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A Techno-Functional Analysis of Fiber-Tempered Pottery from the Squeaking Tree Site (9Tf5), Telfair County, Georgia

by James C. Waggoner, Jr.

Distinctive fiber-tempered pottery traditions are documented from archaeological sites in the Middle Savannah River Valley and along the coasts of Georgia, South Carolina, and Florida (Anderson 1975; Bullen 1972; Caldwell and Waring 1939; DePratter 1979, 91; Elliott and Sassaman 1995; Holder 1938; Phelps 1968; Sassaman 1993:19; Stoltman 1972; Trinkley 1983). Like Stallings, St. Simons, and Orange fiber-tempered wares, early pottery from the Ocmulgee Big Bend (Figure 1) which is located in the interior Coastal Plain of Georgia also displays unique qualities, such as thickness, tempering, vessel shape and size, along with surface decoration that differentiate it from other early pottery types found farther east and along the coast. Based on these characteristics, it has been previously suggested that fiber-tempered pottery from the Ocmulgee Big Bend region should be assigned its own type (Elliott and Sassaman 1995:60). While this statement is predicated heavily on physical attributes such as surface treatment, vessel form, and tempering, early pottery from the Ocmulgee Big Bend may also be differentiated from other established types based on use-wear.

In this paper, I present the results of a techno-functional analysis of fiber-tempered pottery from the Squeaking Tree site which is located along the Ocmulgee River in South Georgia. The findings suggest that vessels at the site shared a similar morphology to those found in the Savannah River Valley but were used for direct as opposed to indirect-heat cooking. This is based partially on the internal oxidation thickness of basal sherds and by rim fragments that display substantial reduction from being in a low-oxygen environment, both of which are associated with a vessel's proximity to open fire during its use-life. Documenting this assemblage represents two important points, one being that it provides previously unrecorded evidence for a type of use-wear that occurs after a vessel is fired and secondly, that it represents a first step in gaining a better understanding of fiber-tempered pottery from the Ocmulgee Big Bend along with its similarities and differences in relation to other early pottery types in the Southeast.

As a second component of the paper, I will discuss the occurrence of soapstone vessels and their relationship to fiber-tempered pottery in the region. Soapstone vessel sherds are often recovered from Late Archaic sites in the Ocmulgee Big Bend, sometimes in association with fiber-tempered pottery (Snow 1977). The association of the two vessel types is noteworthy considering the similarity of form between them. Soapstone vessels were used directly over fire in many parts of the Southeast as was fiber-tempered pottery along the Atlantic Coast, though wares from the interior are noted for their use in indirect-heat cooking (Sassaman 1993). The Ocmulgee Big Bend is devoid of natural soapstone outcrops and people living there would have been
dependent on sources in the Piedmont, either through direct access or exchange, to acquire it.

Despite progress in recent years regarding the chronology and use-wear studies of early pottery (Sassaman 1993), the technological similarities between fiber-tempered wares and soapstone vessels has not received much attention. In particular, their association outside of areas noted for significant concentrations of early pottery needs to be explored. Given its distance from the Piedmont and the tradition of fiber-tempered pottery production in the Coastal Plain, the Ocmulgee Big Bend is a good location to examine the affiliation between these two cooking technologies. I will begin with an overview of Squeaking Tree and archaeological materials recovered from the site, followed by a description of Stallings/St. Simons fiber-tempered pottery, Thom’s Creek sand-tempered pottery, Snow’s (1977) Satilla Series, and Ogeechee River valley forms. The relevance of use-wear analysis is also discussed and how it relates to the methodology developed for the project.

**Background: The Discovery and History of the Squeaking Tree Site**

The Squeaking Tree site (9TF5) is located in Telfair County, Georgia (Figure 2), an area known as the Ocmulgee Big Bend region of the interior Coastal Plain (Snow 1977). It was recorded by Frankie Snow in the fall of 1970 and is the largest of 12 sites located in a large clear-cut along the floodplain of the Ocmulgee River. Snow identified and surface collected the site after it had been harvested for timber and prepared for replanting, which exposed several hundred stone artifacts, soapstone potsherds, a gorget, and fiber-tempered, simple stamped, check stamped, Swift Creek, Ocmulgee
Cord marked, and Carrabelle Punctate pottery. Artifacts recovered from the Squeaking Tree site represent a temporal span from at least the Late Archaic through the Late Woodland Periods. The soapstone sherds were found associated with thick fiber-tempered pottery. This relationship is noteworthy despite its recognition in a surface context. Recent excavations at the Chatterton Spring site bolsters the association of fiber-tempered pottery and soapstone vessels in the interior Coastal Plain as fragments of both were found together in a stratified context (Dwight Kirkland, personal communication 2004).

