pieces of charcoal. Midden may be of La Jollan age, but human remains could be from later period.

**LJ-4568. Soledad Canyon**

Charcoal from Site SDi-4609, ca 180m N of terminus of Roselle St in Soledad Canyon, San Diego Co (ca 32° 53' 35.3" N, 117° 12' 56.9" W), From NW corner of Unit 1, 60cm depth. Unit was in well-developed drainage S of AT&SF RR track, ca 50cm from fill layer that was on top of natural ground surface: some of site was probably covered by this fill. Sample came from interface between ceramic and pre-ceramic-bearing de-

**Campus Point series**

Four shell samples from Site SDM-W-1668, designated Campus Point site, at junction of Interstate Hwy 5 and Genese Ave, San Diego (32° 53' 35" N, 117° 13' 18.37" W). Site is on gently sloping mesa, 11,000m² in area, at alt 107m. Coll Feb 1979 and subm by Darla Ferguson, Regional Environmental Consultants. Dated to determine whether there was temporal difference between two main areas of shell concentrations found at site. Comment: as seen from results below, answer remains ambiguous.

![Image](https://via.placeholder.com/150)

**LJ-4875. Campus Point, top of knoll**

One shell (Chione) from 10 to 20cm depth in smaller, shallower shell concentration on top of knoll.

**LJ-4877. Campus Point, top of knoll**

Two shells (Chione) from 30 to 40cm depth in smaller, shallower shell concentration on top of knoll.

**LJ-4876. Campus Point, SE of knoll**

Three shells (Chione) from 20 to 30cm depth in larger, deeper shell concentration SE of knoll.

**LJ-4874. Campus Point, SE of knoll**

Two shells (Chione) from 70 to 80cm depth in larger, deeper shell concentration SE of knoll.

**Santee Greens series**

Three charcoal samples from Santee Greens, Site SDi-5669, 60,000+ ha, dating to Late Archaic cultural horizon in Santee, San Diego Co (32° 51' 15" N, 116° 58' 08" W). Charcoal was assoc with potsherds. Coll May 1979 and subm by H K Polan. Dated to redefine advent of ceramic manufacture in area.

**LJ-4853. Santee Greens, 70-80cm**

Charcoal from Test Unit E188.5/N26.4, 70 to 80cm depth. Calibration: AD 1720, 1890, 1910 (1650 to 1950).

**LJ-4851. Santee Greens, 100-110cm**

Charcoal from Test Unit E188.5/N30.1, 100 to 110cm depth. Calibration: AD 1190 (1020 to 1270).

**LJ-4852. Santee Greens, 110-120cm**

Charcoal from Test Unit E188.5/N26.4, 110 to 120cm depth. Calibration: AD 1700, 1840, 1910 (1640 to 1950).
LJ-4565/LJ-4566. Encanto

Charcoal flecks from Site SDM-W-1504, “La Jolla” site in S Chollas drainage, on bench of land SW of intersection of 60th St and Federal Ave in Encanto area of San Diego (32° 43' 26.8” N, 117° 03' 43.44” W). Part of sample came from Unit E29/N45, 30 to 40cm depth, assoc with fire-cracked rock and burned artifacts; other part came from similar context in another unit. Site has been destroyed by grading and cannot be re-tested. Coll Dec 1977 and subm by R H Norwood. Comment (RHN): lack of shell and artifact morphology suggested age of ca 2500 to 3600 BP, possible period of re-adaptation from coastal to inland resources just prior to Yuman Indian intrusion. Calibration: 2100 to 1960 BC (2300 to 1710).

Mother Grundy Truck Trail series


LJ-5128. Mother Grundy, 20-30cm

Loose charcoal from Unit 318° 7m, 20 to 30cm level of unstratified midden. Sample is from deepest pottery-bearing level of unit. Non-ceramic-bearing levels were found below this level. While sample was found at relatively shallow level, there was no indication of disturbance, such as Historic artifacts or plowing, at this level. Calibration: AD 1440 (1410 to 1490).

LJ-5129. Mother Grundy, 90-100cm

Charcoal from Unit 318° 7m, 90 to 100cm level of unstratified midden. Sample is free from deep part of lower, aceramic phase of midden. Comment (DMVH): it was suspected that there might have been substantial time gap between deposits of ceramic and aceramic phases. Calibration: AD 1290 (1210 to 1420).

LJ-5094. Jacumba

Charcoal pieces dispersed from campfires at bottom of midden assoc with rock shelter at Site SDi-4326 near Jacumba, SE corner of San Diego Co (32° 39’ 16” N, 116° 10' 00” W). Site was Kumeyaay Indian village, Ha’a’weer. Charcoal recovered from 20 to 30cm depth level of test unit, 2m by 2m and 30 to 39cm deep. 20 to 30cm depth level was almost on bedrock, with max 39cm depth due to pocket of midden in rock. Coll Sept 1979 and subm by R V May, San Diego Co Archaeol Soc. Comment (RVM): area was not dated previously and was possibly earliest site for introduction of pottery and agric in area. Site was 1 of ca 6 major occupation sites in valley; rock shelter with “chain diamond” petroglyph was ca
2m E of test unit. Before this analysis, possible age of >2000 yr BP was hypothesized due to discovery of oxidized flakes; however, assoc of manos, small triangular arrow points, and non-oxidized flakes suggested more modern age. $^{14}$C date suggests that populations assoc with exploitation of Lake Cahuilla (AD 950 to 1500) moved W up into mts after dessication of region (AD 1450 to 1500). Impacts upon mt cultures are presently being studied. Calibration: AD 1470 (1420 to 1640).

**Santa Catalina Island series**

Two charcoal samples from UCLA Site No. SCaI-137, Bullrush Canyon Site No. 1, Santa Catalina I., Los Angeles Co (32° 21' N, 118° 27' W). Coll 3.62km from mouth of canyon, at 229m alt, NW corner of this Southern California coastal island. Coll Apr 1979 by M Cottrell; subm by Adella Schroth. Dated for comparison with those from Little Harbor site.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Location</th>
<th>Depth</th>
<th>Age (BP)</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>LJ-4755</td>
<td>Santa Catalina I., 25cm</td>
<td>25cm depth</td>
<td>270 ± 100</td>
<td>$^{14}$C = 25.3‰</td>
</tr>
<tr>
<td>LJ-4756</td>
<td>Santa Catalina I., Level 1</td>
<td>Level 1</td>
<td>360 ± 100</td>
<td>$^{14}$C = -23.2‰</td>
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<tr>
<td>LJ-4648</td>
<td>Kumeyaay site, SDSU No. F:5:1</td>
<td></td>
<td>310 ± 50</td>
<td>$^{14}$C = -25.4‰</td>
</tr>
<tr>
<td>LJ-5134</td>
<td>Kumeyaay cremation site</td>
<td></td>
<td>280 ± 60</td>
<td>$^{14}$C = -24.1‰</td>
</tr>
<tr>
<td>LJ-5301</td>
<td>Temoris</td>
<td></td>
<td>860 ± 40</td>
<td>$^{14}$C = -26.3‰</td>
</tr>
</tbody>
</table>

**Mexico**

Twisted cordage (possibly *Apocynum sp*) of string skirt of mummy found in cave at alt 2000m in Sierra Madre Occidental Mts, near Temoris, SW part of State of Chihuahua, near border with State of Sonora (27° 40' N, 108° 35' W). Remains found 60cm below surface of dry cave, wrapped in cane mat, with food offerings of corn, berries, and dried meat. Mummy was that of young female, well-preserved by natural dehydration. X-rays show fetus of 7 to 8 months gestational age in pelvic area. Coll winter
1966 by William Glad and Gilbert Ballow, San Diego, from whom it was confiscated by sheriff and brought to Mus of Man. Arrangements made with Inst Nacional Antropologia e Historia, Mexico City for return of mummy following study. Subm by R A Tyson. Calibration: AD 1190 (1040 to 1260).

Belize

Belize series

Eight charcoal samples from Mayan site in Cuello (ca 17° N, 88° W). Coll and subm by Norman Hammond, Archaeol Research Prog, Douglass Coll, Rutgers Univ, New Brunswick, New Jersey. Comment (NH): dates of LJ-4917 to -4920 and -4922 to -4923 are substantially younger than expected on basis of previous Cambridge and UCLA work. “Compression” of dates from long stratigraphic sequence to very short span of ¹⁴C time has been duplicated by Cambridge Univ lab (Q), in that samples with expected ¹⁴C ages younger than 2400 BP have yielded dates in agreement with those expectations, while samples expected to be older than 2400 BP have yielded ages within very narrow range. No explanation is available for this discrepancy, although only restricted area of excavation is involved.

LJ-4921. Belize #6
Charcoal from Late Formative level in Unit 45/50. Dates expansion of NE quad of site. Comment (NH): ¹⁴C age acceptable and within expected range, 2250 to 2950 BP. Calibration: 380 to 180 BC (395 to 20).

LJ-4916. Belize #1
Charcoal from Late Formative, first phase of pyramid construction, from Unit 25/50. Date important to establish beginning of ceremonial construction and to link pyramid sequence with deep sounding in Unit 35/30, 10m to NE. Comment (NH): ¹⁴C age later than expected range, 2950 to 3050 BP, but this may simply indicate initial overestimation of age and later beginning of pyramid construction. Calibration: 385 to 180 BC (400 to 30).

LJ-4920. Belize #5
Charcoal from early Middle Formative (Phase IV) burial (Feature 32), from Unit 35/30. Provides terminus ante quem for building in which burial was intruded. Comment (NH): ¹⁴C age younger than expected range, 2850 to 3050 BP, but still within range of acceptability. Calibration: 765 to 595 BC (775 to 395).

LJ-4919. Belize #4
Charcoal from middle of Building Phase III of Early Formative, from Unit 35/30. Dated to define Phase III/IIIA boundary. Comment (NH): original expected ¹⁴C age, 3250 to 3650 BP, has been reduced since sample
was subm, but result is still several centuries younger than expectation. Calibration: 780 BC (795 to 415).

**LJ-4922. Belize #7**

Charcoal from early Phase III Early Formative patio, from Unit 35/30. Dated to define Phase III/IIIA boundary. *Comment* (NH): same as for LJ-4919, above, except original expectation was 3650 BP for LJ-4922. Calibration: 800 BC (805 to 420).

\[ 2520 \pm 70 \]

\[ \delta^{14}C = -26.5\%o \]

**LJ-4923. Belize #8**

Charcoal from early Phase III of Early Formative, from Unit 35/30. Dated to define Phase III/IIIA boundary. *Comment* (NH): expected age, 3650 BP. \(^{14}\)C age is much younger than expected and is inseparable from late Phase III ages, noted above, which does not accord with stratigraphy or ceramic sequence. Calibration: 790 BC (805 to 420).

\[ 2510 \pm 60 \]

\[ \delta^{14}C = -26.4\%o \]

**LJ-4917. Belize #2**

Charcoal from fireplace (Feature 64) of Building Phase II of Early Formative, from Unit 35/30. This was scaled sample from short-use context early in sequence. *Comment* (NH): expected age, 3550 to 3800 BP. Date is much younger than expected and is inseparable from both late and early Phase III ages, noted above, which does not accord with stratigraphy or ceramic sequence. Calibration: 765 to 595 BC (775 to 395).

\[ 2420 \pm 60 \]

\[ \delta^{14}C = -26.0\%o \]

**LJ-4918. Belize #3**

Charcoal from Early Formative early occupation level with first effigy whistles, from Unit 35/35. Important for linking Units 35/35 and 35/30 and to date earliest musical instrument in Mayan area. *Comment* (NH): younger than expected \(^{14}\)C age, 3750 BP, by several centuries, even at lower limit of calibration. Calibration: 780 BC (790 to 410).

\[ 2470 \pm 70 \]

\[ \delta^{14}C = -27.6\%o \]

**Peru**

**Peruvian Amazonia series**

Eight charcoal samples from Peruvian Amazon forest region. All samples are from middle Yubineto R basin in Secoya Indian territory; Yubineto R is right affluent of Putamayo R, river that forms Colombia-Peru border, on Peruvian side (ca 1° S, 74° to 75° W). Coll Dec 1977 to Sept 1978 by S F Paitan; subm by Jürg Gasché, Paris, France. Dated to provide insight into problems of age of agic in Amazon region, pattern of agic exploitation of forest by Indian farmers, and speed of forest regeneration under native exploitation conditions. This study was part of proj, “Shifting cultivation and evolution of the forest milieu of Northwestern Amazonia. Ecology of native cultivation systems in Peruvian Amazonia,” funded by Swiss Natl Foundation for Sci Research and French Natl Center for Sci Research.
La Jolla Natural Radiocarbon Measurements X

1890 ± 40
LJ-4787. Bellavista, Loma 5, 1Bp-B,
$\delta^{13}C = -28.1\%$
Charcoal from Bellavista site, Loma 5, 5 to 50cm depth. Sample from same site, 100 to 150cm depth, contained no charcoal. Calibration: AD 100 (10 to 230).

1920 ± 60
LJ-4868. Bellavista, Loma 4, 2Bp-B,
$\delta^{13}C = -28.1\%$
Charcoal from Bellavista site, Loma 4, 5 to 50cm depth. Sample from same site, 80 to 120cm depth, contained no charcoal. Calibration: AD 30, 70 (40 BC to AD 230).

1180 ± 60
LJ-4870. Bellavista, Loma 3, 3Bp-B,
$\delta^{13}C = -26.9\%$
Charcoal from Bellavista site, Loma 3, 5 to 40cm depth. Calibration: AD 830 (680 to 980).

1250 ± 60
LJ-4871. Escuela Vieja, 4Bp-EV
$\delta^{13}C = -28.8\%$
Charcoal from Escuela Vieja site, 10 to 40cm depth. Calibration: AD 690, 720, 750, 780 (650 to 900, 900 to 940).

LJ-4872. Escuela Vieja, Purma-8A, 5P-EV, 0cm
$\Delta = +143 \pm 8\%$
$\delta^{13}C = -30.7\%$
Charcoal from Escuela Vieja site, Purma-8A, 0cm depth. Calibration: more recent than AD 1957.

LJ-4873. Escuela Vieja, Purma-8A, 5P-EV, 20-40cm
$\delta^{13}C = -29.1\%$
Charcoal from Escuela Vieja site, Purma-8A, 20 to 40cm depth. Calibration: 375 to 180 BC (390 to 50).

2530 ± 80
LJ-4653. Mamepo, 15Bp, 20-50cm
$\delta^{13}C = -27.0\%$
Charcoal from Mamepo site, 20 to 50cm depth. Calibration: 800 BC (840 to 410).

2430 ± 40
LJ-4652. Mamepo, 15Bp, 50-100cm
$\delta^{13}C = -27.6\%$
Charcoal from Mamepo site, 50 to 100cm depth. Calibration: 770 to 590 BC (780 to 400).

Argentina
Trafal Cave series
Four charcoal samples from Trafal Cave 1, 2km W of Confluencia, Prov Neuquen (40° 43’ S, 71° 07’ W). Site is small cave, containing 2m deposits including rodent bones and Indian artifacts. Cave was occupied alternately by owls and Indians. Long sequence of small mammal bones of 18 sp provided unique opportunity to trace long-term faunal history of region as well as climatic history, since many of these sp have narrow climatic requirements. Dated Indian material from region is very scarce. Coll by Lic M J Silveira and assocs, Inst Ciencias Antropologicas, Buenos
Aires; subm by O P Pearson, Mus Vertebrate Zool, Univ California, Berkeley.

**LJ-5130. Traful Cave, Layer 3a**
Charcoal from Layer 3a, coordinates Iu-Hu, 83 to 87 cm depth. Coll July 1979. Calibration: 490 to 390 bc (490 to 160).

\[ \delta^{13}C = -24.4\% \]

\[ 2330 \pm 40 \]

**LJ-5131. Traful Cave, Layer 6**

\[ \delta^{13}C = -26.4\% \]

\[ 2720 \pm 40 \]

**LJ-5132. Traful Cave, Layer 9**
Charcoal from Layer 9, coordinates Ik, 45 to 51 cm depth. Coll Aug 1979. Calibration: 5300 to 5150 bc (5365 to 4975).

\[ \delta^{13}C = -27.4\% \]

\[ 6240 \pm 60 \]

**LJ-5133. Traful Cave, Layer 10**

\[ \delta^{13}C = -25.1\% \]

\[ 7850 \pm 70 \]

**Egyptian mummy series**
Tissue and wrapping bandages from Manchester Mummy 1770, obtained from Egypt. Subm by A R David, Manchester Mus, Univ Manchester, England. Body material and wrapping bandages were dated not only to determine age of body, but also to determine whether body had been re-wrapped substantially later than death of individual. Comment: \(^{14}\)C ages found by Manchester lab for components of mummy are 2690 ± 180 for right scapula bone collagen, 2740 ± 170 for left scapula bone collagen, 1510 ± 130 for outer bandage, and 1640 ± 140 for part 4 bandage (A R David, pers commun). Manchester lab results indicated either that bones contained carbon of fossil origin, perhaps bitumen from Dead Sea area, used in mummification process, or, more likely, that body was wrapped or re-wrapped substantially later than death of individual. However, La Jolla results, below, further confused resolution of problem.

\[ \delta^{13}C = -25.3\% \]

\[ 2290 \pm 40 \]

**LJ-4915. Manchester Mummy 1770, skin tissue**
Soft tissue (skin) from left humerus. Pretreated only with dilute HCl. Calibration: 580 to 410 bc (580 to 180).

\[ \delta^{13}C = -25.7\% \]

\[ 2920 \pm 60 \]

**LJ-4995. Manchester Mummy 1770, wrapping bandages**
Wrapping bandages from over right side, arm, and chest. Pretreated only with dilute HCl. Calibration: 1340 to 1170 bc (1350 to 895).

\[ \delta^{13}C = -26.2\% \]

\[ 2130 \pm 60 \]

**LJ-4996. Manchester Mummy 1770, wrapping bandages**
Chest bandages from beneath cantannage chest cover. Pretreated only with dilute HCl. Calibration: 375 to 180 bc (390 to 1).
Terqa series

Ten charcoal samples from ancient Terqa (modern Ashara), on edge of Euphrates R, E Syria (34° 55' N, 40° 30' S). Samples 1 to 7 coil from slopes of moat outside city wall and floor deposit just inside city wall of Terqa, major center of civilization from ca 5000 yr BP. Samples 8 and 9 coil from floor deposits inside room of Old Babylonian private house at Terqa, together with small archive of cuneiform tablets. Sample 10 coil from floor deposits in Temple of Ninkarrak, stratigraphically comparable to Samples 8 and 9. Coll Oct and Nov 1978 by David Berry and Maryse Gaborit, both Univ California, Los Angeles; subm by Giorgio Buccellati, Inst Archaeol, Univ California, Los Angeles. Comment (GB): on typologic and stratigraphic grounds, construction of city wall assigned to early part of third millennium BC. Three phases of construction of wall formed massive defensive system—ca 20m of solid mud brick, with protective base in stone, for perimeter of ca 1.6km. This is largest defensive system found in Syria and Mesopotamia, with momentous implications for history of early development of urban civilization.

