Dating Techniques, Part 1—Relative Dating (Cont'd)

Seriation is the ordering of artifacts by shape and design. It is based on the notion of steady, gradual change in those things (shape and design).

How do we do this? Well the frequencies of specific stylistic traits are recorded on certain kinds of artifacts (e.g., pottery) from each stratum (layer) in an excavation. These are plotted as horizontal bars on a graph, then lined up (which hey often do according to early, middle, and late. The resulting graphs are known as "**battleship" or frequency curves**, since they record (in frequency) the introduction of a trait, its maximum frequency, and then its demise. Once again, this is done according to archaeological layer.

I gave you several handout illustrations of this. Refer to those for a visual of all this. I think it's pretty straightforward.

Now, there are **two types of seriation**...

Context Based: involves <u>groups</u> of artifacts that shift through time (e.g., several kinds or types of pottery). In your text book this is shown for the Tehuacan Valley of Mexico (see Figure 7.8). The basic idea is that, rather than account for any one particular kind of artifact's change through time, we consider multiple artifacts and how thy change (or if) they change through time. AS you can imagine, this allows for greater control of time (chronology) since multiple things are involved.

Frequency Based: This involves changes <u>restricted to a particular artifact class</u>, and often something particular to it (e.g., the way designs are painted on pottery). Again, the handouts I gave (e.g., the cemetery stones with the Cherub, death's head, and so on) nicely demonstrate a artifact specific frequency based approach.

Summary of Seriation

- allows us to chronologically order data from one or more sites.
- allows data from other sites to be dated by direct association with the known sequence (as established at the other sites) This is <u>relative</u> chronology/dating at is most basic level

note: styles, of course, come and go. This stuff (establishing stylistic change and recording it) is VERY time consuming work and is often best in terms of securing a reliable chronology is supported by absolute dates (e.g., radiocarbon dates). Why is this? Remember, relative dating is just that: "older than or younger than," but not anchored in "real time" (calendar years).

At a later date we will discuss classification itself---how archaeologists go about ordering of masses of data into meaningful units (creation of types and so on).

Dating Techniques, Part 2—Absolute Dating

Let's start by recapping some of the shortcomings of radiocarbon dating:

1. does not produce precise dates (real time).
2. does not tell us when cultures started or ended.
3. does not tell us the rate of change.

How do we get part this problem? We use...

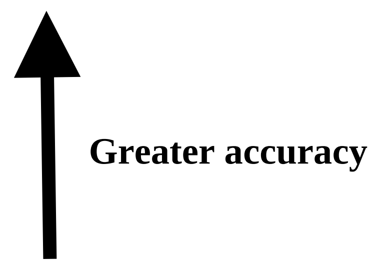
Absolute Dating: provides a specific date in calendar years (rather than "older than" or "younger than").

Absolute dating techniques range from very accurate to fairly accurate

Schema:

Cross Dating
(historical documents, calendars, objects of known age, tree rings)

Chronometric Dating
(radiocarbon, potassium argon, obsidian hydration, & others)



Why is cross-dating more accurate? Because it provides (most often) an exact year—sometimes the day and month and even the time of day! Chronometric dates, on the other hand, always have a margin of error, a statistical estimate of the amount of probable error: e.g., 1000 bc +/- 100 = 1100-900 bc.

Cross Dating – Methods

Basically, cross-dating uses some common indicator to link objects of known age with objects of unknown age. It can, and often does, involve objects of exotic (far away) origin). Let me explain through the methods...

1. Historical Documents & Calendars: this is when a document of known age is used, often to date another document or event mentioned in the text. For example, the Egyptian "king list" (a famous document) lists all the Egyptian Pharaohs from the first to the last, including their date of reign, relations, and so on). Clearly, this is a useful item if one is, say, digging a 7th dynasty site. You would know for sure the range of time you are dealing with and could use relative dating and chronometric dating (radiocarbon, for example) to bolster the observations based on the historical document. In some cases, actual events and places have been found/confirmed through reference to historical documets. Have you ever heard of Troy? (starring Brad and Angelina, most recently).

Well, a fellow in the 1800s looked at this mythical story (written by a Greek scholar over 2,000 yrs ago, traced things geographically and eventually found the actual city of Troy!!

Limitations: written documents are pretty recent....e.g., 3,000 BC in Egypt & the Middle East; 2,000 BC in China, and so on. And <u>most</u> cultures did not use them at all.

2. Objects of Known Age: Usually involves portable artifacts and ones which have a precise date of manufacture known. For example, your textbook mentions clay pipes. These were long-stemmed units used to smoke tobacco for a long time (1600s up till about 1900). The shape, bowl size (and so on) are stylistically distinct through time, but more importantly, the makers of these objects almost always have a particular stamp (and sometimes date) on the object itself. Clearly, this is useful in dating, but is limited to historical era sites.

