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Hominin Food for Thought

As we approach the 50th anniversary of Mary Leakey's famous discovery of "Zinj" (July, 1959) at Olduvai Gorge, now is the perfect time to think about what half a century of research has taught us about australopithecines and other early hominins.

Long thought to have gone extinct because of their specialized low-nutrient/high-fiber diets, early hominins are now believed by some to have had more diverse eating habits. New research—reported in this special thematic issue of the *Bulletin*—indicates a great deal of variation within the diets of individuals, even from those within a single species.

In this issue, there are five research articles that summarize recent findings on early hominin diet. First, Marion Bamford considers evidence from fossil macroplants and other sources to suggest that a suprisingly diverse array of edible plant species would have been available to early hominins. Then, Lucinda Backwell and Francesco d'Errico tell us what we can learn



"On the other hand, three out of four food groups should be plenty, right?" www.cartoonstock.com

Never biting off more than they could chew: Paranthropus were once thought to be picky eaters (preferring tough, fibrous foods), because of their robust jaws and giant molars. Now scientists believe they had a well seasoned palette that welcomed grasses, roots, fruits, nuts, and leaves. about early diets from studying bone tool implements. Next, Nick van der Merwe and colleagues provide interesting new stable isotope data indicating the relative amounts of C_3 and C_4 plants consumed. Peter Ungar then shows us what hominin teeth look like under different feeding adaptations. And finally Jessica Thompson and Curtis Marean present a comparative perspective by considering more recent Middle Stone Age subsistence strategies using GIS image analysis.

The picture that is emerging from these different datasets shows that early hominins had wide knowledge of their environment and the resources they could (and probably did) exploit. It looks as though early hominins did not always consume only what their mouths were designed for.

This work is exciting and relevant, because it suggests that hominins evolved larger brains and experienced a longer period of juvenile development to adapt to the challenges of a complex foraging lifestyle. It also offers a cautionary tale that skeletal morphology may not always directly indicate food choices.

Surely, this new information about diet provides a great deal more for us to chew on (sorry, I couldn't resist!). These and similar studies in paleobiology and paleoecology unambiguously make the point that ancient diet is one of the keys needed to unlock the mystery of our evolutionary history.

E. Christian Wells, Editor

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Employment Opportunities

Research Assistant in Material and Natural Sciences Applications to Archaeology. The Science and Technology in Archaeology Research Center (STARC) of the Cyprus Institute, a research and educational institution based in Nicosia, Cyprus, has been awarded a number of EU and national research projects in the fields of Digital Heritage and of Material and Natural Sciences Applications to Archaeology. The Center is seeking applications from individuals with strong scientific, technical, and organizational skills to participate in such projects, with the requisites described below. Positions will have a duration variable from 18 to 48 months depending on the length of the related project, but may be extended according to needs and quality of the work done. For all the positions, proficiency in spoken and written English is mandatory. Successful candidates will assist the Center's researchers in the activity envisaged in related projects as well as developing their own research activities under the supervision of one of the Center's Research Coordinators. They are also expected to contribute actively to the reporting of the projects they are involved in, and in the preparation of forthcoming grant proposals to national and international funding agencies. For the position candidates must have at least a relevant university degree and proven research experience. Specific analytical skills within one or more of the following fields is an advantage: Applications of material and natural sciences to archaeology and cultural heritage; Human bioarchaeology, physical anthropology, palaeopathology, osteology; Archaeometallurgy. The salary will depend on the experience and qualifications of the successful candidates and will be in the range of 20.000 to 30.000 €/year. The position includes full social security insurance and the other benefits offered by CyI to its staff. Work is full time and will be carried out in Nicosia or other locations in Cyprus. All applications should be accompanied by a letter of motivation, a CV including the date of earliest availability, a list of publications and the names and contact details of three contactable referees should be submitted by May 31, 2009 via e-mail to jobs@cvi.ac.cv quoting ref. STARC-EU/04 for the research assistant position. For the CV, candidates must use the EuroPass template, which is available for download at: http://europass.cedefop.europa.eu/ europass/home/hornav/Downloads.csp.

Post-Doctoral Fellow in Material and Natural Sciences Applications to Archaeology. The Science and Technology in Archaeology Research Center (STARC) of the Cyprus Institute, a research and educational institution based in Nicosia, Cyprus, has been awarded a number of EU and national research projects in the fields of Digital Heritage and of Material and Natural Sciences Applications to Archaeology. The Center is seeking applications from individuals with strong scientific, technical, and organizational skills to participate in such projects, with the requisites described below. Positions will have a duration variable from 18 to 48 months depending on the length of the related project, but may be extended according to needs and quality of the work done. For all the positions, proficiency in spoken and written English is mandatory. Successful candidates will assist the Center's researchers in the activity envisaged in related projects as well as developing their own research activities under the supervision of one of the Center's Research Coordinators. They are also expected to contribute actively to the reporting of the projects they are involved in, and in the preparation of forthcoming grant proposals to national and international funding agencies. For the Post-Doctoral Fellow position candidates must have a doctoral degree or equivalent research experience. Successful candidates should have proven experience in most or all of the following areas: Collaboration in large funded projects; Survey and collation of information on research infrastructures; Report writing within the framework of national and/or EU funded projects; Organizing international workshops and conferences; Networking in an international academic environment, including experience in international research networks. Specific analytical skills within one or more of the following fields is an advantage: Applications of material and natural sciences to archaeology and cultural heritage; Human bioarchaeology, physical anthropology, palaeopathology, osteology; Archaeometallurgy. The salary will depend on the experience and qualifications of the successful candidates and will be in the range of 25.000 to 35.000 €/year. The position includes full social security insurance and the other benefits offered by CyI to its staff. Work is full time and will be carried out in Nicosia or other locations in Cyprus. All applications should be accompanied by a letter of motivation, a CV including the date of earliest availability, a list of publications and the names and contact details of three contactable referees should be submitted by May 31, 2009 via e-mail to jobs@cyi.ac.cy quoting Ref STARC-EU/01. For the CV, candidates must use the EuroPass template, which is available for download at: http:// europass.cedefop.europa.eu/europass/home/hornav/ Downloads.csp.

SUNY Potsdam invites applications for a full-time biological or medical anthropologist or bioarchaeologist for a temporary replacement in the 2010 spring semester. The Department of Anthropology has an active five-field program with majors in Anthropology and Archaeological Studies, and eleven faculty members. Required qualifications: ABD in biological or medical anthropology. Preference will be given to candidates with a PhD in biological or medical anthropology. For full consideration, applicants must apply on-line at employment.potsdam.edu by September 30, 2009. Responsibilities include: teach an introductory physical anthropology course with lab, and two upper division courses in biological and/or medical anthropology (Human Osteology, Archaeology of Death, Nutritional Anthropology, Paleoanthropology, Forensic Anthropology, and Anthropological Genetics are all options), demonstrate excellence in undergraduate teaching, and have an active research program with potential for undergraduate student involvement. Additionally, the candidate must be committed to interdisciplinary learning, the application of new technologies in teaching and scholarship, and the preparation of students for life in a diverse and rapidly changing society. For more information, visit www.potsdam.edu/academics/AAS/Anthro.

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Kenyon College seeks a Visiting Assistant Professor of Anthropology. This position involves working closely with undergraduates on the Kenyon-Honduras Program, an offcampus semester of study in Latin American archaeology, cultural anthropology, and history. The successful candidate will accompany the directors for that spring's program and teach 1 course. In addition to salary, all living and transportation costs will be paid by the program. The successful candidate would then teach full-time for the academic year of 2010-11. The teaching load would include one or two follow-up courses during Fall (depending on program enrollments) 2010 in which s/he would help the Kenyon-Honduras participants describe, analyze, and write-up the results of their field work; two introductory archaeology courses; and one or two upper level courses in New World archaeology and the candidate's specialty, for a maximum of five courses. The area of specialization is Latin American archaeology, with a preference for a specialist in Mesoamerica. A Ph.D. is preferred; ABD will be considered.

Digital Antiquity Seeks a Founding Executive **Director**. Digital Antiquity seeks an entrepreneurial and visionary individual who can play a central role in transforming the discipline of archaeology by leading the establishment of an on-line repository of the digital data and documents produced by archaeological research in the Americas. The Digital Antiquity initiative, generously funded by the Andrew W. Mellon Foundation, seeks to hire an Executive Director to lead the development of a financially and socially sustainable, national/ international, on-line digital repository for the documents, databases, images, and other digital data produced by archaeological research. The repository will secure the longterm preservation of these data and provide enormously enhanced access to them. By allowing archaeologists to leverage the results of previous research in ways that have never before been possible, Digital Antiquity has the potential to truly transform the practice of archaeology and our ability to understand the past. Digital Antiquity is a national initiative that, during its startup phase, resides within Arizona State University but is expected to become financially secure and spun off as an independent non-profit in 4-5 years. Until this transition, the Executive Director will hold the position of Research Professor in ASU's School of Human Evolution and Social Change (formerly, Department of Anthropology) with a joint appointment in the University Libraries. The Executive Director reports to the Digital Antiquity Board of Directors. This is a 12 month, renewable appointment with excellent benefits and an attractive salary and rank (Assistant, Associate, or Full) commensurate with experience. A fixed term secondment or IPA (paid transfer from another permanent position) might also be considered. The position requires relocation to the Phoenix area of central Arizona. The Executive Director will oversee all Digital Antiquity activities, including hiring and supervising the Digital Antiquity staff, marketing the repository services to the professional community, specifying functional requirements of the repository, guiding software development and the acquisition of repository content, and setting standards for quality of repository data, metadata and

services. The Executive Director will work with the Board of Directors and Science Board to achieve the initiative's goals. We seek an entrepreneurial individual who can bring strong leadership and sound business judgment to this initiative. The individual should be poised to take on a major challenge and to quickly acquire needed expertise in unfamiliar areas. The position requires collaboration with computer scientists and informatics professionals as well as substantial interactions with government, consulting, academic, and museum archaeologists and with the institutions responsible for requiring, funding and permitting archaeological projects. We will consider individuals with a range of backgrounds and experience. A graduate degree in informatics, archaeology, anthropology, business, or a related field is required. A PhD is desired. Candidates must have experience in business, archaeology (particularly consulting or government archaeology), informatics, or ideally, some combination thereof. Applicants must have demonstrated leadership skills; a successful and entrepreneurial management record is desired. While an understanding of the U.S. cultural resource management compliance process is desirable, we welcome applications from outside the US. Interested individuals should submit, in electronic form, a letter of application, a résumé or curriculum vitae, and names and contact information for three references to Prof. Sander van der Leeuw, Chair, Digital Antiquity Board of Directors, SHESC - Box872402, Arizona State University, Tempe, AZ 85287-2402 (vanderle@asu.edu). For more information please see http:// digitalantiquity.org or contact Keith Kintigh (kintigh@asu.edu).

Awards, Fellowships, and Training

The Summer Institute in Museum Anthropology (SIMA) is a new program offered by the Department of Anthropology at the Smithsonian Institution's National Museum of Natural History with major funding from the Cultural Anthropology Program of the National Science Foundation. The program seeks to promote broader and more effective use of museum collections in anthropological research by providing a supplement to university training. Working intensively each summer with 12-14 students interested in museum research, the institute will: introduce students to the scope of collections and their potential as data, provide training in appropriate methods to collect and analyze museum data, make participants aware of a range of theoretical issues relating to collections, and position students to apply their knowledge within their home university. The curriculum, including both seminars and hands-on workshops, will teach students how to navigate museum systems, select methods to examine and analyze museum specimens, and explore the wealth of theoretical issues that museum data can address. Topics will include the critical analysis of documentation, the development of observational skills, the definition of appropriate data sets, and reconstruction of the "social life" of objects. Unique Smithsonian resources such as the annual Folklife Festival, the

National Anthropological Archives, the Human Studies Film Archives, and the Museum Conservation Institute will contribute to units exploring the integration of museum-based data with other types of information, whether community fieldwork, critical reading of film and video, or technical analyses of materials. Click to view sample lesson plans. Much learning will center on individual research projects that each student will propose as part of the application process. Over the course of the training, students will engage in initial data collection and will continually rework their project proposals, based on increased understanding of the nature of museum data and construction of a research question. The final product will be a refined, sophisticated prospectus for a research project suitable for implementation upon return to their home university. Smithsonian collections are an integral part of the training. The primary resource will be Dept. of Anthropology Ethnology Collection and related materials in the National Anthropological Archives and the Human Studies Film Archives. Students will be able to explore issues and develop projects on any topic for which there are relevant collections. Explore the databases. The program is intended for graduate students preparing for research careers in cultural anthropology who are interested in using museum collections as a data source. The program is not designed to serve students seeking careers in museum management. Students at both the masters and doctoral level will be considered for acceptance. Students in related interdisciplinary programs (Indigenous Studies, Folklore, etc.) will be considered if the proposed project is anthropological in nature and if an anthropology faculty member at the student's university commits to supervise its implementation. All U.S. students are eligible for acceptance, even if studying abroad, as are international students enrolled in universities in the U.S.A. Full information including application instructions and dates is available at http://anthropology.si.edu/summerinstitute.

INQUA are pleased to announce that Nominations are invited for the Sir Nicholas Shackleton Medal, which is awarded to an early-career scientist, who will normally be under 35 years of age, working in any branch of Quaternary science. In principle, any scientist working in the field of Quaternary sciences may propose an appropriate candidate for the Sir Nicholas Shackleton Medal, but see the nomination form on the INQUA website. Proposals should include a summary and a short personal statement in support of the candidate, the curriculum vitae and list of publications of the nominee, and two letters of recommendation (see details on the nomination form). Proposals should be submitted electronically to both the Secretary-General of INQUA and the Chair of the Award Committee. All nominations will be acknowledged, and nominators are advised to request such confirmation if it is not received. The deadline for the current round is 31st July 2009 and no late proposals will be considered. Proposals will be forwarded to an Evaluation Group composed of eminent Quaternary scientists, who will consider each case in confidence and may seek further information if it is deemed necessary. After completion of the evaluation, the Chairperson of the Evaluation Group will send the recommendation of this Group, together with a one page summary and a two-line citation

of the selected candidate, to the Secretary-General of INQUA. The Secretary General will prepare and forward the necessary documents and citations to the Executive Committee members for final approval. The President of INQUA will then inform the medalist of the award by the end of November 2009. The medalist will be invited to the next General Assembly of the Union, where the medal will be presented. Closing date for receipt of nominations is 31st July 2009. A nomination form is available on the INQUA website at: http://www.inqua.tcd.ie.

