12 Soils, Sediments, and Geomorphology

... it is no more possible for us to understand the nature of the past without an understanding of soil dynamics than it is for a marine biologist to comprehend his discipline without an understanding of the nature of ocean water and its movements (Wood and Johnson, 1978:315).

By far the most abundant material that archaeologists excavate is not lithic, ceramic, or faunal; it is the soil and sediment matrix in which these things are found. This matrix is not simply a passive artifact-bearing medium to be sifted and ignored, for it preserves evidence for archaeological site-formation processes, paleoenvironment, and site chronology. This last type of evidence, principally in the form of stratification, is a topic that we will leave for chapter 13. Here we will introduce the characterization of soils and sediments, which not only helps us recognize stratigraphic episodes, but tells us about the natural and cultural processes of deposition, erosion, and disturbance. Many of the concepts discussed here would be useful during fieldwork, as well as in post-excavation analysis. For more detailed treatment of the subject, readers should consult such references as Courty et al. (1989), Goldberg et al. (1993), Griffiths (1967), Hassan (1978), Holliday (1992), Shackley (1975), and Waters (1992).

Soils and Sediments

"Soil" and "sediment" are not interchaneable terms. The basic difference between them is that soils are products of weathering the earth's crust *in situ*, while sediments are layers or collections of particles that have been removed from the place where they were originally weathered from rock and redeposited elsewhere (Shackley, 1975). Even these definitions can be somewhat ambiguous, because sediments can subsequently be weathered *in situ* to produce soils. Cultural deposits, for example, start out as sediments, but after thousands of years of natural alteration can acquire the characteristics of soils. Geologists consider the "sedimentary cycle" to consist of weathering, transport, deposition, and post-depositional alteration of particles. Most archaeologists use the term, "sediment," in the broad sense to include soils, and reserve "soil," for cases that display clear zonation.

One of the characteristics of soils is that they show zonation with depth, called a profile, and the zones are called horizons. The *A horizon*, on top, is the richest in humus, but rainwater filtering through it has removed some soil components by a process called *leaching*. The *B horizon* is the zone in which the leached materials become redeposited. The *C horizon* consists of weathered bedrock (the parent material for the soil), but is not chemically distinct from unweathered bedrock because no leaching has either removed or redeposited chemicals there. Where there are smaller zones within these three, they are designated as A_1, A_2, B_1, B_2, B_3, etc. It is important to remember that a *profile* describes the internal structure of a uniform sediment (in the broad sense), not a sequence of stratified layers, which should instead be called a *stratigraphic series* (Shackley, 1975:4).

Lithostratigraphy and Archaeological Stratigraphy

Geologists consider the subdivisions of the earth's crust, as defined by their physical, lithologic characteristics, to be **lithostratigraphic units** (NACSN, 1983; Stein, 1987; 1992). Soil scientists also distinguish **pedological units** that consist of mineral and organic materials that climate and living organisms have altered through soil-forming (pedological) processes. In a soil profile, the various horizons are different pedological units, even though they may originally have been deposited at the same time or gradually accumulated without change in depositional process. Although not all authors would agree that pedological units are distinct from lithostratigraphic ones, soil scientists regularly subdivide soil profiles more finely than a geologist would, and pedological units do not necessarily represent separate depositional events. Stein (1992) also distinguishes **biostratigraphic units**, defined by their fossil content. Archaeologists, meanwhile, routinely divide the same record more finely still, and tend to rely on cultural content as well as lithologic characteristics in defining these units, with the result that the boundaries of their major units do not always agree with lithologic ones, sometimes combining several separate lithostratigraphic units into a single archaeological layer. Stein (1992) prefers to call these "ethnostratigraphic units," but other terms that appear in the literature include **anthropogenic** units (formed by human activity), **anthropic soils**, or **archaeological layers**, *loci*, and features (figure 12.1; Courty et al., 1989:32). Archaeological layers are sometimes defined on the basis of a combination of lithological, pedological, and material cultural criteria.

Nonetheless, in modern archaeology it is usual to define basic stratigraphic units on lithological criteria, such as color, texture and particle characteristics, rather than by the artifacts they contain.

Texture and Particle Characteristics

Describing a sediment or soil as clay, silt, or sand is a statement about its texture. Technically this is a characterization of its predominant particle size, but in colloquial usage the terms have come to signify particular sediment types. Although only a careful particle-size analysis can accurately characterize texture, it is possible to make a gross characterization of sediment texture by feel. Squeezing and working a small, wetted

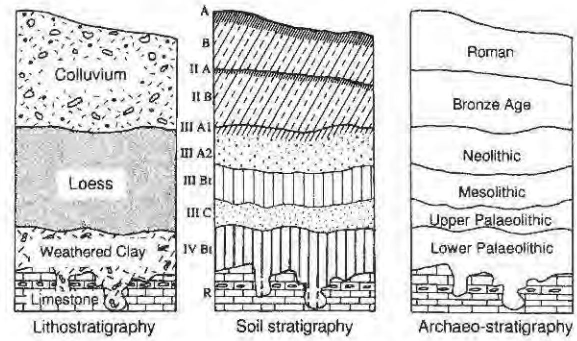

Figure 12.1. Comparison of lithostratigraphic, pedological, and archaeological units (Courty et al., 1989:33).

sample of the sediment between the fingers allows its characterization on a nominal scale (figure 12.6). Some of the major categories in this scale could be characterized as follows.

