ARCH 1764 Under the Microscope: 250 Years of Brown's Material Past
Mondays 3:00 – 5:30 pm
Location: Rhode Island Hall 108

Instructors
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Overview
An archaeologist will tell you that to learn a university's history, you must uncover and investigate its treasures, trash, tools, and toys. An engineer will tell you that to understand such objects, you must study how these things were made, in what materials and with what technologies. This co-taught course unites these two disciplines for a unique exploration of Brown's past, combining interdisciplinary discussions, hands-on laboratory work, and individual historical and material analysis of artifacts selected from 250 years of life on College Hill.

Course Description

- Multiple excavations on College Hill have revealed thousands of artifacts. Students will select some of these objects—including ceramics, metals, and glass—from Brown's past and apply scientific techniques to reconstruct the history of the university from colonial and revolutionary times until the modern era. This type of analysis allows us to write new chapters summarizing 250 years of the university, from the perspective of the "things" that students, faculty, and visitors produced, consumed, and left behind on campus grounds. Application of the physical sciences to reverse engineer archaeological data has become an inseparable component to the study of the human past. The ability to quantify data to the micro- and nano-scale can make powerful research possible into environmental trends, diet, settlement and trade patterns, resource extraction and consumption, issues surrounding human land-use and historical ecology, and others. Students will be trained in analysis of archaeological and ethnographic materials and techniques, and will learn about current trends in archaeometric research. Methods will include portable X-ray fluorescence spectroscopy (pXRF), optical microscopy, and scanning electron microscopy coupled with energy X-ray dispersive spectroscopy (SEM-EDS).

- **Weekly readings** are mandatory and are to be completed before the lecture. Please purchase this textbook online (not available in the bookstore):
  Pollard, A.M., and Carl Heron. 2008. *Archaeological Chemistry, 2nd Edition*. Cambridge: RSC Publishing.
  Additional readings are optional, usually representing more detailed examples of topics that students may choose to pursue. They can be found online or in the library, but if these are not helpful then please ask the instructors for specific copies.

Objectives
By the end of the course, students will be trained in:
1) *the capacity to operate in a professional laboratory setting (for undergraduate students); independent archaeometric laboratory work (for graduate students)*
2) *scientific publication*
3) *scientific grant writing*

- Much of the course will be laboratory focused, with students gaining practical experience on the preparation and analysis of various material types. The instructors will guide the students in the details of laboratory procedure and analysis.
- Grading will be based on attendance and participation, two short examinations, two short laboratory write-ups, and one group Archaeometry Project. Participation grade includes each student leading a class discussion once in the semester. Students will choose two artifacts ("selected samples") of metal, ceramic, glass, or slag, and will conduct the full range of research on the object from sampling to the write-up. The laboratory write-ups will be brief descriptions of the sample preparation and techniques used per selected sample. The Archaeometry Project will be based on the selected samples as well but for this assignment students will combine their samples into one report and conduct further experimentation. For example, for the laboratory write-up a student may prepare a sample and analyze it using optical microscopy, but then with the group also analyze the artifact using electron microscopy. The final product will be a report co-authored by group members and structured in two components: 1) the equivalent of a brief scientific journal article, meaning that the following sections should be represented: Introduction, Materials and Methods, Results, Discussion, Conclusion; 2) a summary of the Intellectual Merits and Broader Impacts based on the National Science Foundation definitions. *Students are encouraged to consider and propose novel methods of investigation*. If a request is made to extend a deadline or turn in an assignment late and still receive full credit, the student must approach one of the instructors before it is due to request an extension, not after. 5% of the grade will be deducted for every day the assignment is late.
- Much of the research will be conducted using the artifacts excavated from Brown University grounds from three semesters of *ARCH1900: The Archaeology of College Hill*. Other artifacts available for students can be accessed from the instructors' study collection of artifacts comprised of hundreds of ethnographic and ancient objects from the Near East, Central Asia, and North Africa.

