XIV. SPATIAL ANALYSIS

Plow Zone Studies

Like many prehistoric archaeological sites in northern Delaware, the Lums Pond site lay in an agricultural field. Much of the archaeological material comprising the site had been disturbed by repeated plowing. Shallow, plow zone sites have often been ignored in archaeological research, dismissed out-of-hand based on a perceived lack of information potential (Custer 1987). As a result, few such resources have undergone intensive archaeological investigation. Nonetheless, an increasing amount of archaeological literature in recent years has addressed the analytical potential of artifact distributions recovered from plow zone deposits. This research has included empirical and experimental investigations, the construction of theoretical models of artifact dispersal, and the presentation of various statistical methods for evaluating these models and, by extension, the archaeological record they describe. While the detailed results of these investigations have varied, the common conclusion reached has been that important archaeological data do remain in plowed contexts.

Previous Research in Plow Zone Archaeology

Many early investigations into the research potential of plow zone sites were empirical in nature, based on observations of the conditions of existing archaeological sites in agricultural fields (Talmage and Chesler 1977). For example, in-depth documentation was carried out of the destructive aspects of agricultural practices in northeastern Arkansas (Medford 1972), where along with deep plowing, grading has been commonplace as a means of erosion control. At Hatchery West, in southern Illinois, Binford and others (1966, 1970) demonstrated the use of surface distributions in plowed contexts as guides in the discovery of subsurface artifact concentrations and subsoil features at a site with discrete, non-overlapping activity areas. Redman and Watson (1970) found a similar degree of association between surface and subsurface artifact distributions at Cayönü, a tell site in southeastern Turkey which had been cultivated for many years, though with non-mechanized equipment. The potential for sub-plow zone features at Lums Pond provided an opportunity to assess the correlation in a typical Coastal Plain context in the Middle Atlantic.

Studies involving repeated surface collections of plow-disturbed sites have indicated that a degree of stability in artifact distributions may be maintained over time, although the appropriate scale of observation appears dependent on a variety of conditions. Robertson (1976) noted gross similarities in patterning between successive collections at the Newton Neck site, located in an active agricultural field in southern Maryland. She suggested that while detailed artifact distribution patterns were seriously disrupted by plowing, in a phenomenon referred to by Tolstoy and Fish (1975) as the merge effect, general artifact clusters were likely to remain distinguishable. At the Claud I site, located in the Genessee Valley of New York, Trubowitz (1978) observed no significant changes in artifact distribution due to plowing over the course of three years. The field had been cultivated for an unknown number of years prior to the study, suggesting that a measure of stability had been reached in the amount of lateral displacement of the archaeological material. Ammerman and Feldman (1978) noted similar correlations between multiple collections at Neolithic sites in southern Italy.

Experimental work has provided initial estimates of the relative amount of disturbance which may be expected from repeated tillage. Robertson's work at Newton Neck included seeding a field with 18 brick halves prior to plowing and controlled surface collection. Nine of the control pieces were relocated, exhibiting a mean displacement of 2.7 meters, and a maximum of 6.7 meters (Robertson 1976:45). Trubowitz simulated an artifact assemblage at Claud I using 746 washers, 148 ceramic tiles, and 5 bricks. After three plowings over a period of 18 months, 2 bricks, 2 washers, and 29 tiles were recovered. The mean displacement of the materials was reported as 1.6 meters, the maximum 9.6 meters (Trubowitz 1978:61-62).

Later experimental work has sought to further define the limits of artifact movement within plowed contexts, both vertically and horizontally, as well as to determine the effects of variation in artifact dimensions on that movement. Several studies have estimated that from 5 to 10 percent of the material within a plow zone will be represented on its surface (Lewarch and O'Brien 1981; Ammerman 1985; Odell and Cowan 1987). The degree of vertical movement within the plow zone has been found to be dependent in part on artifact size. Working initially with archaeological data from a series of sites in Arkansas, Baker and Schiffer (1975) reported what they referred to as the size-effect, suggesting that large artifacts tend to rise to the surface more readily than small artifacts. They noted that this phenomenon may lead to an over-representation of large material in a surface-collected assemblage, a circumstance observed earlier by Redman and Watson (1970). Ammerman and Feldman (1978) made the similar observation that a surface assemblage may not represent a truly random sample of the material in the plow zone. Focusing mainly on varying surface visibility conditions, they noted that the probability of an artifact being recovered was directly related to its size. Experimental work by Lewarch and O'Brien (1981:18-20) found statistical evidence that a maximum dimension of 1/4 inch (6 mm) may serve as a threshold between large and small artifacts (the cut-off point was based on the size-grade intervals chosen for their experiment). While noting that large artifacts were in fact recovered more frequently than small artifacts, they indicated that the difference in recovery rates tended to decrease in proportion to the length of time the field is tilled, citing the mechanics of soil inversion by the plowshare and differential incorporation of objects into the sediments based on size as the forces regulating the rate of recovery. Odell and Cowan (1987) reported a similar finding, using weight as an indicator of artifact size. In contrast, Stevenson (1980) presented statistical evidence that lighter, smaller artifacts tend to occur higher in a plow zone deposit. Using observations from archaeological contexts in central Pennsylvania, he cited a critical size range—less than 12-13 millimeters in length and 0.25-0.35 grams in weight—below which artifacts may "selectively accumulate in the upper 10 cm. of the plow zone" (Stevenson 1980:102).

In terms of horizontal redistribution, it is generally accepted that small artifacts are less likely to be translocated than large artifacts, and when they are, the distance moved will be less. Lewarch and O'Brien (1981) determined that, after repeated plowing, the average lateral displacement of artifacts was approximately 1 meter. Implied in this finding is the assumption that plowing has occurred with equal frequency in opposite directions, creating an equilibrium effect similar to that seen in Trubowitz's New York study. Odell and Cowan (1987) noted a comparable state of balance after an initial period of artifact movement, but observed larger mean displacement values, ranging to 3 meters. They further noted that the extent of their experimentally constructed site had roughly doubled after nine plowings, after which spreading of the distribution began to level off (Odell and Cowan 1987:468). Their recognition of an apparent equilibrium state was based on the stabilization of the curve of cumulative mean displacement of artifacts over time. Reliance on cumulative averages has been questioned as the most appropriate method of documenting relative increase (Yorston 1990). Dunnell (1990), on the other hand, has indicated that while a state of equilibrium may indeed be reached, the rate at which this occurs may be variable, influenced by both the mechanism and the unit of transport; i.e., the characteristics of the tillage equipment and the relationship between artifact size and sediment attributes.

In general, then, the tone of the foregoing studies is optimistic as to the research value represented by plow-disturbed sites. Rejecting such sites as lacking information potential risks the loss of a large and widespread database. Despite cautionary notes that continue to appear (Shott 1995), analysis of archaeological data contained in plowed deposits can, within certain analytical limits, provide useful and important information about prehistoric activity.

Data Collection Procedures at Lums Pond

The data recovery investigations at Lums Pond were aimed at assessing horizontal provenience data in some detail using a computer modeling study. Artifact distributions were analyzed to identify distinct spatial elements signifying activity area patterning or the location of sub-plow zone features. The data used in this analysis were gathered during Stage 1 sampling of Areas 1, 2, and 3 as defined in Phase II testing. The sampling strategy used in the study was selected on the basis of the character of the site and the previous work carried out there. Generally speaking, three types of sample are used in survey and testing operations: judgemental, random, or systematic. Since little was known in detail about site structure at Lums Pond, judgemental sampling was an inappropriate procedure. This in fact points up what has been referred to in theoretical literature as the "sampling paradox" (Roper 1979:9). That is, to construct an efficient, representative sample from a population, some knowledge of the parameters of the population is necessary, although estimating those parameters is the very goal of the sampling procedure.

As an alternative to judgemental sampling, random sampling requires little or no prior knowledge of the site (Redman 1975:150). Yet in practice, completely random sampling may result in gaps in coverage. In wide-area sampling, as was conducted at Lums Pond, a measure of spatial regularity is important, and thus some degree of systematics is needed to ensure that all parts of the site will be included in the sample (Shennan 1988:325). At Lums Pond, aspects of each of the sampling strategies were combined in a form of stratified random sampling, in which the site was divided into subsets, or stratified, and each subset sampled randomly. This method, while in essence random, maintains relatively uniform coverage of the entire site area, avoiding excessive clustering of sample points or the development of wide gaps between points (Binford 1964; Judge et al. 1975:87). A refinement of this method, stratified systematic *unaligned* sampling, has been used on sites in northern Delaware (Custer 1992). This variation is most appropriate in situations in which there is periodicity expected in the data, such as house patterns on historic period sites, which could skew the analysis (Plog 1976:140). Since the distributions at Lums Pond were assumed to be non-periodical, the unaligned variation of the random sample was not considered necessary.

It should be noted that most of the plow zone studies discussed in the preceding introduction are based on the examination of the distribution of artifacts across the entire surface of the site—what the plow brings to the surface. In contrast, the Lums Pond study used 1-meter-square columns excavated through the plow-disturbed layer. This produces a different horizontal scale or resolution, as well as a different vertical scale. Horizontally, the sample is smaller—only one square-meter in 25 is examined, yet all of the material in that location is recovered, not merely what lies on the surface, and thus vertically the sample is larger.

In terms of the size of the sample fraction used in the analysis, theoretical factors as well as practical considerations of time and expense were taken into account. Custer's (1992) recent simulation study of sample size variation from plow zone contexts indicated that within a systematically stratified sampling design such as was proposed for use at Lums Pond, excavation of a sample fraction greater than 20-to-25-percent can be expected to provide redundant information. The study was based on work at a historic period site containing several large and relatively well-defined structural features and a large number of artifacts. Other simulation studies, from historic period as well as prehistoric sites, have suggested sample fractions ranging from 10-to-15-percent as appropriate (e.g., Ammerman et al. 1978:128,130). In the end, the optimum size of a sample can be expected to be variable, depending on the nature of the resource (whether artifacts, features, etc.), their availability, and the type of research questions addressed (Redman 1975:151).

In the present case data collection was staged. A 5-percent sample of each area was selected as an initial sample fraction, to be augmented to 10-percent if analysis of the original sample were to indicate that a larger fraction would provide a qualitative change in the data. Stage 1 of the Phase III investigations consisted of stratified random sampling. Areas 1 and 2 were gridded into 5-x-5-meter squares and Area 3 into 4-x-5-meter squares, the latter to maximize the number of sampling units within the oblong shape of the artifact distribution in that part of the site. The grid coordinates for a single 1-x-1-meter unit were chosen from each square using a random number table. In each of the three areas, Stage 1 investigations comprising a 5-percent sample of the area were sufficient to locate the areas of intensive activity.

An additional 5-percent of each area was examined in Stage 2 using block excavations in the occupation areas. The block excavations represented a shift in the focus of the investigation from testing to data recovery. The initial samples resulting from Stage 1 operations were probabilistic in nature, used to extrapolate the spatial distribution of cultural material across the site areas. In contrast, the block units were no longer representative of the site viewed as a statistical population. These units comprised a qualitative, non-typical portion of the site, and so represented a selective or judgmental sample that contained the highest proportion of the specifically behavioral data sought in the investigation (Asch 1975:181,186).

Mapping and Cluster Analysis

Analysis of artifact distributions at Lums Pond was accomplished using commercially available software that generates topographic plans from grid-based data. The software was originally designed to produce topographic maps diagramming the physiographic features of a landscape. It has subsequently been adopted by other disciplines including archaeology, often in the latter case to perform a type of cluster analysis resulting in plans of horizontal artifact frequency. The isopleths, or lines connecting areas of equal magnitude (in this case artifact frequency), are determined by one of a series of interpolation algorithms which estimate the distribution of material at a given point by examining the arrangement of the surrounding data.

Spatial interpolation was conducted using a method referred to as kriging, a set of algorithms originally designed for forecasting and mapping mineral deposits. More conventional nearest-neighbor techniques such as inverse distance calculation, which presumes that the influence of surrounding data points on each individual point lessens on a regular basis with distance, tend in practice to isolate grid squares, producing more seemingly discrete concentrations than were probably present in the data. Kriging involves the use of regionalized variables that change according to location, though not in a manner that can be described by a fixed mathematical function. Rather, the interpolation is accomplished using moving averages and the estimation of error associated with variable distributions (Zubrow and Harbaugh 1978). The result is a more appealing and perhaps realistic representation of the distribution. This appraisal of mapping algorithms is admittedly based to a large extent on *a priori* assumptions of the proper configurations of the distribution maps. This is not an appropriate forum for a critique of the mathematics involved in the procedures.