4210 ± 80

LJ-4821. Terqa, TQ4-S284, Sample 1

δ¹³C = −21.8‰

Charcoal from ca 4m below surface, just above virgin soil at base of first phase of city wall. From same loc as TQ4-S283, LJ-5052, below, but from lower level. Comment (GB): expected date, 2800 to 2700 BC. Calibration: 2910 BC (3150 to 2555).

4110 ± 70

LJ-5052. Terqa, TQ4-S283, Sample 2

δ¹³C = −21.7‰

Charcoal (reasonably pure, but finely dispersed) from ca 3.5m below surface, 50cm above virgin soil at base of first phase of city wall. Comment (GB): expected date, 2800 to 2700 BC. Comment: no asphaltenes present. See Comment for LJ-5031, below. Calibration: 2880 to 2800 BC (2900 to 2425).

4660 ± 80

LJ-5053. Terqa, TQ4-S311, Sample 3

δ¹³C = −23.8‰

Charcoal from just above base of first phase of city wall, from slightly higher stratigraphic position than LJ-4821 and -5052, above. Comment (GB): expected date, 2800 to 2600 BC. Calibration: 3490 BC (3760 to 3155).

4870 ± 90

LJ-4822. Terqa, TQ4-S314, Sample 4

δ¹³C = −19.6‰

Finely divided charcoal from ca 4m below surface, 50cm above virgin soil, just outside second phase of city wall. Comment (GB): expected date, 2600 to 2500 BC. Calibration: 3780 to 3660 BC (3885 to 3375).

28,800 ± 1300

LJ-5031. Terqa, TQ4-S313, Sample 5

δ¹³C = −24.7‰

Finely divided charcoal and carbonaceous residue from ca 4m below surface, 50cm above virgin soil, further out from second phase of city wall.
than LJ-4822, above; after certain time that second phase of city wall had been in use, under third phase of city wall. Comment (GB): expected date, 2500 to 2400 BC. Comment: organic geochemical analysis of additional material from same sample clearly indicated contamination of charcoal with ancient asphalt (Venkatesan et al, 1982). Asphalt sample from goblet from Terqa area has same n-alkane and triterpenoidal distributions as this sample and LJ-4823 (TQ4-S267), below. H/C ratio and $\delta^{13}C$ for asphaltenes from goblet asphalt and TQ4-S313 and TQ4-S267 also agree. Any Terqa charcoal samples that gave anomalously old $^{14}C$ ages may be assumed to have contained some asphaltic material. See LJ-5362, below.

LJ-5362. Terqa, TQ4-S313, extracted, 27,700 ± 1400
Sample 6
$\delta^{13}C = -28.5\%$

Same material as LJ-5031, above, except Soxhlet-extracted successively with methanol and toluene/methanol (3:7 v/v) for 100 hr. Comment: age is statistically same as that of unextracted sample (LJ-5031, above), which suggests that great age is largely due to insoluble pyrobitumen that could have come from asphalt (Venkatesan et al, 1982).

LJ-4823. Terqa, TQ4-S267, Sample 7
$\delta^{13}C = -25.8\%$

Charcoal from ca 4m below surface, 50cm above virgin soil, just outside base of third phase of city wall. Comment (GB): expected date, 2400 to 2300 BC. Comment: sample contaminated with asphaltenes (ca 17% asphaltene concentration found in TQ4-S313) and with hexane-soluble lipids (ca 10% concentration found in TQ4-S313) (Venkatesan et al, 1982). Calibration: 4730 to 4570 BC (4885 to 4405).

LJ-4824. Terqa, TQ4-S263, Sample 8
$\delta^{13}C = -25.7\%$

Charcoal found in private house together with cuneiform tablets and pottery sherds, from later occupation of site than all samples above. Comment (GB): on second millennium BC samples: my original suggestion of chronologic range between 1700 and 1500 BC was based on preliminary reading of tablets and acceptance of middle chronology. Subsequent study of tablets has narrowed possible range to ca 1720 to 1680 BC according to middle chronology. On the other hand, an important study (Huber, 1982) has proposed strong new astronomical arguments in favor of high chronology; if so, range for tablets accompanying Terqa samples would be ca 1780 to 1750 BC—a date which is generally more in keeping with $^{14}C$ determinations. Calibration: 1930 to 1770 BC (1970 to 1665).

LJ-5054. Terqa, TQ4-S162, Sample 9
$\delta^{13}C = -25.7\%$

Charcoal from same provenience as LJ-4824, above. Calibration: 1920 to 1740 BC (1980 to 1555).

LJ-5055. Terqa, TQ4-S262, Sample 10
$\delta^{13}C = -26.7\%$

Charcoal found in public building adjacent to private house from
which LJ-4824 and -5054, above, were obtained, but from higher level. Calibration: 1960 to 1850 BC (2150 to 1665).

Italy

Scaloria Cave series

Thirteen charcoal samples from Scaloria Cave, 2km NW of Manfredonia, Puglia, SE Italy (41° 39' N, 15° 54' E). Samples recovered deep in cave which contains Neolithic burial site and Mesolithic camp. Coll by S M M Winn, Univ Southern Mississippi, Hattiesburg, and Marija Gimbutas, Inst Archaeol, Univ California, Los Angeles; subm by Marija Gimbutas.

LJ-4650. Scaloria Cave, TR1/L8

Charcoal from Trench 1, Level 8, on and around human skull which is being studied for pathology. Coll Aug 1978. Date important for establishing horizontal stratigraphy, grave types, chronologic use of cemetery, Neolithic sequence, etc. Calibration: 5520 to 5450 BC (5730 to 5110).

6490 ± 140

δ¹³C = -26.2%

LJ-4651. Scaloria Cave, TR1/L8

Charcoal from Trench 1, Level 8, in vicinity of skull mentioned above; charcoal is probably from same source as LJ-4650. Stratigraphy sealed below calcareous level, meaning no possible admixture of later materials. Coll Aug 1978. Sample important for establishing use of cemetery in cave for Scaloria period. Calibration: 5340 to 5250 BC (5545 to 5020).

6330 ± 90

δ¹³C = -24.0%

LJ-4649. Scaloria Cave, TR3/L3

Charcoal from Trench 3, Level 3, 20 to 30cm depth in pit burial, found near mandible. Coll Aug 1978. Important chronologic implications for early Neolithic in Italy; date needed to establish sequence in cemetery and habitation outside cemetery. Calibration: 5650 to 5600 BC (5940 to 5315).

6720 ± 100

δ¹³C = -25.0%

LJ-4983. Scaloria Cave, TR5/L3

Charcoal from Trench 5, Level 3, from Neolithic period. Coll Aug 1979. Stratigraphy and assoc ceramics (eg, Ripoli-style painted ware) indicate latest period (Late Scaloria) of habitation in cave. Calibration: 5130 to 5020 BC (5295 to 4890).

6120 ± 80

δ¹³C = -25.0%

LJ-5095. Scaloria Cave, TR6/L4


6400 ± 80

δ¹³C = -24.5%

LJ-5096. Scaloria Cave, TR6/L6 & 7

LJ-5097. Scaloria Cave, TR7/L1

LJ-4980. Scaloria Cave, TR10

LJ-4981. Scaloria Cave, TR10/L4

LJ-4982. Scaloria Cave, TR8/L3
Charcoal from Trench 8, Level 3, from Upper Palaeolithic/Mesolithic period. From area with concentration of animal bones and teeth; some lithics present. Coll Aug 1979.

LJ-5098. Scaloria Cave, TR8/L4

LJ-4978. Scaloria Cave, TR8/L8
Charcoal from Trench 8, Level 8, from Upper Palaeolithic/Mesolithic period. From soil feature containing abundant lithics and bones. Coll Sept 1979.

LJ-4979. Scaloria Cave, TR8/L9
Charcoal from Trench 8, Level 9, from Upper Palaeolithic/Mesolithic period. From yellowish, sandy soil containing numerous lithic artifacts. Coll Sept 1979.

Romania

Romania series
Three wood charcoal samples from Celei-Sucidava, Bez Oltenien. Samples subm by and previously dated by Günther Kohl, Akad Wissenschaften DDR, Zentralinst f Alte Geschäfte & Archäol, East Berlin. Bln dates below are by pers commun to H E Suess. Bln lab thought that their $^{14}$C ages were 300 to 400 yr too young, but LJ results were slightly younger still.
La Jolla Natural Radiocarbon Measurements X

LJ-5232. Celei-Sucidava #1
Charcoal Sample #1 from Celei-Sucidava, Haüs 1 of Celei-Kirltni. Previously dated at 4225 ± 60 (Bln-2014). Calibration: 2900 to 2820 BC (3035 to 2425).

δ¹³C = −24.1%

4170 ± 110

LJ-5231. Celei-Sucidava #2
Charcoal Sample #2 from Celei-Sucidava, Haüs 2 of Celei-Kirltni. Sample contained many fine rootlets. Previously dated at 4135 ± 95 (Bln-2015). Calibration: 2800 to 2560 BC (2890 to 2315).

δ¹³C = −26.8%

4030 ± 90

LJ-5233. Celei-Sucidava #3
Charcoal Sample #3 from Celei-Sucidava, Haüs 7 of Celei-Kirltni. Previously dated at 4335 ± 45 (Bln-2016). Calibration: 2890 to 2820 BC (3030 to 2425).

δ¹³C = −28.0%

4160 ± 90

LJ-5262. Ganovice
Wood (15 to 20 tree rings) from Ganovice, Bez Poprad/Seovukei, from Brünnen of Bronze age Ottoman culture. Subm by Günther Kohl. Previously dated at 3445 ± 40 (Bln-2011). Calibration: 1940 to 1830 BC (2145 to 1660).

δ¹³C = −26.3%

3500 ± 90

Turkey

West Anatolia series
Four charcoal samples from Demirci Hüyük, early Bronze age site in W Anatolia. Site has 9.5m of deposits with 17 building phases. Subm by Günther Kohl.

LJ-5237. Demirci Hüyük, K8.1227
Charcoal from Phase H of early Bronze age at site. Historic date of ca 3000 to 2500 BC. Calibration: 2970 to 2910 BC (3145 to 2660).

δ¹³C = −24.4%

4250 ± 40

LJ-5235. Demirci Hüyük, L9.123
Charcoal from Phase H of early Bronze age at site. Historic date of ca 3000 to 2500 BC. Calibration: 2900 to 2850 BC (3135 to 2440).

δ¹³C = −23.0%

4190 ± 80

LJ-5238. Demirci Hüyük, K9.Z.65
Charcoal from Phase E2 of early Bronze age at site. Historic date of ca 3400 to 2700 BC. Calibration: 2950 to 2900 BC (3045 to 2655).

δ¹³C = −24.4%

4230 ± 60

LJ-5236. Demirci Hüyük, E8.332
Charcoal from Phase E1 of early Bronze age at site. Historic date of ca 3400 to 2700 BC. Calibration: 2480 to 2400 BC (2765 to 2145).

δ¹³C = −25.5%

3910 ± 90

LJ-5234. Norsuntepe, E Anatolia
Charcoal from Norsuntepe, early Bronze Age I site in E Anatolia.

δ¹³C = −25.4%

4280 ± 120
GEOLOGIC SAMPLES

*Terrestrial—California*

**LJ-5670.  San Emigdio Mts**  
Small snail shells picked from lake sediments in lake bed exposure between Lake of the Woods and Pine Mountain Club, on Mil Potrero Hwy, San Emigdio Mts, on Sawmill Mountain USGS 7.5’ Quad (34° 51’ N, 119° 08’ W). From 4m below surface. Coll Feb 1980 by Thom Davis; subm by Thom Davis and E A Keller, Dept Geol Sci, Univ California, Santa Barbara.

**LJ-5669.  Coyote Lake**  
Fine charcoal in soil matrix from near center of Coyote Lake (dry), from Sec 11, TIN, R7E on Twentynine Palms USGS 15’ Quad (34° 12’ N, 116° 14’ W). From 2m below surface. Coll July 1980 by Thom Davis and Ernest Dubeendorfer; subm by Thom Davis and E A Keller. Dated for age control on magnetic secular variation curve for Holocene.

La Nación Fault series

Seven soil and caliche samples measured to date last movement of La Nación fault; all samples coll from between 59th and 61st St, between Division and Newcastle St, San Diego (ca 32° 42’ N, 117° 04’ W, exact coordinates given below). Two other samples from site contained <0.015% organic carbon (by weight) in soil, providing two samples too small for dating. Coll and subm by Wendell Gayman, Sea Sci Services, San Diego. Interpretation of dates is questionable because of type of materials dated; see Gayman (1979). No chemical pretreatment.

**LJ-4729.  La Nación Fault, Sample 5**  
Inorganic carbon from mixed caliche and clay from backhoe trench dug 2m into alluvium and near-surface formations at site (32° 41’ 52” N, 117° 04’ 13” W). Sample coll at 1.4m depth in Tr T-27, from subsoil in top of Otay Formation, ca 5.5m E of fault. Coll Feb 1979.

**LJ-4730.  La Nación Fault, Sample 28**  
Inorganic carbon from mixed caliche and clay from backhoe trench dug 2.1m deep at site (32° 41’ 50” N, 117° 04’ 10” W). Sample coll from ca 1.1m depth at W end of Tr T-34, from subsoil overlying Pliocene San Diego Formation, ca 6m W of fault. Coll Feb 1979.

**LJ-4745.  La Nación Fault, Sample 45**  
Organic carbon from carbonaceous soil from Tr T-38 dug 5.5m into alluvium and near-surface formations at site (32° 41’ 52” N, 117° 04’ 13” W, 22,000 ± 1800

**20,400 ± 400**

δ13C = -8.0%

**29,800 ± 1100**

δ13C = -8.3%

**18,800 ± 600**

δ13C = -24.3%
La Jolla Natural Radiocarbon Measurements X

W). Sample coll from depth 2.1 to 2.4m below surface. Soil contained 0.24% organic carbon by weight. Coll Mar 1979.

LJ-4746. La Nación Fault, Sample 41
Organic carbon from carbonaceous soil from Tr T-38 dug 5.5m into alluvium and near-surface formations at site (32° 41' 52" N, 117° 04' 13" W). Sample coll from depth 2.1 to 2.4m below surface. Soil contained 1.4% organic carbon by weight. Coll Mar 1979.

\[ 30,300 \pm 1200 \]
\[ \delta^{13}C = -24.8\%o \]

LJ-4747. La Nación Fault, Sample 46
Organic carbon from soil with charcoal fractions (to 2cm size) from Tr T-38 dug 5.5m into alluvium and near-surface formations at site (32° 41' 52" N, 117° 04' 13" W). Sample coll from ca 1.5 to 1.8m below ground surface. Sample contained 0.22% organic carbon by weight. Coll Mar 1979.

\[ 19,800 \pm 1000 \]
\[ \delta^{13}C = -23.3\%o \]

LJ-4748. La Nación Fault, Sample 29
Organic carbon from carbonaceous clay (hard, dry, dark lumps) found at Sta 74 in Tr T-32, ca 1.5m below top of trench dug 3.7m deep by backhoe at site (32° 41' 52" N, 117° 04' 10" W). Soil represented thick sec of alluvium, probably overlying Otay Formation. Sample may have come from 9 to 15m E of fault; exact location of fault was not determined. Sample contained 0.18% organic carbon by weight. Coll Feb 1979.

\[ 14,300 \pm 300 \]
\[ \delta^{13}C = -24.0\%o \]

LJ-4749. La Nación Fault, Sample 10
Organic carbon from dark brown clayey sand taken from depth 1.1m in Tr T-28A at site (32° 41' 57" N, 117° 04' 10" W). Soil sample overlay Miocene Otay Formation, from ca 34m E of fault. Sample contained 0.60% organic carbon by weight. Coll Feb 1979. Calibration: 4120 to 4000 BC (4405 to 3680).

\[ 5220 \pm 130 \]
\[ \delta^{13}C = -16.3\%o \]

Oceanographic—Pacific Ocean

Ontong Java Plateau marine sediment series

Fourteen inorganic carbon samples from deep-sea sediment in W equatorial Pacific Ocean. These samples from top and flanks of Ontong Java Plateau, N of Soloman Is. and ENE of New Guinea, were coll as box cores in Apr-May 1975 during Leg 9 of Eurydice Expedition of Scripps Inst Oceanog on track from Guam, Mariana Is., to Majuro, Marshall Is. Coring device obtained samples of 50cm sq and 30 to 45cm deep. Cores were sub-sampled and analyzed for several physical properties, weight percent CaCO₃, and preservation and sedimentation rates (Johnson, Hamilton, & Berger, 1977; Berger & Killingley, 1982). Samples reported here were taken from top layer of seven box cores; for each sample, two inorganic fractions were dated: a “bulk” fraction consisting of full range of particle sizes and “coarse” fraction consisting only of particles >62μ diam.

Subm by W H Berger, Scripps Inst Oceanog, Univ California, San Diego,
La Jolla. Data presented in table 1, below, are continuation of series begun by Linick (1979) with data from 20 bulk samples. Estimated δ13C of 0.0‰ was used in calculating all apparent ages given below. Comment: comparisons to previous measurements pub in R., 1979, v 21, p 197-198, are as follows: Core 120/1 to 5 cm/3940 ± 100 (LJ-3879), Core 123/1 to 5 cm/3390 ± 80 (LJ-3885), Core 139/1 to 5 cm/5590 ± 130 (LJ-4070), and Core 141/1 to 5 cm/7510 ± 100 (LJ-4073). Comparisons to previous measurements from Peng, Broecker, and Berger (1979) are as follows: Core 92/0 to 2 cm/4230 ± 240 and Core 92/2 to 4 cm/4240 ± 180. Comparisons to previous measurements by Univ Miami as quoted by Berger and Killingley (1982) are as follows: Core 112/1 to 5 cm/4340 ± 70 and Core 128/1 to 5 cm/4015 ± 80. In each of seven cores listed here, coarse fraction gave greater apparent age than bulk fraction, showing effect of better preservation of larger particle sizes relative to re-dissolution.

