SAS BULLETIN

NEWSLETTER OF THE SOCIETY FOR ARCHAEOLOGICAL SCIENCES

VOLUME 40 NUMBER 2 SUMMER 2017

FROM THE EDITOR

We welcome two new Associate Editors to the *SAS Bulletin* with this issue. Rebecca Gibson will assume the role of Associate Editor, Bioarchaeology, and Brett Kaufman will assume the role of Associate Editor, Archaeometallurgy. Let's welcome them both and hope they will fill our collective lives with lots of new and exciting information in those respective areas.

Also, I also would like to announce that we are actively seeking a new Associate Editor of Upcoming Conferences. This individual would need to keep a calendar up-to-date with basic information on conferences that pertain to archaeological sciences directly, or have sessions pertaining to archaeological sciences. Our current President was the last Associate Editor of Upcoming Conferences and you can see her last installment in Vol. 38, No. 3 to see what we are looking for <http://www.socarchsci.org/bulletin/SAS3803.pdf>. Those interested in the position should send an email to me as soon as possible, so we can get you on board and try to get a contribution for SAS Bulletin Vol 40, No. 3.

Thomas R. Fenn
SAS Bulletin Editor

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ANNOUNCEMENTS

Student Research International Travel Award

The Society for Archaeological Sciences is pleased to announce the creation of the SAS Student Research International Travel Award. Up to $1000 is now available to help with costs of international travel for laboratory or field research to students who have been SAS members for more than one consecutive year. Applications will be accepted from undergraduates in their final year of study who are planning to attend graduate school as well as Master's degree and PhD students. Research must be undertaken in a different country than that of their home institution. Funds may not be used to attend conferences, field schools, classes and/or training courses. Application deadlines are February 1 and September 1 each year. Details on how to apply are available through the following link: http://www.socarchsci.org/Student%20Research%20Award.pdf

BIOARCHAEOLOGY

Rebecca Gibson, Associate Editor

A few words about me: Hello readers! I am your new Bioarchaeology Associate Editor, Rebecca Gibson. Currently based at American University, I am finishing my PhD in bioanthropology/bioarchaeology. My primary research interests are female presenting bodies in historical archaeology, skeletal morphology and plasticity and how to differentiate sex in the anthropological record, the thoracic cage, women and the historical treatment of gender and gender roles, corsetry, 3D scanning for artifact preservation, and ethics and the formation of museum collections. I also research how we use science fiction to reflect current trends in robotics, and the desires behind human/robot sexual interaction. I can be reached at rgibson.archaeo@gmail.com, or at my facebook author page, https://www.facebook.com/TheCorsetedSkeleton.

Summary of Relevant SAA Abstracts

Chelsi Slotten, of American University, looked at how bioarchaeology, specifically the patterns of injuries due to domestic violence, can change how we see the gender binary, in a paper titled “Engendering the Bioarchaeology of the Viking Age.” Slotten compares known domestic violence injury types to previously unanalyzed Viking era data.

Jennifer Toyne, of the University of Central Florida, examined 3D photogrammetry as a way of exploring cliff tombs in Peru, combining traditional archaeological methods with long-range photo shots of the La Petaca and Diablo Wasi sites. Toyne seeks to contribute new ways of assessing sites which are difficult to access, and to identify remains in situ. Toyne’s paper was titled “Where Condors Reign: Methodological Challenges in the Bioarchaeology of Chachapoya Cliff Tombs in Peru.”

Courtney Hofman, et al., are working on using minute amounts of bioarchaeological evidence, such as dental calculus, in new ways—at the Laboratories of Molecular Anthropology and Microbiome Research (University of Oklahoma). Their paper, titled “Biomolecular Archaeology: New Insights from the Past,” looks at new directions in the use of genetic analysis of bioarchaeological material. This research can open up older discoveries to reanalysis, and has implications for discussing the diet and health of early Homo and hominids.

Bright Zhou, of the Stanford University Archaeology Center, reexamines concurrent incidents of porotic hyperostosis and cribra orbitalia in the bioarchaeological record of Çatalhöyük, to better understand disease transmission within distinct social groupings. Such work will be useful in pinning down the elusive cause of such unique pathological presentations. Zhou’s paper was titled “Bioarchaeological Assemblages at Çatalhöyük: A Relational Examination of Porotic Hyperostosis and Cribra Orbitalia Etiologies and Transmissions.”

Anna Novotny of Texas Tech University looks at advances in the 3D modeling technology and its use in the digital curation of collections in a paper titled “Curation in the Digital Age: The Potential for Bioarchaeology.” Novotny’s work specifically examines drawing out previously unseen detail from objects and creating comprehensive scans of burials. This has implications for existing collections, as well as artifacts which are too friable to be moved from their excavated locations, and is perfect for skeletal remains.

John Robb of Cambridge University gives a new specific outline for the concept of osteobiography, sometimes termed the bioarchaeology of individuals, integrating biomedicine and life histories into his framework. Bioarchaeology, in his paper “Osteobiography: A Conceptual Framework,” is used as one component of a larger picture.

Jane Wiegand experiments with photogrammetry as a way to determine associations between disparate skeletal remains. Wiegand found this a successful new medium for such work, and was able to recreate 3D models of the remains. Her paper was titled “An Attempt at Digitally Associating Skeletal Elements: A Study of Photogrammetry and Articular Surface Area.”

Summary of Relevant AAPA Abstracts

In their paper “Undisciplining Desire: Bisexual and Queer Approaches to Science,” Samantha Archer, et al., from the University of Texas at Austin examine how breaking the pre-conceived notions of the gender binary in the bioarchaeological record can expand existing experimental parameters. These binaries, whether nature/culture, male/female, or heterosexual/homosexual, are addressed by Archer, et al., as being privileged by the knowledge frameworks of the discipline.

Anne Austin of Stanford University presented a poster titled “OsteoSurvey: An Open-source Data Collection Tool for Studying Commingled Human Remains.” In this poster, Austin outlines bioarchaeological uses for the OsteoSurvey database, including standardized recording techniques, the ability to record methods, and the ability to customize your own data set based on the data’s parameters. While Austin’s presentation focused on commingled remains, this app would also be handy for larger collections to investigate.

Jess Beck of the University of Pittsburgh pioneers a new technique in tooth analysis, in a paper titled “A New Method for Estimating Age from Deciduous Teeth in Archaeological Contexts.” Beck uses a subadult regression model to determine age and sex from loose teeth in the Necropolis 4 collection at Marroquíes Bajos.

In “Oracle platform database: The Wellcome Osteological Research Database (WORD),” Jelena Bekvalac details how the Museum of London’s Centre for Human Bioarchaeology makes use of the WORD database to provide researchers with access to the over 20,000 individual bones held in the Centre. Bekvalac, a curator at the Centre, is continuously updating and refining the WORD database, in an effort to ensure that researchers have accurate and quick digital access to all records.

Benoit Bertrand, et al., advocate for standardized automation of the technique of cementochronology, in their paper titled "Computerized cementochronology—taking the (16)bit between the teeth." Their argument centers on the multitude of methods creating some confusion in resulting age at death estimation. Their solution: semi-automation.

Carlina de la Cova of the University of South Carolina presented a poster titled "Engendering Identity to Anatomical Collections: Using History, Embodiment Theory, and Ethics to Humanize Skeletons." This presentation brought to light ethical ways to use existing bioarchaeological collections, while being mindful both of the human-ness of the remains in the collection and the way scientific racism in early anthropology created them.

Looking at how to engage small data sets, Virginia Estabrook and David Prosser of Armstrong State University and Texas State University, respectively, gave a paper titled "The Statistics of Tiny Samples: The Utility of ACTUS, an Alternative Method of Contingency Table Analysis Using Simulation in Human Skeletal Biology." They noted how few studies of bioarchaeological remains can use the chi-square test based on limited data, and worked to demonstrate that contingency tables can fill in the need for a good statistical model at that scale.

New Studies

A recent letter to the journal *Nature* by Steven Holen, et al., titled "A 130,000-year-old archaeological site in southern California, USA," details findings from a recent reanalysis of mastodon remains from California's Cerutti Mastadon site, first excavated in 1992 and 1993. The reanalysis was both chemical and physical in nature, using thorium/uranium dating to estimate the age of the remains, and taphonomic/trauma analysis to determine the nature of the bone fractures.

The Th/U dating placed the mastodon remains at approximately 130,000 years ago, +/- 34,000 years. Insufficient collagen made C14 dating impossible. Examining the shape of bone fragments, the team determined that there were spiral fractures present, as well as impact flakes/cone flakes. With the concurrent presence of apparent percussive cobble hammer and anvil stones, also exhibiting impact marks, the team interpreted their data as evidence of hominid presence, due to the appearance of tool use on the mastodon bones.

The most recent issue of *National Geographic* has an interview with Lee Berger, who mentions that Homo naledi dates to 250,000 years ago.

Published April 27th, an article in the journal *Science* by Viviane Slon, et al., called "Neandertal and Denisovan DNA from Pleistocene sediments," outlines the process by which DNA was isolated and shown to belong to the two early Homo lineages. They hypothesized that usable mitochondrial DNA (mtDNA) would be found in the cave sediment, and could be more easily accessed than that existing in skeletal elements.

Collecting sediment samples from dozens of Pleistocene sites, the team worked to isolate the mtDNA of the two Homo lineages by first searching for mammalian mtDNA, and then narrowing that resulting group to the mtDNA of hominids. To accomplish that, they looked at identifying changes in known Neanderthal DNA which were potentially wrought during the process of speciation. Comparing the samples of recovered mtDNA to these known variants revealed similarities to both Neanderthals and Denisovans in the experimental sample.

After that determination, the team attempted to identify whether or not more than one individual was present in the two samples with the highest concentrations of mtDNA. They found two incidents of more than one individual, and three incidents of only one individual. Furthermore, concentrations of mtDNA in sedimentary samples were within the normal range for prevalence in bone based samples.

The Williamsburg Yorktown Daily reports April 30th that archaeologists have found the tomb of a "knight," which is presumed to be either Sir George Yeardley or Thomas West, the Lord de la Warre, according to Hayden Bassett, the Assistant Curator. Excavation and preservation of the tomb and any extant skeletal remains are ongoing.

Field Schools, Conferences, and Other Opportunities

The Nineteenth Century Studies Association will hold its 39th annual conference on March 15-17, 2018 in Philadelphia, PA. The call for papers is now open with a deadline of September 30, 2017, and can be found at: http://www.ncsaweb.net/Current-Conference.

The 10th annual ISABS conference on forensics and anthropological genetics will be held June 19-24, 2017, in Dubrovnik. Online registration for attendance can be found at: http://isabs.hr/10th-isabs-conference/.

The Koobi-Fora field school, a six week excursion held at Lake Turkana in Kenya between June 10th and July 23rd with a further commitment for online participation during the month of May, is taking applications for participants. Fellowships are available, but limited. Information can be found at: https://cashp.columbian.gwu.edu/koobi-fora-field-school.

The deadline for the next available application for the NSF DDRIG (Doctoral Dissertation Research Improvement Grants) and for the Senior grants is July 20th, and information can be found here: https://nsf.gov/funding/pgm_summ.jsp?pims_id=5407.

ARCHAEOLOGICAL CERAMICS

Charles C. Kolb, Associate Editor

This issue contains Book Reviews on Ceramics.

Encyclopedia of Geoarchaeology. Alan S. Gilbert (ed.); Paul Goldberg, T. Vance Holiday, Rolf D. Mandel, and Robert S. Sternberg (associate eds.). Encyclopedia of Earth Sciences Series. Dordrecht, The Netherlands: Springer Reference, 2017. xxix + 1046 pp., 158 b/w illustrations, 310 illustrations in color. Print, electronic, and print + electronic versions: ISBN-13: 978-9400748279; ISBN-10: 9400748272; ISBN Electronic publication under ISBN 978-1-4020-4409-0 and Print and electronic bundle under ISBN 978-94-007-4828-6. The print volume, $549.00 US, weighs seven pounds. While there are a number of texts on the subject of geoarchaeology, many written by Paul Goldberg, the OCLC WorldCat (a universal library catalog) lists no published encyclopedias or reference works on the subject. Sorcha Diskin's *Geoarchaeology: A Toolbox of Approaches Applied in a Multidisciplinary Research* (Amsterdam: Elsevier, 2013) isn't quite in that category. Gilbert's volume is pathbreaking in this regard for a subdiscipline of archaeology and geology.
This long-awaited volume has a 35-year publication history, an outline of which is provided below. As a contributor ("Ceramics") I shall provide other insights. Following an overview of the publication history and recruitment of editors, I comment on contributors, provide a short list of the entries, list the goals of the work, outline the structure of the volume, tabulate some contents, and focus on contributions related to soil science and ceramics. Comparisons are made with the contents of a recently published major work, *Encyclopedia of Global Archaeology* (2014).

Readers of the *SAS Bulletin* will be familiar with the names of the editor and his associates, and with the names of many of the contributors. Editor Allan S. Gilbert is Professor of Anthropology at Fordham University in the Bronx, New York. This volume is one of the publications of the Earth Science Encyclopedia Series (EEES) whose found editor was Rhodes Fairbridge. He enlisted Gilbert as editor of the *Encyclopedia* in 1981 but the contract was cancelled in the mid-1980s due to a change in publishers and a realignment of priorities at the new publishing house. Springer offered to contract the project in 2002 and enlisted the assistance of four established geoarchaeologists as Associate Editors. These Associate Editors are Paul Goldberg, Professor Emeritus in the Department of Archaeology, Boston University; Vance T. Holliday, Professor of Anthropology and Geosciences at the University of Arizona; Rolfe D. Mandel is Distinguished Professor of Anthropology at the University of Kansas, and Senior Scientist and Executive Director of the Odyssey Geoarchaeology Research Program at the Kansas Geological Survey in Lawrence, Kansas; and Robert S. Sternberg, Professor of Geosciences at Franklin & Marshall College, a small liberal arts college in Lancaster, Pennsylvania. The latter editor has been associated for many years with the Society for Archaeological Sciences, currently as the General Secretary. This volume is, therefore, dedicated to the memory of the late Rhodes W. Fairbridge (1914-2006).

The 165 contributions vary in length depending on their significance to the encyclopedia's content and goals. All rights are reserved for seven major articles: "Arctic Geoarchaeology: Site Formation Processes" (Kelly E. Graf); "(Ceramics" (Charles C. Kolb); "Dendrochronology" (Jonathan G. A. Lageard); "Living Surfaces" Erin C. Dempsey and Rolfe D. Mandel); "Paleopathology" (Charlotte A. Roberts); "Paleodemography: Methods and Recent Advances" (Maru Mormina); and "Zhoukoudian" (Chen Shen). "'A' type authors (67 in number) who contracted for 5,000-9,000 word articles received one printed free copy of the Work." Manuscripts were due in late 2012 and revisions were accepted through mid-2015. The final publication date has been revised a number of times and the official date of publication of the electronic online version was 21 September 2016 with the print version during the following week. The compendium has an "Editorial Board" (pp. xiii-xiv) of 12 members and there is a tabulation of "Contributors" (pp. xv-xxvi) listing 141 authors and coauthors. A "Preface" (pp. xxvii-xxviii) and "Acknowledgments" (p. xxix) precede the "Contents" (pp. 1-1034). The Back Matter includes an "Author Index" (pp. 1035-1036) and a splendid "Subject Index" (pp. 1037-1046) – the latter a triple column conflation of topics and geosite proper nouns (no human names).

