SECTION C

Archaeological Laboratory Analysis

When people think of what an archaeologist does, they often focus on the field aspect of archaeology. Excavation may be the most visible of archaeological undertakings, but archaeologists actually learn the most after excavation is complete, during the laboratory analysis of the materials recovered. For this reason, knowing about the basic activities that occur in laboratory analysis is helpful to understanding the conclusions summarized in the text.

As we discussed in Chapter 1, cataloging is a critical step in the archaeological process that allows the information about where artifacts and samples were found to be associated with the particular items. If cataloging is done in a field lab set up to process artifacts during the excavation, the excavators will be readily accessible to the lab crew if any problems are noted. Sometimes, however, cataloging is put off until the field portion of the project is done, and the basic catalog is compiled in a consultant's office or in the facilities of a museum or university. Whether done in the field or in the lab, cataloging is only the first step in the process of study of the artifacts after excavation.

WHAT IS IT?

One of the most basic questions to be answered about each item found in archaeological sites is precisely this: "What is it?" Archaeologists collect both artifacts—things made, modified, or used by humans—and ecofacts—things like bone, shell, seeds, and charcoal. For artifacts, archaeologists develop classifications of their own called typologies. For ecofacts, on the other hand, specialists use biological systems of classification.

Archaeologists develop systems of classification that vary in level of specificity. For example, we have general typologies that describe artifacts: terms like biface, uniface, projectile point, and sherd, which provide general labels for classes of things. Some terms, like biface and uniface, are strictly descriptive, while others imply function. Were the things we call scrapers actually used for scraping? How do archaeologists know? Scrapers, choppers, and projectile points are all given these names because they resemble items that were used by Historic peoples for tipping arrows or spears or for tasks like scraping hides or chopping through bone. Simple resemblance in form, however, is not enough to allow firm inferences to be drawn about the function of artifacts. Many artifacts called scrapers, generally unifaces, also would have made excellent cores for getting sharp flakes for general cutting purposes. Things that look like arrow- or spearheads (projectile points) might also have been used as knives, as amulets, or for decoration. Archaeologists today prefer more generalized descriptive terms that do not imply function (uniface instead of scraper, thick biface instead of chopper, biface instead of knife). Throughout the text we use both types, as the older, functional terms are firmly entrenched in the literature.

Artifacts of some types lend themselves to detailed typologies. Ceramics, for instance, have variations in manufacture, form, and decoration that combine in ways that allow elaborate classification systems. Specific types vary both through time and across space and can be used to infer time of site use and the extent of trade in ceramics. In the Southwest, for example, a complex set of types has been established with names like Mancos Gray, Kana-a Black-on-White, and St. Johns Polychrome. The sherds excavated from a specific site, once properly identified, not only can provide information on the dates of site use and on the areas from which nonlocal sherds were obtained, but also can help indicate which of the major archaeological groups occupied the site (e.g., Hohokam, Mogollon, Anasazi—see Chapter 9).

Archaeologists have also developed elaborate typologies for projectile points. Projectiles of some types, like the distinctive fluted Paleoindian Clovis and Folsom points, are clearly associated with a specific time period and way of life. Other types are more controversial. Great Basin archaeologists have described a number of types, and David H. Thomas, in a discussion of these types, has even included a key for identifying them (Thomas 1981). There has been lively debate about whether these points are truly time markers. If some of the types could be created simply by reworking worn artifacts (Flenniken and Wilke 1989), do the differences noted really indicate changes over time? We discuss this particular debate in Chapter 8 (Box 8.1), but the question of how to interpret projectile point morphology can be raised for cultures everywhere on the continent. As we have discussed, bones, shells, charred wood, seeds, and other plant parts often are recovered from archaeological sites. The classification systems used for these materials come from the biological sciences. Biologists have already classified the organisms that produced the ecofacts, and the archaeologist uses these classification systems. Although some common forms may be identified by the field archaeologists, identification of ecofacts is generally left to the specialist—the ethnobotanist or the zooarchaeologist (see Chapter 1). After cataloging, the ecofacts are sent off to the appropriate specialist, who identifies the items, generally to the finest taxonomic levels possible. The specialist uses reference books, but also reference collections. These are systematic collections often found in museums or universities that have assembled documented examples of organisms (e.g., mollusks, mammals, plants) (Figure C.1). In some cases comparison with reference specimens will lead to a change in the identification. The process is the same with shell, charcoal, seeds, and other types of ecofact.