Grade percentages

- Attendance and participation: 25%
- Two laboratory write-ups: 30% (15% each)
- Two examinations: 20% (10% each)
- Group Archaeometry Project: 25%

Part I Archaeometric Approaches to Archaeology

Week 1, January 26

Lecture: **What does physical information tell us about social behavior?** Case studies.
Laboratory: Laboratory safety, procedure, settings, proper handling and storage of artifacts

Readings

Jones, Andrew. 2002. Chapter 1 "The archaeology of 'two cultures'" in *Archaeological theory and scientific practice*. Cambridge: Cambridge University Press, pp. 1-22.

Pollard, A. Mark, and Carl Heron. 2008. Chapter 8 "Amino Acid Stereochemistry and the First Americans" in *Archaeological chemistry*. Cambridge: RSC Publishing, pp. 270-301.

Additional readings

Barnard, H., S.H. Ambrose, D.E. Beehr, M.D. Forster, R.E. Lanehart, M.E. Malainey, R.E. Parr, M. Rider, C. Solazzo, and R.M. II Yohe. 2007. Mixed results of seven methods for organic residue analysis applied to one vessel with the residue of a known foodstuff. *Journal of Archaeological Science* 34, pp. 28-37.

Baxter, M.J. 2008. Mathematics, Statistics and Archaeometry: the past 50 years or so. *Archaeometry* 50.6, 968-982.

Ciliberto, Enrico, and Giuseppe Spoto, eds. 2000. *Modern Analytical Methods in Art and Archaeology*. Wiley-Interscience.

Lechtman, H., and R. Merrill. 1975. *Material Culture: Styles, Organization and Dynamics of Technology. Proceedings of the American Ethnological Society*. St. Paul: West Publishing Co.

Odegaard, N., Carroll, S., and W.S. Zimmt. 2000. *Material characterization tests for objects of art and archaeology*. London: Archetype Press.

Pollard, A. Mark, and Carl Heron. 2008. Chapter 1 "The Development of Archaeological Chemistry" in *Archaeological chemistry*. Cambridge: RSC Publishing, pp. 1-18.

Week 2, February 2

Lecture: **What do archaeological materials look like microscopically? What are some of the differences between ancient and recently produced microstructures?** Materials and materiality: crystalline and non-crystalline solids, phases, phase diagrams; microstructure; inorganic and organic material types.
Laboratory: Demonstration of optical microscopy and electron microscopy

Readings

Jones, Andrew. 2002. Chapter 2 "Science as culture: creating interpretative networks" in *Archaeological theory and scientific practice*. Cambridge: Cambridge University Press, pp. 23-38.

Pollard, A. Mark, and Carl Heron. 2008. Appendix 4, "Isotopes" in *Archaeological chemistry*. Cambridge: RSC Publishing, pp. 420-423.

Additional readings

Scott, David A. 1991. Appendix G, "Phase Diagrams," in *Metallography and microstructure of ancient and historic metals*. [Marina del Rey, CA]: Getty Conservation Institute in association with Archetype Books, pp. 121-136.

Week 3, February 9

Lecture: **What methods do we use to examine the composition and microstructure of ancient and historical artifacts?** Terminology and techniques: definitions and examples of invasive, non-invasive, destructive, non-destructive techniques; pXRF, XPS, SEM-EDS, ICP-MS, GC-MS, EPMA, FTIR, Raman spectroscopy, optical microscopy

Laboratory: Demonstrations of optical microscopy; Students choose materials for experimental component

Readings

Pollard, A. Mark, and Carl Heron. 2008. Chapter 2, "Analytical Techniques Applied to Archaeology" in *Archaeological chemistry*. Cambridge: RSC Publishing, pp. 19-74.

Additional readings

Goldstein, Joseph I., Dale E. Newbury, Patrick Echlin, David C. Joy, Jr. A.D. Romig, Charles E. Lyman, Charles Fiori, and Eric Lifshin. 1992. *Scanning Electron Microscopy and X-Ray Microanalysis: A Text for Biologists, Materials Scientists, and Geologists*. Second ed. New York: Plenum Press.

Week 4, February 16, President's Day, no class

Week 5, February 23

Laboratory: **Portable X-Ray Fluorescence Spectroscopy** (pXRF or handheld XRF) of selected samples, **the most common—and most misused—analytical instrument in archaeology**.

