Department of Defense Guidelines for the Curation of Archaeological Soil Samples

Purpose

The Department of Defense (DoD), like many federal government agencies, pays to curate large quantities of soil that archaeologists collected as samples during excavations. In general, while it is appropriate to store and conserve small or modest amounts of soil from archaeological research projects, it is rarely necessary or desirable to permanently curate large volumes of soil. The purpose of these guidelines is to provide information and direction to DoD elements that are collecting, processing, or curating large quantities of soil.

Background — Purposes for Collecting Soil Samples

Types of Soil Samples

Archaeological soil samples are collected for many purposes:

- <u>Flotation processing</u>: Flotation is a technique designed to recover small (< 1 mm), usually carbonized, paleobotanical elements, like seeds and other diagnostic plant parts (e.g., corn cupules). Employs water and usually agitation to separate carbonized plant remains from soil matrix and make them float to the surface of a tank where they are captured in a screen or cloth. The non-buoyant "heavy fraction" is usually examined carefully for artifacts, faunal remains, and additional botanical remains that may have been dense or waterlogged. Sometimes chemicals (e.g., Calgon, baking soda) for deflocculating clayey sediments are used. Large amounts of soil are sometimes collected and "floated" because of the high rates of recovery of both botanicals and other types of remains (Pearsall 1989: 35-102).

- <u>Fine screening or water screening</u>: Sometimes soil is collected for the purpose of fine screening. Water may be used if the soil is so clayey or silty that it does not easily screen. Generally, fine screening is used to systematically recover small items. This may be necessary for a variety of reasons. Under certain circumstances, fine screening is superior to flotation for recovering small seeds or other botanicals (Pearsall 1989:79-86). It may be necessary to fine screen to recover trade beads for dating and trade studies from early historic sites. Fine screens may be necessary to recover small animal parts, like shrimp mandibles or fish scales, that would otherwise pass through conventional quarter-inch excavation screens. Sometimes samples of soil matrix are fine screened to provide improved statistical control (i.e., as a comparison) over the sample being recovered in the main, coarser excavation screens (Prewitt and Paine 1987: Tables 2 and 3; Wing and Quitmyer 1985). For example, most stone tool debitage passes through a quarter-inch screen and is lost. Yet the presence of microdebitage of a certain size and frequency relation may indicate whether the excavation locus was used for stone tool production or whether it contains a secondary deposit of debitage. The term "fine screening" is not consistently defined in North American archaeology. It may refer to any screen with an aperture less than one-quarter inch (0.635 cm), but sometimes "fine screening" refers to using a mesh with an aperture of 1 mm or less.

Sometimes one eighth-inch mesh is used in the field in preference to the more common quarter-inch hardware cloth. This is not normally considered fine screening as such, but rather is a case of applying a more exacting standard to field recovery. The use of eighth-inch mesh is justified by the known size distributions of cultural materials and should not be considered a deviation from conventional professional methods.

- Soil Characteristics: Soil samples are often collected to study the characteristics of the sediments, particularly if they are suspected of having anthropogenic qualities. Soil studies commonly include testing for phosphates that may indicate elevated levels of human activity (which may signal the presence of an archaeological site or the presence of a cultural feature within a site). Sometimes soil samples are collected to evaluate the carrying capacity or agricultural potential of soils; in such cases, the soil samples may be subjected to the extensive battery of chemical and physical tests involved in determinations of soil taxonomy (National Soil Survey Center 1996). Geomorphologists often study archaeological soils to help understand site formation processes. Such studies may include granulometry (statistical studies of grain size) and grain shape or other particle characteristics (e.g., frosting on aeolian sands, identification of loess). Geomorphological studies of soil often require systematic sampling of soils, both horizontally across the landscape and vertically through the stratigraphy.

- Dating: Archaeologists collect soil samples for dating the bulk carbon present in the soil by ^{14}C dating methods. Oxidizable Carbon Ratio (OCR) dating also operates on soil samples (Frink 1992, 1994). Specially collected sediment samples can be used for archaeomagnetic dating. In addition, soil samples may be taken to study the formation of natural soil horizons. If natural soil horizons have formed within anthropogenic deposits, a gross estimate of age may be made based upon the degree of horizonation.

