The "State Factor" Approach in Geoarchaeology

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ABSTRACT

The study of soils has long been an important component of geoarchaeology (the application of geosciences to archaeological problems). The widest applications of soil science have involved soil chemistry (for detecting the presence, nature, and intensity of human occupation) and the identification of soils as stratigraphic markers and their use as paleoenvironmental indicators. The "state factor" approach to pedology significantly increases the potential applications of soil studies in archaeological contexts. Chronosequences are useful in dating and correlating sites and for predicting the occurrence of sites of a given age. Consideration of the time factor also can profoundly influence interpretations of occupation zones in buried soils. Chronosequences and lithosequences can be important in understanding and interpreting environmental change in an archaeological site and, along with biosequences, are useful in (i) reconstructing the relationship of human occupations to paleolandsapes and landscape evolution (ii) reconstructing paleoenvironments. Understanding and interpretation of soil stratigraphy in archaeological contexts also can be greatly enhanced by consideration of the state factors.

Most archaeologists recognize that a relationship exists between the cultural remains they find in the ground and soils. Beyond that simple relationship, however, archaeologists' understanding of what soils can and cannot tell them and indeed, what a soil is and is not, varies tremendously. In general it seems that the applications of soil studies to archaeology are either very large scale, such as the capability of regional soils to support agriculture or use of soils as stratigraphic markers; or very small scale, for example studying the particle-size distribution or chemistry of a soil. There is a significant middle ground in soil studies that is often overlooked, however. This realm of soil science is pedology, which involves investigation of soils as three-dimensional bodies intimately related to the landscape, focusing on their classification and

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1 This chapter is a modified version of Holliday (1990).
genesis. That aspect of pedology most directly related to archaeology has a geological (rather than agricultural) basis, evolving from Quaternary geology and geomorphology and sometimes referred to as soil-geomorphology (e.g., Ruhe, 1983; Birkeland, 1984; Catt, 1986). Soil-geomorphology is a subdiscipline of pedology with roots in Jenny’s (1941) “state factor” approach to soil genesis (Johnson & Hole, 1994). This chapter reviews current and potential applications of pedology and soil-geomorphology in North American archaeology from the standpoint of the state factors.

There is a considerable and growing body of literature concerning the use of soils in archaeological investigations. Much of the initial, substantive work in this area was done in Great Britain (e.g., Cornwall, 1958, 1960), establishing a tradition that continues to thrive (e.g., Limbrey, 1975; Shackley, 1981; Macphail, 1987). In North American archaeology soils were originally used primarily as stratigraphic markers and continue to be so used, with considerable success (e.g., Judson, 1953; Haynes, 1968, 1975; Hoyer, 1980; Reider, 1980, 1982a,b, 1990; Bettis & Thompson, 1982; Ferring, 1982, 1990; Want et al., 1983; Styles, 1985; Hajic, 1990). There have been some applications of pedology for reconstructing landscapes and climatic conditions in archaeological contexts at general and site-specific levels (Haynes & Grey, 1965; Reeves & Dormaar, 1972; Thompson & Bettis, 1980; Reider, 1980, 1982a,b, 1990; Blair et al., 1990; Hajic, 1990; Mandel, 1992) and for dating (Foss, 1977; Bischoff et al., 1981; Bettis, 1992). There also are several general discussions of applications of pedology to archaeology (Lotspeich, 1961; Fenwick, 1968; Tamplin, 1969, Rutter, 1978; Olson, 1981; Holliday, 1989a). Finally, studies of soil chemistry, particularly P, have long proven quite useful in indicating the presence and measuring the degree of human occupation (Solecki, 1951; Ahler, 1973; Eidi, 1977, 1985; Woods, 1977; Gordon, 1978; Griffith, 1981; Gurney, 1985; McDowell, 1988).

Butzer (1977), in reviewing Limbrey (1975), comments on the general nature of that volume and absence of a “usable methodology” for soil science in archaeology. This paper is an attempt to begin establishment of such methodologies. A review of the factors of soil formation will be provided followed by a discussion of how a consideration of the various factors can be applied in archaeology. The final discussion will deal with aspects of soil stratigraphy in view of the factors.

