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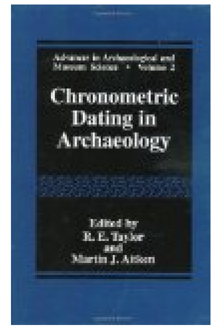
R. E. Taylor, Martin J. Aitken, eds. *Chronometric Dating in Archaeology.* New York: Plenum Press, 1997. xix + 395 pp. $95.00 (cloth), ISBN 978-0-306-45715-9.



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Recent Advances in Methods of Archaeological Chronology

As a practicing archaeologist who has been cross trained in several of the physical sciences and taught archaeological field methods and laboratory analyses at the university level, I approached an assessment of this work with great anticipation and, at the same time, hesitant caution. This is because I am reviewing the volume, in the main, for scholars in the humanities disciplines rather than for scientists; therefore I shall attempt to interest and inform both audiences.

Archaeology is, indeed, one of the humanities (so-defined by the United States Congress in 1965), but it is also one that has borrowed paradigms, methods, and analytical techniques, and adopted analogies and inferences from many of the natural, physical, and social sciences, and the humanities. Chronometric Dating for the Archaeologist isn't bedtime reading, nor is it for the faint-of-heart, but at the same time one does not have to have a background in materials science or organic or inorganic chemistry to understand the basic premise of the work. The editors' goal is to present a factual, current, and well-documented evaluation of a dozen of the major techniques that are used by scientists to determine chronology from archaeological artifacts or contexts. The book may certainly be regarded as a highly technical compendium, an essential reference work that should be acquired by any library and is mandatory for advanced students, and practitioners. This is, however, also a significant document–a status report–which synthesizes the latest thinking about important dating methods written by a distinguished assemblage of international experts.

My review will be in three parts. Initially, I provide a broad assessment that will establish a background and a context for chronology in archaeology, and I shall present an overall evaluation of the volume. In the second section, I furnish a more technical and detailed appraisal of the each of the twelve chapters with comments about those major publications previously regarded by archaeologists as key sources on these specific topics. Lastly, there is a conclusion that incorporates a general discussion about this volume and its relationship to similar works and the current status of chronometric or "time placement" dating. Interested readers and science-oriented scholars may wish to read all three parts; casual readers will benefit from perusing the first and third sections.

Background, Context, and General Assessment

Research conducted by archaeologists, prehistorians, historians of ancient cultures and civilizations, and art historians, among other scholars and scientists, has, in the main, four primary components: 1) description; 2) location, provenance, or provenience; 3) chronology; and 4) explanation, inference, and/or the testing of hypotheses. We could debate the issue whether archaeology is a social science or is a humanities' discipline that employs paradigms, field and laboratory methods, and analytical techniques derived from the natural and physical sciences to verify artifact origins, discern cultural chronology, and interpret or infer human behaviors. Nonetheless, chronology–the science of measuring time in fixed periods and of dating events and epochs and arranging them in their order of occurrence (e.g., the sequential ordering of events or the tabulations derived from this activity)–is a fundamental component of scientific and humanistic inquiry. Basic textbooks on archaeological method and theory relate that there are two methods of establishing chronology: 1) methods of relative dating (ascertaining the correct order of the events) and 2) absolute or chronometric dating (quantifying the measurement of time in terms of years or other fixed units). Relative dating may be derived from sequence dating through seriation (changes in artifact form, function, or style through time), by stratigraphic analysis (geological stratigraphy based upon the "Law of Superposition"), and by cross dating. Chronometric dating can rely upon: 1) historic or written records, 2) non-radiometric scientific studies (such as tree ring, thermoluminescence, or obsidian hydration dating techniques), 3) radiometric analyses (radiocarbon and potassium-argon dating, for example, which rely upon the decay of unstable parent isotopes into stable daughter forms), and 4) biochemical analyses (notably by amino acid dating or isoleucine racemization).