Conference News and Announcements

European Meeting on Ancient Ceramics. The UCL Institute of Archaeology and the British Museum are proud to organize the tenth anniversary European Meeting on Ancient Ceramics (EMAC), to be held at the British Museum in London from the 10-13 of September, 2009. We are committed to make this EMAC especially inclusive, therefore we also solicit contributions from non-European countries, and on non-European ceramics. International keynote speakers include Ian Freestone, Clive Orton, Hector Neff, Venetia Porter and Prudence Rice. The main focus of EMAC is the scientific study and archaeological interpretation of ancient ceramics. Bringing together established scholars and young researchers from a wide range of academic backgrounds, including ceramic petrologists, chemists, material scientists, geologists, archaeologists and art historians, EMAC stimulates an international and cross-faculty exchange of ideas and approaches. London's EMAC '09, coinciding with Wedgwood's 250th anniversary, will have a special themed session "From Craft to Science", to promote and discuss the study of ceramics produced in the wake of the Industrial Revolution. The following themes will be covered as well: Technology and provenance, Methodological developments, Dating, Technical ceramics, Building materials, Islamic ceramics, and Residue analysis. All delegates will receive a copy of the volume that will be published with peer-reviewed conference papers. For further information, registration and submission of abstracts please visit the following website: www.ucl.ac.uk/EMAC09.

5th International Congress on the Application of Raman Spectroscopy in Art and Archaeology (RAA2009-Bilbao), Bilbao, Spain, September 14-18, 2009. This series of conferences has a long tradition, starting in London, and following in Ghent (2003), Paris (2005) and Modena (2007). The venue has been set in the Fine Arts Museum of Bilbao, which is currently one of the main painting and sculpture museums of Spain. Topics for the 2009 conference include: Contamination affecting the Cultural Heritage (decaying, corrosion, etc.); Material characterization and degradation processes (pigments, inks, new materials, gemstones, stones, precious stones, glass, ceramics, etc.); Raman spectroscopy in palaeontology and palaeoenvironment; New Raman instrumentation and applications (combined with other techniques, imaging and mapping, etc.); Chemometrics in Raman spectroscopy; Raman spectroscopy of biological and organic materials (resins, fibers); Forensic applications in art and archaeology; Industrial archaeology. Authors may submit a maximum of 2 abstracts per attending person and only one of them will correspond to an oral presentation. Abstract submission is open already and the deadline is set on: 30th of April 2009. Please indicate whether you request an oral or a poster presentation. Final decision on this will be taken by the Scientific Committee. All the information required about the 5th International Congress on the Application of Raman Spectroscopy in Art and Archaeology is offered on the website of the congress: http://www.RAA2009.org.

Archaeological Sciences of the Americas Symposium 2009 is soliciting paper and poster presentations. The conference will be held at the Hyatt Regency in Tampa, Florida from October 2-4 2009. The goal of the symposium is to address and discuss issues pertaining to the science of prehistoric and historic materials. This symposium traditionally focuses on the archaeology of the Americas; however professionals and students engaged in projects outside the Americas are also encouraged to submit abstracts. We are accepting abstracts for both paper and poster presentations. The symposium is open to students, academic faculty and professionals working in independent and government settings. Please forward this message to others who might be interested. Abstracts are limited to 250 words and the submission/payment deadline is 7 August 2009. Paper presentations will be limited to 20-25 minutes. Please submit abstracts electronically in pdf or word format via e-mail to the following address: asas2009symposium@gmail.com. Snail mail abstracts will be accepted at the address listed below. The fee due for abstract submission includes registration and the general fees for the symposium. Rates for students are \$60 and professionals \$90. Payments may be made online with Paypal through the conference website, http://www.anthro.fsu.edu/news/ asas2009. If you are unable to pay online, registration fees can be paid with checks payable to: Archaeological Sciences of the Americas Symposium 2009. Send checks to: Archaeological Sciences of the Americas Symposium 2009, Florida State University Dept. of Anthropology, 1847 West Tennessee St., Tallahassee, FL 32306-7772. Rooms will be available at the Hyatt Regency Tampa for a reduced rate from 1-3 October for conference participants. To reserve these special-rate rooms please go to http://tamparegency.hyatt.com/ groupbooking/tpartsoci2009. For further session questions or more symposium information, please contact us at asas2009symposium@gmail.com or go to http:// www.anthro.fsu.edu/news/asas2009.

4th International Congress of Chemistry and Environment (ICCE-2009) is being held in year 2009 from 30th Oct. to 1st Nov. 2009 at Tianjin (Near Beijing), China, on the theme of "Agriculture and Environment" along with all broad fields related to chemical sciences, agricultural sciences, soil sciences and environmental sciences. Research Journal of Chemistry and Environment is one of the main sponsors of the conference along with Institute of Agro-Environmental Protection, Ministry of Agriculture, China. ICCE-2009 will be a major forum for international researchers and professionals to present their latest research, results and ideas in all areas of Agriculture and Environment. ICCE-2009 aims to strengthen relation between industry, research laboratories, governmental agencies, private sector and universities on the focal theme Agriculture and Environment. For more information, email conference@chemenviron.org.

American Schools of Oriental Research Annual Meeting, Nov. 18-21, 2009, New Orleans, LA, Session -Artifacts: The Inside Story. This session welcomes submissions in which the analysis of Near Eastern and Eastern Mediterranean artifacts by means of physical or chemical techniques has led to a new or re-interpretation of the archaeological record. Paper topics include provenance, materials characterization, raw material acquisition, workshop activity, manufacturing techniques, and ancient technology. One session is planned for 4-5 speakers. Papers will be limited to 20-25 minutes. Abstracts are limited to 250 words and can be emailed to Elizabeth Friedman, friedman@iit.edu, or Heather Snow, heatherysnow@yahoo.ca. Deadline for abstracts is March 1st, 2009 but the session chairs would welcome them sooner. Please check the ASOR website for membership and participation requirements: http://www.asor.org.

Archaeometallurgy: Technological, Economic, and Social Perspectives in Late Prehistoric Europe, Centro de Ciencias Humanas y Sociales, Madrid, Spain, 25-27 November, 2009. Research on the Bronze Age in Europe has been strongly influenced first by the consideration that metallic objects are the main chronological and cultural markers for periodization and, later on, by the idea that metallurgical activities are related to concepts such as "specialization", "social complexity" and "trade". Since the last decades of the 20th century, other questions have also been posed, these include the importance of the context in which this technology was adopted, as well as technological change conceived from a double perspective: internal and external to metal production. The internal perspective explains the change within the technological system itself: what shifts occur and how they occur due to pre-existing knowledge and innovations. The external one tries to answer the question "why does it change?" by looking at the society, the economy and the politics in which the technology works, acting as factors that unleash this change through innovation and adoption mechanisms. The scientific meeting will take place in Madrid from the 25th to the 27th of November 2009 and it is organized by the Centre for Human and Social Sciences (CCHS) of the Spanish National Research Council (CSIC) of Madrid. The conference will schedule six sessions discussing the following topics: Technological change; Craft specialization and organization of production; Exchange and/or trade of raw materials and objects; Technology and experimental archaeology; Function and use of metal; and Environmental impact of the mining and metallurgical activity. For more information, visit the conference website, http:// www.ih.csic.es.

Foods Available to Early Hominins

Marion K. Bamford Bernard Price Institute for Palaeontological Research, University of the Witwatersrand

The diet of early hominins is of great interest to scientists and non-scientists alike. Food occupies a great deal of time today, and probably even more so in the distant past. Not only is it a necessary commodity, but it is also an important social aspect of our lives. Nutrition is critical for survival of all life forms. Without the sophisticated food storage facilities or means of transport we take for granted, early hominins had to find, collect, and later process their foods, and so would have had to live close to their food sources. This behavior is important in the evolution of humanity, but there are still many unknowns.

Were the nutritional requirements and digestive abilities of the australopithecines the same as modern humans or closer to chimpanzees or baboons? Much work has been done to try to answer this and other questions, for example using light isotopes, food values, tooth morphology, tool use and tool residue analysis. The literature on plant foods consumed by modern humans is also vast but it is difficult to combine the two and get some consensus on dietary requirements. Nonetheless there are a few facts that are not contested: hominins needed vegetable and animal food all year round; they had to forage, scavenge or hunt for the food themselves; and they would have lived where these foods were available and when they were available.

Looking at the problem from the opposite view we can consider what plant foods were *available* where we know early hominins lived by looking at the fossil plant remains. We do not know if these plants were eaten by hominins or primates, but if they were present they can be considered as potential vegetable foods. As part of multidisciplinary research programs at various sites in East and South Africa I have collected and identified the fossil plant material, mainly to reconstruct the palaeoenvironment but the question of food frequently arises.

Fossil macroplants from various early hominin sites have been identified, and using the nearest living relative approach, the palaeovegetation has been proposed. Then using the literature on modern plants that are eaten by humans and primates is the first step to identify available foods at fossil locales. Eventually the palatability, digestibility, nutritional value and seasonal availability of the plants can be analysed and finally the relative importance of the food can be determined, for example staple food, preferred food, drought food, or seasonal food, can be estimated.

Fossil macroplants have been recovered from only a few early hominin sites, and only Sterkfontein, Laetoli, Koobi Fora and Olduvai Gorge will be discussed here. It must be remembered that plants are usually fragmented and then preserved but they can be identified from one of the parts, for example the leaves, wood, fruit or the seeds. Although the edible part of the plant has not necessarily been preserved we can assume that the whole plant was present even if only one part of it has been preserved.

Fossil wood fragments from Member 4 of the Sterkfontein Cave have been identified as Dichapetalum mombuttense (a liana) and Anastrabe integerrima, (a shrub) (Bamford, 1999). Neither of these species has been recorded as edible, but they indicate the presence of a gallery forest, which is likely to have had some edible plants. From the Upper Laetolil Beds at Laetoli in Tanzania silicified woods, seed casts and leaf impressions have been recovered from Tuff 7 (3.8-3.5 Ma) and identified (Bamford in press a, b). Australopithecus afarensis is the hominin from these deposits. Contemporaneous plants (that are eaten today by humans) include the roots of Boscia coriacea (fossil seeds preserved; Figure 1), the fruits of Ximenia caffra or X. americana (fossil seeds) and fruits of Cryptocarya sp. (fossil seeds). Basal culms of a large sedge (Cyperaceae) have also been recovered and many of these are edible for humans, primates and mammals all year round. Many of the fossil woods are poorly preserved and have been identified to the family level only (Araliaceae, Celastraceae, Dichapetalaceae; Euphorbiaceae, Flacourtiaceae, Meliaceae, Mimosaceae), Myrtaceae, Ochnaceae, Rhamnaceae, Rubiaceae, Verbenaceae). All these families have a number of edible species (either fruits, seeds, leaves or roots) but at this stage it is only conjecture that the fossils may have represented the edible taxa.

From Olduvai Gorge fossil wood of Guibourtia coleosperma has been recovered from lower Bed II (Figure 2). The seeds, and arils in particular, of this large shade tree are a favourite food of humans and primates (Coates Palgrave 2003). Sedge culms occur in abundance in upper Bed I and lower Bed II (Figure 3). The rhizomes and culms of many sedge species

 Figure 1. Silicified seeds from the Upper Laetolil beds, Laetoli, Tanzania: probably *Bascia coriacea*. The fossil seeds are white

Figure 1. Silicified seeds from the Upper Laetolil beds, Laetoli, Tanzania: probably *Boscia coriacea*. The fossil seeds are white and the modern seeds are in the open fruit; dark fruits are modern.





Figure 2. Transverse section of a thin section of silicified fossil wood from Olduvai Gorge, Tanzania, *Guibourtia coleosperma* (Caesalpiniaceae). Large circles are the vessels and vertical lines are the rays. Seeds and arils of this tree are a favored food of humans.

provide starchy food all year round (Haines and Lye 1983, Peters et al., 1992; van der Merwe et al., 2008) and I think this plant group has been greatly underestimated as a staple food. A C4 diet signature does not necessarily mean that the food was C4 grasses. Many sedges are C4.

The Upper Burgi Member of the Koobi Fora Formation in north eastern Kenya has many silicified woods representing some species with edible food parts. For example, Drypetes sp. wood (Euphorbiaceae) – some species of this genus have edible fruits (Peters et al., 1992), Pancovia laurentii (Sapindaceae) fruits are edible, Acacia sieberiana (Mimosaceae) seeds and gum are edible (Fox and Young, 1982; Peters et al., 1992). The younger Okote Member at Ileret (ca. 1.5 Ma) also has silicified woods associated with the early hominin, possibly Paranthropus sp. The woods represent families with edible species (seeds, or leaves or gum or roots), such as the Burseraceae, Malvaceae and Palmae. More direct evidence is from the Afzelia spp. (Caesalpiniaceae) with the fruits and seeds of A. africana, A. pachyloba and A. quanzensis being eaten by humans and primates (Peters et al., 1992). Drypetes sp. occurs here too as does Pancovia sp. Ziziphus mauritiana (Rhamnaceae; Figure 4) fossil wood indicates the presence of this tree that has edible and thirst-quenching fruits (Peters et



Figure 3. Cross section of a triangular sedge culm from Lower Bed II, Olduvai Gorge, Tanzania. Rhizomes of some sedges are starchy, nutritious and very palatable.



Figure 4. Transverse section of a thin section of a silicified wood from the Okote Member, Koobi Fora Formation, near Ileret, Kenya, *Ziziphus* sp. Fruits of most species of this genus are edible.

Fox, F.W., Young, M.E.N., 1982. Food from the Veld. Edible wild plants of southern Africa. Delta books, Pty. Ltd,

- Johannesburg. Peters, C.R., O'Brien, E.M., Drummond. R.B., 1992. Edible Wild plants of Sub-Saharan Africa. Royal Botanical Gardens, Kew.
- Van der Merwe, N.J., Masao, F.T., Bamford, M.K. 2008. Isotopic evidence for contrasting diets of early hominins Homo habilis and Australopithecus boisei of Tanzania. South African Journal of Science 104, 153-155.

Bone Tools and Early Hominin Diet

Lucinda Backwell Bernard Price Institute for Palaeontological Research, University of the Witwatersrand and Francesco d'Errico University of Bordeaux & Institute for Human Evolution, University of the Witwatersrand

Bone tools are proving to be a valuable source of information to researchers interested in early hominin diet and cognition. Our current state of understanding is that two early hominin bone tool cultures existed in Africa between one and two million years ago. Bone tools from Olduvai Gorge Beds I-II in east Africa consist mainly of freshly broken bones from very large mammals, modified by flaking and probably used for large mammal carcass processing (Leakey 1971). A few pieces record multiple impact scars interpreted as anvils (Shipman 1989) and single session hammers (Backwell & d'Errico 2004) used on intermediate stone tools, most likely wedges to split bones, fruit or wood (Figure 1). The South

Figure 1. Selection of bone tools from Olduvai Gorge bearing evidence of intentional flaking, battering and abrasion. Scale = 1 cm.

al., 1992). Blighia unijugata (Sapindaceae) has edible fruits (Peters et al., 1992). Of the nine fossil woods positively identified from the Okote Member four species produce fruits that are known to be eaten by humans today, four have closely related species with fruits, seeds, leaves or gum that are eaten by humans today, and the potential food properties of the ninth one is unknown.