- Controls: Soil samples may be taken as controls. For example, soil samples for phosphate testing are sometimes collected outside of the archaeological site to measure background levels of phosphates, and thus provide a measure of whether the concentrations present within the site are truly elevated. Soil samples are often collected adjacent to artifacts that are subjected to protein-residue testing to help eliminate false positives caused by residues in the soils.

- Environmental reconstruction: Pollen samples are often collected at archaeological sites for use in paleoenvironmental reconstruction. Pollen samples may be collected by coring or augering, or they may be extracted from the clean vertical face of an excavation. Phytolith recovery and analysis may reveal information about plants endemic to the area in the past. By dating the soil strata at a site, one can estimate rates of colluviation, mass-wasting, alluviation, and other geomorphic processes, which provide clues to ancient climate.

- Systematic soil collection strategies: Archaeologists often collect soil samples systematically from a site. They may do this by coring or augering, or by excavating column samples in each unit, or by saving a pre-determined volume of soil from each level, stratum, cultural feature, or other provenience. The samples are often taken for multiple purposes. Systematic samples, even if they are individually of modest size, can lead to large total volumes of soil in a collection.

The above list of soil sampling goals is incomplete. A comprehensive list is beyond the scope of these guidelines. Moreover, new applications of soil science and new techniques of archaeological investigation arise constantly. Therefore, any attempt to compile a complete list would soon be outdated.

Guidelines for Collecting, Processing, and Sorting Soil Samples

Size of Soil Samples

Soil samples can range in size from a few grams to metric tons. There is no standard size, but a variety of guidelines exist. In general, sampling must be appropriate to the research design and should be planned in advance. Processing soil samples is often time-consuming, labor-intensive, and expensive. Accordingly, it must be anticipated in the budget and schedule. Samples should never be taken arbitrarily, but rather only with a specific research problem in mind.

The sizes of samples should be appropriate to the research questions being addressed. In many cases, sample sizes should be directly determined by the analytical methods and instrumentation to be employed in the laboratory. Although caution is commendable, little purpose is served in collecting a 5-liter bucket of soil when only 50 grams are required for granulometic analysis. Obviously, field archaeologists need to be in close communication with their collaborators in the laboratory to be sure that they are collecting samples of the correct size, and ones that are no larger than necessary. Archaeologists should consider arranging for specialists to take their own samples during excavation.

The largest soil samples are commonly collected for flotation or fine screening. Sometimes the samples comprise all or a large part of a midden or the contents of many pit features. Occasionally, if a site is embedded in stiff clay, it may be necessary to specially process all excavated soils. However, if it is planned carefully in advance, processing large volumes of soil need not be a problem.

Processing methods like flotation are complex and expensive and should be employed judiciously. The complexity and expense arise not only from the flotation itself, but also from the subsequent drying, sorting and identification of the light and heavy fractions. It is very time consuming to extract, analyze, label and curate all the tiny artifacts and faunal remains that typically emerge from flotation samples. The paleobotanical analysis of the flotation fractions is also quite slow and difficult. Generally, a trained technician has to review the recovered charcoal fragments under a binocular microscope to identify recognizable plant parts and seeds. Essentially the same situation obtains when water-screening. Consequently, flotation and similar methods should not be used indiscriminately, but only when there is a specific methodological purpose.

Samples collected for chemical and geomorphological analysis typically need not be very large, although, as always, the amount required depends on the laboratory methods and instrumentation to be used. For granulometry, a one hundred-gram sample is generally sufficient for most tests. A somewhat larger sample will allow for re-testing if necessary. A variety of methods of phosphate testing exist, including ones that measure anthropogenic phosphates rather than other kinds of phosphates. The field archaeologist should verify the amount of soil necessary for the particular test that will be used.

For dating the bulk carbon in soil, a sample of at least 200 grams is recommended, and even then accelerator mass spectrometry dating is usually necessary. The quantity of soil ultimately required for successful dating will depend generally on how much carbon is in the soil, so smaller of quantities of highly carbonaceous soils will needed. Archaeomagnetic dating is a highly specialized technique, and sampling should be undertaken in consultation with a trained specialist. A relatively new method of dating soils and features, Oxidizable Carbon Ratio (OCR) dating (Frink 1992, 1994), requires at least one hundred grams of soil.