Among the 141 authors and coauthors (the numbers in parentheses refer to the numbers of authorships among the 165 contributions) -- Ron Bishop, Jim Burton, Mike Glascock, Francesco Fedele (3), Paul Goldberg (6), Michael Gregg, Vance Holliday (14), Charlie Kolb, Rolfe Mandel (11), Hector Neff, Rip Rapp (3), Steve Shackley (2), and Alan Simmons (2) -- are likely familiar to readers of this column. The authors collectively come from 17 nations, while the majority of are from English-speaking countries (United States, United Kingdom, Australia, Canada, and South Africa) others are well-represented (Argentina, Czech Republic, France, Germany, Greece, Israel, Italy, Northern Ireland, Norway, Spain, and Switzerland).

An alphabetical list of the 165 entries (sans authors' names and pagination) follows: 'Ain Ghazal.- Akrotiri Aetokremno, Cyprus.- Alluvial Settings.- Amino Acid Racemization.- Analysis of Carbon, Nitrogen, pH, Phosphorus, and Carbonates as Tools in Geoarchaeological Research.- Anthrosols.- 40Ar/39Ar and K-Ar Geochronology.- Archaeological Stratigraphy.- Archaeomagnetic Dating.- Archaeomineralogy.- Archaeoseismology.- Arctic Geoarchaeology: Site Formation Processes.- Artifact Conservation.- Atapuerca.- Beringia, Geoarchaeology .- Big Eddy Site, Missouri.- Blombos Cave.- Boxgrove.- Built Environment.- Burned-Rock Features.- Cactus Hill, Virginia.- Caves and Aqueducts in the Ancient World.- Casper Site, Wyoming.- Catalhoyuk.- Cave Settings.- Ceramics.- Ceren.- Chemical Alteration.- Chronostratigraphy.- Climatostratigraphy (Climostratigraphy).- Coastal Settings.- Colluvial Settings.- Cosmogenic Isotopic Dating.- Data Visualization.- Dendrochronology.- Dmanisi.- Dolni Vestonice, Pavlov, Milovice.- Dumps and Landfill.- Dust Cave, Alabama.- Eastern Sahara: Combined Prehistoric Expedition.- El Miron Cave.- Electrical Resistivity and Electromagnetism.- Electron Probe Microanalyzer.- Electron Spin Resonance (ESR) in Archaeological Context.- Eolian Settings: Loess.- Eolian Settings: Sand.- Ethnogeoarchaeology.- Experimental Geoarchaeology.- Field Geochemistry.- Field Survey.- Fission Track Dating.- Fluorine Dating.- Forensic Geoarchaeology.- Fourier Transform Infrared Spectroscopy (FTIR).- Gas Chromatography.- Geoarchaeology, History.- Geochemical Sourcing.- Geographical Information Systems (GIS).- Geomorphology.- Geophysics.- Gesher Benot Ya'aqov.- Glacial Settings.- Glass.- Grain Size Analysis.- Great Plains Geoarchaeology.- Grimaldi Caves.- Ground-Penetrating Radar.- Harappa.- Harbors and Ports, Ancient.- Harris Matrices and the Stratigraphic Record.- Haua Fteah.- Hearths and Combustion Features.- Hohle Fels.- House Pits and Grubenhauser.- Inductively Coupled Plasma-Mass Spectrometry (ICP-MS).- Inundated Freshwater Settings .- Isernia.- Isochron Dating.- Java (Indonesia).- Kebara Cave.- Kennewick Man.- Kostenki, Russia.- Koster Site, Illinois.- La Micoque.- Lake Mungo and Willandra.- Landscape Archaeology.- Lead Isotopes.- Liang Bua.- Lithics.- Living Surfaces.- Loessic Paleolithic, Tajikistan.- Luminescence Dating of Pottery and Bricks.- Magnetometry for Archaeology.- Mass Movement.- Metals.- Microstratigraphy.- Minnesota Messenia Expedition (MME).- Monte Circeo Caves.- Monte Verde.- Mount Carmel.- Neutron Activation Analysis.- Niah Cave.- Olduvai.- Optically Stimulated Luminescence (OSL) Dating.- Organic Residues.- Otzi, the Tyrolean Iceman.- Oxygen Iotopes.- Paleopathology.- Paleodemography: Methods and Recent Advances.- Paleodiet.- Paleoenvironmental Reconstruction .- Paleomagnetism.- Paleoshores (Lakes and Sea).- Paludal Settings (Wetland Archaeology).- Pastoral Sites.- Petroglyphs.- Petrography.- Pigments.- Pinnacle Point.- Pompeii and Herculaneum.- Poverty Point Site, Louisiana.- Pre-Clovis Geoarchaeology.- Privies and Latrines.- Radiocarbon Dating.- Raman.- Remote Sensing in Archaeology.- Rockshelter Settings.- Santorini.- Scanning Electron Microscopy (SEM).- Sedimentology.- Shell Middens.- Shipwreck Geoarchaeology.- Site Formation Processes.- Site Preservation.- Soil Geomorphology.- Soil Micromorphology.- Soil Stratigraphy.- Soil Survey.- Soils.- Soils, Agricultural.- Southwestern US Geoarchaeology.- Speleothems.- Spring Settings.- Stable Carbon Isotopes in Soils.- Sterkfontein/Swartkrans/Kromdraai.- Stonehenge.- Stratigraphy.- Strontium Isotopes.- Submerged Continental Shelf Prehistory.- Susceptibility.- Swanscombe.- Tells.- Tephrochronology.- Tombs.- Trampling.- Troy.- Tsunamis.- 'Ubeidiya.- U-Series Dating.- Volcanoes and People.- Wells and Reservoirs.- X-ray Fluorescence (XRF) Spectrometry in Geoarchaeology.- X-ray Diffraction (XRD).- York.- Zhoukoudian.

In the Front Matter, the editors comment that “Geoarchaeology is an archaeological subfield focusing on archaeological information retrieval and problem solving utilizing the methods of geological investigation. Archaeological recovery and analysis are already geoarchaeological in the most fundamental sense because buried remains are contained within and removed from an essentially geological context. The fundamental goals of geoarchaeology lie in understanding the relationships between humans and their environment. These goals include: 1) how cultures adjust to their ecosystem through time, 2) what earth science factors were related to the evolutionary emergence of humankind, and 3) which

methodological tools involving analysis of sediments and landforms, documentation and explanation of change in buried materials, and measurement of time will allow access to new aspects of the past. This new encyclopedia defines terms, introduces problems, describes techniques, and discusses theory and strategy, all in a format designed to make specialized details accessible to the public as well as practitioners. It covers subjects in environmental archaeology, dating, materials analysis, and paleoecology, all of which represent different sources of specialist knowledge that must be shared in order to reconstruct, analyze, and explain the record of the human past. *It will not specifically cover sites, civilizations, and ancient cultures, etc., that are better described in other encyclopedias of world archaeology*" (italics mine).
Nonetheless, among the 165 contributions are 38 archaeological sites (spanning 'Ain Ghazal; Cactus Hill, Virginia; and Harappa; through Zhoukoudian) and three expansive geological regions (Great Plains Geoarchaeology; Southwestern US Geoarchaeology; and Loessic Paleolithic, Tajikistan), plus five major hominid sites/areas (Dmanisi, Ötzi, Java, Kennewick, and Niah) and two major expeditions (Eastern Sahara: Combined Prehistoric Expedition and the Minnesota Messenia Expedition). While most authors make compelling cases for the inclusion of these individual sites and regions, what were the criteria for inclusion and/or exclusion of other sites and regions?

More than twenty chronometric and provenance methods are documented: Amino Acid Racemization, ^{40}Ar/^{39}AR, KAR, Archaeomagnetic Dating, Chronostratigraphy, Cosmogenic Isotopic Dating, Dendrochronology, Electron Spin Resonance (ESR) in Archaeological Context, Fission Track Dating, Fluorine Dating, Fourier Transform Infrared Spectroscopy (FTIR), Gas Chromotography, ICP-MS (Inductively Coupled Plasma-Mass Spectrometry), Isochron Dating, Neutron Activation Analysis, Scanning Electron Microscopy (SEM), Tephrochronology, X-ray Diffraction (XRD), X-ray Fluorescence (XRF), and Spectrometry in Geoarchaeology. Thermoluminescence is incorporated into two contributions: "Luminescence Dating of Pottery and Bricks" by Ian K. Bailiff (pp. 494-498) and "Optically Stimulated Luminescence (OSL) Dating" by Zenobia Jacobs (pp. 550-555). Proton-Induced X-Ray Emission Spectroscopy (PIXE) isn't included.

There are eight soils-related articles: Vance T. Holliday and Rolfe D. Mandel "Soil Geomorphology" (pp. 821-830); Panagiotis Karkanas and Paul Goldberg "Soil Micromorphology" (pp. 830-841); Vance T. Holliday, Rolfe D. Mandel, and Timothy Beach "Soil Stratigraphy" (pp. 841-855); Vance T. Holliday and Rolfe D. Mandel "Soil Survey" (pp. 856-862); Vance T. Holliday, Rolfe D. Mandel, and E. Arthur Bettis III "Soils" (pp. 862-877) ; and Jonathan A. Sandor and Jeffrey A. Homburg "Soils, Agricultural" (pp. 877-883); Lee C. Nordt and Vance T. Holliday "Stable Carbon Isotopes in Soils (pp. 901-907). In addition, there are six contributions related to pottery or ceramics: Charles C. Kolb "Ceramics" (pp. 118-128), Gloria I. Lopez "Grain Size Analysis" (pp. 341-348), Ian K. Bailiff "Luminescence Dating of Pottery and Bricks" (pp. 494-498), Ian Whitbread "Petrography" (pp. 660-664), Ian Watts "Pigments" (pp. 664-671), and Katherine A. Adelsberger" Sedimentology" (pp. 764-772).

Although a "Goliath vs. David" contrast in number of volumes and contributions, there is merit in comparing the *Encyclopedia of Global Archaeology*, **11 print volumes (1,626 entries)** (Claire Smith (ed.-in-chief), New York: Springer, 2014. **cxlvi + 8015 pp.**, 791 b/w illustrations, 2619 color illustrations with the *Encyclopedia of Geoarchaeology*, **165 entries** (Alan S. Gilbert (ed.), Dordrecht, The Netherlands: Springer Reference, **2017, xxix + 1046 pp.**, 158 b/w illustrations, 310 illustrations in color). There are 35 subjects represented in both encyclopedias; most of which are archaeological sites or analytical methods. Some of these contributions were prepared by the same authors (noted in brackets): Blombos Cave, Ceramics, Dmanisi, El Mirón Cave, Electron Spin Resonance (ESR) in Archaeological Context, Fourier Transform Infrared Spectroscopy (FTIR) Gas Chromatography-Mass Spectrometry (GC-MS) Geochemical Sourcing, Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) Isochron Dating/Isotope Geochemistry, Java (Indonesia) [both by O. F. Huffman], Kennewick Man, Kostenki, Russia [both by J. F. Hoffecker], Lake Mungo / Willandra, Lithics, Metals, Monte Verde [both by Tom Dillehay], Neutron Activation Analysis, Niah Cave, Olduvai, Organic Residues, Pigments, Pinnacle Point, Pompeii, Poverty Point Site, Radiocarbon Dating [both by Erv Taylor], Scanning Electron Microscopy (SEM [both by Ellery Frahm], Site Formation Processes, Site Preservation, Tells [both by Wendy Matthews], Tombs, Volcanoes and People, X-ray Diffraction (XRD); X-ray Fluorescence (XRF) [both by Steve Shackley],and Zhoukoudian [both by Chen Shen].

"Ceramics" is a special case as there are 15 ceramics-related contribution in Smiths' 11-volume magnum opus (2014) and only one in Gilbert's single-volume compendium ("Ceramics" by Charles C. Kolb, 2017:118-128) which your reviewer prepared to focus specifically on the geoarchaeological aspects of pottery. The contributions in Smith's edited work focus predominantly on pottery in numerous cultural contexts; two, "Provenance Studies in Archaeology [Ceramics, Lithics/Stone, Metals, Glass, Textiles]' by Charles C. Kolb (2014:6172-6181) and "Ceramics: Scientific Analysis" by Bruno Fabbri and Sabrina Gualtieri (2014:1340-1342), considers physicochemical and related procedures in determining provenance and chronology. The other entries in Smith's edited work are: "Ceramics as Dating Tool in Historical Archaeology" by Charles E. Orser Jr. (2014:1291-1292); "Ceramics, Ancient Greek" by Antonis Kotsonas (2014:1292-1303); "Ceramics, Roman Imperial" by Abigail Crawford (2014:1303-1310); "Ceramics, Southeast Asian and Chinese Trade" by Tse Siang Lim (2014:1310-1314); "Ceramics: Colonoware" by Laura J. Galke (2014:1314-1315); "Ceramics: Conservation and Preservation" by Nancy Odegaard (2014:1315-1318); "Ceramics: European Cream to Whitewares in the USA" by Teresita Majewski (2014:1318-1321); "Ceramics: Majolica in Colonial Latin America" by Tony Pasinski and Patricia Fournier (2014:1321-1325); "Ceramics: Roman Republican and Early Principate" by Laura Banducci (2014:1325-1340); "Ceramics: Stonewares" by David Gaimster (2014:1342-1344); "Ceramics: The Ibero-American Shipping Container" by Tony Pasinski and Patricia Fournier (2014:1344-1352); "Chinese Porcelain: Late Ming (1366–1644) and Qing (1644–1911) Dynasties" by Teresa Canepa (2014:1447-1448); Ethnoarchaeology: Learning from Potters in Gilund" by Amrita Sarkar (2014:2545-2549).

Kolb's article on "Ceramics" in the *Encyclopedia of Geoarchaeology* reviews 1) the importance of ceramic products; 2) sources of information ("Table 1: Ceramic Studies in Major Journals," is a compilation from 29 professional journals or monograph series*); 3) clay , ceramics, pottery and other distinctions, and the nature of clay, 4) ceramic research; description and characterization (8 physicochemical methods), methods of determining provenance (9 methods), and methods of ascertaining chronology; 5) emerging analytical techniques (luminescence dating and rehydroxylation); 6) experimental archaeology; and 7) ceramic databases. *This tabulation, dated June 2015, now involves 141 journals and series and title changes through September 2016.

Gilbert and his colleagues are to be commended for preserving in getting this unique and pioneering volume into print and online publication. As can be seen with the comparison to the entries in Smith's (2014) 11-volume compendium, there is much to commend in terms of content in the *Encyclopedia of Geoarchaeology* and being relatively up-to-date on new source materials.

Nishapur Revisited: Stratigraphy and Ceramics of the Qohandez, Rocco Rante and Annabelle Collinet, with contributions by Rajabali Labbaf Khanoiki, A. Bouquillon, Y. Coquinot, C. Doublet, Y. Gallet, A. Genevey, E. and A. Zink; Oxford and Oakville: Oxbow Books, 2013. xv + 210 pp., 107 figures, 33 tables, bibliography (there is no index). ISBN: 9781842174944, £40.00 (hardcover). The archaeological site of Nishapur in eastern Iran was an important Silk Road city, its position providing links to Central Asia and China, Afghanistan and India, the Persian Gulf and the west. Portions of the site had been excavated on two prior occasions, initially from 1935 to 1940 when a team, The American Archaeological Mission in Nishapur, from the Metropolitan Museum of Art led by Charles Wilkinson initiated explorations and again in 1947 interrupted by World War II. Despite these prior excavations there were a number of unresolved questions concerning the site: When was the city founded? Was Nishapur a Sasanian city? And, if so, was it founded by the Sasanian king Shapur I or II? The original excavators had dated the structures and objects between the late 8th and 12th centuries but did not provide appropriate stratigraphic data which impeded research interpretations and the ability to develop a more precise chronological framework. Subsequently (1995 to 2002), an Iranian team conducted excavations in the area of Shadyakh uncovering a large residence; however, no report was ever published. Hence, the chronology of occupation and the ceramic sequence are problematic particularly for Late Antiquity and the medieval period. In addition, a comprehensive topographic site plan is lacking.