Table 1
Ontong Java Plateau marine sediment series

<table>
<thead>
<tr>
<th>LJ no.</th>
<th>Box core no.</th>
<th>Lat</th>
<th>Long</th>
<th>Water depth (m)</th>
<th>Depth in core (cm)</th>
<th>Bulk/ coarse</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5584</td>
<td>92</td>
<td>2° 13.5′ S</td>
<td>156° 59.9′ E</td>
<td>1598</td>
<td>0-3</td>
<td>Bulk</td>
<td>4410 ± 130</td>
</tr>
<tr>
<td>-5585</td>
<td>92</td>
<td>2° 13.5′ S</td>
<td>156° 59.9′ E</td>
<td>1598</td>
<td>0-3</td>
<td>Coarse</td>
<td>4780 ± 120</td>
</tr>
<tr>
<td>-5586</td>
<td>112</td>
<td>1° 37.5′ S</td>
<td>159° 14.1′ E</td>
<td>2169</td>
<td>0-4</td>
<td>Coarse</td>
<td>4550 ± 100</td>
</tr>
<tr>
<td>-5587</td>
<td>112</td>
<td>1° 37.5′ S</td>
<td>159° 14.1′ E</td>
<td>2169</td>
<td>0-4</td>
<td>Coarse</td>
<td>5070 ± 120</td>
</tr>
<tr>
<td>-5636</td>
<td>120</td>
<td>0° 01.0′ S</td>
<td>158° 41.6′ E</td>
<td>2247</td>
<td>0-3</td>
<td>Bulk</td>
<td>5070 ± 100</td>
</tr>
<tr>
<td>-5635</td>
<td>120</td>
<td>0° 01.0′ S</td>
<td>158° 41.6′ E</td>
<td>2247</td>
<td>0-3</td>
<td>Coarse</td>
<td>5600 ± 100</td>
</tr>
<tr>
<td>-5613</td>
<td>123</td>
<td>0° 01.3′ S</td>
<td>160° 24.9′ E</td>
<td>2948</td>
<td>1-6</td>
<td>Bulk</td>
<td>3250 ± 100</td>
</tr>
<tr>
<td>-5614</td>
<td>123</td>
<td>0° 01.3′ S</td>
<td>160° 24.9′ E</td>
<td>2948</td>
<td>1-6</td>
<td>Coarse</td>
<td>3550 ± 100</td>
</tr>
<tr>
<td>-5602</td>
<td>128</td>
<td>0° 00.5′ S</td>
<td>161° 25.6′ E</td>
<td>3732</td>
<td>1-6</td>
<td>Bulk</td>
<td>4010 ± 110</td>
</tr>
<tr>
<td>-5603</td>
<td>128</td>
<td>0° 00.5′ S</td>
<td>161° 25.6′ E</td>
<td>3732</td>
<td>1-6</td>
<td>Coarse</td>
<td>4720 ± 90</td>
</tr>
<tr>
<td>-5634</td>
<td>139</td>
<td>1° 21.7′ N</td>
<td>162° 23.6′ E</td>
<td>4118</td>
<td>0.5-5</td>
<td>Bulk</td>
<td>5400 ± 120</td>
</tr>
<tr>
<td>-5633</td>
<td>139</td>
<td>1° 21.7′ N</td>
<td>162° 23.6′ E</td>
<td>4118</td>
<td>0.5-5</td>
<td>Coarse</td>
<td>6530 ± 110</td>
</tr>
<tr>
<td>-5615</td>
<td>141</td>
<td>2° 21.7′ N</td>
<td>163° 42.4′ E</td>
<td>4324</td>
<td>0.5-5</td>
<td>Bulk</td>
<td>7690 ± 190</td>
</tr>
<tr>
<td>-5616</td>
<td>141</td>
<td>2° 21.7′ N</td>
<td>163° 42.4′ E</td>
<td>4324</td>
<td>0.5-5</td>
<td>Coarse</td>
<td>9260 ± 120</td>
</tr>
</tbody>
</table>

Pleiades sediment series

Five deep-sea sediment inorganic carbon samples from under E equatorial Pacific Ocean. These samples were coll as box cores in July-Aug 1976 during Leg 3 of Pleiades Expedition of Scripps Inst Oceanog on track from Balboa, Canal Zone, to Honolulu, Hawaii. Subm by R C Finkel and W H Berger. For discussion of results, see Berger and Killingley (1982). Data are presented in table 2, below. Comment: comparisons to previous measurements on these cores by L.J lab pub in Berger and Killingley (1982) are as follows: Core 72: 0 to 3 cm/3990 ± 70 (LJ-4518), 3 to 5 cm/4220 ± 110 (LJ-4519), 5 to 7 cm/4060 ± 80, 10 to 12 cm/5260 ± 90, 14 to 16 cm/5640 ± 70, 18 to 20 cm/6830 ± 80 (LJ-4520), 34 to 36 cm/12,570 ± 180 (LJ-4521). Core 74: 1 to 3 cm/4360 ± 90, 7 to 9 cm/4520 ± 70, 18 to 20 cm/7670 ± 110. Dated as part of study of 13C sedimentation rates and benthic mixing suggesting that patterns of mixed layer ages, sedimentation rates, and mixed layer thickness were controlled by gradients of car-
La Jolla Natural Radiocarbon Measurements X

bonate dissolution and fertility and by small-scale redeposition processes (Berger & Killingley, 1982).

### Table 2

<table>
<thead>
<tr>
<th>LJ no.</th>
<th>Box core no.</th>
<th>Lat</th>
<th>Long</th>
<th>Water depth (m)</th>
<th>Depth in core (cm)</th>
<th>δ¹³C ‰</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4973</td>
<td>72-3</td>
<td>1° 00.8' N</td>
<td>109° 15.6' W</td>
<td>3626</td>
<td>8-10</td>
<td>-0.5</td>
<td>4430 ± 70</td>
</tr>
<tr>
<td>-4974</td>
<td>72-3</td>
<td>1° 00.8' N</td>
<td>109° 15.6' W</td>
<td>3626</td>
<td>20-22</td>
<td>-0.4</td>
<td>7250 ± 100</td>
</tr>
<tr>
<td>-4975</td>
<td>72-3</td>
<td>1° 00.8' N</td>
<td>109° 15.6' W</td>
<td>3626</td>
<td>28-30</td>
<td>-0.2</td>
<td>10,430 ± 140</td>
</tr>
<tr>
<td>-4970</td>
<td>74-1</td>
<td>1° 00.1' N</td>
<td>113° 39.5' W</td>
<td>3944</td>
<td>11-13</td>
<td>-0.3</td>
<td>4850 ± 80</td>
</tr>
<tr>
<td>-4972</td>
<td>74-1</td>
<td>1° 00.1' N</td>
<td>113° 39.5' W</td>
<td>3944</td>
<td>28-30</td>
<td>0.0</td>
<td>11,440 ± 240</td>
</tr>
</tbody>
</table>

### Indopac-15 sediment series

Eight samples of sedimentary organic carbon collected June 1977 on Indopac-15 Expedition of Scripps Inst Oceanog in central N Pacific Ocean (28° 35.45' N, 155° 30.39' W). From Box Core 738, H-236, BC-3 in water depth 5584m. Area is extensive abyssal plain below low-productivity surface waters and underlain by red clay. Coll and subm by P M Williams, Scripps Inst Oceanog. Data are given in table 3, below. Comment (PMW): vertical distribution of organic ¹⁴C in this core is similar to that found for Indopac-15 Core 638, H-22, coll June 1977 at 28° 34.4' N, 155° 30.3' W, water depth 5780m. Previously pub results for Core 638 are as follows: (LJ-4054 and -4055: R, 1979, v 21, p 198; LJ-4221, -4222, -4223, and -4301: R, 1980, v 22, p 1042): 0 to 3cm/10,700 ± 600 (LJ-4223), 5 to 7cm/16,000 ± 900 (LJ-4055), 7 to 9cm/18,500 ± 900 (LJ-4221), 11 to 13cm/20,300 ± 2200 (LJ-4222), 13 to 15cm/22,700 (LJ-4301), 19 to 21cm/22,000 (LJ-4054). For interpretation of data, see Williams et al (1978).

### Table 3

<table>
<thead>
<tr>
<th>LJ no.</th>
<th>Depth in core (cm)</th>
<th>δ¹³C ‰</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5067</td>
<td>0-0.5</td>
<td>-18.7</td>
<td>8000 ± 600</td>
</tr>
<tr>
<td>-4695</td>
<td>1-2</td>
<td>-19.2</td>
<td>10,600 ± 800</td>
</tr>
<tr>
<td>-5068</td>
<td>4-5</td>
<td>-18.1</td>
<td>12,400 ± 1000</td>
</tr>
<tr>
<td>-5288</td>
<td>7-8</td>
<td>-17.5</td>
<td>14,000 ± 600</td>
</tr>
<tr>
<td>-5669</td>
<td>9-10</td>
<td>-18.8</td>
<td>14,200 ± 500</td>
</tr>
<tr>
<td>-5289</td>
<td>12-13</td>
<td>-19.3</td>
<td>31,000 ± 4000</td>
</tr>
<tr>
<td>-5290</td>
<td>14-15</td>
<td>-19.0</td>
<td>31,000 ± 4000</td>
</tr>
<tr>
<td>-4696</td>
<td>19-20</td>
<td>-21.3</td>
<td>&gt;23,700</td>
</tr>
</tbody>
</table>

### LJ-5555. Pacific sediment

δ¹³C = -23.1‰

2800 ± 120

Hydrothermal vent marine organism series

Mussel, clam, and vestimentiferan tubeworm samples from Pacific Ocean areas around Galápagos and East Pacific Rise hydrothermal vents. Samples studied to find sources of dietary carbon of organisms living in vicinity of hydrothermal vent systems (Williams et al., 1981). Mussels (Mytilus sp) are filter-feeders; vestimentiferan tubeworms (Riftia pachyptila) lack mouth organs and digestive tracks, and they apparently use organic carbon synthesized internally by symbiotic chemoautotrophs. Possible dietary carbon sources of filter feeders include sedimentary particulate organic carbon (POC) derived from dissolved inorganic carbon (DIOC) originally fixed near ocean surface, POC synthesized by bacteria chemoautotrophically from ambient bottom water DIOC, and POC synthesized chemoautotrophically from magmatic DIOC and/or magmatic methane. Samples subm by P M Williams.

\[ \Delta = -228 \pm 12\% o \]
\[ \delta^{13}C = -32.8\% o \]

**LJ-5059. Mussel, PW-HTG-1-80**

Tissue of mussel coll in peripheral area 8m from Galápagos “Mussel-bed” vent plume (0° 47.89' N, 86° 09.21' W). Water depth 2480m. Dry weight 1.6g. Coll Jan 1979 on Alvin dive 880 by K L Smith, Scripps Inst Oceanog.

\[ \Delta = -263 \pm 8\% o \]
\[ \delta^{13}C = -33.8\% o \]

**LJ-5060. Mussel, PW-HTG-2-80**

Tissue of mussel coll 1m from Galápagos “Musselbed” vent plume (0° 47.89' N, 86° 09.21' W). Water depth 2493m. Dry weight 2.7g. Coll Feb 1979 on Alvin dive 895 by K L Smith.

**LJ-5061. Mussel, PW-HTG-3-80**

Tissue of mussel coll 1m from Galápagos “Musselbed” vent plume (0° 47.89' N, 86° 09.21' W). Water depth 2493m. Dry weight 2.9g. Coll Jan 1979 on Alvin dive 880 by K L Smith.

**LJ-5182. Mussel, N991-103**

Shell of mussel coll 1m from Galápagos “Musselbed” vent plume (0° 47.89' N, 86° 09.21' W). Water depth 2490m. Dry weight 15g. Coll Dec 1979 on Alvin dive 991.

**LJ-5198. Tubeworm, PW-HTG-5-80**

Muscle of vestimentiferan tubeworm (Riftia pachyptila) coll in Galápagos “Garden of Eden” vent plume (0° 47.69' N, 86° 07.74' W). Water depth 2518m. Dry weight 0.29g. Coll Dec 1979 on Alvin dive 993.

**LJ-5140. Clam, PW-HT21-1-80**

Shell of clam coll from East Pacific Rise hydrothermal vent system (20° 50' N, 109° 06' W). Water depth ca 2600m. Dry weight 7.6g. Coll Nov 1979 on Alvin dive 981.
North Pacific gyre marine organism series


**LJ-5091. Rat-tail fish, PW-14C-E-79**

Muscle of rat-tail fish (*Coryphaenoides armatus*) caught in net 716m above bottom at Sta 186 (30° 57.6' N, 159° 04.0' W). Bottom depth 5900m. Dry weight 2g.

Δ = +66 ± 10‰
δ¹³C = -19.3‰

**LJ-5092. Rat-tail fish, PW-14C-F-79**

Muscle of rat-tail fish (*Coryphaenoides armatus*) caught in net 3 to 5m above bottom at Sta 186 (30° 57.6' N, 159° 04.0' W). Bottom depth 5900m. Dry weight 1.3g.

Δ = +85 ± 15‰
δ¹³C = -19.3‰

**LJ-5093. Rat-tail fish, PW-14C-G-79**

Muscle of rat-tail fish (*Coryphaenoides armatus*) caught in net 305m above bottom at Sta 119 (31° 00.1' N, 159° 16.9' W). Bottom depth 5809m. Dry weight 1.5g.

Δ = +62 ± 17‰
δ¹³C = -19.0‰

**LJ-5362. Amphipods, PW-14C-H-79**

Five specimens of amphipod (*Eurythenes* sp) caught in baited traps 4.6 to 6.1m above bottom at Sta 211 (31° 00.6' N, 158° 56.7' W). Bottom depth 5867m. Fish were gutted before drying. Dry weight 1.4g.

Δ = +67 ± 18‰
Est δ¹³C = -21.0‰

**LJ-5363. Amphipods, PW-14C-I-79**

Two specimens of amphipod (*Eurythenes* sp) caught at two slightly different locations: 1) 716m above bottom at Sta 147 (31° 02.2' N, 159° 21.9' W), bottom depth 5789m; 2) 305m above bottom at Sta 175 (31° 08.8' N, 159° 21.9' W), bottom depth 5777m. Combined dry weight 1.8g.

Δ = +110 ± 8‰
δ¹³C = -20.4‰

**LJ-5364. Amphipods, PW-14C-J-79**

One specimen of amphipod (*Eurythenes* sp) caught 914m above bottom at Sta 211 (31° 00.6' N, 158° 56.7' W). Bottom depth 5867m. Dry weight 1.2g.

Δ = +100 ± 9‰
δ¹³C = -21.4‰

**Botanic and Atmospheric Samples**

**Palm tree series**

Three samples from palm tree (*Cocos nucifera*) grown near sea level near Aracaju, Sergipe state, NE Brazil (ca 11° 00' S, 37° 01' W). Continuation of series from Linick (1980), who gave sample treatment details and interpretation of ¹⁴C data. Samples analyzed to determine growth pattern of palm, which does not form annual rings. Subm by L H G Wiesberg, Chemistry Dept, Pontificia Univ Católica, Rio de Janeiro, Brazil. Wiesberg and Linick (1983) discuss growth of palm.
LJ-4949. Palm, 10.4m, inside
\[ \Delta = -9 \pm 4\% e \]
\[ \delta^{13}C = -24.8\% e \]
Wood taken from 0 to 4cm from center of tree 10.4m above ground.

LJ-4950. Palm, 10.4, outside
\[ \Delta = -7 \pm 4\% e \]
\[ \delta^{13}C = -24.6\% e \]
Wood taken from ca 0.5 to 2cm in from bark 10.4m above ground.

LJ-4951. Palm, 9.4m, inside
\[ \Delta = +13 \pm 4\% e \]
\[ \delta^{13}C = -24.8\% e \]
Wood taken from 0 to 4cm from center of tree 9.4m above ground. *Comment:* although this inside sample from 9.4m contained less bomb \(^{14}C\) than another inside sample from same height (\( \Delta = +87 \pm 8\% e, \) LJ-4304: R, 1980, v 22, p 1044), conclusions given by Linick (1980) are still valid; active vascular bundle may have been present more in LJ-4951 than in -495.1.

1942 Fruit series
Two samples of unsweetened fruit preserves made from fruit grown in AD 1942. For comparison, values are \(-19 \pm 2\% e\) for tree rings from 1941 and 1942 and \(-23 \pm 2\% e\) for tree ring from 1943 (Stuiver, 1982).

LJ-5517. Raspberries
\[ \Delta = -27 \pm 3\% e \]
\[ \delta^{13}C = -25.2\% e \]
Raspberry preserves made in 1942 on Nantucket L., Massachusetts (ca 41° 15' N, 70° 00' W).

LJ-5518. Apples
\[ \Delta = -20 \pm 3\% e \]
\[ \delta^{13}C = -20.2\% e \]
Apple preserves made in 1942, location unknown.

1980 Terrestrial vegetation and atmospheric CO\(_2\) series
Several samples of vegetation grown in La Jolla, California, and Heidelberg, West Germany, in 1980 were analyzed to determine whether any geog differences existed and whether there was any difference in \( \delta^{13}C \)-corrected \( \Delta \) values between plants utilizing different photosynthetic pathways (C\(_3\) and C\(_4\)). Samples of atmospheric CO\(_2\) were also coll by two methods at ground level outside La Jolla lab atop Mt Soledad. Samples below are arranged by date of colln. Vegetation samples coll by H E Suess; atmospheric CO\(_2\) samples coll by E M Druffel and T W Linick. *Comment:* no trends discernible, other than possible trend for samples coll later in summer of 1980 to have slightly higher activity than those coll earlier in year.

LJ-5194. Fig, La Jolla
\[ \Delta = +263 \pm 6\% e \]
\[ \delta^{13}C = -25.1\% e \]
Fruit of fig tree. Coll May 1980 at residence of H E Suess, La Jolla, near Univ California, San Diego.

LJ-5196. Wheat, Heidelberg
\[ \Delta = +260 \pm 5\% e \]
\[ \delta^{13}C = -27.0\% e \]
Winter wheat. Coll June 1980 from Waldhilsbach, near Heidelberg.
LJ-5197. Maize (corn), Heidelberg
Maize (corn). Coll June 1980 from Waldhilsbach, near Heidelberg.

\[ \Delta = +257 \pm 5\% \]
\[ \delta^{14}C = -12.4\% \]

LJ-5209. Atmospheric CO$_2$, La Jolla
Atmospheric CO$_2$ coll outside La Jolla lab by bubbling air through CO$_2$-absorber solution for 25 hr on June 19 and 20, 1980. Absorber solution consisted of 454g BaCl$_2$ · 2H$_2$O dissolved in 2668g concentrated NH$_4$OH solution. Air was bubbled through 3 absorber bottles, containing 700, 400, and 250mL, sequentially, of absorber solution.

\[ \Delta = +253 \pm 11\% \]
\[ \delta^{14}C = -20.5\% \]

LJ-5210. Atmospheric CO$_2$, La Jolla
Atmospheric CO$_2$ coll outside La Jolla lab by blowing air from fan over tray containing NH$_4$OH/BaCl$_2$ absorber solution for same 25 hr as LJ-5209, above, on June 19 and 20, 1980.

\[ \Delta = +252 \pm 14\% \]
\[ \delta^{14}C = -26.6\% \]

LJ-5193. Fig, La Jolla

\[ \Delta = +273 \pm 8\% \]
\[ \delta^{14}C = -25.4\% \]

L-5195. Fig leaves, La Jolla

\[ \Delta = +272 \pm 4\% \]
\[ \delta^{14}C = -28.0\% \]

LJ-5213. Atmospheric CO$_2$, La Jolla
Atmospheric CO$_2$ coll outside La Jolla lab by blowing air from fan over tray containing NH$_4$OH/BaCl$_2$ absorber solution for 5 days from Aug 28, 1980, to Sept 2, 1980.

\[ \Delta = +276 \pm 4\% \]
\[ \delta^{14}C = -25.4\% \]

References


LODZ RADIOCARBON DATES I

ANDRZEJ KANWISZER and PAWEL TRZECIAK
Archaeological and Ethnographical Museum in Łódź
91-415 Łódź, pl Wolności 14, Poland

The Radiocarbon Laboratory of the Archaeological and Ethnographical Museum in Łódź was established to meet the growing demand for radiocarbon dating of archeologic and geologic samples. The liquid scintillation technique based on the Polish liquid scintillation counter with a single photomultiplier began operation in 1966. The base for the measurements was ethylbenzene. In 1974 new facilities for the determination of radiocarbon assays were installed. The proportional counter and the electronics supplied by Nuclear Enterprises became routine counting equipment two years later.

