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FIRE AND ICE: NEW EVIDENCE FOR THE PRODUCTION AND PRESERVATION OF LATE ARCHAIC FIBER-TEMPERED POTTERY IN THE MIDDLE-LATITUDE LOWLANDS

Kenneth C. Reid

Fiber-tempered potsherds recovered from three sites of the Nebo Hill phase in western Missouri and eastern Kansas date to between 4550 and 3550 radiocarbon years (2600–1600 B.C.) and represent the earliest dated vessels in the midwest. The occurence of fiber-tempered pottery at this time period and this far north and west of the traditionally-defined southeastern hearth for such wares requires a major reappraisal of the assumed distribution and antiquity of Late Archaic ceramics in eastern North America. This report describes the ceramic sherds from the Nebo Hill type site in terms of their method of manufacture and probable use, and identifies factors influencing their survival and preservation in the middle-latitude lowlands. It is proposed that the temperate latitude distribution pattern of shallowly-buried, fiber-tempered potsherds is shaped primarily by the variables of time, ambient moisture and temperature, and ware porosity, and is not necessarily isomorphic with the prehistoric distribution of fiber-tempered vessels.

Historical sciences such as archaeology and paleontology advance as they become increasingly sophisticated in handling the data gaps produced by long periods of material and information decay. A key premise of all stratigraphic studies, whether of sediments, organisms, or artifacts, is the importance of distinguishing between "the nature of the process and the nature of the record" (Ager 1981:56), that is, of always measuring the few surviving bits of physical data against the great gap of negative evidence.

Taphonomic studies, analyses of the "laws of burial" affecting fossil assemblages, have become increasingly common and sophisticated in paleontology (Behrensmeyer and Hill 1980; Müller 1979; Raup and Stanley 1978; Shipman 1981), and techniques and insights pioneered in this discipline have been skillfully applied to archaeofaunal (Binford 1981; Brain 1976) and archaeobotanical (Hally 1981) assemblages. This paper will suggest that the same taphonomic perspective is helpful in explaining early prehistoric ceramic distributions, especially in the temperate middle latitudes of eastern North America.

It is widely accepted that the archaeological record of the eastern woodlands accurately reflects both the timing and directionality of ceramic innovations and diffusions. Recent discussions of early ceramics agree on several points:

1. The first pots appear at about 2500 B.C. in the southeastern United States, where they were either introduced from South America (Crusoe 1972; Ford 1966), or developed indigenously (Griffin 1978:59–61), but pots do not appear until about 1000 B.C. in the midwest and northeast.
2. The first pots in the southeast are tempered with plant fibers, while the first pots in the midwest and northeast are tempered with mineral inclusions (Stoltman 1978:715).
3. Northeastern and midwestern pottery technology is historically derived from southeastern pottery technology (Mason 1981:209; Snow 1980:242). As ceramic technology spread out of a southeastern source area, various changes were made in fabric composition and surface treatment as the technology diffused to the north and west over a period of about 1,500 years (Dragoo 1976: 16; Griffin 1967:130).

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It is important to note here that regional integrative concepts such as a "fiber-tempered interaction sphere" (Crusoe 1972:69–78; Jenkins 1975:19) and a "Gulf Formational Stage" (Walthall 1980:78; Walthall and Jenkins 1976:43) have been defined in terms of the spatial and temporal distribution of fiber-tempered pottery in the southeast. These units are implicitly contrasted with a contemporaneous aceramic hinterland located to the north and west of the Atlantic and Gulf coastal plains.

Here I wish to propose as an alternative hypothesis that these distributional patterns and the cultural interpretations based on them are significantly biased by unexamined environmental variables, of which latitude is the most important, and that the presumed southeastern hearth of Late Archaic fiber-tempered pottery represents a preservational enclave where porous ceramics are less vulnerable to decompositional processes typical of temperate zones. A taphonomic model is outlined to explain the distribution pattern of fiber-tempered pottery in eastern North America as a product of the interacting variables of ceramic porosity, ambient soil moisture, winter temperature, and time, rather than as a direct reflection of prehistoric cultural dynamics.

This hypothesis is suggested by the recent recovery of small samples of fiber-tempered pottery from three sites of the Late Archaic Nebo Hill phase in the lower Missouri River basin of western Missouri and northeastern Kansas. These include the Nebo Hill type site, 23CL11, overlooking the Missouri River immediately east of Kansas City (Reid 1978, 1980); the Turner-Casey site, 23JA35, in the Little Blue valley south of Kansas City (Schmits and Wright 1981); and the Doherty site, 14MM27, in the upper Marais des Cygnes basin southwest of Kansas City (Blakeslee and Rohn 1982). Pottery recovered from these sites dates to between 4,550 and 3,550 radiocarbon years ago and confirms the presence of fiber-tempered ceramics in Late Archaic contexts on the southern Prairie Peninsula, a hypothesis first advanced on the basis of a single undated fiber-tempered basal sherd recovered from Level IV of Graham Cave, 400 km to the east of the Nebo Hill locality (Logan 1952:60). The largest sample of sherds recovered to date includes 85 fragments from the Nebo Hill excavations, described below.

THE NEBO HILL PHASE

The Nebo Hill phase refers to a Late Archaic culture centered in the Kansas City area of western Missouri and eastern Kansas, extending northward up the major tributaries of the lower Missouri River in northwestern Missouri (Reid 1983). Although first described as a late Paleoindian or Early Archaic complex on the basis of its lanceolate points (Shippee 1948), it is now recognized as a western extension of a larger midwestern technocomplex that includes such Late Archaic units as the Sedalia focus of central and eastern Missouri (Chapman 1975:200–211) and the Titterington phase of western Illinois (Cook 1976:40–68; Montet-White 1968:97–103).

To date, the most complete picture of Nebo Hill material culture and subsistence economy comes from excavations by the University of Kansas at the type site in 1975–1976 (Reid 1978, 1980). These data have since been amplified by excavations and surveys of Nebo Hill components in northwestern Missouri, southwestern Iowa, and eastern Kansas (Figure 1).

Excavations at 23CL11

The Nebo Hill site proper covers an area of at least 9 ha along the summit and spurs of a loess-mantled promontory that overlooks the valley of the lower Missouri River in southern Clay County, Missouri. The surface scatter of fire-cracked rock and chert debris masks a number of smaller discontinuous campsites characterized by dense lithic debris concentrations and organically-stained sediments. A 211 m^2 block excavation of one such concentration contained within a proposed highway right-of-way produced the ceramics described here.

Stratigraphy within the excavation space consisted of a plowzone ranging from 14 to 35 cm in depth, and an underlying dark, midden-stained stratum designated Zone II that averaged 20 cm in depth. The later was formed in culturally sterile Wisconsinan loess that extends 12 m to bedrock. Cultural debris was restricted almost entirely to the plowzone and Zone II, and was concentrated in the latter unit. Sixty-six of the 85 ceramic fragments were recovered from Zone II; the ceramic density was approximately one sherd per 1.5 m^3 of trowel-excavated matrix. No stratigraphic or