Pollen and phytolith studies of sediments from early hominin sites also indicate the regional and local flora so the availability of vegetable foods can be gleaned from these records. There is some bias in preservation of macro-remains or micro-remains, for example at Olduvai Gorge there are no macro-remains of palms but the pollen and phytolith records show their presence (Bonnefille, 1984; Albert et al., 2009). Once all the botanical data are combined we will have a better picture of palaeoecology of the various sites. Available edible foods combined with the light isotope analysis of hominin teeth and bones and residue analysis on tools will help in determining early hominin diets.

Although "nutcracker man" may have been able to crack nuts with his teeth, he might well have eaten many other plant foods as well, especially since fruits and nuts are very seasonal and there is no evidence of hibernation or winter storage of food stuffs.

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African tools from Sterkfontein (Robinson 1959), Swartkrans (Brain & Shipman 1993) and Drimolen (Backwell & d'Errico 2008) consist of long bone shaft fragments and horn cores of medium- to large-sized bovids (Figure 2), collected after weathering and used in specialised activities, the nature of which is a topic of ongoing debate.

The identity of the early hominin bone tool users is also an unresolved issue, with four candidates known between 1-2 Mya. The remains of Paranthropus boisei are found in east Africa, whilst those of Paranthropus robustus occur in South Africa. Based on their highly derived cranio-dental features, robust australopithecines are interpreted as vegetarians, and are not traditionally considered as tool users following the discovery of Homo habilis at Olduvai Gorge (Leakey et al. 1964). Tool making and use is generally considered a preserve of the genus *Homo*, represented throughout Africa by *H*. habilis and H. ergaster, and their associated Oldowan and Acheulian industries. Recent research on Paranthropus robustus dentition, including stable light isotopes (e.g. Lee-Thorp et al. 1994, 2000; Lee-Thorp & van der Merwe 2004; Sponheimer et al. 2005a,b, 2006) and dental microwear analysis (Grine & Kay 1987; Ungar & Grine 1991; Scott et al. 2005), together with the study of associated bone tools (Brain & Shipman 1993; Backwell & d'Errico 2001, 2008; d'Errico



Figure 2. Selection of bone tools from Swartkrans (top row) and Drimolen (bottom row) in South Africa. Lines indicate a cropped image. Scale = 1 cm.

& Backwell 2003, 2009; van Ryneveld 2003) reveals a more complex diet and behavioural repertoire than previously thought.

The site of Swartkrans has yielded 68 fossil bone tools from Members 1-3, dated ca. 1.8-1 Mya, which Brain & Shipman (1993) have interpreted as tools used to excavate underground storage organs and work skins. We reappraised the function of these pieces using a multiple approach study based on data provided by microscopic, taphonomic and morphometric analysis of the purported bone tools, faunal material from the remainder of the assemblage, and experimentally and naturally modified bone. Replicas were made of the worn areas of fossil tools, experimentally utilised implements and comparative collections for microscopic analysis. We used a scanning electron microscope to analyse and compare the wear patterns, and studied the replicas under transmitted light, taking digital images that were analysed using microwear image analysis software to quantify the length, width and orientation of striations. We found that the fossil bone tool striations were consistently narrow and oriented parallel or subparallel to the bone main axis, and that the most similar pattern observed was that resulting from experimental digging in termite mounds (Figure 3). Based on these results we proposed termite foraging as the most probable function for the Swartkrans early hominin bone tools (Backwell & d'Errico 2001, 2003; d'Errico & Backwell 2003; d'Errico et al. 2001).

In our most recent contribution (d'Errico and Backwell, in press), our aim was to refine the functional interpretation of the South African bone tools using a statistical analysis of 2D and 3D roughness variables obtained from worn areas on a representative sample of archaeological, ethnographic, and experimental tools. We used an optical interferometer to scan the worn areas of a sample of bone tools from Swartkrans and Drimolen, an ethnographic collection of implements used for defleshing marula fruits, and a set used experimentally to dig in the ground and excavate termite mounds. Most roughness variables reveal a significant difference between the wear pattern on archaeological tools, particularly those from Drimolen, and those used experimentally to dig up tubers, and a strong degree of similarity between archaeological and termite foraging tools. Some variables detect significant differences between the Swartkrans and Drimolen wear patterns, which suggests that the tools from these sites may have been used with slightly different motions, or in contact with abrasive particles of different size. Principal component analysis of 3D roughness parameters reveals that some tuber digging tools lie within the variation of the archaeological tools from Swartkrans and Drimolen (Figure 4). All the fields falling outside the archaeological variation come from tools used experimentally by Nad Brain, exhibiting marked variation in the orientation of striations. The difference between Nad's and our experimental tools is likely due to the motions used to extract tubers. We used a repeated stabbing gesture perpendicular or subperpendicular to the ground. Nad probably used a similar gesture in addition to a semi-circular scraping motion around the tubers, which resulted in more randomly oriented striations. Our results show that if early hominin bone tools were used, in some



Figure 3. Transparent resin replicas of wear patterns on bone tools from (a) Swartkrans (SKX 1142) and (b) Drimolen (DN 414), showing rounded tips covered with longitudinal striations and flake scars smoothed by use wear. (c) Experimental bone tool used to dig in a termite mound, and (d) tool used by Nad Brain to extract *Scilla marginata* bulbs. Note the similarity in the orientation and width of the striations in (a), (b) and (c). Scales = 1 mm. (After Backwell & d'Errico 2008).

instances, to excavate tubers, it was with the motion performed by us, and not that employed by Nad Brain in this task. In sum the new functional study we have conducted confirms digging in termite mounds to be the closest experimental match, but does not exclude the use of the bone tools in other tasks.

Members 1-3 at Swartkrans contain the remains of the robust australopithecine *Paranthropus robustus*. Members 1 and 2 have yielded the remains of a second hominin designated *Homo ergaster*. The exceedingly low number of stone tools and *Homo* remains, coupled with the high number of *Paranthropus* remains at Swartkrans and Drimolen, supports the hypothesis, proposed by Susman (1988, 1991, 1994, 1998) based on hand anatomy, and followed by Brain *et al.* (1988: 835) and us (Backwell and d'Errico 2001; d'Errico *et al.* 2001; d'Errico and Backwell 2003), that *Paranthropus robustus* was the user of these tools.

Independent isotope studies show that *P. robustus* and *Homo erectus* fossils both show an anomalously high protein component in their diets (Sponheimer & Lee-Thorpe 1999), which may now be explained in terms of termite foraging. Chimpanzees forage for termites across central Africa using

different techniques and tool types (Whiten *et al.* 1999). Isotope data and our results suggest that they may represent a good model for early hominin behaviour. Based on the female aggregation practices present in chimpanzees and gorillas, and the fact that both are proposed as models for early hominin cultural and social behaviour (d'Errico *et al.* 2001; Lockwood *et al.* 2007), we hypothesise that if *P. robustus* was the user of the bone tools, the foraging activity in which they were used was conducted mainly by females.

If the bone tool implements in both east and South Africa are purely extensions of the Early Acheulian Industry, then they are presumably adapted to different regions and resources. Bone digging tools in South Africa might be directly associated with a resource specific to this region, and this may account for their atypical Acheulian morphology. We posit that bone tool utilisation was likely associated with *Homo erectus* in east Africa and *Paranthropus robustus* in southern Arica, and that it was an independent cultural adaptation to different environmental conditions and subsistence strategies. One focused on meat acquisition, and the other on insects and to a lesser extent plant foods. There is therefore no obvious link between early hominin bone tools and a specific type of



Figure 4. Plot of the first two components of the principal component analysis performed on 3D roughness data. The Drimolen cluster (--x), like Swartkrans (+), almost entirely incorporates the termite (\Box) and marula (—o) fields, and excludes tuber digging tools used by Nad Brain (Ä). (After d'Errico & Backwell 2009, in press).

resource, suggesting the context-specific role of bone tool technology within a subsistence strategy. In light of this we should not assume that technological evolution was a gradual process, nor that tool utilisation was limited to the genus *Homo*.

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The Diets of Early Hominins from South Africa and Tanzania: Isotopic Evidence

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During the past 15 years, the diets of early hominin species from South Africa have been intensively investigated by isotopic analysis in the Stable Light Isotope Facility at the University of Cape Town. These have involved three species: *Australopithecus africanus, Australopithecus (Paranthropus) robustus,* and *Homo* sp. (sometimes referred to as *H. ergaster*) from the sites of Makapansgat, Sterkfontein, Swartkrans and Kromdraai, spanning a time period from 3Ma (million years ago) to 1Ma. The results showed considerable variation in individual diets within a given species, but no marked differences between species.

We can now report isotopic dietary studies of two early hominin species from Tanzania: Homo habilis and Australopithecus (Paranthropus) boisei. Five specimens were made available for analysis by the authorities in Tanzania. These included three specimens of *H. habilis* from Olduvai Gorge: Olduvai Hominid 7, or OH7 (Leakey 1961; Leakey, tobias and napier 1964; Tobias 1991); OH62 (Johansson et al 1987); and OH65 (Blumenschine et al 2003). All three are from uppermost Bed 1 at about 1.8Ma; OH 7 and OH 62 are from Olduvai East, while OH65 is from Olduvai West. Two specimens represent A. boisei: OH5 from Olduvai East ('Zinjanthropus'), dating to about 1.8 Ma (Leakey 1959; Tobias 1967) and the "Peninj mandible' from West Lake Natron (L.S.B Leakey and M.D Leakey 1965; Isaac 1965), estimated to date to ca.1.5 Ma. The results show that these two species had very strongly contrasting diets.

The data from Tanzania have been published in the *South African Journal of Science* (van der Merwe, Masao and Bamford 2008). Figure 1 and Tables 1 and 2 from the *SAJS* article have been reproduced here with permission of the editor. Paper reprints or pdf copies of the original article may be obtained from van der Merwe.

Background

Isotopic analysis of fossilized fauna has been developed over the past 25 years and is now widely used in palaeontology. Tooth enamel has proved to be the best sample material, because it is highly crystalline and resists chemical alteration or mineralization over time (Lee-Thorp and van der Merwe 1987, 1991; Lee-Thorp, Thackeray and van der Merwe 2000). It is a biological apatite (calcium phosphate), which contains about 3% carbonates by weight (as = CO_3). The carbon and oxygen isotope ratios (delta ¹³C and delta ¹⁸O, relative to the PDB standard) are measured simultaneously in a mass spectrometer. A sample of 3 mg of tooth enamel, removed with a diamondtipped dental drill of 0.5-1 mm diameter provides for duplicate measurements. The measured delta ¹⁸O values are related to the water intake and excretion of an animal (Sponnheimer and Lee-Thorp 1999a) and are not discussed here.

Carbon isotope ratios (delta ¹³C) measure the ratio of C_3 and C_4 plants at the base of the food web of an animal (for review, see van der Merwe *et al* 2003). This ratio may refer to plants in the diet, to insects and animals that ate the plants, to flesh of herbivores eaten by carnivores, or all these elements included in an omnivorous diet. In Tanzania between ca. 1.8 and 1.5 Ma, the period under discussion here, C_3 plants included algae, water plants such as *Typha* sp., bushes and trees, and some grasses from shaded environments. C_4 plants included most of the grasses and some forbs and sedges.

To interpret stable carbon isotope ratios for mixed-feeding hominins, the C₃ and C₄ end members' of their ecosystem have to be determined. In theory, this can be done by measuring the delta ¹³C values of browsing herbivores that eat 100% C₃ plants and of grazing herbivores that eat 100% C₄ plants. In reality, such animals do not exist in a savanna environment (even longnecked giraffes eat some grass when it is green, while a grazer may eat the occasional leaf of a bush), but the end members can be estimated from their isotope ratios. Some 100 delta ¹³C values are available for animals that lived around Palaeolake Olduvai at ca.1.8 Ma (van der Merwe, unpublished). At the grazing end of the dietary spectrum, the most positive delta ¹³C values are those for 19 specimens of the genera Connochaetes (cf. wildebeest), Parmularius (cf. topi) and *Beatragus* (cf. hartebeest), with a mean value of +2[] (per mil). At the C_3 end of the spectrum, the most negative delta ¹³C values are those for *Giraffa* sp. and *Deinotherium bozasi* (a very large elephant with two tusks in the mandible, pointing downward at right angles to the mandible); the mean value is -11.1[] (per mil). Since *Giraffa* and *Deinotherium* were probable not pure browsers, we can estimate the C_{2} and C_{4} end members at -12 [] and +2 [\], spaced by the 14 [] difference between C₃ and C₄ plants. The same values apply for Peninj at ca.1.5 Ma, where the mean delta ¹³C value for 40 grazing animals (there are no browsers in the collection) is +2 [] (van der Merwe, in press). In South Africa, end members have been estimated for three hominin sites: Makapansgat ca.3 Ma at -12[] and +2[] (Sponnheimer and Lee-Thorp 1999b); Sterkfontein Member 4, ca. 2.5-2.0 Ma, at -13[] and +1[] (van der Merwe et al 2003); and Swartkrans Member 1, ca. 2.0-1.0 Ma, at -12] and +2] (Lee-Thorp and van der Merwe 1993). For each case, the end members for the appropriate time and place are used to calculate the percentage of C₃ and C₄- based carbon in the diet.

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The C_4 dietary components for early hominins of Tanzania and South Africa are compared in Figure 1. The results for five Tanzanian specimens reported in Table 1 are used in this figure, as well as all the published values for South Africa (43 in all), except for one specimen from Kromdraai, for which C_3 and C_4 end members are not available (Sponnheimer et al 2005). We have avoided arguments about the taxonomic status of these early hominins. Some authors use the generic name *Paranthropus* for the two robust australopithecines *A. boisei* and *A. robustus*, and the species name *Homo ergaster* for the undesignated *Homo* sp. from Swartkrans.

Hominin Diets

Figure 1 demonstrates that the two specimens of *A. boisei* had C_4 dietary components (77% and 81%) that far exceeded those of any other hominin species that have been isotopically analyzed. The two australopithecines from South Africa and the two species of *Homo* from South Africa and Tanzania show considerable individual variation, but in no case is the C_4 dietary component as extreme as that of *A. boisei*. The question arises: what did *A. boisei* eat?