Readings

Heginbotham, Arlen, Aniko Bezur, Michel Bouchard, Jeffrey M. Davis, Katherine Eremin, James H. Frantz, Lisha Glinsman, Lee-Ann Hayek, Duncan Hook, Vicky Kantarelou, Andreas Germanos Karydas, Lynn Lee, Jennifer Mass, Catherine Matsen, Blythe McCarthy, Molly McGath, Aaron Shugar, Jane Sirois, Dylan Smith, and Robert J. Speakman. 2010. An Evaluation of Inter-Laboratory Reproducibility for Quantitative XRF of Historic Copper Alloys. Paper read at International Conference on Metal Conservation. Interim Meeting of the International Council of Museums Committee for Conservation, Metal Working Group, at Charleston, SC, pp. 178-188.

Shugar, Aaron N. and Jennifer L. Mass. 2013. Chapter 1, "Introduction" in *Handheld XRF for Art and Archaeology*. Leuven University Press, pp. 17-36.

Additional readings

Shugar, Aaron N. and Jennifer L. Mass, eds. 2013. *Handheld XRF for Art and Archaeology*. Leuven University Press.

Part II Ancient Materials

Week 6, March 2

DUE: Laboratory write-up #1

Lecture: Non-ferrous metals, the **Bronze Age**, ancient alloys of copper, arsenical copper, tin bronze, silver, gold, and lead. **Early smelting and casting technologies**.
Laboratory: Sampling and mounting metallurgical/slag/glass samples or ceramic/petrographic thin sections

Readings

Killick, David. 2014. Chapter 2, "From Ores to Metals," in *Archaeometallurgy in Global Perspective*. Springer, pp. 11-46.

Additional readings

Bray, P.J., and A.M. Pollard. 2012. A new interpretive approach to the chemistry of copper-alloy objects: source, recycling and technology. *Antiquity* 86, pp. 853-67.

Kaufman, B., 2013. Copper Alloys from the 'Enot Shuni Cemetery and the Origins of Bronze Metallurgy in the Levant. *Archaeometry* 55(4), 663-690.

Radivojević, Miljana, Thilo Rehren, Ernst Pernicka, Dušan Šljivar, Michael Brauns, and Dušan Borić. 2010. On the Origins of Extractive Metallurgy: New Evidence from Europe. *Journal of Archaeological Science* 37:2775-87.

Scott, David A. 1991. *Metallography and microstructure of ancient and historic metals*. Marina del Rey, CA: Getty Conservation Institute in association with Archetype Books.

Scott, David A. 2010. *Ancient Metals: Microstructure and Metallurgy*. Vol. 1. Los Angeles: Conservation Science Press.

Week 7, March 9

Lecture: Ferrous metals, the **Iron Age**, iron alloys such as steel, corrosion properties, benefits of iron versus copper alloys.
Laboratory: Grinding and polishing experimental samples

Readings

Craddock, Paul. 1995. Chapter 7, "Iron and Steel," in *Early Metal Mining and Production*. Smithsonian Institution Press, pp. 234-283.

Additional readings

Scott, David. 2013. *Ancient Metals: Microstructure and Metallurgy, Vol. IV: Iron and Steel*. Los Angeles: Conservation Science Press.

Scott, David A., and Gerhard Eggert. 2009. *Iron and steel in art: corrosion, colorants, conservation*. London: Archetype.

Tylecote, R.F., 1980. Crucibles, Furnaces, and Slags, in *The Coming of the Age of Iron*, Wertime, T.A., and J.D. Muhly, eds. New Haven, London: Yale University Press.

Tylecote, R.F., 1962. *Metallurgy in archaeology: a prehistory of metallurgy in the British Isles*. London: Arnold.

Week 8, March 16

Examination #1

Laboratory: Optical microscopy of selected samples; etching

Week 9, March 23, Spring recess, no class

Week 10, March 30

DUE: Laboratory write-up #2

Lecture: Ceramics; how traits like **heat resistance, liquid storage (lack of porosity), durability, malleability of aesthetic form, and ubiquity of raw clay resources** are characteristic of one of most fundamental material types of humanity. Plain and decorative ware from College Hill to be investigated.
Laboratory: SEM-EDS

Readings

Pollard, A. Mark, and Carl Heron. 2008. Chapter 4, "The Geochemistry of Clays and Provenance of Ceramics" in *Archaeological chemistry*. Cambridge: RSC Publishing, pp. 98-143.