In 2004 the Iranian Centre of Archaeological Research (ICAR), directed by Masud Azarnoush, invited a French archaeological team led by Monique Kervsan to assist them in re-opening excavations in Nishapur. The goal of this new project was to revisit the history and material culture of this important city at the nexus of trading routes connecting Baghdad with the cities of Merv, a major oasis-city in Central Asia, on the historical Silk Road, located near today's Mary in Turkmenistan, Balkh and Herat in northeastern Afghanistan, and further east to China and southeast to the Asian Subcontinent. The Irano-French archaeological mission at Nishapur (2004 to 2007) (CNRS-MAEE-Musée du Louvre) focused on the Qohandez, or citadel, the oldest part of Nishapur. Excavations were conducted in different areas of the mound, in order to address these questions. After an introduction to the site and the former American and Iranian excavations, the authors detail the stratigraphy and the pottery of the site. The ceramologists included Annabelle Collinet, Z. Delarami, C. Juvin, J. Kamalizad, S. Khozaymeh, D. Miroudot, A. Mousazadeh, A. Péli, and H. Sharifan. The difficulties involved in establishing a precise history of the site, as well as the complexities of studying the pottery led to a program of analysis undertaken by the Research Centre of French Museums (C2RMF). Chemical and petrographic analysis, thermoluminescence (TL) dating and archaeomagnetism analysis as support to the TL results were undertaken. The chemical and petrographic analyses were undertaken by Anne Bouquillon, Yvan Coquinot, and Christel Doublet. A pottery database was created regrouping the stratigraphical and laboratory analyses data in order to manage and present an organised corpus of 1,000 samples. The combination of the data from the stratigraphical and laboratory analyses gives an accurate and completely new chronology of the site. Moreover, the study also brought to light a new typological sequence of the ceramic, as well as new data about ceramic production at Nishapur. The authors use the term “shards” rather than sherds for pottery fragments.

An “Introduction” (pp. xiii-xv) provides salient background and states three goals: 1) resolve the long accepted relationship between the toponym of Nishapur and its history; 2) develop a more precise chronology of the occupation and the ceramic sequence; and 3) discern the real extent of the archaeological area. Chapter I “Historical and Geographical Background” (pp. 1-12, 7 figures, 1 table). The geographical and historical settings are detailed and a synthesis of the previous American and Iranian excavations is provided. The authors note Wilkinson’s “incomplete” ceramic studies and point out that the 1935-1940 excavation reports characterize briefly the ceramic kilns and the interpretation that most ceramic wares were local products (except for the T’ang and Islamic pottery). His research emphasized the glazed earthenwares, hence, the analysis of unglazed wares and glazed fritwares was perfunctory (C. K. Wilkinson, Nishapur: Pottery of the Early Islamic Period, New York: Metropolitan Museum of Art, 1973).

Chapter II “The Excavation and the Absolute Chronology” (pp. 13-55, 33 figures [24 in color], 10 tables). The site today occupies ca. 3.5 ha and is an “extremely damaged and jumbled mass” (p. 13). The Irano-French Excavation focused on the northeastern portion of the (citadel). The previously noted dating problems were to be resolved using multiple strategies including Thermoluminescence Analysis (TL). Sample preparation, measurement apparatus, luminescence tests, palaeodose, annual dose, and numerical simulation are detailed and studies resulted in discerning three groups from 18 specimens (eight tables provide raw data and interpretations): TL analysis; U-Th-K20 content; annual dose rate, a summary of standard uncertainty components; the seriation matrix; list of samples; locations of external dose rate measurement; and variables using in the Bayesian treatment. The following periods were discerned: Period I: ca. 450-150 BC; Period II: late 4th to late 8th century AD; Period IIIa: 2nd half of the 8th century to early 11th century AD; and Period IIIb: 11th century to 1165 AD (the Mongol invasion). Insights from Archaeomagnetic Analysis are reported as TL support for the dating. The sample collection and magnetic properties, intensity experiments, and archaeointensity results are documented (Table 10). The specimens included 19 fragments (17 pottery shards from the TL study and two from brick) and five other shards. Three chronological groups are discussed: 1) 485 BC – AD 4154; 2) 415-650; and 3) the Islamic period. The stratigraphical sequence was discerned through the results from four test-pits: Test-pit B (Periods I, II, and IIIa); Test-pit 10 (Periods II, IIIa, and IIIb); Test-pit 26 (Periods I, II, IIIa, and IIIb); and Test-pit 27 (Periods II, IIIa, and IIIb). An interpretation of the occupation chronology and urban development (pp. 53-55) concludes the chapter.

Chapter “III - Pottery Study and Analyses” (pp. 56-135, 36 figures, 22 tables). The authors document the recording methodology and the use of data record cards that included nine major variables. The ceramic analysis program is likewise detailed. A total of 7,312 shards (5,590 excavated at Qohandez and 1,722 from the surface survey of the citadel, at Shahrestan, and from the mosque area) were selected and four fabric groups were delineated. Petrographic (optical microscopy) analysis was undertaken on 47 glazed and unglazed shards and seven fritwares while PIXE was used on 52 glazed and unglazed shards, four kiln elements, and seven fritwares. XRD and SEM were used on the fritware glazes. The authors note (p. 128) that there are very few previously published scientific analyses of Iranian ceramics – the vast majority (nine) undertaken in the 1990s and 2000s by R. B. Mason (published in Archaeometry, Iran, and JAS). Color microphotographs of the petrographic thin sections (Figures 51, 55-60, 62-63) and microphotographs of the SEM analysis (Figures 73-76) illustrate studies on the clayey fabrics and fritwares (pp. 68-101). The analysis includes an assessment local manufacture versus importation. The ceramic groups and their production are related to local geological materials (volcanic, metamorphic, and detritic). The clayey fabrics are petrographically homogeneous (Fabrics Aa, Ab, and B) found at Qohandez and Shahrestan during Periods I and IIIb, but less so during IIIa; 12 earthenware fabrics relate to Periods II, IIIa, and IIIb; glazed earthenware to Period IIIa; and two fritware groups to the 12th century AD. The data demonstrates conclusively that the clay was local to Nishapur, confirming that the shard samples were from vessels manufactured in the city.

Chapter IV "Chronology of the Qohandez pottery" (pp. 136-203, 28 figures). The chapter focuses on a discussion of test-pit data and the chronological sequence of the Qohandez pottery and relationships between fabrics, vessel shapes, and decoration. Period I (ca. 450-150 BC): Architectural contexts are lacking so that archaeomagnetic dating data, fabric types, and pottery forms (the vast majority storage vessels) are reviewed. Period II (end of the 4th century AD to 785): Architecture first appears and the vessel forms include large storage and transport jars, jugs, cooking pots, and a preponderance of closed forms. Glazed wares initially appear. Period IIIa (2nd half of 8th century to early 11th century): TL data is employed and related to vessel forms including jars, jugs, and cooking pots; stamped decoration initially appears. The assemblage includes glazed wares (mostly monochrome bowls); opaque white wares; splash and sgraffiato wares; slip painted wares; buff wares; and other polychromes Period IIIb (11th century to 1165 AD): Vessel forms proliferate and consist of jars, jugs, cooking pots, basins, bowls, lids, and dishes. The assemblage includes clayey glazed wares (mostly polychromes); monochrome wares; splash and sgraffiato wares; slip painted wares; buff wares; other polychromes; and fritwares (monochrome turquoise). There is also a useful comparative study with the main Khorasanian sites: Period II: Tureng Tepe, Gurgan Plain, Merv, Balkh (Sasanian levels), and Afrasiab. Period IIIa: Tureng Tepe, Gurgan Plain, Merv, Balkh (Period IV), Herat, and Tashkent Oasis. Period IIIb: Tureng Tepe (11th-14th centuries), Gurgan Plain, Merv, Balkh (pre-Mongol era), Herat, Afrasiab, Tashkent Oasis, Kultepa, Isfahan, and Rayy. In a "Conclusion" the authors summarize the chronological refinements, the periods and fabrics and associated vessel forms, and details the changes that occur in the status of Nishapur and its role in Khorasan. The "Bibliography" (pp. 207-212) provides a list of abbreviations employed and lists six Sources (one Latin and five Persian) and 157 Studies.

This splendid monograph helps to fill a significant gap in the analysis of Iranian ceramics and especially pottery manufacture at Nishapur in the pre-Mongol era. The narrative is clearly and logically presented and includes a great deal of significant data. The color illustrations of the shard specimens are superb and the microphotographs are clear and detailed. Alas, the color designation of the shards and thin sections do not employ the Munsell color notation system so the reader is left to infer colors such as beige orange, beige/buff, red pinkish, etc. from shard photos and photomicrographs. I wish that more had been said about the optical petrographic analysis, particularly about the equipment and procedures employed. Nonetheless, the volume is a valuable contribution to our understanding of pottery production in Iran.

Ancient Cookware from the Levant: An Ethnoarchaeological Perspective, Gloria A. London, Worlds of the Ancient Near East and Mediterranean, Sheffield and Bristol, UK: Equinox Publishing, 2016. xiv + 312 pp., 67 color and black-and-white figures, and 2 maps. ISBN-10: 1781791996, ISBN-13: 978-1781791998, £115.00 / $150.00 US (hardback); less expensive through some vendors. Gloria London is an Independent Scholar. If you are not aware of her devotion to ceramic ethnoarchaeological research and her publications, you are missing something special. I first became aware of London's work in the late 1970s through conversations with my mentor at Penn State, Fred Matson, and have followed her successes since then. [In this important volume, London refers to Matson as "the eminent ceramic technologist" (p. 190).] She holds a B.A. Prehistory and a B.A. in Geography, both from Tel Aviv University (1973), as well as an M.A. in Ancient Cultures of the Near East (1976) from the same institution. Her doctorate is from the University of Arizona (1985) where her thesis was *Decoding Designs: The Late Third Millennium B.C. Pottery from Jebel Qa'aqir*. She researched and published *Traditional Pottery in Cyprus* (Mainz: Philipp von Zabern, 1989) and a 26-minute ceramic ethnoarchaeological DVD, *Women Potters of Cyprus* (2000) which she taped in 1987, wrote, narrated, and edited. The content focuses on the traditional potters of Kornos and Ayios Demetrious (Marathasa) who coil build utilitarian pottery in Cyprus. In 2014 she and Patir Dometios co-created the Museum of Traditional Pottery in Agios Demetrios (Marathassa) in Cyprus. Other information and a list of her publications, some with links to full texts, may be found at http://home.earthlink.net/~galondon/. She is certainly an appropriate scholar to prepare this splendid assessment.

London comments that ancient earthenware cooking pots in the southern Levant are unappealing, "rough pots" not easily connected to meals known from ancient writings or iconographic representations. To narrow the gap between excavated sherds and ancient meals, the approach she adopted in this study begins by learning how food traditionally was processed, preserved, cooked, stored, and transported in clay containers. This research is based on the cookware and culinary practices in traditional societies in Cyprus and the Levant, where people still make pots by hand. Clay pots were not only to cook or hold foods, their absorbent and permeable walls "stored memories of food residue." She comments that clay jars were automatic yogurt makers and fermentation vats for wine and beer, while jugs were the traditional water coolers and purifiers. Dairy foods, grains, and water lasted longer and/or tasted better when stored or prepared in clay pots. Additionally, she points out that Biblical texts provide numerous terms for cookware without details of how they looked, how they were used, or why there are so many different words. Recent studies of potters for over a century in the southern Levant provide a wealth of names whose diversity helps to delineate the various categories of ancient cookware and names in the text.

London's assessment is divided into three parts with a total of 22 chapters. The initial part (11 chapters) focuses on traditional pottery in the Levant and Cyprus commencing with the description of five data sources: excavations, ancient and medieval texts, 20th century government reports, early accounts of potters, and ethnoarchaeological studies. The second part (2 chapters) concentrates on ancient manufacturing techniques for cooking ware. The final part (9 chapters) documents diachronic changes in cookware beginning with the Neolithic through the present, emphasizing vessel shape, style, and manufacture of cookware for the past 12,000 years. Preliminaries include a "List of Tables" (p. viii), "List of Figures" (pp. ix-xi), and "Preface" (pp. xiii-xiv) which includes biographical information and acknowledgments. The "Introduction" (pp. 1-12) focuses on comments on culinary ceramics, cookware in antiquity and traditional societies, and ceramic ethnoarchaeology. The volume also contains a "Glossary" (pp. 277-281) with 132 items, a "Bibliography" (pp. 283-302) with 498 entries, and a double column "Index" (pp. 303-312) incorporating topics and proper nouns as well as illustrations, tables, and notes.

Part I: Traditional Ceramics in the Levant and Cyprus (11 chapters). Chapter 1. "The Levantine Corridor and Cyprus -- Geographical Parameters" (pp. 7-12, 2 figures. London reviews the vegetation, climate, and rainfall patterns of the Levant and Cyprus; the ancient climate of the Levant is also documented. The eastern Mediterranean Levant and Cyprus comprise highly varied landscapes, vegetation, climate, precipitation, and unique geographic features in small areas. Limited seasonal precipitation, a minimum of permanent water resources, and frequent drought years have contributed to a fragile ecosystem. Diversity of topography and vegetation, from the lowlands to mountains and deserts, made this challenging region hospitable for human occupation. Chapter 2. "Ancient Data Sources: Excavations and Ancient Texts" (pp. 13-20). Archaeological excavations, ceramics (sherds and pots) and ancient texts from neighboring cultures (cuneiform and Egyptian hieroglyphics, and Greek, Latin, and Arabic texts) offer only a glimpse of what people ate or aspired to eat without details on how to cook food or how it should taste. Official government reports, early accounts of potters, and ceramic ethnoarchaeological research conducted by London (1987-2002), are noted, and she mentions the residue analysis of ancient pottery. She points out that the "wealth" of Hebrew words in the Bible for pots tells us little about how pots were made, used, or what was cooked in them. Since names of foods could change dramatically in a few hundred years, she asks "how can we define recipes or cooking practices thousands of years old, given the wide range of choices?"

Chapter 3. "Modern Data Sources: Government Reports, Early Visitors and Ethnoarchaeology" (pp. 21-48, 8 figures). Craft specialists worked full time seasonally during the dry months in a small number of villages: Kornos, Ayios Dimitrios, Kaminaria, and Fini. They sold their vessels regionally to inhabitants of the foothills and western coastal strip. The traditional, multi-dimensional industry included private potters working in their courtyards, members of a cooperative who worked in a space reserved for the industry, and itinerant potters. The latter were both *pitharades* and Kornos potters traveling with families. Despite proximity to the coastal towns and the capital city, Kornos potters continued to manufacture traditional pots and no tourist pieces by the end of 20th century. In the Troodos Mountain communities, tourist items geared towards visitors who came for the refreshing cool summer air or to enjoy the winter snow formed a larger part of the late 20th century products than in Kornos. Official government reports, village histories, and early accounts of potters starting in 1549 provide salient information: Ayios Dimitrios (1820s-2000), Kaminaria (1549-2008), and Fini (1898-date). Long term ethnoarchaeological studies by Hampe and Winter (1962) are also noted. The organization of the 20th century ceramics industry is reported, and two traditions (mountain and lowlands) are documented. The archaeological implications from modern data sources include insights on regional traditions, seasonal production, assemblage diversity, transmission of the pottery craft, clay sources, and sherd reuse (filler in building bricks, road construction, etc.).