The bull's-eye effect that is seen on a number of the maps resulting from the analyses is due to several factors. In many cases the recurrence of the pattern resulted from individual proveniences with high counts relative to their surrounding neighbors. The degree to which the arbitrary division of the data into analytical units may have contributed to this effect — whether the size and placement of the grid produced the observed patterns — was examined in some detail. It was clear from the outset that the resolution of the data would indeed dictate to some extent the shape of the distribution plots (Ebert 1992:174). The analytical units were recombined in several ways and the resulting plots examined for changes in artifact clustering. The basic analytical unit in the archaeological analysis was a one-meter-square, and could not be broken down further (and probably should not be, considering the amount of blending of the original spatial distribution that is assumed based on the knowledge that the artifacts are contained in a plow zone). Combining the data into 2-x-2m grid squares produced smoother looking contours, but the same general areas of concentration remained visible. Likewise, pairwise combinations producing 1-x-2m and 2-x-1m units did not mask the overall pattern of distribution seen in the original grid. Shifting the grid origin altered the pattern somewhat, but the main clusters remained in place. It seem s likely, then, that the patterns observed as a result of the analysis are inherent in the distributions, not an artifice of the recovery techniques (grid-based collection) or analytical scale (the size of the grid squares).

Area 1

Cluster analysis of Phase II shovel test data, illustrated in an isopleth map in Figure 111, identified Area 1 as an area of discrete activity containing at least two main artifact concentrations. Four test units, designated Units 1, 23, 24, 25, were excavated in Area 1 to further define the character of the artifacts and their distribution. All artifacts in Area 1 were contained solely within the plow zone. A relatively high incidence of Iron Hill jasper was documented in comparison with other parts of the site, suggesting the presence of a discrete occupation or work area. The only chronologically diagnostic artifact recovered in this phase of testing was a single sherd of aboriginal ceramic that was too fragmentary to be typed confidently. There were no indications of subsoil features.

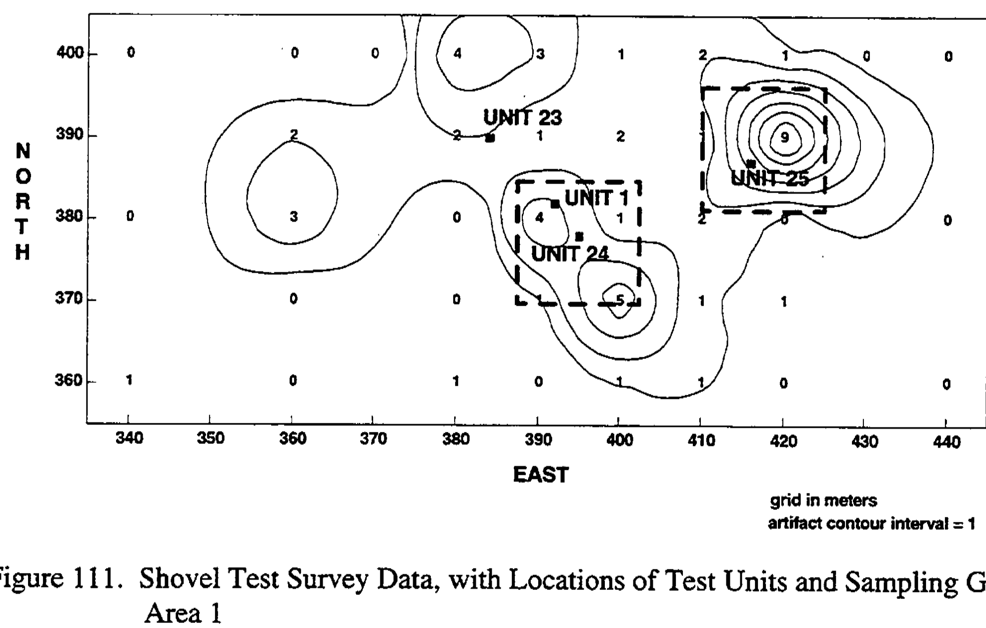

Figure 111. Shovel Test Survey Data, with Locations of Test Units and Sampling Grids, Area 1

For sampling purposes, two sub-areas measuring 225-square meters each were established corresponding to the artifact concentrations identified in the Phase II analysis (Figure 111). Sampling blocks measuring 15-meters-square were laid over each sub-area (Figure 112). The sampling blocks were divided into 5-meter squares from which the initial random sampling fraction was taken. Eighteen units, including three of the Phase II units, were excavated to provide data for the detailed spatial distribution analysis, the results of which are shown in Figure 112. The highest artifact frequencies, up to 48 artifacts per unit, occurred in the western block, particularly in the eastern half of that block. The high relative proportion of Iron Hill jasper among the artifacts that was recorded in the Phase II units was repeated. A stemmed projectile point made of Iron Hill jasper and dated to the early portion of the Woodland I period was also recovered from the western block.

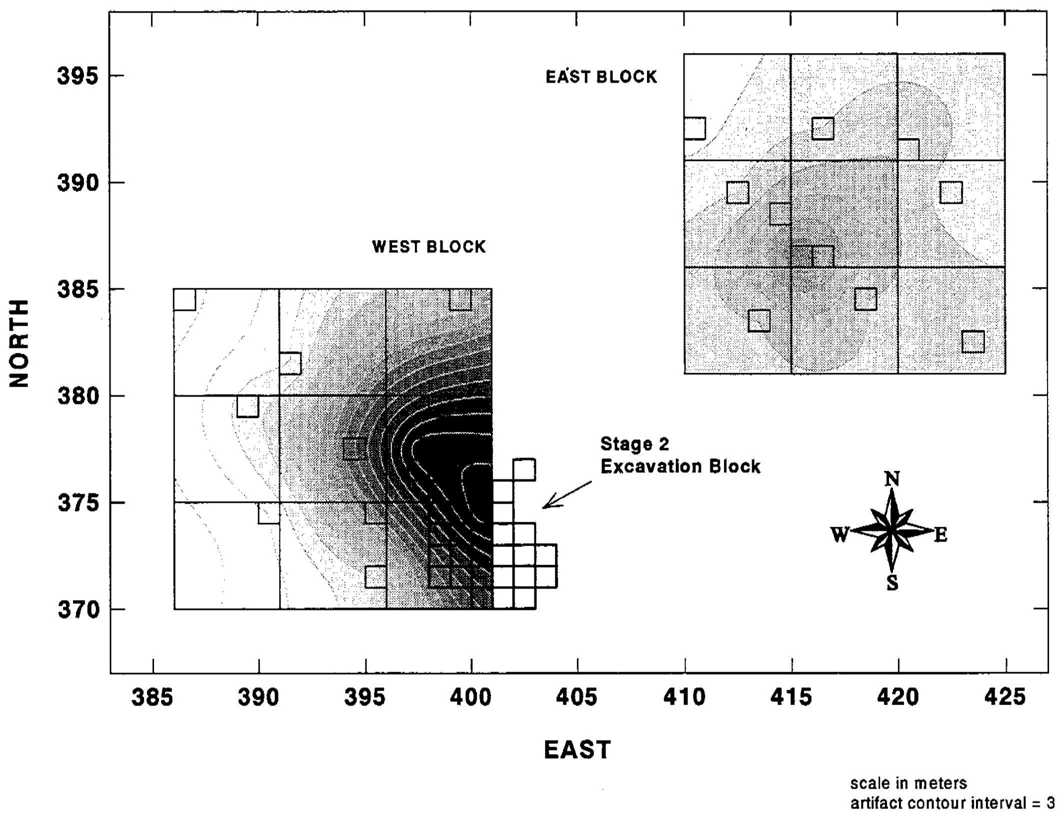

Figure 112. Results of Random Sampling, Area 1

Based on the results of the random sampling, seven additional units were excavated in selected locations to further refine the nature and limits of the artifact concentrations. Relatively high artifact counts, up to 41 per excavation, were recorded in the additional units placed in the western block. In contrast, high counts in the eastern block appeared restricted to a single unit, Unit 25 from Phase II, where no sustained pattern of distribution was observed in the surrounding excavations. Continuing the trend recorded in the Phase II excavations, all artifacts were recovered from the plow zone, and there was no evidence of subsoil features.

These findings suggested that the areas of most intensive prehistoric activity in Area 1 had been identified. To complete data recovery in this part of the Lums Pond site, a block excavation totaling 35 square meters (including Stage 1 units) was placed in the southeast corner of the western square (Figure 113). The initial analysis of spatial distributions in the excavation block was conducted using all of the artifacts, regardless of type or raw material. The results of the cluster analysis are shown in Figure 114. The pattern produced by the analysis is reducible to two main features, a widespread area of high artifact frequency in the lower right (southeast) half of the block, and a more scattered distribution in the upper left (northwest).

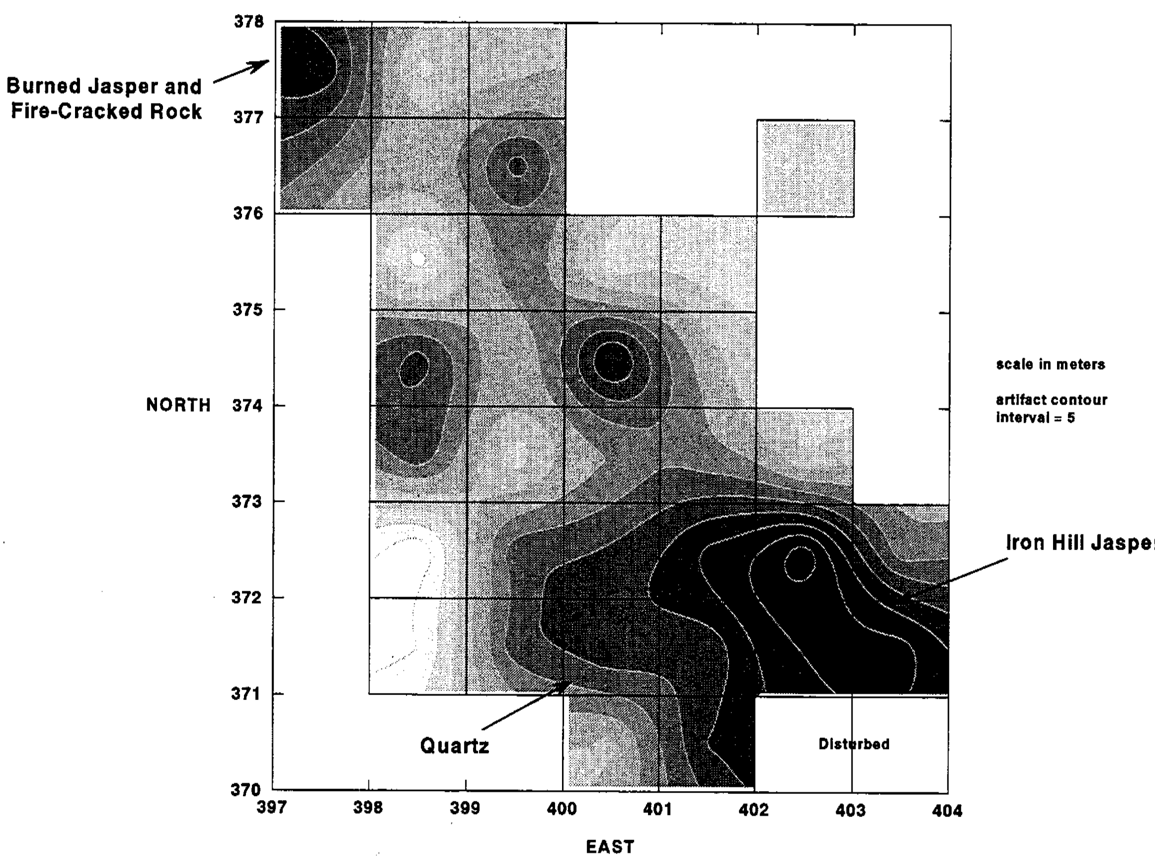

Figure 113. Artifact Distribution in Area 1 Excavation Block

In terms of the potential for activity area definition, the Area 1 artifact assemblage was contained solely within the plow zone, and therefore was assumed to be disturbed.

Nonetheless, the degree of artifact frequency variability observed among the units implied that the site had not been completely rearranged horizontally. Judging from artifact frequency fall-off at the edges of the block as well as from the overall pattern of distribution in Area 1 mapped during Stage 1, a large proportion of the artifacts from the area had been recovered. Artifact refit analysis discovered few refits. Those identified were either within provenience or across only one provenience line. The low number of refits could be interpreted as evidence of extensive disruption in which potentially refittable artifacts were removed from the block altogether Yet the relatively well-bounded artifact assemblage argued against such gross disturbance. Accepting this, the absence of inter-provenience refits argued further that relatively little horizontal movement had occurred, and that activity area definition would be possible.

A limited number of artifact types was recovered from Area 1, implying that the range of activities represented there was not great. Horizontal artifact patterning was interpreted in terms of repetitive knapping episodes. The uniformly greater frequency of material in the southeast half of the block suggested the presence of one or more knapping events, separated from what may have been an additional workshop area to the northwest. Iron Hill jasper debris was mapped separately. This material made up the largest proportion of chipped stone from the block, and its distribution was similar to the total artifact distribution. Minority raw material types were also plotted. Most provided sample sizes that were too small for meaningful analysis, but two variations were selected: quartz and all material assumed to have originated from pebble sources, including quartz, quartzite, chert, and non-local jasper (not derived from Iron Hill).