Specialists provide not only names of the plants and animals whose remains are found in archaeological sites but a host of other information as well. Plants

FIGURE C.1 Reference collections such as this comparative skeletal collection at the University of Missouri are essential to the identification of materials (in this case, animal bones) recovered from archaeological sites.

and animals prefer certain specific habitats, and the identification of plant and animal remains can provide information on the environment of the site at the time it was occupied. These materials also indicate much about subsistence activities and may offer insights into the use of domestic animals. For plant and animal remains that were modified into artifacts, both the biological classification and the artifact typology are important. In Chapter 7, you will see that shell ornament types have been very important in defining time periods and providing information about trade.

HOW OLD IS IT?

Since time is so important in archaeology, one of the most basic questions we ask is 'How old is it?' Archaeologists recognize two types of chronology—absolute and relative. Absolute dating methods provide dates that can be related at some level to calendar years, whereas relative dating methods provide a date only with reference to something else (e.g., this projectile point is older than that sherd, this house is older than that one). Methods of telling archaeological time are continuously improving, and there are many specialized techniques that are not widely used. We review briefly the more common methods.

We have mentioned the role of stratified sites in the Great Basin projectile point typologies. This is the most common type of archaeological dating—relative dating by stratigraphy (the study of stratification or layering in archaeological sites). Where clear strata are found in archaeological sites, it is possible to conclude that artifacts found in the uppermost stratum were used and deposited more recently or are younger than those found in the strata below. Thus the contents of each lower stratum are older than those in the strata above and younger than those in the strata below. This is the geological principle (law) of superposition. While artifacts can be intruded into a stratum from above or below by various means, there is usually some evidence for this disturbance.

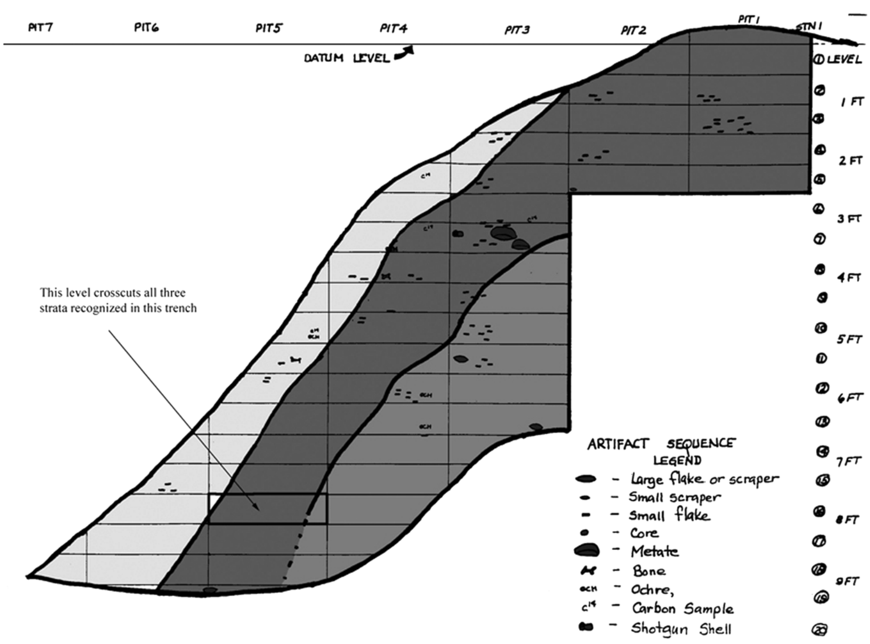


FIGURE C.2 Sketch from a student notebook showing excavation levels in relation to recognized strata at the C. W. Harris site, San Diego County, California. Note how the indicated level crosscuts all three recognized strata.

In sites that lack obvious strata, the deposits are quite homogeneous, and excavation in usually done in arbitrary levels, often 10 centimeters (3.9 in.) thick. These levels are treated as strata, and it is assumed that the deeper an artifact is the older it is. This approach has some utility, but it is also fraught with problems. Arbitrary levels can crosscut sloping strata in sites, mixing materials of different age in the same deposit (Figure C.2). Also, natural forces such as burrowing rodents may mix deposits so that no clear strata are apparent, invalidating the assumption that artifacts in the lower levels of that site are older than those in the levels above them.