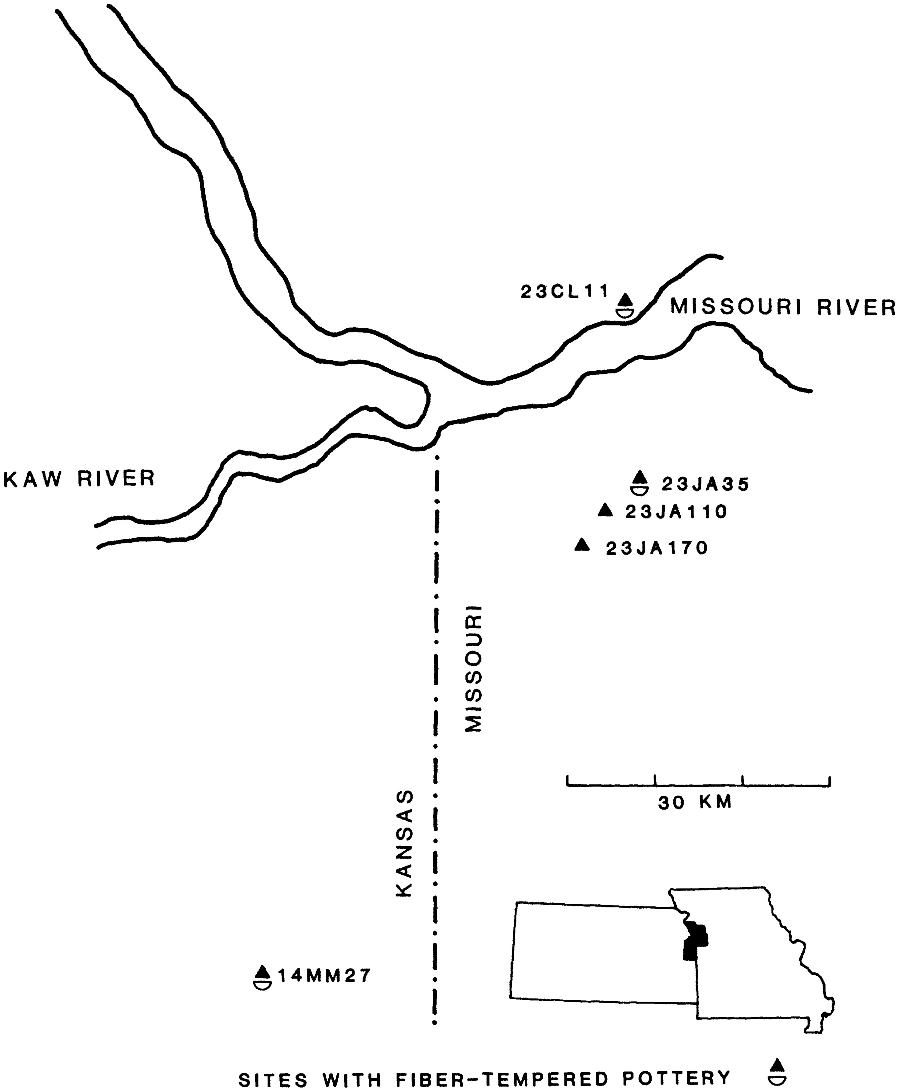


Figure 1. Location of Nebo Hill sites discussed in the text.

artifactual evidence for a second cultural component was observed within the excavation space. However, artifacts diagnostic of Paleoindian, Early Archaic, and Middle Woodland components have been recovered at the surface along the southern end of the ridge, approximately 1 km south of the block excavation.

Features included prepared limestone ovens, shallow basin-shaped cooking pits, diffuse scatters of charcoal flecks, and heaps of hearth-cleaning limestone debris. Evidence of permanent occupation—such as post molds, house floors, or storage facilities—was absent. Although organic remains were poorly preserved due to the shallowness of the deposit, subsistence appears to have been focused on deer and smaller game (Artz 1978), and on oily nuts and starchy seeds such as *Juglans nigra* and *Chenopodium* (Root 1978). A fall occupation is suggested by the plant remains, by cementum analysis of deer teeth (Wright 1976), and by topoclimatic features, such as seasonal nocturnal warm air inversions along the valley bluffs.

The artifact assemblage was dominated by stone tools and manufacturing debris derived from outcrops of local Pennsylvanian cherts and Pleistocene gravels. Formally shaped tools include heat-treated lanceolate dart points and knives, bifacial gouges and silica-polished hoes, greenstone axes and celts, and quartzite shelling and grinding slabs and handstones. Nebo Hill bifacial and ground-stone technology has many formal parallels with the contemporaneous Sedalia and Titterington cultures to the east, minimally suggesting affinity at the technocomplex level (Clarke 1978:495).

Due to their small size, many of the ceramic fragments described here were not recognized as such in the field, but were classified as either daub or burnt earth. As a result, their provenience is referenced to the 1 m^2 or 2 × 2 m unit and 10 cm level, rather than being point-plotted to the nearest centimeter, as were the lithic tools. Nevertheless, no tendency was noted for the ceramics to cluster in the vicinity of hearths or work areas. Instead, they have a relatively uniform distribution across the dumping area, or midden, that occupies the western two-thirds of the block excavation.

Nebo Hill Chronology

At the type site, 23CL11, an age of 3555 ± 65 years: 1605 B.C. (UGA 1332) was obtained from a 47-g sample of carbonized walnut shells recovered from a sealed hearth below the plowzone (Reid 1980:30–31). A smaller sample of charred wood from the Nebo Hill component at the Sohn site, 23JA110, produced an age of 2970 ± 490 years: 1020 B.C. (Reeder 1978:91). Most recently, a 5.1-g sample of carbonized nutshells and small flecks from the Turner-Casey site, 23JA35, was dated to 4550 ± 115 years: 2600 B.C. (Schmits and Wright 1981:511). Currently, these are the three most acceptable dates for the Nebo Hill phase. Absolute dating of these shallowly buried components has been plagued by poor preservation of organic material and by the scarcity of intact sub-plowzone hearths.

For example, two small charcoal samples built up from small bits of carbonized wood picked out of midden units at 23CL11 produced ages of 410 ± 100 years: A.D. 1540 (UGA 1329) and 1605 ± 105 years: A.D. 345 (UGA 1330), while a larger sample of carbonized bark immediately below the plowzone was dated at 470 ± 60 years: A.D. 1480 (UGA 1342). These ages are obviously too recent for the Nebo Hill materials, and because there was no artifactual or stratigraphic evidence for components of either Middle Woodland or late Central Plains tradition age, all three are rejected as inconsistent. They may date post-occupational forest or prairie fires, or they may simply represent badly contaminated samples. Another anomalous age of 2220 ± 195 years: 270 B.C. (DIC 914) was obtained from a composite sample of charcoal from the Nebo Hill component at 23JA110, but was regarded as too recent to date the Archaic occupation (Reeder 1978:91–92). It may reflect disturbance from the Middle Woodland component at the same site, dated to between A.D. 150–290 (Reeder 1978:219).

A series of thermoluminescent dates run on heated chert flakes recovered from a clay foundation wall of a small Nebo Hill structure at 14MM27 has produced ages ranging from between 3920 and 3240 years: 1940–1260 B.C. (Blakeslee and Rohn 1982:669–670). Data from this important site are still being analyzed, and will be discussed fully in a forthcoming report (Blakeslee and Rohn 1982). However, preliminary results suggest that the dating of thermally altered chert may play an important role in securing the chronology of carbon-deficient Nebo Hill occupations.

The clustering of radiocarbon and thermoluminescent dates in the second millennium B.C. is supported by typological cross-dating of projectile points. Small notched points that fall within the range of variability associated with Merom Expanding Stem and Trimble Side Notched forms (Winters 1969:41) were recovered in situ at 23CL11 and 23JA110, and suggest contemporaneity with the Riverton culture of southern Illinois. Ages of 3961 ± 140 and 3411 ± 235 years: 2011–1465 B.C. are attributed to this unit (Winters 1974:xix). Sedalia and Etley points recovered in situ from at least three Nebo Hill components indicate contemporaneity with the Titterington phase or Sedalia focus to the east in central Missouri and western Illinois, dated to between 3950 ± 75 years: 2000 B.C. (Cook 1976:65) and 2910 ± 160 years: 960 B.C. (O'Brien and Warren 1980:60). The proximal fragment of a large, shallowly side-notched blade reminiscent of Osceola or Hemphill Notched forms was recovered in situ from the Nebo Hill component at 23CL109, and a complete