This impressive and well-written volume focuses exclusively upon absolute or chronometric dating techniques and presents an up-to-date wealth of information about methodologies in a dynamic field. This is both a compelling and an essential reference for those scholars who wish to understand current procedures and problems, and future prospects in science-based archaeological chronology. Chronometric Dating in Archaeology is the second volume in a new series initiated by Plenum Press entitled "Advances in Archaeological and Museum Science," and takes its place beside the initial volume in the series, *Phytolith Systematics: Emerging Issues*, edited by George Rapp, Jr. and Susan C. Mulholland (1992). The volumes in this series are published in cooperation with the Society for Archaeological Sciences (SAS), an organization of natural scientists and professional archaeologists. The society's members come from diverse disciplines but share the common belief that natural science techniques and methods constitute an essential component of both archaeological field and laboratory studies. The editors of this distinguished series are Martin J. Aitken (Oxford University), Edward V. Sayre (Smithsonian Institution), and R. E. Taylor (University of California at Riverside). Taylor and Aitken, both of whom are established scientists and scholars, are also the editors of the volume being reviewed.

R. E. (Erv) Taylor is currently Professor of Anthropology and a Research Anthropologist in the Institute of Geophysics and Planetary Physics, but also serves as the Director of the Radiocarbon Laboratory at the University of California at Riverside. His research focuses on the application of dating and analytical techniques in archaeology (the latter known as archaeometry) with an emphasis on radiocarbon dating. Taylor is the author of numerous scientific papers and monographs, including *Radiocarbon Dating: An Archaeological Perspective* (1987) and was coeditor with A. Long and R. S. Kra of Radiocarbon after Four Decades: An Interdisciplinary Perspective (1992). Martin J. Aitkin is now Emeritus Professor of Archaeology at Oxford University and was for many years affiliated with Oxford's Research Laboratory for Archaeology and the History of Art. Holding a doctoral degree in nuclear physics, his principle areas of research were in magnetic prospection, archaeomagnetism, and luminescence dating. In 1983 he was elected a Fellow of the Royal Society of London. Among his major writings are *Thermoluminescent Dating* (1985) and *Science-based Dating in Archaeology* (1990). Taylor's name has become synonymous with the evolution and refinement of methods in radiocarbon dating, while Aitkin is celebrated as one of the leading international authorities on luminescence techniques and the chronologies of ancient climates.

New methods of dating artifacts and archaeological contexts have developed rapidly since the so-called "radiocarbon revolution" which took place shortly after the Second World War. The editors recognize that because of the increasing complexity of many of the dating techniques, it is no longer possible for one or even a few authors to assemble and assess adequately the ever-increasing literature and the current directions of research for more than one or two of the techniques. Aitken's own 1990 work may be the last volume of its type to have sole authorship. Therefore, Taylor and Aitken assembled 19 of the world's leading experts on a dozen aspects of archaeological dating method and theory. The editors encouraged them to provide a summary of progress in their respective techniques during the past three decades (emphasizing the developments that have taken place within the past five years) and the status of current research. This group of outstanding international scholars includes an Australian, two Canadians, one Indian, one New Zealander, two authors from the United Kingdom, and 12 contributors from the United States.

Organizationally, the volume includes an editorial introduction and a preface, twelve topical chapters (varying from 24 to 44 pages in length), and contains 107 figures, 21 tables, and a five-page double-column index. Each chapter assesses a basic archaeometric technique and each has separate references–a total of 1,307 entries–so that every contribution stands by itself as a very useful synthesis. In the main, each contribution is structured similarly, beginning with an abstract, followed by a brief historical overview, and a discussion of how the technique "works" (including, in most instances, complex physical science discussions and/or mathematical formulae). The types of materials or contexts that are dated, potential sources of error or contamination, and results are also considered. In essence, the reader is exposed to a history of the refinement of a scientific procedure. All of the chapters present several examples or practical applications that demonstrate the utility of the technique. Sample preparations, the advantages and disadvantages of particular methods, and error rates are among the topics reviewed. The individual chapter "conclusions" summarize the presentations, relate current uses and trends, and often suggest future research directions or needs. The volume's editors have not prepared an overall assessment or written a summary about the status of chronometric dating or its future prospects. This is not a shortcoming but would make the book even more valuable as a reference and resource.