Other examples include Chinese porcelain, Spanish Majolica (pottery), coins, medals, buttons, etc.

The main point here is that when such things are found in association with things of unknown date, especially if many such objects of known age are found in good contexts, they are extrememmly useful in dating the item of interest, not to mention the stratum or strata in which they are found.

3. Tree Rings – Dendrochronology: Began to be used in the 1920s, extensively used today depending on where one is conducting research. Basically, it involves a comparison of tree rings (the cross section of a tree of great age) with a piece of wood from and archaeological site. The method involves:

- examines annual growth rings of trees
- wood found in archaeological context compared to the tree ring chronology
- good to one year accuracy (e.g., A.D. 1422)

Two basic requirements must be met when this method is used. First, the species being compared must be the same. For example, if you have a wood post made of pine from a site you are excavating, you need to compare it to a master tree ring sequence generated from the same species of pine. Second, the method only works on trees that are found in well drained areas. Why? Well, simply put, the technique measures the different band widths (annual growth rings) of dry and wet years. If the area is always wet or dry, not enough variation will be present such that the recorded annual rings are varying in appearance.

As mentioned above, to do this we compare the cross-section of the “master sequence” (which have been taken from living trees) to the cross section of the wood from the archaeological context (see your handout). Essentially, we “match up” the rings, thus providing an exact date for the final ring. This is much the same, at least the matching part, as fingerprinting in criminal cases. The method is used in the southwestern part of the US, where it is good to approximately 6,000 BC. In Europe (parts of it) it's good up to 8,000 BC.

Problems & limitations: the reuse of logs. This happens, and if you are using a log (say, a post) from a house you are excavating to date the house, but the log has been reused several times, then the date of your house will be older than it actually is. Thus, it's best to date as many pieces of wood as possible to determine the date of the house or whatever else you are trying to date using dendrochronology. The method is also regional is scope, meaning that we cannot use the sequence from Europe to date something in the USA (and the species must be the same too, as mentioned). One big issue is that in most sites we have no wood at all! Wood is perishable (rots quickly, esp. where it it humid or wet), and therefore it seldom preserves. Thus, this method is used mostly in dry or arid areas. Finally some trees do not produce annual rings and, obviously, would not work here.

Chronometric Dating

Radiocarbon Dating (invented early 1950s) what's the technical end of it...in a nutshell:

- a radiocarbon isotope (^{14}C) of carbon that forms in the upper atmosphere and is incorporated into carbon dioxide
- it's taken up by plants during process of photo synthesis.
- Animals eat plants and thus incorporate ^{14}C as well.
- When plant or animal dies, the incorporation of radiocarbon stops.

Then...after death...the carbon 14 (^{14}C) begins to decay at a regular rate

- after 5,730 years ½ is gone This is known as the "half life."
- After 11,100 years ¼ remains
- And so on, until approximately 50,000 years ago (no ^{14}C left). Thus, the method has an age limit of approximately 50,000 years.

Things that can be dated are charcoal, bone, shell, wood; basically ANYTHING organic. The conventional method requires that you have about a gram of material to work with, but in the last couple of decades a newer manner of doing radiocarbon dating allows you to use much smaller sample sizes (e.g., one piece of thread from the Shroud of Turin, or a single human hair...or piece of it!).
This method is called...

AMS (Accelerator Mass Spectrometry). The samples cane be super small for this. The basic difference with the conventional method (although this really isn't a big issue for us here) is that AMS counts individual carbon-14 atoms rather than relative proportion.

Okay, we have just gone over the basics of ^{14}C dating (radiocarbon). There are a few more things I want to add regarding radiocarbon dating here and then I will move on to two other chronometric dating techniques

I briefly mentioned at one point in class that ^{14}C always involves a "correction factor." This is a fact. Remember I said that the date returned from the analysis would be such and such a year (say 1200 bc), but with a +/- 40 years attached to the date....meaning that the actual date would be 1240-1160 bc, with the correction factor taken into account. Clear? Good.

Now, in recent years there have been studies which by physicists indicate that the amount of ^{14}C in the upper atmosphere (where this radioactive isotope is formed) has not been steady. In other words, it has fluctuated though time. In and of itself this is really interesting...fascinating, really (it's due to magnetic field changes and solar issues), but that's not our concern here. The concern is that the radiocarbon dates one gets through standard analyses have to be "corrected" and put into real time to conform to these changes and become "real calendar time." In other words, our date of 1200 bc is a radiocarbon date, not a "real date" in the sense of our calendar. In order to get it into that mode we have to do something...here it comes...