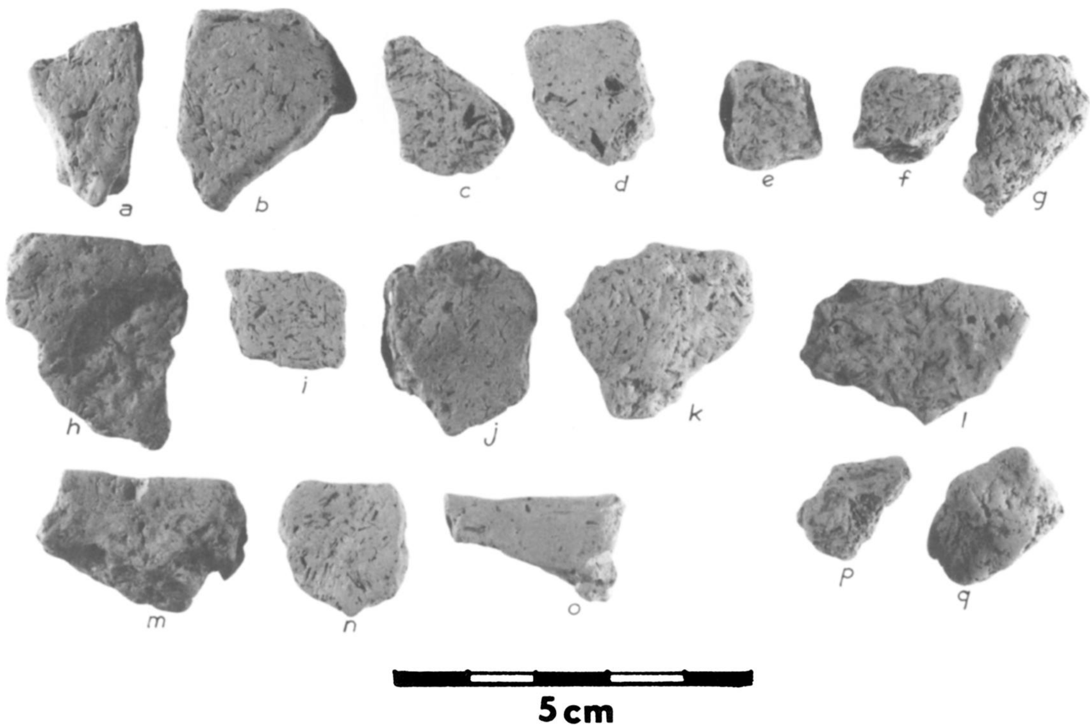


Figure 2. Fiber-tempered potsherds from Nebo Hill (23CL11). a.-l. body sherds; m.-o. rim sherds; p., q. internal sherd fragments or pieces of fired paste. Reprinted with the permission of Academic Press.

specimen of the same type was in the landowner's collection from the site (O'Brien 1977:67). These blades suggest contemporaneity with the Old Copper complex of the northern midwest, dated at 3450 ± 250 years: 1500 B.C. (Stoltman 1980:139). Finally, a stemmed Dustin point recovered from 23JA35 indicates contemporaneity with the El Dorado phase centered in the Flint Hills of eastern Kansas, dated at 3600 ± 100 and 3500 ± 100 years: 1650–1500 B.C. (Schmits 1980:23).

Collectively, the absolute and relative dates from five excavated components suggest a chronological position for the Nebo Hill phase of between 2600–1000 B.C.; when the large standard deviation of the date from 23JA110 is considered, this interval may contract to between about 2600 and 1500 B.C. In either case, both the radiocarbon and the typological evidence indicate that the Nebo Hill phase is contemporaneous with the fiber-tempered ceramic horizon in the southeastern United States. The earliest Stallings Plain sherds from South Carolina have ages of 4465 ± 95 and 4450 ± 135 years: 2515–2500 B.C. (Stoltman 1966:872), and fiber-tempered pots are replaced by various wares tempered with mineral particles after about 1000 B.C. throughout the southeast (Stoltman 1978:715).

DESCRIPTION AND ANALYSIS OF THE CERAMICS

The Nebo Hill ceramic sample includes three rim sherds, 32 body sherds, one probable lug, and 49 badly eroded internal fragments lacking interior or exterior wall surfaces (Figure 2). The sherds are quite small, with a modal weight of less than 1 g and a modal maximum dimension of 1.5 cm. Of the 19 body sherds with both interior and exterior wall surfaces, thickness ranges from 5 mm to 12.3 mm, with a mean of 8 mm (Figure 3a). In thickness, the Nebo Hill sherds resemble contemporaneous southeastern wares such as Stallings Plain, Orange, and the Wheeler series from Poverty Point, but are considerably thinner than such Early Woodland midwestern wares as Marion Thick and Schultz Thick (Figure 3b).

Bond fractures on all three rims and on four body sherds suggest that the vessels were built up

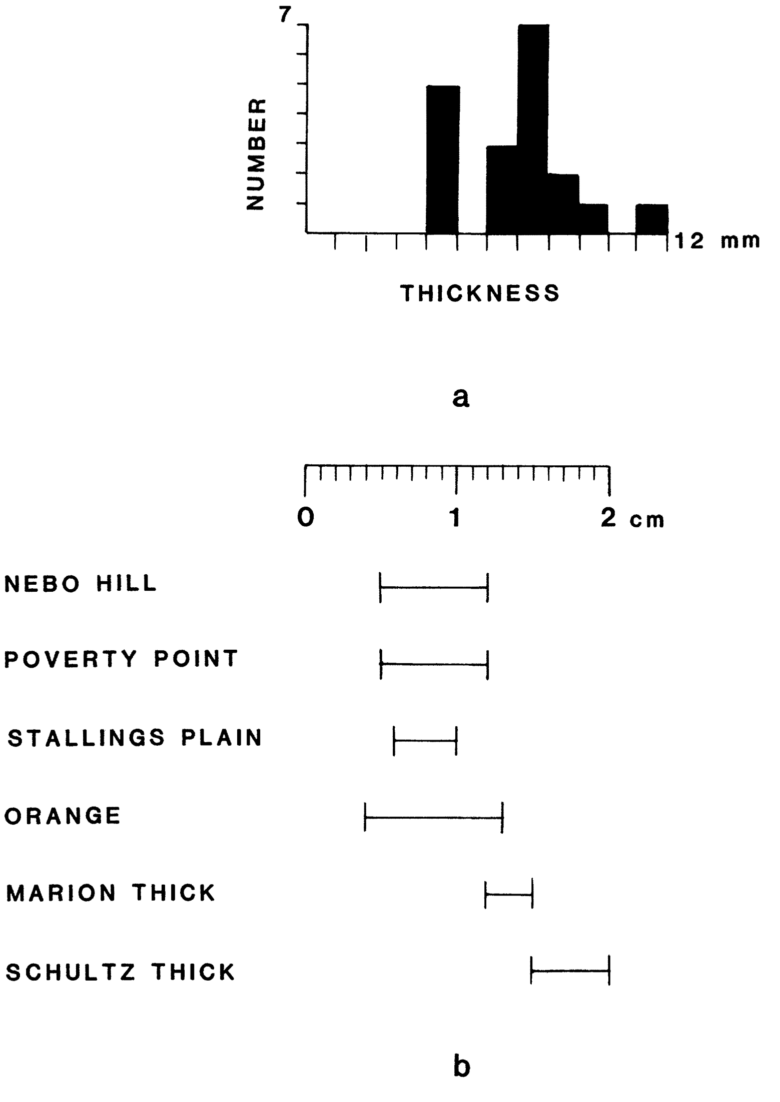


Figure 3a. Thickness distribution of 19 Nebo Hill body sherds with interior and exterior wall surfaces.
Figure 3b. Comparative thickness ranges for Late Archaic fiber-tempered wares (Nebo Hill, Wheeler series from Poverty Point, Stallings Plain, and Orange) and Early Woodland thickwares. Data from Bullen 1972; Ford and Webb 1956; Griffin 1943; Ozker 1977.

from strips or coils, rather than having been slab-built or molded by pinching. Curvatures on two of the rims indicate mouth openings of 30–35 cm, suggesting bowls rather than jars. The rim forms are direct, two with rounded lips and one with a flattened lip. A small boss occurs on one body sherd, but surfaces are otherwise undecorated and unsmoothed. No basal fragments were recovered. Contemporaneous wares in the southeast are typically flat-bottomed with cylindrical or rectangular walls (Griffin 1965:106; Jenkins 1972:164), with a few rounded bases reported in the Wheeler (Haag 1942:514) and Norwood (Phelps 1965:67) series.

Color ranges from a very pale buff or white (5YR8/1), to reddish yellow (5YR7/6), to light gray (5YR7/1), to dark gray (5YR4/1), with light values and yellow and red chromas predominating.

Most sherds were fired completely in an oxidizing atmosphere and lack dark reduction cores. Hardness is less than 2.5 on the Mohs scale. In this measure the Nebo Hill sherds resemble Middle Woodland and Mississippian wares from the Kansas City region, but they feel somewhat softer and chalkier than either Kansas City Hopewell or Steed-Kisker ceramics.

The matrix is a homogeneous clay with no calcareous or glacial till inclusions. Silt-sized particles range from a low of about 5% to a high of about 15% in four petrographic thin sections. Sand particles are absent both in the thin sections and in megascopic examination of sherd surfaces. The paste appears to have been smooth and compact, well consolidated, and lacking in organic inclusions such as rootlets.