Sinopoli, Carla M. 1991. Chapters 1 and 2, "Approaches to Archaeological Ceramics," and "Defining Ceramics," in *Approaches to Archaeological Ceramics*. Plenum Press, pp. 1-42.

Additional readings

Goren, Y., 1996. The Southern Levant in the Early Bronze Age IV: The Petrographic Perspective. *BASOR* 303, 33-72.

Maniatis, Y. 2009. The emergence of ceramic technology and its evolution as revealed with the use of scientific techniques, in *From Mine to Microscope: Advances in the Study of Ancient Technology*, Shortland, Andrew J., Ian C. Freestone, and Thilo Rehren, eds. Oxford: Oxbow Books.

Rice, Prudence M. 1987. Introduction, in *Pottery Analysis: A Sourcebook*. Chicago and London: The University of Chicago Press.

Sinopoli, Carla M. 1991. *Approaches to Archaeological Ceramics*. Springer.

Thornton, C.P., Rehren, T., 2009. A truly refractory crucible from fourth millennium Tepe Hissar, Northeast Iran. *Journal of Archaeological Science* 36, 2700-2712.

Week 11, April 6

Lecture: Glass – **from Egyptian faience, to elegant Roman glasses, to the historical material found on College Hill**.
Laboratory: Research on selected samples

Readings

Pollard, A. Mark, and Carl Heron. 2008. Chapter 5, "The Chemistry, Corrosion and Provenance of Archaeological Glass" in *Archaeological chemistry*. Cambridge: RSC Publishing, pp. 144-192.

Additional readings

Shortland, Andrew J., Ian C. Freestone, and Thiloh Rehren, eds. 2009. *From mine to microscope: advances in the study of ancient technology*. Oxford: Oxbow Books.

Smirniou, M., and T. Rehren. "Shades of blue–cobalt-copper coloured blue glass from New Kingdom Egypt and the Mycenaean world: a matter of production or colourant source?" *Journal of Archaeological Science* 40.12 (2013): 4731-4743.

Smirniou, M., and T. Rehren. "Direct evidence of primary glass production in Late Bronze Age Amarna, Egypt." *Archaeometry* 53.1 (2011): 58-80.

Week 12, April 13

Lecture: Metallurgical slag, the **industrial byproducts of ancient material production**, **early pollution**.
Laboratory: Research on selected samples

Readings

Hauptmann, Andreas. 2014. Chapter 5, "The Investigation of Archaeometallurgical Slag," in *Archaeometallurgy in Global Perspective*. Springer, pp. 91-106.

Additional readings

Bachmann, H. G. 1982. *The Identification of Slags from Archaeological Sites, Occasional Publication No. 6*. London: Institute of Archaeology.

Charlton, Michael F., Peter Crew, Thilo Rehren, and Stephan J. Shennan. 2010. Explaining the evolution of ironmaking recipes - an example from northwest Wales. *Journal of Anthropological Archaeology* 29:352-67.

Eliyahu-Behar, Adi, Naama Yahalom-Mack, Sana Shilstein, Alexander Zukerman, Cynthia Shafer-Elliott, Aren M. Maeir, Elisabetta Boaretto, Israel Finkelstein, and Steve Weiner. 2012. Iron and bronze production in Iron Age IIA Philistia: new evidence from Tell es-Safi/Gath, Israel. *Journal of Archaeological Science* 39:255-267.

Week 13, April 20

Examination #2

Lecture: Environmental archaeology: archaeobotany, vegetational and arboreal proxy data, pollen cores, zooarchaeology, osteoarchaeology, diet. **How do humans use their landscapes and resources, and how can we measure this in quantifiable ways? What are the long-term impacts of early industry in Providence?**

Laboratory: Research on selected samples

Readings

Butzer, Karl W. 1982. Chapter 2, "Environmental Systems: Spatial and Temporal Variability," in *Archaeology as Human Ecology: Method and Theory for a Contextual Approach*. New York: Cambridge University, pp. 14-34.