Radiocarbon dating is the most common absolute dating technique used in archaeology. Radiocarbon dating measures the ratio of two forms, or isotopes, of carbon: radioactive carbon (^{14}C, or carbon-14) and stable carbon (^{12}C). Radioactive carbon is created in the upper atmosphere by the interaction of gas molecules and cosmic rays and is incorporated into carbon dioxide (CO_2), which is taken in constantly by plants. Plants, in turn, are eaten by animals, so that all organisms living at the same time should have the same ratio of ^{14}C to ^{12}C. Although ^{14}C is unstable and decays, intake in a living organism is constant, and thus the ratio is maintained. When a plant or animal dies, no new ^{14}C is incorporated into it, and the ratio changes (Figure C.3). The decay of ^{14}C proceeds at a known rate, so that if the ratio of radioactive carbon to stable carbon had been constant, the difference in the ratio of radioactive to nonradioactive carbon should be proportional to the time since the death of the organism. We know, however, that the amount of ^{14}C being produced in the atmosphere varied in the past. This means that radiocarbon dates must be calibrated against samples of known age (e.g., the rings of old trees) to develop a reliable calendar year estimate. For dates beyond the range of calibration specimens, the dates are reported

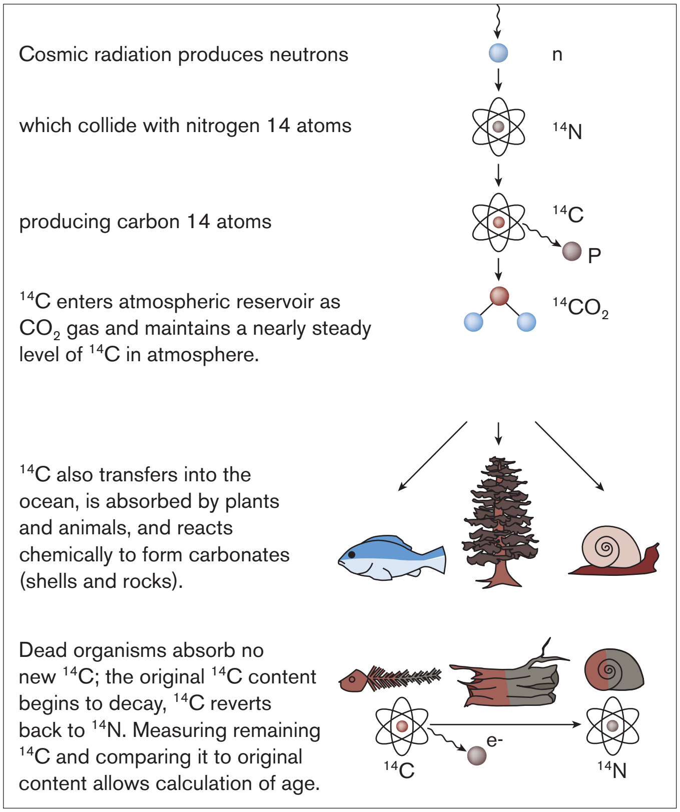


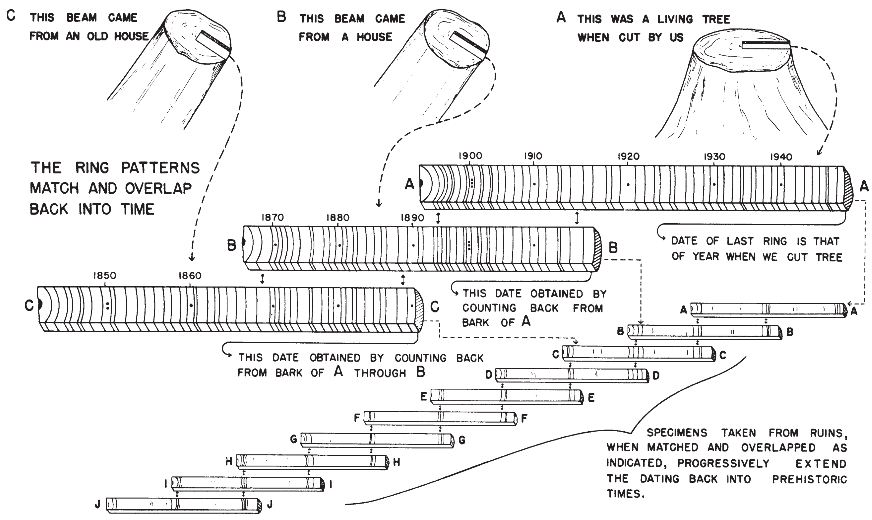
FIGURE C.3 The underlying principles of radiocarbon dating.