The individual presentations, in the main, follow a chronological progression, beginning with those techniques developed earliest and concluding with those more recently developed. The first contribution is on "Climatostratigraphy" and considers varve analysis and marine sediment and ice core studies used to discern past climatic history and chronology. "Dendrochronology" (so-called tree-ring dating) is explicated next, and its nearly world wide applications are reviewed. The subsequent group of techniques depends upon the physicochemical premise that unstable parent isotopes decay at a known rate and produce stable daughter isotopes. "Radiocarbon Dating," perhaps the best known of the chronometric techniques, is admirably reviewed by Taylor, who divides studies into three successive generations, each more refined than its predecessor. The complex procedures of "Potassium-Argon/Argon-Argon," "Fission-Track," and "Uranium Series" dating are admirably reviewed, with emphasis on determining the dates of geologic layers and events and associated hominid biological and cultural evolution (the latter seen in the form of stone tools). "Luminescence Dating" includes the analysis of pottery, other heated materials, stalagmite calcite, and unburned sediments. ESR or "Electron Spin Resonance Dating" involves the analysis of a variety of materials including tooth enamel, speleothems, deposited travertine rock, marine shell, and burnt flint. Known rates of changes in amino acids are central to "Protein and Amino Acid Diagenesis Dating" and hold great promise for the dating of bone, mollusk and non-mollusk shell, and egg shell. Volcanic glass artifacts absorb water by diffusion, the basic premise of "Obsidian Hydration Dating," a relatively simple chronometric method but one that is complicated by a number of dependent and independent variables. "Archaeomagnetic Dating" is founded on the principle that directions and intensities or polarities in archaeological materials or rocks that have been magnetized during archaeological time will change through time. Lastly, rocks from arid and semi-arid regions may acquire a dark colored. silica-rich coating, the basis of "Surface Dating Using Rock Varnish."

Chapter Appraisals

In my critique I shall summarize the salient features of each of the dozen chapters and then evaluate the volume and those significant predecessors that documented the status of specific dating techniques employed in archaeological investigations.

The initial chapter, "Climatostratigraphy" (30 pp., 6 figures, 2 tables, 105 references), is co-authored by Martin J. Aitken and Stephen Stokes–the latter is at the School of Geography at Oxford University. In geology courses we learned that the initial framework for global Quaternary climate change was based upon the advance and retreat of the European and North American alpine glaciers. Glacial periods, interstadials, and interglacials were identified subsequently on the basis of climatic indicators including fossil pollen, and annually-laid down layers of sediments or dust. Distinctions between birch and pine versus mixed oak (oak, elm, ash, and hazel) forests as seen in pollen changes, annual layers (varves) of sands and sediments associated with glaciers, and profiles of wind blown silt-size sediments (loess) assisted archaeologists working on Ice Age/Old Stone Age dating. However, during the past quarter century, our knowledge about past climatic episodes has been "revolutionized" by the study of oxygen isotope ratios. Aitken and Stokes summarize the state of research on and interpretations of marine and ice cores, including saline sea versus glacial fresh water isotopes as reflected in marine shell (glacial water is isotopically "lighter" than sea water, hence, shells found in the latter are "heavier"). Deep ocean core studies have lead to the identification of Marine Isotope Stages (MIS) which can be dated astronomically. Variations in isotopes, methane, and aeolian (wind-deposited) dust in ice cores from Greenland and the Antarctic also lead to chronological assessments. This up-to-date summary goes well beyond any prior assessments of varve and core analyses (for example, Aitken 1990; Brothwell and Higgs, eds., 1963, 1969; Parkes 1986; Zeuner 1970).