Sand — Sand has particle sizes in the range 4-0.5 ϕ, and the lack of finer material to hold it together makes it very loose, especially when it is dry, so that it is impossible to squeeze it into a ball. Instead it falls between your fingers. If you rub it into your skin, you will feel the gritiness of it, especially in coarse sand (with particle sizes of 1 to 0.5 ϕ).

Silt — Silt has a smaller particle size than sand, so that individual grains are not visible except under magnification. Although it can be somewhat gritty, it feels much smoother or silkier than sand when rubbed between your fingers.

Clay — Clay has an extremely small particle size (less than 8 ϕ). Its main characteristic is that it is sticky and plastic when wet, but dries into hard lumps that have shrinkage cracks running through them.

Sandy loam — This is a sandy sediment that contains enough clay and silt to make it hold together, rather than falling apart. Sandy loam consists of about 50% sand, 30% silt, and 20% clay (Shackley, 1975:12).

Loam — Consisting of roughly 40% sand, 40% silt, and 20% clay, loam is only a little gritty, and is more plastic than sandy loam.

Silty loam — This is a mixture of at least 50% silt and sand, and 12 to 25% clay that feels somewhat silky and forms clods when dried out. The clods break into soft, floury powder.

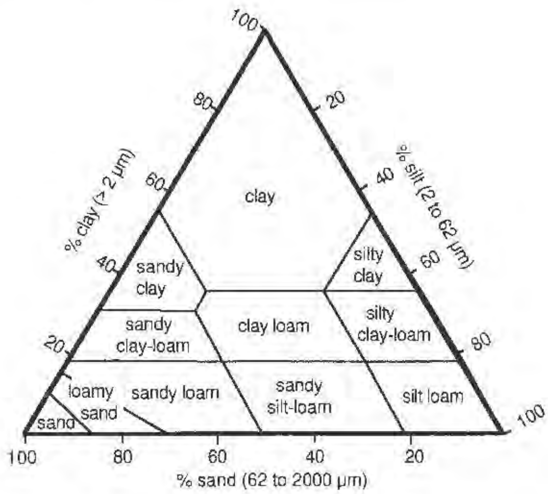

Figure 12.2. Ternary diagram to show the basic classes of sediment texture used in soil science (after Courty et al., 1989:37).

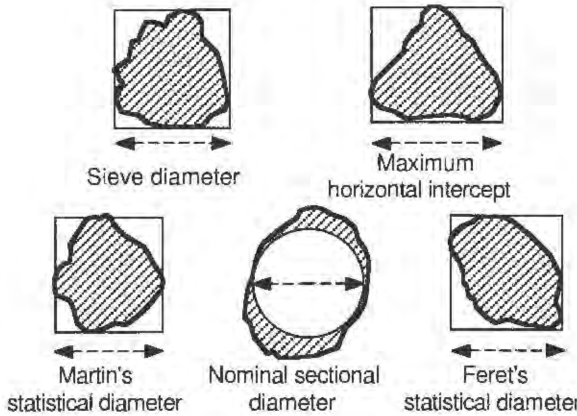

Figure 12.3. Differing definitions of particle "size" (after Shackley, 1975:89).

Clay loam — With roughly equal parts sand and clay, clay loam is a fine-grained material that is plastic and cohesive when wet, but makes hard clods when dry.

Particle size is a key piece of information to help us identify the agent, environment, and process of a sediment's deposition (Allen, 1968; Friedman, 1961; Mason and Folk, 1958), as well as to correlate stratigraphic deposits. Although "size" can be defined in many ways (Folk, 1966), and methods for analysing size that are based on volume or some indirect measure will result in quite different size distributions, here we will concentrate on a few of the simpler size measures, based on the linear dimensions of the particles.

The most common definitions of particle size are based on sieve diameter, on maximum length, on some kind of statistical average diameter, or on the diameter of the largest sphere that would fit within the particle (figure 12.3). By far the simplest of these, although by no means the best, is the sieve diameter. This can be quite deceiving because typical sediments contain particles that are far from spherical, while smaller particles sometimes adhere to larger ones to be caught in sieves through which they should, ideally, have passed. One compelling reason to use sieve diameter, at least in cases where it is not too misleading, is ease of measurement. One need only pass a properly prepared sample through a stack of sieves of gradually decreasing mesh size, catching each increment of particle size on the way down.

Sieving sediment samples requires care and common sense. Sieve sets are available in a variety of standard aperture series, the ASTM (American Society for Testing Materials), Tyler, and British Standard series being quite common. The sieves usually consist of a shallow brass cylinder, most often 8 inches in diameter, with a mesh prepared from woven brass or steel for the coarser apertures and phosphor bronze or nickel mesh for increasingly finer apertures. For the sieves to maintain their precision, they must be treated with care. Using the same sieves for both wet and dry sieving, for example, is poor practice, and corrosion build-up on the mesh will tend to close up the apertures. Gentle brushing of the meshes after each use will help to prevent this. Careless handling, and particularly rubbing or prodding with fingers or screwdrivers can stretch and tear the mesh, allowing large particles to pass through to smaller meshes. Putting too much sediment on the sieve will stretch or tear it in the same way. You can check the accuracy of the mesh periodically either by passing standard glass beads through or by measuring portions of the mesh under a microscope with a micrometer. Sieving too long is also