Little comparative data exist on ceramic pastes in the Kansas City region. Sources of clay available to prehistoric potters have not been systematically investigated, and little is known about changes in clay exploitation through time or space. A petrographic analysis of Late Woodland sherds from the Little Blue valley concluded that they were made from a glacial till clay with a high percentage of included granitic particles (O'Malley 1981:248–249). The paste of the Nebo Hill sherds does not appear to derive from such a till clay, and the low silt fraction and absence of calcareous inclusions are not typical of the lean and silty clay bodies in local Peorian loess (Frye et al. 1949:74–77). The closest sources of homogeneous, nonorganic clays are probably alluvial pockets of Tina and Wabash soils located on higher bottoms of the Missouri trench immediately south of Nebo Hill (Mausell et al. 1976:16), and it is possible that the exploited deposit lies within 1 km of the site.

Fabric and Temper Analysis

In view of the small size of the individual specimens, inferences concerning their technology of manufacture and their function must be based on analysis of fabric and temper rather than on estimates of vessel size or shape. As used here, fabric refers to the fired paste and its inclusions, whether particles or voids (Rye 1981:145), and temper refers to particle inclusions purposefully added to the unfired paste, rather than to the voids left by the burning out of organic temper inclusions in the fired fabric.

The particle inclusions are pieces of crushed potsherds or grog that range up to 5 mm in diameter and have an average sample density of about one visible particle per sherd. Buff or reddish colors suggest derivation from earlier vessels of the same ware. Because grog particles have the same thermal expansion properties as unfired paste made from the same clay, their presence suggests an experimental familiarity with different paste-strengthening materials on the part of the potters. In this respect, the sherds do not suggest the fumbling first efforts of ceramic neophytes.

Much more abundant than grog particles are the negative molds or impressions of various vegetal elements, including short sheath or stem segments, seeds, culms, and isolated hair-like, filamentary fibers. The estimated average areal density of surficial or apparent pores and voids ranges between 10% and 25%, with pore diameters ranging from a modal value of less than 1 mm up to a high of 4.5 mm.

The plant fiber impressions are readily distinguished from holes produced by leached-out shell temper by the presence of discernible botanical structure within the former. The impressions are well-dispersed throughout the fabric, and do not form a separate carbonized veneer between two layers of paste, as has been reported for palmetto-tempered sherds from Georgia (Crusoe 1971:113). Their regular distribution, combined with the chopped appearance of some of the stem impressions, argue against the hypothesis that they are natural inclusions in an organically rich clay.

Botanical identifications made from some of the larger plant impressions include switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardi*), and a monocotoledenous sedge that is probably bulrush (*Scirpus*). Switchgrass was identified from the shape and markings of the nodal portion of a grass culm on one specimen, and from a vein impression on another. The negative impression of an intact floret of big bluestem was identified from its size, shape, and dorsal groove. Bulrush was identified from a characteristic pattern of lacunae that recurred in four separate cross-sections in a single petrographic thin section (Reid 1983:33). All botanical identifications were made by Ronald L. McGregor, Director of the Herbarium at the University of Kansas.

Table 1. Temper Identifications of Late Archaic Fiber-tempered Ceramics.

Descriptive Name	Common Name	Scientific Name	Region(s)	Source(s)
palmetto	cabbage palmetto	*Sabal palmetto*	Savannah River	Holmes 1903
	dwarf palmetto	*S. minor*	St. Johns River	Bullen 1972
	saw palmetto	*Serona repens*	Florida gulf coast	Peterson 1980
	salt marsh rush	*Scirpus robustus*	Savannah River	Crusoe 1971
	Spanish moss	*Tillandsia usneiodes*	St. Johns River	Williams 1965
"flat grass-like fiber"	—	—	Tennessee River	Jolly 1974
	switchgrass	*Panicum virgatum*	Lower Missouri River	Reid 1980
	big bluestem	*Andropogon gerardi*		
	bulrush	*Scirpus*		

It is widely thought that Late Archaic ceramics from the Atlantic and Gulf coastal plains were predominantly tempered with palmetto fibers derived from one or more of three species common to the southeastern woodlands. Other plant impressions tentatively recognized in southeastern sherds include an unidentified grass, salt marsh rush, and Spanish moss (Table 1), though the latter identification is controversial (Weaver 1963:55). Some investigators interpret the correlation between palmettos and early pots as a causal one, arguing that the range of the first fiber-tempered wares was determined by the distribution of *Sabal palmetto* (Brain and Peterson 1971:72; Peterson 1980: 369).

The Nebo Hill sample does not support the latter suggestion. The impressions of prairie tallgrasses and sedges in the western Missouri sherds, together with the tentative identification of grass and rush fibers in other southeastern wares (Table 1), support the more general proposition that *all* Late Archaic fiber-tempered wares fall within a broad regional tempering horizon based on both temperate and subtropical herbaceous monocots.

Fibers of prairie tallgrasses, sedges, and rushes all form linear, strand-like, biosiliceous bundles comparable to those of palms, from which they are all ultimately descended through neotonic reduction (Corner 1966:269). The use of any fiber in a ceramic paste increases its tensile strength in the plastic state; nylon, carbon, and fiberglass strands are used for the same purpose by contemporary potters (Brody 1979:8; Davidge 1979:111–117). The high opaline silica content of monocot fibers (Rovner 1971:345) may have been especially advantageous for stabilizing plastic body walls, and the tensile strength of prairie tallgrasses, braced by fibers that permit them to stand erect as high as 2 m, presumably was recognized as technologically useful by potters coping with homogeneous clay deposits.

Once fired, the most distinctive property of fiber-tempered pottery is its high porosity. This variable has important implications for both the function of the vessels, and for the post-breakage fate of the sherds derived from them. These topics are discussed in the following sections.

Porosity and Vessel Function

It is assumed here that pots used in domestic contexts functioned primarily as either cooking vessels or liquid storage containers, and that their formal attributes reflect intelligent compromises between the often conflicting requirements of manufacture and utilization (Braun 1983; Rye 1976: 135). For example, all pots have to withstand the shock of initial firing, but cooking pots require sufficient thermal shock resistance to survive repeated firing episodes, while the major functional consideration for water pots is the ability to provide for evaporative cooling. Vessels designed for such different functions can be expected to differ in a variable as critical to performance as porosity.

Thermal shock resistance is the set of properties that permit a vessel to survive repeated cycles of heating and rapid cooling without cracking or spalling (Rye 1976:113). It is controlled by a combination of vessel shape, the thermal expansion properties of mineral inclusions, and porosity. Only the latter two variables are addressable with the Nebo Hill sherds. The particle inclusions observable in the fabric are pulverized bits of pottery that appear to derive from the same paste and probably have the same thermal expansion properties.

High porosity (at least 10% surficial porosity) is a desirable property in low-fired earthenware cooking pots because the larger pores function to arrest the propagation of cracks that are generated by the differential expansion of heated exterior and interior wall surfaces. Experiments reported in Rye (1976:114) indicate that pores in the size range between 5–10 mm can substitute for mineral inclusions without changing the cooking efficiency of a pot because for a given volume of air in the pore space, "there is a temperature at which the quantity of heat passing through it by radiation equals that which would be carried by a solid substance occupying the same space."

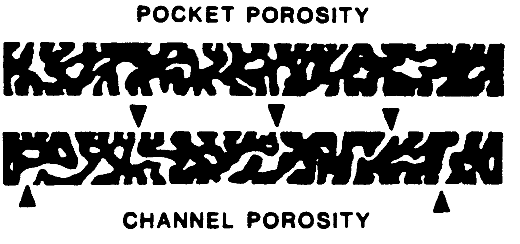
These considerations suggest that the simplest strategy for producing an earthenware cooking vessel is to use a temper combination composed of pulverized sherd particles to improve paste workability, and chopped or crushed biosiliceous plant fibers to both improve the tensile strength of the malleable paste, and to produce large, crack-arresting pores in the fired fabric (Rye 1976: 114–116). This formula is documented among contemporary Amazonian potters, where cooking pots are made from a paste tempered with a mixture of old sherd particles and pulverized tree bark (DeBoer and Lathrap 1979:104–116; Linné 1965:28–31; Rye 1981:34–35).

A similar tempering compromise is seen in the Nebo Hill sherd fabrics. The grog particles would thicken the homogeneous clay paste, and the grass and sedge fibers would provide tensile strength to the unfired body, preventing the walls from sagging. Upon firing, the larger pores produced by the burning out of stem and leaf segments, seeds, culms, and larger plant parts would provide crack-arresting voids suitable for cooking vessels. Although most of the pores are considerably smaller than the 5–10 mm range suggested for optimal thermal shock resistance, it is likely that sherds with pores in this size range would be among the first to disintegrate under frost wedging of pore ice, biasing the sample toward sherds with atypically small cavities.