**FACTORS OF SOIL FORMATION**

The state factor approach to soil genesis (Jenny, 1941, 1980) is the theoretical framework for much of pedology. This approach has many applications to archaeology and will be that followed throughout most of this paper. Jenny(1941, 1980) defined the factors of soil formation as climate, organisms (flora and fauna), relief (or landscape setting), parent material, and time, often written as the equation

\[ S = f(c, o, r, p, t, \ldots) \]

where the upper case S is the whole soil. This equation defines the state of the soil as a function of the five factors (the state factors) and other, unspecified factors of local or minor importance (\ldots). The equation as a whole has never been solved, but Jenny (1941, 1980) proposed solving the equation by studying the variation in a soil as a function of one factor, keeping the others constant or accounted for. For example, one could study the variation in soils due to differences in climate by keeping all factors except climate constant. Variations in any soil property or properties can then be attributed to variations in climate. This is written

\[ S or s = f(c, o, r, p, t) \]

where the lower case s denotes a soil property or properties. Qualitative statements about soils forming as a function of any one factor are called sequences (climosequence, biosequence, toposquence, lithosequence, chronosequence) and quantitative statements, where functions have been solved for any one factor, are called functions (climofunction, biofunction, toposfunction, lithofunction, chronofunction).

The state factor approach to the study of soil genesis is not without criticism, which is summarized by Birkeland (1984, p. 162–168). In particular, the factor approach tends to treat the factors individually, although they often act together, such as climate and biota. Additionally, there are other theoretical approaches to soil genesis, such as the energy model of Runge (1973), and some of these are summarized and compared by Gerrard (1981). For the most part, however, the general validity of the state factor approach has been upheld (e.g., Yaalon, 1975; Bockheim, 1980; Birkeland, 1984) and applied in related fields (e.g., Major, 1951). This approach to pedology is particularly useful “from the point of view of a field-oriented geologist-pedologist, working with a wide variety of soils at the earth’s surface” (Birkeland, 1984, p. 166). Because this is the same point of view taken by many geoarchaeologists, the state factor approach also is considered valid in archaeological pedology.

**THE STATE FACTOR APPROACH TO ARCHAEOLOGICAL PEDOLOGY**

The factors of soil formation that are generally of most concern in archaeology are time and climate. Specifically, this includes using soils as indicators of age, past climates and climate change. The following sections will deal with the archaeological applications of the state factor approach to time and climate in pedogenesis. The influence of the other factors will then be discussed. Some of the examples are not related to archaeological research, because so little of this type of soils work has been done in archaeological contexts, but these examples illustrate the principals and the potential for archaeology.
Time and Pedogenesis

The concept that some time must elapse before a soil can form is probably one of the most significant aspects of pedology in archaeology (Holliday, 1992). The presence of a soil in an archaeological site indicates that there has been a significant period of landscape stability, i.e., relatively little or no erosion or deposition. In the author's experience it seems that many investigators assume that in an archaeological site of some depth, especially a stratified site, sedimentation occurred more or less continuously. However, in many situations, such as alluvial or eolian depositional environments, deposition can occur relatively instantaneously; conceivably in a matter of days, certainly in a matter of years or decades. Soils almost invariably take longer to form; usually at least 100 or several hundred years, commonly thousands of years. A case in point is the Lubbock Lake site on the Southern High Plains of Texas, where the writer has conducted geological and pedological studies for several years (Holliday, 1985a,b,c,d,e, 1988b). Sediments ranging from 3 to 6 m thick accumulated episodically over the past 11,000 yr. The periods of deposition and soil formation are well-dated by over 100 radiocarbon ages (Holliday et al., 1983, 1985) and a plot of sedimentation rates through time (Fig. 4-1) shows that the landscape was stable and soils formed for 6000 out of the past 11,000 yr.