The second contribution, "Dendrochronology" (34 pp., 3 figures, 183 references), was prepared by Jeffrey S. Dean (Laboratory of Tree-ring Research, University of Arizona, Tucson, AZ). Dendrochronology (DC), the science that uses tree-rings for dating past events and for inferring past environmental episodes, was employed initially in the American Southwest but has now become a global phenomenon (tropical Africa excepted) with over one hundred tree-ring programs world wide. Dean conveys the historical background and principles, and relates five research objectives: 1) data capture or measurement, 2) standardization, 3) comparison or cross dating (with radiocarbon dating most commonly used), 4) data consolidation and chronology building, and 5) environmental reconstruction. Tree-ring analysis results in chronological, behavioral, and environmental assessments, including inferences about the human impact on the environment, selection of and human use of tree species, and tools and techniques of tree felling. Environmental data regarding hydrological changes (drought and flood), volcanism, stream flow changes, and the composition and distribution of plant communities may be evaluated. The future holds great promise for expanding DC's geographic scope, developing more precise climatic modeling, and resolving archaeological problems (sample preservation and curation, standardizing nomenclature, and procedures to evaluate challenged and anomalous data). This evaluation is preferable to more lengthy treatments of the topic by Eckstein et al. (1984) and by Fritts (1976, 1991), or summaries presented in more general works (for example, Aitken 1990; Brothwell and Higgs, eds, 1963, 1969; Guksu et al., eds., 1991; Michael and Ralph, eds., 1971; Michels 1973; Zeuner 1970).

"Radiocarbon Dating" (32 pp., 5 figures, 6 tables, 101 references), authored by R. E. Taylor (Radiocarbon Laboratory, University of California at Riverside), begins with a review of the history of 14C dating and the influence it has had on the disciplines of archaeology and Pleistocene geology. Taylor summarized three generations or phases of radiocarbon studies: incipient analyses (1950-1970), the calibration of results (1970-1980), and "extending the calibration" (1980-date). He also carefully explicates phenomena such as the Libby (or nuclear device testing), Suess (or industrial), and the de Vries effects on sample analysis. The advantages of using Accelerator Mass Spectrometry (AMS) as opposed to older measurement techniques are also reviewed. Among the case studies employed are studies of the Shroud of Turin, the domestication of corn (maize) in Mexico, and experimental work on non-collagen protein dating. Taylor states that "the impact of 14C dating on the conduct of archaeological research has been, in some aspects, clear and explicit and in others, subtle...Radiocarbon data provides the foundation on which most of the prehistoric archaeological time scales in most areas of the world for the last 40,000 years are, directly or indirectly, constructed" (p. 91). Earlier considerations of radiocarbon dating, whether general summaries (Aitken 1990; Brothwell and Higgs, eds., 1963, 1969; Guksu et al. eds., 1991; Michael and Ralph, eds., 1971; Michels 1973; Parkes 1986; Zeuner 1970) or book-length assessments (Berger and Suess, eds., 1979; Lowe 1996; Mook and Waterbolk 1985; Taylor 1987, Taylor et al., eds., 1992) are made obsolete by this chapter. Taylor and his associates continue to publish important analyses of significant early human remains from North America Taylor et al. 1998).

