

VOLUME 28 / NUMBER 2A / 1986

Radiocarbon

Published by THE AMERICAN JOURNAL OF SCIENCE



12th International Radiocarbon Conference

June 24-28, 1985

Trondheim, Norway

Edited by Minze Stuiver and Renée Kra

Kline Geology Laboratory
Yale University
New Haven, Connecticut 06511

ISSN: 0033-8222

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 . We would like to encourage this type of publication on a regular basis. In addition, we will be publishing compilations of published and unpublished dates along with interpretative text for these dates on a regional basis. Authors who would like to compose such an article for his/her area of interest should contact the Managing Editor for information.

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** and *RADIOCARBON Style Guide* (R, 1984, v 26, p 152-158). Our deadline schedule for submitting manuscripts is:

For	Date
Vol 29, No. 1, 1987	Sept 1, 1986
Vol 29, No. 2, 1987	Jan 1, 1987
Vol 29, No. 3, 1987	May 1, 1987

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 ± 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 ± 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 cal AD/BC, citing the specific calibration curve used to obtain the estimate. Calibrated dates will now be reported as "cal BP" or "cal AD/BC," according to the consensus of the Twelfth International Radiocarbon Conference, Trondheim, Norway, 1985.

Meaning of $\delta^{14}\text{C}$. In Volume 3, 1961, we endorsed the notation Δ (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 $\delta^{14}\text{C}$ that entered the calculation of Δ 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 $\delta^{14}\text{C}$ as the observed deviation from the standard. At the New Zealand Radiocarbon Dating Conference it was recommended to use $\delta^{14}\text{C}$ 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 $\delta^{13}\text{C} = -19\text{‰}$.

In several fields, however, age corrections are not possible. $\delta^{14}\text{C}$ and Δ , 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 Δ notations for samples not corrected for age.

*Suggestions to Authors of the Reports of the United States Geological Survey, 6th ed, 1978, Supt of Documents, U S Govt. Printing Office, Washington, DC 20402.

Radiocarbon

Published by THE AMERICAN JOURNAL OF SCIENCE

Editor

MINZE STUIVER

Associate Editors

To serve until January 1, 1989

STEPHEN C PORTER *Seattle, Washington*

To serve until January 1, 1987

W G MOOK *Groningen, The Netherlands*

HANS OESCHGER *Bern, Switzerland*

RONALD B DAVIS *Orono, Maine*

To serve until January 1, 1990

ANDREW MOORE

Managing Editor

RENEE S KRA

**Proceedings of the Twelfth International
Radiocarbon Conference—Trondheim, Norway**

Editors

MINZE STUIVER and RENEE S KRA

CONTENTS

FOREWORD and ACKNOWLEDGMENT.....	ii
PARTICIPANTS	v
I. AMS TECHNIQUES	
<i>RJ Batten, CR Bronk, Richard Gillespie, JAJ Gowlett, REM Hedges, and Colin Perry</i> A Review of the Operation of the Oxford Radiocarbon Accelerator Unit.....	177
<i>Gert Hut, H Göte Östlund, and Klaas van der Borg</i> Fast and Complete CO ₂ -to-Graphite Conversion for ¹⁴ C Accelerator Mass Spectrometry	186
<i>AJT Jull, DJ Donahue, AL Hatheway, TW Linick, and LJ Toolin</i> Production of Graphite Targets by Deposition from CO/H ₂ for Precision Accelerator ¹⁴ C Measurements.....	191
<i>Françoise Yiou, Grant Raisbeck, Dider Bourles, Jacques Lestringuez, and Dominique Deboffe</i> Measurement of ¹⁰ Be and ²⁶ Al with a Tandem Accelerator Mass Spectrometer Facility	198
<i>Günther Haberstock, Johann Heinzl, Gunther Korschinek, Haruhiko Morinaga, Eckehart Nolte, Ulrich Ratzinger, Kazuo Kato, and Manfred Wolf</i> Accelerator Mass Spectrometry with Fully Stripped ³⁶ Cl Ions	204
<i>GM Raisbeck, Françoise Yiou, Maurice Arnold, and JC Duplessy</i> Measurement of ¹⁴ C Directly from CO ₂ Using a Tandem Accelerator Mass Spectrometer Facility	211
<i>DE Nelson, JS Vogel, JR Southon, and TA Brown</i> Accelerator Radiocarbon Dating at SFU	215
<i>BE Lehmann, HH Loosli, Hans Oeschger, Dominique Rauber, GS Hurst, SL Allman, CH Chen, SD Kramer, Norbert Thonnard, and RD Willis</i> Laser Resonance Ionization Mass Spectrometry for Krypton-81 Analysis	223
<i>Roelf P Beukens, Debbie M Gurfinkel, and Henry W Lee</i> Progress at the Isotrace Radiocarbon Facility	229
<i>PM Grootes, Minze Stuiver, GW Farwell, DD Leach, and FH Schmidt</i> Radiocarbon Dating with the University of Washington Accelerator Mass Spectrometry System	237
<i>Georges Bonani, H-J Hofmann, Elvezio Morenzoni, Marzio Nessi, Martin Suter, and Willy Wölfli</i> The ETH/SIN Dating Facility: A Status Report	246
II. NATURAL VARIATIONS	
<i>Hans E Suess</i> Secular Variations of Cosmogenic ¹⁴ C on Earth: Their Discovery and Interpretation.....	259