The distribution of quartz varied from that of Iron Hill jasper in the southeast half of the block, the greatest concentration being centered south and west of the main jasper concentration. There was in addition little evidence of a relative concentration of quartz in the northwest portion of the block. These data suggested separate reduction areas or, more likely, different reduction episodes for the raw material types. The distribution of pebble material was different from that of quartz, which was somewhat surprising since quartz accounted for over 65 percent of the material classed as pebble. The greatest concentration of pebble material lay in roughly the same location as Iron Hill jasper, again suggesting that quartz had been reduced separately, either spatially or during an earlier or later episode.

Heat treated or burned Iron Hill jasper showed a slightly different distribution from that of unburned material. While unburned Iron Hill jasper was concentrated in the southeastern portion of the block, relative concentrations of burned jasper occurred to the east and north. The northern distribution correlated roughly with the occurrence of fire-cracked rock, which was mapped both by weight and by mean weight per fragment. Fire-cracked rock appeared to be distributed north of the main concentrations of unburned Iron Hill jasper. Burned pebble jasper was recovered in roughly the same locations as heat treated Iron Hill jasper, though none occurred in the northwest corner of the block excavation.

These findings suggested that separate work areas or different reduction episodes were present in Area 1. Iron Hill jasper, pebble cryptocrystalline material, and quartz appeared to have been worked in the southern part of the block. The quartz debris may have resulted from a separate knapping episode. A second work area was indicated by clusters of burned Iron Hill jasper and fire-cracked rock in the north of the block. The fire-cracked rock may have been the remains of a hearth used to bake the jasper. There was little evidence of either fire-related artifact to the south.

Area 2

Phase II shovel testing identified Area 2 as an area of discrete prehistoric activity, comprised of two general artifact concentrations as indicated on the isopleth map in Figure 114. Five test units were excavated to refine data as to the character of the artifact distributions in the area. A relatively high incidence of fire-cracked rock in several units suggested the potential for residential or domestic activities, or possibly some form of resource processing. While artifacts were contained largely within the plow zone, there was occasional evidence of sub-plow zone deposition as well as at least one subsoil feature, a large and deep pit feature encountered in Unit 22.

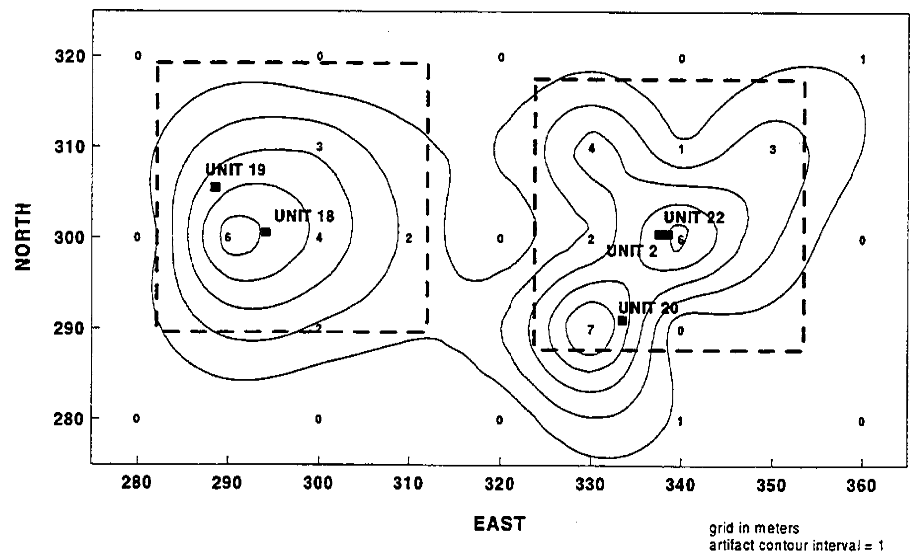

Figure 114. Shovel Test Survey Data, with Locations of Test Units and Sampling Grids, Area 2

Two sub-areas, each measuring 900 square-meters, were established corresponding to the artifact concentrations (Figure 115). Sampling blocks measuring 30-meters-square were laid out in each sub-area. The sampling blocks were divided into 5-meter squares from which the initial random sampling fraction was taken. Seventy-two units, including the Phase II units, were excavated to provide data for the detailed area spatial distribution analysis, the results of which are shown in Figure 115. An additional 18 units were excavated following the random sample in order to clarify distribution data in specific areas, bringing the total number of units to 90.

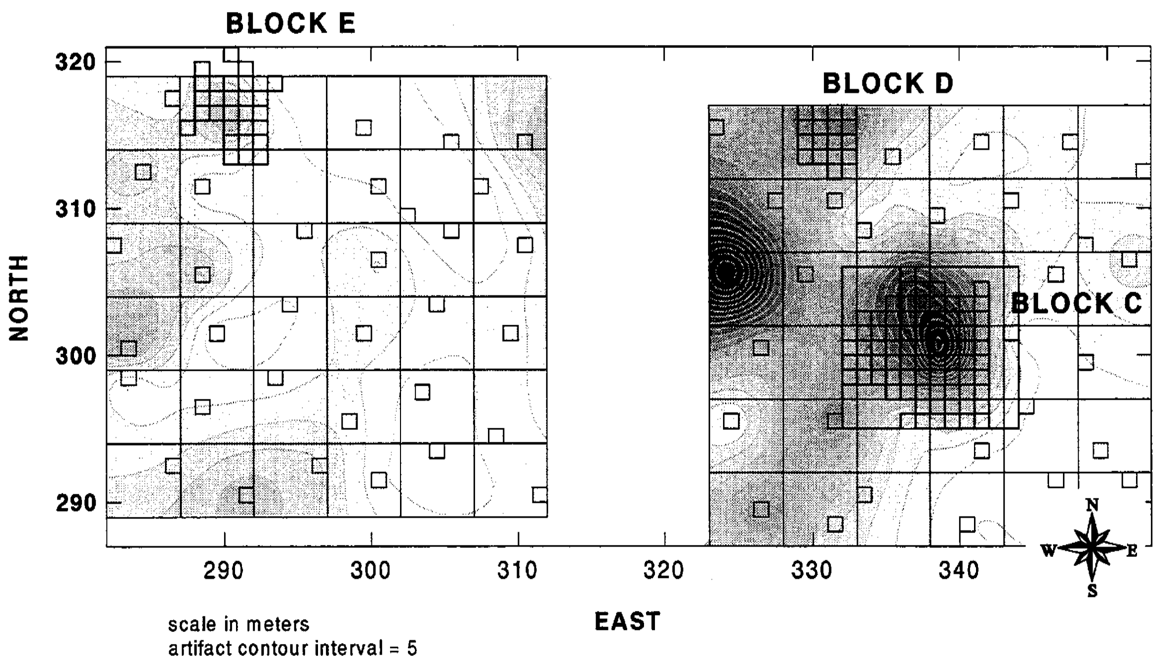

Figure 115. Results Random Sampling, Area 2

The distributions of fire-cracked rock and of most of the chipped stone raw materials represented in the artifact assemblages plotted out the same in the eastern half of the gird, where the majority of the artifacts were located. The two most intensive clusters lay in the eastern block, one near the center of the grid, at N301 E338-9 and another on the western edge at N306 E325. In both instances artifact counts were at or above 100 per meter-square. Analysis of the distribution between the two clusters suggested a regular fall-off in frequency. The plots of most individual artifact types and raw materials in the eastern block that displayed representative sample sizes showed little variation from the overall distribution. One of two plots which did not follow the general pattern was that of fire-cracked rock. Fire-cracked rock was almost absent at N316 E333, one of the units along the northern edge of Area 2 that yielded a high total artifact count. The other variation from the overall pattern of distribution in the eastern grid block was the almost complete absence of Iron Hill jasper from the high concentration of artifacts at the center of the grid.

Artifact distribution in the western block was more sporadic. Total counts were lower than in the eastern block, and there were few distinct artifact clusters observed. Counts were generally higher near the western edge of the gird. The low counts to the east coincided with a swale that appeared to be the filled-in channel of a spring or run-off stream, extending southeastward through Area 2. Artifact counts were low enough west of the swale that analysis of the distribution of individual raw material types was inconclusive. The only obvious pattern in the data was the virtual absence of Iron Hill jasper in the entire western sampling area.

The distribution of chronologically diagnostic artifacts was plotted to examine the potential for horizontal stratification within the surface deposits. A high frequency of occurrence of long-bladed, stemmed projectile points was noted in the general artifact analysis. These points were typically classified as Poplar Island/Lackawaxen or Bare Island points, both diagnostic of the early portion of the Woodland I period. A second point type, the Teardrop point, was also recovered in several proveniences. These points have been similarly cast as early Woodland I in date range. Their spatial overlap with the long-bladed, stemmed points suggested that the deposits in Area 2 were largely single component. Ceramic fragments and triangular points, the latter probably related to Woodland II use of the area, were also recovered. Yet these materials were few in number and were widely scattered, suggesting considerably less intensive or even incidental land use during later periods.

General artifact distributions and the distribution of fire-cracked rock were examined as potential indicators of feature presence. As a premise of the analysis, it was supposed that fire-cracked rock concentrations might represent either separate hearth features that had been disturbed by plowing but were essentially in place, or alternatively, material fed into the plow zone from underlying features thus revealing the general locations of features or feature clusters. Figures 116 and 117 show the results of several spatial analyses using data from plow zone proveniences in Area 2 overlaid on the actual feature distributions. Cluster analysis of the Stage 1 sample revealed a concentration of artifacts in the general area of Feature 10. Closer examination of the data from the excavation block associated with the feature (Block E) showed no correlation between the feature and the deposit above (Figure 116).

A similar situation was noted for the cluster of pit features in the eastern block, where analysis of the random sample indicated a concentration of artifacts in the general region of the feature cluster, while analysis at a higher resolution (Block C) showed no

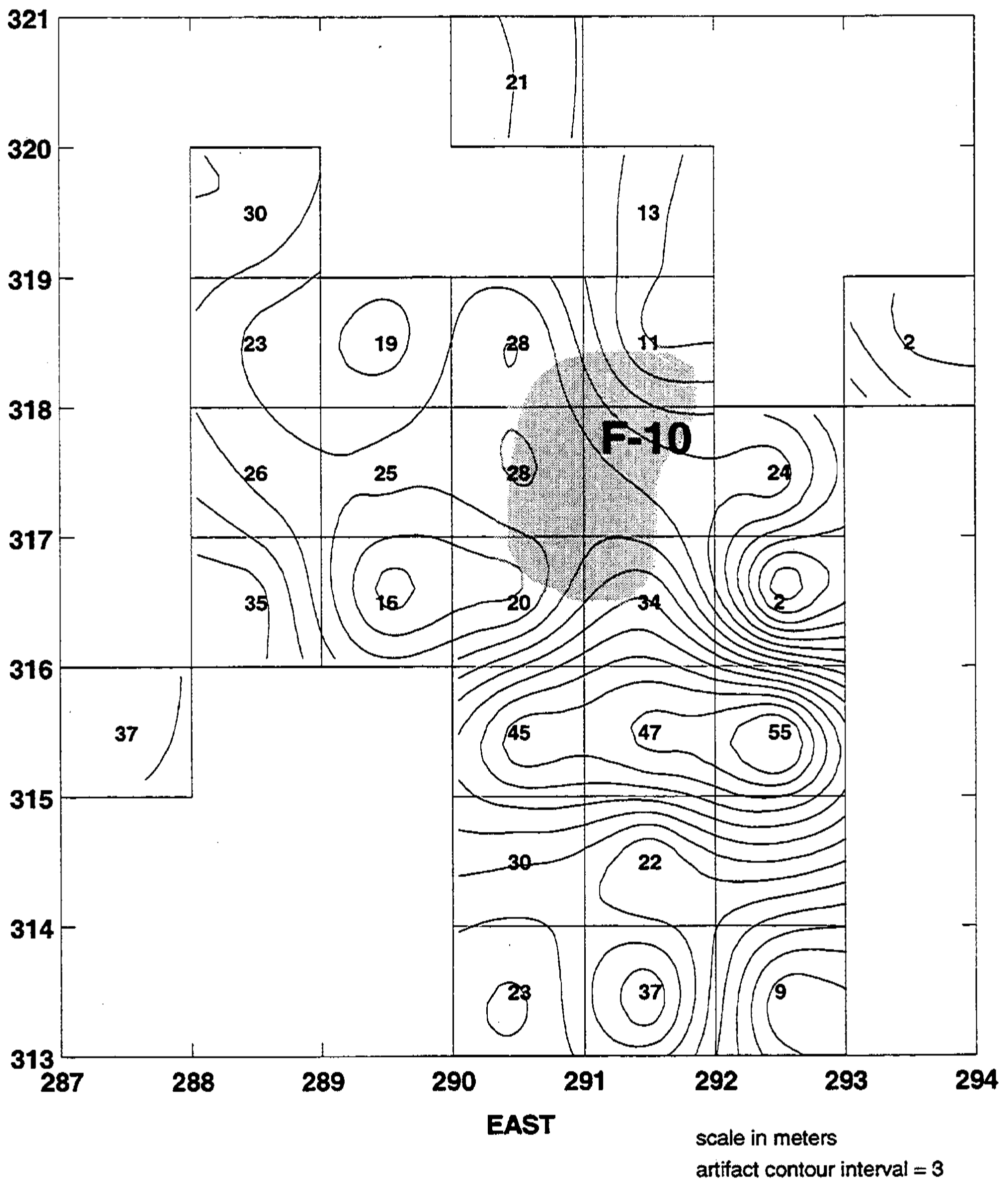

Figure 116. Comparison of Plow Zone Artifacts and Feature Location, Block E, Area 2

direct correlation (Figure 117). Note that a second, equally intensive artifact concentration occurred along one edge of the eastern block. Additional testing in that area revealed no associated features. That there was no one-to-one correspondence between the plow zone clusters and the underlying features was not surprising once the contents of the features were determined, since there was little artifactual material in the pits to be contributed to the plow zone distribution. The lone exception was the unit at N304 E337, directly over Feature 19. That unit yielded a high artifact count (n=80), and much of the material was fire-cracked rock (n=53). Feature 19 contained more fire-cracked rock than most of the pits in the cluster, and thus it may have been the source of some of the material occurring in the plow zone above.