Chapter 4, "Potassium-Argon/Argon-Argon Dating Methods" (30 pp., 4 figures, 106 references), is by Robert C. Walter (Institute of Human Origins, Berkeley, CA). [Reviewer's Note: On 1 July 1997 the Institute of Human Origins relocated to Arizona State University, Tempe, AZ, where Walter continues his geochronological research.] Through time, due to the radioactive decay of a parent isotope, a daughter isotope is accumulated; hence potassium, a common rock-forming element, has the electronic configuration of the noble gas argon plus a single valence electron. Both potassium and argon have three natural isotopes (two of which are stable); unstable 40K decays to 40Ar and 20Ca at a quantifiable rate. Walter considers the analytical procedures, assumptions, and limitations of this commonly used method of chronometric dating. However, the argon-argon method has distinct advantages in terms of more precise measurement and chronometric accuracy, so that the decay of 40Ar to 39Ar has been employed in numerous studies of Pleistocene hominid evolution in East African localities such as Olduvai Gorge, Koobi Fora, Hadar, and Konso-Gardula. Quantifying one rather than two sets of isotopes (Ar instead of K and Ar), a need for smaller samples, error reduction, and the use of pulsed laser-fusion techniques have revolutionized this radiometric method–hence the argon-argon method is preferred and replaced conventional Ar dating. The assessment of the K-Ar method by Dalrymple and Lanphere (1969), once an important text, is relegated to the status of an historic treatise. Specific technical reports (McDougall and Harrison 1988; Shaeffer and Zarling 1966) and general evaluations (Aitken 1990; Brothwell and Higgs, eds., 1963, 1969; Michael and Ralph., eds, 1971; Michels 1973; Parkes 1986) are updated by the materials in this chapter. A recent report on argon-argon intercalibration (Renne et al. 1998) and the confirmation of the chronology of a new fossil hominid, Australopithecus anamensis, in May (Leakey et al. 1998), are of more than passing interest to some readers.

Chapter 5, "Fission-Track Dating" (32 pp., 16 figures, 3 tables, 74 references), is co-authored by John Westgate (Physical Sciences Division, University of Toronto, Scarborough, Ontario, Canada), Amanjit Sandhu (Department of Physics, Guru Nanak Dev University, Amritsar, India), and Philip Shane (Department of Geology, University of Auckland, Auckland, New Zealand). Fission tracks (F-T) are zones of intense damage formed by the passage of fission fragments through a solid. The fission of 238U occurs at a known rate, hence, the age of a mineral or vitreous substance can be calculated from the number of spontaneous fission tracts that it contains. The authors detail the procedures, problems of "fading" tracks, correction methods, and limitations (not all tephra beds are datable). The analyses of examples of volcanic glass from Alaska and Indonesia, the analyses of zircon grains from the Indian Subcontinent, and hominid-bearing geological strata from Ethiopia, and Cenezoic beds from Alaska are reported. The authors conclude that tephrochronological and magnetostratigraphic techniques used in conjunction with isothermal plateau fission-tract (ITPFT) dating methods form a valuable analytical toolkit. F-T dating as been summarized in a number of previous works on chronometric techniques (Aitken 1990; Brill, ed., 1971; Brothwell and Higgs, eds., 1963, 1969; Guksu et al., eds., 1991; Michael and Ralph, eds., 1971; Michels 1973) but this chapter is current and clearly written.

The sixth contribution, "Uranium Series Dating" (24 pp., 6 figures, 43 tables, 50 references), was prepared by Henry P. Schwarcz (School of Geography and Geology, McMaster University, Hamilton, Ontario, Canada). U-series assessments are the "methods of choice" for determining ages earlier than 40,000 BP [Before the Present]. Following the initial decay, the daughter elements are different; hence, 238U becomes 226Ra and 235U produces 231Pa. Schwarcz explicates the theoretical concepts and presents a well-documented but highly technical review. The range of datable materials is impressive: carbonates, speleothems (stalagmites and stalactites) travertine deposits, marls, shells (snails, bivalves, and some eggshell), bones and teeth, and even peat and wood. The major analytical techniques include alpha particle spectrometry (APS), thermal ionization mass spectrometry (TIMS), and isochron analysis. The author employs examples from Lower and Middle Paleolithic cultural and hominid-bearing sites in Spain, France, and Germany to illustrate the procedures and results. Because of its recent and dynamic development, only a few other works have attempted to summarize U-series research (Aitken 1990; Guksu et al., eds, 1991; Parkes 1986).