The degree of development of a soil profile or specific pedologic features in a profile can be used as relative indicators of time elapsed after deposition of parent material and, in some situations, as a more or less absolute indicator of age. This application of soils is derived from the concept of the state factors of soil formation. In a situation where there are a number of soils and where the influence of parent material, landscape position, climate, and flora and fauna can be considered negligible, held constant or otherwise accounted for, the soils with stronger profile development can be considered older than those that are less developed. Pedologic features that are time dependent include overall profile morphology as determined by soil indices (Bilzi & Ciolkosz, 1977a; Harden, 1982), profile thickness (Machette, 1975; Birkeland, 1984), illuvial clay content and reddening of the B horizon (Gile et al., 1981; Harden, 1982; Birkeland, 1984; McFadden et al., 1986), calcium carbonate accumulation (Gile et al., 1981; Machette, 1985; McFadden et al., 1986), alteration or formation of certain clay minerals (Shroba & Birkeland, 1983; Birkeland, 1984; McFadden & Hendricks, 1985), and alteration or translocation of certain forms of Fe, Al, and P (W. Scott, 1977; Birkeland et al., 1979; Birkeland, 1984; McFadden et al., 1986).

In an archaeological site with a chronosequence and also producing time-diagnostic artifacts, radiocarbon ages, or some other form of absolute age control, one can determine rates of soil formation and carry this information to other sites in similar situations and use the soils to provide an age for natural or cultural deposits (Fig. 4-2). The Lubbock Lake site is just such a situation. A late-Holocene chronosequence was defined at the site (Holliday, 1985c, 1988a). Rates and characteristic features of soil development were established by combining field and laboratory data with the well-dated geo-

chronology (Holliday et al., 1983, 1985) (Fig. 4-3, 4-4). The resulting information on pedogenesis is now being used to determine the age of soils, and by inference the age of their parent materials, at other localities in similar settings on the Southern High Plains (e.g., Holliday, 1989b).

In making comparisons of soils from site to site for dating purposes the soils being compared must be in similar landscape positions and parent material. These factors can exert a strong influence on soil morphology even in very young soils (discussed below). Furthermore, other considerations, such as stratigraphic relationships and archaeology must be taken into account. Soils similar in morphology can form at different periods in time.

Baseline studies on rates of soil development such as that described for Lubbock Lake are available or are emerging for other parts of the USA, albeit with varying degrees of age-control reliability. Gile et al. (1981) summarize a classic investigation of soil-geomorphic relations in the desert around Las Cruces, NM, including information on rates of argillie and calcie horizon formation in parent materials of different lithologies and in different landscape positions. G. Scott (1963), Machette (1975) (Fig. 4-2) and Holliday (1987a) discuss various aspects of soil development on terraces of the South
Fig. 4.2. A chronosequence from the South Plate drainage in Colorado showing maximum soil development on parent materials of different ages. The three youngest soils formed in sandy alluvium, the 140,000-yr-old in pebbly sand, and the two oldest soils in sandy gravel (modified from Mathette, 1975, with permission).

Fig. 4.3. Generalized soil-stratigraphic relationships at the Lubbock Lake site.
Platte River in eastern Colorado, an area famous for its abundance of Paleoindian sites (e.g., Holliday, 1988b). In Wyoming, Reider et al. (1974) established a late Quaternary chronosequence in the Laramie Basin and incorporated their data into related archaeological investigations. A number of chronosequences are available in the far western USA. For example, Shlemon (1978) defined a chronosequence in the southeastern Mojave desert of California and Arizona and has used this data to provide age estimates for several controversial archaeological sites in the area (Bischoff et al., 1978, 1981; Shlemon & Budinger, 1990). McFadden et al. (1986) also carried out research on rates of pedogenesis in the eastern Mojave and McFadden and Weldon (1987) conducted a similar study in the Transverse Ranges of California. Harden et al. (1986) describe a chronosequence along the California coast at Ventura, and Dethier (1988) investigated rates of pedogenesis along the Cowlitz River in western Washington.

Several Holocene chronosequences were investigated in the eastern USA including the upper Susquehanna River basin of New York (Scully & Arnold, 1981), the Ridge and Valley area of central Pennsylvania (Bilzi & Ciolkosz, 1977b), and the Tallapoosa River system in east-central Alabama (Markewich et al., 1988). Limited information on the degree of profile development at archaeological sites in the Brooks Range of Alaska also is available (Bernal, 1982). Finally, Harden and Taylor (1983) present a fine example of the use of soil indices for comparing pedogenesis in chronosequences in different climatic regimes.