In early February 1995, Elliott and Sassaman (1995) examined the Squeaking Tree artifacts while compiling information on archaeological materials for a manuscript on the Archaic Period of the Coastal Plain of Georgia. Based on a preliminary observation, Sassaman proposed that the thick fiber-tempered pottery warranted its own type based on differences with other early pottery traditions such as Stallings Island of the Middle Savannah River and St. Simons which is found along the south Atlantic Coast of Georgia. Snow also drew similar conclusions in his report of the survey of the Big Bend (Snow 1977). Sassaman (1997) removed a soot sample from one of the soapstone sherds to get an AMS C-14 determination that returned an uncalibrated date of 3460 +/- 60 BP, which postdates the abandonment of the Middle Savannah River Valley.

Fiber-Tempered Pottery and Soapstone Vessels at Squeaking Tree

Fiber-tempered pottery from Squeaking Tree is represented by 204 sherds that are coarse and thick, heavily tempered with fiber, and predominantly plain. In some instances, sherd surfaces
can be worn and eroded and may display surface pitting (Figure 3). Decorated fiber-tempered pottery is also occasionally recovered from sites in the Ocmulgee Big Bend, though it is rare and generally conforms to the characteristics of Stallings/St. Simons or Orange wares (Elliott and Sassaman 1995:61).

Two basal fragments from the assemblage have intact wall portions which are useful to illustrate the base to wall attachment, both fragments start out thick and relatively flat and transition into thinner walls (Figure 4). These two sherds combined with the thickest sherds indicate that the vessels were likely flat-bottomed. Two rim fragments also stand as evidence of vessel form. They are fairly elongate in vertical orientation with slight curvature compared to the other sherds and may represent almost complete walls from base to lip. A small bit of curvature is also present at the bottom of each sherd which suggests that the vessels were flat-bottomed, though this needs to be corroborated through the examination of other local assemblages with a greater quantity of large rims and definite basal fragments (Figure 5).

The association of fiber-tempered pottery and soapstone vessel sherds is a significant aspect of the Squeaking Tree assemblage, especially considering the 3460 +/- 60 BP AMS date associated with a soapstone sherd from the site. The presence of soapstone in the Coastal Plain represents a connection with the Piedmont either through direct access to material sources or, more likely, through a system of exchange. Prior to the date presented by Sassaman (1997:8), the co-occurrence of soapstone vessel sherds and fiber-tempered pottery at Squeaking Tree suggested a date of 3500 BP, a date considered to be relatively late (Elliott and Sassaman 1995:61). Soapstone vessels postdate pottery in many areas of the Southeast and their use reached its height somewhere around 3300-2900 BP (Elliott

![Figure 3. Fiber-Tempered Pottery from 9Tf5.](image-url)
Figure 4. Base to wall transition.

Figure 5. Artist's rendering of Ocmulgee Big Bend fiber-tempered pottery vessel (courtesy of Frankie Snow).
and Sassaman 1995:64). Their relationship to fiber-tempered pottery is complex and its widespread adoption was likely influenced by socio-cultural factors. For example, their initial occurrence in the Middle Savannah River Valley coincided with the demise of Stallings culture around 3500 BP (Sassaman 1997:14).

Soapstone vessels were used directly over fire based on the occurrence of soot on the exterior surface of vessel walls (Sassaman 1993:181). The use of early pottery for direct-heat cooking is believed to have developed along the coast and later spread into the interior (Sassaman et. al 1995). Thick walled soapstone vessels may have also served as models for fiber-tempered pots. Conversely, fiber-tempered pottery could have been models for soapstone vessels. Fiber-tempered wares at Squeaking Tree are similar in form to soapstone vessels and may have been used as an alternate technology when soapstone was scarce or difficult to obtain. The Squeaking Tree assemblage is therefore distinctive based on stylistic and technological qualities that are best illustrated by comparing them to other localized early pottery traditions such Stallings/St. Simons, Thom's Creek, Satilla Series, and the fiber-tempered wares of the Ogeechee River valley that are the subject of the following section.