"Luminescece Dating" (34 pp., 12 figures, 74 references) by Martin J. Aitkin (Research Laboratory for Archaeology, Oxford University, UK) is the seventh chapter. The author admirably synthesizes the two branches of luminescence dating: 1) optical dating (OD) used on sediments, and thermoluminescence (TL) which can be employed on a variety of burned materials including burnt flint, sediments, and pottery. Sample collection, preparation, and measurement (paleodoses and glow curves) are reviewed, and Aitken argues convincingly that trapped electron dating (TED) is preferable to electron spin resonance (ESR). The relatively recent development of the optical dating of pottery, the author believes, shows "encouraging results." Other topics clearly presented include limitations to age ranges, problems of accuracy, error limits, and citation methods. The chronometric potential of luminescence dating ranges from a few decades to over one million years. Aitken's current assessment supercedes all prior reviews of the methods and the reported results (Aitken 1985; Brill, ed., 1971; Brothwell and Higgs, eds., 1963, 1969; Fleming 1979; Guksu et al., eds., 1991; Michael and Ralph, eds., 1971; Michels 1973; Parkes 1986), even Aitken's (1990) most recent evaluation.

"Electron Spin Resonance Dating" (44 pp., 23 figures, 115 references), Chapter 8, is written by Rainer Grüen (Quaternary Dating Research Centre, Australian National University, Canberra, Australia). The distinguished author has written more than a dozen and a half publications on ESR dating and is a superb choice to explicate recent methods and analyses. The basic principle is that when released, trapped electrons produce heat and light at quantifiable rates. ESR dating is applicable to a wide range of materials: tooth enamel, speleothems, travertine, shells (mollusks and corals), and burnt flint. Analyses of quartz particles extracted from pottery have resulted in dates less sensitive than those determined by thermoluminescence (TL). Basic principles, measurements (accumulated dose and dose rate) by spectrometry, methodological limitations, and the inability to date bones, are well documented in the chapter. Case studies of different types of datable materials from sites in the eastern Mediterranean (the Levant), Germany, and

Sri Lanka. Grüen concludes that the technique is in a "rapid phase of development" and he believes that ESR combined with U-series dating may be "the most powerful tool to extend chronologies into the past." In addition, because of refinements in the method, he cautions the acceptance of dates that were calculated in the early 1980s. Only Aitken (1990) has attempted a prior evaluation.

Chapter 9, "Protein and Amino Acid Diagenesis Dating" (36 pp., 6 figures, 2 tables, 202 references) is co-authored by P. E. Hare (Geophysical Laboratory, Carnegie Institution of Washington, Washington, DC), David W. Von Endt (Conservation Analytical Laboratory, Smithsonian Institution, Washington, DC), and Julie E. Kokis (Geophysical Laboratory, Carnegie Institution of Washington). [Reviewer's Note: The Conservation Analytical Laboratory (CAL) was renamed the Smithsonian Center for Materials Research and Education (SCMRE) on 26 January 1998 by the Smithsonian's Board of Trustees.] The authors discuss general biogeochemical principles underlying the use of various proteins and the decomposition of amino acids that can be used to obtain chronological inferences. The complex processes and rates of racemization (interconversion of L- and D-[levo and dextro] forms of isomers, such as isoleucine) and epimerization (interconversion of chiral carbons) are presented. Amino acid racemization (AAR) studies of Pleistocene bone specimens (examples from East Africa and California), the human use of fire (England), and shell, marine and non-marine mollusks, and avian eggshell (many examples) are presented as case studies. Problems with bone collagen, and temperature and chemical environmental factors are reviewed; and excellent results from shell are documented. Technical aspects of AAR dating continue to be refined. The earlier literature on chronological determinations through amino acid racemization (Aitken 1990; Guksu et al., eds., 1991; Parkes 1986) has been rendered obsolete by the information documented in this chapter.

