

# Outline of the Archaeological Sciences

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This paper has been prepared as an outline of the archeological sciences presented by the Asian-Pacific Cultural Centre for UNESCO (ACCU) in the 2012 Training Programme for the Preservation of Cultural Heritage in the Asia-Pacific Region – Research, Analysis and Preservation of Archeological Sites and Remains. It systematically explains the archeological sciences and summarizes the important points in the practice thereof. It also traces the history of the archeological research structures built in Japan and introduces the activities of the Nara National Research Institute for Cultural Properties. It is strongly hoped that the information herein will serve the trainees as a useful reference when they go to build research systems in the archeological sciences in their respective countries.

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## 1. What Are the Archeological Sciences?

The remains and artifacts investigated in archeology are of great variety. For this reason, not just the humanities of archeology, history and anthropology but also research that employs natural scientific analysis, i.e., physics, engineering, agriculture, medicine and so forth, is needed. The field of interdisciplinary research that applies the humanities and natural sciences to archeology is called the “archeological sciences.”

Research in the archeological sciences can be broken down specifically into “conservation science,”

“materials and sources,” “paleoenvironment and subsistence,” “geophysical prospecting” and “dating.”

## **2. Conservation Science**

The field of research that aims to preserve for future generations cultural properties that have been unearthed from sites is called “conservation science.” Buried artifacts that have survived until today thinkably owe their preservation to a balance with the surrounding underground environment. That balance is disrupted when excavations unearth the artifacts from the soil and expose them to air. Particularly metal and wood artifacts can deteriorate and crumble in a short amount of time of being unearthed unless adequate measures are promptly taken upon excavation. Iron artifacts unearthed in good condition can turn into a rusted iron oxide and wood artifacts unearthed from wetland sites can shrink and deform. The objective of conservation science is to prevent this progressive degradation as best possible and stabilize the materials by suitable preservation techniques so that important archeological finds can be preserved for the future.

Also, the archaeological features discovered in excavations are the target of preservation techniques. Currently in Japan, the preservation and practical use of buried cultural properties are being constructively promoted and, like artifacts, uncovered sites are being preserved and opened for viewing.

## **3. Materials and Sources**

Knowing the materials that make up an artifact is key to preserving and restoring it. Especially when using chemicals to treat and preserve artifacts, it is imperative to know what the artifacts are made of and to use suitable chemicals to treat them.

Artifacts unearthed from sites are roughly categorized as inorganic material and organic material. X-ray fluorescence spectroscopy can qualitatively and quantitatively analyze the elemental composition of inorganic artifacts. X-ray diffraction analysis can identify the crystalline structure of inorganic artifacts. Then, infrared absorption spectroscopy and fluorescence spectroscopy are used to identify organic materials in fibers, dyes, lacquer, etc.

Furthermore, pinpointing the origin of materials and manufactured articles aids the study of not only the distribution of those materials and articles but also the movements of the people who carried them and their social backgrounds. In Japan, X-ray fluorescence spectroscopy has helped to identify the source of obsidian and sanukite stone tools, unglazed pottery, ceramics, etc. Moreover, lead isotope analysis has identified the source of bronze artifacts such as swords, bells, halberds and

mirrors. From the materials and sources, one can deduce the distance to the excavation site and investigate the movements of those artifacts. The movement of artifacts correlates to the movements of those who carried them, which spurs discussion of the relations between sites.

#### **4. Paleoenvironment and Subsistence**

By analyzing the animal and plant remains unearthed from sites, the paleoenvironment of a site and its surrounding area can be reconstructed and the interactions between mankind and his environment clarified. The interactions with the environment explain how people of that day and age adapted to their natural surroundings, what resources they acquired from their natural surroundings and how they changed those natural surroundings.

To reconstruct the vegetation surrounding a site, a comprehensive approach that employs diverse analyses and shows consideration for the properties of samples, such as remains of wood, seeds and fruits, pollen, phytoliths,

diatoms and so forth, is needed. Moreover, at the sites of settlements, the animals and plants that are unearthed as food remains support investigations into what people of that day and age ate. Moreover, stable isotope analysis of human remains helps to determine the relative ratio of animal and plant consumption. Whereas animal and plant remains tell about the feeding habits of the overall site (settlement), stable isotope analyses of human remains can reconstruct the eating habits of a specific individual.

#### **5. Geophysical Prospection**

Excavation means to destroy an archeological site. Alongside this approach, geophysical prospection that employs nondestructive techniques to locate buried sites and artifacts is an effective way for understanding a site.

Geophysical prospection uses active techniques that apply vibrations or electric waves to the ground and pick up the reactions thereto, and passive techniques that observe anomaly in buried objects. These active techniques include resistivity surveying, which supplies electric current and measures the specific electrical resistance. These passive techniques include electromagnetic surveying, which picks up anomaly caused by magnetic artifacts and sites.

It is necessary to select a prospecting technique that is suited to the presumed underground targets. Moreover, employing multiple techniques draws a more detailed picture of the situation underground.