Chapter 4. "Ceramic Ethnoarchaeology" (pp. 49-67, 7 figures). J. W. Fewkes, an archaeologist working in the American Southwest, introduced the term "ethnoarchaeology" over a century ago. Recent studies focus on any aspect of material culture, including ceramics. The late William A. Longacre developed a long-term project in the northern Philippines to investigate Kalinga rural potters who largely make pottery for their families and friends but also trade or sell some wares (*Ceramic Ethnoarchaeology*, 1991, and, with James Skibo, *Kalinga Ethnoarchaeology: Expanding Archaeological Method and Theory*, 1994). London, building on Longacre's research among "household" potters, revisited the Philippines and compared Gubat and Kalinga potters, then focused her research on rural Cypriot potters. She outlines the 15 goals of her research and discusses sampling strategies in studying potters from the villages of Koros, Ayios Dimitrios, Kaminaria, and Fini. Pots made in 1930, 1986, and 2013 were studied. Pottery production is seasonal work limited to summer when dry clay, kilns, and fuel are available. Remote Troodos Mountain potters produced old-fashioned pots no longer needed in lowland towns or cities. Nuances in the fabrication and decoration reflect different workshops and lifestyle rather than chronological differences. Although the Troodos and Kornos potters produce some of the same types of pots, they have village-specific decorative patterns and names for deep and shallow cookware as well as other ceramic containers. Archaeological implications include production loci, vessel terminology, diachronic changes in repertoires, locational variation, specialization, and pot uses and reuses.

Chapter 5. "Clay Deposits, Traditional Mining and Clay Preparation in Cyprus" (pp. 69-80, 6 figures). Data on clay procurement from 1986 and 2000 were contrasted. The traditional technique of clay preparation in all villages was identical until electrical equipment came to Kornos. Older practices for mining and preparing clay prevailed longer in the remote Troodos area. Potters or their spouses beat clay with a bent wooden stick and mixed clay in the traditional *skafi*. Kornos potters worked with only one red-firing clay. In Ayios Dimitrios and Kaminaria, potters ideally combine two clays to benefit from the properties inherent in each, unless they shaped porous-walled jugs. Kaminaria potters used red clay alone if white was not available. Potters added nothing except water in preparing clays suitable for coarse ware ceramics of all shapes and sizes. Over the past 50 years, clay sources changed three times in Kornos, the major supplier of handmade pots to lowland consumers. Pottery is made in a small number of rural communities, but during the winter, evidence of its production is not evident as the villagers repurpose limited courtyard space to shelter livestock. Archaeological implications include changes in clay sources, organization of the industry, and correlating pottery production areas with ancient production loci.

Chapter 6. "Manufacturing Technique for Cypriot Red Clays" (pp. 81-92, 8 figures). Three stages of manufacture (fabrication, drying, and firing) are documented and vessel vs. lid production are characterized, other topics include the weekly output of a "private potter" in Ayios Dimitrios. Handmade coiled pottery requires an interrupted manufacturing technique with drying intervals to allow the clay to slightly harden before additional work is carried out. The turntable is used preliminarily to shape a flat bottom. Coils were added and pulled up or thinned with a split cane tool. Each stage of work varied in time, but during the height of the pottery-making season, when the air is dry and hot, it is possible to start and finish pots in one day. "Cypriot potters who coil build coarse wares from local clays provide an ideal model for the study of ancient potters who hand build ceramic containers." Kiln shapes (pp. 88-89) and sales and distribution are elaborated**.** Alas, the section of kiln shapes and dimensions is, unfortunately, extremely brief.

Chapter 7. "Traditional Firing Techniques for Ceramics" (pp. 93-101, 3 figures). She notes that firing pots is the most risky stage of pottery manufacture. Pit and bonfire techniques are documented through experimental research and ethnoarchaeological observation. Traditional craft specialists who fabricate handmade pots employ a variety of techniques: soft temporary or hard permanent and pit or above-ground. Smaller pieces can be stacked inside larger pots without resulting in fire clouds. Fuels are mentioned and deserve elaboration as to types and quantities of fuel. London reports that the rate of loss is low for the Cypriot and Filipino potters. Broken vessels and sherds are scarce at production locations for a number of reasons, including sherd reuse and the overall low rate of misfires or wasters. The numbers of firings and who fires the pottery (and with whom) are detailed. The final firing color varies depending on placement in the kiln, temperature, and the length of firing. The work of a single potter or more than one often fires together in the same kiln for many reasons. If necessary, pots can be refired in a kiln to enhance their color or hardness without damage. Another reason to refire pots is to burn out foods absorbed by their porous walls. Given that pits and temporary firing platforms leave hardly any trace and given the dismantling of permanent kilns once a potter stops working, few are available for archaeologists to excavate. Archaeological implications include rates of loss and sherd reuses.

Chapter 8. "How to Treat Clay Pots Prior to Use with Food" (pp. 103-110, 1 figure). This is a topic that few other researchers have investigated. Cross-cultural examples from Nepal, Syria, Guatemala, and Cyprus are included. Low-fired clay cooking pots have porous walls that absorb minute food particles. To minimize food residue, ethnoarchaeological studies provide details of temporary and more permanent methods to season, pre-treat, or coat interiors and/or exteriors to reduce porosity. Ancient solutions reduced "leaky" pots and vessel porosity. The reapplication of organic linings is necessary each time cooking pots were used. Jars with solid linings, such as resin, bitumen or tannin were retreated annually, due to the acids that caused deterioration of seemingly solid surface treatments. She notes that these treatments are the responsibility of the pot owner and not the potter. Other pots, especially water containers, were valued for their ability to sweat to keep the contents cool. Medieval-era recipes acknowledge the usefulness of old pots with walls saturated with oil that proved useful for storing cheese and other perishable foodstuffs. Archaeological implications include pottery sources and distribution and porosity reduction. The chapter could be expanded based on the work of Longacre and his students.

Chapter 9." Making Breads, Roasting Grains and Cooking Other Food" (pp. 111-117, 1 figure). Contemporary and ethnographic data from traditional cultures in the Levant and Anatolia, textual sources, and archaeological research provides content for this chapter; the focus is on the Early Islamic era. Bread baking in shallow pans or conical molds is reviewed and she discusses "cooking without pottery" -- grain roasting using hot stones or clay lumps. Baking and cooking in deep pots and in subsurface ovens is discussed. Bread baking was highly varied, as evidenced by the different shapes, grains, and baking techniques for leavened or unleavened varieties. Traditional ceramic bread moulds, plain or simple, have ancient counterparts. Several cooking and baking techniques do not require pots or permanent ovens but rely on organic materials that will not be preserved. Roasting grain at night, after cooking the daily meal, was a sensible use of a dying fire in traditional societies and perhaps in antiquity. Jars could hold either wine or oil, but not both. Traditional plates to bake and serve *pitta* resemble their ancient counterparts. There was a close connection between pot shape and the foods cooked or processed in them. Traditional Cypriot pottery includes specific containers suitable for meat and a completely different set of pots for dairy foods. Archaeological implications discusses include artifact names.

Chapter 10. "Foods Processed, Preserved, Distilled or Transported in Ceramics" (pp. 119-134, 5 figures). London's documentation primarily includes Medieval texts, data on traditional societies, and archaeological sources since the Neolithic. Nearly a dozen topics are discussed: dairy products (yogurt, soups, and cheeses); olives and olive oil [data also from 13th century cookbooks and experimental archaeology]; seed oils (castor, flax, sesame, and safflower); fowl and fish (including pickled birds); processing and storing water; and alcoholic beverages (wine, eau de víe, and beer) [other sources mentioned include iconographic sources and texts]. In addition, she characterizes sugar, syrup, and candy; rosewater; salt; meat; and animal byproducts (she cites "biproducts"). Efficient and inexpensive ceramic containers were necessary to process and preserve a wide variety of foods for long and short-term storage. The "memory of fermented foods, including dairy, wine, and beer that was retained in porous clay walls made ancient pots ideal for making yogurt, soup, and other milk products." The pot walls embedding the memory of yogurt made processing excess milk easy in the absence of refrigeration. Jugs and jars of all sizes functioned as refrigerators and filters for water. Oils, birds, and wine benefitted from processing and/or storage in clay pots. Repurposed jugs and jars can be found in any type of deposit once the pottery could no longer perform its original function. Memories of foods trapped in the clay pots were critical in the fermentation and preservation of alcoholic beverages in particular. The cooling ability of clay pots may also have made them potential containers to transport fresh fish from the coast to inland sites. Beer was a nutritious and relatively germ-free beverage consumed by the entire family. Archaeological implications include pots to process and store foods, ceramic use life, preparing hot soups without cooking, and low alcohol barley beer.

Chapter 11. "How to Clean Clay Pots" (pp.135-143, 1 figure). The topic is one that archaeologists and ethnologists normally ignore and is a difficult and infrequent chore noted in Hebrew, Latin, and Arabic texts. Natural materials to clean clay pots in traditional societies use some of the same antibacterial ingredients used to present times. Ethnoarchaeological research demonstrates that biblical and medieval texts can be understood to refer to safe practices for cooking and cleaning pots. People responsible for daily food preparation in antiquity and in traditional societies knew not to use dairy pots for meat, regardless of religion or ethnic origin. Texts from classical and medieval times encourage people to use clean pots. In this context, the kosher laws can be understood as advice for cooking for large groups of people at special occasions, when the usual precautions might have been overlooked, given the need to prepare food for so many. "Ancient and traditional societies not only are better able to reuse artifacts, they also knew how to reduce their footprint and eliminate unwanted artifacts better than our own society."

Archaeological implications considered include pot cleaning, reuse, discard and use life. The seasonality of site use and husbanding livestock are also relevant topics.

Part II: Ancient Manufacturing Techniques for Cookware (2 chapters). Chapter 12. "Ancient Clay Containers to Process, Cook and Preserve Food" (pp. 147-154). London cites data from Longacre's Kalinga Archaeological Project in the Philippines and from her own research in Cyprus. Cookware, bakeware, kitchenware, tablewares, and utilitarian containers for food processing and storage and delineated. A very important distinction is made regarding cooking post shapes – rounded rather than flat bases -- and she discusses the implications of this distinction and the fabrication technologies employed. Clay pots, both large and small as well as open and closed, were suitable for the processing, preparation, cooking, storing, and serving of food. In Cyprus, ovens begin as fired pots that are placed on their side and encased in mud and brick. The same oven could bake breads, meat and vegetables in deep globular cooking pots. Cookware in particular was multi-functional and was used for many of the processing activities related to food. Round bases were beneficial in traditional and ancient societies. Flat-bottomed ceramics are less desirable for multiple reasons. Bases round or flat can be manufactured in a number of ways. Bases often preserve evidence of how the pot was made, in contrast to well-smoothed rims and upper bodies. While people accustomed to flat stoves and flat-based pots are dubious about round-bottomed pots, stands made of wood, clay, reused pots, and metal easily accommodate traditional and ancient pots. With a short uselife of slightly over two years and the rapid replacement of cookware, archaeologists nevertheless can detect features characteristic of each time period. An analysis of overall vessel proportions and morphological features might lead to even further differentiation within each time period. Archaeological implications include shapes and uses, and uselife. She notes that very large ceramic containers were often set in place prior to room construction.

Chapter 13. "Ancient Manufacturing Techniques and Clay Bodies" (pp. 155-171, 4 figures). The techniques of producing traditional pottery have always been a limited and she reviews pinch pots, coils, slabs, paddle and anvil, moulds, turning, and wheel-throwing. Round and flat bases can be made using any of these techniques. Round bottoms often begin flat unless they are made with a mould. Rims are usually finished at an early stage in the work, while bases are completed as the final step. She notes that "more rim sherds than bases are preserved archaeologically; unfortunately, they offer less information on overall pot manufacture than bases and lower bodies." Clay preparation may involve nothing more than pounding the clay and mixing it with water. At other times, it involved the removal and/or addition of material, known as inclusions, temper, non-plastics, filler, or grits. Most ancient fabrics have clay bodies comprising over 40% inclusions. To create fabrics with a single predominant non-plastic intentionally required effort. Until Classical times, ancient potters in the Levant often used clay as it was found in nature after removing the largest rocks, but to make cooking pots, they preferred a coarse textured clay body with abundant, often calcareous inclusions. Surface treatments varied for ancient and traditional cookware. In the Levant, plain and smooth exteriors predominated, until ribbed surfaces began in the Classical era. Smudging may have been intentional, especially during the Early Bronze Age III. Surface treatments and accessory pieces depend on the raw materials used, the manufacturing process, firing techniques, and cultural preferences. Changes in pyrotechnology alone can end a tradition of handles and spouts. Round bases present ample advantages over flat bases to manufacture, dry, fire, use, heat, and clean. The burnished surface of the earliest and latest pottery manufactured in the southern Levant attests to its suitability for local clays. Handles and handle shapes are also discusses. Archaeological implications include discerning manufacturing techniques and surface treatments.

Part III: Cookware through the Ages (9 chapters) "Introduction" (p. 175). Ancient clay cooking pots in the southern Levant are" rough in texture and not easily associated with meals known from ancient writings or iconographic representations." To narrow the gap between excavated sherds and ancient meals, the approach London adopted started by examining the way food is traditionally processed, preserved, cooked, and stored in clay containers. The next part of the volume focuses on the shape, style, and manufacture of cookware for the past 10,000 years. Eight chapters focus on chronologies and characteristics of the pottery produced during these eras.

Chapter 14. "Neolithic and Chalcolithic Cookware" (pp. 177-181, 2 figures): Neolithic (ca. 9000-4300 BCE, Chalcolithic 4300-3400 BCE. Jars, churns, spouted vats (early distillation equipment?), spoons, and trays are documented. Round and even flat-bottomed jars with holemouth rims were used for cooking but are likely not the earliest cookware in the Levant. The first Neolithic examples have probably not survived. "If early cooking pots were fabricated from clay bodies without calcite and low fired, they were unable to resist repeated thermal stress and their likelihood to survive was in jeopardy." In contrast, baking trays were thick enough to survive although archaeologically they are highly fragmented and in poor condition. Spouted vessels were used to milk goats and to distill or process foodstuffs. Chalcolithic-era churns are clearly associated with processing dairy foods.

Chapter 15. "Early Bronze Age Cookware" (pp. 183-193, 3 figures): Early Bronze Age (ca. 3500-1900 BCE). EBA I (ca. 3500-3100 BCE): Holemouth calcite tempered cookware predominates, jars, spouted jars, baking bowls/bread molds, basins, and scoops were fabricated. EBA II (ca. 3100-2800 BCE): Jars, spouted jars and kraters, and graters. EBA III (ca. 2800-2200 BCE): Globular or ovoid jars, spouted kraters, vats, and andirons; Khirbet Kerak Wares (KKW). EBA IV / MBA I (ca. 2200-2000) BCE: Globular round-bottom cooking pots, bread molds or hot plates, spouted pots, and perforated cups or funnels were made. There is also a discussion of "how and why" flat bottomed ceramics were made. Coil or mold-made ceramics in the Intermediate Early Bronze Age IV/MBI period were not wheel-made but display thin walls. Globular cookware retained soot on both the inside and outside. Spouted pots held some type of beverage or other food and likely attest to goat-milking activities. Perforated cups may have been associated with processing dairy products (why not brewing activities?). Round-bottomed pots at northern sites were manufactured in molds, unlike flat-bottomed contemporaneous pots characteristic of southern sites.