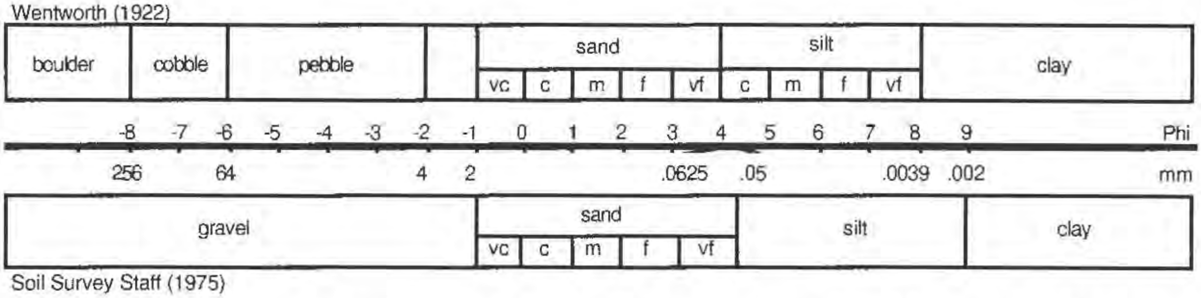

Figure 12.4. Competing scales for measuring particle sizes in sediments (after Courty et al., 1989:36). Note abbreviations very coarse (vc), through medium (m) to very fine (vf).

poor practice, as it can start to erode the larger particles as well as wear out the mesh itself. Run the screen shaker that agitates the sediment in the sieve series for only about 10 min, and no longer than 15 min (Shackley, 1975:109-111).

Sediments can be screened wet or dry, although dry sieving is usually to be preferred in archaeological situations in which wetting, followed by agitation, could destroy delicate artifacts or organic remains, such as carbonized seeds (chapter 11). You should use wet sieving for very fine-grained sediments that will clump when dry.

To dry sieve, measure the mass of each clean, empty sieve, and the collection pan, on a calibrated electronic balance and then stack the sieves in serial order from the finest, set on the collection pan, to the coarsest, on top. If you are using the entire set of sieves (as many as 21!), you will have to work with several sub-sets, beginning with the coarsest sieves. Make sure that the total volume of sediment from a sample is sufficient for a meaningful analysis. Dry the sediment sample in an oven set at about 105°C for several hours, or by leaving the sediment in a warm, dry place in clean, cloth bags for several days, unless you plan to look for organic material, such as charred seeds or charcoal. If the sediment contains a lot of clay, which would bake into hard clumps at 105°, reduce the oven temperature to about 50°C and hold it for several days. Pour the entire sample into the uppermost (coarsest) sieve, cover with a lid, and clamp the stack of sieves down to secure them. Set the timer for 10 min, and turn the screen shaker on.

After the screen shaker turns itself off, remove the sieves and remeasure the mass of each with the balance. The net mass, obtained by subtracting the masses of empty sieves from the gross mass, should be recorded.

When you have finished, carefully empty the sieves into labelled sample bags for each size fraction, and brush the sieves gently to clean them.

Although the size distributions in a sediment are a continuum, it is usual to express these on an ordinal scale, and several of these have some currency (figure 12.4). The most commonly used scales in Anglo-American archaeology are the Wentworth (1922) scale and the British Standard scale or Soil Survey Staff (1975) scale. Shackley (1975:91-92) prefers the Krumbein (1934) scale (ϕ units) for its logarithmic elegance.

The use of histograms to display particle-size distributions can be quite misleading if you forget that it is the area of each bar, and not its height, that conveys the abundance of particles in each size interval (see above, pp. 25-26, and Shackley, 1975:94). Since most analyses use substantially unequal size intervals, this is quite important. A common error is to show all the intervals as equal, when in fact they are far from it. Ensuring that the bars of unequal width show magnitudes by their *area* suppresses the heights of the wider bars and gives a truer representation of particle-size distribution. If you choose a graph with particle size measured in Krumbein's logarithmic ϕ units, you should remind viewers in the label that the units are logarithmic, not

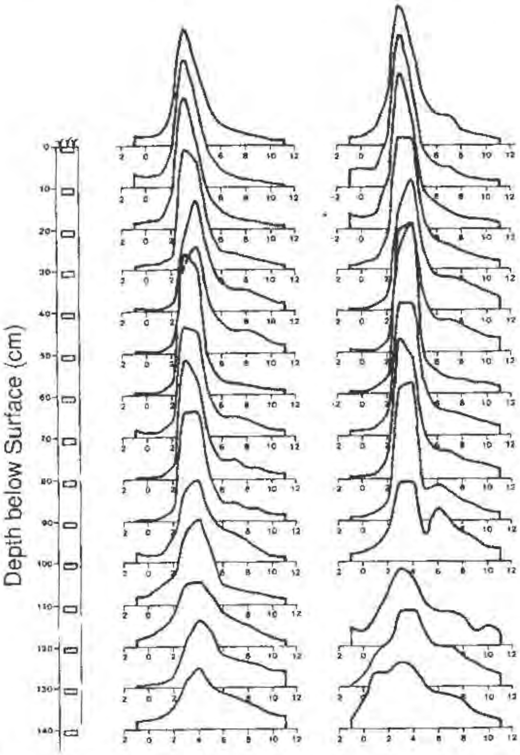

Figure 12.5. Particle-size distributions for samples taken at various depths down a soil profile (Stein, 1992:142). Samples at left have had $CaCO_3$ removed, while those at right are untreated.

