Spring 2024
M 1:45 - 4:45 PM
Museum 190

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Geophysical Prospection for Archaeology

AAMW 5720 ANTH 5720 CLST 7315 NELC 5925

Overview

Near-surface geophysical prospection methods are now widely used in archaeology as they allow archaeologists to rapidly map broad areas, minimize or avoid destructive excavation, and measure the physical dimensions of archaeological features that are outside of the range of human perception. This course will cover the theory of geophysical sensors commonly used in archaeological investigations and the methods for collecting, processing, and interpreting geophysical data from archaeological contexts. We will review the physical properties of common archaeological and paleoenvironmental targets, the processes that led to their deposition and formation, and how human activity is reflected in anomalies recorded through geophysical survey through lectures, readings, and discussion. A large proportion of the course will be computer-based as students work with data from geophysical sensors, focusing on the fundamentals of data processing, data fusion, and interpretation. Students will gain experience collecting data in the field. We will then use these data to reconstruct the original plans, untangle site taphonomy, and assess our results for each site. Some familiarity with GIS and a background in archaeology is recommended.

Upon completion of this course students should be:

- familiar with geophysical methods used in archaeology
- able to understand and evaluate academic literature
- able to plan a geophysical survey on an archaeological site
- able to carry our basic data processing on some types of geophysical data
- able to interpret data from geophysical survey on an archaeological site

Organization:

Class meetings will be divided between classroom lecture and discussion sessions and practical exercises in both the laboratory and field. Lectures and presentations will take place in the Museum 190 classroom. Practical exercises could take place in the CAAM Digital Lab (under construction) or in the field.

There will be five course practica in which you will work through processing and analyzing our data. These will be completed in-part during class time. You may need to spend some extra time using the software outside of class sessions.

There will be at least one class session that will take place in the field for students to have the opportunity to work with the equipment and collect data (See S*pecial Considerations for*

Fieldwork below). **The course schedule may be adjusted at any time to accommodate opportunities for fieldwork or the weather.**

There will also be *optional* field excursions outside of the class period in which the students can gain experience collecting data in the field. These will be on the weekends and transportation will be offered. Individual transportation costs could be reimbursed if the student's schedule will not fit the transportation schedule.

Course Materials

All readings will be available on the class Canvas site or online via the Library. The Penn Libraries provides free access to many of the major texts in archaeological geophysics.

Assignments will be turned in through the Canvas website.

Software

We will try to rely primarily on QGIS and GRASS to process and present our data. These programs will run natively on both MacOS and Windows. These GIS and image processing packages were not developed specifically for geophysics so we will need to invent some of the processes ourselves! You can download and install both QGIS and GRASS here: https://www.qgis.org/en/site/

Academic Integrity

Collaborative learning among students is encouraged. The completion of the assignments themselves, however, must be done by each student on their own in order to best internalize the techniques. It is your responsibility to be familiar with the University's Code of Academic Integrity, which can be found at this link:
http://provost.upenn.edu/policies/pennbook/2013/02/13/code-of-academic-integrity

Student Disabilities Services

The University of Pennsylvania provides reasonable accommodations to students with disabilities who have self-identified and been approved by the office of Student Disabilities Services (SDS). Please make an appointment to meet with me as soon as possible in order to discuss your accommodations and your needs. If you have not yet contacted SDS, and would like to request accommodations or have questions, you can make an appointment by calling SDS at 215-573-9235. The office is in the Weingarten Learning Resources Center at Stouffer Commons 3702 Spruce Street, Suite 300. All services are confidential.

Special Considerations For Fieldwork

This course will include some work outside during the winter and early spring months, therefore participants must be prepared to protect themselves from the elements. Participants will need to

bring appropriate attire and containers for water. We will normally have access to restroom facilities, but they may be a short walk (or drive) from the field sites.

At least one class session will be conducted at the Woodlands Cemetery where we will use a range of geophysical instruments to map elements of the 18th and 19th century landscape surrounding the Hamilton Mansion. There may be additional field opportunities on the weekends. During these trips we will collect data, meet with our partners, and communicate our results with our collaborators and the broader community. While these trips are not required, they will be the source for data used in course exercises and could also be used for individual final projects. Transportation can be provided.