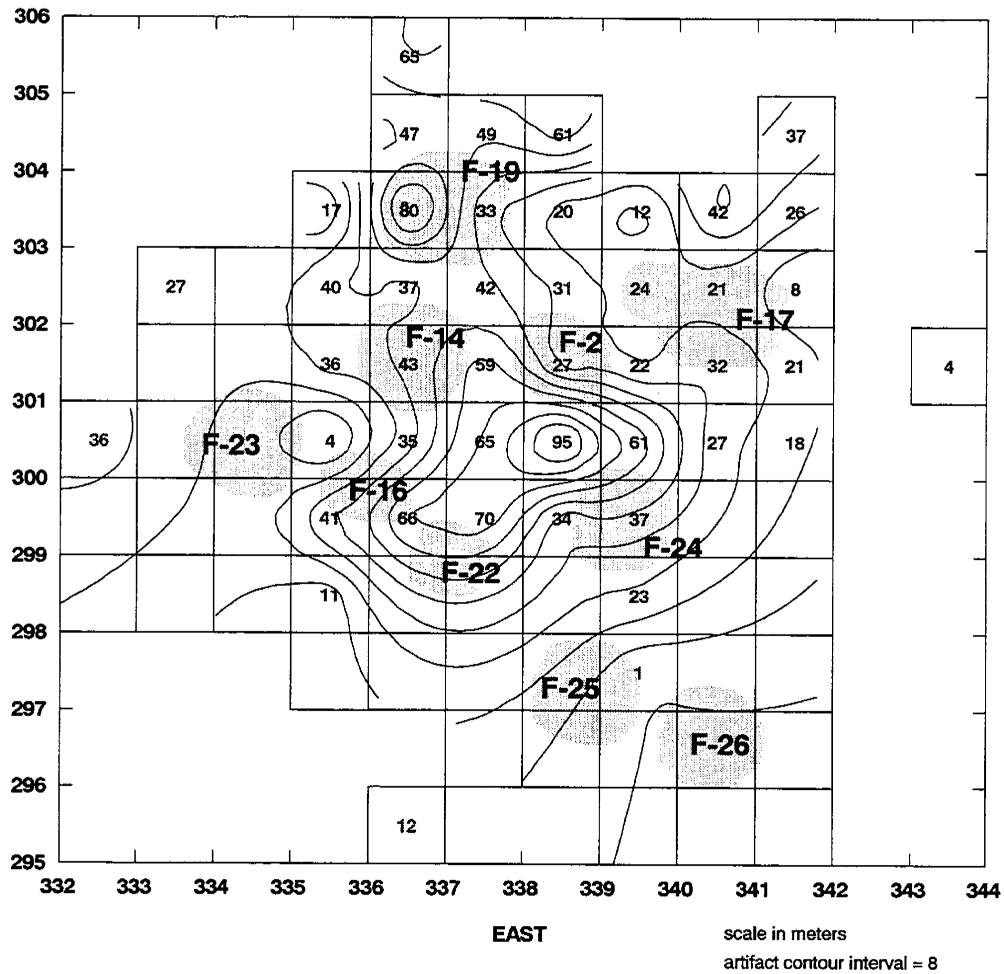

Figure 117. Comparison of Plow Zone Artifacts and Feature Location, Block C, Area 2

In sum, while there was not a specific correlation between the distribution of artifacts in the plow zone and the features below it, the features were associated with concentrated activity which was evident in the general clustering of artifacts across the area. Significantly, these clusters were composed in large part of fire-cracked rock—from 33 to 55 percent of the artifact total in each case—suggesting the presence of hearths in immediate association with the pits.

Block D

Separate analyses were carried out on the material from Block D, since the block was excavated in the only area of intact, unplowed deposition identified in Area 2. Artifact analyses reported in Chapter XIII indicated that there were potentially significant differences in the compositions of the artifact assemblages in the two deposits. It appeared that the artifacts in the sub-plow zone layer had not merely filtered down from the overlying deposit.

Plots of the horizontal distribution of artifacts in the sub-plow zone levels were compared with those of the plow zone deposit (Figure 118). For the analysis, the three 10cm levels comprising Stratum B were collapsed into a single surface. Cluster analysis indicated a wide variation in the distributions between the deposits. Several excavation units contained high artifact counts in Stratum A, implying various centers of concentration, while artifacts from Stratum B were concentrated in only a single unit near the center of the block, N315 E332.

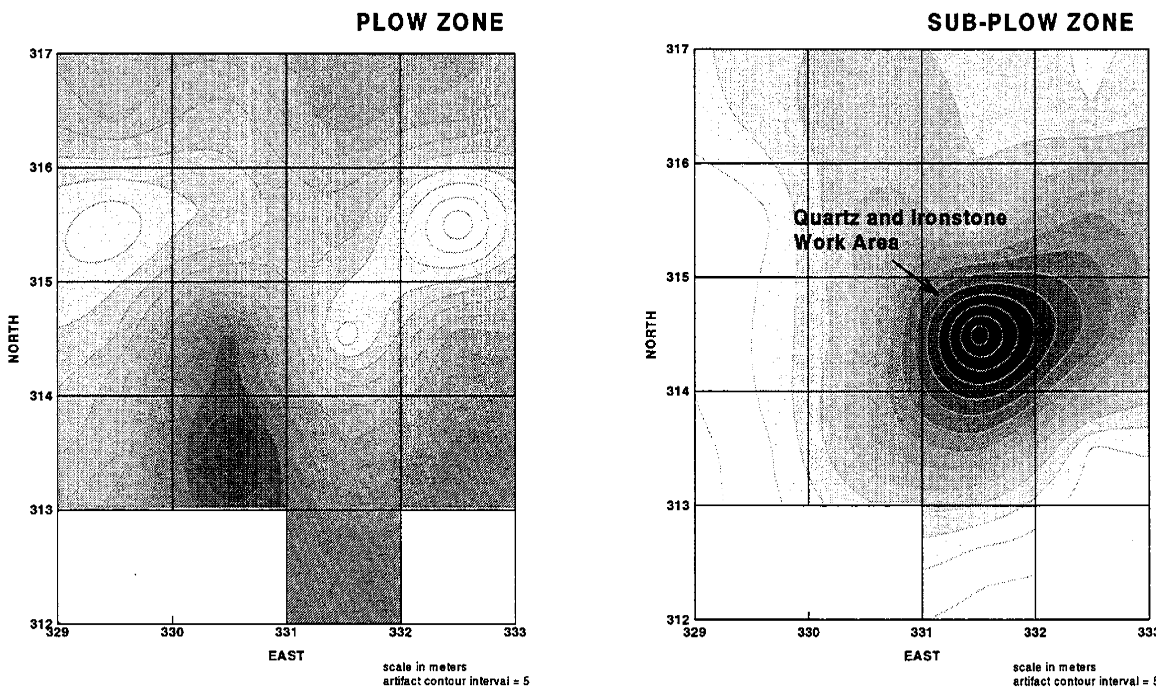

Figure 118. Comparison of Plow Zone and Sub-Plow Zone Artifact Locations, Block D, Area 2

A breakdown of the spatial data from Stratum B by raw material type showed that Iron Hill jasper material was spread evenly across the block, while quartz, pebble cryptocrystalline lithics, and ironstone were clustered to the east. Ironstone and quartz displayed the tightest clustering. Analysis of spatial distributions by size indicated that large and small flakes occurred unevenly across the block. A check of the size distribution of flakes of each raw material type showed relative uniformity, suggesting that no single material was responsible for a disproportionate amount of the spatial patterning. Small flakes (size-grades 3 and 4) tended to cluster around the unit in the high ironstone flake count. Large flakes (size-grades 1-2) did not occur in that unit but were scattered to the south and east. Several bifaces and unifaces of quartz and ironstone and a small hammerstone were recovered from nearby units as well (Figure 119). In the absence of gross horizontal disturbance, which is assumed from the recovery of the material from a developed soil horizon, the finding argued for the presence of an isolated lithic reduction area. Judging from the small sizes of the flaking debris, the activity appeared to have been the tool finishing or maintenance.

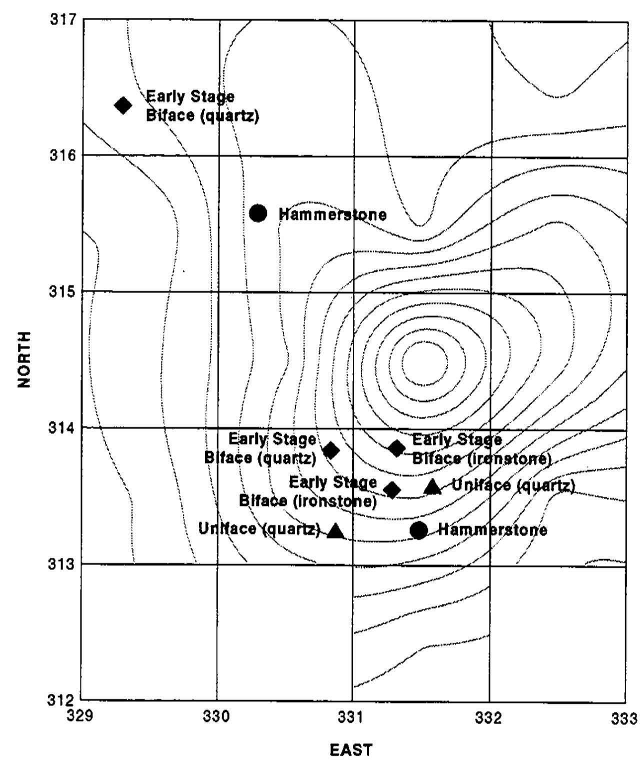

Figure 119. Location of Tools, Sub-Plow Zone, Block D, Area 2

The Correlation of Plow Zone and Sub-plow Zone Artifact Distributions

General systemic rules regarding the relationship between plow zone and sub-plow zone artifact distributions have not as yet been articulated, and indeed the mechanics of the relationship are not well understood. The results reported by Binford and others (1966, 1970) at Hatchery West, in southern Illinois, and Redman and Watson (1970) at Cayönü, in southern Turkey, were mentioned earlier in the introductory section. These studies suggested that there may be a positive correlation between plow zone and sub-plow zone deposits at some sites. In a more recent study, Shott (1995:485) observed a limited correspondence between surface and underlying assemblage distribution, based on data collected from the Butler site, a Paleoindian site in Michigan.

A variety of contrasting data are available from sites in the Middle Atlantic region where surface distributions have often not been found to be good indicators of feature distribution; e.g., the Connoquenessing site in western Pennsylvania (Knepper and Petraglia 1996); and in northern Delaware the Wrangle Hill site (7NC-G-105) (Custer et al. 1995); and the Leipsic site (7NC-K-194A) (Custer et al. 1996:77). Dunnell and Simek (1995) have argued the complete disassociation of the plow zone and any underlying deposits. The plow zone "is a unit [with] a contemporary stratigraphic age. Because the plowzone is a stratigraphic unit in the ordinary geological sense of the term, there is no reason, *a priori* or otherwise, for any correspondence between the distribution of artifacts in a plowzone and in other, lower stratigraphic units." Yet they do see possibilities for correlating the two types of deposition, considering the potential of "degradable" artifacts, meaning bone and low-fired pottery, for predicting sub-plow zone distributions from plow zone distributions.

The results obtained from Area 2 at the Lums Pond site indicated both -- There was not a direct relationship observed in any part of the site area. The data from Block D exemplified the of lack of correspondence on a fine scale of resolution, where relatively small artifact clusters in the plow zone bore no resemblance to the distribution of artifacts below. In contrast, the general artifact concentrations in the central portion of the area were aligned with subsurface features. There are a variety of factors which may influence the degree of association witnessed. Potential reasons include the type and degree of intensity of prehistoric activity (intensive occupations tend to exhibit closely spaced or overlapping activity areas which become mixed and indistinct with plowing), the type and intensity of modern disturbance (deep, multi-directional plowing over long periods will increase the amount of dilation of the original clustering of data), and the scale of resolution of data collection. In Area 2, relatively non-overlapping occupations appeared to have led to the maintenance of some correlation on a wide scale.