In defining various chronosequences and determining rates of pedogenesis, the effects of climate cannot be held constant because the climate has fluctuated considerably during the Quaternary. This does not pose as big a problem as it might seem. A steady rate of soil development does not have to be assumed in using soils as age indicators. For relative age estimates one is simply assigning a qualitative estimate of soil age (e.g., is the soil “young” or “old”? A soil with a well-expressed profile probably had more time to form than one with a poorly expressed profile if both formed in the same area in the same parent material and in similar landscape setting. If degree of soil development is used to make numerical age estimates then one must start with independent age control such as radiocarbon determinations. Then the rate of soil development is calculated relative to either a given number of years or a specified period in the geologic past (e.g., the early Holocene). With sufficient comparative data it should be possible to sort out in a general manner what, if any, effect climate changes had on soil formation. These data can then be applied accordingly when using the soil information to determine ages for other sites in the region.

Climate and Pedogenesis

Often, one of the goals of archaeological research is the reconstruction of the climate when a site or region was occupied or the detection of climate change over a long period of occupation or relative to abandonment. Certain soil properties and soil types are related to climate and if the effects of
other factors of soil formation can be held constant or considered negligible. For a variety of reasons, however, soils probably have limited applications for reconstructing past climate conditions. In general, soils are not sensitive to climate changes that are too slow. Furthermore, climate changes detected from soil properties may reflect changes in the environment that occurred over a long period of time. Thus, soil properties can be used to infer past climate conditions, but they cannot be used to infer past climate conditions with high precision.

In some situations, however, soils have proven useful in providing some information about past climate. For example, the presence of carbonate in soils is often used as an indicator of past climate conditions. Carbonate is formed when calcium carbonate is dissolved in water and then precipitated again as calcium carbonate. When this process occurs, it is called precipitation. The amount of carbonate in a soil sample can be used to infer past climate conditions because it is influenced by temperature and precipitation. Warmer temperatures and higher precipitation will result in more carbonate being formed, while cooler temperatures and lower precipitation will result in less carbonate being formed.

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ately well-developed Bw or Bt horizon underlain by a distinct zone of CaCO3 accumulation (Bk). The carbonate accumulation in particular is taken to represent pedogenesis under warmer and possibly drier conditions related to the middle Holocene “thermal maximum” or Alithermal. In very few instances, however, is the precise age of the soil known, particularly the age of burial by the overlying sediments. In the absence of such data an alternative hypothesis is that such a soil is not related to a short interval of drier climate, but formed over a longer period of time. For example, at the famous Clovis site (Blackwater Draw Locality 1) Haynes (1975) reported a well-developed soil believed to have formed in the middle Holocene and considered to be related to a short period of warmer and drier climate. Data now shows that at that site and across the Southern High Plains the middle Holocene or Alithermal was characterized was characterized by eolian deposition not soil formation (Holliday, 1985d, 1989). The well-developed soil observed at Clovis and reported at many other sites in the area formed in the late Holocene (Holliday 1985c,d,e, 1989b). Therefore, it may be argued that in at least some situations climate change or climate extremes are represented by depositional or erosional events rather than periods of soil formation.

Organisms, Relief, and Parent Material

The pedologic information based on the influence of the factors of organisms, relief, and parent material has, at present, more restricted applications in archaeological research than data derived from studies of the state-factors time and climate. There are some aspects of the influence of each of these factors that do have some practical applications in archaeology, however. Flora and fauna certainly exert a tremendous influence on the soils in which they form, and they can leave a variety of physical remains (e.g., pollen and phytoliths) in the soil that can be used as clues to reconstructing floral and faunal assemblages, but these studies are the topics of other disciplines. Plants also influence the isotope chemistry of soils, and studies of stable C isotope are yielding valuable insights into past vegetation (Cerling, 1984; Cerling & Hay, 1986; Amundson et al., 1989).