<i>Paul E Damon and Timothy W Linick</i> Geomagnetic-Heliomagnetic Modulation of Atmospheric Radiocarbon Production.....	266
<i>DM Brown, MAR Munro, MGL Baillie, and JR Pilcher</i> Dendrochronology—The Absolute Irish Standard	279
<i>Claus U Hammer, Henrik B Clausen, and Henrik Tauber</i> Ice-Core Dating of the Pleistocene/Holocene Boundary Applied to a Calibration of the ¹⁴ C Time Scale	284
<i>GW Pearson</i> Precise Calendrical Dating of Known Growth-Period Samples Using a “Curve Fitting” Technique	292
<i>CY Fan, Chen Tie-Mei, Yun Si-Xun, and Dai Kai-Mei</i> Radiocarbon Activity Variation in Dated Tree Rings Grown in Mackenzie Delta....	300
III. THE CARBON CYCLE	
<i>Wallace S. Broecker and Tsung-Hung Peng</i> Carbon Cycle: 1985: Glacial to Interglacial Changes in the Operation of the Global Carbon Cycle	309
<i>DD Harkness, AF Harrison, and PJ Bacon</i> The Temporal Distribution of “Bomb” ¹⁴ C in a Forest Soil.....	328
<i>Helmut Dörr and KO Münnich</i> Annual Variations of the ¹⁴ C Content of Soil CO ₂	338
<i>Kai-Mei Dai and CY Fan</i> Bomb Produced ¹⁴ C Content in Tree Rings Grown at Different Latitudes	346
<i>Robert H Brown</i> ¹⁴ C Depth Profiles as Indicators of Trends in Climate and ¹⁴ C/ ¹² C Ratio.....	350
<i>Bernard John O'Brien</i> The Use of Natural and Anthropogenic ¹⁴ C to Investigate the Dynamics of Soil Organic Carbon	358
<i>Tsung-Hung Peng</i> Uptake of Anthropogenic CO ₂ by Lateral Transport Models of the Ocean Based on the Distribution of Bomb-Produced ¹⁴ C.....	363
<i>SW Leavitt and Austin Long</i> Trends of ¹³ C/ ¹² C Ratios in Pinyon Tree Rings of the American Southwest and the Global Carbon Cycle	376
<i>Peter Becker-Heidmann and Hans-Wilhelm Scharpenseel</i> Thin Layer δ ¹³ C and D ¹⁴ C Monitoring of “Lessive” Soil Profiles	383
<i>Reiner Schlitzer</i> ¹⁴ C in the Deep Water of the East Atlantic	391
<i>ERM Druffel, Susumu Honjo, Sheila Griffin, and CS Wong</i> Radiocarbon in Particulate Matter from the Eastern Sub-Arctic Pacific Ocean: Evidence of a Source of Terrestrial Carbon to the Deep.....	397
IV. METHODS AND APPLICATIONS	
<i>Michael Andrée, Hans Oeschger, Ulrich Siegenthaler, Trudi Riesen, Markus Moell, Brigitta Ammann, and Kazimierz Tobolski</i> ¹⁴ C Dating of Plant Macrofossils in Lake Sediment	411
<i>Michael Andrée, Juerg Beer, HP Loetscher, Ernst Moor, Hans Oeschger, Georges Bonani, HJ Hofmann, Elvezio Morenzoni, Marzio Nessi, Martin Suter, and Willy Wölfli</i> Dating Polar Ice by ¹⁴ C Accelerator Mass Spectrometry.....	417