Participants should have one metal-free outfit in order to participate in data collection since ferrous metals can affect the readings that we take in the field. Clothes must be free of metal zippers, rivets, grommets, snaps, belt buckles or other metal attachments. Metal-free field trousers can be difficult to find, save for sweatpants or warm-ups. Military-style trousers are sometimes metal free or have metal that is easily removed. Metal jewelry should be removed before survey, and sometimes eyeglass frames can pose a problem.

It is particularly important that participants **wear appropriate, metal-free footwear for fieldwork**. Footwear must not have rivets or steel shanks in soles. For many, sneakers or light hiking shoes will do. There may be some occasions when athletic sandals will be more comfortable.

Evaluation

Proportion of Grade		Description
Participation	15%	Attendance, presentation of four case study(/ies), regular contribution to class discussion, and involvement in field exercises.
Practica	50%	Each stage of the course will involve one or more skills that will be acquired through practica. These assignments, written by the instructor, will serve as a combination instruction set and worksheet that walk students through collecting, processing, and interpreting geophysical data. Practica will be completed in part during class periods and partly on the student's own time outside of class
Midterm Exam	5%	45-minute exam covering concepts from the first half of the term.
Final Exam	5%	A comprehensive final exam will assess students' retention of key concepts covered in the course. The final exam will take place during the exam period assigned by the university.
Final Project	25%	A final paper can be: 1. a report on a geophysical survey that we have carried out in class using original data. 2. A report on an external geophysical survey using data that is approved to be shared with you 3. a review of geophysical surveys as applied to your area of interest Project proposals are 1 page documents that include: 1. a description of the project, listing the project objective and data sources 2. at least 5 articles that describe the results of relevant surveys or otherwise guide expectations and interpretation.

TENTATIVE Schedule

The instructor reserves the right to change any part of this syllabus at any time to accommodate the weather, incorporate emerging materials, or take advantage of unanticipated opportunities.

DATE	TOPIC	READ BEFORE CLASS	IN-CLASS EXERCISE	DELIVERABLE
22-JAN	Introduction to ANTH 572. History of Archaeological Geophysics			
29-JAN	Archaeological Geophysics, Fundamentals of data, data structures	(David 2001; Kvamme 2003; Johnson 2006, chap. 1: Introduction)		
5-FEB	Magnetometry	(Johnson 2006, chap. 9: Magnetometry Nature's Gift to Archaeology; Gaffney et al. 2000; Aspinall, Gaffney, and Schmidt 2009, chap. 1: Concepts)	Woodlands Cemetery Survey, could be moved for weather	Case study presentations: **Practicum 1**. Creating and displaying raster data
12-FEB	Field Survey at the Woodlands	(Aspinall, Gaffney, and Schmidt 2009, chap. 4: Data Collection; Oswin 2010, chap. 5: Geophysics Survey Campaign)		
19-FEB	Magnetometry	Fassbinder 2015; Benech 2007; Johnson 2006, chap. 10)		Case study presentations:
26-FEB	Resistivity	(Schmidt 2013, chaps. 1–3) optional:(Clark 2003, chap. 2; Johnson 2006, chap. 6)		Case study presentations: **Practicum 2**. Magnetometry Processing, interpolation

SPRING BREAK	------			
11-MAR	Resistivity	(Schmidt 2013, chaps. 4–7; Tsokas et al. 2018)		Case study presentations:
18-MAR	Electromagnetic Induction - Conductivity	(Johnson 2006, chap. 5; Clark 2003, 171–82 Supplement)		Case study presentations: **Practicum 3**
25-MAR	Electromagnetic Induction- Magnetic Susceptibility	(Clark 2003, chap. 4; Johnson 2006, chap. 8; Optional: Dalan 2008)		
1-APR	GPR	(Johnson 2006, chap. 7; Conyers 2016, chaps. 1–3)	Woodlands Cemetery GPR Survey	Case study presentations: **Project Proposals due**
8-APR	GPR	(Trinks et al. 2018; Conyers 2012, chaps. 7–11)		Case study presentations: **Practicum 4**. Conductivity and magnetic susceptibility processing, grid square balancing, profile filters
15-APR	Other Methods or Flex Day	(Thompson et al. 2011; Conyers and Leckebusch 2010; Conyers 2010)		
22-APR	Data Fusion and Interpretation	(Johnson 2006, chaps. 11–12)		**Practicum 5.** GPR, 3D operations
29-APR			**Project Presentations**	
Exam Date				Final Projects due

Readings and Related References

This list is not comprehensive. Book chapters can be found on the Ebook Central Bookshelf which you should be able to access after logging in to the PennLibraries website. Link to books: https://ebookcentral.proquest.com/lib/upenn-ebooks/showSharedBookshelfFolder.action?sKey=3bf0ce820f194ce79eac0f19a49affce&tm=1579707663796

Aspinall, Arnold, Chris F. Gaffney, and Armin Schmidt. 2009. *Magnetometry for Archaeologists*. Rowman Altamira.