Area 3

Cluster analysis of Phase II shovel test data identified Area 3 as an additional area of discrete prehistoric activity (Figure 120). Phase II testing included the excavation of three test units in Area 3 to further define the character and distribution of the artifacts there. The artifacts recovered included 165 flakes, with raw materials ranging from Iron Hill jasper, chert, and quartz to coarse-grained materials such as quartzite, rhyolite, and andesite. Also recovered were two projectile points—a Teardrop point of brown quartzite, and a triangle of black chert—and a fragment of shell-tempered pottery. Floodplain deposits associated with the stream were identified by the presence of a buried A-horizon. The terrace forming the edge of the floodplain ran on a northeast/southwest line roughly parallel with the present watercourse. Alluvial deposits were recorded below the Ab horizon containing artifacts buried as deeply as 85cm below grade.

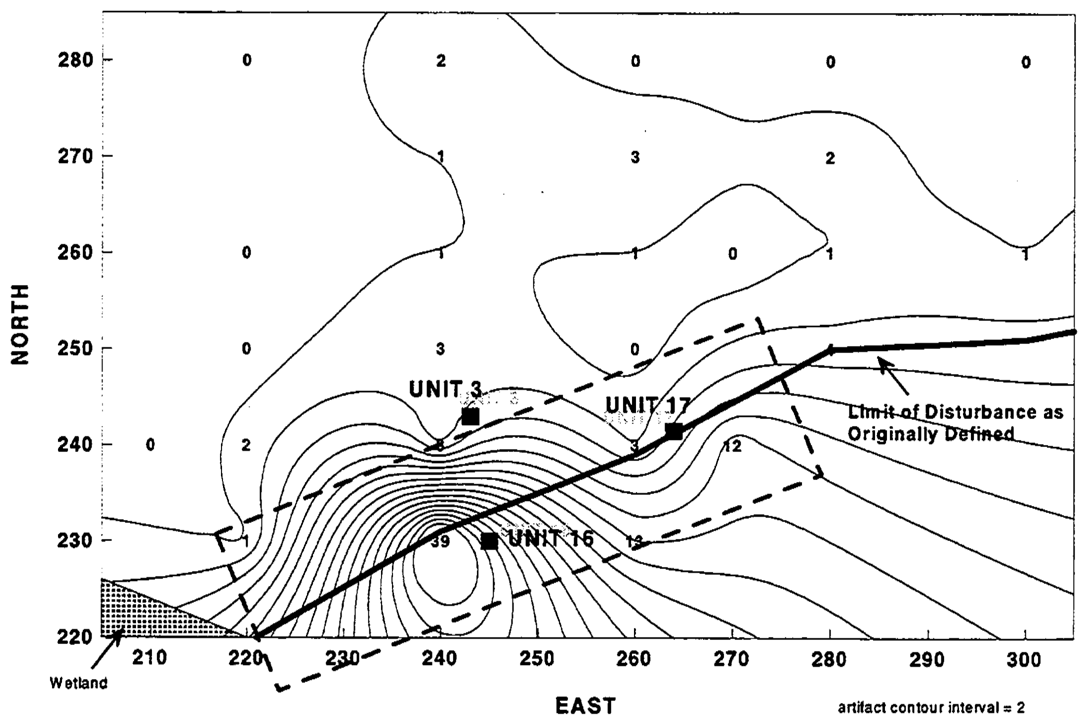

Figure 120. Shovel Test Survey Data, with Locations of Test Units and Sampling Grids Area 3

The Phase III random stratified sample for Area 3 was taken from an area measuring approximately 820 square-meters lying within the rectangle depicted in Figure 120. Rather than the 5x5m grid used as the sampling base in Areas 1 and 2, a 4x5m grid was employed in Area 3 to fit the elongated shape of the space between the edge of the buried terrace and the current floodplain of the stream (Figure 121). Of the initial 5 percent sample fraction (41 units), five units in the northwestern part of the grid overlapped the edge of terrace deposit, where coarse Pleistocene sand lay immediately below the plow zone. These units were not included in the analysis.

Units along the southern edge of the area yielded high artifact frequencies as evidence of concentrated prehistoric activity. Five additional test units were excavated to further define these areas, replacing the units on the terrace to the northwest and bringing the excavated sample to 41 square-meters. Plots of the cluster analyses of various artifact types and lithic raw materials were examined for potentially significant patterning. The available chronological data consisted of a series of projectile points and ceramics, all of which were recovered from plow zone levels. These artifacts showed little chronological pattern other than a tendency for somewhat more late material than early. There was no horizontal separation by period. Levanna and Teardrop points were the most frequent types, occurring in all parts of the area. Other types, including Rossville, Adena Stemmed, Fishtail, Bare Island, Poplar Island/Lackawaxen, St. Albans, and another Archaic serrated point, were also present, but arranged in no distinctive spatial pattern. Ceramics were spread thinly across the area as well.

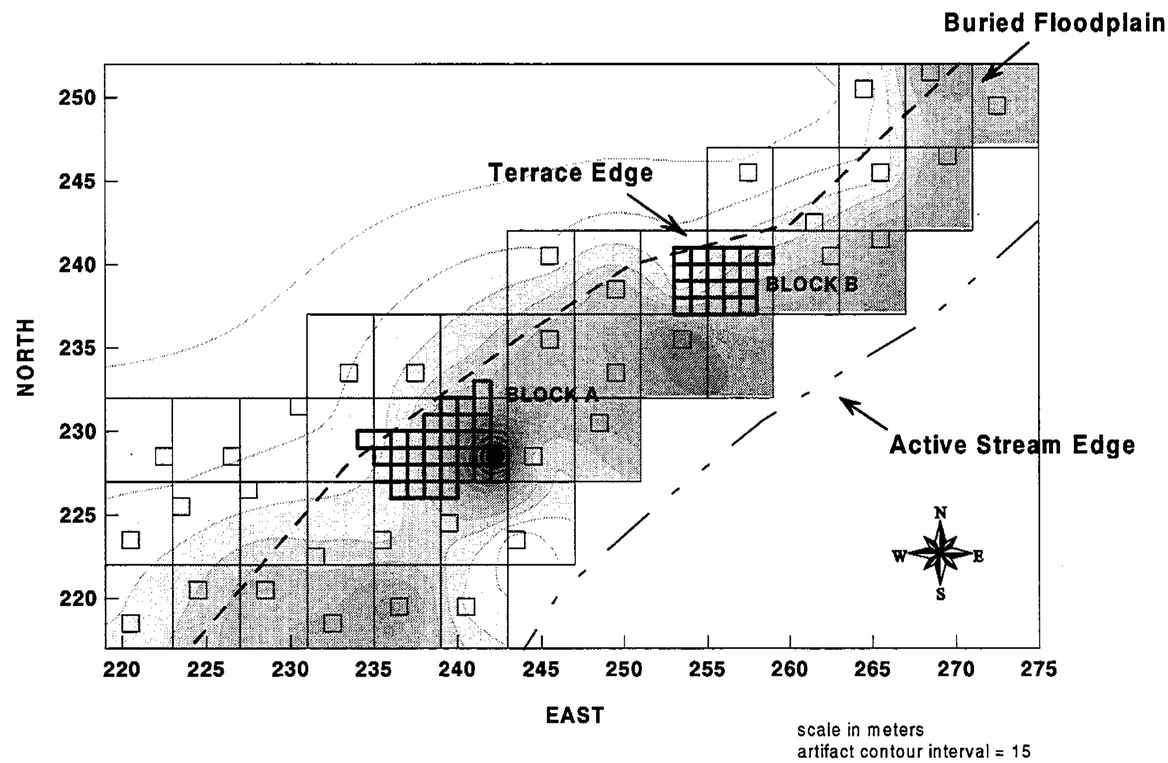

Figure 121. Results Random Sampling, Area 2

The densest occurrence of fire-cracked rock was observed southeast of the center of the area (N229 E243), suggesting the potential for fire-related activity in that area. Lithic raw material distributions mirrored the general artifact distribution. Quartz was the single exception, occurring in conspicuously low counts in the central area (N229 E243) and higher counts to the northeast (N236 E254).

Stage 2 data recovery block excavations were placed in areas with deep sub-plow zone deposits and associated artifact concentrations. Note that the artifact distributions illustrated in Figure 121 consist of material from the plow zone and sub-plow zone deposits combined, and thus the block locations do not correspond with the highest artifact concentrations as mapped. Block A was situated to recover data from near the center of the area where the highest sub-plow zone artifact concentration was recorded. Block B was placed in a second, non-contiguous area to the northeast that displayed relatively high artifact frequencies in Stage 1 units as well as several early artifacts.

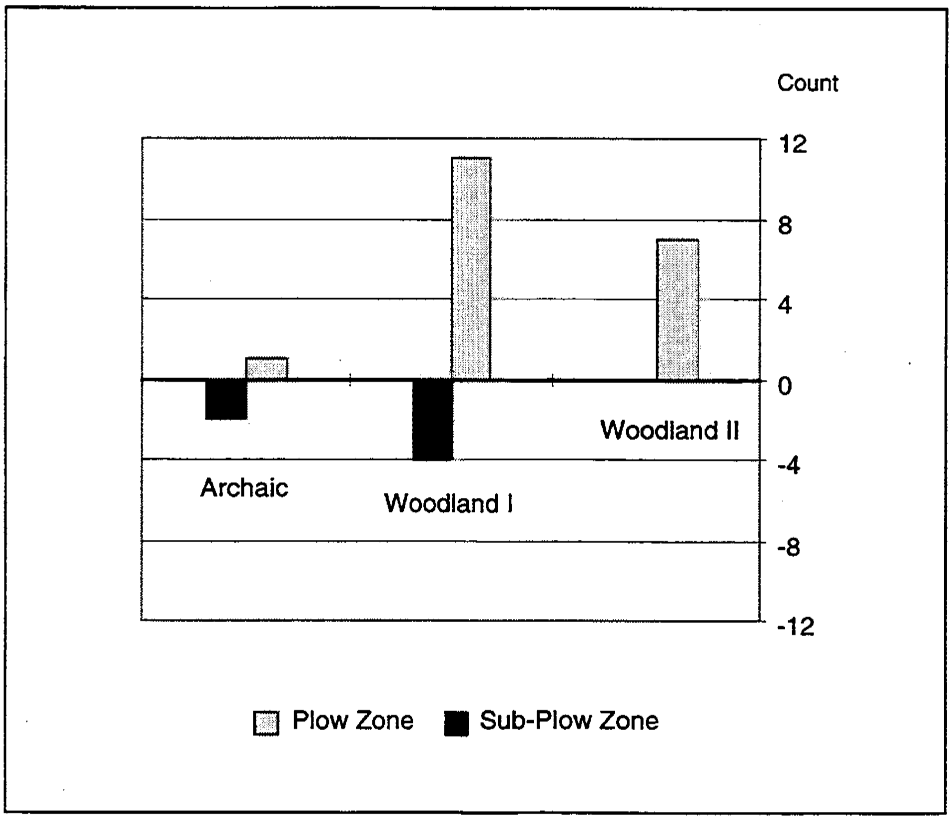

Figure 122. Vertical Proveniences of Diagnostic Projectile Points Grouped by Chronological Period

Vertical

Plow Zone — Sub-Plow Zone Correspondence

Figure 122 displays the proveniences of diagnostic projectile points in Area 3. A clear trend was evident in which earlier types occurred more frequently in sub-plow zone contexts, later types in the plow zone. The chart implied that the original stratigraphic sequence in the area may have been relatively straightforward, with later Woodland deposits generally overlying earlier Woodland and Archaic deposits, and the plow zone truncating the profile within the Woodland I levels. The presence of a range of chronological diagnostics in the upper deposit indicated that those levels were mixed, and geomorphological analysis suggested this could have been a partial consequence of slope wash.