Measurements are performed with the help of a ca 2L effective volume proportional counter with methane as the operating gas. The main detector is surrounded by a 10L dead methane flow counter which forms the anticoincidence system. The counter system is totally covered with a massive 25 to 30cm iron shield, 10 to 15cm block of borax/polyester resin, and an extra 5cm layer of old lead. At a working pressure of methane equal to 1000 torr, the background and net contemporary values (95% of NBS oxalic acid) are, respectively, 4.26 ± 0.04 and 19.60 ± 0.20cpm. Every sample is measured 80 times for 60 minutes. The NBS oxalic acid standard and background are counted once a month. Dates are expressed in years BP. Age calculations are based on the 5570-year Libby 14C half-life and on a contemporary value equal to 0.95 of the activity of the NBS oxalic acid standard. Deviations reported are based on counting statistics of sample, background, and modern, and are ± 1σ, except that when sample count approaches either modern or background, 2σ limits are reported. The results are not corrected for the 12C fractionation.

The method applied for methane conversion is based on the modified technique of organic combustion analysis. Samples are combusted in a quartz tube in a stream of purified oxygen (Libby, 1952) or by the combustion bomb method (Barker, Burleigh, and Meeks, 1969; Switsur, Hall, and West, 1970; Switsur, 1974) followed by trapping and purification of the CO2 and subsequent conversion to CH4 by hydrogenation via Ru catalyst (Fairhall, Schell, and Takashima, 1961). All methane samples are stored for one month in stainless steel containers to permit radon decay. The basic pretreatment of samples which are generally wood, peat, or charcoal, consists of visual examination for intrusive rootlets followed by boiling in 2% HCl, 2% NaOH, and 2% HCl, successively (Ben et al, 1978). Between each treatment the sample is washed in boiling distilled water and finally is kiln-dried at 100° C in a vacuum.

ACKNOWLEDGMENTS

We would like to express our gratitude to J Kroh, Director, Radiation Technique Institute, Łódź Technical University, for his scientific
support. We also acknowledge B Zaborski of Canada for his kind service of dispatching the complete set of *Radiocarbon* to us for the past 14 years.

SAMPLE DESCRIPTIONS

ARCHAEOLOGIC SAMPLES

**Radziejów Kujawski series**

Charred grains from Radziejów Kujawski (52° 35' N, 18° 30' E) and Opatowice (52° 50' N, 18° 50' E), Włocławek prov, extremely rare discovery in area of TRB culture. Thirty pits excavated in area 325m². Largest pits were 1.8 to 2m diam; 2 pits contained several kg of charred wheat. One pit situated at Radziejów Kujawski (Gabałówna, 1970; Grygiel, 1977). Another pit was discovered at Opatowice on Site 12, in NE part of rise partly destroyed by gravel quarry. At Opatowice charred wheat lay in shallow pit in TRB settlement at depth 1.15 to 1.3m below ground surface. Paleobotanic analysis of grain was made by M Klichowska, Paleobot Centre, Inst Hist Material Culture, Polish Acad Sci, Poznań. First sample coll and subm by L Gabałówna, Archaeol and Ethnog Mus, Łódź. Second sample coll and subm by R Grygiel, Archaeol and Ethnog Mus, Łódź.

**LOD-1. Radziejów Kujawski**  
4670 ± 380  
Charred wheat.

**LOD-20. Opatowice**  
4320 ± 180  
Charred grains, depth 1.1m.  
*General Comment:* charred wheat from Opatowice and Radziejów Kujawski should be interpreted as sacrificial offerings made during ritual practices.

**LOD-2. Kozienice**  
150 ± 45  
Wood, remains of bridge from Kozienice (51° 50' N, 21° 30' E), Radom prov. Coll and subm by A Kanwiszer.  
*General Comment:* bridge built by Napoleon’s soldiers in 1812 (check sample).

**Leczyca series**

Three samples of oak from Lęczyca and Tum (52° 10' N, 19° 20' E), Płock prov. Samples date from medieval fortress town complex near Lęczyca, established on main crossroad of central Poland (Warsaw-Berlin ice-marginal valley and Bzura valley). Settlement controlled passage through Bzura R. Coll and subm by T Poklewska, Inst Material Culture Hist, Polish Acad Sci, Łódź.

**LOD-3. Lęczyca**  
1860 ± 120  
Oak fragments of well boarding, surfical part of trunk. Well was on grounds of coal mine in Lęczyca.
<table>
<thead>
<tr>
<th>LOD-6.</th>
<th><strong>Tum 1</strong></th>
<th>1740 ± 120</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oak, surfical part of trunk from timber fortification.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>LOD-7.</th>
<th><strong>Tum 2</strong></th>
<th>1710 ± 120</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oak trunk, 0.25m thick, surfical part.</td>
<td></td>
</tr>
</tbody>
</table>

**Przywóz series**

Charcoal from Przywóz (50° 05' N, 18° 40' E), Sieradz prov. Some 400km N of ancient Roman frontier towns there was, in 2nd and 3rd centuries AD, a small settlement and two assoc barrows, on upper Warta, tributary of Odra R, in area called “Barbaricum”. Studies were made in village of Przywóz which lies on border of two historical provs, Great Poland and Silesia. Village is in S part of central Poland, on left bank of Warta R. The only commodity valued during Roman period until Late Middle ages was iron ore available over large subsurface area, mined for several centuries.

*General Comment:* two methods were used for dating settlement at Przywóz—classic archaeol method based on comparison of uncovered material such as terra sigilata, local pottery, coins and fibulae, and 14C analysis. On archaeol grounds, beginning of settlement was assigned to 2nd half of 2nd century AD, and its end to 1st half of 4th century AD.

Coll and subm by K Jazdzewski, Archaeol and Ethnog Mus, Łódz.

<table>
<thead>
<tr>
<th>LOD-4.</th>
<th><strong>Przywóz 1</strong></th>
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</thead>
<tbody>
<tr>
<td></td>
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<table>
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<td>Charcoal, Sec XLIX, Pit 207.</td>
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<thead>
<tr>
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<td>Charcoal, Sec XLIII, Site 1a, hearth of 2nd cottage.</td>
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</table>

<table>
<thead>
<tr>
<th>LOD-66.</th>
<th><strong>Przywóz 4</strong></th>
<th>1800 ± 100</th>
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<tbody>
<tr>
<td></td>
<td>Charcoal, Sec XXXIX in ditch, ca 160m from N wall at W wall.</td>
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<table>
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<th>LOD-67.</th>
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<table>
<thead>
<tr>
<th>LOD-68.</th>
<th><strong>Przywóz 6</strong></th>
<th>1780 ± 100</th>
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<tbody>
<tr>
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<td>Charcoal, Sec XLIV, Trench 44, Cottage 3, Pit 226.</td>
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<th>LOD-69.</th>
<th><strong>Przywóz 7</strong></th>
<th>5490 ± 140</th>
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<td>Charcoal, Sec I, Pit 218, depth 0.5 to 0.6m.</td>
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<th>LOD-75.</th>
<th><strong>Przywóz 8</strong></th>
<th>1760 ± 100</th>
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<tbody>
<tr>
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<td>Charcoal, Sec XLIII, Trench 43 and 44 (subterranean hut), from hearth overlying ash.</td>
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<th>LOD-76.</th>
<th><strong>Przywóz 9</strong></th>
<th>1860 ± 110</th>
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<tbody>
<tr>
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<td>Charcoal, Sec XLIII, hearth of 2nd cottage.</td>
<td></td>
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</tbody>
</table>
LOD-79.  Przywóz 10  
Charcoal, Sec LI, Trench 47.  
1830 ± 100

LOD-80.  Przywóz 11  
Charcoal, Sec LI, Trench 48.  
1640 ± 120

LOD-5.  Kałdus  
Charred wood from Kałdus (52° 25' N, 18° 35' E), Toruń prov.  
Sample coll from multicomponent settlement. Coll and subm by J Jani-
kowski, Dist Mus, Toruń.

Rekoraj series  
Excavations were made in single-enclosure ring earthwork at Rekoraj  
(51° 30' N, 19° 40' E), Piotrków Trybunalski prov. Study of Site 1 was  
conducted in 1967-69 and 1971. Site lies on right bank of Moszczanka R  
in watershed of Pilica R on promontory of sandy rise which gently  
descends into marshy valley of Moszczanka R. Timber-earth rampart was  
raised on slope of promontory. ¹⁴C dates were measured on charred timber  
from main rampart. Samples coll and subm by A Chmielowska, Archaeol  
and Ethnog Mus, Łódź.

LOD-9.  Rekoraj 1  
Charcoal, depth 0.5m.  
760 ± 90

LOD-51.  Rekoraj 2  
Charcoal, Unit 1, Sec 3, depth 0.9m.  
920 ± 100

LOD-52.  Rekoraj 3  
Charcoal, Unit 1, Sec 3, N part of Rampart I. Depth 0.9m.  
840 ± 120

LOD-54.  Rekoraj 4  
Charcoal, Unit 1, Sec 3, depth 0.9m.  
860 ± 120

LOD-55.  Rekoraj 5  
Charcoal, carbonized wood of construction, Unit 1, Sec 3, depth 0.9m.  
730 ± 120

LOD-56.  Rekoraj 6  
Charcoal under clay floor taken for paleomagnetic study. Unit 1,  
Sec 4.  
900 ± 110

LOD-57.  Rekoraj 7  
Charcoal, Unit 1, Sec 3, Quarter B, depth 0.6 to 0.7m.  
770 ± 110

LOD-58.  Rekoraj 8  
Charcoal, Unit 1, Sec 4, depth 0.1m.  
760 ± 110

LOD-59.  Rekoraj 9  
Charcoal, Unit 1, Sec 3, depth 0.08m.  
840 ± 110
Parleza Mała series
Two samples of charcoal from Parleza Mała (53° 51' N, 21° 03' E), Olsztyn prov. Coll and subm by K Nowak, Inst Archaeol, Warsaw Univ.

LOD-38. Parleza Mała 1 6230 ± 170
Charcoal, Unit 1. Sample coll 0.6m under humus.

LOD-39. Parleza Mała 2 6560 ± 190
Charcoal, Unit 1, Pit 5, depth 0.5 to 0.7m below top of pit.

Zawada series

LOD-42. Zawada 1 2390 ± 110
Charcoal, probably remains of charred pillar beams, Trench 16, E part of excavations, depth 0.9 to 1.1m.

LOD-45. Zawada 2 2380 ± 110
Charcoal post hole filling, Trench 16, E part of excavations, depth 0.94 to 1.24m.

LOD-46. Zawada 3 2400 ± 130
Charcoal filling of Pit 80, Trench 18, NW part of excavations of cultivated field, depth 1 to 1.2m.

LOD-48. Zawada 4 2420 ± 130
Charcoal, burn layer at bottom of Pit 83, Trench 16, S part of excavations, depth 0.85 to 1m.

LOD-50. Zawada 5 2320 ± 120
Charcoal, lower part of filling, Pit 70, Trench 17, NW part of excavations on cultivated field, depth 0.5 to 0.9m.

LOD-53. Zawada 6 2340 ± 90
Charcoal, Pit 72, Trench 15, E part of excavations, depth 0.4 to 0.6m.

LOD-88. Zawada 7 2440 ± 130
Charcoal, bottom of Trench 103, W part of rise, at culmination of rise, depth 1.1 to 1.2m.

LOD-89. Zawada 8 2450 ± 130
Charcoal from filling material of Trench 112, NW part of site, on point of rise.

LOD-90. Zawada 9 2390 ± 110
Charcoal from filling material of S part of Trench 113, NW part of site, on point of rise.
LOD-49. Iwanie 3310 ± 140
Charcoal, Komorow culture barrow, Równe dist (50° 25' N, 25° 40' E), USSR. Coll and subm by I Swiesznikowa, Lwów.

LOD-60. Wietrzychowice 5170 ± 180
Charcoal from Wietrzychowice (52° 10' N, 18° 55' E), Konin prov. Sample from Kuyavian barrow cemetery of Funnel Beaker culture from beginning of Period II of Polish Neolithic, 3650-2600 yr BC. Second tomb. Cemetery is in forest on small flexure of ground, on meadow bog, remains of ancient river. Depth 1.2 to 1.4m. Coll and subm by K Jazdzewski.

Stryczowice series

LOD-61. Stryczowice 1 5400 ± 240
Charcoal, arable field, Trench 1 on plateau, depth 0.7 to 0.8m.

LOD-62. Stryczowice 2 4250 ± 180
Charcoal, fragments scattered in trench, on Neolithic deposit. Arable field, Trench 5a on plateau, depth 1 to 1.3m.

LOD-63. Stryczowice 3 4360 ± 210
Charcoal, fragments scattered in Trench 5b on plateau. Arable field, depth 1.2 to 1.5m.

Lesno series
Three samples from Leśno (58° 57’ N, 17° 42’ E), Bydgoszcz prov. First sample coll from skeletal tomb. Two remaining samples come from prince’s tomb which dates from Roman period. Coll and subm by A Kanwiszer.

LOD-70. Lesno 1 1920 ± 110
Moss, skeletal tomb No. 1, Sec 4.

LOD-71. Lesno 2 140 ± 60
Charcoal, prince’s grave. Sample coll from layer under pavement.

LOD-81. Lesno 3 130 ± 60
Charcoal, prince’s grave. Sample coll from external layer of stone pavement, from geometric center of stone circle.

Czerchów series
LOD-72. **Czerchów 1** 740 ± 70
Charcoal, Excavation I, Sec 11, Profile E, suburb, depth 0.4m.

LOD-73. **Czerchów 2** 660 ± 90
Charcoal, Excavation I, Sec 11, Layer 2, depth 1.77m.

LOD-74. **Czerchów 3** 650 ± 90
Charcoal, Excavation I, Sec 11, NE corner, suburb.

LOD-82. **Leg Piekarski** 1920 ± 110
Wood from Leg Piekarski (51° 55’ N, 18° 39’ E), Konin prov. Sample comes from cemetery which dates from early Roman period. Dated material was taken from outside part of press-boarded floor of grave. Quarter 3 and 4, Grave A. Coll and subm by K Jazdewski.

LOD-92. **Kreta** 9650 ± 220
Reindeer antler from Kreta (53° 01’ N, 22° 55’ E), Białystok prov. Sample coll and subm by M Prószczyński, Quaternary Research Comm, Warsaw.

**Brzesć Kujawski series**
Three samples from Kuczyna and Brzesć Kujawski (52° 36’ N, 18° 53’ E), Włocławek prov. Material dates from Linear Pottery culture. Samples dated to establish evolution of Kuyavian Funnel Beaker culture. Coll and subm by R Grygiel.

LOD-93. **Kuczyna** 5530 ± 220
Charcoal from clay pit, depth 0.8 to 1m.

LOD-110. **Brzesć Kujawski** 5160 ± 180
Charcoal, Site 3, Pit 773, depth 1.2m.

LOD-127. **Brzesć Kujawski** 5850 ± 170
Charcoal from burn layer of hearth, depth 0.7 to 0.9m.

LOD-107. **Mosty Village** 11,290 ± 280
Charcoal from Mosty Village (50° 47’ N, 20° 25’ E), Kielce prov, from hearth, depth 0.3 to 0.35m. Dated to assign dwelling feature of hut type to definite culture. Coll and subm by K Cyrek, Archaeol and Ethnog Mus, Łódź.

LOD-111. **Olbrachcice** 12,680 ± 230
Charcoal from Olbrachcice (51° 40’ N, 16° 30’ E), Leszno prov. Sample was scattered within pressed wood at depth 0.4 to 0.6m. Dated to establish chronology of Hamburg culture in Poland. Dates from NW Europe contradict each other. Coll and subm by M Burdukiewicz, Inst Archaeol, Warsaw Univ.

**Winnica series**
Three charcoal samples from Winnica (50° 29’ N, 21° 17’ E). Tar-
Andrzej Kanwiszer and Pawel Trzeciak

nobrzeg prov, from box construction of rampart. Dated to establish chronology of 1st stage of earthworks in Winnica. Coll and subm by E Tworowska, Inst Archaeol, Warsaw Univ.

**LOD-124. Winnica 1**
Charcoal, depth 2.6 to 2.65m.  
920 ± 90

**LOD-125. Winnica 2**
Charcoal, depth 2.55 to 2.6m.  
870 ± 90

**LOD-126. Winnica 3**
Charcoal, depth 2.5 to 2.58m.  
800 ± 90

**Stobnica Trzymorgi series**

Stobnica Trzymorgi (51° 25' N, 19° 55' E), Piotrków Trybunalski prov, is on left bank of Pilica R, in region of greatest loop of middle course of river. Site is on point of dune elev, on left bank of Stobniczanka R near its juncture with Pilica R. Site is multicomponent unit consisting of Neolithic settlements and traces of habitation from Bronze Age III, Hallstatt period, Late La Tène period, Roman period, Early Middle Ages. Settlement of Venedian culture, which dates from Late La Tène, is richest—60 hearths and 5 traces of post-supported dwellings were discovered. Excavation was conducted by H Wiklak who coll and subm all samples described below.

**LOD-128. Stobnica 1**
Charcoal, Hearth 12, depth 0.4 to 0.6m.  
2160 ± 110

**LOD-129. Stobnica 2**
Charcoal, Hearth 16, depth 0.4 to 0.6m.  
2130 ± 110

**LOD-130. Stobnica 3**
Charcoal, Hearth 11, depth 0.4 to 0.6m.  
2160 ± 100

**LOD-131. Stobnica 4**
Charcoal, Hearth 10, depth 0.4 to 0.6m.  
2190 ± 100

**LOD-132. Stobnica 5**
Charcoal, Hearth 18, depth 0.4 to 0.6m.  
2110 ± 110

**LOD-133. Stobnica 6**
Charcoal, Hearth 15, depth 0.4 to 0.6m.  
2240 ± 100

**LOD-134. Stobnica 7**
Charcoal, Hearth 20, depth 0.4 to 0.6m.  
2160 ± 100

**LOD-135. Stobnica 8**
Charcoal, Hearth 46, depth 0.4 to 0.6m.  
2190 ± 110

**LOD-136. Stobnica 9**
Charcoal, Hearth 59, depth 0.4 to 0.6m.  
2070 ± 110
LOD-137. Stobnica 10  
2150 ± 110
Charcoal underlying stone pavement which composed bottom of hearth no. 2, depth 0.4 to 0.6m.