<i>Michael Andrée, Hans Oeschger, WS Broecker, Nancy Beavan, Alan Mix, Georges Bonani, HJ Hofmann, Elvezio Morenzoni, Marzio Nèssi, Martin Suter, and Willy Wölfli</i> AMS Radiocarbon Dates on Foraminifera from Deep Sea Sediments	424
<i>Ingrid U Olsson</i> A Study of Errors in ^{14}C Dates of Peat and Sediment	429
<i>Ines Krajcar-Bronić, Nada Horvatinčić, Dušan Srdoč, and Bogomil Obelić</i> On the Initial ^{14}C Activity of Karst Aquifers with Short Mean Residence Time	436
<i>Alison J Fowler, Richard Gillespie, and Robert EM Hedges</i> Radiocarbon Dating of Sediments	441
<i>Richard Gillespie, REM Hedges, and MJ Humm</i> Routine AMS Dating of Bone and Shell Proteins	451
<i>Timothy Yates</i> Studies of Non-Marine Mollusks for the Selection of Shell Samples for Radiocarbon Dating.....	457
<i>Yijian Chen and Henry Polach</i> Validity of ^{14}C Ages of Carbonates in Sediments	464
<i>Herbert Haas, Vance Holliday, and Robert Stuckenrath</i> Dating of Holocene Stratigraphy with Soluble and Insoluble Organic Fractions at the Lubbock Lake Site, Texas: An Ideal Case Study	473
<i>Horst Willkomm</i> Anomalous High ^{14}C Activity Found in Recent Corals from the Philippines.....	486
<i>Dušan Srdoč, Bogomil Obelić, Nada Horvatinčić, Ines Krajcar-Bronić, Elena Marčenko, Joseph Merkt, How Kin Wong, and Adela Šliepčević</i> Radiocarbon Dating of Lake Sediment from Two Karst Lakes in Yugoslavia	495
<i>Mebus A Geyh and GJ Hennig</i> Multiple Dating of a Long Flowstone Profile	503
<i>Dušan Srdoč, Nada Horvatinčić, Bogomil Obelić, Ines Krajcar-Bronić, and Peg O'Malley</i> The Effects of Contamination of Calcareous Sediments on their Radiocarbon Ages.....	510
<i>Dušan Srdoč, Ines Krajcar-Bronić, Nada Horvatinčić, and Bogomil Obelić</i> Increase of ^{14}C Activity of Dissolved Inorganic Carbon Along a River Course	515
<i>TW Linick, AJT Jull, LJ Toolin, and DJ Donahue</i> Operation of the NSF-Arizona Accelerator Facility for Radioisotope Analysis and Results from Selected Collaborative Research Projects.....	522
<i>Anna Pazdur and Mieczysław F Pazdur</i> ^{14}C Dating of Calcareous Tufa from Different Environments.....	534
<i>Paul Ennis, EA Noltmann, PE Hare, PJ Slota, Jr, LA Payen, CA Prior, and RE Taylor</i> Use of AMS ^{14}C Analysis in the Study of Problems in Aspartic Acid Racemization-Deduced Age Estimates on Bone	539
<i>Jeffrey Klein, Robert Giegengack, Roy Middleton, Pankaj Sharma, JR Underwood, Jr, and RA Weeks</i> Revealing Histories of Exposure Using <i>In Situ</i> Produced ^{26}Al and ^{10}Be in Libyan Desert Glass	547
<i>NJ Conard, David Elmore, PW Kubik, HE Gove, LE Tubbs, BA Chrunyk, and Martin Wahlen</i> The Chemical Preparation of AgCl for Measuring ^{36}Cl in Polar Ice with Accelerator Mass Spectrometry	556
<i>Sheela Kusumgar, DP Agrawal, Navin Juyal, and Prabhakar Sharma</i> Palaeosols Within Loess: Dating Palaeoclimatic Events in Kashmir	561

