A Brief History of Archaeological Soil Chemistry

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Soil chemistry has played an important role in archaeological research for nearly a century. Much of the early work focused on the relationship between soil phosphate and ancient human settlement to identify archaeological sites. Today, however, archaeologists draw on more complex multi-elemental assessments of anthrosols to consider links between soil chemistry and a wide variety of human behavior, including agricultural traditions, household activities, and ritual practices, among others.

This article presents a brief history of archaeological soil chemistry, with the aim of increasing awareness among soil scientists of the ways in which soil chemistry articulates with archaeological research. Generally, soil chemistry in archaeology considers three areas of study: detecting and dating prehistoric sites, reconstructing past agricultural practices, and determining the location and structure of ancient activity areas.

Detecting and Dating Archaeological Sites

The first influential studies on archaeological soil chemistry were published in Europe during the 1920s and 1930s, and were concerned with the application of phosphate analysis for detecting archaeological sites. In generating soil maps for the Swedish Sugar Manufacturing Company, Arrhenius observed that soils from areas of medieval occupation contained elevated levels of phosphorus compared to unoccupied spaces. The archaeological importance of this observation relates to the unique manner in which humans interfere with phosphorus cycling in ecosystems and to the fact that this element is relatively inert once fixed in soil.

Arrhenius' studies, along with those of Lorch, Dauncey, and others in the decades that followed, led to the development and application of a variety of field and laboratory techniques designed to detect soil phosphates with the objective of prospecting for archaeological sites. The influential work of Eidt and others in the 1970s and 1980s contributed to important methodological advancements, including techniques derived from chromatography and fractionation. Working together over the past ten years, archaeologists and soil scientists have refined these techniques and developed alternatives. Today, archaeologists mostly employ qualitative field procedures using commercial test kits, although some have begun to experiment with laboratory-based weak acid-extraction and strong acid-digestion approaches using ICP-spectroscopy, which produces quantitative results.

Since the early 1960s, soil chemistry also has been employed in radiocarbon studies of soil organic matter and pedogenic carbonates to determine the chronological significance of archaeological deposits. However, these approaches are not often applied to archaeological work because they are currently cost prohibitive for the meager budgets of many research projects, although they have proven useful for studying long-term changes in ancient environments.

Reconstructing Prehistoric Agricultural Traditions

While soil chemistry and agricultural science share a long history, their application to archaeological domains of inquiry is a relatively recent phenomenon. One of the earliest studies was by Cowgill and Hutchinson in the mid-1960s, in which they employed soil chemical analysis of a lake sediment core in the Maya Lowlands of Central America to investigate the effects of intensive cultivation of the region's soils prior to the sixteenth century. They found that widespread cultivation accelerated soil erosion, which resulted in the accumulation of thick clay-rich deposits in Petén lakes. Not long after this work, another study, by Provan in the early 1970s, applied chemical analyses to anthrosols from Bjellandsøynæ, an Early Iron age farm site in Norway. By investigating exchangeable Na, K, Ca, Mg, organic C, total P, and total N, Provan observed that the distribution of brown podsols correlated with cultivated parcels of land, while iron-humus podsols signaled undisturbed soils. These early studies were important because they not only provided archaeologists with a research design and methodology for identifying ancient cultivated landscapes and modeling their impacts on local environments, but they also demonstrated that elements other than phosphorus can be used to investigate the ways in which agricultural societies practiced cultivation.

Aside from these isolated cases, however, only since the mid-1970s has soil chemistry played a major role in archaeological research concerned with reconstructing prehistoric agriculture. At first, these studies were largely limited to research on enrichment and depletion of certain plant macronutrients, namely P, N, and K, over time. More recently, however, soil chemistry has been incorporated into large, interdisciplinary projects that combine archaeological survey and excavation with physical and chemical analysis of sediments, palynology, and molluscan ecology.

In addition to elemental detection, studies of stable carbon isotope ratios (i.e., 13C/12C ratios) have become particularly important to prehistoric agricultural studies because of the characteristic isotopic signatures of C3 and C4 plant groups. Corn, for example, is a C4 plant that is enriched in 13C relative to most other cultivated and wild plants. As a result, distinctive carbon isotope signals produced by ancient corn crop residues may be preserved in the humic component of soil organic matter. Humus extracted from buried A-horizons of soils that were likely used for agriculture is enriched in 13C, indicating that corn was grown in these areas. These kinds of studies have been used to trace the spread of corn agriculture in the woodlands of North America and in the tropical forests of Central and South America.