Chapter 16. "Middle and Late Bronze Age Cookware" (pp. 195-202, 2 figures). Middle Bronze Age (ca. 2000-1550 BCE, Late Bronze Age (ca. 1550-1200 BCE); urbanization and trade characterize this era. MBA II A-C (ca. 2000-1200 BCE): Closed globular cooking pots, open carinated cooking pots, spouted pots, open cookers/bread bakers, stoves, and baking trays were fabricated. "Late Bronze Age society could not support potters who made thin vessel walls from carefully prepared clay." LBA I (ca. 1550-1400 BCE): Wide shallow pots with carinated bodies, cooking bowls, and baking trays were produced. LBA II (ca. 1400-1200 BCE): Canaanite jars; open globular and carinated cookware predominates, baking trays, and scoops were made. Egyptian-style "flower pots" and "beer bottles" attest to foreign influence or presence and impact on local foodways. Cookware at coastal sites was highly varied and reflected increased international connections. For the first time, carinated cooking pots appeared alongside globular pots; both types were moldmade as were decorated baking trays and/or griddles. Scoops, an intentionally asymmetrical bowl-like form, made its first appearance. More than one cookware fabric has been identified at individual sites, which is a trend that expanded during subsequent periods. The cookware was often made of tempered clay designed to withstand heating. She also points out that there is little doubt that despite its bulk, cookware was traded – either empty or filled with food.

Chapter 17. "Iron Age and Persian Era Cookware" (pp. 203-216, 3 figures). Iron Age (ca. 1200-586 BCE, Persian Period (539-332 BCE). Red fired quartz or calcite cookware was characteristic until IA II, Iron Age I (ca. 1200-1000 BCE): Wide-mouthed shallow cooking pots, closed cookware and pots (for processing dairy products), amphorae, and cooking jugs were made. Beer-making apparatus included beer bottles and strainer jugs; other wares included baking trays and convex platters, bread molds, cooking bowls, and spouted pots. Iron Age II-III (ca. 1000-586 BCE): Wide, shallow cooking pots were characteristic; closed deep globular cookware, flat bottomed cookware/ovens, jugs or decanters, cooking jugs, beer jugs, scoops, graters, grinding bowls, and mortaria, and *mansaf* bowls were also produced. A break with ceramic tradition occurs as does pottery distribution and the production loci of cooking wares. The Persian Period (539-332 BCE): Globular open-mouthed cooking pots, closed-mouth high-necked globular or bag-shaped pots, casseroles, amphorae, mortaria, graters, ceramic grinding bowls, baking trays, and scoops were produced. In the Persian era, large shallow mortaria were associated with food preparation and joined globular and bag-shaped deep pots as part of the kitchen repertoire. These were traded over long distances via sea routes but did not reach inland sites. In Transjordan, grinding bowls resembling stone mortars were in culinary use. Closed jars or amphora (possibly used to transport fresh fish) may have functioned as a "cooling" container brought from the coast. At the site of Hisban, the transition from calcite to quartz temper for cookware was completed by the Persian era. The same shift for jars, jugs, and other types of pottery followed. "It would seem that potters who made cookware led the change, which was followed by potters who made the rest of the ceramic repertoire.

Chapter 18. "Classical Era Cookware" (pp. 217-228, 3 figures). The time period is divided into three cultural chronological units. The Hellenistic Era (332-63 BCE): London discussed the production of deep globular pots, shallow cookware (Casseroles), mortaria, baking dishes or large trays (both handmade and wheel-thrown), baking pans, cooking bowls, lids, and cooking pot "props." Pompeian Redware was fabricated and Hellenistic tombs included cookware. The Roman Period (63 BCE-330 CE) was a time the "internationalization" of cookware through trading. Globular deep cookers, casserole, cooking jugs, and baking pans are described. The Byzantine Era (330-660 CE) featured glazed pottery, globular cooking pots, cooking jugs and jugs with sieves, casseroles, frying pans, and bread stamped molds. "The perfect cooking pot lid was finally invented (p. 226). Red, often ribbed "Brittle Ware" was mass-produced in Roman and Byzantine-era workshops and factories in Lebanon, Cyprus, and the southern Levant. During Byzantine times, Italian influence introduced flat and shallow cookware (casseroles and frying pans). Thin-walled, hard, brownish-red or gray, and smooth coarse cookware was made in multiple production locations in the Galilee or the Golan. One-handled cooking jugs with various rims were made of cookware fabrics that varied regionally. Open, shallow baking and frying pans (with handles) never out-numbered deep cookware. "An accidental glaze on cookware south of the Dead Sea was a fleeting occurrence."

Chapter 19. "Medieval Era Cookware" (pp. 229-243, 3 figures). London divides this era into three cultural chronological units. Despite dramatic political changes, ceramic traditions from the Classical periods continued into the Medieval era. Early Islamic Era (660-908 CE): Deep globular and bag-shaped wheel-thrown cooking pots were produced along with cooking jugs, amphorae, casseroles, casserole lids, sauce pans, frying pans, and basins. Middle Islamic Era (980-1516 CE): Wheel-thrown globular pots and deep cookware, handmade deep globular pots, frying pans, cooking bowls/baking dishes, handmade cooking bowls, baking trays, scoops, water jugs, sugar pots and syrup/molasses jars, cups, and jugs were fabricated. London also discusses Mamluk foodways and the organization of the ceramics industry, noting glazed wheel-thrown and industrial ceramics for the sugar industry. The Middle Islamic-era ceramics industry was divided between wheel-thrown vessels, some of which were glazed, and handmade coarse wares, plain, painted, slipped, or burnished. Deep globular pots never lost their prominence. Hand Made Geometric Painted ceramics and sugar pots joined the repertoire. Regardless of Fatimid, Crusader, or Mamluk rulers, local ceramic traditions prevailed. Crusader- era imports and exports demonstrate that cooking pots were traded across long distances. Beirut cookware reached coastal and inland sites. Late Islamic /Early Modern Period – the Ottoman Era (1516-1918 CE). Wheel-thrown Gaza Gray Ware (GGW) and imported glazed wheel-thrown cookware from Europe, Istanbul, and Syria were notable. Cooking wares included deep globular cooking pots, shallow cookware (casseroles, cooking bowls, and pans), trays, basins, wheel-made mortars or grinding bowls, and wheel-thrown pots for milk or yogurt. During Ottoman times, emphasis moved away from glazed and imported wares to handmade pottery, especially for kitchenware and cookware, a trend that continued from Mamluk times. Handmade deep globular and shallow pots, casseroles, pans, trays, cooking bowls, and other forms were local products. In addition to deep cooking pots and milk containers, GGW wheel-thrown mortars or grinding bowls were used for grating and serving food. Despite the efficiency of glazed cookware, handmade pottery never ceased completely but was always practiced in rural locales, where people made what they needed. GGW pottery continues into the 21st century and provides a recent example of fragile, breakable wares traded long distance, across mountains and the deep Rift Valley.

Chapter 20. "Late Ottoman/Mandate and Recent Wheel-thrown Ceramics" (pp. 245-256, 3 figures). "Modern factories and imported kitchenware largely replaced clay pots, but wheel-thrown and handmade pots are still produced in town and village settings" (p. 245). Wheel-thrown pottery made in small workshops of family potters persisted for three reasons: low cost, functionality, and nostalgia. Pots made in Rashaad al-Euchar, Jab‘, Hebron, Gaza, Nazareth, Ceramic, Ziizika, and Jerusalem were relatively inexpensive because they were made from raw materials that were free for the taking. London notes that people profess a fondness for water stored in clay pots and foods cooked in clay pots, one reason being that clay jars and jugs kept water cool and filter bitter minerals. The shift of certain larger traditional jars, ovens, beehives, and goat-milking pots from kitchens into gardens or cemeteries and from functional to decorative pieces has preserved the traditional industry into the 21st century. In Jordan as in Cyprus, people can acquire the full range of modern appliances made in factories. Nevertheless, there is a place for old-fashioned clay pots that remind us of home, our youth, and family. No pots fill this need better than clay cookware and water jugs. When the older generation is asked why traditional pottery remains in demand, invariably people give two reasons: the food tastes better when made the old-fashioned way, and everyone wants children and grandchildren to experience food that tastes good. Archaeological implications include different names for clay and pottery, regional differences, and the organization of the ceramics industry.

Chapter 21. "Late Ottoman/Mandate and Recent Handmade Ceramics" pp. 257-268, 3 figures). London notes early deports about traditional potters and recent ethnoarchaeological studies. Handmade pottery is remarkably resilient and has survived into the 21st century at a handful of villages in the Levant and Cyprus. The Arabic names for traditional cookware, other pots, and household artifacts made of clay vary considerably within the small region of the Levant; Greek names vary across the island of Cyprus. The variety and abundance of contemporaneous terms in two small areas, Cyprus and the Levant, mimics the large number of words for cookware mentioned in the Hebrew Bible. Variation in the ancient terminology likely results from many subtle distinctions concerning how and where pots were made and finished, by whom, and how they were used to heat meat or dairy foods. In addition, diachronic and regional preferences add to the wealth of names for cooking pots used daily and for family and community special occasions. Archaeological implications include distinction made in potter used for dairy versus meat foodstuffs, pottery production locations, distribution, and seasonality. Table 9,"Cookware types through the ages" (p. 268) provides a valuable summary.

Chapter 22. "Implications of Ethnoarchaeological Studies for Ancient Cookware" (pp. 269-275). London reviews the evidence and preference for rounded pot bottoms, changes in surface treatments, variations in contemporary cookware shapes and clays used to make them, workshop locations, and who made the pots. The perspective from pot-maker to pot-user shows modifications in all aspects of manufacture: fabric composition, manufacturing technique, vessel shape, surface treatment, and firing, over seven or eight millennia. New manufacturing techniques inspired and required new tempering materials and experimentation, yet old ways did not disappear quickly or vanish entirely – especially not for round-bottomed cookware. Two resilient and practical traditions for handmade pottery that began in the Early Bronze Age, burnishing and calcite temper, eventually acquiesced to wheel-thrown pots and quartz fabrics in the Late Iron Age/Persian Period. Nevertheless, local, traditional limestone-rich fabrics remained part of the repertoire, especially for large vats and basins that were made with coils or slabs. From Medieval times onward, potters resorted to the same Bronze Age practices because they provided practical solutions for local clays. "All potters in the southern Levant, who built containers with coils, molds, or slow-moving turntables, confronted the same challenges, regardless of the time period. Rather than a revival of earlier traditions or direct continuity, the persistence of calcite temper in burnished, handmade cookware represents indigenous potters responding to the intrinsic limitations of the local clays with the same ageless solutions."

This magnificent volume is a landmark publication in ceramic studies and, of course, ceramic ethnoarchaeology and should be a "must have" volume along with Prudence M. Rice's *Pottery Analysis: A Sourcebook*, 2nd ed., Chicago: University of Chicago Press, 2015, reviewed in *SAS Bulletin* 38(3):3-7, Fall 2015. By far and away, this is an historical overview of selected ceramic studies by archaeologists working in the Levant and Cyprus. Her synthesis and analysis provides archaeologists with significant information on cooking pot morphology and chronology. The survey of pottery shapes in Israel, Palestine, and Jordan illustrates how different shapes were made and used. London provides a brief but useful summary of the history of ceramic ethnoarchaeology. The "archaeological implications" at the end of the chapters in Part II provide an appropriate set of thinking points for any archaeologist who studies ceramics. The chapters on "How to Treat Clay Pots Prior to Use with Food" and "How to Clean Clay Pots" consider extremely relevant activities often overlooked by archaeologists and ethnographers.

London's volume does not attempt to integrate her analysis and chronological assessment of ceramic changes with archaeological theory regarding pottery production and distribution. Research conducted by archaeometrists, bioarchaeologists, and chemists is *not* a part of London's assessment. She cites only three sources dealing with petrographic analyses and one INAA study. There are many citations to the archaeological studies by Franken, Herr, Longacre, and Stern, and the bibliography lists 30 of her own publications. The classic work of Dean E. Arnold on potters and their resource procurement, *Ceramic Theory and Cultural Process* (Cambridge and New York: Cambridge University Press, 1985) is not cited. Regarding ceramic production and distribution, she does not consider his recent studies on Yucatecan potters, *Social Change and the Evolution of Ceramic Production and Distribution in a Maya Community* (Boulder, CO: University Press of Colorado, 2008) reviewed in *SAS Bulletin* 32(2):24-27 (Summer 2009) nor *The Evolution of Production Organization in a Maya Community* (Boulder: University Press of Colorado, 2014) reviewed in *SAS Bulletin* 38(1):2-5 (Spring 2015). London discusses only one potter's workshop in any detail (p. 251) whereas Arnold considers diachronically an entire community of potters' workshops. Her discussion about pottery kilns is exceedingly brief, and archaeologists would desire more information, descriptions and measurements. In addition, London does not attempt to characterize production loci in terms of Cathy Costin's paradigm first published in 1991 and modified slightly since, see "Craft specialization: Issues in defining, documenting, and explaining the organization of production," *Archaeological Method and Theory* 3:1-56 (1991).

Regarding ceramic use life, Jim Skibo's works are not mentioned: James M. Skibo, *Understanding Pottery Function* (Manuals in Archaeological Method, Theory, and Technique, New York and Heidelberg: Springer, 2013) reviewed in SAS Bulletin 35(4):28-30 (Winter 2012) and "Comparative Review" of *Understanding Pottery Function*," James M. Skibo, Manuals in Archaeological Method, Theory and Technique, New York: Springer, 2013, and *Pottery Function: A Use-alteration Perspective*, James M. Skibo, New York: Plenum Press, 2002. *Amazon.com*, November 27, 2012. http://www.amazon.com/Understanding-Pottery-Function-Archaeological-Technique/product-reviews/1461441986/ref=cm_cr_dp_text?ie=UTF8&showViewpoints=0#R10H3FS2YU37XH

Lipid residue analysis is mentioned only in passing with no references to the research published by Richard P. Evershed and his colleagues. London does note that some ceramics were designed particularly for daily products, meats, and other foodstuffs, but her analysis does not cite sources that determined these distinctions. For more comprehensive treatments see: C. Knappett and V. Kiliklglou (2005), The circulation and consumption of Red Lustrous Wheelmade Ware: petrographic, chemical and residue analysis. *Anatolian Studies* 55: 25-59; and M. W. Gregg (2010) *Organic Residue Analysis and the First Uses of Pottery in the Ancient Middle East*. British Archaeological Reports International Series 2065. Oxford: John and Erica Hedges Limited, Oxford. And "Comparative review of Three Books on Archaeological Chemistry": *Analytical Chemistry in Archaeology* (A. M. Pollard, C. M. Batt, B. Stern, and S. M. M. Young; Cambridge Manuals in Archaeology, Cambridge and New York: Cambridge University Press, 2007; *Archaeological Chemistry*, 2nd ed. (A. M. Pollard and C. Heron; 2nd ed., Cambridge, UK: RSC Publishing [The Royal Society of Chemistry], 2008; and *Archaeological Chemistry*, 2nd ed. (Zvi Goffer, Hoboken, NJ: Wiley-Interscience, a John Wiley & Sons, Inc. Publication; Volume 170 in Chemical Analysis: A Series of Monographs Analytical Chemistry and Its Applications, 2007) appearing in *SAS Bulletin* 32(1):22-25 (Spring 2009).

Nonetheless, this is an important benchmark volume that provides a great deal of information about ceramic production in Cyprus and the Levant but also offers evidence and thoughts valuable to any archaeologist attempting to define cooking wares.