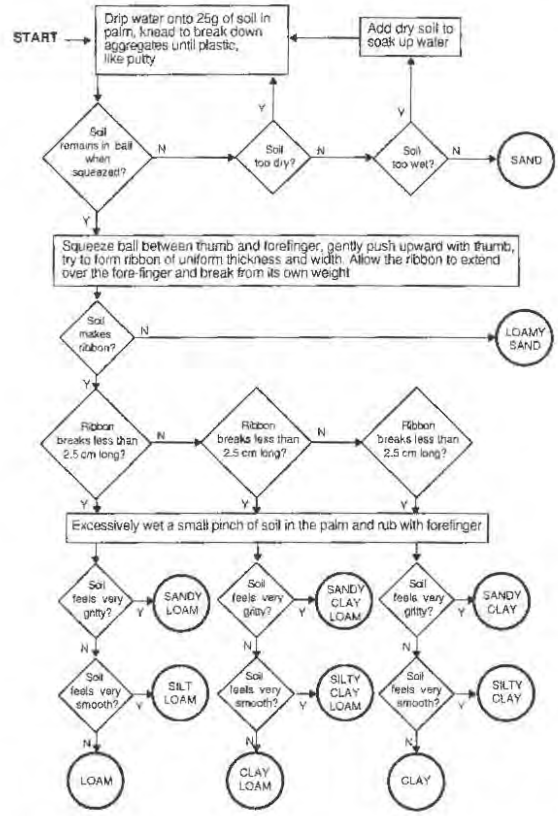

Figure 12.6. Step-by-step program to help classify sediments by texture.

linear. When properly constructed, the histogram can be helpful in revealing some general characteristics of the sediment. For example, a bimodal distribution could result from the work of two separate depositional processes (Shackley, 1975:94). In figure 12.5, Stein (1992:142) shows how the grain-size distribution (using the Krumbein ϕ scale) can vary with depth in a soil column, with larger particles being better represented at greater depth.

Other forms of presentation include triangle graphs and pictorial graphs. The triangle graph simultaneously shows the percentages of clay, silt, and sand and is a good way to characterize and compare sediment textures (figure 12.2). Pictorial graphs are popular in geology and geomorphology for presenting the broad outlines of sediment characteristics over a profile or stratigraphic series (figure 12.7). In the latter, bar graphs or line graphs are oriented vertically to produce a metaphor for the depth of the profile, and are shaded to represent visually the gross characteristics of the sediment, with the bar height showing texture.

For most archaeological applications, it is possible to characterize the texture of sediments without tedious measurements of individual particle sizes, simply by moistening it and manipulating it in your hand. Following the program steps in figure 12.6 will allow you to characterize sediments fairly consistently.

Particle Shape

Describing the shape of particles in a sediment is, in many ways, just like describing the morphology of lithics, especially for the largest particles (pebbles, cobbles, and boulders).

One simple shape measure involves three linear measurements — the long axis (length, l), the axis perpendicular to it (width, w), and the short axis (s) — with calipers or in a right-angled measuring frame. Shape can then be characterized by ratios, especially l/w and s/w, for each

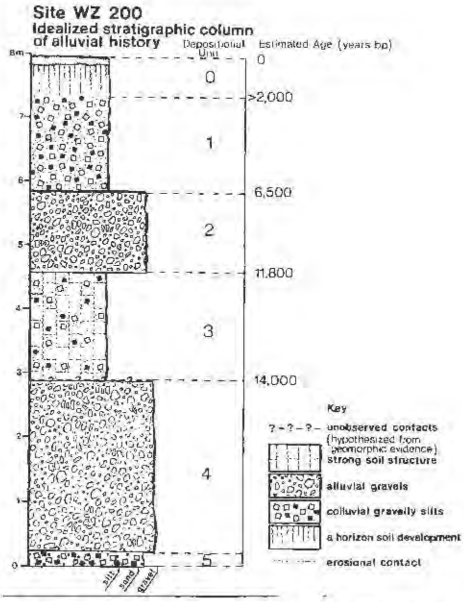

Figure 12.7. Example of a stylized profile that doubles as a kind of bar graph (Banning et al., 1992:46).

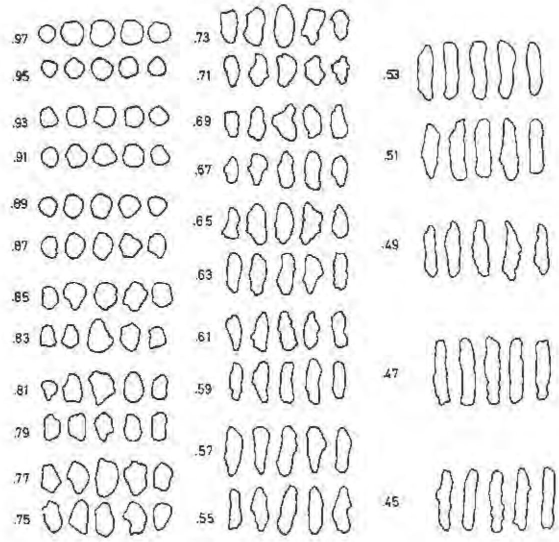

Figure 12.8. Scale for estimating sphericity visually (Shackley, 1975:50).

pebble, and the results for many particles of a given size presented in a histogram or ternary graph. Such graphs from different archaeological contexts can then be useful in attempting to tell whether the pebbles in these contexts come from the same statistical population, and therefore might belong to the same stratigraphic depositional event or be due to the same site-formation process.

In other cases, it is usual to employ a nominal scale for characterizing the shape of particles or their aggregates (**peds**) in sediments. One of the simplest such scales is as follows (see also figure 12.9).