Porosity and Permeability. The molds or voids produced by the burning out of plant fibers are sometimes interpreted as indicating use as water pots rather than as cooking pots. A correlation is often stressed between the distribution of fiber-tempered pottery and shellfish middens in the southeast (Caldwell 1958:15; Peterson 1980:367; Stoltman 1972a:iii), and it has been suggested that plant fibers functioned to increase vessel porosity (Holmes 1903:117; Peterson 1980:369), which in turn permitted the liquid storage of live shellfish (Peterson 1980:369; Stoltman 1972b:44).

In evaluating such hypotheses, it is helpful to distinguish between the closely related properties of porosity and permeability. These terms are used interchangeably in some contexts (Peterson 1980:369–370; Rye 1976:113), but are usefully distinguished in others (e.g., Chandler 1967:43; Fournier 1973:168, 177–178; Shepherd 1954:125–126). Thus Shepherd defines permeability as "the condition which permits gases and liquids to pass through a porous body. It depends on connecting channel pores and capillaries that extend from one surface to the other" (Shepherd 1954:125). In contrast, porosity is a measure of body structure that includes either total or apparent (surficial) pore space in relation to total volume. In other words, permeability implies porosity, but porosity does not imply permeability. Chandler (1967:43) makes the same point with his useful distinction between "pocket" and "channel" porosity, with only the latter entailing permeability or the passage of gas or liquid from one wall surface to the other (Figure 4).

The kind of porosity produced by the burning out of plant fibers will be controlled largely by the length and thickness of the temper segments, and by how they are mixed into the paste. Materials such as the chopped straw and chaff used in various early wares in southwest and southeast Asia (Franken 1974:183; Hole et al. 1969:111, 352; Solheim and Ayres 1979:68–74), the "short, cut fibers" of early Jōmon pots (Kidder 1968:47), or the chopped grasses and sedges in the Nebo Hill sherds, appear to be better designed for thermal shock resistance than for the evaporative cooling



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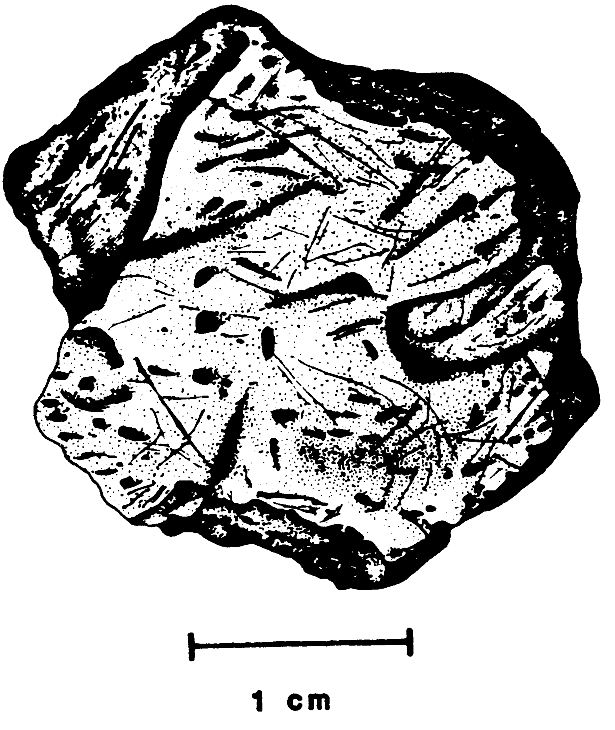

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Figure 4a. Schematic wall profiles showing the distinction between "pocket" and "channel" porosity (after Chandler 1967).
Figure 4b. Pocket porosity pattern on Nebo Hill body sherd.

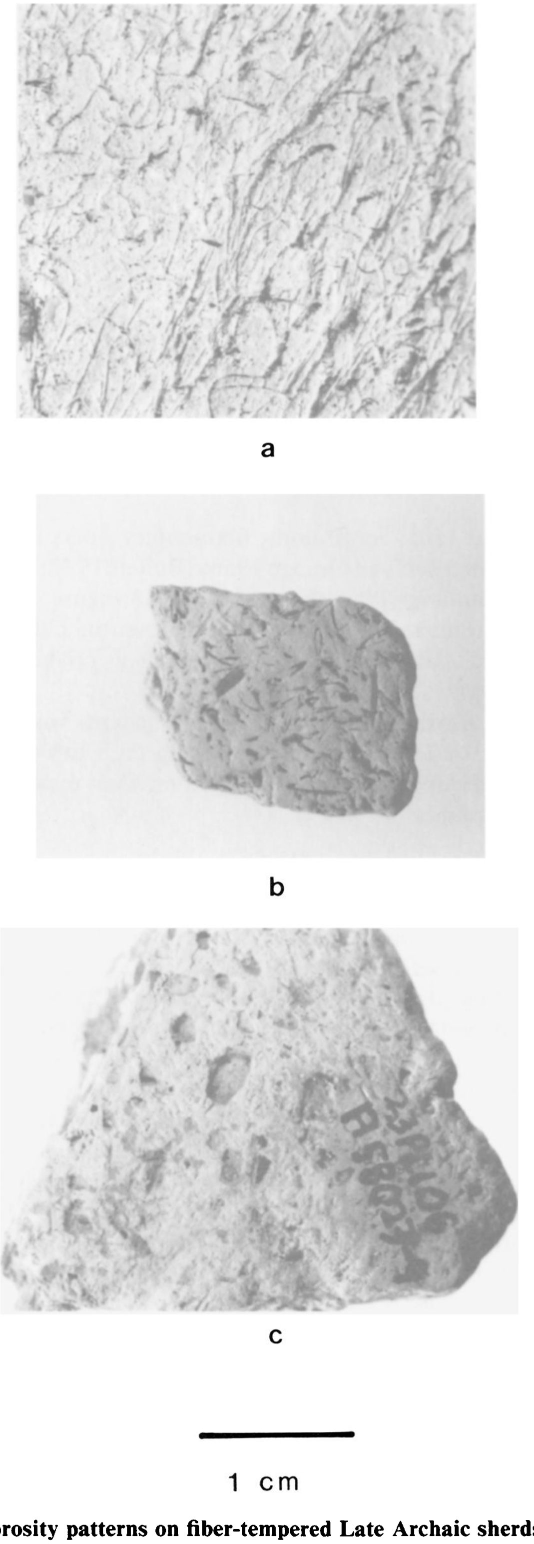

Figure 5. Comparative porosity patterns on fiber-tempered Late Archaic sherds and leached shell-tempered Mississippian (Caddoan) sherd. a. Channel pores produced by filamentary fibers in Wheeler series sherd from 1LU59; b. Pocket pores in Nebo Hill sherd; c. Pocket pores in leached shell-tempered sherd from 34WG8.

Table 2. Comparative Absorption Data for Late Archaic, Middle Woodland, and Mississippian Potsherds.

Site	Ceramic Ware[a]	Period	Temper	Apparent Porosity	Percent Absorption
23CL11	Nebo Hill	Late Archaic	Plant fiber	Pocket	22 ± 5
1LU59	Wheeler	Late Archaic	Plant fiber	Channel	15 ± 5
23PL72	Kansas City Hopewell	Middle Woodland	Sand	None	12 ± 3
23PL106	Kansas City Hopewell	Middle Woodland	Sand	None	10 ± 3
34WG8	Cooper Havana	Middle Woodland	Sand	None	13 ± 3
34WG8	Neosho Plain	Mississippian	Leached shell	Pocket	54 ± 14
34MC244	Indeterminate	Mississippian	Leached shell	Pocket	20 ± 5

[a] (n = 10 for all wares.)

of liquid contents. However, the long, continuous, filamentary fibers illustrated in photographs of southeastern fiber-tempered wares such as Orange Plain (Bullen 1972:Figure 10-l, m, n), Norwood Plain (Phelps 1965:Figure 2), Stallings Plain (Stoltman 1972b:Figure 15a), and the Wheeler series sherd illustrated here (Figure 5a) do appear to provide the potential channel continuity desirable in water pots. This would not preclude use of permeable vessels as cooking pots, since food particles would seal off such narrow channels fairly quickly.