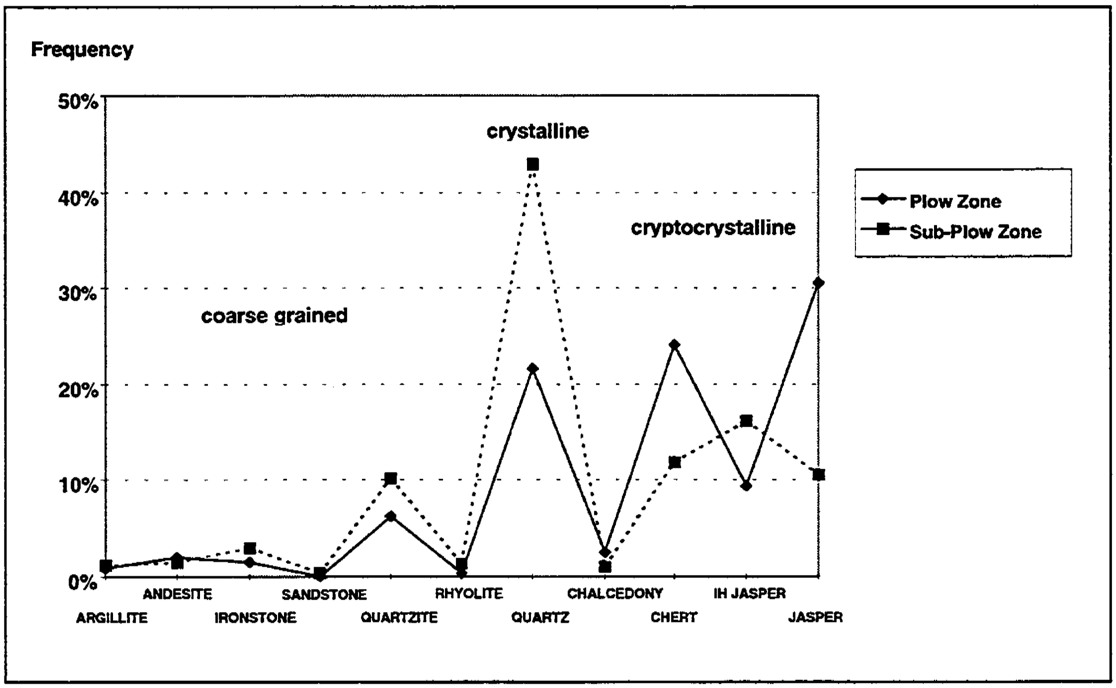

Figure 123. Lithic Raw Material Distribution in Plow Zone and Sub-Plow Zone Contexts, Area 3

Lithic raw material distributions tended to follow the chronological trend implied by the diagnostic artifacts (Figure 123). Research throughout Delaware and the Middle Atlantic region has noted that coarse grained lithic material was commonly used for stone tool manufacture in the early portions of the Woodland I period, while there was an increasing reliance on locally available stone types, which in this case would include cryptocrystalline pebble materials, in later cultural periods (Custer 1989; Dent 1995). A plot of the relative frequencies of coarse-grained and cryptocrystalline lithics in the two contexts indicated less quartzite and ironstone in the plow zone than below, along with a higher incidence of pebble chert and jasper.

Block Stratigraphy

The general stratigraphic correspondence between the two excavation blocks in Area 3 was initially evaluated through analysis of artifact type frequency and lithic raw material distributions. To assess level correspondences within each stratum, the number of units in which each stratum/level combination occurred in each block was tabulated. Stratum C, for example, was confined to one 10cm level in Block A, while in Block B it comprised three levels. Proportionately more artifactual material could thus be expected from Stratum C in Block B than in Block A. The second level of Stratum C occurred in less than one-half of the units in Block B, while the third level was present in even fewer units and did not measure a full 10cm.. A fall-off in the vertical frequency distribution of artifacts was thus expected at the base of Stratum C in Block B corresponding to this decrease in excavated volume. Stratum D in Block A consisted of 4 main levels and two abbreviated levels. The last two, Levels 5 and 6, were not extensive, Level 5 occurring in one-quarter of the units (in the northern part of the block) and Level 6 occurring in only one unit. By comparison, Stratum D in Block B also consisted of four complete levels, although Level 4 occurred in roughly one-half of the units. In both blocks, an artifact frequency drop-off at the base of D may be in part attributable to the lesser areal extent of the deposits. Below Stratum D, there were two artifact bearing levels of Stratum E, both of which were extensive in each block.

Overall, the major depositional units in each block appeared to be similar: one-to-two levels of an Ab-horizon (Stratum C), followed by four-to-five levels of a BC-horizon (Stratum D) (note that Joe refers to this as an AC horizon followed by several C horizons) and at least two of a Cg-horizon (Stratum E). For the purposes of the ensuing artifact analyses, the data from the following levels were combined—Block A: D5 and D6; Block B: C2 and C3; D4 and D5.

Block A

Stratigraphic and vertical artifact analyses indicated that at least two distinct depositional episodes were represented in the sub-plow zone levels across Area 3. Archaeological Stratum C was a buried topsoil layer, formally a 2Ab soil horizon. Archaeological Strata D and E consisted of a series of interrelated 2C soil horizons lying directly below the buried A.

The vertical frequency distribution of artifacts in Block A, illustrated in Figure 124, was examined for evidence of variation in artifact assemblage make up that would imply depositional separation. While the distribution appeared bimodal, with peak frequencies occurring in D3 and E1, Stratum D5 extended across only one-quarter of the units in the block—the limited areal extent of D5 accounted for most of the fall-off at that level. An essentially unimodal distribution was implied for the distribution as a whole. At the bottom of the profile, frequencies in Stratum E decreased gradually suggesting that these levels represented the base of the deposit in Stratum D. Artifact type and lithic raw material types in Stratum C and Stratum D were similar, yet there was variation observed in the relative frequencies of fire-cracked rock, chips, and bifaces.

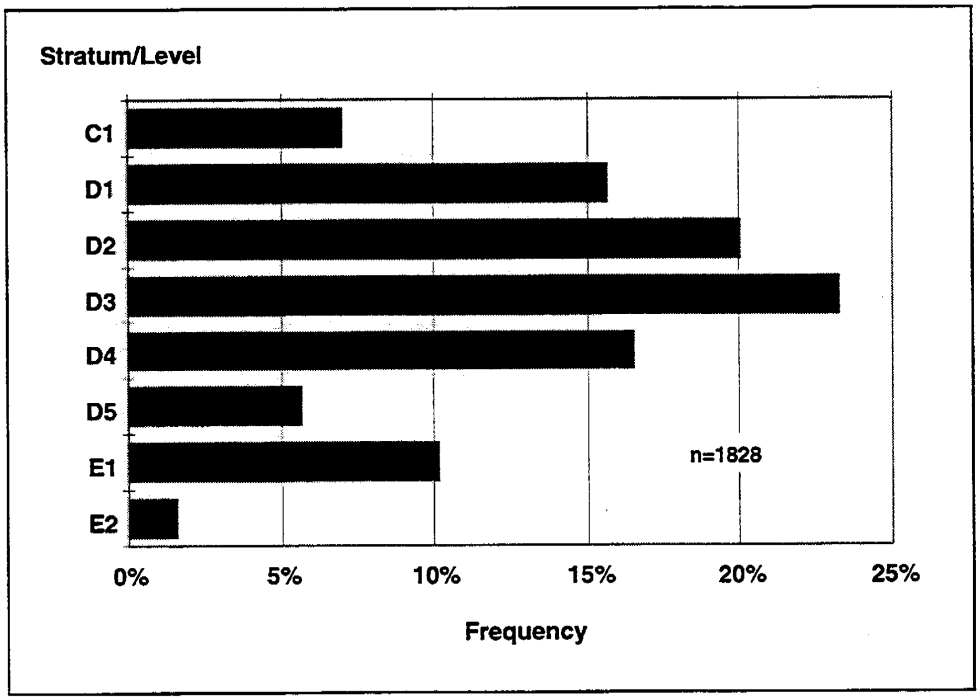

Figure 124. Vertical Frequency Distribution of Artifacts in Sub-Plow Zone Levels of Block B

Artifact size variation was examined between the strata, as indication of size sorting that would imply gross stratigraphic mixing and the settling out of smaller or larger artifacts. No pattern of decrease or increase was observed in the variation of artifact weight with depth within the block. A slight increase in mean weight with depth was noted (r^2 , the measure of linear correlation between the variables was 0.45). This finding appeared related to the sample from the lowest level, Stratum E2, which was small (n=29), and contained a large anvil stone in the deposit pushed the mean from that level upward. Without Stratum E2, the graph of weight against depth showed a distribution approaching normal, with a consequent lack of linear correlation (r^2=0.27). A similar outcome was recorded for deposits below Stratum C (r^2=0.09).

Size-grade data were also analyzed through plots of the frequency distribution of size-graded flakes constructed for each level. Size-grade 3 contained the greatest number of flakes in each case, while there was a consistent drop-off in size-grade 4 reflecting the incomplete nature of the sample from that grade that resulted from the size of the standard screen mesh used in the field. To normalize differences in the sizes of the remaining samples, the ratio of small-to-large flakes was calculated for each level. Ahler employs the ratio of size-grade 4 to size-grade 1-3 for such purposes. Since size-grade 4 was not representative in the Lums Pond samples, the ratio was calculated for size-grade 3 to size-grade 1-2. The ratio was found to vary widely with depth in Block A, with high values, indicating proportionately more small flakes, calculated for C1 and D5, and considerably lower values for the remaining levels. There was no evidence of linear correlation (r^2=0.09). There was a slight tendency for smaller artifacts lower in the profile below Stratum C, although the correlation was relatively weak ($r^{2=}$=0.46). Based on the analysis of weight and size grade distributions, then, there was little evidence of size sorting within the block.

Artifact refit analysis suggested a main level of deposition near the central portion of Stratum D. Upward and downward spreading, or dilation, of the original deposit was indicated by vertical transformations recorded in refits between stratum levels. This migration showed a degree of mobility within the profile, yet the relatively low number of artifacts displaying such movement suggested that postdepositional reordering of the profile was limited. There were few refits between Stratum C and Stratum D, implying the deposits were stratigraphically distinct.

Finally, radiometric data derived from the two deposits indicated a clear difference in age. Combined with the foregoing artifact analyses, the results suggested that Stratum C and Stratum D were chronologically discrete and that both were relatively intact. Stratum D and E appeared to be related, and so were combined for analysis.

Stratum C

The gross distribution of artifacts in the deposit is depicted in Figure 125, showing two main artifact clusters generally confined to single units and surrounded by units with few or often no artifacts. The central concentration consisted mainly of pebble flaking debris—flakes and chips of quartz and pebble chert. The cluster in the far north was made up largely of quartz debris. Comparatively little fire-cracked rock was present, clustered near and along the east edge of the block in amounts that signaled little substantial fire-related activity.

The assemblage from Stratum C provided a relatively small sample for analysis. While stratigraphic analysis was unable to determine precisely the amount of disturbance to the original deposit had occurred as a result of historic period agriculture, it appeared that the horizon had indeed been truncated by the plow zone. Based on the large amount of artifactual material contained in the plow zone compared with the material in Stratum C, it was likely that a substantial portion of the deposit had been disturbed. The artifact assemblage that remained appeared to represent portions of two lithic reduction areas, one near the center of the block focused on pebble quartz and chert reduction, and another to the north focused on quartz reduction alone.

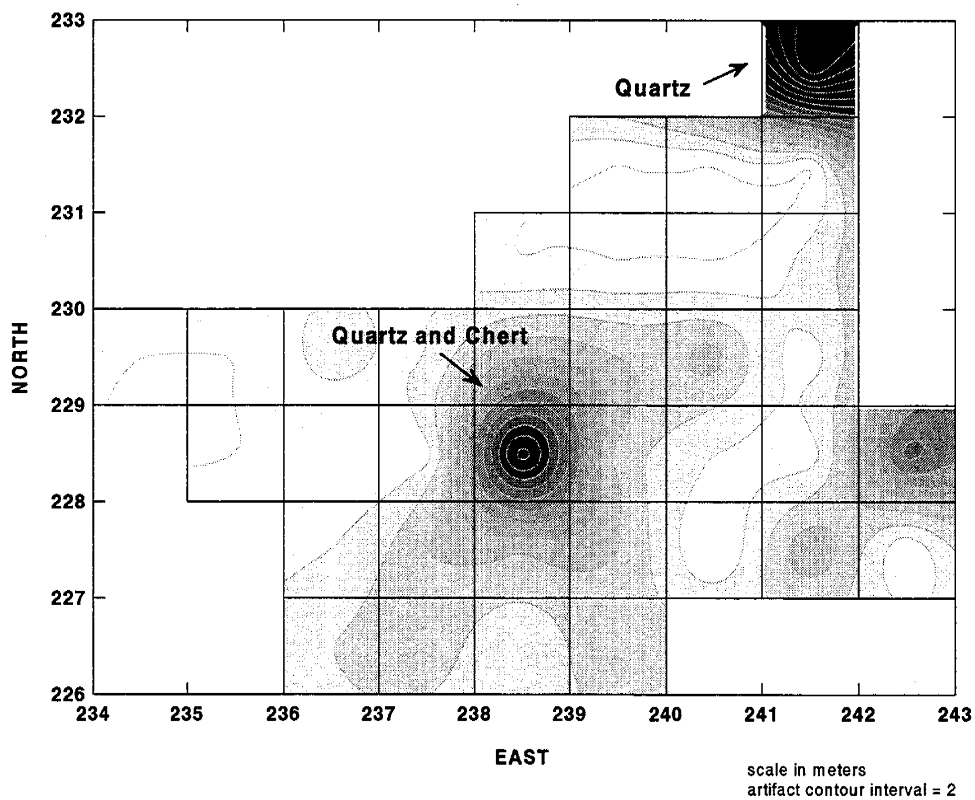

Figure 125. Artifact Concentrations in Stratum C, Block A

Stratum D/E

The underlying deposit, Stratum D/E, contained a considerably richer artifact assemblage than Stratum C, providing a large data set for analysis. For the purposes of the spatial study, the several levels of the deposit were combined into a single analytical surface. The overall distribution of artifacts in the deposit is depicted in Figure 126, illustrating the results of a cluster analysis conducted on the entire database from the deposit. Two main artifact concentrations were revealed, one dense cluster contained in a series of eight excavation units in the northeast portion of the block, and the other a slightly smaller and less dense group contained in five units near the southwest corner of the block.