Platy: Plate-like particles with nearly horizontal grain surfaces.

Prismatic: Prism-like blocks with well defined vertical faces (relatively high l/w ratio) and angular vertices.

Columnar: Much like prismatic, with strong vertical faces, but with rounded vertices that give the particles or peds a pillar-like shape.

Angular Blocky: Grain surfaces are fairly flat, vertices are angular, and both l/w and s/w ratios are not much greater than 1.0, so that the long axis is not all that obvious.

Subangular Blocky: Much like angular blocky, except that there are both flat and rounded surfaces and most of the vertices are rounded.

Granular: Particles are roughly spherical or polyhedral, and nonporous.

Crumbs: Aggregates of particles that are spherical or polyhedral, but porous.

One useful measure is *roundness*, which varies not only with the composition of the grain, but also its depositional history and environment (Shackley, 1975:46). It is possible to estimate roundness on an ordinal scale using a chart such as that in figure 12.10, or we can calculate roundness indices based on the radius of circles that fit into the grain corners.

Sphericity measures can also be useful, particularly in identifying sediments that have been moved through an agency that erodes the particles. As with roundness, there are indices that can be calculated from linear measures on the particles. Krumbein's Intercept Sphericity, for example, is the cube-root of the length, width, and short axis divided by the square of the length:

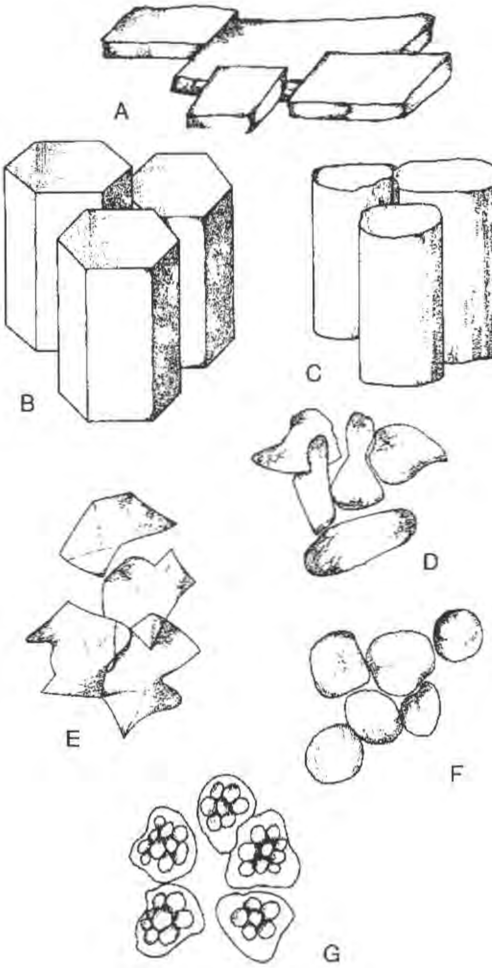

Figure 12.9. Nominal-scale classes for the description of particles and aggregates (peds): A - platy, B - prismatic, C - columnar, D - subangular blocky, E - angular blocky, F - granular, G - crumbs (Shackley, 1975:45).

$$\psi = \sqrt[3]{\frac{LWS}{L^2}}$$

Wadell's Sphericity, meanwhile, is based on the diameter of the smallest circle that will fit around the grain:

$$\psi = \sqrt{\frac{4Ad}{W^2}}$$

where A is the area of the particle, and d is the diameter of the circle.

The simplest way to estimate sphericity, however, is again with a visual chart (figure 12.8), which is usually sufficient for archaeological purposes (Shackley, 1975:49).

Sediment Color

You are probably familiar with the way to characterize a sediment's color, as the Munsell soil chart is also used to measure the colors of pottery and other artifacts.

In the Munsell system, colors are measured along three different dimensions: *hue*, *value* (lightness or darkness), and *chroma* (departure from grey), making a three-dimensional paradigmatic classsification. To measure the color of a sediment sample, place a small amount on a clean trowel or spatula and hold it under the holes in the chart's pages so that you can attempt to find a matching color chip. Make sure that you do this in natural, indirect sunlight (not fluorescents or in bright, direct sunlight), unless you have special lamps designed for this purpose, and without wearing sunglasses. Generally the sample should be moist, but not wet, to bring the color out, although it can be useful to record color twice, once dry, once moist. You record the color in the order, hue, value/chroma, such as 10YR 4/6.

pH

pH is a measure of the concentration of hydrogen ions in the sediment, along a scale from 0 to 14 such that numbers less than 7 indicate acidity and ones higher than 7 indicate basic (alkali) material. Most sediments have pH ranging between 5 and 9 (Shackley, 1975:65). Since pH is one of the factors that heavily affects the likelihood that some materials of archaeological interest, such as bone and pollen, will be preserved, it is very important to record it both in the field and in the lab.

