Phyical Anthropology: Expanded Lecture Notes (Paleoanthropological Methods)

For the rest of the semester, we will be exploring: 1) how and when most of those traits seen as “uniquely human” were derived from earlier ones, 2) the development of the occasional new trait, and 3) how the totality of their interactions has led to where we are today and where we might be headed as a species.

Archaeology is the study of human culture through examination and interpretation of its material remains; this is a polite way of saying they look at garbage. In essence, archaeologists are cultural anthropologists whose subject populations are often no longer around to speak for themselves, thus requiring the development of techniques that can elicit from the mute archaeological record hints about what people were like and how they lived in times past. The further we go back in time, the more blurred the line gets between archaeology and paleontology (study of life’s origins, or ancient life, usually exclusive of humans). The reason for this is that humanity is a relatively new species making its mark on the globe, with a lineage that can be traced back at best only five to six million years. Beyond that time, there is no evidence (yet, anyway) of anything quite like us around. In this course we are interested ultimately in this critical juncture - the point at which humanity’s line diverged from our most likely ancestors – the other hominioidea (great apes). The specialized researchers who delve into this critical period call themselves paleoanthropologists, a marriage of archaeology and paleontology. What follows are their methods and some of the terms needed to understand them.

Artifact – anything that has been made anew or modified from its original form by members of a culture. By definition, artifacts are portable.

B.P. – Acronym for “before present”. Refers to a number of years prior to 1950. To standardize scientific dating, 1950 (the year C-14 dating was invented) was declared as the reference year from which all absolute dates would be reported.

Culture – the patterns of learned and shared behavior that are used by individuals to adapt to their environments.

Diagenesis – literally, second birth. The process of mineral replacement of organic matter that leads to fossilization. Remember that fossilization is not an event, it is a process.

Ecofact – anything of an unmodified nature discovered in an archaeological context that has cultural significance (e.g. finding dozens of dog skeletons inside a large pot).

Site – a collection in one geographical locality of culturally significant remains. Sites contain portable artifacts, ecofact, and non-portable features (larger, often multipart components of site. To move one would destroy it, e.g. hearth, house pit, etc.)

There will always be some holes in the archaeological/fossil record since many culturally significant items tend to rot rather than become part of the archaeological record. Even when a site is discovered though, it may not be of stupendous use in dating the origins of humanity. A “perfect” site will have several characteristics that are often hard to obtain together (see below).
Elements of the Perfect Site

1) Clear evidence of human/human ancestor occupation. This is easy if a set of hominid remains is found, but less clear if very primitive tools are discovered. Even Louis Leakey was fooled in the 1960s into thinking that human made tools dating to 200,000 years of age had been found at Calico, California! Some primitive tools look like little more than river cobbles with a flake or two knocked off (we will see some of these Oldowan tools later).

2) Stratigraphy. Remember our friend Cuvier who gave us catastrophism? He also was the first to develop the notion that things found buried under layers must have been deposited there earlier than the layers under which they lay (superpositioning). An archaeological site that is a surface exposure – that is, it has no layers above it – is potentially subject to contamination, mixing of remains from several time periods, and so forth. The best sites are effectively sealed ones; the archaeologist or paleoanthropologist is the first to excavate them and thus the first to expose them to the light of day since their original deposition. Surface sites are notoriously difficult to date (see below).

3) Corroborating paleoenvironmental data. We can help cross-check for errors if we can corroborate our ideas about site formations and dates through other, independent means. For example, if we say that a site excavated is 10,000 years old based on the artifacts found there, we would expect any animal remains from the same levels to also be from that time period. Similarly, if in my analysis of the Colusa County Courthouse (ca.1850) faunal material I discover catfish remains, I will be in trouble since catfish were not introduced to California until many years later (ca. 1871). Evidence can also come from fossil pollens (palynology is the study of these), accumulations of glacial sediment, and so forth that confirm age and/or the actual environment as it was at the time (e.g. how would you explain finding fossil mammoths in Bidwell Park today?).

4) Controlled Taphonomy. Taphonomy is the study of the processes that are undergone by organisms following death: decay, movement, breakage, fossilization, weathering, and so forth. Because these processes can influence what we find in the archaeological record, much effort is spent on understanding how they work and what specific effects they are likely to have. Think about this when we watch Raymond Dart later talk about the finding of Paranthropus remains in South African caves: were they living there, did they fall in and die, or were they dropped in by predatory leopards dining in trees over the entrances?

5) Datable material. Placing information from hundreds of sites around the world into context is difficult with some means of at least placing them in the right rough chronological order. There are over a dozen methods of archaeological dating, including some in which I am admittedly not particularly well versed. All of the various methods can be broken into one of two basic categories, Relative and Chronometric (aka Absolute)

Relative Dating

This group of dating methods is designed to provide the age of an object in relation to another, but lacks the capability of giving an exact number of years distance. This category is the older of the two, even though some of its included methods are relatively recent in the overall scheme of things. Relative techniques are still used today, since they are cheap, often quick, and can usually be done in the field. Your text mentions three of these techniques: stratigraphy, biostratigraphy, and paleomagnetism. I refer you to your text for specific descriptions of them. Here, I also include another example.
Fluorine analysis

Fluorine is a naturally occurring mineral in many parts of the world and is found there in the groundwater. When a bone comes into contact with the fluorine-saturated water and begins diagenesis, the fluorine begins replacing some of the natural mineral composition of the bone. A bone that has been in the ground longer than a second bone, then, will have more of its matrix replaced by fluorine than the later-deposited specimen. It is through this technique, developed in the 1950s, that the famous Piltdown hoax was discovered. Because the rates of fluorine absorption are variable to a degree, one cannot state exactly how much longer a bone has been in the ground than another. The technique is also limited in that it can only be used to analyze material excavated from the same site.