Beyond isotopes, there is only a limited amount of information relating pedologic features to past plant and animal communities. As well, plant and animal distribution is so closely linked to climate that sorting out the effects of each is often difficult. The best results achieved along these lines have been vegetation reconstructions in restricted areas where the regional climate can be assumed to have been constant at any one time. Most of this work focused on studies of the ecotone between forested and unforested (including both prairie and tundra) regions. Alfisols with E horizons and Spodosols will typically form under forested conditions while Mollisols, Alfisols without E horizons, and Inceptisols are common in the nonforested areas. Because the forest boundary fluctuated through time as a function of climate change, the forest soils left their imprint in the soils of the nonforested areas. The above-cited work by Sorensen et al. (1971), Sorensen and Knox (1973) and

Sorensen (1977) is an example of such a study. The mapping and dating of buried and altered forest and tundra soils allowed for a reconstruction of shifts in the forest–tundra boundary throughout the Holocene. A number of similar sorts of investigations have been carried out along the ecotone of the forests of eastern North America and the prairies of the Great Plains (e.g., Ruhe & Cadz, 1969; Ruhe, 1970; Al-Barrak & Lewis, 1978, Anderson, 1987) and in an archaeological context at the foot of the Canadian Rockies (Reeves & Dormaar, 1972). Soil morphology and chemistry, along with other lines of evidence, also was used to dispel the long-held belief that the Southern High Plains was covered by a boreal forest at the close of the Pleistocene, the time of the earliest human occupation of the region (Holliday, 1987b).

It is important to understand how the properties of a soil can vary as the parent material or relief changes. These variations can influence soil profile morphology such that tracting a particular soil or using a soil as a stratigraphic maker could be difficult. This could be especially significant when working on a large archaeological site or over a larger area such as a drainage basin and where only limited natural or artificial exposures are available. On the time scale of the Holocene probably one of the most significant influences that parent material can have on a soil is in water movement through the soil. Coarser-textured soils allow much faster through-flow of water than fine-grained soils. Gile et al. (1966, 1981), for example, show quite clearly how the morphology of calcic horizons varies markedly as the texture of the parent material changes. Furthermore, textural variations in parent material at one locality (e.g., an alluvial deposit consisting of a layer of fine sand over a lens of gravelly sand) also can significantly influence the resultant profile morphology.

Clayey soils, particularly Vertisols, can have a profound influence on archaeological sites. The shrinking and swelling characteristic of this type of soil can destroy the stratigraphic and cultural contexts of a site (Duffield, 1970; Wood & Johnson, 1978; Johnson & Watson-Stegner, 1990). Duffield (1970) goes on to suggest that in Texas, where Vertisols are widespread and were probably difficult to till by prehistoric agriculturalists, these soils may have been significant in restricting the westward spread of village farmers.

Slope position can affect soil profile morphology in several ways. With in a large area such as a drainage basin the orientation of the slopes is important. For example, Lotspeich and Smith (1953) show that significant differences in soil morphology are apparent between north-facing and south-facing slopes. Water movement over and through soils also is strongly influenced by slope position. It has been observed in many situations that soils near the summits of slopes are better drained, but receive less effective moisture (due to run off) than soils at the foot of slopes (e.g., Ruhe, 1969; Daniels et al., 1971; Jenny, 1980; Hall, 1983; Birkeland, 1984). Soils in upslope positions also will tend to have material constantly removed from their surfaces, whereas the soils at the foot of the slope will tend to accumulate the materials eroded from upslope. The morphology of a soil can therefore vary markedly along a slope (e.g., Swanson, 1985; Berry, 1987; Birkeland
An understanding of such pedologic variation as a function of slope position is particularly significant when using soils to date landscapes. The concept of variation in soil morphology as a function of landscape setting can be quite useful in the reconstruction of landscapes and local environments. This principle is particularly applicable to buried soils, which represent buried landscapes. Daniels and Jordan (1966) and Ruhe (1969), among others, have applied these principles to regional and local reconstructions of Quaternary landscapes in a series of landmark investigations in Iowa. In strictly archaeological contexts, this principal is well illustrated at the Lubbock Lake site. Holliday (1985b) shows that there is considerable variation in the above-mentioned Firstview Soil as a function of landscape setting and microenvironment. Along the valley margin the soil is well drained, as indicated by oxidation colors (Fig. 4-3). The presence of some CaCO_{3} in the profile and a thin A horizon with low organic C content also suggests relatively dry conditions in this position. Along the valley axis the soil was very poorly drained (Fig. 4-3), as described above. A somewhat similar situation was described for the overlying Yellowhouse Soil. At the Clovis Site, several early to middle Holocene soils also exhibit considerable variation due to landscape setting (Haynes, 1975; Holliday, 1985d). Archaeological uses of buried soils to reconstruct landscapes are further discussed by Ferring (1990, 1992) and case histories include the Cherokee (Hoyer, 1980), Delaware Canyon (Ferring, 1982), Napoleon Hollow (Wiant et al., 1983; Styles, 1985), and Koster (Hajic, 1990) sites, and studies in western Kansas (Mandel, 1992) and the Missouri drainage of Iowa (Thompson & Bettis, 1980).