Pottery, Peoples and Places: Study and Interpretations of Late Hellenistic Pottery, Pia Guldager Bilde and Mark L. Lawall (eds.), Danish National Research Foundation's Centre for Black Sea Studies, Black Sea Studies 16. Aarhus, Denmark: Aarhus University Press [Universitetsforlag], 2014. 387 pp., 332 illustrations, 6 tables, 1043 endnotes. ISBN-10: 8779345328, ISBN-13: 978-8779345324, kr. 449.95 / $72.00 US (hardcover). This volume, and other BSS publications, is open access. The URL for this monograph is: http://www.pontos.dk/publications/books/BSS%2016

Pia Guldager Bilde, a specialist on the ancient history and archaeology of the region of the Black Sea and Crimea, was a graduate of the University of Copenhagen and Aarhus University (1990), a field archaeologist and director of the Danish National Research Foundation's Centre for Black Sea Studies. She also served on the staff of the University of Aarhus's Department of Classical Archaeology from 1993 until 2012, and was the director of the Museum of Antiquity. Pia (11 February 1961 - † 10 January 2013) passed away after finishing the bulk of the editorial work for the volume under review. On the University Staff page she wrote: "I am particularly interested in ancient cult/religion as a particular arena for meeting of cultures and construction of identity. I have made a general study of 'temple' architecture of the Black Sea region and several studies of Artemis and Parthenos and the relationship between the two goddesses. My main focus is on Dionysos and his role in negotiating identities of the Greek settlers not just in the early period but also - and in particular - in the Hellenistic period. My ongoing work with the Mouldmade bowls, the so-called 'Megarian bowls' combines several of my interests. These pieces of mass-production fabricated in most of the Hellenistic cities are precious evidence for trade relation and traveler's networks. But they are also completely overlooked testimonies of Dionysian imagery of the late Hellenistic period."

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35(2):9-11, 2012). In addition, he has written more than a dozen refereed journal articles and 27 book chapters.

The volume is divided into three parts containing 17 chapters plus a "Preface" and "Introduction." The "Preface" (p. 7) informs the reader that Pia Guldager Bilde was never able to see the final results of her efforts. The "Introduction" (pp. 9-14, 5 endnotes) by Pia Guldager Bilde and Mark L. Lawall provides background information. These contributions were presented at a conference held at the Sandbjerg Manor, Denmark, in late November 2008, focused on the study of ceramics in the Mediterranean and Pontic regions in the 2nd century BC. The host of the conference, the Danish National Research Foundation's Centre for Black Sea Study, was in the process of finalizing the manuscript on the Lower City excavation at Olbia Pontike where the 2nd century BC was a period both of great activity and of significant decline. Though not the only artefacts attesting to this tumultuous period of Olbia's history, the ceramic remains provided, by far, the most compelling evidence for the chronological sequence of events and for the cultural contacts shaping Late Hellenistic life at Olbia. The Centre's work at Olbia and the thriving network of scholars that developed around that work, whether working in the Pontic region or in the Aegean/Mediterranean worlds more generally, created the opportunity to open new discussion on the ceramic record of the Greco-Roman world of the 2nd century BC. The resulting conference addressed three main themes: (a) chronologies; (b) production, distribution and influence of selected ceramic types; and (c) broader socio-economic interpretations based on the ceramic record. The volume is supplemented by a "Bibliography" (pp. 337-370) with 668 entries, an "Index" (pp. 371-383) of conflated topics and proper nouns, and a "List of Contributors" (pp. 385-387) -- 27 individuals, two now deceased.

Pottery, Peoples and Places derives from a conference held in November 2008 at Sandbjerg, Denmark. The late Hellenistic period, spanning the 2nd and early 1st centuries BCE, was a time of great tumult and violence as a result of nearly incessant warfare. During this same time period there was a great expansion of "'Hellenistic" Greek culture and material culture including ceramics. The 17 papers in this volume explore three themes: 1) chronologies, specially ceramic chronology (often based on evidence dependent on the violent nature of the period), 2) the production and consumption of Hellenistic ceramics particularly in Asia Minor and the Pontic region, focusing on selected ceramic types, and 3) and Hellenistic socioeconomics and the impact of ceramic culture across much of the eastern Mediterranean and into the Black Sea. The volume has a "Preface" (p. 7), editorial "Introduction" (pp, 9-14, 5 endnotes), and extensive "Bibliography" (pp. 337-370) containing 622 entries, a comprehensive combined topical and proper noun "Index" (pp. 371-383), and "List of Contributors" (pp. 385-387) with addresses and emails for the 26 authors. The 17 contributions (unnumbered chapters) are divided and grouped into three parts defined by the three themes.

Part 1. Chronologies: five chapters. "The Contribution of Inscriptions to the Chronology of Rhodian Amphora Eponyms" by Nathan Badoud (pp. 17-28, 59 endnotes). The author deconstructs past scholarship and proposes new correlations. He details possibilities and limitations of traditional dating methods and focuses on what can be learned from inscriptions. "The Lower City of Olbia Pontike Occupation and Abandonment in the 2nd Century BC" by M. L. Lawall, P. Guldager Bilde, L. Bjerg, S. Handberg, and J. M. Højte (pp. 29-45, 24 figures [10 in color], 57 endnotes). Datable artifacts include vessels stamped with makers' marks and coins. In addition, there is a valuable discussion of pottery accumulations and discard. The color illustrations are magnificent. "Bridging the Gap: Local Pottery Production in Corinth 146-44 BC" by Sarah James (pp. 47-63-3 figures, 1 table, 75 endnotes). She argues against the view that Corinth was utterly abandoned ca. 146-44 BCE , noting that there was a continuation of the production of local Corinthian pottery. Previous research is recounted and data from the 2006 excavations are summarized. South Stoa wells contained Linear Leaf moldmade bowls. "A Re-examination of some of the South Stoa Wells at Corinth" by Guy D. R. Sanders, Yuki Miura, and Lynne Kvapil (pp. 65-81, 3 tables, 43 endnotes). The author reexamine material evidence from wells in the Corinthian South Stoa, the proposed dated when these were filled, and the morphological development of Corinthian pottery types. Few moldmade bowls appear in the ceramic assemblage. "Sulla and the Pirates" by Susan Rotroff (pp. 83-109, 6 figures, 2 tables, 112 endnotes). Rotroff employs evidence from French and Greek excavations in order to distinguish two textually attested attacks on Delos. Materials from Athens and Delos are documented. Fine wares included Eastern Sigillata A, Proto-ESB, Pergamene sigillata, plain wares, and cooking vessels.

Part 2. Typology: nine chapters. "Mouldmade Relief Bowls from Ephesos - The Current State of Research" by Christine Rogl (pp.113-139, 23 figures [8 in color], 32 endnotes). Hellenistic pottery research is summarized and the author details moulds, signatures, rosette types, vessel profiles, ten fabric groups, decorations and motifs, phases of production, and pottery workshops. Scale of production includes a discussion of exports, imitations, and local production. "The Hellenistic Mouldmade Bowl

Production at Priene: A Case Study Concerning the Reception of Ephesian Examples" by Nina Fenn (pp. 141-156, 10 figures, 53 endnotes). The history of production is documented and the characteristics of local moldmade bowls focus on six motifs rather than fabrics. Mouldmade bowls imported from Ephesos are detailed in terms of types and locations of molded decorations. "Table Ware from Knidos: The Local Production during the 2nd and 1st Centuries BC" by Patricia Kögler (pp. 157-173, 23 figures, 14 endnotes). Eight vessel types and their molded decorations are documented. "Hellenistic Pottery from the Necropolis of Olbia Pontike" by Georgij Lomtadze and Denis Žuravlev (pp. 175-197, 10 figures, 96 endnotes). The authors review the history of early excavations and focus on a detailed analysis of the ceramic assemblages from Graves 34, 41, 25, 35, and 39 dating from early 3rd to early 1st century BC. "A Pontic Group of Hellenistic Mouldmade Bowls" by Anelia Bozkova (pp. 199-214, 32 figures, 40 endnotes). Pottery of East Aegean origin or of East Aegean type is the emphasis of this research with variants among skyphoi, cups, amphorae, kraters, and unguentaria detailed. Pontic pottery including kantharoi and skyphoi are briefly detailed. "Imports and Local Imitations of Hellenistic Pottery in the Northwest Black Sea Area: Hadra and Pseudo-Hadra Wares" by Aneta Petrova (pp. 215-231, 16 figures, 58 endnotes). The author reviews the "technology" of clays – fabrics are identified by the use of Munsell color chart references. Vessel shapes, molded decoration, Pontic area distribution, chronology (2nd-1st century BC), and origins of moldmade vessels are reviewed. "Late Hellenistic Pottery and Lamps from Pantikapaion: Recent Finds" by Vasilica Lungu and Pierre Dupont (pp. 233-254, 20 figures [3 in color], 99 endnotes). The authors focus on imports and the fabrication of local imitations of Hadra style ceramics which are identified by decorative technique. Shapes and fabrics, ten decorative motifs, and chronology are reviewed, and the results of XRF analyses of 24 sherds reported by cluster analysis. A majority of the specimens had a chemical pattern "fitting quite well with those of Istro-Pontic colonial products" while the imported material "inspired a new, diverse, and rich Pontic tradition" (p. 248). Further details on the chemical analysis are not provided. "Late Hellenistic Pottery and Lamps from Pantikapaion: Recent Finds" by Denis Žuravlev and Natalia Žuravleva (pp. 255-286, 23 figures [7 in color], 125 endnotes). Imported moldmade Hellenistic tablewares documented include Bosporean moldmade bowls (late 3rd and most of the 2nd century BC), Pergemene sigillata (mid-2nd century BC), Eastern Sigillata A, Late West Slope Ware, Pelikai moldmade bowls, Bosporean sigillata, Bosporean wheel-made lamps, and both imported and local wheel-made relief lamps. "Late Hellenistic Red-Slip Ware in Oblia" by Valentina Krapivina (pp. 287-394, 23 figures [7 in color], 125 endnotes). Two types of jugs, two types of bowl-cups, one type of cup, two types of plates as well skyphoi, beakers, saltcellars, a krater, and a lekanis are characterized primarily by Munsell Color Charts.

Part 3. Ceramics and Culture: three chapters. "Pots and Politics: Reflections on the Circulation of Pottery in the Ptolemaic and Seleukid Kingdoms" by John Lund (pp. 297-205, 80 endnotes). Lund reports on pottery produced within 1) the Seleukid kingdom: Antiocheia moldmade bowls and Eastern Sigillata A; 2) the Ptolemaic kingdom: Ptolemaic queen's oinochoai and Cypriot Sigillata; and 3) produced outside of the Seleukid and Ptolemaic kingdoms: Gnathia vases, Hadra vases, Graeco-Italic amphorae (Will type 1), and Rhodian transport amphorae. Lastly, he discusses five preliminary conclusions. "Dining In State: The Table Wares from the Persian-Hellenistic Administrative Building at Kedesh" by Andrea Berlin, Sharon Herbert, and Peter Stone (pp. 307-321, 14 figures [13 in color], 25 endnotes). The authors report tablewares recovered from a storeroom at the Levantine site of Kedesh, a large administrative center dated 3rd-2nd century BC. Petrographic analysis defined the fabrics as from the coastal plain near the Carmel Mountains, hence, the ware is called Central Coastal Fine. The precise production locale is unknown and there may have been multiple fabrication sites. Serving vessels (table amphorae, jugs, and dipper juglets) are in a peach-brown n fabric called Semi-fine. Saucers and small bowls in an orange-red slip, Northern Coastal Fine, are also documented. The authors ask the question: what do archaeologists mean when talking about ESA and proto-ESA and what do we think this meant in antiquity. Lastly, "Les campaniennes A et B, deux aspects d'une 'globalisation' économique et culturelle des céramiques tardo-hellénistiques" by Jean-Paul Morel (pp. 323-335, 6 figures, 25 endnotes). Morel documents these two pottery types in the late Hellenic world in terms of vessel forms, especially variations in vessel ring bases. He perceives relationships between forms and geography – Germany and France, the Pontic Black Sea coast, the North African littoral, and Eastern Mediterranean.

In the main, the volume contains specialist research for a specialist audience. Two of the 18 chapters provide some use of scientific analyses: Vasilica Lungu and Pierre Dupont (pp. 233-254) discuss the results of XRF, while Andrea Berlin, Sharon Herbert, and Peter Stone (pp. 307-321) employed petrographic analysis. Bibliographic references provide some documentation of these scientific studies.

ARCHAEOMETALLURGY

Brett Kaufman, Associate Editor

It is with great pleasure that I join the *SAS Bulletin* team as Associate Editor of Archaeometallurgy. From personal experience, it's clear to me that staying appraised of publications and activities within our field is of great interest to many archaeological scientists. It is with this spirit that the *SAS Bulletin* concerns itself, so I'm just happy to be a part of it. For all of our members, please do not hesitate to contact me with new ideas, developments, or suggestions to improve content. For more details about my background, visit my bio at http://www.socarchsci.org/board1.html, and please email me at bkaufman@ucla.edu with any questions or comments.

Brett Kaufman

The column in this issue includes a progress report by A. Mark Pollard for the ERC funded FLAME project at Oxford University, and a review of archaeometallurgy from the 82nd Annual Meeting of the Society for American Archaeology by Lam WengCheong.

FLAME: The FLow of Ancient Metal across Eurasia – a progress report

A.M. Pollard (Research Laboratory for Archaeology and the History of Art, School of Archaeology, University of Oxford)

The FLAME project, funded by the European Research Council (ERC 670010), started in October 2015 and has been running for 18 months. The focus is on the chemical and isotopic composition of copper alloy objects across Eurasia during the Bronze Age. The aim is to use variations in the spatial and chronological distribution of copper and its alloys as a proxy for understanding the relationships between different societies across Bronze Age Eurasia. Taking existing data on the chemical and isotopic composition of copper alloy objects and combining them with typological and chronological information within a GIS framework, FLAME aims to illuminate the history of human engagement with copper and its alloys across Eurasia from approximately the late 3rd to early 1st millennia BCE.

In order to do this, we have tried to shift the focus of chemical and isotopic studies of metal away from a purely ‘provenance-based’ approach towards a broader framework (‘form and flow’) that acknowledges variation in the *life histories* of both *objects* and *materials* and uses this to enrich our interpretations of the past. Whilst acknowledging that the original chemistry of the ore is a significant contributor to the composition of archaeological artefacts, our approach exploits incremental shifts in chemistry, which occur during the production, use, and re-use of material. In other words, the provenance model has to be extended to include the consequences of mixing together metal from different sources, including the possibility that copper may be recycled, re-alloyed or generally re-used. In this way, we are seeking to celebrate and engage with the complexity of human interactions with metal in the past. This reassessment of archaeological metal chemistry is underpinned by a new set of interpretative tools designed to characterise *change* in the archaeometallurgical record, and is conducted within a Time-GIS framework.

‘Form and Flow’

In our view, this approach represents a powerful and archaeologically accessible toolkit. It allows us to combine data from many different sources, and link chemical and isotopic data to human behaviour. It has been very helpful in guiding the development of the tools and ideas discussed below. The central concept is one of metal ‘flowing through society’, and being affected by a series of human interventions, some of which might influence the composition of the ‘flow’, and hence the composition of the objects produced from it. Such interventions might include:

- the mixing of ore or smelted metal from more than one mining source;
- alloying copper with significant quantities of another metal, such as tin or lead, to create a new material;
- re-working an object into a new shape, or recycling objects to create new objects.

Through characterising these processes we can bridge the various scales at which metal can act within social structures, from variation within one object, through regional traditions, up to continental patterns of metal movement and use.