The C_4 foods that were available to all these early hominins included grasses, some sedges and forbs, and a variety of animals (invertebrates, reptiles, birds, mammals) that ate C_4 plants. Chacma baboons are frequently observed to eat grass seeds and early hominins may well have done the same, but



Figure 1. The C_4 dietary components (C_4 %) of early hominins of Tanzania and South Africa. The results for individual specimens from Tanzania have been calculated from the delta ¹³C values reported in Table 1 and are given in the left column for each specimen. For South African hominins, the left column lists the site and stratigraphic unit (e.g., Sterkfontein 4 for Member 4), the approximate age of the unit(s), the number of specimens of each species for which isotopic values are available, and the full range of C₄ dietary components represented by these specimens. In the box-and-whisker plots for South African hominins the vertical line is the mean, the box covers 25 to 75% of the range, and the whiskers cover 10-90% of the range. For calculation of the C_4 dietary components for South African hominins, all the published carbon isotope values for Makapansgat (Sponnheimer and Lee-Thorp 1999b), Sterkfontein (van der Merwe et al., 2003; Sponnheimer et al., 2005), Sterkfontein (van der Merwe et al., 2003; Sponnheimer et al., 2005), and Swartkrans (Lee-Thorp et al., 1994; Lee-Thorp et al., 2000; Sponnheimer et al., 2005; Sponnheimer et al., 2006) have been used.

this food item is only available for about one month of the year. Early hominins may also have eaten various animals, but there is a limit to how much of this food type they could metabolize. Modern humans are limited to about 20-50% protein-rich foods for their energy requirements. Excess consumption of lean meat (fat is rare in savanna wildlife) cause protein poisoning and may have fatal consequences (Noli and Avery 1988).

Table 1. Stable carbon isotope ratios (delta ¹³C values) for tooth enamel of Tanzanian hominins, relative to PDB. Precision of repeated measurements were better than 0.1‰.

Lab. No.	Taxon and Specimen	Tooth	Origin	delta ¹³ C (‰)	C ₄ % in diet
	Homo habilis				
UCT7483	OH7 (type specimen)	LM_2	Olduvai East	-8.8	23.0
UCT7481	OH62	LM^2	Olduvai East	-8.3	27.0
UCT7484	OH65	LM^3	Olduvai West	-5.2	49.0
	Australopithecus boisei				
UCT7081	OH5 (type specimen)	LM^2	Olduvai East	-1.2	77.0
UCT7483	Peninj mandible	LM_2	Peninj	-0.7	81.0
C3 end member (Giraffa sp., Deinotherium bozasi)			-12.0	0.0	
C4 end member (Connochaetes, Beatragus, Parmularius) +2 100					100.0

C_4 Foods in a Wetland and the Diet of H. boisei

The environments of both Olduvai at ca.1.8 Ma and Peninj at ca.1.5 Ma were that of the extensive wetlands of Palaeolake Olduvai and extant Lake Natron, with rivers that fed into and drained from these lakes. To investigate the C_4 foods that are available in such environments, two of the authors (van der Merwe and Bamford) visited the Okavango Delta in Botswana. A guide who grew up in this wetland, Ezaya Karesaza, pointed out all the plants that can be eaten raw. Among these were two C_4 species of sedges that grow in the grasslands on the seasonally inundated floodplains, Cyperus denudatus and C. dives, with culms (stalks) of about 1 cm in diameter. They are green year-round, unlike the grasses, and their rhizomes and culms are edible, but they are not particularly prolific. The most common C₄ sedge by far is *Cyperus papyrus*, which grows in dense thickets in the shallows along the water edge. Its culms grow as high as 4 m, of which the local people frequently chew the lowermost 0.5 m. It is about 3 to 4 cm in diameter, of which the outer 0.5 cm is a soft white rind and the interior is more fibrous; it has a pleasant taste. The thick rhizome of papyrus is more fibrous and starchy than the culm and has a slightly astringent taste. It takes considerable chewing effort and forms a thick bolus in the mouth, which we spat out at intervals. The plant can be pulled up out of the mud by standing in the water and using muscle power.

Papyrus compares quite well with the nutritional qualities of the domesticated potato; the results are reported in Table 2. Papyrus rhizome and culm have more carbohydrates and fat than potato, but somewhat less protein. A daily consumption of about 2 kg of papyrus would provide the energy requirements of a human adult, although the digestion of all the cellulose in it could prove to be a bit of a chore. It is not unlikely that *A. boisei* had more capacity for digesting cellulose than modern humans.

Bamford has identified a number of fossil plant remains from Olduvai East. Most of them are of woody plants, which Table 2. Nutritional analysis of raw rhizome and culm (base of stem) of papyrus (*Cyperus papyrus*) and raw potato tuber (*Solanum tuberosum*). Analysis by Biofoodtek, CSIR.

	Papyrus		Potato	
	Rhizome	Culm	Tuber	
Volume (ml)	150.0	300.0	89.0	
Weight (wet, g)	100.0	100.0	100.0	
Carbohydrates (calculated, g)	25.0	17.0	18.0	
Fat (acid hydrolysis, g)	0.4	0.2	0.1	
Protein (g)	1.0	0.5	2.1	
Kilojoules	438.0	282.0	332.0	
Kilocalories	104.0	67.0	79.0	

Note : daily requirement (human adult): 2000 kcalories/ 8400 kjoules

are more likely to become fossilized, but about 5% were species of sedges with culm diameters of about 1 cm. These were probably growing in the seasonally inundated grasslands. The fact that no papyrus fossils have been identified at Olduvai or Peninj is probably the result of a lack of preservation, not the absence of the plant at the relevant time.

A. boisei clearly had a diet that included a lot of C_4 plants. Papyrus is a good candidate for a staple in this diet, since it is available year-round and is highly prolific. As measured at Lake Naivasha in Kenya, it produces 6.3 kg (dry weight) per square meter per year, among the highest productivity recorded for natural ecosystems (Jones and Muthuri 1997).

Two areas of investigation would help our understanding of the diets of early hominins. One would be an investigation of tooth wear that can be associated with extensive chewing of papyrus. The other would be the isotopic analysis of early hominin tooth enamel from Kenya and Ethiopia, which has not been attempted yet.

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Dental Microwear Texture Analysis and Fallback Adaptation: Implications for Early Hominin Diets

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Dental microwear refers to the microscopic scratches and pits that form on a tooth's surface during feeding. We can use dental microwear to reconstruct diets of past peoples, fossil hominins, and other extinct primates because different sorts of foods leave different and predictable patterns of scratching and pitting on or in teeth.

We know from studies of living primates that diets of hard, brittle items, such as palm nuts, produce pits as foods are crushed between opposing occlusal surfaces (think of a hammer and anvil). In contrast, diets dominated by tough foods, such as many leaves, typically result in long, parallel scratches as abrasives are dragged across facets that slide past one another during shearing (think of a pair of scissors). Primates that eat foods with intermediate fracture properties, or have mixed diets, typically have intermediate microwear patterns (Teaford, 1988).

Dental Microwear Textures and Feeding Adaptations

An exciting new avenue of research for microwear analysis is the study of the nature of selective pressures for tooth form. We can start with the observation that most living things doomed to be eaten have hard or tough tissues that prevent the start or spread of cracks. Nature should therefore select for teeth wellsuited to overcome resistance to fracture by whatever foods an animal chooses to eat. Living primates that consume tough, pliant foods (such as many leaves and stems) for example, typically have long shearing crests on their molars, whereas those that more often eat hard, brittle foods (such as palm fronds and some nuts or seeds) tend to have blunt, flat cusps (e.g., Kay, 1978; Ungar, 1998). This is because the "tools" needed to start and spread cracks through foods depend on their fracture properties (Lucas, 2004). Cracks are forced through tough foods with "wedge-like" crests. Hard, brittle items may require less work to propagate cracks, but blunt cusp tips are needed to concentrate high forces needed to initiate food breakdown while protecting the tooth from fracture.

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While such form-function relationships hold up reasonably well under scrutiny, dental shape actually tells us more about potential for food breakdown than how a tooth is used on a daily basis. Dental form can evolve as a primary specialization for preferred foods or as a secondary one for occasionally eaten items that are nevertheless important for survival (Kinzey, 1978). It doesn't matter what your teeth look like if you eat mush most of the time, but if you have to consume fracture resistant foods even rarely to survive lean times, you had better have the right tools for the job. This leads to the question "how do we know whether tooth form is selected for preferred foods or for fallback items?" This question has important implications for our reconstructions of diet based on dental specializations of early hominins and other fossil primates.

Recent studies have suggested that dental microwear can help us understand how teeth are used on a day-to-day basis and, therefore, whether they are adapted to preferred foods or fallback items. It turns out that tooth surfaces "turn over" as they wear down and old features are replaced by new ones. Individual features often appear and disappear in a matter of days (Teaford and Oyen, 1988) (Figure 1). Because of this "last supper" phenomenon (Grine, 1986), a sufficiently large and representative sample give us a sense of ranges of variation over time and dietary preferences of a species. If most individuals in a sample consumed tough foods during their last few meals, microwear surfaces should be dominated by long, parallel striations. If most ate hard, brittle foods, those surfaces should cluster in the heavily pitted range. Species that fall back on hard, brittle foods on one hand, or very tough ones on the other, are predicted to have a few individuals out toward the heavily pitted and highly scratched extremes respectively (Figure 1). These are just the sorts of data needed to help interpret dental functional morphology.

The assessment of within species variation in dental microwear is not a trivial task though. Surfaces can have





Figure 1. Microwear turnover and pattern predictions. Left: pattern predictions for samples with the diets listed. Right: a microwear surface before (above) and after (below) three days of feeding. Note the new features evident. The photomicrographs are presented courtesy of Mark Teaford.

hundreds of small, overlapping features prone to measurement error (Grine et al., 2002). Also, conventional studies have relied on shading to show relief on 2D representations of 3D surfaces, and microwear patterns can appear to change with geometric relations between light or electron source used to "illuminate" a tooth and its surface (Gordon, 1988). In order for us to be confident that our data reflect the subtleties of within species variation rather than "noise" due to observer error or the vagaries of instrument settings, we need automated characterizations of 3D surfaces.

This is where dental microwear texture analysis comes in (Ungar et al., 2003; Scott et al., 2005; Scott et al., 2006;Ungar et al., 2007). My research group uses a Sensofar Plì whitelight scanning confocal profiler (Solarius Development Inc., Sunnyvale, CA) with a 100x objective lens to generate 3D point clouds representing a microwear surface. These point clouds each have a lateral sampling interval of 0.18 μ m, a vertical resolution of 0.005 μ m, and a field of view of 138 μ m x 102 μ m. Data are then collected for four adjoining fields to yield a total planimetric working area of 276 im x 204 im. This gives resolutions and work envelops that compare favorably to "traditional" feature based microwear studies that use a scanning electron microscope at 500x magnification (see Figure 2).

Individual scan data are then analyzed using Toothfrax (Surfract, www.surfract.com) and SFrax scale-sensitive fractal analysis (SSFA) software packages. SSFA operates on the principle that surface textures appearing smooth at a course scale can be rough at a finer scale. In fact, several aspects of surface texture can be characterized by considering change with scale. A surface that appears to increase progressively in



Figure 2. Microwear texture analysis. Left: microwear photosimulations generated from 3D point clouds of *Australopithecus africanus* (above) and *Paranthropus robustus* (below) individuals; Right: complexity plots for specimens of *Australopithecus africanus* (above) and *Paranthropus robustus* (below) individuals. See Scott et al. (2005) for details.

relative area when measured at finer and finer scales, for example, is considered complex (Figure 2). Area-scale fractal complexity (*Asfc*) can be measured as the slope of the steepest part of the curve fit to a log-log plot of relative area over the scales at which measurements were made. High texture complexity is often recorded for heavily pitted surfaces, and has been suggested to be a good proxy for the consumption of hard, brittle foods (Scott et al., 2005; Scott et al., 2006; Ungar et al., 2007). Other texture attributes have also proven useful for distinguishing microwear surfaces, including anisotropy, heterogeneity, scale of maximal complexity, and textural fill volume. While space limitations prevent their consideration here, each is described in detail in the literature (Scott et al., 2006; Ungar et al., 2007).

An Example from Hominin Evolution

Some complexity data compiled from published sources (Scott et al., 2005; Scott et al., 2006; Ungar et al., 2007) are illustrated in Figure 3. These data include high-resolution epoxy replicas (14-15) of the second molars of wild-caught individuals representing two relatively folivorous living primate species, Alouatta palliata, and Trachypithecus cristatus, and two known to consume hard, brittle foods at times of resource scarcity (Lambert, 2007), Lophocebus albigena and Cebus apella. Complexity data for two fossil hominin species, Australopithecus africanus and Paranthropus robustus, are also presented. Both hominins have large, flat cheek teeth with thick dental enamel well-suited to crushing hard, brittle food items (Kay, 1985). The more "robust" P. robustus takes this morphology to an extreme, and has often been considered a hard-object specialist when compared with A. africanus (e.g., Robinson, 1954; Grine, 1981). We can interpret the adaptive significance of tooth shape in these fossil species by comparing their dental microwear textures with those of the living primates.



Figure 3. Microwear texture complexity results for samples of living primates and fossil hominins. *Alouatta* and *Trachypithecus* are principally folivorous, whereas *Lophocebus* and *Cebus* specimens are hard-object fallback feeders. See Scott et al. (2006) and Ungar et al. (2007) for further details.

The living primate and fossil hominin taxa all have at least some specimens with low surface complexity values. This suggests a lack of consumption of hard and brittle abrasive foods by those individuals during their last few meals. In fact, all of the extant folivores fall into in this category. By contrast, the two groups known to consume hard, brittle foods have a few specimens with high levels of complexity. This is as expected for a hard-object fallback feeder.

Results for the early hominins can be understood in this light. Australopithecus africanus and Paranthropus robustus have been known for some time to evince more striated and pitted microwear surfaces respectively (Grine, 1981). This has been taken to indicate that P. robustus specialized on hard, brittle foods, as implied by its very robust craniodental toolkit (Robinson, 1954; Grine, 1981). Texture data also show P. robustus to have more complex microwear surfaces on average, but hint that the story may actually be more complicated than originally suggested. First, there is overlap in microwear complexity between the samples. Low Asfc values suggest a lack of hard-brittle foods in the diets of A. africanus and some *P. robustus* individuals. The pattern of a few high complexity values for *P. robustus* on the other hand, is similar to that of Lophocebus albigena and Cebus apella. This is consistent with the hypothesis that the "robust" australopiths occasionally consumed hard objects, not unlike grey-cheeked mangabeys or brown capuchins today.

If so, anatomical specializations of the Paranthropus robustus craniodental toolkit may reflect a "fallback" adaptation rather than selection for preferred food items. This interpretation mirrors recent work on stable isotopes and occlusal morphology of these hominins, as well as models derived from studies of living great apes (Sponheimer et al., 2006; Ungar, 2007; Wrangham, 2007). It also follows a more general principle in ecology known as Liem's Paradox (Robinson and Wilson, 1998). Animals with highly specialized feeding adaptations can have broader diets than less specialized forms, especially when the ability to eat extremely hard or tough foods does not preclude the consumption of other items. The paradox is that specialized animals may actually avoid the types of foods they are adapted to eat if higher quality ones that require less work to fracture are available. In such cases, morphology reflects a fallback adaptation on foods accessible at environmental "crunch times" when preferred, less fracture resistant items cannot be found.