Investigating Ancient Activities

Applications of soil chemistry to site prospection and ancient agriculture have opened up a new avenue of archaeological research: the investigation of ancient activity loci in prehistoric households, plazas, and other spaces. The basic premise is that certain chemical compounds are deposited in soils as a result of particular human activities. For example, phosphates are deposited as a result of food preparation and consumption, sodium and potassium compounds are generated by the production of wood ash in hearths and kilns, and iron oxide and mercuric sulfide are accumulated in soils through the use of certain pigments (i.e., hematite and cinnabar) in ritual settings, such as burials and caches. Since these compounds are rapidly fixed to the mineral surfaces of sediments, they tend to remain stable and immobile (resistant to horizontal and vertical migration) for very long periods in the form of adsorbed and complexed ions on clay surfaces, and as insoluble oxides, sulfides, and carbonates, all of which can be detected with extraction or digestion procedures and appropriate analytical instrumentation.

In the mid-1960s, Cook and Heizer of the United States noted a number of chemical properties of anthropogenic soils from archaeological sites, including high concentrations of P, Ca, and organic matter. Soon thereafter in the early 1970s, Heidenreich and colleagues published their work on Iroquoian long houses at the site of Robitaille in southern Ontario, Canada, which examined the distribution of Ca, P, Mg, and organic carbon. By mapping the distribution of these elements across the archaeological site, they were able to determine the precise locations of the long houses.

More recently, researchers have recognized that different activities can result in similar chemical signatures. As a result, many of the studies carried out today that are focused on activity areas make use of ethnographic observations of human behavior, specifically, the ways in which human activities impact soil chemistry in non-industrial, “traditional” societies. Luis Barba and his colleagues at the Laboratory of Archaeological Prospection, part of the Mexican National Autonomous University's Institute for Anthropological Studies, have been at the forefront of this research. Working in the households of indigenous groups in small, rural villages in various parts of Mexico, they have demonstrated that variation in certain chemical elements, compounds, and soil properties can be used to detect and study domestic activities, such as cooking, storage, and craft manufacture.

Concluding Thoughts

Although soil chemistry is only now becoming a standard instrument in archaeologists' toolkits, it is nonetheless of critical importance in some areas of investigation. Chemical analyses of anthrosols that combine both organic and inorganic material residues provide a powerful means to reconstruct past human behavior in a range of contexts. Future advancements in the method and theory of archaeological soil chemistry inevitably will rely on ethnoarchaeological research aimed at linking soil chemical signatures of modern human activities with those of prehistoric peoples in archaeological sites.

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V.A. Kovda - Meetings with a Great and Unique Man

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Friends, colleagues, young and old soil scientists, pedosphere and biosphere fancier. I have come to commemorate the birth one hundred years ago of a great and unique man – Viktor Abramovich KOVDA with whom I had the privilege to exchange ideas intermittently over a period of 30 years. I have met Viktor Abramovich for the first time in 1960 during the 7th International Congress of Soil Science in Madison, WI, USA. By then the 56 years old Viktor Kovda was a well known soil scientist, especially dealing with the origin and properties of saline soils, a Moscow University Professor and vice-president of the pedological commission of the ISSS, and widely traveled.[1] For me it was the first trip to America, a few years after my Ph.D.[2] Viktor Kovda and his *a la mode* colorful shirts was much in evidence.

The meetings and the field trips of the Madison congress were memorable for a number of reasons. At the previous 1956 Soil Congress in Paris it was decided to prepare for publication, with the help of FAO, general soil maps of continental regions, several drafts of which were presented in 1960 in Madison. It was now decided to publish a complete set of Soil Maps of the World in several sheets, with the active help of UNESCO and FAO. This took some 20 years to accomplish under the actual direction of a number of coordinating committees of international soil scientists. Kovda and others reported regularly in the literature on the progress of this grandiose effort . And it was memorable for the introduction of the new USDA Soil Taxonomy (7th approximation), another cause for some divergence in approach with our Russian colleagues. Equally memorable were the extremely well organized pre- and post-congress field trips enabling an East to West review of the variable soils and the acquaintance with the diverse American countryside. The saying that "the more soil profiles you examine and discuss with others, the better you understand soil formation and distribution" was brilliantly demonstrated.

For some of us, highly appreciative of the early significant contributions of Russian

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[1] Viktor Kovda visited first time outside Russia in 1930/31 for a one year stay with the well known soil chemist George Wiegner in his Zurich laboratory and also participated in the 3rd ISSS Congress of Soil Science in Oxford, U.K. in 1935. He became fluent in English and German and good in French, certainly a rarity in those years after the Soviet revolution.

[2] My research thesis at the Hebrew University of Jerusalem dealt with physico-chemical aspects of salinization in calcareous soils and was followed by a post-doc stay at the Rothamsted Experimental Station in England, catching up on pedology, geochemistry and clay mineralogy.