The underground state identified by prospection only demonstrates the differences in underground structure and buried materials; it does not date a site or provide other archeological information such as the nature of a site. It is important to effectively use prospection in cohort with excavation rather than as an alternative thereto.

## 6. Dating

Historical research is the study of the past, therefore it is imperative to accurately date artifacts and sites. However, unlike documents that specify calendar years, it is generally difficult to determine dates from archeological finds. Archeological materials have a relative date and an absolute date, and it is important to use both in surmising the date of an artifact or site.

The relative date gives a relative idea of how old or new an artifact is. It can be deduced from a combination of typology, which identifies the transition of an artifact, and stratigraphy, which identifies the sequence between old and new. The relative date serves to distinguish the cultural transitions of a particular locality, but cannot be readily used to comparatively date larger or far-off areas.

In contrast, the absolute date is estimated using materials known to change over time and dating techniques rooted in the natural sciences. Some of these dating techniques are radiocarbon dating, dendrochronology and thermoluminescence dating. Each of these techniques is based on different principles and suppositions, therefore their applicable materials and scope of dating differ. For this reason, it is necessary to select dating techniques according to research objectives and sample characteristics. Dating based on the natural sciences produces numerical results, but these results must be assessed in consideration of hypotheses drawn from various suppositions. It must be understood through what process and from what principles obtained results were deduced.

### **Radiocarbon Dating**

This dating technique uses Carbon 14, a radioisotope that radioactively decays at a known rate of time. In recent years, the introduction of accelerator mass spectrometry (AMS) has enabled carbon dating with minute quantities of sample. Radiocarbon dating is the generic technique used in archeology and widely used across Japan.

Archeological finds that contain carbon can be measured by radiocarbon dating. This includes plants remains such as nuts and fruits, wood and carbonized wood, animal remains such as shells and bones, pottery adhesions (burnt food residue on the inside of pottery and soot on the outside), etc. Select the best samples for dating. Samples that have been affected by seawater, such as shells and fish bones, can produce older C14 dates because of a “marine reservoir effect.” For this reason, whether the

pottery adhesion originated on land or in the sea is an important matter, therefore it is desirable to identify the material and source by stable isotope analysis.

When organizing samples for dating, careful attention must be paid to preventing the infiltration of material that contain modern carbon. When mailing samples for dating, modern organic matter from paper bags, cloth bags and absorbent cotton that wrapped the sample can contaminate the sample with modern organic matter, resulting in younger C14 values than what they should be. Place samples in polyethylene bags or similar, and preserve them in a cold dark place where they will not be damaged. Also, chemicals such as ethanol used to prevent mold with nuts and fruits, and polyethylene glycol (PEG) used to preserve wood, can impact analytical results.

The resulting C14 dates are theoretical at best. This is because the initial C14 concentration is estimated, current research uses a different half-life and other factors that can produce ages that are different from what they actually are. For this reason, C14 values must be calibrated to a calendrical age. Accordingly, C14 dates prior to this calibration are labeled "BP=Before AD 1950," and those after calibration are marked as "calAD," "calBC" or "calBP." When reporting findings, it is necessary to provide analytical results and fundamental data that enables verification and reassessment if new correction methods were applied, such as the half-life of carbon-14, stable carbon isotope ratio, C14 date and calendrical calibration program.

## **7. Characteristics of Samples Handled in the Archeological Sciences**

There are many scientific technologies in the world, but there is a limit to the natural scientific analyses that can be applied in archeology. That is because the buried cultural properties handled in the archeological sciences have some very important characteristics.

For one, since they are valuable cultural properties, non-destructive analyses must be prioritized. However, these analyses often prohibit the use of high performance instruments, which means that accuracy is unavoidably low. Even if sampling is permitted, destruction must be kept to the bare minimum and care must be shown not to damage the appearance of the artifact.

The second characteristic is that artifacts come in various shapes and sizes. Yet, many of the analytical instruments that are used to study them were designed for industrial or physiochemical applications rather than cultural properties. Also, some equipment used in industrial or scientific fields cannot be directly converted for analyzing cultural properties. Moreover, most unearthed artifacts are damaged or not shaped like museum pieces, therefore they must each be handled individually.

The third characteristic is that buried cultural properties have been in the ground for a long period of time, therefore deterioration and rust have likely progressed. Moreover, while buried, their

components are replaced with elements found in soil, so the composition of their materials may have been altered from the original state. These changes to artifacts depend greatly on the underground environment, therefore each artifact must be looked at carefully and individually.

Given the characteristics of buried cultural properties as explained here, natural scientific analyses cannot be openly applied. In practicing the archeological sciences, it is important to consider the characteristics of samples, the objectives of research and the required analytical accuracy.