**SOILS AS STRATIGRAPHIC MARKERS**

Soils commonly have been used as stratigraphic markers in archaeological research. The unique physical and chemical properties that distinguish soils from sediments make soils quite useful for stratigraphic subdivision and correlation. However, the nature of soils also necessitates the exercise of a certain amount of caution in their use as stratigraphic markers.

The presence of a soil in a stratigraphic sequence marks the passage of some amount of time with no or very little erosion or sedimentation, but the parent material for that soil may have been deposited virtually instantaneously, as discussed earlier. If the soil in such a sequence is buried, the contact of the top of the soil with the sediments that bury it marks the gap in time. This means that cultural material found at the top and bottom of even a thick deposit may be nearly contemporaneous, whereas the artifacts near the top of the unit may be considerably older than an artifact immediately above, on the paleosurface (Fig. 4-4). Moreover, artifacts found on the paleosurface may well represent a mixture of cultural material left on the surface during the entire period of soil formation (Fig. 4-4). The artifacts and occupations also are subject to mixing by biological and geological activities (Duffield, 1970; Wood & Johnson, 1978; Hole, 1981; Stein, 1983; Johnson & Watson-Stegner, 1990) as well as stratigraphic compression. This situation was encountered at the Lubbock Lake site (Johnson & Holliday, 1986), Wilson-Leonard site, in central Texas (Holliday, 1992), at several sites in southwestern Oklahoma (Ferring, 1982), Shawnee Minisink site, Delaware (Dent, 1985), and probably occurs at many other stratified sites. On the positive side, the surface of a buried soil may be a zone likely to contain archaeological material because it does represent a stable landscape. A consideration of the time represented by the surface of a buried soil is also important in interpreting radiocarbon ages determined on the organic matter found in buried A horizons. Because the organic matter accumulates over time, the radiocarbon age will be the nonmathematical average age or "apparent mean residence time" of the A horizon plus the time since burial. Samples from buried A horizons are subject to contamination by younger organic compounds moving in from overlying soils, among other problems (Campbell et al., 1967; Scharpenseel, 1971, 1979; Martel & Paul, 1974; Burleigh, 1974; Matthews, 1985). Under proper circumstances, however, such dating can be useful in providing a minimum date for deposition of the parent material and beginning of pedogenesis and a maximum date for burial of the soil (e.g., Holliday et al., 1983, 1985; Matthews, 1985; Haas et al., 1986).

In using buried soils as stratigraphic markers it also should not be assumed that the amount of time represented by the contact with the overlying sediment is always the same. Burial of the surface may take place at different times in different places (Fig. 4-4).

Soils can be useful in identifying various strata, but they should never be considered strata themselves or referred to as "strata" or "layers," or otherwise treated like geological deposits. This point is well made by Tamplin (1969). At the Lubbock Lake site almost all of the A horizons of the various buried soils have been designated as some sort of strata since the first excavations in 1939. It cannot be overemphasized that a soil profile is imprinted over geologic deposits through time. Furthermore, the boundaries between soil horizons often have no relationship to geological layering. Depending on the slope of the surface associated with the soil and variations in the permeability of the parent material, soil horizons can crosscut depositional layering. At the Lubbock Lake site a prominent calcic horizon was designated as a "strata" during early investigations and artifacts were excavated accordingly (Johnson & Holliday, 1986). It is now apparent that where the earlier excavations took place the calcic horizon crosscuts two geologic deposits and an intervening buried soil (Fig. 4-4). Artifacts found in the calcic horizon could be as much as 6000 yr old or less than 5000 yr old.