Benech, Christophe. 2007. "New Approach to the Study of City Planning and Domestic Dwellings in the Ancient Near East." *Archaeological Prospection* 14 (2): 87–103. https://doi.org/10.1002/arp.306.

Campana, Stefano, and Salvatore Piro. 2010. *Seeing the Unseen. Geophysics and Landscape Archaeology*. CRC Press.

Clark, Anthony. 2003. *Seeing Beneath the Soil: Prospecting Methods in Archaeology*. London: Routledge. https://ebookcentral-proquest-com.proxy.library.upenn.edu/lib/upenn-ebooks/reader.action?docID=3060325&ppg=1

Conyers, Lawrence B. 2004. *Ground-Penetrating Radar for Archaeology*. Walnut Creek, CA: AltaMira Press.

———. 2010. "Ground-Penetrating Radar for Anthropological Research." *Antiquity* 84 (323): 175–84. https://doi.org/10.1017/S0003598X00099841.

———. 2012. *Interpreting Ground-Penetrating Radar for Archaeology*. Left Coast Press. https://ebookcentral-proquest-com.proxy.library.upenn.edu/lib/upenn-ebooks/detail.action?docID=1043163

———. 2016. *Ground-Penetrating Radar for Geoarchaeology*. Analytical Methods in Earth and Environmental Science. John Wiley & Sons. https://ebookcentral-proquest-com.proxy.library.upenn.edu/lib/upenn-ebooks/detail.action?docID=4338098

Conyers, Lawrence B., and Dean Goodman. 1997. *Ground-Penetrating Radar: An Introduction for Archaeologists*. Walnut Creek, CA: AltaMira Press.

Conyers, Lawrence B., and Juerg Leckebusch. 2010. "Geophysical Archaeology Research Agendas for the Future: Some Ground-Penetrating Radar Examples." *Archaeological Prospection*, n/a-n/a. https://doi.org/10.1002/arp.379

Dalan, Rinita A. 2008. "A Review of the Role of Magnetic Susceptibility in Archaeogeophysical Studies in the USA: Recent Developments and Prospects." *Archaeological Prospection* 15 (1): 1–31. https://doi.org/10.1002/arp.323

David, A. 2001. “Overview- the Role and Practice of Archaeological Prospection.” In *Handbook of Archaeological Sciences*, edited by A. M. Pollard and Don R. Brothwell, 521–42. Chichester ; New York: J. Wiley. https://catalog.hathitrust.org/Record/004199157.

Fassbinder, Jörg W. E. 2015. “Seeing beneath the Farmland, Steppe and Desert Soil: Magnetic Prospecting and Soil Magnetism.” *Journal of Archaeological Science*, Scoping the Future of Archaeological Science: Papers in Honour of Richard Klein, 56 (Supplement C): 85–95. https://doi.org/10.1016/j.jas.2015.02.023.

Gaffney, C. 2008. “Detecting Trends in the Prediction of the Buried Past: A Review of Geophysical Techniques in Archaeology*.” *Archaeometry* 50 (2): 313–36. https://doi.org/10.1111/j.1475-4754.2008.00388.x.

Gaffney, C. F, J. A Gater, P Linford, V. L Gaffney, and R White. 2000. “Large-Scale Systematic Fluxgate Gradiometry at the Roman City of Wroxeter.” *Archaeological Prospection* 7 (2): 81–99. https://doi.org/10.1002/1099-0763.

Goldberg, Paul, and Richard I. Macphail. 2005. *Practical and Theoretical Archaeology*. John Wiley & Sons, Ltd. DOI:10.1002/9781118688182.

Johnson, Jay K., ed. 2006. *Remote Sensing in Archaeology: An Explicitly North American Perspective*. University of Alabama Press. https://ebookcentral-proquest-com.proxy.library.upenn.edu/lib/upenn-ebooks/detail.action?docID=438187

Kluiving, Sjoerd J., and Erika Guttmann-Bond. 2012. *Landscape Archaeology Between Art and Science: From a Multi- to an Interdisciplinary Approach*. Amsterdam, NETHERLANDS, THE: Amsterdam University Press. http://ebookcentral.proquest.com/lib/upenn-ebooks/detail.action?docID=1773726.