LOD-138. Stobnica 11  
2110 ± 100
Charcoal, Hearth 2, depth 0.4 to 0.6m.

Kochlew series
Site is on high sandy terrace of upper course of Warta R (51° 12’ N, 18° 48’ E), Sieradz prov. This is well studied Late Palaeolithic camp with highly developed flint production. Near flint workshop were found hearths, domestic pits, and two features of hut dwelling. Samples coll and subm by K Cyrek. Excavation was conducted from 1975-1979.

LOD-141. Kochlew 1  
140 ± 90
Charcoal, depth 0.5m.

LOD-142. Kochlew 2  
10,320 ± 220
Humus with charcoal, depth 0.8 to 1m.

LOD-143. Kochlew 3  
10,260 ± 210
Humus sand with charcoal, depth 0.9 to 1m.

LOD-144. Kochlew 4  
11,180 ± 220
Peat, depth 0.9m.

Lykowe series
This multicomponent site is on high, sandy terrace of upper course of Warta R (51° 12’ N, 18° 47’ E), Sieradz prov. Oldest complex of site dates from Late Palaeolithic period, rich in lithic workshop inventory with diagnostic leaf-shaped points of tundra cultures. Mesolithic parts of wooden foot-bridge and fragments of burials are present among dating samples. Coll and subm by M Cyrek and K Cyrek.

LOD-145. Lykowe 3  
5430 ± 190
Charcoal with humus, depth 0.9m.

LOD-146. Lykowe 2  
5380 ± 180
Charcoal, depth 0.7 to 0.9m.

LOD-147. Lykowe 9  
4630 ± 160
Sandy peat, depth 0.7m.

LOD-148. Lykowe 8  
10,380 ± 220
Oozy sand with humus fragments, depth 1.8m.

LOD-149. Lykowe 7  
9150 ± 210
Sandy peat, depth 1.1m.

LOD-150. Lykowe 6  
8070 ± 180
Sandy peat, depth 1m.
LOD-151. Lykowe 1  
Charcoal with humus, depth 0.8m.

**GEOLOGIC SAMPLES**

**Chrpanów series**
Humus from Chrpanów (50° 50' N, 21° 43' E), Tarnobrzeg prov. Samples coll from fossil soil in lower level of ditch, fossil soil. Samples were dated to determine age of erosion fossil forms as well as age of sedimentation in Czyżówka R valley, effluent of Vistula R near Zawichost. Samples coll and subm by D Kosmowska-Suffczyńska, Inst Geog, Warsaw Univ.

LOD-17. Chrpanów site; Level A  5140 ± 120  
Depth 5 to 5.25m.

LOD-18. Chrpanów site; Level B  11,000 ± 380  
Depth 5.25 to 5.5m.

LOD-21. Strbskie Pleso, Czechoslovakia  7070 ± 240  
Lacustrine, non-carbonate organic sediment from Strbskie Pleše lake, Slovak Tatras, (49° 20' N, 20° 02' E) at depth 15m. Sample coll by K Więckowski with metal sampling probe of his own design from sediment bed at 1.9 to 2.4m below bottom of lake. Dated to determine age of Tatras Mt lakes. Sample subm by J Kondracki, Inst Geog, Warsaw Univ.

**Lomzyca series**

LOD-22. Lomzyca 2  11,220 ± 280  
Slightly decomposed and pressed peat coll from wall of drainage ditch at depth 2.4m.

LOD-23. Lomzyca 1  11,790 ± 290  
Brown decomposed peat with small admixture of sand coll from S side of viaduct at depth 3.3 to 3.4m.

LOD-24. Lomzyca 3  >28,000  
Dark gray, sandy silt from foundation trench of factory building at 4.6 to 4.65m depth. Sample overlay sediments from which LOD-22 and -23 were coll. Comment: this series probably extracted from sediments of cold period which preceded max extension of continental glacier that covered Baltic Sea (Borówka-Dłużakowa, 1957; Straszewska, 1968).
LOD-119. Lomzyca 5 \( 10,900 \pm 230 \)
Decomposed peat with loam from site on grounds of “Korgaz” Gas Communal Bottling Plant, Lomza. Sample coll with borer from depth 3.3 to 3.7m.

LOD-139. Lomzyca 7 \( >35,000 \)
Gyttja from well boring at depth 5.7 to 7.8m, from “Korgaz” Gas Communal Bottling Plant, Lomza.

LOD-140. Lomzyca 6 \( 11,030 \pm 380 \)
Fossil soil with slight amount of carbon (2.8%). Sample coll with borer on grounds of lacustrine reservoir from depth 3.3 to 3.6m.

Skorupy series
Peat from Skorupy village (52° 03' N, 21° 26' E), Warsaw prov. Samples removed with borer from top part of organic drift series. Samples coll to study character of fossil and relict soils created from rocks of different origins. Samples coll and subm by D Baraniecka, Inst Sci Soil, Acad Agric, Warsaw.

LOD-25. Skorupy 1 \( >28,000 \)
Peat from depth 6.9 to 7.7m.

LOD-26. Skorupy 2 \( >28,000 \)
Peat from depth 6.9 to 7.7m.

Niewiadowo series
Samples from Niewiadów village (53° 08' N, 22° 11' E) near Lomza. First sample was within range of water-level oscillation of Narew R at depth 2 to 2.3m. Age of samples should contribute to dating of Narew R Quaternary series and determine upper age limit for formation of fossil soil. Coll and subm by K Straszewska.

LOD-27. Niewiadowo 1 \( 1420 \pm 130 \)
Wood from oak trunk underlying sediment of Quaternary formation of Narew R, depth 2 to 2.3m.

LOD-99. Niewiadowo 2 \( 1380 \pm 110 \)
Charcoal in fossil soil from dune, depth 1.5 to 2m.

Osuchy series
Peat from Osuchy village (50° 29' N, 22° 58' E), Zamość prov, from uncropped layer at terrace edge of Tanew R undercut by stream. Samples dated to determine age of terrace of Tanew R. Coll and subm by W Laskowska-Wysoczyńska, Dept Sci, Polish Acad Sci, Warsaw.

LOD-28. Osuchy 418 \( 8900 \pm 220 \)
Peat, depth 1m.
LOD-98. Osuchy 420  9380 ± 230  
Peat, depth 1.4m.

Rosle series
  Peat and charcoal from Rosle (52° 08' N, 18° 54' E), Konin prov coll from different parts of dune near Ner R. Dated to reconstruct evolution of dune formation, ie, paleogeography of Warsaw-Berlin ice-marginal valley near Uniejów. Strata from which samples were coll probably date from early Holocene (Krajewski, 1976) or Late Pleistocene. Coll and subm 1975 by K Krajewski, Inst Geog, Lódź Univ.

LOD-29. Rosle 12,420 ± 280  
Peat from top stratum at base of dune, depth 4m.

LOD-37. Rosle 7 12,140 ± 290  
Peat from stratum of base of dune, depth 4m.

LOD-40. Rosle 5 11,920 ± 240  
Charcoal with single coal from stratum of fossil soil, depth 2.7m.

LOD-41. Podgórze 3740 ± 150  
Charcoal from stratum of fossil soil, with single coals, depth 2.5m.

Cieciwa series
  Samples from Cieciwa (52° 15' N, 21° 28' E) and Wiązowna (52° 10' N, 17° 20' E), Warsaw prov coll from sand quarry. Dated to determine stratigraphic division of dunes and fossil soil, as element of geog environment near Warsaw. Coll and subm by K Konecka-Betley, Inst Sci Soil, Acad Agric, Warsaw.

LOD-30. Cieciwa 3/6 11,150 ± 300  
Charcoal from soil layer, depth 6m.

LOD-31. Cieciwa 3/2 6150 ± 270  
Peat from top layer of fossil soil, depth 2m.

LOD-32. Wiązowna 10,340 ± 450  
Mineral soil including humus fragments, depth 18m.

LOD-47. Cieciwa 7150 ± 350  
Mineral soil including humus fragments, depth 2m.

LOD-33. Kunów 3410 ± 160  
Charcoal from Kunów (50° 57' N, 21° 16' E), Kielce prov, scattered in loess. Sample coll from natural outcrop in valley; dated to determine age of fossil soils and evolution of soil-forming process during Holocene (Jersak, 1965), depth 4.35 to 5.2m. Coll and subm by J Jersak, Inst Geog, Lódź Univ.

LOD-34. Nietulisko Male 8420 ± 170  
Charcoal from Nietulisko Male (50° 58' N, 21° 15' E), Kielce prov
from layer of bones and coals deposited on bottom of partly buried suffosio tunnel. Research site was set up at side branch of large gorge, +218m, ca 38m above bottom of Swiślina Valley. Coll and subm by Z Snieszko, Inst Geog, Łódź Univ.

**LOD-35. Odonów I**

6020 ± 250

Humus from Odonów (50° 15' N, 20° 30' E), Kielce prov from arable level formed on loess, depth 2m. Coll and subm by Z Snieszko.

**Szynkielów series**

Three samples from Szynkielów site (51° 22' N, 18° 45' E), two samples from Kamion site (52° 21' N, 20° 11' E) and one from Młodzieszyn site (52° 21' N, 20° 10' E), Skierniewice prov. Dated to determine age of fossil soil as part of study of evolution of soil cover in Late Pleistocene and Holocene (Manikowska, 1977; Wasylikowa, 1976). Samples coll from sand pit of dune. Coll and subm by B Manikowska, Inst Geog, Łódź Univ.

**LOD-36. Szynkielów 1**

4720 ± 140

Charcoal from humus level of fossil podzol in dune 0.1m thick, depth 0.5m.

**LOD-43. Kamion 1**

12,230 ± 260

Humus scattered in sand with admixture of dust from initial level of humus of fossil soil in dune, depth 1 to 1.5m.

**LOD-44. Szynkielów 2**

5310 ± 150

Humus from sandy Quaternary formation at level of fossil podzol, depth 0.75m.

**LOD-83. Szynkielów 3**

8790 ± 190

Charcoal, depth 2m.

**LOD-84. Młodzieszyn 1**

10,830 ± 250

Charcoal, depth 1.2 to 1.7m.

**LOD-85. Kamion 2**

14,590 ± 270

Humus scattered in argillo-arenaceous sediment, depth 2.5m.

**Skarzysko series**

Fossil soil and peat from Skarzysko Kamienna (51° 07' N, 20° 50' E) and Brody Iłżeckie (51° 02' N, 21° 05' E), Kielce prov. Samples come from continuous soil level, coll by J Bartosik, Inst Geog, Paedagog Coll, Kielce; subm by Z Ksizak, Inst Geog, Paedagog Coll, Kielce.

**LOD-77. Skarzysko Kamienna**

>28,000

Black peat with organic fragments, depth ca 8m.

**LOD-78. Brody Iłżeckie**

11,080 ± 280

Fossil soil, peat, depth ca 2m.
LOD-86. **Kalinko**  \[28,300 \pm 900\]

Humus scattered in oozy and sandy material from Kalinko village (51° 38' N, 19° 33' E), Lódź prov. Sample from irrigation ditch, Pilica R, Lódź, depth 1.3 to 1.5m. Test sample contained min amount of organic compounds. Dated to study Würmian stratigraphy and palaeogeography of Lódź region. Coll and subm by B Manikowska.

LOD-87. **Gaski 1**  \[10,450 \pm 260\]

Peat underlying dune sands of Baltic beach, depth 2.5m, from Gąski village (54° 15' N, 15° 34' E), Koszalin prov. Dated to study evolution of shoreline and formation of coastal dune (Marsz, 1966). Coll and subm by K Krajewski.

**Kampinos Nart series**

Peat from dune near Kampinos Nart village (52° 17' N, 20° 29' E), Warsaw prov. Dated to explain formation of dunes in Kampinos Natl park. Coll and subm by K Konecka-Betley.

- **LOD-91. Kampinos Nart 1**  \[5400 \pm 250\]
  Peat, depth 1.55 to 1.7m.

- **LOD-94. Kampinos Nart 2**  \[7110 \pm 320\]
  Peat, depth 2.3 to 2.8m.

- **LOD-103. Kampinos Nart 3**  \[6850 \pm 200\]
  Peat, depth 1.55 to 1.7m.

- **LOD-104. Kampinos Nart 4**  \[7300 \pm 230\]
  Peat, depth 2.3 to 2.8m.

- **LOD-105. Kampinos Nart 5**  \[5650 \pm 210\]
  Peat, depth 1.55 to 1.7m.

- **LOD-106. Kampinos Nart 6**  \[5200 \pm 180\]
  Peat, depth 1.55 to 1.7m.

**Zerniki series**

Samples from Zerniki (50° 46' N, 20° 24' E), Kielce prov. Dated to study evolution of valley bottom of Nida R during Holocene. Coll and subm by Z Snieszko.

- **LOD-95. Zerniki 1**  \[1930 \pm 190\]
  Wood from trunks in so-called “black oaks level”, depth 2m from basal sediment of Holocene terrace.

- **LOD-96. Zerniki 2**  \[2200 \pm 200\]
  Charcoal within fossil soil, depth 1m.

**LOD-108. Osówka Stara**  \[5200 \pm 190\]

Fossil soil with charcoal from Osówka Stara village (50° 37' N, 21° 00' E), Kielce prov, depth 2.6m. Coll and subm by K Książak.
Lack series
Samples from Łąck (53° 32' N, 19° 36' E), Płock prov. Gyttja coll from lake basin, in run-off water discharge basin between oozes. Coll and subm by K Konecka-Betley.

**LOD-109. Lack 1**
Gyttja, depth 6.52 to 6.99m.

**LOD-123. Lack 2**
Gyttja, depth 6.45 to 6.6m.

Belchatów series
Samples from Rogowiec and Bełchatów (51° 14' N, 19° 23' E), Piotrków Trybunalski prov, from open mine in Bełchatów or from directly adjoining fields. Dated to elaborate on cross-section of Würmian sediments. Coll and subm by J Goździk, Inst Geog, Łódź Univ.

**LOD-115. Rogowiec**
Charcoal from fossil soil in cut near mine, depth 1.2m.

**LOD-116. Bełchatów-“Piaski”**
Fir cone and other vegetal remains coll from top layer of brook sediment and from bottom side of silty sediment in cross-section of mine, depth 2.5m.

**LOD-117. Bełchatów-“Piaski”**
Ooze with organic material (humus) from organic ooze underlying Würmian sediment of brook in cross-section of mine, depth 20m.

**LOD-118. Bełchatów-“Piaski”**
Sample from ooze formation with admixture of organic material underlying sediments of brook, depth 18m.

Inowlódz series
Samples from central part of ancient Pilica riverbed meander Inowlódz (51° 31' N, 20° 13' E), Piotrków Trybunalski prov. Samples were bored manually, dated to study transitions of horizontal river bed of Pilica R from Middle ages to 19th century. All samples coll by W Balinski, subm by J Augustyniak, The Centre for Research in Documentation of Monuments, Łódź.

**LOD-120. Inowlódz I/1**
Peaty silt, depth 1.4 to 1.6m.

**LOD-121. Inowlódz I/2**
Peaty silt, depth 1 to 1.3m.

**LOD-122. Inowlódz I/4**
Peaty silt, depth 1.4 to 1.6m.
LOD-152. **Inowłódz II/5**
Ooze with organic fragments, depth 1.2 to 1.6m.

LOD-153. **Inowłódz II/4**
Peaty silt, depth 1m.

LOD-154. **Inowłódz II/3**
Ooze with organic fragments, depth 0.8m.

LOD-155. **Inowłódz II/2**
Silt with organic fragments, depth 1.2 to 1.3m.

LOD-156. **Inowłódz II/1**
Peat, depth 1.3 to 1.4m.

**References**


MUSEO DE LA PLATA RADIOCARBON MEASUREMENTS I

ANIBAL FIGINI, GABRIEL GOMEZ, JORGE CARBONARI, ROBERTO HUARTE, and ALICIA ZUBIAGA

Laboratorio de Tritio y Radiocarbono, Facultad de Ciencias Naturales y Museo, Paseo del Bosque, 1900 La Plata, Argentina

INTRODUCTION

The reinstallment, operation, and the $^{14}$C measurements reported here were made since 1976 in the LATYR, the Radiocarbon Dating Laboratory of the Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata. Sample preparation is preceded by careful visual separation and hand removal of gross impurities. This is followed in all cases (charcoal, wood) with successive washings of the sample with boiling 2% HCl and 1% NaOH solution for removal of carbonates and humic acids. Thereafter, it is washed with distilled water and acidified to pH = 3. Individual variations in the pretreatment are not described in the date list, but they are usually reported directly to the collector together with the data obtained.

Shell is dissolved in two fractions by HCl. The outer part of the shell (20% in weight) is discarded to reduce possible surface contamination. The inner part (20 to 100% in weight) is used for dating. In some cases these two fractions are dated separately. Bone is pretreated by solution of collagen in acid hot water, according to Longin (1970; 1971) with slight modifications. The chemical procedure for the groundwater samples preparation is to precipitate the carbon already in the field as barium carbonate. Atmospheric samples are collected by weekly static absorption in sodium hydroxide solution. In the lab, the solutions are converted to carbon dioxide by acid hydrolysis.

For organic materials the CO$_2$ is produced in a tube combustion unit with an oxygen stream, with initial purification by CuO (600°C), acid potassium permanganate, and precipitation in sodium hydroxide solution in the form of barium carbonate. The solution is acid hydrolyzed in vacuo using phosphoric acid.

CO$_2$ is evolved from carbonate samples by means of acid hydrolysis. We obtain the purest gases by final purification through a vacuum line with a water vapor trap (−80°C), Cu furnace (450°C), water vapor trap, and liquid air trap for CO$_2$. Then, it is stored for three weeks for complete decay of radon.

Radioactivity is measured with a gas proportional counter, using carbon dioxide at 820mm Hg as filling gas, at room temperature (20°C). The dating system has a 381ml copper-walled proportional counter, surrounded by 3cm of selected lead, which is encircled by a ring of 14 cosmic-ray Geiger counters. Working voltage is 5200v with a plateau length of 300v and a plateau slope of ca 1% per 100v (for mesons).

Influence of cosmic and local environmental radiation on the counters is reduced with a composite shield consisting of layers of iron (10cm),...
paraffin (15cm), and iron (30cm), at the top. All samples are counted at least twice for periods of not less than 2000 minutes each.

Age calculations are based on a contemporary value equal to 0.950 the specific activity of NBS oxalic acid standard and on the conventional Libby half-life for $^{14}$C of 5570 ± 30 years. Results are reported in years before 1950 (years BP). Errors quoted (1σ) include standard deviations of count rates for the unknown sample, contemporary standard, and background. Background CO$_2$ is obtained from the acidification of marble and combustion of petroleum coke. The modern standard is prepared from NBS oxalic acid (SRM 4990 B) by wet oxidation with great care to achieve complete reaction (Valastro, Land, & Varela, 1977; 1979). No corrections were made for isotopic fractionation and/or reservoir effect.

The description of each sample is based on information provided by the submitter.

**ACKNOWLEDGMENTS**

Financial support from the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) of Argentina is gratefully acknowledged, and we would like to thank O Salvigsen and H S Jansen for providing inter-laboratory check samples. We also express our special recognition to Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Argentina.