Furthermore, it should be kept in mind that pedogenesis can obscure sedimentary features. One of the criteria often used to differentiate between the B horizon and a C horizon is whether bedding in the parent material has been observed. Evidence of bedding can persist in a B horizon if the original beds included lenses of gravel; otherwise the sedimentological history of the parent material will have to come from laboratory data. However, the original particle-size distribution of the parent material also can be obscured by pedogenesis. Significant amounts of illuvial (post depositional) clay can accumulate in Holocene soils, which could make some sedimentological in-
CONCLUSIONS

Soils have long been recognized as important components of archaeological sites. They have most commonly been used as stratigraphic markers. Soil chemistry also has been used as a tool to identify habitation areas or specific activity areas or to detect evidence of agricultural activity. Soils have been viewed less commonly as natural entities, constituting a type of near-surface weathering phenomena that grows as a three-dimensional body in sediment through time, under the influence of its parent material, the slope of the associated surface, and the climate. In addition, archaeological data can be useful to pedologists (e.g., Sandor et al., 1986a,b,c; Collins & Shapiro, 1987; Foss & Collins, 1987).

The above-outlined approach to soils is derived from pedology, which is concerned with the genesis and classification of soils and founded on strong geomorphic principles and data. In particular, this soil-geomorphic approach to geoarchaeology and pedology is derived largely from the work and ideas of Hans Jenny, beginning with his landmark 1941 volume, which we honor here, and continuing through his 1980 work.

Many archaeologists seem to have some familiarity with soil classification, but in archaeological pedology and soil-geomorphology classification is only one of many research tools and the complete integration of pedology into these areas of research requires an understanding of soils far beyond basic terminology. No archaeologist is expected to become a pedologist any more than they are expected to become palynologists, zoologists, or sedimentologists. However, an understanding of the basic principles of pedology, as well as other disciplines, is essential for communication with specialists in such disciplines. A knowledge of the potentials and limitations offered by soils and knowing what questions to ask of a pedologist can aid considerably in conducting an efficient and more complete investigation.

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REFERENCES


STATE FACTOR APPROACH IN GEOARCHAEOLOGY

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Factors Controlling Ecosystem Structure and Function

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ABSTRACT

Factors of Soil Formation is a seminal book in terrestrial ecosystem ecology much as it is in pedology. The insights and syntheses therein remain a driving force in studies of natural and managed ecosystems. The influence of Factors of Soil Formation is illustrated by recent examples of ecological studies based explicitly on the climate, organism, relief, parent material, time, and human activity factors. Where single-factor studies are impractical, ecosystem studies treat the interactions of state factors (with each other and with processes internal to ecosystems) in process-based models whose development and validation are themselves dependent on state factor-based approaches. Finally, the legacy of Factors of Soil Formation, and the man who created it, is now being felt in the development of ecological research programs to analyze causes, consequences, and feedbacks of global environmental change.

Factors of Soil Formation is focused on ecosystems—the term is synonymous with the “larger system” that is the explicit focus of much of Jenny’s work. Jenny did not invent the ecosystem concept—but Factors of Soil Formation, and other publications by Jenny, introduced ways of thinking about ecosystems that today continue to represent a dominant conceptual approach to the field. Jenny’s contributions include: (i) he identified potentially independent factors that could control terrestrial ecosystems (in an ultimate sense), and distinguished these from processes internal to ecosystems, and (ii) he suggested, and demonstrated, that analyzing variations in the structure and dynamics of ecosystems in relation to variations in those independent factors yields insight into the control of ecosystem processes—and a crucial background for experimental analyses.

In addition to these conceptual underpinnings, Factors of Soil Formation brought a number of empirical approaches to the attention of ecosystem scientists—and synthesized a great deal of basic information that remains useful today. Consequently, I believe it is reasonable to regard Jenny as the