Kvamme, Kenneth L. 2003. “Geophysical Surveys as Landscape Archaeology.” *American Antiquity*, 435–457. https://doi.org/10.2307/3557103.

———. 2006. “Integrating Multidimensional Geophysical Data.” *Archaeological Prospection* 13 (1): 57–72. https://doi.org/10.1002/arp.268.

———. 2007. “Integrating Multiple Geophysical Datasets.” In *Remote Sensing in Archaeology*, edited by James Wiseman and Farouk El-Baz, 345–74. Interdisciplinary Contributions To Archaeology. Springer New York. http://link.springer.com/chapter/10.1007/0-387-44455-6_14.

———. 2018. “Getting Around the Black Box: Teaching (Geophysical) Data Processing through GIS.” *Journal of Computer Applications in Archaeology* 1 (1): 74–87. https://doi.org/10.5334/jcaa.14.

Leach, Peter. 2021. *A Theory Primer and Field Guide for Archaeological, Cemetery, and Forensic Surveys with Ground-Penetrating Radar*. Nashua NH: Geophysical Survey Systems, Inc.

https://www.geophysical.com/wp-content/uploads/2021/02/MN10-376-Rev-A-GPR-Theory-Primer-and-Field-Guide-for-Archaeology.pdf

McKinnon, Duncan P., Jason L. King, Bryan S. Haley, Rory Becker, Daniel P. Bigman, Jane E. Buikstra, Shanna Diederichs, Scott W. Hammerstedt, Edward R. Henry, and Jason T. Herrmann. 2017. *Archaeological Remote Sensing in North America: Innovative Techniques for Anthropological Applications*. University of Alabama Press. http://ebookcentral.proquest.com/lib/upenn-ebooks/detail.action?docID=4987821.

Oswin, John. 2010. *A Field Guide to Geophysics in Archaeology*. Springer.

Pollard, A. M., and Don R. Brothwell. 2001. *Handbook of Archaeological Sciences*. Chichester ; New York: J. Wiley. https://catalog.hathitrust.org/Record/004199157.

Ralph, Elizabeth K. 1967. “Instrument Surveys.” In *The Search for Sybaris, 1960-1965*, by Froelich G. Rainey and Carlo M. Lerici, 53–123. Rome: Lerici Editorial. https://www.worldcat.org/title/search-for-sybaris-1960-1965/oclc/373723.

Scollar, Irwin, A. Tabbagh, A. Hesse, and Irmela Herzog. 2009. *Archaeological Prospecting and Remote Sensing*. Topics in Remote Sensing 2. Cambridge, UK: Cambridge University Press.

Schmidt, Armin. 2013. *Earth Resistance for Archaeologists*. Rowman & Littlefield. https://ebookcentral.proquest.com/lib/upenn-ebooks/reader.action?docID=1126476.

Somers, Lewis. 2006. “Resistivity Survey.” In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by Jay K. Johnson, 109–29. University Alabama Press. https://ebookcentral-proquest-com.proxy.library.upenn.edu/lib/upenn-ebooks/detail.action?docID=438187

Thompson, Victor D., Philip J. Arnold, Thomas J. Pluckhahn, and Amber M. Vanderwarker. 2011. “Situating Remote Sensing in Anthropological Archaeology.” *Archaeological Prospection* 18 (3): 195–213. https://doi.org/10.1002/arp.400

Trinks, Immo, Alois Hinterleitner, Wolfgang Neubauer, Erich Nau, Klaus Löcker, Mario Wallner, Manuel Gabler, et al. 2018. “Large-area High-resolution Ground-penetrating Radar Measurements for Archaeological Prospection.” *Archaeological Prospection* 25 (3): 171–95. https://doi.org/10.1002/arp.1599

Tsokas, Grigorios N., Panagiotis I. Tsourlos, Jung-Ho Kim, Myeong-Jong Yi, George Vargemezis, Michel Lefantzis, Elias Fikos, and Katerina Peristeri. 2018. “ERT Imaging of the Interior of the Huge Tumulus of Kastas in Amphipolis (Northern Greece).” *Archaeological Prospection* 25 (4): 347–61. https://doi.org/10.1002/arp.1718.

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