In sum, dental functional morphology cannot, in and of itself, tell us what individual early hominins ate on a day-to-day basis. Microwear can help though, and new technologies are beginning to allow us to tease apart whether dietary specializations related to preferred foods or fallback resources.

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Using Image Analysis to Quantify Relative Degrees of Density-mediated Attrition in Middle Stone Age Archaeofaunas

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The fossilized animal remains from Middle Stone Age (MSA) sites provide essential evidence for understanding early human diet. The MSA, and its temporal equivalent in Eurasia (the Middle Paleolithic), are a key time for studies of ancient diet as it is widely recognized that modern humans evolved during this time, which stretches from ca. 280 – 30 thousand years ago (Mellars, 2007). Unfortunately, most MSA archaeofaunas are the end result of a complex series of taphonomic processes and not a 'pure' signal of human behavior (Lyman, 1994).

Zooarchaeologists must first understand these taphonomic processes before proceeding to higher-level interpretations of MSA subsistence. Unraveling the complex histories of fossil assemblages is challenging, but one of the biggest obstacles to understanding larger patterns in the MSA record has been a lack of comparability between datasets from different sites. One reason for this is the unstandardized nature of data collection and analytical techniques. Another is difficulty in quantifying key taphonomic parameters. A method is illustrated here that employs image analysis software to standardize and quantify the degree of density-mediated attrition in three coastal MSA archaeofaunas from South Africa: Pinnacle Point Cave 13B, Blombos Cave, and Die Kelders Cave 1 (Figure 1).



Figure 1. Map of the three MSA sites used in this study.

Density-mediated Attrition and Zooarchaeological Interpretation

Density-mediated attrition occurs to some degree in most zooarchaeological assemblages (Lam et al., 1998; Lam et al., 2003). In most cases epiphyses and elements comprised mainly of trabecular bone are the portions most susceptible to densitymediated destructive processes such as carnivore chewing, sediment compaction, and destruction by geochemical processes (Cleghorn et al., 2004; Klein and Cruz-Uribe, 1984; Lam et al., 2003; Marean and Spencer, 1991).

Unfortunately, many elements that rank high in caloric returns are often completely destroyed by these processes, while the most easily-identified portions of long bones (such as femur and tibia) also tend to be destroyed Marean and Cleghorn, 2003). As a result, elements with less nutritional return such as head and foot elements are over-represented because they have portions that survive well and are easily identified (Bartram and Marean, 1999; Marean et al., 2004).

Analyses that include dense and well-preserved long bone shaft fragments can partially overcome this systematic bias (Assefa, 2006; Marean et al., 2000; Thompson, 2009). However, it has still proven difficult to assess overall bone transport decisions made by past human groups because axial elements associated with the highest caloric return are comprised mainly of easily-destroyed trabecular bone (Cleghorn et al., 2004; Marean and Cleghorn, 2003). The picture is further complicated because under some conditions dense long bone shafts can be secondarily modified or fragmented past the point of being identifiable through repeated episodes of wetting/drying and heating/cooling, selection by rodents for gnawing, or shaping into bone tools (Conard et al., 2008).

It is critical to quantify the degree and direction of densitymediated destruction that each faunal component at each site has undergone, and then ideally disentangle the variety of taphonomic processes that produced this destruction. Doing so accomplishes four important objectives: 1) Provides a method to make quantified inter- and intra-site comparisons of density-mediated attrition; 2) Standardizes the amount of correction or caution that is required in further analyses from each analytical unit; 3) Justifies any analyses that rely on relative skeletal element abundances; and 4) Potentially identifies different intersite and intra-assemblage taphonomic processes. With these data available, large mammal exploitation strategies can be more confidently explored and larger behavioral patterns revealed. While most of the concern and method-development has occurred in Paleolithic zooarchaeology, it is clear that these same problems hold for all zooarchaeological assemblages

Methods

(Marean and Frey, 1997).

Each ungulate fragment that could be identified to element and confidently placed on a digital template of that element was drawn into a GIS image-analysis program developed by Marean et al. (2001), and linked by specimen number to an external database created in Microsoft Access. The minimum number of elements (MNE) was estimated from these GIS images on the principle of overlaps: where two fragments overlap on a given element they cannot be from the same individual (Marean et al., 2001). It provides a way to rapidly and effectively estimate MNE values from any given subset of data without manually revisiting the collection, but as with any method of estimating MNE values it may miss an overlap or indicate a very slight overlap (in terms of pixels) where there isn't one (Lyman, 2008). However, there is no reason to believe that this error is directional, so the problem is only relevant for very small samples where small errors would have an impact. All images produced by the program were also inspected for areas where the MNE value may have been inflated in this way, and the smallest number of definite overlaps was the one recorded as the MNE (Figure 2).

Each final MNE image is effectively a map of a complete bone comprised of thousands of pixels. Each pixel in the map has a numeric value that corresponds to the MNE value calculated at exactly that spot. For example, a pixel with a value of '2' represents one place on a complete bone where at least two digital fragments overlap. The pixel counts representing each fragment can therefore be added to one another and multiplied by the MNE value to obtain the total bone area (expressed in pixels) represented by all the digital fragments together. The image-analysis software described above can then compute an exact number (in pixels) represented within any designated part of that map. We did this for each of five long bone zones designated by (Abe et al., 2002): two epiphyses, two near-epiphysis shafts (defined as a length of shaft with a medullary cavity and some attached trabecular bone), and one midshaft (Figure 3).

To obtain the final long bone portion representation data, the proportion of the total area that fell within each of the five



Figure 2. MNE image of the left ungulate femur (all body sizes) for Layers 9 - 15 at DK1. Red is the area of the highest MNE and pink is areas where an MNE of zero would be obtained.



Figure 3. The process of using composite MNE images to obtain total area counts for each of the five bone portions in Abe et al. (2002). Three fragments (labeled A, B, and C) are placed on a femur. White areas show where no fragments are located. These have an MNE of 0. Gray areas have one fragment located there, represent an MNE of 1, and each pixel carries a value of 1. Black areas show where two fragments overlap, representing an MNE of 2, and each pixel carries a value of 2.

zones was expressed as a percentage. For example, if the proximal end, proximal shaft, midshaft, distal shaft, and distal end were comprised of a total area of 1500, 2000, 3000, 2000, and 1500 pixels respectively, then the proportions would be 15%, 20%, 30%, 20%, and 15% respectively. Once quantified, these proportions were input as the y-axis into a regression with density as the x-axis (density values are from computed tomography [CT] scans of a sheep skeleton in Lam et al. [1998]). Spearman's Rho (R_s) was then used to assess the degree and significance of correlation between bone portion density and representation within each data subset, as this nonparametric test is less susceptible to small sample sizes and influence by outlying points.

Results

The faunal assemblages from all three sites are typical shaft-dominated assemblages (Marean et al., 2004). This is

immediately apparent in the proportions of long bone fragments by NISP that are shaft fragments, near-epiphysis shaft fragments and epiphyseal portions (Figure 4). It is also apparent from MNE estimates on each of the five long bone zones (Figure 5). Given that shaft fragments are the densest bone portions, these figures illustrate three different ways to evaluate relative degrees of density-mediated attrition. However, each only provides a relatively rough measure of the degree to which taphonomic processes have differentially destroyed bone.

Figure 6 shows a new and more precise method to quantify the degree of density-mediated attrition by using image analysis to examine the relationship between bone density and bone portion representation (Lam et al., 1998; Marean et al., 2001). This relationship can be further explored using a simple linear regression, which assists with interpretation of the spread and position of the data points. For example, the residuals from all three sites show that near-epiphysis shafts are betterrepresented than would be predicted by their density, while epiphyseal fragments are even less well-represented than expected (with the exception of the distal humerus, which has a positive residual in all three cases).

Near-epiphyses possess both a dense midshaft portion that is likely to survive and a less dense but generally more easilyidentified near-epiphysis portion. Similarly, the distal humerus has relatively denser portions within it that are easier to identify. These results illustrate the complex interactions between density-mediated attrition and bone portion 'identifiability' in analysis.

Table 1 gives Spearman's R_s and the p-value for the relationship between bone portion representation and bone density for a variety of data subsets and ungulate body sizes within the assemblages from Pinnacle Point Cave 13B, Blombos Cave, and Die Kelders Cave 1. This provides a final quantified assessment of the degree of density-mediated attrition



Figure 4. Relative proportions of long bone fragments from each site that are epiphyses, near-epiphysis shafts, and midshafts. PP13B = Pinnacle Point Cave 13B, BBC = Blombos Cave, DK1 = Die Kelders Cave 1.



Figure 5. MNE estimates derived from each bone portion at the three sites (all body sizes and layers included).

both between and within sites. For those datasets where the correlation is not significant (such as the M2 phase of Blombos), cautious use of complete skeletal element abundance data may be possible. For datasets where the relationship is significant corrections can now potentially be made. Such a correction might be the use of a limited subset of 'high-survival' elements, as recommended by Marean and Cleghorn (2003).

Finally, for all datasets this method allows standardized assessment of the degree of density-mediated attrition, such that the taphonomic and analytical processes behind these patterns can be systematically evaluated and their effects on the assemblage understood. For example, the role of carnivore attrition and the size of the carnivores involved can be further explored using independent surface modification data (Dominguez-Rodrigo and Piqueras, 2003), the relationship between intertaxonomic bone density and bone portion representation can be more precisely quantified (Lam et al., 1999), and the complex interactions between bone fragmentation, ungulate body size, and analytical 'identifiability' can be more readily teased apart.

Conclusions

Detailed understanding of ancient subsistence is not possible without the application of rigorous taphonomic methods that allow the human-accumulated portion of cave fossil assemblages to be identified and quantitatively compared. Density-mediated attrition is one of the most ubiquitous taphonomic processes that can introduce systematic bias into these assemblages. Image analysis software combined with simple statistical correlations of bone portion representation and bone density provide a precise method for quantifying the extent of this attrition.

When this method was applied to three MSA coastal cave sites, a high degree of variability in relative destruction was identified. This allows for the reconstruction of taphonomic processes, the application of appropriate corrective measures, and the justification of further analyses of skeletal element abundances. It further illustrates the variability that may be found *within* a single site, and between different ungulate body sizes.



Figure 6. Bone portion representation at each site (y-axis) versus bone density from Lam et al. (1998) (x-axis). Open circle = distal end, open square = proximal end, gray circle = distal shaft, gray square = proximal shaft, black diamond = midshaft.

Table 1. Spearman's R_s for each data subset at each site (indicated on left). Bars to the right of each dataset show relative degrees of correlation. Gray bars indicate correlations not significant below the alpha = 0.05 level.

Pinnacle Point	Cave 13B			0	0.4	0
Ungulate Size	Dataset	Spearman's R _s	p-value	_		
Small	MIS 5	0.4315	0.0160	-		
Large	MIS 5	0.6772	< 0.0001			
Small	MIS 6	0.4587	0.0130			
Large	MIS 6	0.5442	0.0040			
Blombos Cave						
Ungulate Size	Dataset	Spearman's R _s	p-value			
Small	M1	0.4999	0.0049			
Large	M1	0.4732	0.0083			
Small	M2	0.3348	0.0705			
Large	M2	0.3699	0.0442			
Small	M3	0.3880	0.0341			
Large	M3	0.4625	0.0101			
Die Kelders Ca	ave 1					
Ungulate Size	Dataset	Spearman's R _s	p-value			
Size 1	Layers 9 - 15	0.4052	0.0263			
Size 2	Layers 9 - 15	0.1934	0.3058	2000	a	
Size 3	Layers 9 - 15	0.3183	0.0865			
Size 4	Layers 9 - 15	0.7471	< 0.0001	8		

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Remote Sensing and GIS

Apostolos Sarris, Associate Editor

Workshop on Geophysics for Archaeology: surveying methods, elaboration and 2D and 3D representation, Rome, Italy, 8-15 June 2009. The Institute for Technologies Applied to Cultural Heritage (ITABC-CNR), with the collaboration of LAP&T (University of Siena) and Research Area of CNR (Romal) organizes a training program on "Geophysics for Archaeology: surveying methods, elaboration and 2D and 3D representation". The workshop aims to address both theoretical topics and case histories, coupled with field training and hands on experience on different techniques and processing methods with an ultimate goal to enhance the knowledge of geophysical methods applied in archaeological prospection. The topics of the workshop include archaeological questions with different scale (large, medium, small), extensive and detailed topographical surveys; magnetic methods, GPR, ERT, quantitative integration of geophysical methods, remote sensing, data management employing GIS technology, processing of data for 2D and 3D representation of geophysical results, field acquisition and instrument experiments. More information can be retrieved at: http://www.britarch.ac.uk/briefing/ArcheoGeophysics 2009 Announcement Final.pdf.

III International Conference on Remote Sensing in Archaeology, Tiruchirappalli, India, 17-21 August 2009. The particular conference is a follow up of the International conference at Beijing and Rome, aiming to promote multidisciplinary activities of remote sensing archaeology throughout the world. The 3rd International Conference will be organized by Bharathidasan University, Tiruchirappalli, the University of California, Merced and Berkeley, the University of Siena (Italy) and by the REACH Foundation, Chennai at Tiruchirappalli, India. The conference will present the emerging trends in Remote Sensing and it will explore promising new directions of multi-disciplinary research. The following themes and related topics will be discussed: Aerial archaeology, satellite, aerial photography and airborne scanning, 3D remote sensing, aerial photography, Ground-based sensing archaeology, Integrated remote sensing technologies for the interpretation of landscape ecosystems, archaeological interpretation of remote sensing data, cyber archaeology and 3D landscapes visualization through the time, remote sensing standards, a.o. For more information: http://www.spacetimeplace2009.org

8th International Conference on Archaeological Prospection & the 7th "colloque de GEOFCAN", Paris, France, 9-12 September 2009. The conference entitled "Mémoire du sol, Espace des hommes"; is focused on the history of human settlement and its impact on the landscape and our environment. The thematic topics of the conference include Methods and innovation, Sites and their landscapes, Landscape evolution, History and evolution of the urban subsoil. In this way, emphasis will be on the way that archaeological prospection techniques can allow a reconstruction of the ancient landscape and environmental conditions and how they influenced the economic and social context of human occupation. The conference is organised by the Conservatoire National des Arts et Métiers, the Centre National de la Recherche Scientifique, the Université Louis Lumière (Lyon 2), the Université Pierre et Marie Curie (Paris 6), the initiative of the laboratories Archeorient (UMR 5133, Maison de l'Orient et de la Méditerranée), Sisyphe (UMR 7619), and the Chaire de Géotechnique from the CNAM. More information can be found at: http://www.archeorient.mom.fr/colloqueap2009eng/ indexeng.html.