The taking of soil samples for controls or to estimate “natural” background conditions depends on the kind of testing or experimentation that is being controlled for. Soil samples for protein residue controls are quite small. If cross-over electrophoresis is the laboratory method to be used in the protein testing, then fifty to one hundred grams will suffice for the control. Off-site controls for phosphate testing will be comparable in size to those taken for primary testing within the site or from features. Samples for soil taxonomy range from 0.5 to 3 kg, depending on the tests to be conducted (National Soil Survey Center 1996:1-5).

Like many types of soil samples, pollen samples require special collection methods. A sample size of 0.5 and 1.0 liters is recommended for archaeological samples, and is sufficient for re-testing (Bryant and Holloway 1983). Palynology has well-established methods for creating pollen profiles from sediment cores and other types of non-archaeological samples. Appropriate sampling protocols should be established in consultation with a palynologist. Soil samples for the identification of opal phytoliths should measure one to two hundred grams (Piperno 1988:110)

Because many types of soil samples must be specially collected (e.g., pollen, archaeomagnetic, OCR, protein residue, etc.), “general” soil sampling of strata, cuts or proveniences has limited value. One sample will not serve all purposes. Systematic sampling strategies need to take into consideration the varied needs of the investigation and avoid either over or under sampling.

Conservation of Soil Samples

Many soil samples require immediate conservation or stabilization. The process of excavating the sample chemically and biologically de-stabilizes it and any remains it contains. The excavated sample is exposed to massive changes in oxygen, water-content, light, temperature, and bacteria (Cronyn 1990:29-39). Corrosion and decay begin almost immediately. The chemical alterations of the sample may invalidate the results of chemical tests that are not conducted promptly. Samples generally need to be dried, without contamination, to reduce microbial damage or decay to the contents (Sease 1994:86), unless the sample is waterlogged, in which case it should be kept wet. Pollen samples may be treated with fungicide to prevent the growth of mold (Bryant and Holloway 1983:199). Freeze-drying can also be used to preserve pollen samples (Faegri and Iversen 1989:70-71). If proper steps are not taken to conserve the samples, all kinds of organic remains (paleobotanical remains, faunal remains, human remains, basketry, cordage, textiles) as well as some types of stone, ceramics, and metals, can all deteriorate rapidly, resulting in the loss rather than the recovery of data. It is highly irresponsible to leave artifacts and other remains moldering in soil samples. Because of the difficulty, complexity and expense of properly conserving soil samples, it is imperative to process samples promptly.

Processing of Soil Samples

Soil samples should be processed promptly. However, it is common and appropriate to re-evaluate all the recovered material after excavation to develop laboratory protocols, select samples for processing, take subsamples, and so forth. This re-evaluation normally takes place because of the additional information that has been revealed during excavation. Excavation and preliminary review of artifacts, stratigraphy, and other information normally reveals weaknesses or false assumptions in the original research design and suggests new avenues for investigation. This is the natural and proper course of investigation and does not imply any failure of planning. Major changes in the research design may require further consultation with the State Historic Preservation Officer (SHPO), the Advisory Council on Historic Preservation (ACHP), or other signatories to a memorandum of agreement (MOA) concluded under the National Historic Preservation Act.

The number and amount of soil samples processed will be guided by a number of factors, including time, money, and the research design. Many samples may not be processed, or soil may be left over after all appropriate processing. Such remaining material should normally be processed as it would have been in the field if it had not been specially collected. For example, if the regular soil matrix from the site was screened through quarter-inch or eighth-inch hardware cloth, then the remainder of excess soil samples should be screened through the same size hardware cloth after all processing and sampling is completed. Any artifacts or other significant remains recovered from the screen should be washed, labeled, identified, and curated as they would have been had they been recovered normally in the field and had not been specially collected. Thus, if unmodified stone was discarded from the quarter-inch screen in the field, so it should be under these circumstances in the laboratory. If possible, any remains that are retained should be combined with materials from an appropriate, congruent field provenience. Otherwise, the project will have two sets of very similar, probably spatially overlapping, proveniences that will seriously complicate data processing, inventory, spatial analysis, and curation. However, if a soil sample has a spatially unique provenience, the materials from the sample should retain that provenience.