Chapter 10, "Obsidian Hydration Dating" (25 pp., 9 figures, 1 table, 82 references) is a joint contribution by Irving Friedman, Fred W. Trembour (both, Laboratory of Isotope Geology, United States Geological Survey, Denver, CO), and Richard E. Hughes (Geochemical Research Laboratory, Portola, Valley, CA). Friedman was the scientist who initially developed the OHD technique in 1960 and he has continued to refine the method. Obsidian (a glassy rhyolitic volcanic rock used to make a variety of chipped stone tools) absorbs atmospheric water at a rate that may be calculated. The authors discuss factors related to hydration rates (the chemical composition of obsidians, trace elements, relative humidity, and regional rates, for example), laboratory techniques (the preparation of thin sections and the optical measurement of hydration rim/rind thickness measured in microns), and the conversion of hydration rate data to age. The interesting case studies include archaeological specimens from New Mexico, central Mexico, Belize, Honduras, and Ohio (the latter imported from Wyoming). Studies of Mexican, Guatemalan, and Sardinian obsidians by Michels and his colleagues are critiqued. The authors also compare OHD results cross dated by radiocarbon dating, archaeomagnetism, or ceramic phasing. Lastly, they suggest four projects for future research: 1) an inexpensive method of measuring rinds less than 1.5 microns wide, 2) determine hydration rates for a wider variety of obsidian sources, 3) develop a non-destructive method of measurement, and 4) standardize laboratory procedures. OHD is a relatively inexpensive and "simple" scientific technique for determining absolute chronologies, so that the masterful treatment presented in this chapter replaces earlier general assessments (Aitken 1990; Brothwell and Higgs, eds., 1963, 1969; Guksu et al., eds., 1991; Michael and Ralph, eds., 1971; Michels 1973; Taylor, ed., 1987).

"Archaeomagnetic Dating" (34 pp., 10 figures, 3 tables, 120 references), the eleventh chapter, is by Robert S. Sternberg (Department of Geosciences, Franklin and Marshall College, Lancaster, PA). Archaeomagnetic dating is a "derivitive" dating method, that is, one that is dependent upon the correlation of an archaeological sample with an extant master pattern. It is also is a subfield of paleomagnetic dating which employed to resolve geological and geophysical problems rather than cultural ones. The technique is based upon a pattern comparison of past magnetic directions and strength or intensities (both of which are regional phenonema), or polarity (a global phenomenon). Dating principles, sample collection, and the construction of master records of change are considered. Applications from the American Southwest, Arkansas, Sicily, and Bulgaria are reviewed, and case studies from Arizona, the Basin of Mexico, and Minoan Thera and Crete presented. Sternberg also reports on the principles of magnetic reversal dating and cites studies of sites from China and Spain where Homo erectus or Homo sapiens specimens have been found. Several texts concerned with chronometric dating in archaeology have documented archaeomagnetic theory and methodological procedures (Aitken 1990; Brothwell and Higgs, eds., 1963, 1969; Eighmy and Sternberg, eds., 1990; Guksu et al., eds., 1991; Michael and Ralph., eds., 1971; Michels 1973; Parkes 1986). Tarling's (1983) treatment of paleomagnetism has been rendered obsolete by the more current research Sternberg summarizes in this chapter.

The final contribution, "Surface Dating Using Rock Varnish" (32 pp., 7 figures, 1 table, 95 references) is written by Joan S. Schneider (Department of Anthropology, University of California at Riverside) and Paul R. Bierman (Department of Geology University of Vermont, Burlington, VT). Rock varnish is a dark-colored, magnesium, iron-, and silica-rich coating which forms on exposed rock surfaces over time, especially in arid and semi-arid environments. Although the mechanism of its formation is not completely understood (microbiological and physicochemical processes are suspected) and it forms on rough surfaces rather than smooth ones, it has been used as a chronometric dating tool by archaeologists and geologists. Rock art, pebble "pavements" (as in Nasca, Peru), and stone and masonry structures have been dated. The authors detail the cation-ratio (C-R) dating process, seven underlying assumptions, provide an historical overview. And render a well-documented critique. R. I. Dorn proposed the method in 1983 but fundamental questions were raised by Robert Bednarik, among others, about the research design. They contend that experimental replication is not assured. Notably there is a lack of sampling information, data tables, and analytical procedures). Schneider and Bierman relate the problems and limitations in chronology, interpretation, sample sizes, and comparability, and also report the issue of measuring titanium in the presence of barium. In conclusion, the authors state that there is "no agreement in the rock-varnish community regarding the reliability of C-R dating" and note the method has been little used since the early 1990s. None of the scientists whose works appear in the References Cited in my review have considered rock varnish.