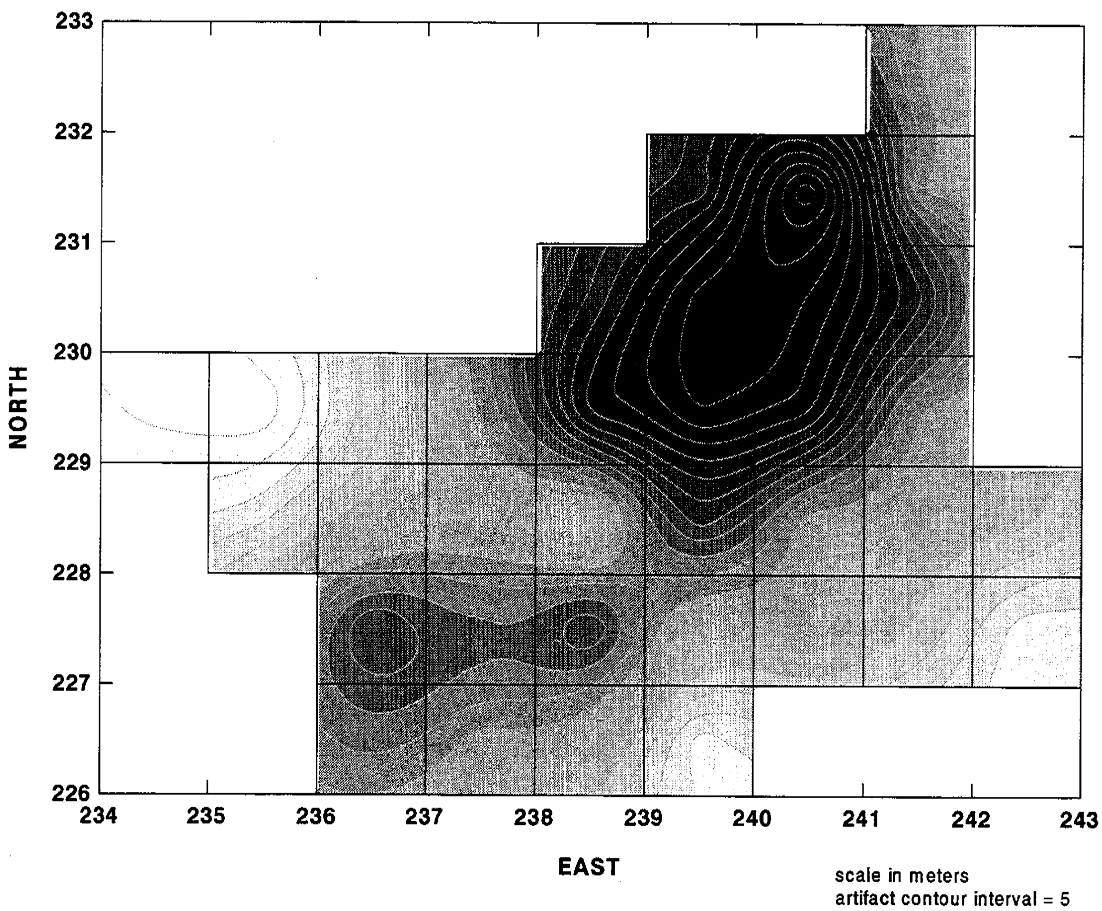

Figure 126. Artifact Concentrations in Stratum D/E, Block A

Artifact analysis indicated that fire-cracked rock was not a major constituent of the total artifact assemblage, and the distribution of that material across the stratum reflected that finding. Fire-cracked rock was more prevalent in association with the artifact concentration to the northeast, but was not present to the southwest in quantities greater than the general distribution across the block.

Breakdown of the data by raw material type showed quartz present in both areas, with higher counts in the northeast matching the general distribution. A similar distribution was observed for Iron Hill jasper. In contrast, pebble cryptocrystalline materials and quartzite were more heavily concentrated in the southwest area. The locations of cores and tool forms manufactured from the various raw materials were overlaid on the distributions and indicated some variation in the reduction trajectories of the raw materials. Quartz cores were scattered within both artifact clusters along with unifaces and early stage bifaces, suggesting a range of tool forms as the endproducts of quartz reduction in those areas. Pebble chert and jasper cores were similarly distributed within both concentrations along with a number of unifaces, an indication that, in contrast to quartz, pebble cryptocrystalline reduction was focused on the manufacture of a specific tool form. Again, the distribution data suggested little difference in the pebble reduction activity between the two artifact clusters.

Evidence of the heat treatment of certain cryptocrystalline artifacts as a variation in knapping technology was implied by analysis of the distribution of burned artifacts among the two assemblages. Burned artifacts were identified as either artifacts with crazed or potlidded surfaces, the potlids themselves, or, for jasper artifacts, a red or gray coloration. Cluster analysis indicated that burned cryptocrystalline artifacts and fire-cracked rock were more frequent in association with the northeast artifact cluster (Figures 127 and 128). Within this part of the block there was an approximate correlation between the two variables, although the heated chipped stone occurred slightly to the north and west of the densest concentration of fire-cracked rock. Examination of the material types included in the heated artifacts indicated even proportions of Iron Hill jasper (44 percent) and pebble jasper (47 percent)—the remaining 8 percent consisted of chert. In addition to flaking debris, there were 2 unifaces (1 each of Iron Hill and pebble jasper), a projectile point of pebble jasper, and a Iron Hill jasper core. The distributions of burned jaspers were separate and clustered differently from the distributions of unburned material in the assemblage, which argued strongly that the material did not result from incidental or postdepositional burning. Cluster analyses run on the two jasper types indicated a separation in their distributions, with the Iron Hill material concentrated in units west of the main fire-cracked rock cluster, and pebble jasper concentrated to the north. The analysis thus suggested the possibility of separate reduction locales within the main artifact cluster in which the processing and reduction of the two types of heat treated jaspers was carried out.

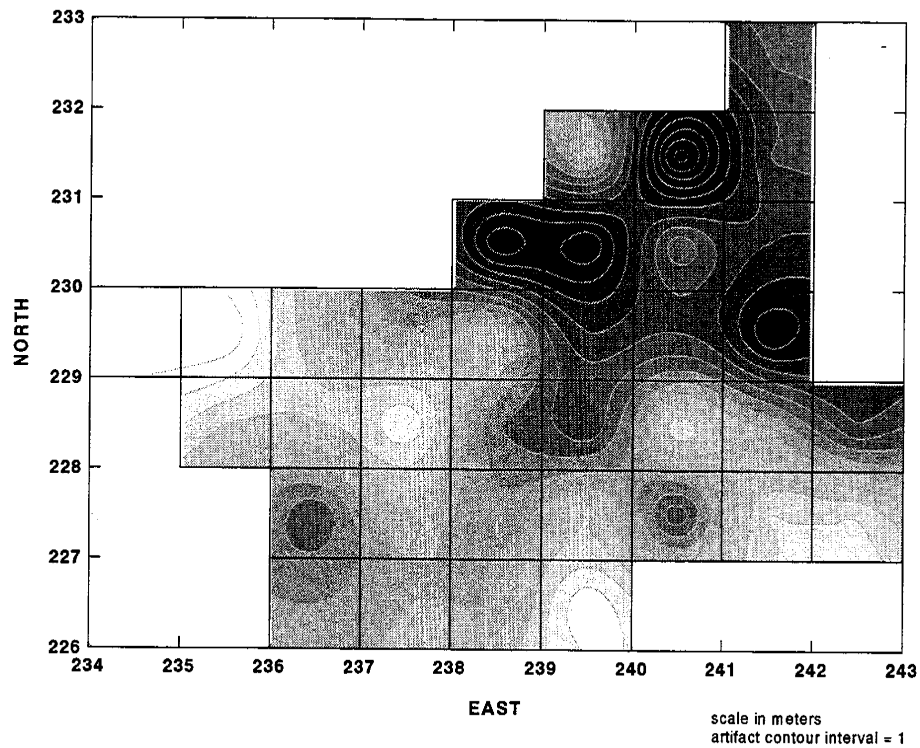

Figure 127. Concentrations of Heated Jasper and Chert in Stratum D/E, Block A

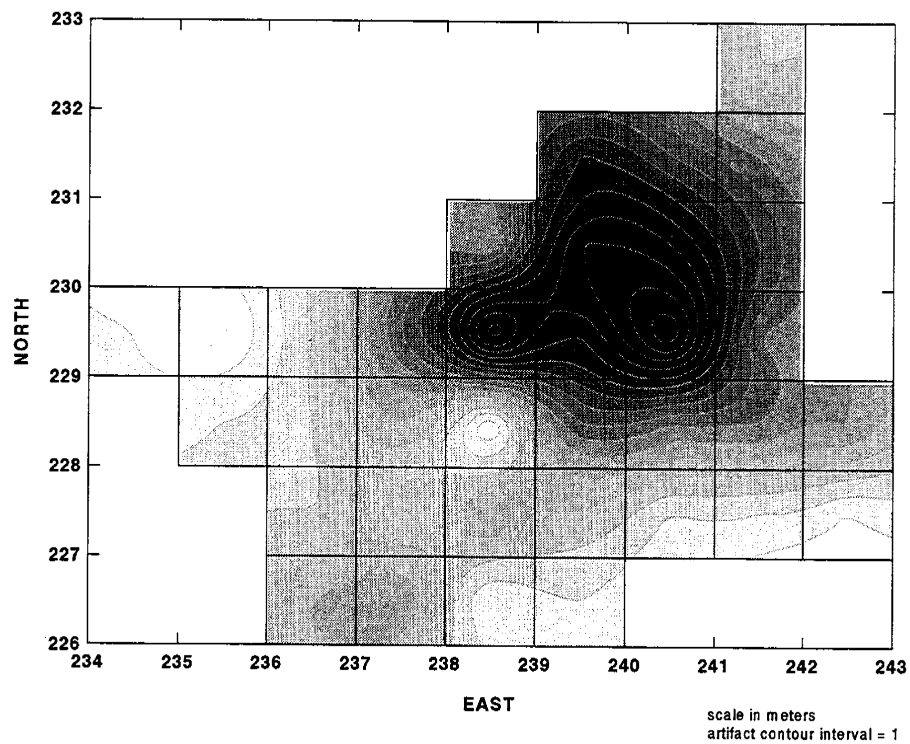

Figure 128. Concentration of Fire-Cracked Rock in Stratum D/E, Block A

Block B

Vertical

As in Block A, two distinct depositional episodes were recognized in the sub-plow zone levels: Stratum C, a buried topsoil; and Stratum D/E, a series of unconsolidated sands. Several analyses were conducted to determine the degree of stratigraphic integrity represented by the deposits.

The vertical frequency distribution of artifacts in Block B, illustrated in Figure 129, was examined for evidence of variation in artifact assemblages that would imply depositional separation. Two distinct deposits were implied by a bimodal distribution. The highest artifact frequencies occurred in C1, falling off in C2, and climbing through D1 to a second mode in D2. There was a gradual fall off again through E4. Differences were seen in the distributions of artifact types and raw materials between the strata, including varying incidence of fire-cracked rock, bifaces, as well as variations in the proportions of quartz and Iron Hill jasper flaking debris.