SPIE Europe Remote Sensing 2009 Symposium, Berlin, 31 Aug.-3 Sept. 2009. SPIE is Europe's largest international forum on remote sensing. The 16th SPIE Europe Remote Sensing will be co-located with the 6th SPIE Europe Security+Defence. The event covers a broad spectrum of remote sensing applications, including next-generation satellites, SAR image analysis, Lidar technologies, image and signal processing, a.o. More Information can be obtained from the website, http://spie.org/x6262.xml.

Archaeological Ceramics

Charles C. Kolb, Associate Editor

The column in this issue includes five topics: 1) Obituary; 2) Reviews of Books; 3) Previous Meetings; 4) New Journal; and 5) Exhibition.

Obituary

Alan G. Vince (b. 30 March 1952-d. 23 February 2009), one of Britain's leading experts on the ceramics of the medieval and early modern periods and a scholar at the forefront of Anglo-Saxon studies, died at the age of 56. He employed the geological sciences – especially petrological analysis — in the study of archaeological ceramics and integrated computer analyses into his research long before it became a norm. Vince analyzed ceramics from hundreds of sites and eventually founded his own company "The *Alan Vince* Archaeological Consultancy." Americans perhaps know him best as the coauthor of *Pottery in Archaeology* (Cambridge Manuals in Archaeology, Cambridge and New York: Cambridge University Press, 1993) with Clive Orton and Paul Tyers. He authored more than 250 technical analyses which are listed on his Web site, http://www.postex.demon.co.uk.

A lengthy obituary and tributes from his colleagues appears on the Internet at http://www.anddidthosefeet.blogspot.com/ 2009/03/alan-vince-alife-in-archaeology.html. He was born in Bath, educated at Keynsham Grammar School, and studied at the University of Southampton for eight years, where he came under the influence of David Peacock, who was in the 1970s pioneering the application of geological techniques to his studies of Roman pottery. Vince's unpublished undergraduate dissertation at Southampton was 1974 The Distribution of Some Medieval Pottery Fabrics in the West of England (1974) and he wrote The Medieval Ceramic Industry of the Severn Valley as his doctoral thesis (1984). Vince was Urban Archaeologist with the Berkshire Archaeology Unit, served as supervisor at the Eastgate and St Albans Abbey excavations, and directed excavations in Newbury during 1979. That same year he assumed a position in the Museum of London's Department of Urban Archaeology (DUA) where he remained until 1988, eventually taking charge of research and the publication of artifacts of all culture periods. The Department of Urban Archaeology was joined with the Department of Greater London Archaeology to form the Museum of London Archaeological Service (MoLAS). In 1988 he moved from London to Lincoln to work for the Trust for Lincolnshire Archaeology. Here he realized that the use of personal computers could transform the day-to-day processing of archaeological data, and he created the Urban Archaeological Database for Lincoln. His coauthored publication The City by the Pool: Assessing the Archaeology of the City of Lincoln (Michael J. Jones, David Stocker and Alan Vince, edited by David Stocker; Lincoln Archaeology Studies 10, Oxford: Oxbow Books, 2003), covering the period from prehistory through 1945, has been acclaimed as a model of urban archaeological assessment.

In 1995, Vince took a part-time post in the Department of Archaeology at the University of York and from 1995 to 1999 served as the first editor of the new on-line journal, Internet Archaeology. While continuing to work at York, he also founded his own company, "The Alan Vince Archaeological Consultancy" in 1997. The demand for his ceramic petrological assessments of material culture for numerous archaeological projects throughout the world became so great that within two years he decided to focus his work entirely on the consultancy. Vince worked on a diverse array of ceramics from sites in Britain and Europe, as well as overseas — Taiwan and Madagascar, for example. His analyses played a major role developing an understanding of pottery and building materials such as tiles and brick. Based on data collected from sites across mainland Britain, he established the AVAC "Ceramic Chemical Composition Database" and "UK Ceramic Thin-Section Database." The consultancy Web site, http:// www.postex.demon.co.uk, provides a great deal of additional information on the Database of Chemical Analyses, Ceramic Petrology, the Chemical Analysis of Ceramics, Pottery Assessment, Pottery Analysis and Publications; there is also a List of Clients and lists of Publications and Unpublished Reports, as well as Current Projects.

He was Secretary of the Society for Medieval Archaeology from 1988 to 1993 and between 1996 and 1999 served as President of the Medieval Pottery Research Group. He is survived by his wife, Joanna and their three children, Leon, Amy and Kate. His colleagues point out that Vince "rigorously" applied the geological and archaeological techniques eschewing the traditional art-historical approach that had previously dominated studies of medieval pottery. He examine the petrological composition of pottery vessels and sherds, compared its constituents with rocks and clays from known geological deposits and using thin-section analyses and other methods (INAA, XRF, ICP-ASE, and ICP-MS) determined the chemical analysis of these clays. In England, he was able to deduce the geographical origin of the vessel, sometimes even to the precise kiln that had produced it.

His pioneering work and enthusiasm will be sorely missed.

Reviews of Books

Dean E. Arnold, Social Change and the Evolution of Ceramic Production and Distribution in a Maya Community by Dean E. Arnold, Boulder: University Press of Colorado, 2008; 432 pp., 52 black-and-white photographs, 42 line drawings, 3 maps; ISBN 978-0-87081-9230- , \$65.00 (cloth). [Note: Charles C. Kolb, editor of this SAS Bulletin column, reviewed the manuscript of this volume for the University of Press of Colorado in the summer of 2007 and recommended that it be published; the book was published in November 2008.] Dean E. Arnold, Professor of Anthropology at Wheaton College (Illinois) is an internationally-known scholar of ethnographic ceramics and contributor to ethnoarchaeological studies. His in-depth synchronic and diachronic research has benefited the academic community of material culture specialists both anthropological/ethnographic and archaeological. Indeed, his research has especially benefited and illuminated ceramic ethnoarchaeological investigations in Latin America, the American Southwest and Northeast, the Mediterranean, Southeast Asia, and Africa In 1996 the 7,000-member Society for American Archaeology bestowed upon him its "Award for Excellence in Ceramic Studies" in honor of his signal achievements – fewer than ten scholars have earned this accolade during the past two decades. Arnold classifies himself as an ethnographer – a scholar of contemporary societies – but this honor demonstrates that his careful, meticulous, longitudinal studies have benefited archaeology as well as researchers in archaeometry and materials science.

During the past 20 years, archaeologists and anthropologists interested in materials culture studies, and especially scholars of ceramics, consistently cite two seminal works which have become "classics," namely, Dean Arnold's (1985) Ceramic Theory and Cultural Process (Cambridge University Press) and Prudence M. Rice's (1987) Pottery Analysis: A Sourcebook (University of Chicago Press). Ceramic Theory and Cultural Process has gone through four editions and is now available as "print on demand." Arnold's theoretical volume, backed with much substance, was much-praised by reviewers. In it he devised a theory of ceramics which elucidated the complex relationship between ceramics and culture and society. Drawing upon the theoretical perspectives of systems theory, cybernetics and cultural ecology, he develops cross-cultural generalizations to explain the origins and evolution of the craft of pottery making. These processes were organized into a series of feedback mechanisms which limit or stimulate the initial production of pottery and its transition from a part-time to a full-time specialized activity. Arnold provided extensive ethnographic documentation, taken from a wide-ranging synthesis of the available literature and employing many data from his own long-term fieldwork in Peru, Guatemala and Mexico, to illustrate the existence of these feedback relationships in societies around the world. Each mechanism is seen, not as a relationship which exists in a few of the world's cultures, but as a universal generalization often based on some unique physical or chemical aspect of the pottery itself. Ceramic Theory and Cultural Process remains an innovative approach to the archaeological interpretation of ceramics which significantly extends our understanding of the social, cultural and ecological processes of ceramic production. Arnold's later book, Ecology and Ceramic Production in an Andean Community (Cambridge University Press, 1993), followed the theoretical perspective of his 1985 volume. In this ethnoarchaeological study he examined the relationships of ceramic production to society and its environment in the Peruvian Andes. The book traced these contemporary linkages through the production, decoration, and use of pottery and relates them to the analysis and interpretation of ancient ceramic production. Utilizing an ecological approach within a single community (District of Quinua), Arnold expands the scope of previous ceramic theory by focusing on the population as the unit of analysis in production and decoration. Ecology and Ceramic Production is also available as "print on demand."

Social Change and the Evolution of Ceramic Production and Distribution in a Maya Community is the third volume of what many of us thought was to be a trilogy, but Arnold informs us that he wants to work on a fourth monograph – a description of the pottery-making families of Ticul, Yucatan, México and he has other Ticul materials for a fifth volume. Social Change isn't a traditional ethnographic treatment - it is that and more - and follows the theoretical underpinnings of his 1985 volume. A quick review of the chapter titles tells us that he is tackling significant questions – problems that are perplexing to scholars of material culture as well as ceramics. Herein lays the strength of this informative volume - issues that transcend technological and cultural changes in the community of Ticul, the Yucatan, Mexico, and Latin America, The questions and in depth assessments have great value well beyond these geographic and cultural entities. He asks: How and why do ceramics and their production change through time? And then attempts to answer these questions by tracing social change among potters and changes in the production and distribution of their pottery in a single Mexican community over a period of thirty-two years. From 1965 to 1997, he made ten visits to Ticul, and witnessed changes in transportation infrastructure, the use of piped water, and the development of tourist resorts, which changed the demand for pottery. Nonetheless, most of the potters in 1997 came from the families that had also made pottery in 1965. Following his introductory chapter and the second chapter -"How Have the Population and Organization of Potters Changed?"- Arnold asks fundamental questions about modifications that have occurred in demand and consumption, pottery distribution, clay procurement, temper procurement, forming technologies, and firing technology and procedures. Hence, his synchronic and diachronic observations are informed by an intimate knowledge of the ecology, the physical characteristics of the community, the artisans themselves and their descendants. The impacts of technological changes and rapid cultural change (e.g., "modernization") are documented and the impact of the influx of non-Maya-speaking entrepreneurs into the community are also characterized and explained in depth. Yet, Arnold's work isn't just with the native potters themselves, but is also informed by his interactions with other ethnographers, archaeologists, and archaeometricians. He correctly reminds us that "no one paradigm explains all."

Although Arnold provides an assessment of ceramics, much of what he says in the "Introduction" (pp. 1-29) is also applicable to other forms of material culture and is a valuable resource for archaeologists as well as ethnologists who are interested in ceramics or other artifacts. New and Old World archaeologists would benefit from reading this analysis. His introductory essay provides an essential context for the volume and he considers paradigms of pottery and social change as well as specialization and evolving complexity, e.g., from Adam Smith and Emile Durkheim through Prudence Rice and Cathy Costin (notably the latter's paradigm of context, concentration, scale, and intensity). He also visits evolutionary processes and technological choices, as well as cognitive anthropology and engagement theory and employs the latter two in his presentation. Arnold also discusses data reduction and analysis, noting that his longitudinal analysis at Ticul derives from three data bases he devised and updates during his many visits to Ticul since 1965: genealogical (n = 1,024 individuals), production units (300), and potters (451). The subsequent chapters assess how changes have taken place through time in terms of: the population and organization of the potters (pp. 31-91), pottery demand and consumption (pp. 93-125), distribution (pp. 127-151), clay procurement (pp. 153-189), temper procurement (pp. 191-220), composition of the pottery fabric (pp. 221-228), forming technology (pp. 229-279), and firing technology (pp. 281-307). Let me highlight some of the parameters he considers in these chapters with emphasis on those of great interest to archaeologists (Chapters 5 through 9).

Both the population and organization of the potters changed dramatically during the study period. Arnold examines economic and social changes, noting the composition and continuity and growth of the population of potters and their production units. He reports on the evolution of full-time specialists, social continuity and how potters learn the craft, the shift from patrilocal to virilocal postmarital residence, forces of social change, and the increase in the size of the production unit (both permanent and temporary increases are documented). In the third chapter, he focuses on the shifting demand for traditional pottery and the collapse of the demand for water vessels but with a continuity and conservatism in the production of ritual vessels. Innovation and new demands from tourism are also reviewed and the importance of the regional geology, topography, hydrography, and water table as well as calcite inclusions are reported. Pottery distribution changed markedly from 1965 through 1997, notably in the transportation infrastructure as well as in markets, fiestas, fairs, stores (local and non-local), and the evolution of brokers as intermediaries between producers and consumers – a vertical integration issue. The pros and cons of brokers are also considered.

In chapter five, Arnold details under what conditions clay procurement changes, noting changes in resource ownership, clay scarcity and interpersonal politics, clay exhaustion and constraints of elite control, and the development of alternative sources. Organizational changes with the emergence of parttime and full-time specialists are documented in shifts in mining technology and a new procurement organization. He also provides three surrogate measures of production intensity and considers evolutionary social change in terms of elite control, procurement technology, social complexity, efficiency, and task specialization. Temper procurement (Chapter 6) provides valuable ethnoarchaeological information in the analysis of changes in tempers for cooking pottery versus non-cooking ceramics. Changes in procurement, land tenure and the expansion of sources, the depletion of raw materials and changes in sources, the development of mining specialists, and changes in temper variability are all documented, as are behavioral changes. Three surrogate measures of production intensity are also provided. Behavioral changes in fabric composition are reviewed, including changes in clay preparation, clay quality, mixing the pastes, and modification of paste recipes.

Arnold also notes diachronic changes in paste composition seen in INAA studies of kiln wasters.

The chapter on changes in forming technologies is especially compelling. He reviews technological as well as social and cultural choices in asking the question why new fabrication techniques were adopted in the face of conservatism and resistance. Arnold masterful discussions and documentation of the advantages and disadvantages of adopting three new techniques provide great food for thought. The adopted techniques include the potter's wheel, the ball-bearing turntable, the borrowing and adoption of the molding technique, and - an "unlikely adoption" – slip casting. He reviews changing explanation of dimensional variability in traditional vessels and measuring techniques used by the potters, and points out the variability of vessels produced after the late 1970s, noting behavioral and organizational innovations. The conclusions are essential reading (pp. 272-279). His discussion of changes in firing technology focuses on issues of procurement and the use of fuels. Firewood demand and supply became a specialization as did kiln-making technology, with task segmentation, changes in kiln ownership, and specialization in firing. Most kilns are small updraft beehive-shaped but the producers also use square and pot kilns as well as gas and hybrid kilns. In addition, Arnold provides important observations on kiln size increases (as measured by the amount of wood needed to fire one), and their numbers and distributions, and knowledge needed to fabricate kilns.