in "radiocarbon years," which we recognize do not match calendar years, but we do not know how big the differences are. Dates that have been calibrated are reported in "calibrated radiocarbon years."

The amount of ^{14}C in an archaeological sample is determined in one of two ways: by counting decay events with a detector that is a bit like a Geiger counter, or by using a particle accelerator and a mass spectrometer to measure the amount directly. The first method requires relatively large amounts of carbon. Large amounts of charcoal (which is primarily carbon) or even larger amounts of bone, shell, or wood, which contain carbon in much smaller quantities relative to other elements, are needed to obtain a date in this procedure. Accelerator mass spectrometry (AMS) dating can use much smaller samples, often smaller than a grain of rice. Although this method costs more, the expense can be justified for tiny samples or for rare specimens, when it is desirable to minimize the amount that must be destroyed. Some random error is associated with measurements of both types, however, and radiocarbon dates are reported as a midpoint and a range that represents that error. A typical radiocarbon date would be reported as, say, 1050 ±20 years BP, where BP stands for "before present." The date of AD 1950, close to when the technique was developed, is arbitrarily used as "the present" in dates in this system, to eliminate the need to add 1 to all such dates each year. In our example, the "1050" is the midpoint, and the "±20 years" means that the range is defined as the midpoint minus 20 years to the midpoint plus 20 years. The range, then, is 1030 to 1070 years BP. What this range means is that there is a specific statistical probability (essentially two out of three chances) that repeated measurements of this sample would yield a midpoint or point estimate within the range.

You are no doubt aware that you can count the rings in a tree to see how old it is. This principle, that trees add a growth ring each year, is the basis for dendrochronology, or tree-ring dating. This technique, developed by the astronomer A. E. Douglass (see Section A), provides absolute dates for archaeological sites. Tree rings vary in width depending on how favorable or harsh the growing conditions are. Thick rings indicate good conditions, and thin rings indicate some stress to the tree. By matching patterns of thin and thick rings, a master chronology is constructed anchored by living trees and by wooden beams in structures of known date. Archaeological specimens can be dated by comparison to the master plot (Figure C.4). The date for the outermost ring on the archaeological specimen is the date assigned, but care is taken to determine whether the outer ring is in contact with bark or has other indications of being the last ring added to the tree. If it is the last ring, then we can infer that the date represents the year in which the tree was cut. If there is evidence that rings are missing, then the date is not a cutting date, but is somewhat older than the date the tree was cut. The practice of pre-Columbian peoples of recycling beams can result in tree-ring dates that are older than the construction of the structure from which they were obtained. Of course it is much more interesting to know when the structure was built than when the tree was cut. In some years trees may be so stressed that they do not add a ring, whereas in other years climatic conditions lead to the development of two rings, complicating interpretation. Also, not every piece of wood can be dated by dendrochronology. If no master chronology has been developed for an area, no date can be obtained. Even in areas where there are good master chronologies, some trees grow in locations that are so favorable that there is no variation in the width of the rings—they are all large. Dendrochronology is

FIGURE C.4 Building a dendrochronological sequence.



particularly important in the Southwest, where it was developed using beams and posts for Historic churches and pueblos, as well as numerous archaeological pithouses and pueblos.