There are several ways to measure pH, ranging considerably in their precision and accuracy. The simplest, but most inaccurate and imprecise, is with litmus papers. You make a measurement by dipping the papers into a beaker containing a suspension of the sediment in distilled water, shaking off the excess liquid,

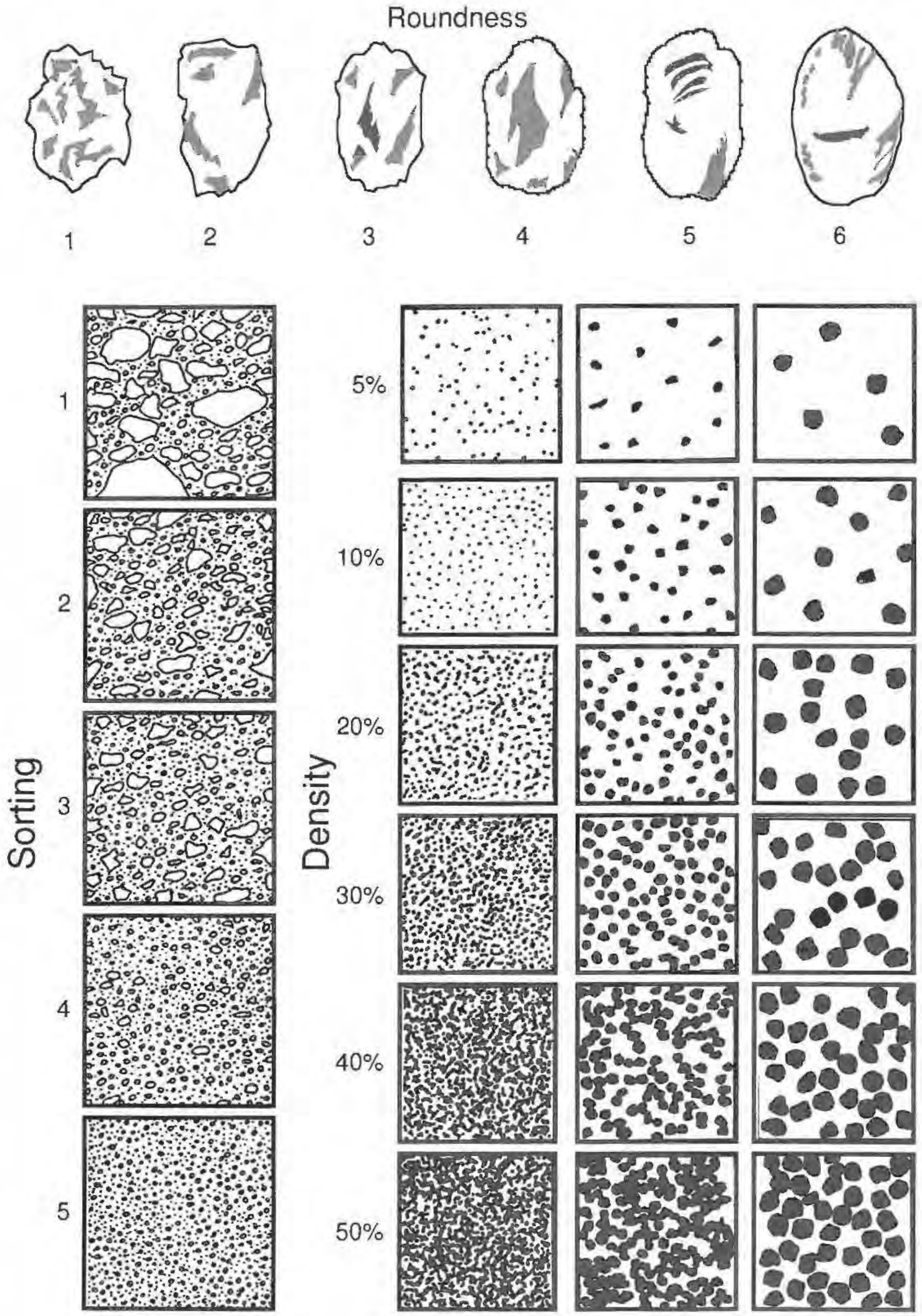

Figure 12.10. Charts for estimating roundness, sorting, and density of larger particles within a sediment (after Courty et al., 1989:69 and others).

watching the paper change color, and comparing this color with a chart. Typically this allows measurement of pH in steps of 1 pH with an error of $\pm$ 0.5 pH, especially if you check your readings against a "buffer" solution of known pH. Even if you are very careful, however, the presence of some chemicals, such as proteins, salt, or sulphur dioxide, in the sediment will result in biased measurements

A somewhat better method is to use indicator solutions. Some substances, such as phenolphthalein, change color markedly when they reach different pH levels, but are difficult to use. A "universal" indicator, such as BDH universal indicator, is easier to use. You mix a small amount of the sediment with some distilled water in a test tube and stir it into a suspension, then add a few drops of the suspension (avoiding large grains) to a piece of white, glazed tile. You then add a couple of drops of the indicator and compare the resulting color with standards (Shackley, 1975:66). Similarly, commercially available gardeners' test kits sometimes include indicator solutions that allow you to estimate pH and Nitrogen levels. You add a few milliliters of the indicator to a small amount of dry sediment and compare the color of the suspension that results to a standard color chart.

The best way to measure pH is with a pH meter. This measures the "effective" pH of the sediment, which is the electrical potential measured with a glass electrode, and is affected by all sources of hydrogen ions. The meter is calibrated by taking measures on standard "buffer" solutions, known to have pH of 4.0 and 9.0. After mixing the sediment with distilled water to make a muddy paste, you insert the glass electrode into the mud and read the digital value. Make sure that you rinse the electrode with distilled water between measurements, and never let the electrode dry out. If you are testing sediments containing carbonates, you may need to rinse the electrode with a mild acid, such as acetic acid (vinegar) periodically to remove carbonate build-up. With a pH meter, readings are easy and accurate, and modern pH meters are light and often quite precise (Shackley, 1975:66-68).