**INTER-LABORATORY CHECK SAMPLES**

<table>
<thead>
<tr>
<th>Lab no.</th>
<th>LP date</th>
<th>Other lab no.</th>
<th>Other date</th>
<th>Refs</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP-71</td>
<td>9910 ± 240</td>
<td>T-2917</td>
<td>9580 ± 150</td>
<td>Pers commun</td>
</tr>
<tr>
<td>LP-72</td>
<td>9280 ± 250</td>
<td>T-2919</td>
<td>9480 ± 140</td>
<td>Pers commun</td>
</tr>
<tr>
<td>LP-73</td>
<td>7460 ± 210</td>
<td>R-9048*</td>
<td>7670 ± 70</td>
<td>Pers commun</td>
</tr>
</tbody>
</table>

* Internal no.—New Zealand lab

**General Comment:** apparent differences are considered statistically insignificant (Ward & Wilson, 1978) and LP dates are in statistical concordance with those provided by other labs.

**SAMPLE DESCRIPTIONS**

**GEOLOGIC SAMPLES**

**Argentina**

**Las Escobas I series**

Marine coastal deposits corresponding to Las Escobas Fm, Prov Buenos Aires. Coll and subm by F Fidalgo, Fac Sci Nat Mus (FCNyM), Univ Nac La Plata (UNLP).

**LP-7. Rincón Grande**

Pelecypod shells from Rincón Grande (35° 49' 28" S, 57° 29' 20" W), Partido de Castelli, depth 0.9m.
LP-8. **Rincón de López, Sample 1**  
3050 ± 160  
Pelecypod shells from Rincón de López (35° 47’ 08” S, 57° 24’ 20” W), Partido de Castelli, depth 1.2m.

LP-9. **Canal 18**  
5770 ± 170  
Pelecypod shells from exposed profile near Estancia San Horacio (35° 42’ 51” S, 57° 35’ 30” W), partido de Chascomús, depth 0.7m.

*General Comment:* results confirm Holocene age of Las Escobas Fm (Fidalgo, 1979).

**Bahia San Antonio series**

Marine shells coll from Baliza San Matías and San Antonio Fms (Angulo *et al*, 1978; Fidalgo *et al*, 1980), Bahía de San Antonio, Prov Río Negro. Both deposits record marine advances during Upper Pleistocene and Holocene times, respectively. Mollusk shells were taxonomically determined by Z Castellanos (FCNyM, UNLP). Coll and subm by F Fidalgo.

**LP-33. Baliza San Matías**  
>27,000  
Shells (*Crepidula dilatata*) (40° 49’ 22” S, 64° 45’ 17” W), Baliza San Matías Fm. *Comment:* inner fraction (80%) was used.

**LP-35. San Antonio, Sample 1**  
>28,000  
Shells (*Amiantis purpurata*) (40° 42’ 22” S, 64° 51’ 40” W), San Antonio Fm. *Comment:* inner fraction (80%) was used.

**LP-36. Ruta no. 3**  
>40,000  
Shells (*Glycimeris longior*) (40° 41’ 55” S, 65° 02’ 30” W), San Antonio Fm. *Comment:* inner fraction (80%) was used.

**LP-44. San Antonio, Sample 2**  
>40,000  
Shells (*Clamys* sp) (40° 42’ 22” S, 64° 51’ 40” W), San Antonio Fm. *Comment:* inner fraction (80%) was used.

**LP-45. Caleta Falsa**  
>40,000  
Shells (*Chionidae* sp) (40° 47’ 56” S, 64° 50’ 38” W), Baliza San Matías Fm. *Comment:* inner fraction (80%) was used.

*General Comment:* geologically, difference observed between 14C ages and relative age assigned to San Antonio Fm deposits would indicate that mollusk specimens might have been retransported from older units. Min ages obtained (3σ criterion) are related to pelecypod ages and not deposit age (Fidalgo *et al*, 1980).

**Las Escobas II series**

Samples were coll from Destacamento Río Salado and Las Escobas Fms, Prov Buenos Aires. First lithostratigraphic unit could have developed during last glaciation, and other unit during Holocene (Fidalgo, 1979). Samples coll by F Fidalgo. Mollusk shells were coll by LP lab (Fidalgo *et al*, 1981). Bone was taxonomically id. by E Tonni (FCNyM, UNLP). Mollusk shells were id. by Z Castellanos (FCNyM, UNLP). X-ray diffraction analyses were made by M Iñíguez Rodríguez (FCNyM, UNLP).
LP-46. Villa Catella  
Collagen extracted from the mandibular branch fragment of *Eubalaena sp*, Villa Catella (34° 53' 39" S, 57° 56' 47" W), Partido de Ensenada, from within sediments of ancient shoreline pertaining to Las Escobas Fm.

LP-47. Villa Catella  
Bone apatite extracted following Haynes (1968) from same mandibular branch fragment of *Eubalaena sp*; thus, same sample as LP-46.

LP-49. Rincón de Lópex, Sample 2  
Shells (*Mactra isabelleana*) extracted from Rincón de López (35° 46’ 07” S, 57° 24’ 30” W), Partido de Castelli, from upper part of Destacamento Rio Salado Fm. *Comment*: inner fraction (80%) was used.

LP-50. Canal Las Escobas, Sample 1  
Shells (*Tagelus plebeius*) extracted from exposed profile in Las Escobas Channel (35° 58’ 21” S, 57° 29’ 16” W), Partido de Castelli, Las Escobas Fm, from depth 0.5m below surface. *Comment*: inner fraction (80%) was used.

LP-51. Ruta Provincial no. 11, Sample 1  
Shell (*Adelomedon sp*) extracted from profile above Ruta Provincial no. 11 (35° 37’ 57” S, 57° 18’ 19” W), Partido de Magdalena, Las Escobas Fm, from depth 0.4m under edaphic sediments. *Comment*: inner fraction (80%) was used.

LP-52. Rincón de Lópex, Sample 3  
Shell (*Adelomedon brasiliensis*) coming from Rincón de López (35° 46’ 07” S, 57° 24’ 30” W), Partido de Castelli, extracted from Las Escobas Fm. *Comment*: inner fraction (80%) was used.

LP-54. Manuel B Gonnet  
Evaporite sample from Calle 516 and Calle 7 (34° 52’ 28” S, 58° 00’ 11” W), Manuel B Gonnet, Partido de La Plata, extracted from Las Escobas Fm, by sounding from depth 0.5m from surface.

LP-66A. Canal Las Escobas, Sample 2  
6490 ± 230

LP-66B.  
6760 ± 190

Shells (*Tagelus plebeius*) extracted from exposed profile in Las Escobas Channel (35° 58’ 21” S, 57° 29’ 16” W), Partido de Castelli, Las Escobas Fm from depth 0.5m below surface. *Comment*: for LP-66A, outer fraction (20%) was used; for LP-66B, inner fraction (80%) was used.

LP-67A. Rincón de Lópex, Sample 4  
6060 ± 200

LP-67B.  
5930 ± 220

Shell (*Adelomedon brasiliensis*) from Rincón de López (35° 46’ 07” S, 57° 24’ 30” W), Partido de Castelli, extracted from Las Escobas Fm. *Comment*: for LP-67A, outer fraction (20%) was used; for LP-67B, columella was used.
Museo de La Plata Radiocarbon Measurements I

LP-68A.  **Ruta Provincial no. 11, Sample 2**  \(3760 \pm 240\)

LP-68B.
Shells (\emph{Mactra isabelleana}) extracted from exposed profile at Ruta Prov no. 11 (35° 37' 57" S, 57° 18' 19" W), Partido de Magdalena, Las Escobas Fm, from depth 0.4m below edaphic sediments. \textit{Comment:} for LP-68A, outer fraction (20%) was used; for LP-68B, inner fraction was used.

\textit{General Comment:} (Fidalgo et al, 1981): results from mollusk shells in life position — tanatocenosis — especially LP-50 and -66, yielded ages greater than those determined by other authors for these deposits (Cigliano, 1966; Cortelezzi, 1977). Obtained results from Destacamento Río Salado Fm (LP-49), older than most data from Las Escobas Fm, is consistent with geol relationships between both units: Las Escobas Fm overlies unconformable Destacamento Río Salado Fm. Evaporite sample (LP-51), with 111% modern, would indicate contamination by infiltrated meteoric and phreatic waters very close to surface. This result shows age younger than first thermonuclear explosions. X-ray diffraction analyses of samples LP-66B, -67B, and -68B show no evidence of contamination by mineralogic conversion, since these samples are composed of aragonite.

\textbf{Salina del Bebedero series}
Gastropod shells from ancient shorelines in Salina del Bebedero (33° 20' S, 66° 45' W), Prov San Luis (González et al, 1981). Most samples were taken from different outcroppings, except for LP-57 and -58, which come from same profile, at depth of 2m and 5.5m below surface, respectively. Samples were coll by M A González and taxonomically determined by A Pérez, Univ Nac del Sur (UNS), Bahía Blanca, and D Fernández (FCNyM, UNLP); subm by R Pascual (FCNyM, UNLP). These dates were measured as part of palaeogeog and palaeoclimatic regional study, particularly related to Cordilleran ice ablation from last glaciation to Holocene.

LP-57A.  **Acceso a Dos Anclas, Sample 1**  \(15,500 \pm 550\)

LP-57B.  \(17,090 \pm 790\)
Shells (\emph{Chilina parchapei}). \textit{Comment:} for LP-57A, inner fraction (80%) was used; for LP-57B, outer fraction (20%) was used.

LP-58.  **Acceso a Dos Anclas, Sample 2**  \(18,630 \pm 860\)
Shells (\emph{Chilina parchapei}). \textit{Comment:} inner fraction (80%) was used.

LP-59.  **Puente Arroyo Bebedero**  \(16,160 \pm 710\)
Shells (\emph{Chilina parchapei}). \textit{Comment:} inner fraction (80%) was used.

LP-60.  **Sector SO**  \(13,910 \pm 530\)
Shells (\emph{Chilina parchapei}). \textit{Comment:} inner fraction (80%) was used.

LP-61.  **Camino Dos Anclas-El Lechuzo**  \(17,060 \pm 660\)
Shells (\emph{Chilina parchapei}). \textit{Comment:} inner fraction (80%) was used.
LP-63. **Camino Dos Anclas-Ruta**

Shells (*Chilina parchapei*). *Comment*: inner fraction (80%) was used.

**San Luis/Beazley**

LP-64. **Hostería Dos Anclas**

Shells (*Chilina parchapei*). *Comment*: inner fraction (80%) was used.

*General Comment*: antiquity of these deposits represents initial ablation of Andean Cordillera ice pertaining to last glaciation (González et al., 1981).

**ARCHAEOLOGIC SAMPLES**

**Argentina**

**LP-53. Arroyo Seco**

Collagen extracted from femur fragment of *Megatherium americanum*, from Arroyo Seco, Partido de Tres Arroyos (38° 21' 38" S, 60° 14' 39" W), Prov Buenos Aires. Sample from eolian sediments over carbonate level, from depth 0.6 m below surface. Coll and subm by G Politis (FCNyM, UNLP), and L Meo Guzmán (Mus Mun Tres Arroyos). Taxonomic determination by E Tonni (FCNyM, UNLP). *Comment*: first determination in Prov Buenos Aires of extinct megamammalian remains in stratigraphic assoc with unifacial lithic material, with marginal retouch, without projectile points.

**LP-62. Cuyín Manzano**

Charcoal fragments of Cueva Traful I (40° 43' S, 71° 07' W), Prov Neuquén, from hearth in Bed 10d, at depth 1.5 m below surface. Coll by D Curzio and E Crivelli; subm by M Silveira (all of Fac Filosofía y Letras, Univ Buenos Aires). *Comment*: absolute age of cultural remains belonging to guanaco hunters with triangular apedunculated projectile points.

**GEOCHEMICAL SAMPLES**

**Hydrogeologic samples**

Measurements of environmental isotope content (²H, ²³H, ¹⁸O, and ¹⁴C) were made on meteoric, surface, and underground waters in vicinity of Mar del Plata (38° 08' S, 57° 35' W) and surroundings, Prov Buenos Aires (table 1). This study was requested by Cátedra Hidrogeol (FCNyM, UNLP), as part of geohydrol investigation, required by Empresa Obras Sanitarias de la Nación (OSN), Argentina. Aim of study was to formulate series of preliminary hypotheses, related to temporal and spacial origin of groundwaters, and to explain aquifer salinization processes within mentioned area. ¹⁴C samples were extracted April 1978 from groundwater at different depths and may belong, in most cases, to more than one productive bed. Results of these measurements are given as percent of modern (% mod):

\[
\% \text{ mod} = \frac{A \text{ sample} - A \text{ std}}{A \text{ std}} \times 100
\]

A is net cpm
**Table 1**

Mar del Plata — $^{14}$C measurements in groundwater

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>Well no. (OSN)</th>
<th>% modern</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP-20</td>
<td>105</td>
<td>71 ± 1</td>
</tr>
<tr>
<td>-21</td>
<td>130</td>
<td>79 ± 1</td>
</tr>
<tr>
<td>-22</td>
<td>27</td>
<td>72 ± 2</td>
</tr>
<tr>
<td>-23</td>
<td>55</td>
<td>83 ± 1</td>
</tr>
<tr>
<td>-24</td>
<td>49</td>
<td>85 ± 1</td>
</tr>
<tr>
<td>-25</td>
<td>314</td>
<td>94 ± 1</td>
</tr>
<tr>
<td>-26</td>
<td>165</td>
<td>75 ± 1</td>
</tr>
<tr>
<td>-27</td>
<td>186</td>
<td>60 ± 1</td>
</tr>
<tr>
<td>-28</td>
<td>16</td>
<td>88 ± 1</td>
</tr>
<tr>
<td>-29</td>
<td>34</td>
<td>70 ± 1</td>
</tr>
<tr>
<td>-30</td>
<td>330</td>
<td>112 ± 1</td>
</tr>
<tr>
<td>-31</td>
<td>128</td>
<td>91 ± 1</td>
</tr>
<tr>
<td>-39</td>
<td>32</td>
<td>102 ± 3</td>
</tr>
<tr>
<td>-40</td>
<td>56</td>
<td>88 ± 2</td>
</tr>
<tr>
<td>-41</td>
<td>78</td>
<td>79 ± 2</td>
</tr>
<tr>
<td>-42</td>
<td>29</td>
<td>70 ± 2</td>
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<tr>
<td>-43</td>
<td>58</td>
<td>73 ± 1</td>
</tr>
<tr>
<td>-48</td>
<td>94</td>
<td>63 ± 1</td>
</tr>
</tbody>
</table>

**General Comment:** two groundwater samples (near surface) from “rural” area (LP-25 and -30) show high concentration of $^{14}$C. This is evidence of atmospheric contamination which started in 1954 and indicates active recharge by meteoric waters in recent years. Other samples, from “urban” area (average depth 90m), were assembled in geog secs:

1) “harbor” (LP-23, -28, -31, -40): measured activity shows recharge by relatively recent rain.

2) “downtown” (LP-22, -29, -41, -42, -43): groundwater of this sec has relatively major residence period and corrected ages should lie between 590 to 1560 $^{14}$C yr.

3) “northern” (LP-20, -21, -26, -27, -48), divided in two sub-secs: S sub-sec shows water mixture of relatively “old” with relatively “young” waters, and N-most sub-sec, with relatively “old” waters, 1000 to 2800 $^{14}$C yr (Figini et al, 1981).

**Table 2**

$^{14}$C measurements on atmospheric samples

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>Exposure period</th>
<th>% modern</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP-3</td>
<td>14 Oct. - 20 Oct 1976</td>
<td>127 ± 1.0</td>
</tr>
<tr>
<td>-4</td>
<td>09 Nov - 15 Nov 1976</td>
<td>135 ± 1.0</td>
</tr>
<tr>
<td>-5</td>
<td>23 Dec - 29 Dec 1976</td>
<td>133 ± 2.0</td>
</tr>
<tr>
<td>-6</td>
<td>18 Feb - 24 Feb 1977</td>
<td>136 ± 1.0</td>
</tr>
<tr>
<td>-10</td>
<td>25 Mar - 31 Mar 1977</td>
<td>131 ± 2.0</td>
</tr>
<tr>
<td>-12</td>
<td>22 Apr - 27 Apr 1977</td>
<td>135 ± 1.0</td>
</tr>
<tr>
<td>-11</td>
<td>27 May - 02 June 1977</td>
<td>132 ± 2.0</td>
</tr>
<tr>
<td>-13</td>
<td>11 July - 18 July 1977</td>
<td>132 ± 1.5</td>
</tr>
<tr>
<td>-14</td>
<td>26 Aug - 01 Sept 1977</td>
<td>136 ± 1.2</td>
</tr>
<tr>
<td>-15</td>
<td>29 Sept - 06 Oct 1977</td>
<td>135 ± 1.5</td>
</tr>
<tr>
<td>-16</td>
<td>01 Nov - 07 Nov 1977</td>
<td>131 ± 1.5</td>
</tr>
<tr>
<td>-17</td>
<td>30 Nov - 05 Dec 1977</td>
<td>130 ± 1.0</td>
</tr>
</tbody>
</table>
Atmospheric samples

Determinations were made with samples which cover period, Oct 1976 to Dec 1977, from sampling sta at FCNyM, UNLP (34° 54' 36" S, 57° 56' 03" W), Prov Buenos Aires (table 2).

General Comment: aim of this series was to determine ¹⁴C level in atmosphere and influence of nuclear explosions in these latitudes. ¹⁴C excess data obtained correspond to theoretical and experimental models of diminution in atmospheric ¹⁴C level (Figini et al, 1978).

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UNIVERSITY OF WISCONSIN RADIOCARBON DATES XXI

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Procedures and equipment used in the University of Wisconsin laboratory have been described in previous date lists. Except as otherwise indicated, wood, charcoal, and peat samples are pretreated with dilute NaOH-Na₄P₂O₇ and dilute H₃PO₄ before conversion to the counting gas methane; marls and lake cores are treated with acid only. Very calcareous materials are treated with HCl instead of H₃PO₄. Pretreatment of bone varies with the condition of the bone sample; solid bone with little deterioration is first cleaned manually and ultrasonically. The bone is treated with 8% HCl for 15 minutes, then dilute NaOH-Na₂P₃O₇ for 3 hours at room temperature, washed until neutral, and the collagen extracted according to Longin (1971). Charred bone is treated with dilute HCl, NaOH-Na₄P₂O₇, and then dilute HCl again.

The dates reported have been calculated using 5568 yr as the half-life of ¹⁴C. The standard deviation quoted includes only 1σ of the counting statistics of background, sample, and standard counts. Background methane is prepared from anthracite, standard methane from NBS oxalic acid. The activities of the dated samples for which ⁸¹⁸ values are listed have been corrected to correspond to a ⁸¹⁸C value of −25‰; the activity of the standard methane has been corrected to −19‰.

Sample descriptions are based on information supplied by those who submitted samples.