Conclusions and Assessment

Archaeologists who concern themselves with problems of chronology often publish in or consult frequently several major American and European technical journals including Archaeometry, Geoarchaeology, Geochimica et Cosmochimica Acta, Journal of Archaeological Science, Radiocarbon, and SAS [Society for Archaeological Sciences] Bulletin, as well as Science and Nature, among others. The British journal Antiquity and its counterpart American Antiquity are the major archaeological publications in which reports appear. Readers desiring additional, specific information on chronometric techniques and archaeometry may wish to visit some of the two dozen websites hotlinked to a URL entitled "Archaeology on the Net" which may be accessed at <http://www.serve.com/archaeology/ametry.html$>$. However, in the volume being reviewed, the literature search and synthesis of salient and the latest research has been done for the reader and both a bibliography of essential references and well-documented assessments appear in this compelling book.

Taylor and Aitken selected leading international authorities to review each of a dozen primary techniques that archaeologists may employ to derive absolute chronology. The past half-century has witnessed remarkable changes in archaeological method and theory, as well as in scientific advancements in techniques to determine provenance and chronology. By emphasizing the advances that that taken place during the past decade in each archaeometric technique provides the reader with an important baseline for assessing the status of chronology in archaeology and preparing for the challenges of the next millennium. Pollard and Heron's Archaeological Chemistry (1996; see also Kolb 1997) would make a very suitable pedagogical companion with Taylor and Aitken's superb treatise.

Chronometric Dating in Archaeology is well organized, clearly written, and contains the most up-to-date information available on a dozen dynamic topics. The volume certainly replaces the earlier edited works by Brill (1971), Brothwell and Higgs (1963, 1969), Michael and Ralph (1971), and Güksu and his colleagues (1991). The days of single-author syntheses have passed simply because there is no one person who is able to keep up with the voluminous flow of archaeometric literature. Dating Methods in Archaeology by Joseph Michels (1973) is a good example; with the exception of obsidian hydration dating, he synthesized six of seven chapters on chronometric dating from the published literature. Because of a lack of familiarity with actual laboratory procedures, Michels, in his discussion of radiocarbon dating, erred in differentiating liquid scintillation systems versus proportional gas counting systems. In addition, he apparently did not realize that there were two sets of secular correction values (Suess and MASCA [Museum Applied Science Center for Archaeology]). Penelope Parkes's sole-authored synthesis, Current Scientific Techniques in Archaeology (1986), which has full chapter treatments on radiocarbon dating, thermoluminescence, and archaeomagnetism, also contains brief reviews of uranium-series, potassium-argon, and amino acid methods. All of these works are now dated so that Taylor and Aitken and their colleagues provide us with the most current assessments. It is a reference work and synthesis that will be useful into the next millennium.

This work has only a few typographical errors (primarily in reference citations), and occasionally a few British English spellings have crept into the narrative. Alternative spellings (such as mollusc and mollusk) occur–even on the same page (p. 278)–but instances of this sort are rare. I am informed that this rather expensive hardcover volume ($95.00) has a "text adoption price" of $45.00 on orders of six or more copies. However, outside of the United States and Canada, Plenum Press book prices are 20 percent higher. There are, apparently, no plans to issue a paperback edition. In my view, this is unfortunate. On the other hand, Michaels and Ralph's (1971) 228 pp. hardbound volume and Michels' cloth volume of 230 pp., originally cost, respectively, $12.50 and $6.95.

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