Residual Porosity. The residual porosity of the Nebo Hill sherds was estimated by an absorption test on a sample of 10 specimens. This involved measuring their dry weight to the nearest .1 g on an electric balance, boiling them for 60 minutes in tapwater, then measuring their wet weight. The percent of absorbed water is equal to

$$\frac{\text{Final weight} - \text{Original weight}}{\text{Original weight}} \times 100$$

Recommended boiling lengths vary considerably in the ceramic science literature, ranging from five minutes followed by slow cooling before re-weighing (Hamer 1975:230), to immediate re-weighing after two to five hours of boiling (Brody 1979:10; Lawrence 1972:45). The one-hour interval used here was chosen because of the small size of the individual specimens, and to minimize damage to the sample remaining after thin sectioning.

Six unrelated samples of prehistoric midwestern pottery were tested under the same controls to provide comparative data. Each sample consisted of ten sherds of the same temper ware. These include the fiber-tempered Wheeler series from site 1LU59, a Late Archaic shellmound in northwestern Alabama; two samples of sand-tempered Middle Woodland sherds from the Kansas City Hopewell components at 23PL72 and 23PL106 in Kansas City; a Middle Woodland (Cooper Havana) sample of sand/grit-tempered sherds from site 34WG8 in northeastern Oklahoma; and two samples of badly leached, formerly shell-tempered sherds from Mississippian (Caddoan) components in eastern Oklahoma (Table 2).

The data in Table 2 indicate that the pocket-pored Nebo Hill sherds, tempered with short, chopped fibers, are significantly more absorptive than the contemporaneous channel-pored Wheeler series sherds, which are tempered with longer, continuous fibers resembling those identified as palmetto in the literature. It is emphasized that what is being measured here is residual porosity, or the absorption capability of old pot fragments, not true porosity in the fabric volume of functioning vessels, which may range up to 10–15% for earthenwares fired to 1,150°C (Chandler 1967:97). The figures presented here refer to remnant performance (Braun 1983:112) on the porosity variable, and are of interest primarily for the insight they provide into sherd survival probabilities rather than vessel performance.

Nevertheless, modern ceramists describe functional earthenwares as having absorption values of

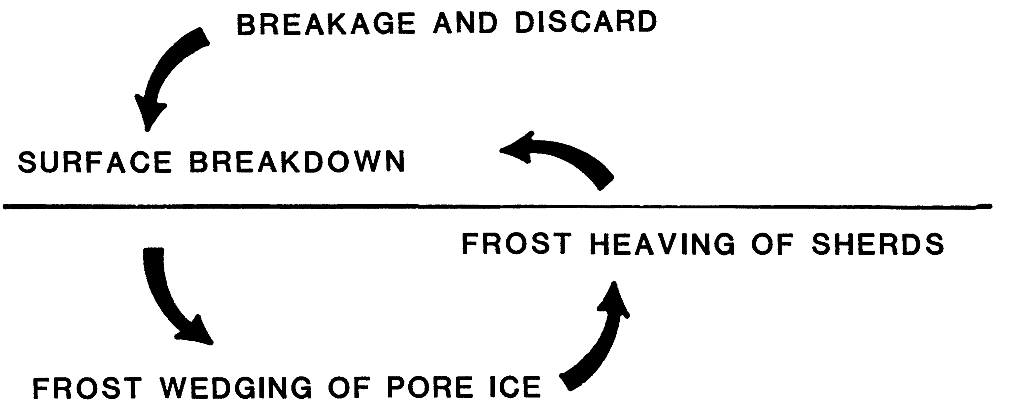

Figure 6. Model of taphonomic processes operating on shallowly-buried assemblages of fiber-tempered pottery in the middle-latitude lowlands.

6–8% (Rado 1969:189) and as weak and fragile if absorption is greater than 10% (Brody 1979:10). If it is assumed that the samples described here are broadly representative of general trends in midwestern ceramic development, these figures suggest that sand- and grit-tempered Kansas City Hopewell and Cooper Havana vessels of the Middle Woodland period were measurably more robust than their Late Archaic predecessors.

A second conclusion suggested by these comparisons is that Late Archaic fiber-tempered sherds with pocket porosity patterns are susceptible to the same weathering processes that affect shell-tempered sherds once the calcium carbonate has been leached out by chemical solution. It is widely recognized that the leaching out of shell, caliche, bone, and other calcium carbonate temper particles weakens the mechanical strength of sherds and increases the surface area available to further chemical weathering. This process is thought to bias the recovered sample of many ceramic assemblages in eastern North America after about A.D. 800 when shell-tempering became increasingly popular (e.g., Slovacek 1968:150). Post-depositional processes affecting the burial and preservation of fiber-tempered potsherds are considered in more detail in the following section.

Sherd Taphonomy

Ceramic density at Nebo Hill was approximately one specimen per 1.5 m^3 of trowel-excavated sediments. The low density and small size of the sherds, combined with the absence of refits and the abraded condition of many breakage surfaces, all indicate that the sample has experienced considerable post-depositional attrition. Thus the size and condition of the sample should not be translated directly into behavioral hypotheses concerning the significance of pots to Nebo Hill hunter-gatherers. In examining small ceramic samples, we should recognize that a little bit of pot is like a little bit of pregnancy; "any excavated sherd represents a successful combination of materials and techniques . . . unsuccessful experiments leave no archaeological record" (Rye 1976:135).

For the present we may assume that Nebo Hill pots were made to be used, probably as cooking vessels rather than water pots, and that the scarcity of their remains reflects primarily the processes that formed the archaeological record, and only secondarily the behavior of their makers. Identification of the more salient assemblage formation processes is critical to an understanding of how representative or anomalous the Nebo Hill pots are in the wider context of Late Archaic hunter-gatherer adaptations in the riverine midwest.

It is proposed here that the surviving sherd sample reflects the long-term operation of three interrelated processes. These are (1) the surface breakdown of an initial set of larger fragments into a larger set of smaller fragments, (2) the frost wedging of pore ice formed within fiber impressions; and (3) the frost heaving of buried sherds from frozen ground, resulting in their eventual return to the surface, where they undergo further breakdown, eventual re-burial, and so on (Figure 6).

Surface Breakdown. Once a pot breaks, unless the pieces are placed immediately in a protected context such as a trash pit, they will be further reduced as people and animals step on them. Over time, the sample will achieve a relatively uniform size distribution as the initial set of large fragments is reduced to a larger number of smaller ones (Kirkby and Kirkby 1976:237–238). Eventually, such a sample of similarly-sized sherds will decrease in number as individual fragments are reduced to their constituent particles. This natural breakdown process may have been accelerated by the purposeful recycling of potsherds into grog temper particles, either by the Nebo Hill potters or by later collectors. The systematic collection of potsherds for temper is well documented among contemporary primitive potters (DeBoer and Lathrap 1979:111; Rogers 1936:30–31), and it may be assumed that over long periods of time sherd recycling becomes a significant component of the surface breakdown process.

Eventually, however, processes other than treadage and cultural recycling will assume breakage priority. The precise nature of these processes will depend on both the technology of manufacture of the ceramics in question, and on local environmental conditions. For fiber-tempered pots, the relevant variables are identified as porosity, moisture, temperature, and time. The high porosity of the grass- and sedge-tempered Nebo Hill sherds is critical to the estimation of their survival probabilities in the temperate midwest because of their susceptibility to absorption of groundwater and to freezing.

Frost Action. Among periglacial environments characterized by intense seasonal frost action, the Nebo Hill region of the lower Missouri basin is part of the zone classified as middle-latitude lowlands. This zone is defined as having an average temperature in the coldest month of less than −3°C, but having more than four months with an average temperature of greater than +10°C (Washburn 1980:7). The middle latitude lowlands are located between approximately 35° and 60° north latitude, and are bordered on the south by the subtropical lowlands, where frost action is marginally active, and on the north by the subpolar lowlands, where frost action is increasingly important.

Periglacial processes that are variably active north of about 35° latitude include frost wedging, frost heaving or upfreezing, frost thrusting, frost cracking, frost sorting, and mass wasting. The dynamics of these processes are thoroughly reviewed from a geomorphological perspective by Washburn (1980), and archaeologists have been made increasingly aware of the potential influences of frost heaving or upfreezing on the contents of shallowly buried sites through the experiments of Johnson and his colleagues (Johnson and Hansen 1974; Johnson et al. 1977; Wood and Johnson 1978). For example, field and experimental studies have demonstrated the frost-induced vertical movement of buried specimens from the edgewise orientation of tabular rocks (Washburn 1980: 81–82), and from the oblique orientation of cylindrical wooden dowels (Johnson and Hansen 1974: 91).