Phosphates

Phosphate content of soils and sediments can be an important piece of archaeological evidence. Elevated phosphate levels are often associated with soils and sediments that contain decayed bone or feces and, consequently, measurement of phosphates can be useful in the identification of habitation sites, middens, and graves, even when the skeletons have completely decayed. The "background" phosphate levels of some rocks and sediments, meanwhile, are often low, although some limestone-derived soils can have higher than usual phosphate from fossils. Some deposits that originally were high in phosphate could have the phosphate leached out, however, while in some areas recent use of high-phosphate fertilizers could have altered the phosphate content.

Accurate measurement of phosphate involves boiling an acid extract of the sediment with ammonium molybdate and nitric acid (Shackley, 1975:68), a procedure that requires considerable care, expertise, and equipment to complete safely, or use of a colorimeter (Shackley, 1975:69-70). However, archaeologists can estimate phosphate content more simply and safely with gardeners' soil test kits.

One simple test for phosphates is called the Gundlach test. Here you put a small amount of the sediment on a filter paper in a Petri dish and add two drops of a solution of ammonium molybdate and sulphuric acid by pipette. After a couple of minutes, you add two drops of an ascorbic acid solution. As the liquids are absorbed into the filter paper phosphates will cause a color change to yellow and then blue. The amount of color change can be used as a rough indication of the amount of total (organic and inorganic) phosphate present. Schwartz (1967) presents a scale of five color-intensity increments (Shackley, 1975:68-69).

Geomorphology and Site-Formation Processes

Although the cultural and natural processes that contribute to the formation of an archaeological site are many and complex, those that occur in the archaeological context conform to a number of basic geological principles that govern the deposition and removal of sediment, and analysis of the sediments in deposits provides important clues as to what those processes were.

Some of the most basic processes involve the erosion of rock, soils, and sediments from one location and their redeposition as sediments in another location (figure 12.11). The mechanisms that remove material are often the same as those that transport it to the new location: wind, water, gravity, and the activity of plants and animals, including humans. Quite commonly, for example, wind, rain, and the force of gravity remove material from the tops of hills and ridges and move it to lower elevations, such as valley bottoms. The soil profile upslope is truncated by the removal of material (perhaps the A horizon is missing), while the lower slopes and edges of the valley may be buried with **colluvium** (formed by the movement of material downslope by gravity) or **loess** (formed by the deposition of wind-borne particles). There the A horizon of the original soil profile is buried, making it a **paleosol**, while the newer deposits on top of it will begin to be altered, eventually forming new zonation so that there is more than one A horizon. We tend to think of most of these processes as rather slow, but colluviation can sometimes be quite dramatic, taking the form of landslides. In once instance in Jordan, a recent land slump rather suddenly moved an entire small archaeological site from one side of a valley to the other (Field and Banning, 1998).

When water transports particles, they are carried along watercourses until the water's velocity is not great enough to keep them in suspension and they settle out as **alluvium**. Typically alluvium has large, rounded particles where water velocity was high, and fine particles (silts and clays) downstream, where water velocity slowed down enough to allow them to settle (figure 12.12). But fast-moving water also cuts into alluvium that was previously deposited and carries away particles, so that there is typically a channel, with a levee on either side formed from the settling of large particles when the channel overflows, and with silts and clays on the plain either side of the levee. As a result of alluvial deposition, the channel is often higher than the surrounding plain.

Particle size, rounding, sorting, and orientation of particles are all important clues as to what sort of transport is responsible for the deposition of sediments (Friedman, 1961; Mason and Folk, 1958; Sneed and Folk, 1958; Udden, 1898). Artifacts also act as particles, and attributes of artifact orientation and damage can reveal such things as artifact transport and processes that selectively remove evidence from sediments (Schiffer, 1987:267-79; Shea, 1999).

Archaeologists often describe some of the processes that act on archaeological sites as "disturbance" because they tend to displace artifacts from their original points of deposition. More recently they have viewed archaeological deposits as dynamic, rather than static, so that "disturbance" is not as useful a concept. Instead they refer to the natural and cultural processes that have acted or continue to act on deposits. Schiffer (1987) refers to the natural processes as "N-transforms" and the cultural ones as "C-transforms." Sometimes there is an interplay between the two. For example, human activity, such as forest clearance, can cause a drop in water tables or increase erosion, which in turn have natural effects on sites, their landscapes, and their contents.

Some natural processes act on sites on small scales, and not just on the larger earth-moving scale we tend to associate with geomorphology. Among these are the action of frost and growing plants and the activities of burrowing animals (Wood and Johnson, 1978; Schiffer, 1987:207-215). In areas that are prone to heavy frost, capillary action and the expansion that water undergoes when it freezes can lift stones out of the soil, while in very cold weather ice crystals will decrease in volume. Alternate freezing and thawing over many centuries can move material considerably, and sometimes has unexpected effects, such as tending to sort pottery from lithics vertically (Limbrey, 1975; Rolfsen, 1980) or creating stone patterns that look like manmade structures (Wood and Johnson, 1978:344-46). **Bioturbation**, the movement of materials in deposits by plant roots and burrowing animals,

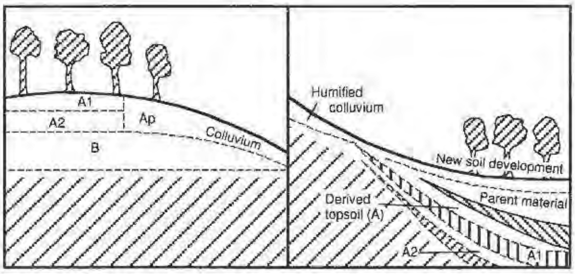

Figure 12.11. Truncation of soil profiles upslope and development of paleosols and new soil development downslope (after Butzer, 1982:133).

can also have substantial effect on the distribution of artifacts and other remains in those deposits. Already Darwin (1882) demonstrated how earthworms could bury ancient Roman pavements, while animals such as insects, crayfish, voles, and mole rats may not only bring older materials up to a recent surface, but also introduce recent materials into deeper levels or concentrate items in their burrows so that they could be mistaken for cultural activity areas. Tree falls can bring great masses of soil up to the surface with the roots, while root growth itself displaces sediment and artifacts, and root casts are left where roots have decayed away (Rolfsen, 1980; Wood and Johnson, 1978:318-33).