Chronometric Dating

Techniques in this category have the capability of actually telling us how old something is, whether it is measured in hundreds, thousands, or millions of years. With one exception, the earliest of these techniques were discovered as part of the atomic age of the 1950s; they rely on our knowledge of nuclear physics. Most are referred to as radiometric techniques because they analyze the breakdown of various radioactive isotopes into more stable forms. The exception mentioned above is dendrochronology.

Dendrochronology

An astronomer developed dendrochronology in the 1930s and 40s as a means of dating remains of the Pueblos in the American Southwest. As most of you know, trees lay down new growth rings (annuli) at a rate of roughly one per year, in most species. Because tree growth is dependent upon environmental conditions, periods of wet abundance will show greater thickness of rings than periods of stress, thus creating a sort of “fingerprint” keyed to a particular period of time in the tree’s life. Unlike human fingerprints, though, trees share theirs – at least trees in the same region that underwent the same basic environmental stressors. Thus, one can look for overlapping patterns in the rings of trees in one area, beginning with a tree of known age (i.e. you just cut it down) and looking for overlap in trees that were cut down earlier. This method can thus push a date back sometimes thousands of years. It has some severe limits, though:

a. Requires trees to have been used by people; not all cultures use them, although Pueblo Indians did and still do today as elements in their housing!

b. Requires an environment that will preserve trees, either an anaerobic swamp or an arid desert.

c. Is limited to particular regions only; a chronology developed in America will not work for British trees.

d. Is limited in its scope; so far our chronologies only go back maybe 10,000 years – much too recent to talk about human origins.

e. Is subject to error (e.g. what happens if a tree is reused in dwellings for several hundred years? Our date of the most recent dwelling use will be off).
Radiocarbon dating

This is the first radiometric technique, developed by Willard F. Libby in 1949/1950. This technique is covered well in the text, although I summarize some important points here:

a. Requires formerly living (organic) material since it relies on the continual intake of radioactive C-14 isotopes over the course of one’s lifetime. Metal and stone tools cannot be dated with this, and bone is also difficult to do due to its high mineral content. Note also that we can indirectly date a stone tool by dating material from the same stratigraphic level as the tool, so all is not necessarily lost!

b. Is a destructive technique. It requires the sacrifice of the material to be dated in order to measure the relative amounts of C-12 and C-14 present.

c. Has a short half-life (5730 years). Thus, after about 40-50,000 years, we are unable to detect the remaining C-14, limiting the technique’s usefulness in true fossils.

d. Is subject to contamination, thus requiring a sealed site for the most part to be unequivocal.

Potassium-Argon (K-Ar)

A similar technique, this one relies on the degradation of radioactive potassium to inert argon gas. Again, this one is well-covered in the book, although please note:

a. Requires igneous (heated during deposition) rock in order to release any already present argon and reset the clock; any argon produced after cooling will be trapped in the matrix of the rock and is measured by heating the stone in a lab.

b. Has a huge half-life (1.3 billion years). Thus, it can only be used on very old samples (100,000 plus years). In a way, it has the reverse of C-14’s time limit problem!

c. Cannot directly measure the age of organic specimens, so it is used to measure layers above and below the stratum in which the artifacts or ecofacts were found, or rarely it can measure the layer in which they were found, as was done with the Laetoli footprints.

d. Because it requires volcanic rock to work, it is not of use in areas with no volcanism, such as South Africa, where the bulk of sites are in karst topography, and are thus sedimentary.

Also pay attention in the text to fission tracking (another useful one, but limited to volcanic glasses such as obsidian), thermoluminescence, and ESR (both limited to specific materials under 1,000,000 years in age.

Footnote: Corroborating Dates

Given the idea that chronometric dates are more informative than relative ones, why use them at all? Take the case of South Africa for example. As mentioned above, the geology of the area eliminates the use of most chronometric methods. Biostratigraphy, however, allows us to indirectly date what we find. Pigs are a ubiquitous native species in Africa and are found across the continent. Is it not reasonable to assume that if a particular species of pig (remember that species all evolve and change over time) is found at a datable site in East Africa, then we can say that the same type of pig found in a South African cave probably came from about the same time period? The answer is yes, especially since the premise has been tested using two datable sites, and other animals (as well as pigs) and found to work well. So relative dating isn’t necessarily useless; it is used to help confirm or sometimes call into question the other dating techniques applied. Remember that good scientists are always trying to disprove themselves, so they look for as many exceptions as they can think of to their hypotheses!