Our aim has been to develop a quantitative methodology to disentangle this complex system. The concept of metal flow in archaeology has been emphasized by many scholars, usually in the context of attempting to model trading networks and technological pathways. Our ‘flow’ is more abstract than this, although it does also encompass the idea of trading networks. Essentially it is a theoretical construct which enables us to link together the data from mines and smelted metals to objects.

The guiding principle of the new framework is to focus on detecting and quantifying *change over time* and *differences over space* in the archaeometallurgical record. This is fundamentally different from 'provenance', i.e., attempting to match the trace element or isotopic composition of a group of objects with those of a putative source. The character and expression of metal use is mostly only meaningful when inferred from group properties, defined on as large a number of objects as possible, which are allocated into *assemblages*. These assemblages are then taken to represent the composition of the metal flow at a particular place and time. The concept of an assemblage is itself fluid, but is essentially a thematically defined group, the nature of which is not fixed but depends on the question being asked. It could be all the metal artefacts from a particular tomb, or all the metal objects belonging to a particular archaeological culture, or all the bronze daggers of a particular shape from across Eurasia. The toolbox summarized below is designed to reveal changes in the chemical and isotopic composition between such assemblages. A key point is that our attention is focussed on archaeological metal *objects*, or more strictly on assemblages of objects, and our methodologies have been developed accordingly. That is not to say we are not interested in other sources of evidence relevant to metal artefacts, such as the mineralogy and chemistry of known mining sites, or the chemical metallurgy of the smelting process, or the metallographic structure of the objects themselves, but we regard these as independent sources of information, to be compared with the results of the analysis of the artefacts themselves. Our ultimate task is to use these observed changes or differences to infer human action and intention.

We need to think about the distinction between the life (object biography) of a single object, and that of the underlying hypothetical metal flow. The biography of a single object may be simple – it is made, used, and deposited, to be found by archaeologists. We term such an object biography a *simple* or *linear trajectory*. After it has been smelted, alloyed, and manufactured, neither its composition, form nor decorative features are altered. It is an instantiation of the composition of the metal in use at the time it was made. The traditional 'provenance' models using chemical and isotopic data appear to have generally assumed (often only implicitly) that all archaeological copper alloy objects more or less follow this simple (linear) path. For objects which do, then the traditional approaches to provenance are likely to be valid. Although such a simple short biographical pathway is of course possible, it is, however, not the only trajectory we can imagine. For example, it might remain in use for several generations, being inherited, curated, and passed on repeatedly. It may be remelted and recast several times within the same cultural context. Following burial, it might have been looted. In a new social context, it may be seen more as an *ingot* containing a convenient source of raw material rather than as an *object* containing significant symbolic capital, at which point it may simply become 'scrap metal', to be mixed with other unvalued object forms, and potentially reworked into some other completely unrelated form. We would term such a life history a *branched* or *complex biography*. The mutability of copper and its relative resistance to corrosion lends itself to such long and complex biographies, although perhaps not to the same extent as gold and silver.

At each event in this chain, there is the potential for the metal of one object to be divided between many objects, or many objects to be amalgamated into one object, or new metal from a different source to be added. As a consequence, we suggest that it is better to expand our focus from *the biography of individual objects* or sequences of objects to include the *biography of the metal* contained within these objects, since it is this metal which is actually being manipulated by human agency. Objects are often transitory forms within a much longer and expansive *flow* of material; precisely characterising these processes is at the heart of FLAME. The composition of this metal flow can change over time, as new sources of metal are added to the flow, even though the composition of individual objects within the flow may not change over their own lifetimes. We can conceive of a metal flow which can change composition without objects being recycled, simply by a new stock of fresh metal being injected into the flow. This new stock may come from a new mine source, added to an existing flow of metal, causing a significant change in the composition of the flow. We see this hypothetical 'flow' of metal as a useful tool for linking the composition of metal flowing from many mines, as well as being a mechanism for handling the possibility of the large-scale recycling of objects. It is almost certain that the balance between the influences of these two mechanisms will vary over space and time, as well as by social context. Nevertheless, by developing a series of tools which allows us to detect change in the hypothetical flow of this metal, we believe we have provided a means of untangling the complex nature of the interaction between humans and metal.

GIS Database

So far, we have constructed a GIS database for Eurasia, now containing approximately 70,000 geo-located analyses of individual objects. The coverage is still patchy, with western Europe relatively well-represented, but eastern Europe and parts of central Asia still sparsely covered. However, more data are being added all the time. At the end of the project, this database will be publically accessible on the Oxford University School of

Archaeology website, as a free resource for all archaeologists. The database will also include in-house tools for carrying out the analyses described below.

Trace elements in Copper – 'Copper Groups'

In order to detect changes in the flow of copper, we focus on four trace elements, namely arsenic (As), antimony (Sb), nickel (Ni) and silver (Ag). The reasons for this are primarily practical. Firstly, most chemical analysis of copper alloys that include trace element data will report these four trace elements. This allows us to consider the largest possible number of samples when considering copper groups. Secondly, these four elements cover a range of thermodynamic behaviours in molten copper – under oxidising conditions, As is volatile, Sb less volatile, and Ag and Ni stable. All possible combinations of presence/absence for four elements give 16 possible 'copper groups'. If we were to use five elements, there would be 32 copper groups, which would be cumbersome to display and manipulate. We do not claim that the four elements used are the only ones to carry useful information – plainly not. Where reported, for example, bismuth (Bi), cobalt (Co), and sulfur (S) can be extremely useful in distinguishing between copper from different sources. However, the combination of the overall availability of data for the four elements selected, and the potential complexity of using five elements, has resulted in our standard practice being the use of As, Sb, Ag and Ni. We see a definite advantage in using the same set of elements (and cut-off values for presence, 0.1%) as the starting point for all analyses – that of *universality*. This means that copper groups from, for example, the Caucasus, can be directly compared with those from Mongolia. In a project such as FLAME, which considers Bronze Age Eurasia as a set of interlinked metal systems, it is extremely important to be able to compare directly across space and time.

The first step is to carry out a simple presence/absence classification system based on the four trace elements. This is a simple heuristic sorting step, which allows us to see the dominant chemical signals running through the data. These elements are most likely related to ore-source, since they tend to be either present or absent in the ores known to have been used in antiquity, but we make no assumptions about allocating a particular copper group to a specific ore source, known or unknown. A single ore source could produce copper classified into more than one copper group, and conversely copper of a single group could come from more than one mine. At this stage, we are only interested in the geographical, typological or chronological patterns in the object data that are revealed by this process, with no prior assumptions required about mines or geology. Tracing these changes over time, through a landscape, or between social contexts is at the heart of interpreting metal flow.

New definitions of alloys

We take a similar approach to classifying archaeological copper alloys - a preliminary classification step based on presence/absence, this time of tin, lead and zinc, (this time with the cut off for presence at 1%) followed by ubiquity analysis, profiling and mapping. Traditionally, archaeological copper alloys are classified using the same definitions as used for modern alloys, which are effectively production specifications that have emerged as being optimum compositions for particular applications. We believe that these definitions can hide important information when applied to archaeological objects. It is clear from many chemical analyses of archaeological objects that they do not correspond directly to modern alloy definitions. Forcing these analyses into such definitions implies that all ancient alloy formulation was deliberate and intended to produce alloys with approximately modern specifications. Although we do not dispute for a moment that certain alloyed metals in antiquity *were* designed so as to optimise the physical properties or appearance of the finished product, it is the information contained in the 'non-standard' alloys that we wish to capture by using a different approach. We have therefore adopted a presence/absence definition, in which for the alloying metals (Pb, Sn, Zn, and possibly As) we set the threshold of 'presence' at 1%. We feel justified in doing so because such an approach tends to highlight the intermediate levels of alloying metals (above accidental but below deliberate) which we think contains considerable information about the biography of metal flow.

This system has the advantage of highlighting rather than hiding the presence of such mixed alloys in assemblages. If a high proportion of an assemblage is made up of such alloys, it suggests that those objects may be the result of mixing metals of more than one alloy type, rather than of deliberate alloy design. Rather than denying the existence of 'designed alloys', however, it enables us to identify them more clearly when they do appear in the metal flow. For example, in a study of first millennium AD copper alloys in Britain, we have used this methodology to show continuity of metal circulation from the Late Roman period into the Early Anglo-Saxon, with a marked change occurring only in the Middle Saxon period, which we attribute to the arrival of fresh stocks of metal. Moreover, using the ubiquity of the quaternary alloy leaded gunmetal (defined as above) as a proxy for the amount of recycled metal in circulation, we have suggested that by the end of the Early Anglo-Saxon period, approximately 70% of objects analysed contained recycled metal.

New presentations of Pb isotope data

If we accept that, at least at certain times and places, the mixing of metal from different sources, or metal recycling, was a significant facet of human behaviour, then the uncritical use of lead isotope data on copper alloys is potentially misleading in terms of provenance. We argue that 'conventional' lead isotope plots, consisting of two bivariate diagrams, displaying all three measured isotope ratios, may not be the best way of disentangling this information. Little or no consideration has been given to how to display and interpret the data *from archaeological artefacts*, as opposed to from metalliferous ores. The traditional pairs of bivariate plots of the three isotope ratios (preferably ratioed to ^{204}Pb) work well for geological data, and potentially also for archaeological objects with no added lead or mixing of copper sources, but not necessarily for objects which may have such features. We have therefore reconsidered the way in which lead isotopes can be used archaeologically. The objective is less to match the objects to specific ores, but more to look for changes in the archaeological isotopic record, some of which may well be due to changes in ore source, while admitting other possibilities, such as mixing and recycling.

We have proposed a different set of three diagrams, which plot the inverse of the Pb concentration (1/Pb) in the object against its lead isotope ratio. This is similar to the method of presentation used for strontium isotope data, with the express purpose of being able to detect mixtures of two components. Although for lead there are three such diagrams (1/Pb vs ^{206}Pb/^{204}Pb, 1/Pb vs ^{207}Pb/^{204}Pb and 1/Pb vs ^{208}Pb/^{204}Pb) rather than one for Sr, this method has proved extremely useful in a wide range of cases, especially when lead has been deliberately added to the copper alloy. It provides a way of simultaneously displaying the concentration of lead in an object and its isotope ratio in the same diagram. If lead is added to a low-lead copper base to form an alloy, then the lead isotope signature will be dominated by that of the added lead, not the copper, since the concentration of lead in most smelted copper is low. Because the horizontal axis is inverse concentration, crudely speaking we can think of the right hand side of the diagram (with Pb concentration <1%) as representing unalloyed copper, and the left hand side as being deliberately added lead. Objects lying on the same horizontal line have the potential to come from the same source, or at least from sources sharing the same isotopic value.

The practice that developed in the 1990s of drawing '90% confidence ellipses' around data presented in an isotope ratio biplot to define an orefield has drawn much criticism. The use of Kernel Density Estimates has been shown to be much more robust in defining the actual distribution of an orefield, but has not been widely adopted until recently because of the lack of simple algorithms to perform the calculation. Kernel density estimates (KDEs) are a non-parametric way to convert continuous data into a smoothed probability density function. KDEs can easily generate a multi-dimensional visualisation to compare different datasets in a way that histograms cannot. A key additional capability is to test the degree of overlap between two distributions. Thus we can address the question of whether two sets of lead isotope data are likely to have come from the same or different sources, and also, by modelling, assess the likelihood that one particular distribution might have come from the mixing of two other distributions.

Data quality

It is inherent in the methodology described here that the bigger the dataset the more reliable will be the inferences derived from it, subject of course to the requirement that the assemblage (sample) is representative of the objects under consideration (population). It is this that has drawn us into considering the use of *legacy datasets* - chemical data compiled from published sources, but some of which may be old, and perhaps using now obsolete methods of analysis. The obvious alternative would be to restrict the analysis to only high quality modern data. However, this would probably reduce the volume of data available for Bronze Age Eurasia from approximately 100,000 analyses to fewer than 10,000, and would mean that vast areas would have no representative data at all. It would of course be ideal to initiate a new programme of chemical and isotopic analysis of Bronze Age metalwork to the highest possible standards, but the cost, time required and difficulties associated with obtaining sampling permission means that this is unlikely to happen in the near future. We are therefore presented with a dichotomy – either find a way of using a heterogeneous compilation of legacy data which gives the largest possible dataset, or use only high quality data but with fewer numbers and less geographical coverage. For a project which aims to cover all of the Eurasian Bronze Age, we have chosen the former.

The use of legacy chemical data compiled from published sources gives rise to the obvious concern of consistency between datasets. Apart from the fact that not all analysts report data on what we would regard the minimum set of elements (Cu, Pb, Sn, Zn, Fe, As, Sb, Ag, Ni), it is also well-known that some methods have systematic problems with certain elements. Moreover, virtually none of the published literature contains information on primary or secondary standards, levels of detection, precision, or accuracy. How, then, can such datasets be combined? We would argue that our approach to trace and alloying elements, starting with presence/absence, and then building on profiles of elements in assemblages, is *less* susceptible to the vagaries of inconsistent analytical data than those which use absolute values, such as cluster analysis and principal components. One further advantage we have is that we can often *identify* deviant sets of analysis by comparisons within the database, such as comparing the work of different analysts on similar sets of materials.

Our practice is to record the data exactly as published in the base layer of the database, and not to allow any modifications to this layer. We then generate a second layer to be used in calculations, where any obvious errors are corrected and also where any changes to remove non-numeric characters can be made, according to a specified protocol. One problem is that there is no uniformly accepted convention to differentiate between all the possible variations of 'trace', 'not determined', 'not detected' or just 'absent'. Similar considerations apply to the interpretation of entries such as 'tr', or semi-quantitative results such as '+', '++', '+++' etc. Some attempts have been made to convert these semi-quantitative recording systems into a quantitative scale, but they cannot be regarded as accurate.

FLAME case studies

The FLAME project team currently consists of Peter Bray, Peter Hommel, Laura Perucchetti, Ruiliang Liu, Yiu-Kang Hsu and John Pouncett. The FLAME methodology, or earlier versions of it, has now been applied to a wide range of geographical and temporal situations, most of which have been published. These include Bronze Age Britain and Ireland, Iran, the European Alps, Central China and the northern borders of China. Other published studies have focused on Roman and Anglo-Saxon Britain. Ongoing work includes the Bronze Age eastern Mediterranean, Anatolia and the Caucasus, as well as some work on Roman coins, Medieval European brass, and Chinese coinage.

FLAME and related publications:

Oxford DPhil Theses:

Bray, P.J. (2009). *Exploring the social basis of technology: reanalysing regional archaeometric studies of the first copper and tin-bronze use in Great Britain and Ireland*.

Cuénod, A. (2012). *Rethinking the bronze-iron transition in Iran: copper and iron metallurgy before the Achaemenid Period.*

Perucchetti, L. (2015). *Physical barriers, cultural connections: a reconsideration of the metal flow at the beginning of the metal age in the Alps.*

Hsu, Y.-K. (2016). *Dynamic flows of copper and copper alloys across the prehistoric Eurasian steppe from 2000 to 300 BCE.*

Liu, R. (2017). *Capturing changes: applying the Oxford system to further understand the movement of metal in Shang China*.

Howarth, P. (in prep.).

Journal articles:

Bray, P.J. and Pollard, A.M. (2012). A new interpretative approach to the chemistry of copper-alloy objects: source, recycling and technology. *Antiquity* **86** 853-867.

Bray, P.J. (2012) Before ^{29}Cu became *copper*: tracing the recognition and invention of metalleity in Britain and Ireland during the third millennium B.C. In M. Allen, J. Gardiner and A. Sheridan (eds.) *Is there a British Chalcolithic: people, place and polity in the later 3rd millennium.* The Prehistoric Society Research Paper 4: 56-70.