ACKNOWLEDGMENTS

This research is supported by the National Science Foundation under Grant ATM-7926039. We thank the Chemistry Department for the use of the RMS 6-60 mass spectrometer. We also wish to thank Steven V Bittorf for his technical assistance.

ARCHAEOLOGIC SAMPLES

United States

Illinois

Fentress Lake Slew Site (11JD126) series

Samples from Fentress Lake Slew site in Jo Daviess Co (42° 27’ N, 90° 35’ W) coll Sept 1982 and subm by D F Overstreet, Great Lakes Archaeol Research Center, Waukesha. Samples date Middle and Late Woodland occupation zones and provide information on Holocene sediment geochronol (Boszhardt & Overstreet, 1981).

WIS-1492.

1670 ± 70

Charcoal from Feature 7, Level 5, Middle Woodland storage pit. Dates unreported aspect of subsistence and settlement behavior for Allamakee/Millville phase populations. Comment: current models suggest
this is an environmental context utilized only as short-term shellfish extraction camp. Subsurface features, range of cultural materials, and stratigraphic contexts provide new insights into prehistoric adaptive strategies.

**WIS-1493.**

Charcoal from Level 8, Late Woodland component, represents unreported aspect of subsistence and settlement behavior for Effigy Mound culture (Keyes phase). *Comment:* same as for WIS-1492.

**Minnesota**

**WIS-1502. Triangle Island site (21Ka29)**

Wood charcoal from Triangle Island site, Kanabec Co (53° 00’ N, 98° 15’ 15” W) coll and subm by P H Salkin, Archaeol Consulting & Services, Madison. Dates Feature 7 which is in direct assoc with Kathio phase ceramics.

**South Dakota**

**Sod Table Site (39Pn102) series**

Samples from Sod Table site in Pennington Co (43° 44’ N, 102° 25’ W). Coll 1982 and subm by T W Haberman, South Dakota Archaeol Research Center, Ft Meade. This is a distinctly buried cultural horizon containing charcoal, bone fragments, and fire-cracked rock exposed by erosion. Assoc artifacts are inadequate for confident cultural affiliation and temporal estimate for site.

**WIS-1494.**

Grass and wood charcoal from well-developed buried soil above cultural horizon.

**WIS-1495.**

Wood charcoal (*Populus sp*) from Sq W20S3 in W portion of site.

**WIS-1496.**

Wood charcoal (*Populus sp*) from Sq W24S2 in W portion of site.

**WIS-1497.**

Wood charcoal (*Populus sp*) from Sqs E38N20, E39N20, E40N20, and E39N21 in E portion of site.

**Wisconsin**

**WIS-1437. Beach site (47Da459)**

Wood charcoal coll Sept 1979, from Beach site, Dane Co (42° 00’ N, 87° 20’ W) and subm by P H Salkin. *Comment:* dates Early Woodland-Early Middle Woodland occupation of S-central Wisconsin. It is significant in determining relationships between similar, and assumed older, components in Illinois Valley. Date may also indicate approx time when ceramics were more widely introduced into area (Salkin & Emerson, 1976).
WIS-1476. Chido site (47Wb58) 420 ± 70
Sample coll Sept 1982 from Chido site, Washburn Co (45° 48’ N, 91° 53’ W) by C L Rohrbaugh and subm by J T Penman, Wisconsin State Hist Soc, Madison. Comment: dates Late Woodland occupation of site (Ford, Penman, & Knox, 1982).

Sand Lake Site (47Le44) series
Samples coll Aug 1982 from Sand Lake site, La Crosse Co (43° 55’ N, 91° 13’ 30” W) by J P Gallagher et al and subm by J P Gallagher, Mississippi Valley Archaeol Center, La Crosse. Dates are of Oneota ridged fields buried under alluvial fan (Gallagher, Boszhardt, & Stevenson, 1983).

WIS-1477. 470 ± 90
Sample from Oneota Feature 1, at top of alluvial sediments just below plow zone.

WIS-1478. <200
Sample from Oneota Feature 5, at top of alluvial sediments just below plow zone.

WIS-1479. 500 ± 70
Sample from Oneota cultural horizon midway in alluvial sediments, 165cm below surface.

WIS-1480. 490 ± 70
Sample from interface of alluvial sediments over ridged wetland silts, 240 to 250cm below surface. Dates beginning of upland erosion and sedimentation over ridges.

GEOLOGIC SAMPLES
United States
Connecticut
Mohawk Pond series

WIS-1452. 3270 ± 70
Gyttja from 350 to 355cm depth. Dates increase in chestnut (Castanea) pollen.

WIS-1453. 5562 ± 70
Gyttja from 580 to 585cm depth. Dates decline in hemlock (Tsuga) pollen.

WIS-1483. 7220 ± 80
Gyttja from 720 to 725cm depth. Dates increase in hickory (Carya) pollen.
**WIS-1484.**  
8560 ± 90  
Gyttja from 920 to 925cm depth. Dates initial increase in beech (Fagus) pollen.

**WIS-1485.**  
9640 ± 100  
Gyttja from 1050 to 1055cm depth. Dates interval of high pine (Pinus) pollen percentages in early Holocene.

**Massachusetts**

**WIS-1421. Tom Swamp**  
4850 ± 70  
Core coll Nov 1979 from Tom Swamp, Havard Forest, Worcester Co (42° 31′ N, 62° 13′ W) by C Lenk et al, subm by T Webb, III. Sample 203 to 210cm below sediment surface dates rise in spruce pollen in late Holocene. Pollen diagram has been pub (Davis, 1958). Dates on other levels were reported (R, 1982, v 24, p 89; R, 1983, v 25, p 158).

**Minnesota**

**Lake Ann series**

Core coll March 1981 from Lake Ann, Sherburne Co (45° 26′ N, 93° 41′ W) and subm by K L Keen, Univ Minnesota, Minneapolis. Water depth 5.6m; all depths are from sediment surface (Cooper, W S, 1935; Keen, K L, The sand dunes on the Anoka Sand Plain, ms in preparation).

**WIS-1462.**  
7420 ± 80  
Lacustrine sediment, silty, marly, fine-detritus copropel with trace very-fine sand from 880 to 890cm depth. Sample dates initial dune-forming period of St Francis River Dunes.

**WIS-1463.**  
4390 ± 80  
Lacustrine sediment, fine-detritus copropel, with trace very-fine sand and silt from 560 to 570cm depth. Sample marks end of major eolian activity of St Francis River Dunes.

**WIS-1467. Dogfish Lake**  
840 ± 70  
Sample coll 1972 from Dogfish Lake, St Louis Co (48° 11′ N, 92° 11′ W) and subm by H E Wright, Jr, Univ Minnesota. Lake sediment, homogeneous “biopel” from 50 to 60cm below sediment surface. Comment: date will establish sedimentation rate in upper part of core (Bradbury et al, 1975).

**Lily Lake series**

Core coll Dec 1977 from Lily Lake, Washington Co (45° 2′ 70″ N, 92° 49′ 30″ W) by H E Wright, Jr et al and subm by H E Wright, Jr. Series will aid in interpretation of river-dominated pollen site 5km to SE (Lake St Croix) where much of pollen record is obscured by waterborne pollen from N (Eyster-Smith, 1977; 1978; Wright, Winter, & Patten, 1963). Water depth 18m; all depths are from water surface.

1 biopel—organic component of lake mud regardless of its origin (Bradbury & Waddington, 1973)
**WIS-1450.** 11,770 ± 110
Lake sediment from 2154 to 2164cm depth, dates transition from spruce/ash to spruce/birch and beginning of diatom occurrence.

**WIS-1470.** 9680 ± 100
Lake sediment from 2080 to 2090cm depth, dates spruce/pine boundary recorded in other Minnesota lakes.

**WIS-1471.** 7220 ± 80
Lake sediment from 1900 to 1910cm depth, dates evidence of E-ward expansion of prairie into E Minnesota or artificial rise in oak/herb pollen percentages resulting from decreased pine influx.

**WIS-1472.** 4050 ± 70
Lake sediment from 1715 to 1725cm depth, dates evidence of E-ward expansion of prairie/savannah into E Minnesota. Oak pollen increases from 25 to 40%.

**WIS-1473.** 3570 ± 70
Lake sediment from 1625 to 1635cm depth, dates diatom boundary and decrease in herb pollen coincidence. Sample may indicate end of “prairie period.”

**WIS-1474.** 2160 ± 70
Brown gyttja from 1475 to 1485cm depth, dates diatom boundary.

**WIS-1475.** 350 ± 60
Gyttja from 1310 to 1320cm depth, dates Ambrosia rise.

**Moran Lake series**

Livingstone core, 5cm diam, from Lake Moran, Hubbard Co (46° 51’ N, 95° 01’ W). Coll Dec 1981 by J C Almendinger et al; subm by H E Wright, Jr. Measurements from sediment surface; water depth 364cm. Dated to determine rate of sediment influx. Date previously reported (R, 1983, v 25, p 159).

**WIS-1486.** 5280 ± 80
Organic lake sediment from 425 to 435cm depth.

**WIS-1487.** 6200 ± 80
Organic lake sediment from 530 to 540cm depth.

**WIS-1488.** 6830 ± 80
Organic lake sediment from 630 to 640cm depth.

**WIS-1489.** 8450 ± 100
Organic lake sediment from 730 to 740cm depth.
New Jersey

**Alpine Bog series**
Core col 1978 from Alpine Bog, Bergen Co (40° 57' N, 73° 54' W) and subm by R Nickmann, Univ Minnesota. All depths are from surface of bog.

**WIS-1464.** 5020 ± 80
Peat from 207 to 213cm depth, dates level with 16% *Alnus* and 44% *Quercus* pollen.

**WIS-1465.** 5940 ± 80
Peat from 407 to 413cm depth, dates slight decrease in percentages of *Alnus* pollen from 8 to 4% and end of peak values of *Quercus* pollen.

**WIS-1466.** 8980 ± 100
Peat from 607 to 613cm depth, dates first time *Quercus* pollen reached 60%.

**WIS-1481.** 10,000 ± 100
Peat from 707 to 713cm depth, dates level just before decline in *Picea*, peak in *Pinus*, and rise in *Quercus* pollen percentages.

**WIS-1482.** 12,840 ± 110
Peat from 825 to 832cm depth, dates initial rise of *Picea* pollen from 8 to 20%.

New York

**WIS-1417. Deep Pond** 13,520 ± 130
Core from deep pond, Suffolk Co (40° 56' N, 72° 50' W) coll and subm by W A Patterson, Ill, Univ Massachusetts, Amherst. Limnic sediments from 1854 to 1866cm depth, measured from water surface. Water depth 12m. Dates accumulation of basal organic sediment of this kettle pond in outwash just S of Harbor Hill Moraine.

**WIS-1438. West Sand Lake** 9260 ± 90
Limestone core, 5cm diam from West Sand Lake peat bog, Rensselaer Co (42° 38' N, 73° 36' W) coll by D C Gaudreau et al, subm by T Webb, Ill. Sample 228 to 234cm below surface dates basal peaty gyttja overlying marly sediment. Core is being used for Holocene pollen analysis.

North Dakota

**Pelican Lake series**
Core col Aug 1980 from Pelican Lake, Bottineau Co (48° 57' N, 100° 16' W) and subm by A M Swain, Univ Wisconsin-Madison. Water depth 7.5m. Measurements from sediment/water interface.

**WIS-1490.** 450 ± 70
Gytija from 50 to 60cm depth, dates marked decline in oak pollen.
WIS-1491.  490 ± 70
Gyttja from 90 to 100cm depth, date provides age at 1m depth.

Washington
Carp Lake series
Core from Carp Lake, Klickitat Co (45° 55' 05" N, 120° 53' 00" W). Coll and subm by C W Barnosky, Univ Washington, Seattle. Carp Lake, with basal date 32,000 yr BP provides only record of late Quaternary vegetation in SW Columbia Basin (Barnosky, 1982). Water depth 2m. All measurements from sediment surface.

WIS-1460.  8760 ± 90
Organic silty clay from 240 to 247cm depth, dates initiation of organic silty clay deposition, following apparent unconformity.

WIS-1461.  21,600 ± 360
Clay gyttja from 510 to 520cm depth, dates end of clay-gyttja deposition. (One 4-day count.)

WIS-1468.  9470 ± 100
Clayey silt from 252 to 272cm depth, dates end of clayey-silt deposition.

Wisconsin
Lake Waubesa series
Livingstone core, 5cm diam, from Lake Waubesa, Dane Co (43° 00' N, 89° 20' W). Sample coll by A M Swain et al and subm by A M Swain. Water depth 688cm; all depths are from sediment surface. Acid treatment only.

WIS-1418.  1110 ± 70
Fine silt and clay from 82 to 92cm depth.

WIS-1419.  3080 ± 70
Fine silt to clay from 275 to 285cm depth. Sample shows sharp decrease in percent of grass pollen.

WIS-1420.  6820 ± 80
Fine silt to clay from 545 to 555cm depth. Sample shows decline in elm pollen.

WIS-1423.  11,220 ± 100
Greenish gray silty clay from 713 to 723cm depth. Sample shows a sharp decrease in spruce pollen.

WIS-1424.  23,020 ± 370
Mottled black and gray clay from 975 to 995cm depth. (One 5-day count).
Lima Bog series

WIS-1425. 16,600 ± 160
Gray and brown silty organic lake sediment, 1355 to 1365cm depth, marks peak in Picea pollen at 70%.

WIS-1426. 18,090 ± 190
Gray silty organic lake sediment, 1625 to 1638cm depth. During deposition sample was dominated by non-arboreal pollen. Vegetation was probably taiga with Picea mariana growing in lowlands and open herbaceous plants on uplands.

WIS-1429. Dark Lake 9430 ± 100
Livingstone core, 5cm diam, from Dark Lake, Chippewa Co (45° 16' N, 91° 29’ W). Sample coll by J T Overpeck et al and subm by J T Overpeck, Brown Univ. Water depth 18.6m. Base sample was 451 to 456cm from sediment surface. Lake has varved sediments; sample was laminated.

Spruce Lake series
Livingstone core, 5cm diam, from Spruce Lake, Taylor Co (45° 08’ N, 90° 39’ W). Coll by J T Overpeck et al and subm by J T Overpeck. Water depth 18m. All measurements are from sediment surface. Lake has varved sediments; all segments were laminated.

WIS-1430. 1980 ± 70
Organic lake sediment from 140 to 145cm depth.

WIS-1432. 3660 ± 70
Organic lake sediment from 250 to 255cm depth.

WIS-1434. 5320 ± 70
Organic lake sediment from 372 to 379cm depth.

WIS-1436. 9500 ± 100
Organic lake sediment from 530 to 535cm depth.

WIS-1441. 10,920 ± 100
Organic lake sediment from 653 to 660cm depth.

WIS-1443. 12,550 ± 120
Organic lake sediment from 727 to 735cm depth.

Lake Mendota series
Livingstone core, 5cm diam, from Lake Mendota, Dane Co (43° 06’
N, 89° 25' W). Coll Feb 1982 and subm by A M Swain. Dates from cores coll along transect of varying water depth in University Bay should date low and high water levels during Holocene. Date previously reported (R, 1983, v 25, p 164). Acid treatment only. All measurements from sediment surface.

**WIS-1449.** 1310 ± 70
Gray-brown gyttja from 60 to 70cm depth in 10m core, Core C. Water depth 5.9m.

**WIS-1454.** 3280 ± 70
Marl from 185 to 195cm depth, Core C, dates decrease in grass pollen and further increase in oak pollen.

**WIS-1455.** 5840 ± 90
Silty marl from 481 to 491cm depth, Core C, dates decrease in elm pollen.

**WIS-1459.** 8610 ± 90
Clayey marl from 820 to 840cm depth, Core C, dates transition from high pine to increasingly high oak pollen percentages.

**WIS-1451.** 12,970 ± 120
Clayey silt and sand from 965 to 985cm depth, Core C. Basal date in spruce zone directly before diploxylon pine pollen increases.

**WIS-1447.** 1560 ± 70
Marly, silty, gyttja with broken shell from 22 to 32cm depth in 5m core, Core D. Water depth 3.7m.

**WIS-1456.** 8070 ± 90
Marly silt from 160 to 170cm depth, Core D, dates transition from dominant pine to dominant oak pollen.

**WIS-1457.** 10,990 ± 100
Marly clay from 260 to 270cm depth, Core D, dates transition from high spruce to high pine pollen percentages.

**WIS-1458.** 16,440 ± 190
Silt and clay from 475 to 495cm depth, Core D. Basal date in spruce zone.

**Green Lake series**
Livingstone core, 5cm diam, from Green Lake, Oconto Co (45° 10' N, 88° 27' W). Coll and subm by A M Swain. Water depth 7.5m. All measurements from sediment surface.

**WIS-1431.** 1090 ± 70
Sediment from 35 to 55cm depth, dates settlement which should be ca 100 yr BP. Human disturbances, limestone road building, and home construction caused redeposition of sediments.
WIS-1433.  
1040 ± 70
Sediment from 100 to 110cm depth, dates rise in hemlock, oak, and birch and decrease in spruce, tamarack, and cedar pollen.

WIS-1435.  
2130 ± 70
Sediment from 230 to 240cm depth, dates rise in spruce, fir, and cedar and decrease in birch and pine pollen.

WIS-1469.  
4080 ± 70
Sediment from 410 to 420cm depth, dates significant rise in hemlock, white pine, and birch and decrease in red/jack pine and alder pollen.

WIS-1439.  
5610 ± 70
Sediment from 520 to 530cm depth, dates first occurrence of hemlock, rise of tamarack, red/jack pine, maple, and oak, and decrease in white pine and elm pollen.

WIS-1440.  
8880 ± 90
Sediment from 655 to 665cm depth, dates rise in white pine, beech, and alder and decrease in red/jack pine pollen.

WIS-1442.  
10,410 ± 100
Sediment from 800 to 810cm depth, dates rise in red/jack pine, white pine, and elm and decrease in spruce, fir, tamarack, cedar, sage, and grass pollen.

WIS-1422.  Cox Creek Site 2  
5560 ± 70
Wood coll June 1982 from bucket auger hole on terrace of Cox Creek tributary, Vernon Co (43° 33’ N, 91° 07’ W) by J C Knox et al and subm by J C Knox, Univ Wisconsin-Madison. Date is for terrace deposit underlying surface at Late Woodland archaeol site 47Ve505 (Ford, Penman, & Knox, 1982; Knox, McDowell, & Johnson, 1981).

WIS-1448.  Little Plover River site  
6760 ± 100
Wood (Fraxinus) sample coll Oct 1981 on Little Plover R, Portage Co (44° 28’ N, 89° 29’ W) and subm by F Madison, Geol and Nat Hist Survey, Madison. Sample depth 1m, taken from base of organic deposit underlain by sand.

Mirror Lake series
Core coll March 1982 from Mirror Lake, Waupaca Co (44° 21’ N, 89° 05’ N) and subm by P J Garrison, Wisconsin Dept Nat Resources, Madison. Diatom study has been completed (Farris, 1981). Samples were calcareous and treated with acid only.