Calibration. This is done using tree rings/dendrochronology (discussed above). Again, a radiocarbon date is not equivalent to a calendar date until this is done and the correction made. This is why a date presented in lowercase letters "bc" is different from one in our system; "BC." In the latter case, it is in real time because calibration has been performed; in the form it's uncorrected.

Now have a look at the accompanying "how to read a radiocarbon date" handout. You will see that the date changes after calibration (in the case on the handout by some 150-200 years, if I recall correctly). On the handout, I walk you through the whole thing in stepwise fashion.

Okay...enough of that...on to the next method.

Potassium Argon Dating

Potassium Argon involves a radioactive isotope (^{40}k). It is found in rock. The whole physical science process involved here is pretty complicated, but in simple terms it goes like this: when rock melts the argon in ^{40}k in it is driven out completely (i.e., all of it is driven out). After that, the rock (now solidified) starts to reincorporate new argon *at a known rate*. That's the key. So, by comparing the remaining potassium with the accumulated argon we can determine an age for the rock. In short, the older the rock, the more accumulated argon.

Date range. It can be used to date rock no younger (recent) than 100,000 years ago and can go back in time to 4.6 billion years ago! We're talking the formation of the planet now, folks.

The **half life** (recall that from the ^{14}C notes, above) of 40K dating is 1.3 billion years.

Okay, so when is this dating technique used in archaeology? Basically, in *REALLY* old sites, like those bearing the remains of our early hominid ancestors. For example, at the site of Olduvai Gorge the technique has been used to date the human remains (relatively speaking) found between rock layers/strata. In one case, two such layers yielded ^{40}k dates that indicated the remains found between them dated between 1.7 and 1.2 million years ago.

Limitations. The range of error is very high...ca. 10-50%. Here, I am talking about the "plus/minus" factor discussed for ^{14}C dating. So, dates incorporate huge spans of time, as in the case just mentioned above. Still, it's better than nothing, eh, and it is used extensively in such cases. In addition, only rock of volcanic origin can be used. That's a bit limiting too...

Other Chronometric Dating Techniques

Obsidian Hydration. This one's cool. It's used on obsidian rock...which is basically the glass (solidified melted rock) flow from a volcano. You've all probably seen it. This rock can be broken and made into razor sharp blades and flakes...if done correctly, sharper even than a modern razor blade. Such blades have actually been used to perform eye surgery in modern times to see how effective they are compared to steel scalpels. How'd you like to be the volunteer for that! They (blades) were also used to perform auto-sacrifice by the peoples of some ancient cultures, like the Maya (this is ritual self-mutilation, often involving the genitals...but more on this lovely and exciting topic later in the course...)

The date range for obsidian hydration is from 0-500,000 years before present.

Here's how the physical science aspect of this works. When a piece of obsidian rock is freshly broken (say, a flake broken off parent rock), it begins to absorb water (from the air around it) until the outer surface of the freshly broken piece is fully saturated. The water then begins to migrate deeper into the body of the rock, effectively forming a hydration layer that varies in thickness depending on how long the absorption has been going on. So, the thicker the layer, the older the object is in terms of its surface's exposure to air. Cool, eh. So, let's say we find an obsidian point used to hunt animals (strapped onto a spear or whatever), on the basis of the hydration layer (again, the depth of the water penetration into its surface) we can get a date for that object!

Like life in general, however, it comes with problems/limitations. First, the hydration rate is temperature sensitive and humidity sensitive; factors which must be taken into account. Also, as you can imagine, the absorption rate depend on the physical properties (composition) of the obsidian, which can vary depending on the sources (i.e., obsidian from one volcano may be more sensitive to absorption [more “porous”] than obsidian from another volcano). Still these matters can be dealt with (and are) and the technique can and does provide reliable dates. Again, a plus and minus factor is associated, which is generally a little larger than that of ^{14}C, but much better than the potassium argon method. Also, the method covers the gap between ^{14}C (which is only good to ca. 50,000 years ago and potassium argon, which only begins to be useful at 100,000 years before present).

There are a few other methods discussed in Fagan (your text book) that you should have a look at. And, as a closing statement here, let me make the most important point with respect to all of this chronometric/absolute dating stuff...

****   Such absolute dates are most always used with, or to support, observations (dating) by relative means (say, style or whatever). This is important because* ^{14}C *or potassium argon (or whatever) can be misleading and potentially very misleading if other lines of evidence are ignored. And they can sometimes be wrong, too. So, more absolute dates are better than less. You would not, for example, want to go out on a limb with conclusions based on only one or two dates. I think you get the picture...*

Enough said...

cheers, D

PS. ALL OF THE ABOVE IS GOOD TO READ ALONGSIDE YOUR HANDOUTS, WHICH WILL NICELY ILLUSTRATE ANYTHING CONFUSING (AT LEAST THAT’S THE INTENTION!)