In Chapter 10, "Conclusion" (pp. 309-326), Arnold summarizes the changes - all of which occurred at different rates – noting that changes in vessel shapes reflected social changes, while increased numbers of potters and production units resulted in more complex organization and task segmentation. Nonetheless, learning patterns are still householdand kin-based, reflecting the conservative nature of household production. He reconsiders social change and specialization, the latter as an evolutionary process, noting that social change is a stimulus for increased production, and examines two trajectories (task segmentation and vertical integration) while pointing out the need to examine issues holistically. Arnold also notes how Costin's paradigm has been modified through several publications (1991, 2001, 2005) and he observes that his data does not fit her "efficiency" component. Lastly, he assesses Costin's parameters versus the assembled data (pp. 322-323). There is a cautionary tale here.

Arnold's well-known *Ceramic Theory and Cultural Process* (1985) remains a landmark publication and is now joined by this new, significant study which helps to bridge the gap between archaeology and ethnography, in that Arnold employs analyses of contemporary ceramic production and distribution to generate new paradigms useful to archaeologists who work with ancient ceramics. His explanations are placed in the context of the literature on craft specialization, so that insights can be applied to the archaeological record that confirm, contradict, and nuance generalizations concerning the evolution of ceramic specialization. *Social Change and the Evolution*

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of Ceramic Production and Distribution in a Maya Community is "must" reading.

MRS MIAA VIII Papers on Ceramics: P. Vandiver, F. Casadio, B. McCarthy, R. H. Tykot, and J. L. R. Sil (editors), *Materials Issues in Art and Archaeology VIII*, MRS Proceedings Volume 1047. Pittsburgh, PA: Materials Research Society. The published proceedings articles from Symposium Y from the 2007 MRS Fall Meeting includes 27 papers, four of which are on ceramics:

Theodore Borek, Curtis Mowry, and Glenna Dean, "Analysis of Modern and Ancient Artifacts for the Presence of Corn Beer: Dynamic Headspace Testing of Pottery Sherds from Mexico and New Mexico." A large volume-headspace apparatus that permits the heating of pottery fragments for direct analysis by gas chromatography/mass spectrometry is described here. A series of fermented-corn beverages were produced in modern clay pots and the pots were sampled to develop organic-species profiles for comparison with fragments of ancient pottery. Brewing pots from the Traumata of northern Mexico, a tribe that regularly uses corn kernels to ferment a weak beer, were also examined for volatile residues and organic-species profiles were generated. Finally, organic species were generated from ancient potsherds from an archaeological site and compared with the modern spectra. The datasets yielded similar organic species, many of which were identified by computer matching of the resulting mass spectra with the NIST mass spectral library. Additional analyses are now underway to highlight patterns of organic species common to all the spectra. This presentation demonstrates the utility of GC/MS for detecting fermentation residues in the fabric of unglazed archaeological ceramics after centuries of burial. This, in turn, opens unexpected new doors for understanding the human past by means of GC/MS analyses. Paper #: 1047-Y01-05, pp. 185-194.

Charles C. Kolb, "Prehistoric Ceramics of Northern Afghanistan: Neolithic through the Iron Age." For nearly four millennia, Afghanistan has been at the crossroads of Eurasian commerce and remains ethnically and linguistically diverse, a mosaic of cultures and languages, especially in the north, where the Turkestan Plain is a conduit for the so-called Silk Route, a series of "roads" that connected far-flung towns and urban centers and facilitated the transfer of goods and services. The research reported herein involves the comparative analysis of archaeological ceramics from a series of archaeological sites excavated in northern Afghanistan in the mid-1960s by the late Louis Dupree and me. I served as the field director (1965-1966) and analyzed the ceramics excavated from all six archaeological sites. These were Aq Kupruk I, II, III, and IV located in Balkh Province (north-central Afghanistan) and Darra-i-Kur and Hazar Gusfand situated on the border between Badakshan and Tarkar Provinces (extreme northeastern Afghanistan). Ten of the 72 ceramic types from the Ag Kupruk area have been published [1, 2, 3] but none of the 53 wares from northeastern Afghanistan have been described. The majority of the Aq Kupruk materials are undecorated (plain

ware) ceramics but there is a unique series of red-painted decorated ceramics (Red/Buff, numbered types 45 through 52) with early first millennium BCE designs but the pottery dates to the BCE-CE period. The results of ceramic typological, macroscopic, binocular and petrographic microscopy (thinsection analysis and point counting) are reported. Paper #: 1047-Y01-02, pp. 147-174.

Chandra L. Reedy, "Preserving Intangible Aspects of Cultural Materials: Bonpo Ritual Crafts of Amdo, Eastern Tibet." Ancient and historic products of past technologies exist in the form of material culture and archaeological finds, available for materials analysis. Technical studies and analytical work, coupled with the study of historical texts and archival documents, can help in reconstructing past technologies. But the act of making an object is, by its very nature, also an intangible part of human heritage. Production of material culture may be accompanied by specific rituals, social behaviors and relationships, music, knowledge gained from oral histories, meanings, intents, beliefs, and reasoning processes. For ancient objects, gaining access to these intangible aspects of cultural heritage may be extremely difficult, if not impossible. However, there are many societies where traditional crafts are produced within a context where the intangible aspects can still be recorded. Yet, these opportunities are disappearing at an alarming rate as development and globalization rapidly overtake more and more traditional communities. Documenting intangible data about craft processes can promote fuller understanding of the objects themselves, and aid long-term preservation of both the objects and the processes used to make them. Examples here are drawn from fieldwork conducted in 2007 at a Bonpo monastery (Serling) and nearby villages in the Amdo region of the eastern Tibetan culture area (in Sichuan Province, China). Bonpo practices, which pre-date the introduction of Buddhism into Tibet, incorporate a variety of ritual crafts that are strongly rooted in a complex web of intangible relationships, behaviors, meanings, purposes, and beliefs. This paper focuses on votive clay objects (tsha-tshas) and barley-dough offering sculptures (tormas). Processes encompassing intangible aspects that are explored include the decision to make an object, when to make it and in what form, selection of raw materials, methods for processing the raw materials, fabrication procedures, selection of who will be involved in fabrication steps, where to place the finished object, and whether it will be preserved for the long term or considered to be only a temporary object. Results are placed in the context of larger theoretical issues regarding documentation and preservation of intangible elements of cultural heritage as part of a study of materials and technological processes. Paper #: 1047-Y02-03, pp. 331-351.

Pamela B. Vandiver, "A Ceramic Plaque Representing a Part of the Moses Panel by Lorenzo Ghiberti in the East Baptistery Doors (Florence, Italy)." A ceramic plaque was studied that depicts the figurative part of the lower half of the Moses Panel from the Gilt Bronze doors that Lorenzo Ghiberti and his workshop installed on the east side of the San Giovanni Baptistery in Florence, Italy. The doors were completed in 1452, and thermoluminescence dating of two areas of the ceramic relief panel gave a broad, but consistent fifteenth century date. No differences were found in the composition, microstructure or phase assemblage of the two stylistically distinct parts. Microscopy and radiography were used to reconstruct the forming methods and sequence of steps in manufacture and restoration. Paper #: 1047-Y02-01, pp. 71-88.

Marc Walton and Karen Trentelman, "Trace Element Indicators of Fabrication Technology for Coral Red and Black Gloss Decoration on Greek Attic Pottery." Laser ablation inductively coupled plasma time-of-flight mass spectrometry (LA-ICP-TOFMS) was used to study the trace element chemistry of coral red and black gloss slip decoration on Greek Attic pottery (6th century BC). The distribution of trace elements in the body fabric and glaze slips were found to be correlated suggesting the raw materials came from a single source. Furthermore, the so-called high calcium and magnesium (HCM) coral red was found to be a less refined material than black gloss, with trace element characteristics suggestive of a carbonate phase in the raw material. This carbonate component may have imparted refractory properties to the HCM coral red slip material during the three-stage oxidative-reductiveoxidative firing used to produce Attic pottery, allowing it to remain porous and re-oxidize during the final firing step, thus creating its final red color. The so-called low calcium and magnesium (LCM) coral red, on the other hand, was found to be more refined than the HCM coral red slip, which suggests that two separate firings were needed to produce the red color of this material. Paper #: 1047-Y02-06, pp. 19-29.

Bradley D. Fahlman, Materials Chemistry. Dordrecht, The Netherlands: Springer, 1st ed. 2007; Corr. 2nd printing, 2007, xi, 485 p. 328 illus., 60 in color. ISBN: 978-1-4020-6119-6 (Hardcover Print) 978-1-4020-6120-2 (Online).74,85 €, \$89.95. This book was designed to fill the need for a textbook that addresses inorganic-, organic-, and nano-based materials from a structure versus property treatment. Materials *Chemistry* has the goal of providing a suitable breadth and depth coverage of the rapidly evolving materials field in a concise format. This volume offers innovative coverage and practical perspective throughout; for example, the initial solidstate chemistry chapter uses color illustrations of crystalline unit cells and digital photos of models to clarify their structures, plus an ample amorphous-solids section; the metals chapter treats the full spectrum of powder metallurgical methods, complex phase behaviors of the Fe-C system and steels, and topics such as corrosion and shape-memory properties; the semiconductor chapter addresses evolution and limitations/ solutions of modern transistors, as well as IC fabrication and photovoltaics; the polymer and "soft" materials chapter describes all polymeric classes including dendritic polymers, as well as important additives such as plasticizers and flameretardants, and emerging applications such as molecular magnets and self-repairing polymers; final chapters on nanomaterials and materials-characterization techniques are also carefully surveyed, focusing on nomenclature, synthetic techniques, and applications taken from the latest scientific literature. Each chapter concludes with a section that describes important materials applications, while appendices include laboratory modules for materials synthesis and a comprehensive timeline of major materials developments.

The author prepared this text for advanced undergraduate students and first-year graduate students in chemistry, physics, or engineering fields. *Materials Chemistry* can also be employed as a reference work by industrial researchers in materials science, polymer science, materials characterization, and nanomaterials. The book is the winner of a 2008 Textbook Excellence Award from the Text and Academic Authors Association (TAA). Readers of the "Archaeological Ceramics" column should note that this is the corrected second printing of this text and will find "Chapter 7: Materials Characterization" up-to-date and especially useful as a reference or for pedagogy.

There are seven chapters: "Chapter 1: What is Materials Chemistry?" which includes sections on Historical Perspectives; Considerations in the Design of New Materials; Design of New Materials Through a "Critical Thinking" Approach; References and Notes; Topics for Further Discussion; and Further Reading. "Chapter 2: Solid-State Chemistry" conveys materials on Amorphous vs. Crystalline Solids; Types of Bonding in Solids; Ionic Solids; Metallic Solids; Molecular Solids; Covalent Network Solids; The Crystalline State; Crystal Growth Techniques; The Unit Cell; Crystal Lattices; Definitions and Nomenclature; Interstitial Crystal Lattices; Metal Oxide Lattices; Crystal Imperfections; Phase-Transformation Diagrams; Crystal Symmetry and Space Groups; Physical Properties of Crystals; Hardness; Cleavage and Fracturing; Color; Properties Resulting from Crystal Anisotropy; The Amorphous State; Sol-Gel Processing; Glasses; Cementitious Materials; Important Materials Applications I: Fuel Cells; References and Notes; Topics for Further Discussion; and Further Reading. "Chapter 3: Metals" has sections on the Mining and Processing of Metals; Powder Metallurgy; Metallic Structures and Properties; Phase Behavior of Iron and Iron-Carbon Alloys; Hardening Mechanisms of Steels; Stainless Steels; Non-Ferrous Metals and Alloys; The Coinage Metals; Aluminum Alloys; Refractory Metals; Shape-Memory Alloys; Metal Surface Treatments for Corrosion Resistance; Magnetism in Metals, Alloys, and Organometallic Complexes; Reversible Hydrogen Storage; Important (and Controversial) Materials Applications II: Depleted Uranium; References and Notes; Topics for Further Discussion; and Further Reading. "Chapter 4: Semiconducting Materials" contains information on Properties and Types of Semiconductors; Silicon-Based Applications; Silicon Wafer Production; Integrated Circuits; Field-Effect Transistors: Structure and Properties; Integrated Circuit Fabrication; Thin-Film Deposition Methodologies; Light-Emitting Diodes: There is Life Outside of Silicon!; Thermoelectric (TE) Materials; Important Materials Applications III: Photovoltaic (Solar) Cells; References and Notes; Topics for Further Discussion; and Further Reading. "Chapter 5: Organic 'Soft' Materials" focuses on topics including Polymer Classifications and Nomenclature; Polymerization Mechanisms; Addition Polymerization;

Heterogeneous Catalysis; Homogeneous Living Catalysis; Step-Growth Polymerization; "Soft Materials" Applications: Structure vs. Properties; Molecular Magnets; Polymer Additives: Plasticizers and Flame Retardants; Important Materials Applications IV: Self-Healing Polymers; References and Notes; Topics for Further Discussion; and Further Reading. "Chapter 6: Nanomaterials" considers What is "Nanotechnology?"; Nanoscale Building Blocks and Applications; Zero-Dimensional Nanomaterials; Mechanism for the Nucleation/Growth/ Agglomeration of Metal Nanoclusters; The First 0-D Nanoarchitecture: The Fullerenes; The Solution-Phase Synthesis of Nanoparticles; Self-Assembly of Nanoparticles/ Nanoclusters into Arrays; One-Dimensional Nanostructures; Carbon Nanotubes; Growth of 1-D Nanostructures; Top-Down Nanotechnology: "Soft Lithography"; Important Materials Applications V: Nanoelectromechanical Systems (NEMS); References and Notes; Topics for Further Discussion; and Further Reading. "Chapter 7: Materials Characterization" has section devoted to Optical Microscopy; Electron Microscopy; Transmission Electron Microscopy (TEM); Sample Preparation Techniques; Non-Imaging Applications for TEM; Scanning Transmission Electron Microscopy (STEM); Electron Energy-Loss Spectroscopy (EELS); Scanning Electron Microscopy (SEM); Structure Determination using SEM; Sample Considerations and Auger Electron Spectroscopy (AES); Environmental SEM (ESEM); Photoelectron Spectroscopy (PES); Structure Determination using XAFS; Surface Characterization Techniques Based on Ion Bombardment; Scanning Probe Microscopy (SPM); Bulk Characterization Techniques; Important Materials Applications VI: So Which Acronym Shall I Use?; References and Notes; Topics for Further Discussion; and Further Reading. There are three appendices: Appendix A: Timeline of Materials Developments; Appendix B: "There's Plenty of Room at the Bottom," and Appendix C: Materials-Related Laboratory Experiments. The volume also has a comprehensive "Bibliography."