In the West, where volcanic activity left outcrops of volcanic glass or obsidian, a prized material for making sharp tools, obsidian hydration dating is important. Obsidian, when it is broken and a fresh edge is exposed, begins to absorb water into its structure. The depth to which the water penetrates the obsidian is determined both by the time that has elapsed since the surface was exposed and the temperatures to which the piece has been exposed. When a small piece of obsidian is cut out of the edge of an artifact and made into a thin section by mounting it on a microscope slide and grinding it very thin, the depth of water penetration is visible under a petrographic microscope. The rim or rind can be measured. Generally, the thicker the rind, the longer the time since the surface was exposed by a break. Thus, artifacts with thicker rinds are older than artifacts with thinner rinds. Since obsidian was a popular toolmaking material, humans exposed fresh edges on the artifacts through the toolmaking process. Many attempts have been made to develop hydration rates that can be applied as an absolute dating method, but generally, obsidian hydration dating is used as a relative dating technique. This is because temperature variation is hard to reconstruct for individual pieces. It also has been demonstrated that obsidian from different flows can hydrate at very different rates, so it is important to know the sources of obsidian samples that are being compared. Determining sources of archaeological material is discussed shortly, under "Source Analysis."

Historic artifacts are also very useful in dating sites. Some artifacts, such as coins, actually have dates on them. If a deposit contains a coin minted in 1898, then that deposit can be no older than 1898, though it may be a lot younger, since coins may stay in circulation for decades, and people may have kept them as heirlooms. Of course it is important to be sure the coin is not intruded into the deposit from an overlying or underlying stratum.

Other historic artifacts can be dated by their style. For example, round nails replaced square nails around the turn of the twentieth century. Sites with exclusively square nails probably date to the nineteenth century. Historic china fragments may have been stamped with maker's marks by the manufacturer, and archaeologists can consult records to determine when particular marks were in use. Bottles, cans, smoking pipes, china, ironstone, and even ammunition can be useful in dating Historic or post-Contact sites.

WHAT WAS IT USED FOR?

To understand what people were doing in the past, it is important to get as much information as possible about what their tools were used for. Archaeologists reconstruct the function of tools in several ways. Among these are use wear analysis, residue analysis, and context.

Performing tasks with tools can leave patterns of wear on those tools. By examining the edges or surfaces of tools under magnification ranging from 20× to the extreme magnification obtained with scanning electron microscopes, use wear analysts look for striations, polish, chipping, and crushing that can indicate the kinds of material worked and the motions involved in the work. A knife used only for slicing, for example, should have oblique wear striations. On the other hand, combinations of different kinds of wear can indicate use of a tool for scraping soft materials, such as hides. Use wear analysis has been applied successfully to flaked stone tools and to ground stone tools, particularly manos.

Ceramic vessels can also show use-related wear. The presence on the rim of a bowl of distinctive wear patterns due to the use of clay ladles allows us to infer use as a serving vessel. Use wear analysis is a time-consuming activity, especially when applied to stone tools. It is seldom performed on more than a small sample of the tools recovered from a site.

Some tasks leave residue on the tools that were used in their performance. In sites with excellent preservation, bits of fiber or hide might adhere to the edge of a tool, indicating the material worked. Plant phytoliths may also adhere to tools, allowing determination of the plants that were processed. With the popularity of crime scene investigation shows on television and high-profile legal cases featuring the testimony of forensic experts, you are probably aware that blood residues are almost ineradicable. The same techniques that criminalists use to analyze blood evidence have been adapted to archaeology. Immunological markers are used to determine what kinds of material were processed with both flaked and ground stone tools. Washing the tool with a special solution and exposing the resultant liquid to antisera of various kinds allows the identification of the type of animal (or in some cases plant) cut or ground by the tool. This technique has been developed relatively recently and its accuracy is still being debated, but it is being used more often and has a devoted corps of adherents.

Finally, the context in which artifacts are found can give clues to their function. On the Dolores Archaeological Program (see Section D.5), for example, archaeologists consistently found hammerstones tucked under grinding slabs where corn had been ground. Many of these grinding stones had tiny pockmarks indicating that they had been pecked to roughen the surface to make them effective in corn grinding. It became apparent that the hammerstones, which exhibited crushing and battering on their edges, were used to sharpen the grinding stones. Without the context, we could have concluded that the tools were used for some sort of battering, but we would not have known what was being battered.