At Nebo Hill the entire cultural assemblage was contained within the zone of maximum frost penetration, which has a depth of approximately 90 cm in the Kansas City region (Washburn 1980: 20). Orientations characteristic of frost heaving were common among the stone artifacts. Pieces of fire-cracked rock often had an edgewise rather than a planar orientation. A quartzite anvil weighing 15.2 kg was similarly positioned on edge rather than on the flat plane opposite the working surface. Long, narrow Nebo Hill lanceolate projectile points with robustly biconvex, dowel-like cross-sections were encountered below the plowzone at angles ranging up to 85° with respect to the present ground surface. These positions are suggestive of considerable vertical disturbance within the excavation space. Additional evidence includes refitted pieces of the same bifaces, vertically separated by as much as 17 cm.

Among lithics, frost heaving primarily disturbs the spatial rather than the formal integrity of artifacts. However, the same processes operating on mechanically weaker potsherds would significantly reduce and relocate a sample through time. Movement through the sediment matrix abrades sherd edges, as does contact with other buried objects, and the ultimate reintroduction of a buried sherd to the surface subjects it to further trampling and subaerial erosion processes.

Attrition from frost heaving can be assumed to have influenced all shallowly buried ceramic assemblages in the middle-latitude lowlands. The potential importance of this factor at Nebo Hill is emphasized only because of the relatively greater age of the sample. Thus, assuming that buried potsherds in the lower Missouri basin experience at least one freeze-thaw cycle per year, possibly an unrealistically low estimate, the 85 ceramic fragments from Nebo Hill have experienced at least 3,500 frost cycles, and the three specimens from the Turner-Casey site at least 4,500, compared with about 2,600 cycles for the earliest Woodland sherds in the Kansas City area.

However, probably the most important periglacial process affecting porous potsherds in the middle-latitude lowlands is frost wedging, or the prying apart of materials by the expansion of frozen porewater, sometimes accompanied by the directional growth of ice crystals (Washburn 1980:73). The pressure generated by the 9% expansion in volume of frozen water will eventually disintegrate a porous host material, whether rock or fired clay. Many low-fired and unglazed earthenware ceramics contain fissile planes through which groundwater can migrate from entrypoints at sherd fracture surfaces, as well as from surface or channel pores. The high pocket porosity and residual absorption capability of the Nebo Hill sherds suggest extreme vulnerability to seasonal freezing of absorbed porewater. The laminar or foliated fractures caused by the loss of one wall surface observed on 16 of 32 body sherds may reflect frost wedging from along internal planes of fissility or large fiber pockets. These fiber-tempered sherds appear significantly more vulnerable to ice damage than do the sand-tempered Middle Woodland sherds from the Kansas City region.

DISCUSSION

The pottery sample described here is small and nondescript, of interest primarily because of its spatio-temporal position and its manufacturing parallels with contemporaneous fiber-tempered wares in the southeast. Attention has focused on the technological implications of using chopped prairie tallgrasses and sedges to temper clay paste, and on the functional implications of the resulting high porosity in the fired fabric. It was suggested that tallgrass fibers have paste-bracing properties comparable, though not equivalent, to that of palms, for strengthening homogeneous clays with low sand or silt fractions. The pocket porosity resulting from the burning out of short and discontinuous plant segments can be argued more easily to be an adaptation to thermal shock resistance, than to be suited for enhancing permeability or the evaporative cooling of liquid contents. On these grounds, the Nebo Hill vessels are more appropriately identified as cooking pots than as water pots.

Questions concerning the adaptive significance and historical relationships of the Nebo Hill ceramics have not been explicitly addressed here. However, it should be noted that these sherds postdate the appearance of fired clay beads and small figurines recovered from components of the Munkers Creek phase in the Flint Hills of northeastern Kansas, where a rudimentary ceramic technology dates to the close of the Hypsithermal, about 5000 B.P. (Schmits 1978:123–214; Witty 1982:124–126). Possibly the ultimate origins of the Nebo Hill ceramics will be traced to these Archaic prairie foragers.

The contemporaneity of the Nebo Hill pots with the early tropical cultigens recovered from Phillips Spring (Chomko and Crawford 1978; Kay et al. 1980), 100 km to the south in the western Ozark highland, should also be noted. Although no direct evidence for plant food cultivation was recovered at either 23CL11 or any other excavated Nebo Hill component, the most immediate explanation for the absence of cultigens is the poor preservation of organic material in such shallowly buried sites. In addition, certain elements of Nebo Hill lithic technology are compatible with the hypothesis of a proto-horticultural economy. These include bifacial hoes, the fragment of a silica-polished knife that may have been used to harvest or process grasses for food and temper, edge-ground tools such as axes and celts and bifacial gouges suitable for clearing garden plots, and grinding and milling slabs. Many of these tools have close formal, and probably functional, parallels with artifacts from Phillips Spring. The tools hint at a wider regional pattern in the lower Missouri basin that will eventually reveal deeply buried Late Archaic sites that are both ceramic and horticultural.

Elsewhere in eastern North America, interpretations of initial ceramic complexes vary considerably from region to region. In the southeastern lowlands, the first fiber-tempered pots are commonly seen as incremental additions to a gradually expanding Late Archaic material culture, without major adaptive consequences in foraging economies (Caldwell 1958:15; Griffin 1967:180; Stoltman 1972b:

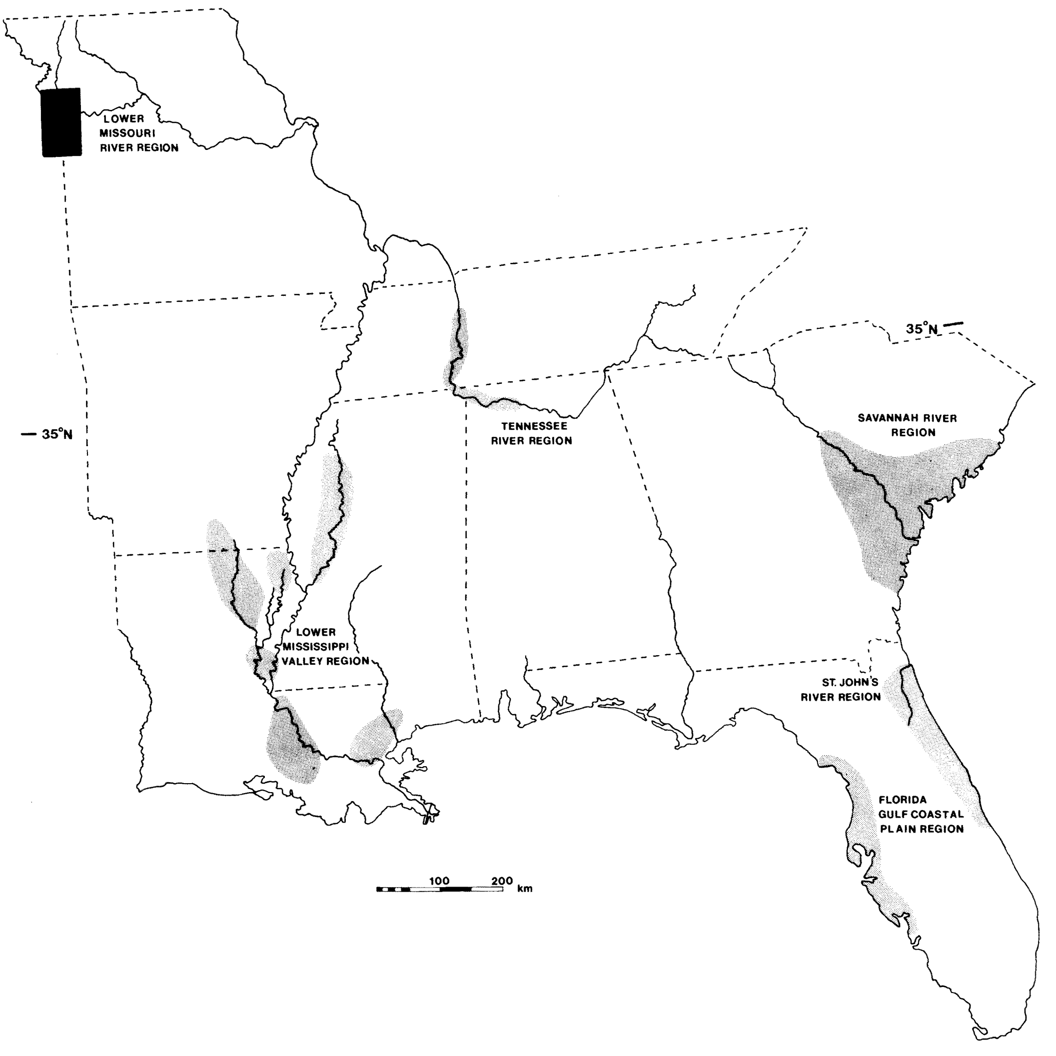

Figure 7. Distribution pattern of fiber-tempered pottery in eastern United States.