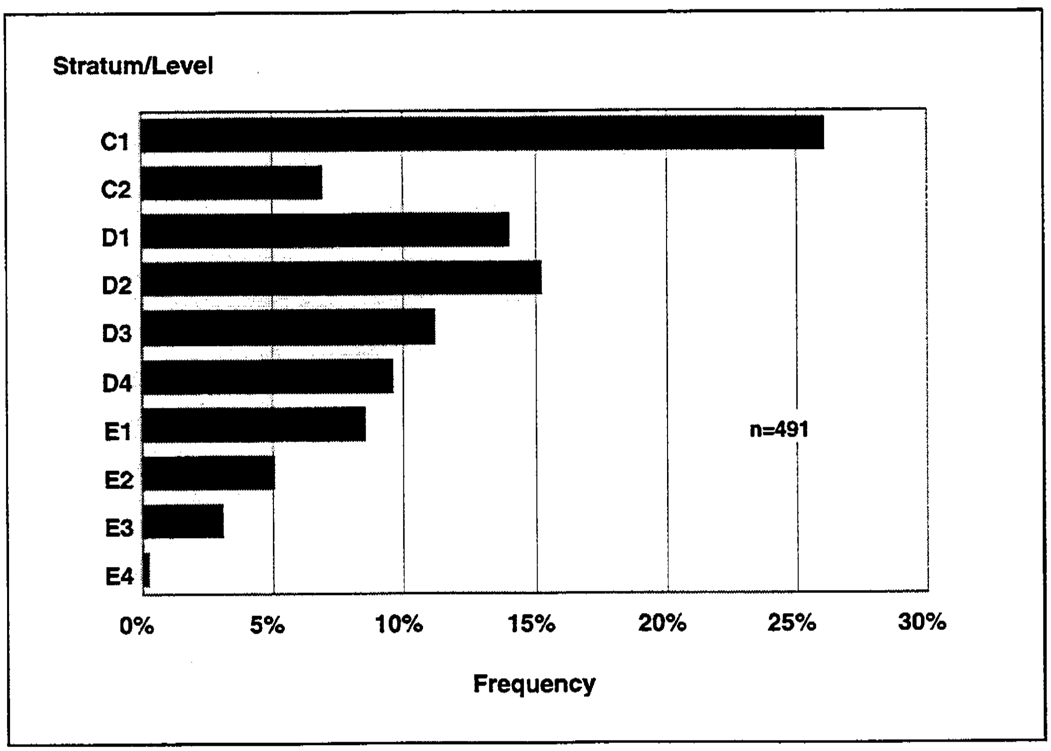

Figure 129. Vertical Frequency Distribution of Artifacts in Sub-Plow Zone Levels of Block B

Artifact size variation was examined between the strata, as indication of size sorting and stratigraphic mixing. The vertical distribution of artifacts by weight showed little evidence of size sorting. Mean artifact weight was high in the lower level of the Stratum C due to the presence of several large fragments of fire-cracked rock whose effect in the mean was magnified by a low overall artifact frequency in the level. Below, in Strata D and E, there was no significant correspondence between mean artifact weight and depth (r^2 , the linear correlation statistic for mean weight vs. depth was 0.32).

The frequency distribution of size-graded flakes was plotted for each level, and the ratio of small-to-large flakes (size-grade 3 to size-grade 1-2) was calculated to normalize differences in the sizes of the samples. This ratio was found to vary widely with depth ($r^2 = 0.10$), with high values, indicating proportionately more small flakes, calculated for D1, D3, and E2, and considerably lower values for the remaining levels. These data indicated convincingly that there had been little sorting of artifacts by size in the soil column in Block B such as would be expected if the deposits had been subject to extensive in-place perturbation.

Artifact refit data suggested that deposition was distinct between Stratum C and Stratum D. Some vertical transformations were recorded within Stratum D and Stratum E, implying mobility within those levels. The number of refits was relatively low in general, and there were no refits between Stratum C and Stratum D.

Radiometric data from the deposits paralleled data from Block A, indicating a clear difference in the ages of the strata. The results of the analyses suggested that Stratum C and Stratum D were chronologically discrete relatively intact, with deposition occurred with in a comparatively restricted zone in each stratum and was followed by limited postdepositional movement. Stratum D and E appeared to be related, and so were combined for analysis.

Stratum C

The gross distribution of artifacts in Stratum C is depicted in Figure 130, showing a distinct cluster of material in the central portion of the block. The cluster was largely contained in four excavation units—N240 E256, N240 E257, N241 E255, and N241 E256—and the material from those units was analyzed in detail. A large proportion of the cluster, over 60 percent, was made up of fire-cracked rock (n=51), the remainder consisting of flaking debris. The flakes were mostly quartz (37 percent) and pebble chert (26 percent). With chips and potlids added to the flake totals, quartz was even more heavily represented (48 percent as opposed to 22 percent for chert). Tabulation of the frequency of cortical flakes among the two materials, between 15 and 20 percent, indicated that there was initial reduction debitage present, but little appreciable difference between the material types. While direct attributes of bipolar flaking were not apparent, use of that technique was assumed based on the pebble form of the raw materials.

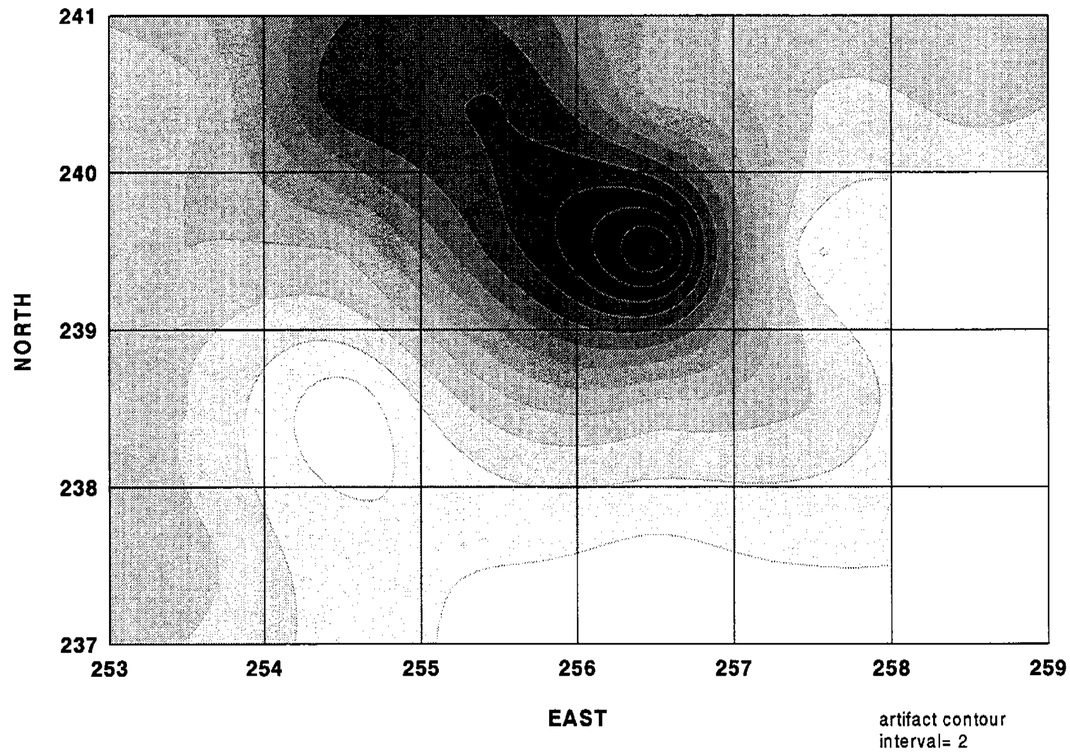

Figure 130. Artifact Concentrations in Stratum C, Block B

In sum, analysis suggested that the artifact cluster represented the remnants of a localized lithic reduction area with a small hearth nearby. The debris may have been discarded in this part of the site during site maintenance, or alternatively it may have resulted directly from knapping in this area. Stratigraphic evidence did not provide a clear indication of the original vertical extent of the Stratum C deposit, although comparisons of plow zone and sub-plow zone artifact distributions suggested that, as in Block A, a considerable portion of the deposit may have been disturbed by historic period land use in the form of plowing. It was assumed that the material recovered from Stratum C comprised only a portion of the original debris.

Stratum D/E

As in Block A, Stratum D/E contained a larger artifact assemblage than the material from Stratum C, and formed a more complete data set. Stratigraphic analysis suggested that the various levels comprising the deposit could be combined into a single surface for spatial analysis. The results of a cluster analysis using all of the artifacts from the deposit is depicted in Figure 131. Two artifact concentrations were defined by the analysis, one in the southwest portion of the block and the other near the center of the block. Each cluster was contained in five excavation units, the southern cluster with 136 artifacts, the central cluster with 102 artifacts. Two of the units forming the groups were contiguous, and at the level of resolution represented by the meter-square provenience units, it was difficult to determine whether the clusters denoted separate episodes of activity or concentrations within a larger activity area. To help resolve the question, the groups were examined individually in some detail.

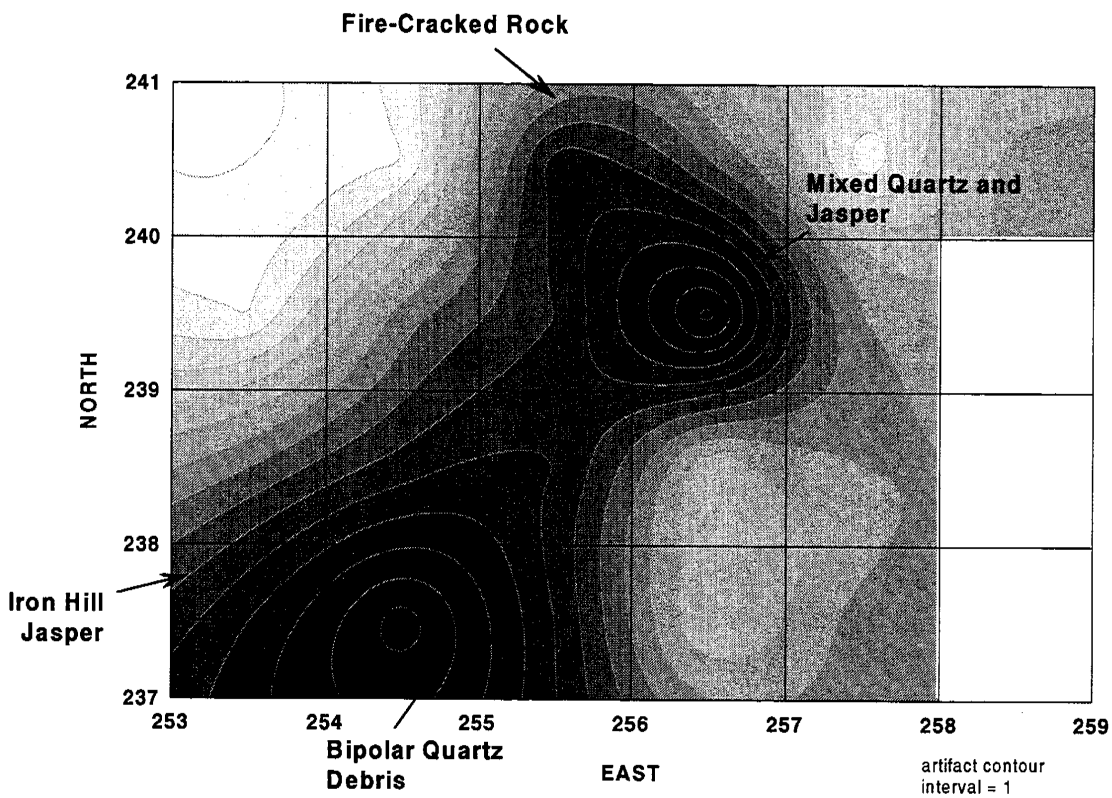

Figure 131. Artifact Concentrations in Stratum D/E, Block B

The main difference between the clusters in terms of artifact types lay in the relative proportions of fire-cracked rock and chips: proportionally two-and-one-half times the fire-cracked rock in the central cluster, and twice as many chips in the southern cluster. The southern area contained several bifaces and cores, while points were present in both assemblages. Both areas contained knapping artifacts: a hammerstone in the southern group, an anvil in the central group.

Raw material distributions varied somewhat between the clusters as well. There was proportionally more quartz in the southern cluster, concentrated along the southern edge of the group. While there was more Iron Hill jasper in the central area, a relative concentration of that material lay isolated along the western edge of the southern cluster. More raw material variation was seen in the flakes in the central area, with the most significant difference being the roughly equal proportions of quartz and Iron Hill jasper. To help assess the variation in raw material types among the two flake assemblages, a significance test was conducted on the material distributions (Table 119). Three categories were used: quartz, Iron Hill jasper, and other, the latter being a grouped category employed to raise cell frequencies to acceptable limits for the statistical test. The test indicated rejection of the null hypothesis of equal distributions among the raw material figures, with the differing ratios of quartz-to-Iron Hill jasper contributing most to the outcome.

material	**south**	**center**	*row*
quartz	50	22	72
Iron Hill jasper	24	23	47
other	8	15	23
column	82	60	142

$\chi^2 = 9.87$ $p = 0.007$, $df = 2$

Table 119. Contingency Table: Raw Material Types Among Flake Assemblages, Block B, Stratum D. Category "other" consists of grouped data

Nevertheless, the data overall suggested that while there was considerably more fire-cracked rock in the central cluster, other differences in the compositions of the two groups of artifacts were not substantial. The spatially distinct appearance of the groups may have been due to a combination of the scale at which the data were collected and the algorithm used in the cluster analysis. Yet the material was presumed to represent a single depositional episode. That concentrations were noted within the entire distribution indicated a degree of internal structure to the material, with discrete groups of knapping debris identifiable on the basis of raw material variation. There was evidence of quartz and Iron Hill jasper reduction debris in the south and southwestern portions of the block respectively. A greater frequency of chips in the quartz cluster there may imply more use of bipolar percussion in that area. A second concentration of mixed quartz and jasper debris lay near the center of the block, along with the apparent remnants of a small fire-related feature, probably a hearth, lying on the northern edge of the concentration.

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