Dalfes, N. 1997. "Environmental Vulnerability of Early Societies: Some Reflections on Modeling Issues," in *Third Millennium BC Climate Change and Old World Collapse*, ed. Dalfes, H. N., G. Kukla, and H. Weiss. Berlin: Springer, pp. 691-697.

Additional readings

Kaufman, Brett and David Scott. 2014. Fuel Efficiency of Ancient Copper Alloys: Theoretical Melting Thermodynamics of Copper, Tin, and Arsenical Copper and Timber Conservation in the Bronze Age Levant. *Archaeometry*, doi:10.1111/arcm.12127.

Marston, John M. 2009. Modeling wood acquisition strategies from archaeological charcoal remains. *Journal of Archaeological Science* 36.10, 2192-2200.

Riehl, S., Bryson, R., Pustovoytov, K., 2008. Changing growing conditions for grops during the Near Eastern Bronze Age (3000-1200 BC) : the stable carbon isotope evidence. *Journal of Archaeological Science* 35, 1011-1022.

Roberts, N., Eastwood, W.J., Kuzucuoglu, C., Fiorentino, G., Caracuta, V., 2011. Climatic, vegetation and cultural change in the eastern mediterranean during the mid-holocene environmental transition. *Holocene* 21, 147-162.

Rosen, A.M., 1986. Environmental Change and Settlement at Tel Lachish, Israel. *BASOR* 263, 55-60.

Seetah, T. Krish, Andrea Cardini, and Preston T. Miracle. 2012. Can *morphospace* shed light on cave bear spatial-temporal variation? Population dynamics of *Ursus spelaeus* from Romualdova pećina and Vindija, (Croatia). *Journal of Archaeological Science* 39.2, 500-510.

Week 14, April 27

Lecture: Physics in archaeology: **GIS, magnetometry, GPR, resistivity, and radiocarbon dating**

Laboratory: Research on selected samples

Readings

Clark, Anthony. 2003. Chapter 6, "Choice of method: choice of site," in *Seeing Beneath the Soil: Prospecting Methods in Archaeology*. Routledge, pp. 124-131.

Taylor and, R.E. and O. Bar-Yosef. 2014. Chapter 1, "Basic Elements," in *Radiocarbon Dating: An Archaeological Perspective, 2nd edition*. Left Coast Press, pp. 19-42.

Additional readings

Conyers, Lawrence B. 2006. Ground-Penetrating Radar Techniques to Discover and Map Historic Graves. *Historical Archaeology* 40.3, 64-73.

El-Gamili, M.M. A.S. el-Mahmoudi, S. Sh. Osman, A. Gh. Hassaneen, and M.A. Metwaly. 1999. Geoelectric Resistance Scanning on Parts of Abydos Cemetery Region, Sohag Governorate, Upper Egypt. *Archaeological Prospection* 6, 225-239.

Levy, T.E., Higham, T. 2005. *The Bible and Radiocarbon Dating: Archaeology, Text and Science*. Oxford University.

Lück, E., and M. Eisenreich. 1999. Geophysical Prospection of Archaeological Sites in Brandenburg, Germany. *Archaeological Prospection* 6, 125-133.

Neighbour, T. R. Strachan, and B.A. Hobbs. 2001. Resistivity Imaging of the Linear Earthworks at the Mull of Galloway, Dumfries and Galloway. *Archaeological Prospection* 8, 157-162.

Papamarinopoulos, St., R.E. Jones, and H. Williams. 1988. Electric Resistance Survey of the Southern Part of the Buried Ancient Town of Stymphalos. *Geoexploration* 25, 255-261.

Peters, Jr., Leon, and Jonathan D. Young,. 1986. Applications of subsurface transient radar. In *Time-Domain Measurements in Electromagnetics*, Edmund K. Miller, ed. New York: Van Nostrand Reinhold Company.

Tayler, R.E. 2014. *Radiocarbon Dating: An Archaeological Perspective, Second Edition*. Left Coast Press.

Week 15, May 4

Laboratory: Research on selected samples

Finals Period: May 6-15

Archaeometry Project due May 6