WIS-1445.  
2250 ± 70
Gyttja from 54 to 58cm depth.

WIS-1446.  
2360 ± 70
Gyttja from 68 to 74cm depth.
**WIS-1444.** 860 ± 70
Gyttja from 84 to 88cm depth.

**WIS-1427.** 1660 ± 70
Gyttja from 116 to 120cm depth. This is not basal date.

**Washburn Bog series**
Livingstone core, 5cm diam, from Washburn Bog, Sauk Co (43° 32’ N, 89° 39’ W) coll and subm by M Winkler, Univ Wisconsin-Madison. Dates to be used in Holocene pollen analysis. Measurements from bog surface.

**WIS-1504.** 2440 ± 70
Fibrous peat from 226 to 230cm depth, dates beginning of Sphagnum-Ericaceous bog at site.

**WIS-1505.** 6110 ± 80
Decomposed peat from 697 to 701cm depth, dates beginning of decrease in mesophytic tree pollen.

**WIS-1506.** 10,320 ± 100
Gyttja from 1031 to 1041cm depth, dates beginning of haploxylon pine and decrease of birch pollen.

**WIS-1507.** 10,430 ± 100
Gyttja from 1051 to 1061cm depth, dates beginning of spruce decline and increase in diploxylon pine pollen.

**WIS-1428. Ruby Lake**
Livingstone core, 5cm diam, from Ruby Lake, Chippewa Co (45° 16’ N, 91° 28’ W). Sample coll by J T Overpeck et al and subm by J T Overpeck. Water depth 19.5m. Basal sample was 471 to 476cm from sediment surface. Lake has varved sediments; sample was laminated.

**Harrlie Lake series**
Livingstone core, 5cm diam, from Harrie Lake, Labrador, Newfoundland (52° 56’ N, 66° 57’ W) coll and subm by H E Wright, Jr and G A King. Dated to calculate sediment accumulation rates and pollen influx. All measurements from water surface. Water depth 5.4m (Short, 1981; Stravers, 1981).

**WIS-1498.** 4990 ± 80
Silty gyttja 1092 to 1104cm depth, marks middle of sharp increase in *Picea* pollen percentages. Spruce needle found in sample.

**WIS-1499.** 4500 ± 80
Silty gyttja 1020 to 1032cm depth, marks *Picea* zone.

**WIS-1500.** 4250 ± 80
Silty gyttja 940 to 952cm depth, marks *Picea* zone, and dates an increase in pollen concentration.
Raymond L Steventon and John E Kutzbach

WIS-1501. 3290 ± 80
Silty gyttja 840 to 852 cm depth, marks middle of *Picea* zone.

WIS-1503. 2440 ± 70
Silty gyttja 740 to 750 cm depth, marks *Picea* zone, and dates a decrease in pollen concentrations.

Czechoslovakia

Komoranske jezero-Lake series (PK-1-B)


WIS-1410. 1490 ± 70
Gyttja from depth 30 cm.

WIS-1411. 2590 ± 70
Gyttja from depth 90 cm.

WIS-1412. 6570 ± 80
Clay gyttja from depth 116 to 119 cm.

WIS-1413. 7770 ± 80
Clay gyttja from depth 128 to 129 cm.

Trabonska’ paven-Basin series (JC-16-A)

Samples coll Oct 1976 from Trebonska’ paven-Basin, near town of Trebon, S Bohemia (49° 00′ N, 14° 45′ E) by V Jankovska’ and J Kynel. Samples subm by T Webb, III. Total thickness of profile 370 cm (Jankovska’, 1980). Acid treatment only.

WIS-1408. 7390 ± 80
Peat from depth 225 cm.

WIS-1409. 8180 ± 90
Peat from depth 285 cm.

WIS-1414. 8650 ± 90
Peat from depth 326 cm.

WIS-1415. 9630 ± 100
Peat from depth 355 cm.

WIS-1416. 9600 ± 100
Peat from depth 363 to 365 cm.

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RECALIBRATION OF HEIDELBERG 14C LABORATORY DATA

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A sodium bicarbonate solution with a 10-fold activity compared to oxalic acid is used as a secondary standard in the Heidelberg 14C Laboratory. All routine checks and counter tests are greatly facilitated because of the high activity of the solution.

The activity ratio of this substandard to oxalic acid was determined initially (1960-1969) to $A_H/A_{0.95\text{ox}} = 10.30$; this value has been in use since then. Recent interlaboratory comparison studies on tree-ring (Stuiver, 1982) and oceanographic samples (GEOSECS) revealed an offset of 14C results.

A recheck of our previous calibration data yielded an erroneous conversion from the previously used wood standard and, in addition, there is the possibility that newer batches of the substandard differ from the 1960-1969 batches in 14C activity. Dates reported prior to 1971 are considered to be correct based on substandard calibration at that time.

In a careful recalibration, the total offset has been determined to $\Delta^{14}C = 10.2\%$, ie, all dates reported by the Heidelberg laboratory since 1971 have to be increased by 82 years ($\Delta^{14}C$ values decreased by 10.2%).

The correct normalization to oxalic acid is in effect since June 1, 1983.

To distinguish between previous 14C dates, we have adopted the following notation:

All “new” dates, ie, those referred to the correct normalization, are given the laboratory prefix “Hd” instead of the prefix “H” assigned to the Heidelberg laboratory up to now. The prefix “H” is no longer used.

With the correction given above 14C results of four GEOSECS stations (Stuiver & Östlund, 1982) were compared to Heidelberg 14C data of comparable “Meteor” stations. The mean difference of 25 pairs (GEOSECS-Heidelberg) is $\Delta^{14}C = 1.0\%$. Details of the comparison are discussed in a forthcoming paper (Schlitzer et al, A meridional 14C and 39Ar section in the deep water of the north Atlantic, ms in preparation).

REFERENCES
A major collective effort was made to develop a data base for establishing the relationship between $^{14}$C and calendric ages (Stuiver, 1982). The early “cosmic schwung” fit between the two ages (Suess, 1970a, p 310) and the 10,350 yr period of the grand trend (Suess, 1970b, p 596) have recently been replaced by the period of 12,100 yr (Suess, 1980). The period of the grand trend was estimated by correlating the data with an $a$ priori postulated sine function (Suess, 1970, p 596), or more recently a polynomial fit of the sixth degree was used (Klein et al, 1982). In the detrended data, periods (wiggles) of between 2400 yr and 104 yr were identified by conventional time series analysis. This approach could not be used to estimate the period of the grand trend, because the time series includes less than one cycle, whereas several cycles are required in order to get a meaningful result.

The prospect of extending the time series back several thousand years in order to complete at least one cycle of the grand trend, is not very good, as older woods suitable for dendrochronologic and $^{14}$C dating are hard to find. Furthermore, if a sample is found, the necessary determination of its age by both methods is difficult and time consuming.

A new method of time series analysis, the Maximum Entropy Spectral Analysis (MESA) (Ulrych & Bishop, 1975), offers many advantages over conventional approaches. One of these is the ability to identify long periods using relatively short time series. We report on the use of MESA to identify periods in the $^{14}$C time series including the period of the grand trend, making no $a$ priori assumptions.

We used the time series published by Suess (1978), which includes 449 data points. Since the time series is not equally spaced, as required by MESA, we averaged the data over each century, weighting the data points according to their errors. The gap between 5965 and 5402 bc could not be resolved by this procedure and the data prior to 5400 bc were omitted. To complete the time series between 5400 bc and AD 1300, three data points were inserted by linear interpolation. The averaged time series contains 67 data points. Figure 1 displays the original and modified time series.

For the calculation we applied a program of MESA based on Barrodale and Erickson (1980a,b) and used a filter length of 26, determined by Akaike’s Final Prediction Error (FPE) criterion (Ulrych & Bishop, 1975). Figure 2 displays the relative power density spectrum of the averaged time series. Since the time step is 100 yr, no periods of $<200$ yr were detected. Periods $>200$ yr, found by Fourier Analysis (Suess, 1980) are 202 yr, 308 yr, 498 yr, 930 yr, and 2400 yr. Using MESA, without detrending and without making any $a$ priori assumptions, we reproduce all of the above periods $>200$ yr, except that we obtain a period of 700 yr instead of 308 yr.
Furthermore, we get a very prominent peak at 13,200 yr, representing a direct determination of the period of the grand trend.

After having determined the period of the grand trend by MESA, we calculated its amplitude and phase by a non-linear least square fit on the original time series. The grand trend can be approximated by

\[ \Delta \text{AGE} = 440 + 490 \cos \left( \frac{2\pi \text{AGE}}{13,200} + 2.744 \right) \]

where \( \Delta \text{AGE} \) is the difference between calendric and \(^{14}\)C ages. Accepting the grand trend to be a cyclic phenomenon, the calendric age of samples can be calculated by several successive iterations of the formula:

\[ \text{AGE}_{n+1} = ^{14}\text{C AGE} + 440 + 490 \cos \left( \frac{2\pi \text{AGE}_n}{13,200} + 2.744 \right) \]

using

\[ \text{AGE}_0 = ^{14}\text{C AGE} \].

References


Radiocarbon—A Direct Calculation, Period of the Grand Trend

Fig 1. Time series of ΔAGE (Suess, 1978)—diamonds
Average values for consecutive centuries—full line

Fig 2. MESA relative power density spectrum of the averaged time series
RADIOCARBON

STYLE GUIDE

Manuscripts of $^{14}$C papers and date lists should follow the recommendations in “Suggestions to Authors of the Reports of the US Geological Survey,” 6th ed, 1978, Superintendent of Documents, Government Printing Office, Washington, DC 20402. All copy, including the references, must be typewritten in double space: manuscripts must be submitted in duplicate. Computer print-out sheets may be used in letter-quality printing form. Manuscripts should be checked with meticulous care before they are submitted, for the author, not the editor, is finally responsible for errors other than those made by the printer. Revised manuscripts must be submitted in duplicate along with the original edited manuscript.

General or technical articles should follow the editorial style of previous Proceedings issues. Special instructions and typing sheets will be sent to authors of papers for the next Proceedings. For date lists, descriptions of samples should follow as closely as possible the style shown in the most recent volume of RADIOCARBON. They must be brief and precise, but informative, and easily understood by the general reader as well as the specialist. Full geographic and stratigraphic information should be given for geologic samples and cultural affiliation or period and relevance of dating should be included for archaeologic samples. Liberal reference to published literature should be made, but where this is not made available, it is the responsibility of the dating laboratory to collect the pertinent facts, by requiring thesubmitter to provide them in publishable form.

In addition to date lists and technical articles, RADIOCARBON also publishes a section called “Notes and Comments” which includes short technical notes or discussions. Laboratories may also seek assistance in technical aspects of radiocarbon dating in this section.

Short notes or comments should follow the style for general articles. Book reviews of special editions should follow the style set forth in the 10th Proceedings issues.

Titles should avoid abbreviations. Authors names should be written in full or with first initials. Addresses should be complete, including zip code numbers. Address changes may be footnoted with an asterisk (*).

Date lists should be divided into sections such as ARCHAEOLOGIC SAMPLES, GEOLOGIC SAMPLES, etc. Dates should be reported under geographic headings such as North America, further subdivided by country, such as United States, and then by state. The use of letters and numerals with these headings is discontinued.

Each sample should have a descriptive name, usually that of the locality of collection, and preferably a name different from those of all other samples.

Each description should include the following data, if possible, in the order given below:

- Laboratory number, descriptive name, and date expressed in years BP (ie, before AD 1950). The general designation of AD/BC, obtained
by subtracting AD 1950 from conventional BP determinations is discontinued in radiocarbon. Authors or submitters may include calendar estimates as a comment and report these estimates as AD/BC*, citing the specific calibration curve used to obtain the estimate. The standard error following the date should express, within limits of ±1σ, the laboratory’s estimate of the accuracy of the $^{14}$C measurement, as judged on physico-chemical (not geologic or archaeologic) grounds. Both dates and standard errors should be rounded off according to Stuiver and Polach (1977, R, v 19, p 362). $\delta^{13}$C or other measurements should be placed below the BP date and aligned with the laboratory number and name:

$\textbf{AA-1923. Poundbury}$

$1500 \pm 40$

$\delta^{13}C = 20.8\%_e$

— For geochemical measurements, the accepted standards are 1) 0.95 times the age-corrected (to AD 1950) activity of the old National Bureau of Standards (NBS) oxalic acid ($\delta^{13}C = -19.0\%_e$), and 2) 0.7459 times the age-corrected (to AD 1950) activity of the new oxalic acid standard ($\delta^{13}C = -25\%_e$, see Stuiver (1983) R, v 25, no. 2, p 793). Geochemical measurements may be reported as “per cent of modern,” but where $^{13}$C/$^{12}$C assays are available or can be reasonably assumed, we recommend the $\Delta$ notation. See Stuiver and Polach (1977) R, v 19, p 355-363, for further discussion, especially on rounding off numbers. Values of $\delta^{13}$C should be listed when known, and records of $\delta^{14}$C values should be retained by the laboratory in accessible form, whether or not they are published in the original entries. $^{14}$C laboratories and users of $^{14}$C dates may wish to note a paper by Austin Long and Bruce Rippeteau, “Testing contemporaneity and averaging radiocarbon dates,” American Antiquity, 1974, v 39, p 205-215. For lists of published date lists, see “A Bibliography of Radiocarbon Dating,” R, 1959, v 1, p 200-214; “Radiocarbon Measurements: Comprehensive Index, 1950-1965,” R, 1967, 221 p. For additional literature on $^{14}$C dating, see Polach, Dilette, 1979, “First 20 years of radiocarbon dating: an annotated bibliography, 1948-1968,” Canberra, Australian National University, 124 p.

— Superscripts for mass numbers should precede chemical symbols, eg, $^{13}$C. The use of ”$^{14}$C” is preferred to “radiocarbon,” in most cases.

— Laboratory number and sample title appear at left margin of page, unless in a series. A series title does not have a laboratory number, and the word, series, is not capitalized. In a series, individual sample numbers and titles are indented under the series heading.

— Substance of which the sample is composed: if a plant or animal fossil, the Linnaean name, if possible; otherwise, the popular name, but not both. Also, where pertinent, the name of the person who identified the specimen. Scientific names should be italicized for both genus and species or genus alone. Italics, when not available in typing, should be indicated by underlining.
Style Guide

— Precise geographic location, including latitude-longitude coordinates, enclosed in parentheses. Do not use “Lat” and “Long,” but merely the abbreviations, N, E, S, W, eg, (34° 10’ N, 15° 3’ E). Degrees, minutes, and seconds, (°, ′, ″) are the standard units used. Additional map locations, (Natl Grid Ref TL 887075) should also be included in the parentheses. Use abbreviations N, E, S, W for directions.

— Occurrence and stratigraphic position, including depth or elevation, or cultural association, including period or name of culture, in precise terms, using the metric system exclusively. Interpretations of stratigraphic or cultural associations should be included in the Comment.

— Use decimals: 5.5km from sea.

— Use “to” instead of a hyphen: 1 to 1.5m asl, not 1-1.5, which could be misread as minus, although hyphens are acceptable in titles.

— Leave no space between number and measurement unit, eg, 32cm, not 32 cm.

— For routine reports the per mil δ¹³C values should be rounded to the tenth decimal place, not the hundredth: δ¹³C = −25.5‰, not −25.49‰.

— Reference to relevant publications. Citations within a description should be to author, year, and pages. References should be cited by sample no., journal, year, volume, and page (eg, UCLA-1222: R, 1968, v 10, p 150), not to date lists. See below for more details.

— Date of collection and name of collector.

— Abbreviations used should follow those listed in “Suggestions to Authors . . .” and the updated list that appears below. Omit periods after abbreviations and initials except where confusion may arise (no., I., unid.). Omit articles, “a, an, and the” wherever possible. When spelling varies, Americanized are preferred over British spellings.

— Date of submission and name of submitter and address. A collector’s or submitter’s affiliation and address are given the first time only, and his/her title is omitted.

— Comment, usually comparing the date with other relevant dates, for each of which sample numbers and references must be quoted, as prescribed above. Interpretive material, summarizing the significance of the ¹⁴C measurement belongs here, as do technical matters, eg, chemical pretreatment, special laboratory difficulties, etc. The importance of this section cannot be overstated for it is here that the value of the date should be described. Each sample or series of samples should have a Comment. Authors or submitters may include calendar estimates reported as AD/BC* citing the specific calibration curve used to obtain the estimate. Comment: continues in the text of the description.

General Comment: begins a new line at the margin and usually deals with a series or any group of related samples. If Comment is made
by the submitter rather than by the author, initials are written in parentheses, eg, Comment (BGA). If more than one person is involved, use “Comments”. A colon follows both Comment: and General Comment: and the words are italicized, indicated by underlining. Do not capitalize the first letter of the first word of this section.

— Tables must have titles and numbers. Columnar headings should be clearly marked.

— Figures must have captions and numbers. Line drawings must be done in dense black ink and should be an original drawing, a glossy print, or a very sharp copy.

— Plates (half-tones or screened prints) must have titles and numbers. All illustrations should be clearly identified on the back.

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References are indicated in the text by placing within parentheses the author’s last name, year of publication, and pages or illustrations. If the author’s name falls within the sentence, only the date and page reference are included in parentheses, separated by a comma.

Up to three authors are written out in the text; et al is used for more than three, but all authors are cited in the references. Within parentheses, “&” should be substituted for “and”: (Johnson, Treadgold, & Stipp. 1983).

A manuscript in preparation should be cited in the text, not in the references, with the title followed by “ms in preparation.” If data is used from notes or observations, they should be cited as such in the text. An unpublished manuscript (eg, a doctoral dissertation) should be cited as (ms) both in the text and in the references. The date should appear after (ms) in the references.

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For a paper presented at a conference that has not been published, give the author, year, and title followed by: Paper presented at Internatl radiocarbon conf, 11th, Seattle, Washington, June 20-26.

We have noted a number of radiocarbon dates that appear in publications without laboratory citation or reference to published date lists. We ask that laboratories remind submitters and users of radiocarbon dates to include proper citation (laboratory number and date-list citation) in all publications in which radiocarbon dates appear.

An index of samples appears in the third number of each volume. Authors of date lists are asked to prepare index material for archaeologic samples only according to the format of previous indexes. Sample forms are available upon request. Geologic samples are indexed by Radiocarbon.

A list of laboratories appears at the end of the third number of each volume. A new laboratory must publish a date list before it can be included in our list of active laboratories. Please send changes of address, status, or personnel to the Managing Editor.
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ref — reference
tpk — turnpike
rept — report
trans — transaction
rev — review	tr — trench
rm — room	unid. — unidentified
rr — railroad
univ — university
rte — route
v — volume
sci — science, s
yr — year, s
ref — reference
sec — section, sector
1st — first
ser — series
tech — technical
soc — society
tech — technical
sq — square
unid. — unidentified
sta — station
univ — university
strat — stratigraphy, stratigraphic, al
v — volume
subm — submitted
temp — temperature
supp — supplement
terr — territory
tech — technical
unid. — unidentified
univ — university

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