A Guide to Spanish Colonial Ceramics in Texas by Anne A. Fox and Kristi M. Ulrich (San Antonio: University of Texas at San Antonio, Center for Archaeological Research, reprinted 2009). The first printing of CAR Special Report No. 33 was sold out and the Center is offering pre-orders for a second printing of this volume. A minimum of 50 orders were required for this edition to go to press. Pre-orders closed on 15 February 2009 and will be shipped in April. One hundred copies were printed and 85 have been sold as of 1 April 2009; when all of the copies are sold, the Center intends to make the publication available as a CD, at approximately half the cost of the hardcopy. Details on this will be forthcoming once all hard copies are gone. For all orders, please include a check made payable to the Center for Archaeological Research. The cost of a hardcopy of Special Report #33 is \$35.00. Include Texas state sales tax (\$2.84) for each volume on all in-state orders, and \$4.00 postage and handling for each publication. If more than three volumes are requested, reduce postage and handling charges by 50%. If publications are being ordered for a taxexempt organization, please include tax-exempt certification with the order form: http://car.utsa.edu/Publications/ SpanishColonialCeramicsorderform.pdf the mailing address is: The Center for Archaeological Research, University of Texas at San Antonio, One UTSA Circle, San Antonio, Texas 78249-0658, USA.

Excerpted from the "Editor's Preface": While we have tried to include the entire state in our discussion, the book is written from a South Texas perspective as these are the primary collections to which we have access and the sites with which we are most familiar. The manuscript is divided into four chapters. The first three chapters offer abbreviated background information. Chapter 1 is a brief history of the Spanish occupation of Texas, included to provide a background against which the details of ceramic types and dating will fit. Chapter 2 is a very brief summary of the history of Spanish ceramic manufacture in Mexico and a discussion of the importation of these ceramics into Texas. Chapter 3 provides a brief summary of the methods of manufacturing seen in Spanish ceramics in Texas, including the surface treatments and vessel forms. A glossary of terms used in ceramic analysis is included in Appendix A. Chapter 4 is the heart of the publication. It consists of type descriptions of Spanish colonial ceramics found in Texas. In most cases, each type includes a plate with several examples in color facing the text of the type descriptions. The layout is designed to facilitate identification. Each illustration will include the location at which the specific item was found, but in order to keep in-text citations to a minimum in Chapter 4, reference to the specific project during which each was recovered is not made. Instead, Appendix B consists of an extensive bibliography of archaeological site reports and artifact analyses.

Andrew Fairbairn, Sue O'Connor, and Ben Marwick (eds.), New Directions in Archaeological Science. Terra Australis 28. Canberra: Australian National University Press, ANU E Press, http://epress.anu.edu.au/ta28 citation.html, 2009, ISBN 9781921536489 \$49.50 (GST inclusive), ISBN 9781921536496 (Online), \$49.50 AU. New Directions in Archaeological Science contains refereed papers from the 8th Australasian Archaeometry meeting and covers the thematic fields of geoarchaeology, archaeobotany, materials analysis and chronometry, with particular emphasis on the first two. The three editors outline the special value of these contributions in the introduction. The entire volume, published in February 2009, may be freely accessed and downloaded from http:// epress.anu.edu.au/ta28 citation.html and is a part of the Terra Australis series, recent issues of which are all available on-line gratis via http://epress.anu.edu.au/titles/terra australis.html. ANU E-Press also has numerous books on anthropology, environmental issues and numerous other topics that may be of interest to readers of this column. To download the PDF files, users will need the latest version of Adobe Reader (version 7 or later). Two papers concern ceramics: Todd Craig, Peter Grave and Stephen Glover, "HPLC-MS Characterisation of Adsorbed Residues from Early Iron Age Ceramics, Gordion, Central Anatolia" (pp. 203-212) and Peter Grave "Melting Moments: Modelling Archaeological High Temperature Ceramic Data" (pp. 215-232) which concerns East and Southeast Asian ceramic analysis via ICP-OES.

The Berkshire Encyclopedia of China: Modern and Historic Views of the World's Newest and Oldest Global Power, 5 volumes, Linsun Cheng (University of Massachusetts, Dartmouth), General Editor; Great Barrington, MA: Barrington Publishing Group, 2009, 2,500 pp., 1,200 illustrations, ISBN: 0-9770159-4-7, \$675.00, was published in late March. The five large-format volumes contain nearly 1,000 articles (500-3,000 words each) on Chinese history, culture, and politics with topics ranging from "Adoption" and "Banking" to "World Literature" and "Zhou Dynasty." Readers of this column will find contributions on: Celadon, Jingdezhen, Joseph Needham, Porcelain, and Terracotta Soldiers, among others. With every print sale the publisher will provide a free one-year individual license (or comparable discount from the institutional license) to a digital edition hosted by ExactEditions.com. This is a searchable e-book of all volumes.

Previous Meetings

The 2009 annual meeting of the *Mid-Atlantic Archaeological Conference* was held 19-22 March 2009 in Ocean City, Maryland, USA. Among the 34 presentations was one dealing with ceramics: "Those Poor Pots: A look at the Ceramic Assemblage from The Philadelphia City Almshouse Privy Excavation (1732-1767)" by Mara Kaktins, URS Corporation, mara-kaktins@urscorp.com.

The 37th Annual Conference on Computer Applications and Quantitative Methods in Archaeology (CAA) was hosted by The Colonial Williamsburg Foundation and The University of Virginia 22-26 March 2009 in Williamsburg, Virginia, USA. The theme of this year's meeting was "Making History Interactive." Nine of the 200+ presentations concerned ceramics. The conference program, authors and their affiliations, and abstracts are available on line at http://www.caa2009.org/ CAA2009 CompletePrelimProgram030409.pdf (page numbers refer to the locations of the abstracts): "Virtual Reconstruction of a Ceramic Vessel: A Case Study from The Pas, Manitoba" by Morgan John Tamplin, Kevin Brownlee, Leigh Syms, Andrew Fallak, and Myra Sitchon (pp. 121-122); "A Proposal of Ceramic Typology Based on the Image Comparison of the Profile" by Ana Luisa Martínez-Carrillo, Arturo Ruiz-Rodriguez, Manuel Lucena, and Jose Manuel Fuertes (p. 153); "Visualization and Automatic Typology Construction of Ceramics Profiles" by Laurens van der Maaten, Guus Lange, and Paul Boon (pp. 153-154); "3D Pottery Shape Similarity Matching Based on Digital Signatures" by Anestis Koutsoudis and Christodoulos Chamzas (pp. 154-155; "A System of Pottery Shape Recovery and Repairing" by Mingquan Zhou, Guo-hua Geng, Zhongke Wu, and Wuyang Shui (pp. 189-190); "Inside Greek Vases — On Examining the Skill of Ancient Greek Craftsmen Producing Complex 3D Shapes Using Current Technologies" by Martin Arthur Boss, Martin Meister, and Dominik Rietzel (pp. 199-200); "Implementing RDFa in the Publication of Ceramic Data from Troy (Turkey)" by Sebastian Heath and Billur Tekkök (pp. 226-227); "Computer-Assisted Recovery Technology of Broken Rigid Objects and Its Applications in Terra Cotta Warriors and Horses" by Mingquan

Zhou, Zhongke Wu, and Wuyang Shui (pp. 270-271); "Integrated Computer Modeling of Archaeological Potsherd Pavement Site at Ajaba-Kajola, Southwestern Nigeria" by Adekunle Abraham Adepelumi, Olajide Temitayo Ajigo, and Dele Ebenezer Falebita (pp. 271-271): "Continuity and Change: A Study of the Shape of Late Neolithic and Early Bronze Age Vessels from the Netherlands" by Vincent Mom and Erik Drenth (p. 278); and "An Interactive System for Storage, Analysis, Query and Visualization of Archaeological Pottery" by Ana Luisa Martínez-Carrillo, Arturo Ruiz-Rodriguez, Francisco Mozas-Martinez, and Jose Manuel Valderrama-Zafra (p. 292).

The Association for Asian Studies Annual Meeting held in Chicago, Illinois, USA from 26-29 March 2009, included a session on 27 March (sponsored by the Thailand, Laos, Cambodia Studies Group) entitled "The Scholarship of Roxanna Brown and Its Implications for Future Research on the Ceramics, Art, and Trade of Southeast Asia." Robert L. Brown (UCLA) chaired the session and presented the initial paper, "Roxanna Brown's scholarship and Southeast Asia in the 15th and 16th Centuries." Louise Cort (Freer and Sackler Galleries, Smithsonian Institution) presented "Bringing Ceramics into the Study of Southeast Asia – Where Do We Go from Here?" and Pattaratorn Chirapravati (California State University, Sacramento) gave a paper "Ming Gap, Pot Shards, and Dating of Temples." Caverlee Cary (University of California, Berkeley) served as discussant.

"Art Revealed by Industry: Painters, Sculptors and Designers Create Trenton's Ceramics" was the theme of the 2009 symposium co-sponsored by The Potteries of Trenton Society (POTS) and the New Jersey State Museum, 4 April 2009, New Jersey State Museum Auditorium, 205 West State Street, Trenton, NJ, USA. The symposium focused on the role of artists and designers in developing wares produced in Trenton. These presentations were augmented by a walkthrough of the new Lenox exhibition at the State Museum. Diana Stradling (Independent Scholar) discussed the work of modelers in developing designs for New Jersey's Rockingham wares, mottled-brown kitchen wares that were ubiquitous in American homes in the 1800s. These modelers learned their skills working in English and American factories, and invented, combined and recombined a variety of motifs to appeal to American retailers and homemakers. The keynote speaker, Ulysses Dietz (Curator of Decorative Arts at the Newark Museum) reviewed the life and work of sculptor Isaac Broome ranging from his Parian wares for Ott & Brewer's display at the Philadelphia Centennial exhibition in 1876 through his late 19th century contributions to tile design for Providential and Trent Tile and concluding with his return to Trenton's pottery workshops in the early twentieth century. Ellen Denker (Independent Scholar), formerly the archivist for Lenox China, discussed design at Ceramic Art Company/Lenox China through the work of Walter Lenox, Frank Holmes, and a myriad of post-war dinnerware designers that moved the company from the dominance of a single design vision to design by committee. Collector and POTS board member Emma Lewis gave a virtual walk-through of the exhibition "Faces and

Flowers: Painting on Lenox China," which opened in February 2009 at the University of Richmond, Virginia. This exhibition features the work of Bruno Geyer, William Morley, Jan Nosek, and other painters, enamellers, and gilders who decorated the special-order wares produced by Ceramic Art Company and Lenox China from 1889 into the 1930s. Lastly, Ellen Denker provided a walk-through of a new exhibition at the New Jersey State Museum that celebrates the recent gift from the Lenox Archives, donated by the china maker's former parent company Brown-Forman Corporation. This exhibition opens 4 April.

New Journal

Ethnoarchaeology: Journal of Archaeological, Ethnographic, and Experimental Studies, edited by Lisa Frink and Kathryn Weedman Arthur and published by Left Coast Press, Inc. will be semi-annual in April and October; see http:// /www.lcoastpress.com/journal.php?id=9 Ethnoarchaeology, a cross-cultural peer-reviewed journal, will focus on the present position, impact of, and future prospects of ethnoarchaeological and experimental studies approaches to anthropological research. The primary goal of this journal is to provide practitioners with an intellectual platform in which we may showcase and appraise current research as well as foreground theoretical and methodological directions for the 21st century. One need that *Ethnoarchaeology* addresses is that there is little that unifies or defines this subdiscipline, although there has been an exponential increase in ethnoarchaeological and experimental research in the past thirty years. With such growth scholars must explore what distinguishes these approaches as a subdiscipline, what methods connect practitioners, and what unique suite of research attributes practitioners contribute to the better understanding of the human condition. In addition to research articles, the journal will contain book and other media reviews, periodic theme issues, and position statements by noted scholars.

Exhibition

"Painted Metaphors: Pottery and Politics of the Ancient Maya" is an exhibition scheduled from 5 April 2009 into the Fall of 2009 at the University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, Pennsylvania, USA. Around 700 CE, Chamá and the other towns and villages along Guatemala's Chixoy River were hubs of activity located at the crossroads of trade and pilgrimage, channeling the movement of people and ideas at the height of Maya civilization. This exhibition presents the story of the ancient Maya as lived by these villagers and the rediscovery of their history by archaeologists today. Penn Museum's unique collection of brilliantly painted Chamá Polychromes opens a window into the lives of the ordinary Maya of 1300 years ago, and the way they dealt with the challenge of forced change. More than 150 objects — figurines, jades, musical instruments, ritual objects, weaving implements, cooking pots and projectile pointsconvey vibrant evidence of ancient Maya life, as revealed by archaeological discovery and scientific analysis. For more information, visit http://www.museum.upenn.edu.

Upcoming Conferences

Rachel S. Popelka-Filcoff, Associate Editor

2009

24-27 May. American Geophysical Union, 2009 Joint Assembly (The Meeting of the Americas); Toronto, Ontario, Canada. General information: http://www.agu.org/meetings/ja09.

25-29 May. DIG: Developing International Geoarchaeology Conference and Instrumental Neutron Activation Analysis Workshop; McMaster University, Hamilton, Ontario, Canada. General information: http://socserv.mcmaster.ca/dig.

31 May-5 June. Radiocarbon 2009 Conference; Kona Hawaii, USA. General information: http://www.radiocarbon2009.org.

1-4 June. 24th International Association of Geochemistry Symposium (IAGS2009); Fredericton, New Brunswick, Canada. General information: http://www.unb.ca/conferences/IAGS2009.

6-11 June. 46th Annual Meeting of the Clay Minerals Society "Clays of the Big Sky;" Billings, Montana, USA. General information: http://www.clays.org/home/HomeAnnualMeeting. html.

8-12 June. E-MRS 2009 Spring Meeting; Strausbourg, France. General information: http://www.emrs-strasbourg.com.

21-26 June. Goldschmidt 2009: "Challenges to Our Volatile Planet;" Davos, Switzerland. General information: http://www.goldschmidt2009.org.

23-26 June. 11th International Paleolimnology Symposium; Guadalajara, Jalisco, Mexico. General information: http://www.paleolim.org/index.php/symposia.

6-11 July. 7th International Conference on Geomorphology (ANZIAG): Ancient Landscapes- Modern Perspectives; Melbourne, Australia. Special session: "Geoarchaeology." General information: http://www.geomorphology2009.com.

27-31 July. 58th Annual Denver X-ray Conference; Colorado Springs, Colorado, USA. General information: http://www.dxcicdd.com.

2-7 August. Heritage Science Symposium - 42nd IUPAC Congress; Glasgow, Scotland, UK. General information: http://www.rsc.org/images/Heritage_Science_Publicity_tcm18-127442.pdf.

17-20 August. International Conference on Remote Sensing in Archaeology; Tiruchirappalli, India. General information: http://www.spacetimeplace2009.org.

30 August-3 September. Colloquium Spectroscopicum Internationale XXXVI; Budapest, Hungary. General information: http://www.csixxxvi.org.

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