WHERE DID IT COME FROM? SOURCE ANALYSIS

Archaeologists are extremely interested in where things came from because such data provide insights into where people traveled or where they had trade relationships. Sometimes simply identifying an artifact to a biological taxon can allow an origin to be inferred. For example, different species of *Olivella* shells can be found in the Pacific Ocean, the Gulf of California, and the Gulf of Mexico; accordingly, the identification of olive shell beads provides information on trade. Some artifacts, like pottery in the Southwest, can occur in restricted areas geographically. That means when a pottery type is found outside the range where it is known to have been made and used, it may represent either trade or travel.

Certain chemical techniques allow the source of a material to be determined as well. The location at which a material originated is called its provenance, not to be confused with "provenience," which refers to the location at which an artifact was recovered. Chemical techniques can be used to measure the elemental composition of materials, focusing on trace elements, elements not fundamental to the

FIGURE C.5 Ceramic sherds such as those being studied here are one of the types of artifacts whose composition may be studied to establish provenance.

makeup of the material that occur in very small amounts. Trace elements can be distinctive to a particular outcrop, and to check for their presence, archaeologists accumulate geological samples of known origin as a reference collection. The elemental composition of the reference samples is measured, and archaeological samples that are to be analyzed by the same techniques can be compared with the reference samples to determine whether there are any matches. Geochemists use techniques such as neutron activation analysis, X-ray diffraction, and electron microprobe analysis to measure elements. Statistical techniques are used to assess the degree of similarity or "goodness of fit" between known source samples and archaeological specimens. Obsidian was one of the first materials that was routinely "sourced." Today turquoise, clays, cherts, and metals are also analyzed to determine provenance (Figure C.5).

Many of the techniques for sourcing, dating, and use analysis can be expensive. University archaeologists may be able to convince colleagues in other departments of their institution to perform specialized analyses like X-ray diffraction; otherwise, they must raise grant money to pay for the expensive assays. If these costs are anticipated early enough in a CRM project and can be justified satisfactorily, they can be built into the contract.

WHAT HAPPENS TO THE COLLECTIONS? CURATION

A common misconception notwithstanding, archaeologists do not own the materials they excavate. All the collections an ethical professional archaeologist makes in the course of doing archaeology should wind up in universities, museums, or curation facilities. Ideally, these institutions care for the collections in perpetuity (both the artifacts and the associated records) and make them available for further research, as well as for public education (Figure C.6).

FIGURE C.6 Preparing collections for long-term curation can be a complicated process; here a student labels artifacts from transportation projects administered by PennDOT in preparation for submission to the Pennsylvania State Museum.

Why is it important to take care of collections? You might think that once the report on an archaeological project has been written, the collections would be unnecessary. Nothing could be further from the truth. First, archaeologists cannot study every possible aspect of the materials they recover. Other researchers approaching the same set of artifacts, features, and contexts might pursue very different research avenues, as various case studies in the text have shown (see Section D.1 for an example). Second, archaeologists draw conclusions from their research. Just as new excavations provide the opportunity for retesting, others can check an archaeologist's conclusions by returning to curated collections. For CRM projects, where excavated sites often are destroyed for development purposes, curated collections may be the only means by which conclusions can be checked. Finally, as archaeologists, we learn how to investigate the past better each year. New technologies are being developed all the time that allow us to wring more information from artifacts. As confirmation of the value of collections in contemporary research, we cite Section D.3, as well as the case studies in Chapters 11 and 12 of the text.

In the last quarter of the twentieth century, archaeologists developed a conservation approach to archaeology, which holds that archaeological resources are nonrenewable and precious. We should never excavate a site unless it is threatened or has the potential to provide data that are critical to the development of our understanding of the past. The notion that the best way to treat sites was to preserve them rather than excavate them led to a common pronouncement in discussions of cultural resources on development projects: "Avoidance of the site is the preferred alternative." Curated collections become even more important in a world where new excavation is discouraged unless absolutely necessary.

Unfortunately, as discussed in Chapter 1, not all collections are properly curated, but efforts are under way in many parts of the country to deal with this situation. Section F.2 addresses the topic and notes the growth of awareness of the problem in the archaeological community.

Thus archaeological work goes on after excavation is completed, often lasting much longer than the fieldwork. Making sense out of what has been found at sites can be a complicated, though truly fascinating process, and we hope you now have a better sense of all that can be involved.