In some cases, it may be appropriate to retain small subsamples from judiciously selected soil samples for long-term curation. Such subsamples should not exceed 500 grams without a clear and substantial reason, and they may reasonably be as small as 250 grams. Samples that are appropriate for retention may include ones from unusual, unique, or especially important strata or cultural features. It is difficult to conceive of circumstances under which the permanent retention of large numbers of random or systematic soil samples could be justified. Samples for long-term curation should be carefully selected and individually justified. The mere idea that new techniques of analysis may be discovered in the future should not be used as a blanket justification for retaining large numbers of samples or large quantities of otherwise unremarkable soils. Note that many repositories will not accept large quantities of soil or special samples. Repositories may enforce limits on the size of individual soil samples or on the total amount of soil they will accept. Such limits should be taken into consideration in the field, in the laboratory, and when preparing a collection for transfer to a repository.

Soil Samples in Existing DoD Collections

The DoD is presently curating some archaeological collections that contain large quantities of soil. Curation is expensive and is rapidly growing more expensive. It was not uncommon in the past to uncritically retain and curate quantities of soil that had been collected for various purposes but that were never fully processed. Given the costs of curation and changing repository policies, the curation of large quantities of soil needs to be reviewed and carefully justified. As discussed earlier, soils require careful conservation before and during storage. Many DoD collections do not receive a level of care that is likely to ensure the continued stability of their soil samples or any other remains or artifacts within them. If soils are being stored without clear justification and were never processed as intended, then those soils should be promptly and appropriately processed.

Archaeological soils may have the potential to contain NAGPRA (Native American Graves Protection and Repatriation Act) cultural items. Burial fill soils are more likely to contain these items. If soils remain unprocessed, one's organization may be open to the charge that it has not reviewed collections appropriately for the purpose of preparing the summaries and inventories required by NAGPRA. Similarly, a SHPO or other consultation partner might be able to object to one's adherence to a MOA if one does not perform the laboratory processing and analysis called for in the data recovery treatment plan or other document.

In this context, "appropriate processing" may consist of processing soils as originally intended by the excavators, as indicated in their field notes, inventories, and reports. In other cases, the decision about what processing is appropriate may require an evaluation or re-evaluation of the research goals of the project and the research potential of the samples. In some cases, it may not be possible to determine why old samples were collected. If so, a reasonable research design should be developed taking into account the goals and results of the original project as well as all information available. Depending on the history of the collection, consultation with the SHPO or the Advisory Council may be necessary.

At a minimum, processing should include a reasonable effort to recover the artifacts, other remains, and the information that would have been collected if that material had not been segregated as a soil sample. Consider a hypothetical case in which the original excavators of a site collected many pollen samples. The other sediments from the excavation were systematically screened through quarter-inch mesh. After laboratory analysis of a few samples, it became apparent that pollen was not well preserved in the site soils, and the pollen analysis was abandoned. The pollen samples were neither discarded nor further processed. Some years after the project was finished and the final report accepted, the collection, including the pollen samples, was transferred from the consultant's office to a repository. It seems reasonable to consider that, absent the abortive pollen sampling, those same soils would have been screened through quarter-inch screen. Doing so now is consistent with purposes of the original investigation and with archaeological and museum ethics.

The artifacts and other remains recovered during additional, belated processing of soil samples should be collected, conserved, labeled, identified, analyzed, and curated in accordance with appropriate protocols. Additional data and information that is collected during this process should be integrated with the results of the original research and disseminated as an annex or supplement to the original report.

In summary, the curation of large quantities of unprocessed soil is generally expensive and unnecessary. The cost continues to grow. When one does not process or conserve the soil correctly, one allows the artifacts and other remains in the soil to deteriorate. The chemical, physical, and biological alteration that soils undergo during excavation and storage renders them nearly useless for study after the passage of long periods. In addition, the slow and eventual loss of associated archaeological records means that the possibility of appropriate processing gradually decreases with the passage of time. One should extract the information in soil samples as quickly as possible. It is ethical as well as economically responsible to do so.

DoD elements should program monies for the processing of soils in collections to comply with applicable rules and regulations.

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