Pollard, A.M., Bray, P.J. and Gosden, C. (2014). Is there something missing in scientific provenance studies of prehistoric artefacts? *Antiquity* **88** 625-631.

Pollard, A.M., Bray, P., Gosden, C., Wilson, A. and Hamerow, H. (2015). Characterising copper-based metals in Britain in the First Millennium AD: A preliminary quantification of metal flow and recycling. *Antiquity* **89** 697–713.

Pollard, A.M. and Bray, P.J. (2015). A new method for combining lead isotope and lead abundance data to characterise archaeological copper alloys. *Archaeometry* **57** 996–1008.

Bray, P., Cuénod, A., Gosden, C., Hommel, P., Liu, R., Perucchetti, L. and Pollard, A.M. (2015). Form and flow: The 'karmic cycle' of copper. *Journal of Archaeological Science* **56** 202-209.

Ruiliang Liu, Peter Bray and A.M. Pollard (2015). Chemical analysis of ancient Chinese Bronzes: past, present and future. *Archaeological Research in Asia* 3 1–8, July 2015 (doi:10.1016/j.ara.2015.04.002).

Aurélie Cuénod, Peter Bray and A. Mark Pollard (2015). The 'tin problem' in the Near East – further insights from a study of chemical datasets on copper alloys from Iran and Mesopotamia. *Iran* **LIII** 29-48.

Perucchetti, L., Bray, P., Dolfini, A. and Pollard, A.M. (2015). Physical barriers, cultural connections: prehistoric metallurgy in the Alpine region. *European Journal of Archaeology* **18** 599–632.

Bray, P.J. (2016). The Saltonstall Early Bronze Age Axe, *Prehistoric Yorkshire* **53** 99-103.

Bray, P.J. (2016). Metal, metalwork and specialisation: The chemical composition of British Bronze Age swords in context. In Koch, J. (ed.) *Celts from the West III*, Proceedings of the AEMA Conference, Cardiff 2014. Centre for Welsh and Celtic Studies, University of Aberystwyth.

Yiu-Kang Hsu, Peter J. Bray, Peter Hommel, A. Mark Pollard and Rawson, J. (2016). Tracing the flows of copper and copper alloys in the Early Iron Age societies of the eastern Eurasian steppe. *Antiquity* **90** 357-375.

Pollard, A.M. (2016). The first hundred years of archaeometallurgical chemistry: Pownall (1775) to von Bibra (1869). *Historical Metallurgy* **49(1)** for 2015 (published 2016) 37–49.

Pollard, A.M., Bray, P., Hommel, P., Hsu, Y.-K., Liu, R. and Rawson, J. (2017). Applying the Oxford System to further understand Bronzes in China. *Kaogu* (In Chinese).

In Press:

Pollard, A.M., Bray, P., Hommel, P., Hsu, Y.-K., Liu, R. and Rawson, J. (in press). Bronze Age metal circulation in China. *Antiquity*.

Jin, Z., Liu, R., Pollard, A.M. and Rawson, J. (in press). Revisiting lead isotope data in Shang and Western Zhou bronzes. *Antiquity*.

Bray, P.J. (in press). Biography, prosopography, and the density of scientific data: Some arguments from the metallurgy of Early Bronze Age Britain and Ireland. In Armada, X.-L., Murillo Barosso, M., and Charlton, M. (eds) *Metals, minds and mobility: Integrating scientific data with archaeological theory*. Oxford: Oxbow Books

Perucchetti, L. (in press). *Physical Barriers, Cultural Connections: A Reconsideration of the Metal Flow at the Beginning of the Metal Age in the Alps*. Archaeopress Archaeology.

Submitted:

Pollard, A.M., Rawson, J. and Liu, R. (submitted). Some recently rediscovered analyses of Chinese bronzes from Oxford.

Pollard, A.M., Hsu, Y.-K., Liu, R. and Rawson, J. (submitted). Chinese bronzes: from alloy composition to alloying practices.

Yiu-Kang Hsu, Jessica Rawson, A. Mark Pollard, Qiang Ma, Feng Luo, Pei-Xuan Yao, Chuan-Zhou Shen (submitted). Charting metal supplies in late-prehistoric northern China: reflections from lead isotope analyses.

New trends and insights for archaeometallurgical research in East Asia and beyond: a brief summary report on metallurgical talks in the SAA 82nd meeting

Lam WengCheong (Department of Anthropology /History, Chinese University of Hong Kong)

The Society of American Archaeology annual meeting (SAA) is a major platform where archaeologists exchange information and idea of latest discoveries, methodology, and research frameworks. Although the society is mostly dedicated to the archaeological and heritage research, interpretation and protection[1] in the Americas, its annual meeting also attracts scholars worldwide to share and present their work as it relates to similar research themes and ideas from cross-cultural perspectives. The SAA meeting in Vancouver this year included several panels[2] focusing on the latest research in archaeometallurgy, in addition to a number of metallurgy-related presentations in different panels. Covering different regions and times, these talks offered some insights into new methods and frameworks for the development of archaeometallurgy in East Asia and beyond. Therefore, I report here three research trends summarized[3] from the presentations I attended, with the hope that the summary can foster additional information and idea exchange. For readers who are interested in some of these presentations, abstracts are available via the abstract archive online[4].

First, operation sequences in craft production and the identification of physical locations of production activities are widely considered as foundational in the study of craft production. With the help of advanced analytical equipment, e.g., portable XRF, several reports introduced fine-grained analyses to articulate the heterogeneity of metallurgical knowledge and source supply in a micro-regional scale that has not been fully recognized. For instance, Nathaniel Erb-Satullo (Space and Scale in Reconstructions of the Social Organization of Craft Production) introduced copper production in Georgia, Southern Caucasus, and the potential relationship between craftsmen and political control. Based on the ratio of Zn in slag from metal production sites, his report showed that production sites acquired raw materials from different geological occurrences, while within the same production site raw materials from different sources may have been utilized, indicating a dispersed distribution pattern of raw materials. Similarly, Mitch Hendrickson and his team (The Industry of Empire: Investigating the Spatial and Technological Organization of Angkorian Iron Production around Phnom Dek, Cambodia) employed on-site XRF analysis to study slag heaps in Angkor, which cover at least 22 sites dating between 10-20th centuries AD, and reported that ore sources were differentiated based on qualitative chemical variation. David Killick and Francis Hayashida's presentation (Lung-Powered Copper Smelting on Pampa de Chaparri, Lambayeque Department, Peru) also highlighted the new discovery of a copper smelting process through an in-depth metallurgical analysis of a case study in Northern Peru, which is different from previous case studies in the same region dating to the Sican period. Recently, archaeometallurgy research in Southern Anhui, Middle Yangtze River Valley, China, achieved significant results. New discoveries not only documented a series of smelting, melting and casting sites that might be independent from Bronze Age states in the Central Plains but also confirmed the local technological tradition of smelting copper sulphide ores[5]. Taking insights from these recent research projects, the investigation on micro-regional heterogeneity in terms of source-supply and technological choices appear to be a productive way to further explore local metallurgical traditions outside the arena of central dynasties.

Second, the internal organization of production sites and external association of production loci were other key themes attested at the SAA. For instance, via looking at clusters of production sites, Colleen Zori's presentation (Multiscalar Analysis of Copper and Silver Production under the Inka: A Case Study from Northern Chile) reported changes in the distribution of silver production sites from scattered to concentrated in northern Chile, which may indicate the strengthening of Inka control. Building on his previous ideas about holistic understandings of craft production, Izumi Shimada (Nested-Context Perspective of Craft Production: Middle Sican Metallurgy) proposed a new concept, "nested-context approach", to investigate the distribution of "series of linked contexts of increasing or decreasing inclusiveness or spatial extent, from activity and workshops to settlements in which they are housed and the surrounding region". Through the case of Sican metallurgy, Shimada used this framework to illustrate the importance of looking at locale associated with different procedures to re-construct the organization and social articulation of metal production. Via metallurgical analyses and metric measurement of bronze weapons from terra-cotta soldier pits, Li Xiuzhen's presentation (Casting Metal for the Qin Emperor and his Underground Empire) exemplified the pattern of "cellular production" (i.e., multiple units making goods at the same time) and challenged the assumption of "steam-line production". Thus, employing the "multi-scalar" and "multi-unit" perspective, the latest research draws our attention to the realistic interaction of different production units in the past and the organization of these production units in different regional context.

As discussant Cathy Costin remarked in one of these panels, we also need to raise concerns of overestimating the dimension of "proximity" in the interpretation of spatial data and the study of organization. Shimada's case in fact shows that the separation and decentralization of smelting and metal production clusters may have reflected a decision imposed from top-down by the central state; the correlation between disperse distribution and loose control is not always the case. Nonetheless, most metallurgy-related talks showed the importance of shifting the paradigm from mechanic reconstruction of production stages to the interaction of workers belonging to different stages and on different scales. In fact, there are rich data in Bronze Age China for more in-depth research on relations and association between different production units. As Li Yung-Ti's previous study[6] and presentation on Anyang bronze production illustrated, most bronze foundries in Anyang were under tight administrative control by the Shang court, and some of them can be characterized as "prescriptive production", i.e., workers just focused on a few steps of the entire production. In those bronze foundries in Anyang and later Western Zhou centers, to what extent could concepts like cellular production and nested-context approach be applicable in the analysis of organization? The interaction of different procedural workers in the same production unit will be an insightful aspect to explore and may contribute to a study on the social aspects of metal production from cross-cultural perspectives.

Last but not the least, some presentations emphasized the multidisciplinary and long-duration importance to integrate metallurgical studies in a broader social context. For instance, Vincent Pigott (Putting a "Human Face" on Prehistoric Mining/Metallurgical Communities in the Khao Wong Prachan Valley of Central Thailand) introduced the framework of the Thailand Archaeometallurgy Project. The aim of the project tries to foster more communication between experts in different fields, including metallurgy, paleoenvironment, biology, etc. in order to form a holistic view of the site. Because of the rich historical and ethnoarchaeological information in places like Mesoamerica and Andes, some talks mentioned the significance of using a *longue durée* perspective in approaching ancient metallurgy. For instance, Mary Van Buren (The Environmental Effect of Indigenous Smelting in the Southern Andes) introduced research into local silver smelting technology after the Spanish conquest. Even after the introduction of techniques from Europe, indigenous tradition (*huayrachinas*) still continued in places like Potosi to adapt to certain conditions of the local environment, which eventually left long term evidence in environmental records. Thus, the syntheses of technological analysis within long-duration and multidisciplinary perspectives addresses questions about not only the spread of technology but also the availability of technological choices among local workers. Echoing this research trend, recent ground-breaking metallurgical research on zinc and silver production during the late historical period in the Middle Yangtze River Valley[7] also significantly enhances knowledge about metal production. With the help of multi-disciplinary collaboration, especially within historical anthropology and its rich oral and chronicled records and collections, studies in China promise to contribute to the discussion about metallurgical research from a *longue durée* perspective.

With the employment of more advanced research methods and analytical skills, information about metallurgical technology is being accumulated at a rapid pace every year. Yet, besides updated factual information about the latest discoveries, intellectual inspiration and frameworks to synthesize data from different case studies and fields will offer new ways to illustrate the significant social meanings behind material culture associated with metal production. It is exactly the intention of the SAA conference to provide a platform to foster communications between scholars, exchange their ideas and engage in anthropological archaeology dialogue. The 82nd Annual Meeting did just that by inspiring theoretical frameworks, cross-cultural perspectives, and the brewing of new ideas to apply to future archaeometallurgical studies.

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[1] http://www.saa.org/Home/tabid/36/Default.aspx

[2] Symposia related to archaeometallurgy in 82nd SAA meeting include:

- Casting Empire: Metal Production in Early Imperial China
- Ancient Metallurgy in Mesoamerica: Local Expression and Interregional Connections
- Archaeometallurgy of The New World: Current Research, Approaches, and Methods
- Recent Developments in East and Southeast Asian Archaeology I: Material Culture Studies Spatial Approaches to Craft Production

Other metallurgy-related talks were scattered throughout, information for which can be found in the SAA program: http://www.saa.org/Portals/0/SAA/MEETINGS/2017%20Program/2017_SAA_Annual%20Meeting_Final%20Program.pdf

[3] The report will only briefly recap and summarize the presentation based on my notes and abstract.

[4] http://www.saa.org/AbouttheSociety/AnnualMeeting/SAAAnnualMeetingAbstractArchive/tabid/1422/Default.aspx

[5] Chen, Jianli 2014. *Exploration of the Metal Smelting and Casting Civilization in Ancient China*. Beijing: Science Press, p.99.

[6] Li, Yung-Ti 2007. Co-Craft and Multicraft: Section-Mold Casting and the Organization of Craft Production at the Shang Capital of Anyang. In *Craft Production in Complex Societies: Multicraft and Producer Perspective*, edited by I. Shimada, pp. 184-223. Salty Lake City: University of Utah Press.

[7] Chen, Jianli 2014. *Exploration of the Metal Smelting and Casting Civilization in Ancient China*. Beijing: Science Press, p.411-433.

RESEARCH OPPORTUNITIES

Call for Proposals: NSF Subsidized Projects At the Elemental Analysis Facility (EAF), The Field Museum, Chicago, IL (2016-2019)

Each March 15 and Sept. 15.

The Elemental Analysis Facility (EAF) at the Field Museum, Chicago, Illinois, is developing for the period 2016-2019, a NSF subsidized program to enhance outside collaborations in its LA-ICP-MS laboratory. Proposal must be received by March 15 and September 15, each year.

The EAF hosts a Thermo ICAP Q inductively coupled plasma-mass spectrometer (ICP-MS) and two laser ablation systems: a New Wave UP213 laser ablation (LA) system with a 5 cm x 6 cm chamber and a New Wave UP266, with an experimental adaptable chamber, dedicated to the study of large objects. Complementing the ICP-MS instrumentation, the EAF also hosts a LEO EVO 60 XVP Scanning Electron Microscope with an environmental chamber equipped with an Oxford Inca Energy Dispersive Spectroscopy system, two portable XRF systems and a digital imaging petrographic microscope.

This NSF funded program aims at facilitating the access of the EAF to researchers and students by offering funding to offset 2/3 of the LA-ICP-MS analytical costs. Researchers should indicate whether they will be in residence at the Museum to run their samples, or whether they are requesting Museum staff to undertake the analysis. In some cases, students from outside the Chicago area are eligible for limited funding for travel and accommodation. Students requesting travel funding should submit a travel budget.

A panel including outside and Field Museum scholars will review proposals. All parties who wish to undertake a collaborative project in the lab should forward a short proposal (4 pages) for consideration. The proposal should address the research problem, the size of the specimens, and the type, number, and contexts of the samples, whether the scholar will be in residence and travel budget if appropriate. Curriculum vitae for the principal collaborator(s) should also be included. You should inquire with Laure Dussubieux, lab manager, before submitting any proposal at ldussubieux@fieldmuseum.org.

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NEWSLETTER OF THE SOCIETY FOR ARCHAEOLOGICAL SCIENCES

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Publication and mailing expenses for the SAS Bulletin have generously been donated by the College of Letters, Arts, and Social Sciences (CLASS), California State Polytechnic University, Pomona, California.

Published quarterly by the Society for Archaeological Sciences
Distributed to subscribers: $20/yr regular membership (electronic); $25/yr regular membership (paper);
$15/yr student and retired (electronic); $20/yr student and retired (paper); $35/yr institutional; $300 lifetime.
Individuals add $115/yr for *J. of Archaeological Science*; $45/yr each for *Archaeometry* and *Archaeological & Anthropological Sciences*.
ISSN 0899-8922.