V. CONVENTIONAL TECHNIQUES

<i>Adam Walanus</i> A ^{14}C Electronic Measurement System with a Microcomputer	569
<i>Richard Burleigh, Morven Leese, and Michael Tite</i> An Intercomparison of Some AMS and Small Gas Counter Laboratories	571
<i>Kazimierz Jelen and Mebus A Geyh</i> A Low-Cost Miniature Counter System for Radiocarbon Dating.....	578
<i>Janet Ambers, Morven Leese, and Sheridan Bowman</i> Detection of Bias in the Background of Vials Used for Scintillation Counting	586
<i>Sheridan Bowman</i> The Potential of the London Underground for Liquid Scintillation Counting.....	592
<i>Fernando E Angiolini and Miguel C Albero</i> Optimization of Liquid Scintillation Counting for ^{14}C Dating	597
<i>RL Otlet, George Huxtable, and DCW Sanderson</i> The Development of Practical Systems for ^{14}C Measurement in Small Samples Using Miniature Counters.....	603
<i>HH Loosli, Markus Forster, and RL Otlet</i> Background Measurements with Different Shielding and Anticoincidence Systems	615
VI. ANTHROPOGENIC VARIATIONS	
<i>GA Klouda, LA Currie, DJ Donahue, AJT Jull, and MH Naylor</i> Urban Atmospheric ^{14}C and $^{14}\text{CH}_4$ Measurements by Accelerator Mass Spectrometry	625
<i>Martin McCartney, MS Baxter, Keith McKay, and EM Scott</i> Global and Local Effects of ^{14}C Discharges from the Nuclear Fuel Cycle	634
<i>Bogomil Obelić, Ines Krajcar-Bronić, Dušan Srdoč, and Nada Horvatinčić</i> Environmental ^{14}C Levels Around the 632 MWe Nuclear Power Plant Krško in Yugoslavia.....	644
<i>Tadeusz Kuc</i> Carbon Isotopes in Atmospheric CO_2 of the Krakow Region: A Two-Year Record	649
<i>Romuald Awiuk and Mieczysław F Pazdur</i> Regional Suess Effect in the Upper Silesia Urban Area	655
<i>Rainer Berger, David McJunkin, and Roberta Johnson</i> Radiocarbon Concentration of California Aerosols	661
<i>Pavel Povinec, Martin Chudý, and Alexander Šivo</i> Anthropogenic Radiocarbon: Past, Present, and Future	668
<i>LA Currie, GA Klouda, Jørgen Schjoldager, and Thomas Ramdahl</i> The Power of ^{14}C Measurements Combined with Chemical Characterization for Tracing Urban Aerosol in Norway	673
<i>AJ Walker, RL Otlet, and H Longley</i> Applications of the Use of Hawthorn Berries in Monitoring ^{14}C Emissions from a UK Nuclear Establishment over an Extended Period	681

VII. APPLICATIONS IN ARCHAEOLOGY

<i>Christiane Pachiaudi, Joelle Marechal, Mark Van Strydonck, Michel Dupas, and Michelle Dauchot-Dehon</i> Isotopic Fractionation of Carbon During CO ₂ Absorption by Mortar	691
<i>RJ Batten, Richard Gillespie, JAJ Gowlett, and REM Hedges</i> The AMS Dating of Separate Fractions in Archaeology	698
<i>Mark Van Strydonck, Michel Dupas, Michelle Dauchot-Dehon, Christiane Pachiaudi, and Joelle Marechal</i> The Influence of Contaminating (Fossil) Carbonate and the Variations of $\delta^{13}\text{C}$ in Mortar Dating	702
<i>Martine Gabasio, Jacques Evin, GB Arnal and Philippe Andrieux</i> Origins of Carbon in Potsherds	711
<i>RA Johnson, JJ Stipp, MA Tamers, Georges Bonani, Martin Suter, and Willy Wölfli</i> Archaeologic Sherd Dating: Comparison of Thermoluminescence Dates with Radiocarbon Dates by Beta Counting and Accelerator Techniques	719
<i>Romuuald Awiśnik, Władysław Filipowiak, Tomasz Goslar, Anna Pazdur, and Mieczysław F Pazdur</i> Early Slavonic Settlements and Navigation at the Mouth of the Odra River	726
<i>Barbara S Ottaway</i> Is Radiocarbon Dating Obsolescent for Archaeologists?	732
<i>Olav Sverre Johansen and Karl-Dag Vorren</i> The Prehistoric Expansion of Farming into "Arctic" Norway: A Chronology Based on ¹⁴ C Dating	739
<i>Miguel C Albero, Fernando E Angiolini, and Ernesto L Piana</i> Discordant Ages Related to Reservoir Effect of Associated Archaeologic Remains from the Tunel Site, Beagle Channel, Argentine Republic	748
<i>Olav Sverre Johansen, Steinar Gulliksen, and Reidar Nydal</i> $\delta^{13}\text{C}$ and Diet: Analysis of Norwegian Human Skeletons	754

VIII. REPORTING AND MANAGEMENT OF DATA

<i>Renee Kra</i> Standardizing Procedures for Collecting, Submitting, Recording, and Reporting Radiocarbon Samples	765
<i>Dilette Polach</i> Toward a Thesaurus of Radiocarbon Dating and Related Terms	776
<i>JD Wilcock, RL Olet, AJ Walker, SA Charlesworth, and J Drodge</i> Establishment of a Working Data Base for the International Exchange of ¹⁴ C Data Using Universal Transfer Formats	781
<i>FMR Engelsman, E Taayke, and WG Mook</i> Groningen ¹⁴ C Data Base	788

IX. REPORTS, COMMENTS, AND REMARKS

<i>Willem G Mook</i> Business Meeting	799
<i>Renee Kra</i> Report of the ¹⁴ C Data Base Workshop	800
<i>Paul E Damon</i> Twelfth International Radiocarbon Conference After Dinner Remarks	803