## **8. Research Systems for Practicing the Archeological Sciences**

The archeological sciences have their methodological premises and limitations. The results obtained from them are little more than theories of the past. For that reason, rather than to blindly accept analytical results on their own, it is necessary to pursue a highly probable interpretation that includes other archeological findings and takes into account the problems posed by sample characteristics and methods. Moreover, archeologists should assess and summarize analytical results based on findings from excavations and cataloging, rather than leaving all results and any interpretation thereof to natural scientists. This is why archeologists need only to have a general understanding of analytical principles and methods, and do not have to conduct these analyses themselves.

Archeological science is joint research between archeologists and natural scientists. The two parties must establish a cooperative structure that allows them to share a common and clear understanding of objectives, maintain objectivity and keep records in a way that allows for verification.

Research in the archeological sciences is extracting a variety information out of artifacts that was difficult to obtain from conventional archeological methods. Nonetheless, natural scientific methods cannot just be applied to archeology in a straightforward manner. It is necessary to understand the characteristics of samples and to build a research system. And, the natural scientific methods that are employed require equipment, and basic research must be done. To identify the source of materials and manufactured artifacts, it is imperative to steadily amass fundamental data by collecting ores from sources and analyzing artifacts unearthed from kiln sites. Also, plant and animal remains cannot be identified without ample samples of modern-day specimens.

## **9. Archeological Research in Japan**

Interdisciplinary research in the archeological sciences requires researchers from the natural sciences and humanities to understand one another and to establish a cooperative structure of work. On this point, this paper will recount Japan's history of organizing cooperative research in the archeological

sciences and will introduce some of the activities of the Nara National Research Institute for Cultural Properties.

Archeological research in Japan began around the end of the 19th century. It involved research into animal and plant remains, and component analyses of bronze bells. In the field of dating, the radiocarbon dating established by W. F. Libby stirred great controversy in research of Japan's Jomon Age in the 1950s ~ 1960s.

In the field of conservation science, natural scientific methods were applied to preserve and restore wall paintings in Horyu-ji Temple's Kondo Hall. In 1916, a research team was formed for the project. They investigated emergency measures for the wall paintings and permanent preservation methods, and as support thereof, analyzed wall materials, pigments, ways to prevent peeling and strengthen the walls, lighting, etc. This project at Horyu-ji Temple and preservation work launched in 1934 under the title of "Major Restoration in the Showa Era" can be looked at as the starting point of conservation science in Japan. Since 1948, various natural scientific analyses have been applied to the treasures of Shoso-in Temple.

Research in the archeological sciences in Japan reached a major turning point with programs sponsored by the Ministry of Education into "Archeological Sites and Properties Using Methods of the Natural Sciences (1976 ~ 1978)" and "Conservation Science, Humanities and Natural Sciences Related to Ancient Properties (1980 ~ 1982)." These programs aimed to (1) promote the development and application of effective natural scientific analyses for the research of ancient cultural properties in Japan, and (2) develop conservation sciences for restoring and permanently preserving valuable cultural properties. These projects enlisted the services of some 350 archeological and natural science researchers who did basic and advanced research into the archeological sciences, and produced more than 3,000 pages of reports. The original plans were to publish the reports also in English, but unfortunately the reports came out only in Japanese. On the opportunities presented by these projects, the Japanese Society for Scientific Studies on Cultural Properties (JSSSCP) was established with the objectives of developing and diffusing interdisciplinary research into cultural properties involving the natural sciences and humanities. As of 2012, membership in the JSSSCP stands at 826 and 29 meetings have been held across Japan.

The Nara National Research Institute for Cultural Properties that was established in 1952 began aggressively promoting research into conservation science after a large number of artifacts were unearthed from the Heijo-kyo Palace site in the 1960s and their preservation became a serious issue. The Center for Archeology Operations was launched in 1974 and tasked with providing expert instruction on investigating buried cultural properties to local governments, training people from local governments in buried cultural properties, collecting, organizing and releasing information on buried cultural properties and developing technologies for investigating buried cultural properties.

Currently, the Center for Archeology Operations at the Nara National Research Institute for Cultural

Properties has four departments in the Conservation Science Section, Environmental Archaeology Section, Dating Section and Archaeological Research Methodology Section.

Over the five-year period from 1998 to 2002, “Interdisciplinary Studies of Archeological Sciences” were conducted under the COE Program of the Ministry of Education, Culture, Sports, Science and Technology. Within that project, international conferences were held every year with researchers from abroad to note “Wood and Bone Culture” in 1998, “How Far Back Should Dating Go in Natural Scientific Research” in 1999, “Geophysical Prospecting by Radar in Archeology” in 2000, “International Conference on the Preservation and Restoration of Ancient Artifacts: Latest Progress” in 2001 and “Latest News in Archeology” and “Interdisciplinary Studies in Archeological Sciences” in 2002.

At the Nara National Research Institute for Cultural Properties, excavations are done jointly by experts in archeology, historical documents, architectural history and gardens. If necessary, a system is put in place to add the cooperation of experts in preservation and restoration, environmental archeology, dendochronology and geophysical prospecting. Excavations of ancient capitals such as the Heijo-kyo Palace and Fujiwara-kyo Palace are done jointly by researchers from diverse fields rather than just experts in the archeological sciences.

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