54). In contrast, in the riverine midwest, the grit-tempered Early Woodland wares that appear after about 1000 B.C. are often identified as a revolutionary advance in cooking technology with far-reaching nutritional, and ultimately demographic, implications (Dunnell 1972:68; Munson 1976: 9–10; Ozker 1977:100–113; see also Binford and Chasko [1976:138–139]; Braun [1983]).

Specifically, it has been suggested that ceramic vessels permitted the extraction and storage of oils from nut meat, significantly expanding the volume of Late Archaic food niches and contributing to the demographic growth and cultural elaboration of Early Woodland populations in the deciduous midwest after about 1000 B.C. (Keene 1981a:189; Ozker 1977). These are important hypotheses requiring continued careful analysis.

For example, while skepticism has been expressed concerning the adaptive advantages of Early Woodland ceramics over Late Archaic stone-boiling or rock-steaming techniques (Ford 1977:176–177; Keene 1981b:75), strong counterarguments can be made for increased time-efficiency, labor-efficiency, and land-efficiency (Jochim 1981:114–121) in subsistence activities conferred by culinary

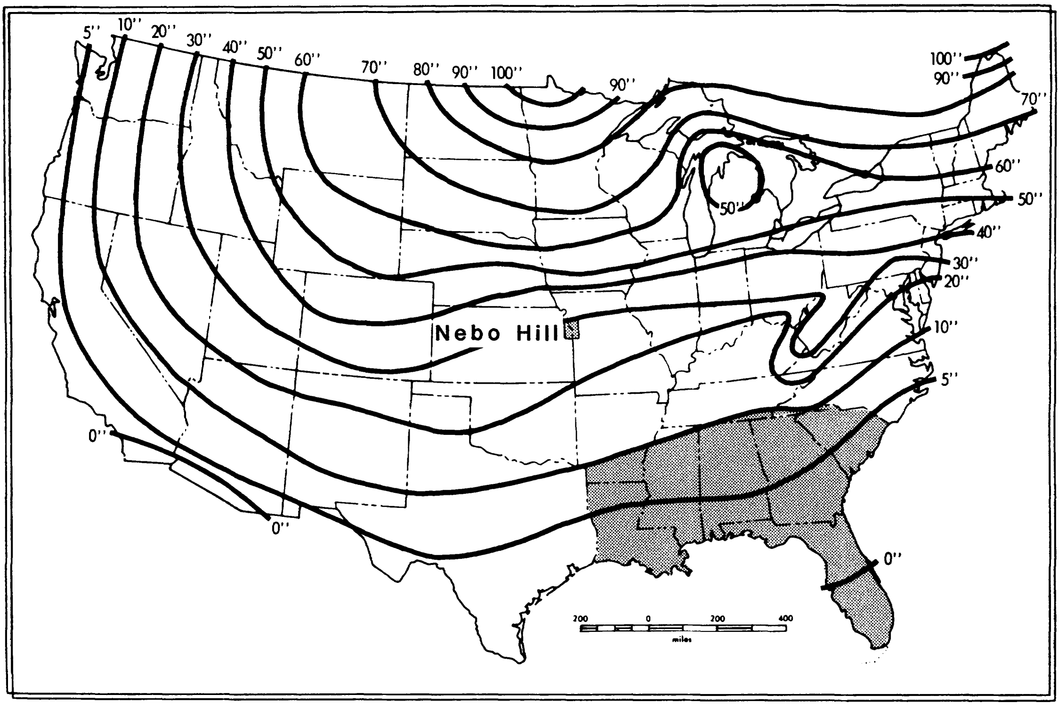

Figure 8. Maximum frost penetration isotherms in the United States (after Wood and Johnson 1978:336). Shaded area shows core area of fiber-tempered ceramic compexes concentrated below the 10″ (25 cm) maximum frost penetration line.

ceramics. Cooking pots permit a wider range of hard foods, such as seeds, nuts, and marrow-rich bone fragments to be heated for longer periods with less effort than stone-boiling in lined pits or baskets, and the nutritional value of the soups, broths, and gruels cooked in impermeable containers is greater than that of the same food units steamed in rock hearths or earth ovens.

Softer, more liquified foods could permit earlier weaning of infants and reduced birth-spacing intervals, and relaxation of these constraints on population growth might be rapidly expressed in larger domestic labor forces (Binford and Chasko 1976:138–139). Softer foods might also prolong the lives of older members of the community, thereby increasing the total amount of information and collective life-experience available to it. These consequences are potentially adaptive at the level of group selection, and it can be hypothesized that populations equipped with cooking vessels would have a measurable competitive reproductive advantage over groups not so equipped. At the level of individual selection, improvements in cooking technology have been linked to the organismically adaptive advantages associated with reduced tooth size and more efficient "somatic energy budgets" among Upper Paleolithic and Mesolithic populations in Europe (Frayer 1978:127–134). Similar trends may await documentation for Late Archaic or Early Woodland populations in the midwest.

These arguments refer to the behavioral processes involved in the "ceramicization" of Late Archaic cultures in the midwest. As such they are peripheral to the main point of this paper, which was prompted by the archaeological record of these processes. The most immediate significance of the Nebo Hill ceramics is their spatio-temporal position and their few surviving traces. These are related phenomena.

The position of the Nebo Hill pottery on the eastern edge of the Great Plains between 2600–1600 B.C. argues for a sharp inflection of the diffusion slope linking the southeast and midwest. In many ways the apparent contemporaneity of the Nebo Hill ware with the earliest Savannah River ceramics is unsurprising. Abundant evidence now exists documenting widespread communication of ideas and exchange of goods throughout eastern North America during the Late Archaic period (Cook 1976; Kay et al. 1980; Simms 1979; Stoltman 1978; Walthall 1981; Webb 1977; Winters 1968). In this context of rapid information flow along both the Atlantic and Gulf coastal plain and the riverine interior, the hypothesis that the practice of making fired clay pots took 1,500 years to diffuse over distances of less than 1,000 km raises as many questions as it answers.

Perhaps a more realistic approach is to assume that knowledge of fiber-tempered pottery diffused very rapidly from some unknown point of origin prior to 2600 B.C., was variably incorporated into certain receptive technologies where it was modified according to local cultural and environmental constraints, and was then variably subtracted from the archaeological record along a north-south gradient of active periglacial processes. If we look at the distribution of porous, fiber-tempered potsherds from a taphonomic rather than a cultural perspective, then the clustering of these wares below 35° north latitude (the approximate southern limit of the middle-latitude lowlands) (Figure 7) and their concentration south of the 10″ (25 cm) isotherm of maximum frost penetration mapped in Figure 8, appears more an artifact of preservation than one of cultural networking.

CONCLUSION

It is estimated that the permanent or seasonal conversion of water to ice plays a predominant role in shaping the geomorphology of 25% of the earth's land surface (Tricart 1970:xii). The comminution of friable and porous objects such as potsherds by frost action and cryoturbation is a potentially critical agency of mechanical destruction in shallow deposits, with many implications for the cultural interpretation of spatial patterns over both temperate latitudinal and altitudinal gradients. Broadly speaking, these processes should be most influential north of 35° latitude, and in frost-susceptible highlands below this latitude. Each particular site situation will be further influenced by specific local variables such as cold air drainage, aspect, and other microclimatic phenomena, and by the depth and rapidity of burial and the physical and chemical structure of the sherd-enclosing matrix. Careful field and experimental investigations into these and other agencies of ceramic attrition should lead to a fascinating reappraisal of Late Archaic cultural dynamics in interior eastern North America.

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