Environmental Interpretation

The processes that cause, affect, and remove deposits are not only of interest because they potentially confuse our interpretation of archaeological distributions. In their turn, these processes provide important clues to environmental conditions in the past (Hassan, 1978). Because river downcutting and transport of large particles to be deposited elsewhere as alluvium requires high water velocities, for example, it implies that there must have been, at least occasionally, fast water such as you would find in flash floods. Deposition of colluvium can occur very quickly, during landslides and mudslides caused by sudden, high rainfall, or very slowly where there is dense vegetation cover to prevent erosion by sheetwash during rains. The kind of particle transport has a relationship to rainfall intensity, valley shape, and vegetation cover.

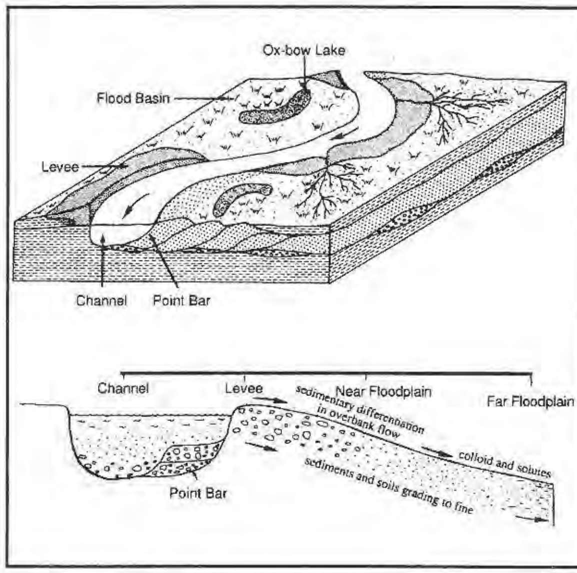

Figure 12.12. Sediments and transport in streams (Courty et al., 1989:87).

Cultural Interpretation

Knowing something about the kinds of processes that deposited sediment in an archaeological site and affected it afterward is extremely important in archaeological interpretation. Many of these processes are cultural (Butzer, 1982:78; Hassan 1978; Schiffer, 1987:288-91). For example, careful consideration of particle-size distributions and the orientation of elongated particles might help us recognize that a rather mixed-up collection of artifacts within a large pit or within the walls of a structure occur in a fill deposit, with many more-or-less distinct basket-loads of sediment deposited over a fairly short period of time. Tipping of the basket-loads into the pit would cause size-sorting of particles at different places along the slope, for example. It might help us distinguish the surfaces that ancient people walked on from pseudo-surfaces caused by bioturbation or interfaces caused by erosion. Trampling and sweeping, for example, have a real effect on average particle size and on the spatial distribution of larger particles (Nielsen, 1991; Simms, 1988). It may help us to recognize the remnants of mud, adobe, or mud-brick architecture amid the sediments derived from decaying mud walls. It might also help us distinguish genuine activity areas from artifact concentrations made by burrowing animals. In sites ranging from single-component post-hole configurations truncated by plowing to complicated shell middens and Near Eastern tells, sediment analyses provide much-needed clues to the human and natural circumstances that led to the form and character of the deposits we excavate (e.g., Holliday, 1992; Rosen, 1986; Stein, 1992).

Stratigraphic Correlations

One of the applications of sediment analysis is to determine whether stratigraphic contexts in different excavation areas are really part of the same archaeological (or lithostratigraphic) layer. If the sediments were deposited at the same time, by the same process of transport and deposition, they may be closely similar in their sediment characteristics, such as color, texture, particle roundness, and, of course, material-culture content. On the other hand, similarity between contexts in these respects, by itself, does not absolutely guarantee that they are from the same layer, as the same combination of processes could occur more than once on the site.

Because artifacts and micro-artifacts can be among the particles in sediments, some archaeologists have used peaks in their density in a series of pits, sections, or auger-holes to identify and map buried landscape surfaces. For example, Russell Stafford (1992) reconstructed the topography of a buried Early Woodland surface around the Ambrose Flick site in the Upper Mississippi Valley by plotting the mid-elevations of density peaks in vertical artifact distributions.

Conclusions

Understanding sediments and soils is important for archaeologists because they almost always hold the key to archaeological context. We cannot be sure that artifacts and other kinds of material culture we find together are culturally associated, for example, by having been deposited during a particular activity, unless we know something about how the deposit in which they were found was formed and transformed over time. Sediment characteristics, such as particle size, shape, and sorting can help us identify such site-formation processes as natural colluviation, frost-heaving, and tipping of refuse into a midden. In addition, they can help us associate sediments in different parts of a site that are probably portions of a single stratigraphic layer and to reconstruct ancient environmental changes.

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