**Early Pottery Traditions of Georgia, Florida, and the Carolinas and their Relationship to the Squeaking Tree Assemblage**

Stallings/St. Simons and Thom’s Creek pottery traditions are among the earliest in the Southeast and range over the eastern and coastal portions of Georgia and the Carolinas (Figure 6). The Stallings series fiber-tempered pottery distribution encompasses much of the Savannah River valley from the coast to the lower reaches of the Piedmont and along the Atlantic Coast from roughly the Santee River in South Carolina to the

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Figure 6. Distribution of Fiber-Tempered Pottery in the Atlantic Coastal Plain (Adapted from Sassaman 1993 and Saunders and Hays 2004).
Altamaha River, Georgia (Anderson 1975; Elliott and Sassaman 1995; Sassaman 1993:19; Stoltman 1972; Williams and Thompson 1999). Fiber-tempered pottery encountered along the Georgia coast is generally designated as St. Simons (Caldwell and Waring 1939; DePratter 1979, 1991; Holder 1938).

Interior and coastal fiber-tempered wares are separated based on their geographical distribution and technological and stylistic differences. This differentiation has been cited as evidence for distinctive cultural-historical diversity between the coast and the interior (Elliott and Sassaman 1995:54; Sassaman 1993). Slight temporal differences also exist between them, with Stallings dates ranging from 4465 +/- 95 to 3110 +/- 110 BP. St. Simons fiber-tempered pottery is generally observed to occur from 4190 +/- 90 to 3010 +/- 80 BP. It is suggested, however, that earlier St. Simons sites were located on the coast but were subsequently buried by marsh infilling associated with sea-level rise (Brooks et al. 1990; Sassaman 1993:19). Both Stallings and St. Simons have similar vessel forms that are documented as shallow, open bowls with slightly rounded or flattened bottoms. Rim forms are straight to slightly incurvate and surface treatments are plain, punctated, incised, and stamped (Sassaman 1993:19). Orange series fiber-tempered pottery occurs intermittently along the Georgia coast but is predominately found south of the St. Marys River (Elliott and Sassaman 1995:60).

In contrast to the fiber-tempered wares of Stallings and St. Simons, Thom's Creek pottery is noted for its sand-temper or lack of temper. It ranges from the mouth of the Savannah River Valley to the coast of North Carolina, and unlike St. Simons, it penetrates well into the interior (Phelps 1968; Sassaman 1993:20; Trinkley 1983). Thom's Creek pottery dates range from 4170 +/- 350 to 2885 +/- 175 BP. Three vessel forms are identified which Trinkley (1983) characterized as, "a shallow bowl with a slightly constricted orifice, a shallow bowl with an unconstricted orifice, and a deep, open jar." Surface decoration was achieved with the use of reeds, shells, or fingers to create shallow punctations and incisions on the exterior of pre-fired Thom's Creek vessels (Sassaman 1993:69).

The Satilla and Ogeechee rivers must also be taken into account when contextualizing the Squeaking Tree assemblage. Distinctive fiber-tempered pottery assemblages are documented in both areas. As such, they are the closest local examples of fiber-tempered pottery encountered outside the Big Bend. Both rivers are smaller drainages that loosely border the Ocmulgee Big Bend. The Satilla River lies towards the southeast and the Ogeechee is a more distant neighbor to the east. The Ogeechee River valley also stands as the western boundary of Late Archaic shell-middens in the interior Coastal Plain of the South Atlantic slope (Sassaman et al. 1995:20). Fiber-tempered pottery from the Ogeechee valley is stylistically similar to pottery from the middle Savannah, though it varies technologically due to the prevalence of sand tempering and thick vessel walls. Vessel reconstructions suggest that the typical form consisted of "a heavy, shallow jar with a wide orifice and rounded base" (Sassaman et al. 1995:27). There is little evidence to suggest that vessels were used for direct-heat cooking. Early pottery from the Ogeechee River valley is also easily differentiated technologically from St. Simons because coastal assemblages bare evidence for direct-heat cooking (Sassaman et al. 1995:37).

Satilla Series fiber-tempered pottery is noted for its semi-fiber tempered paste, wall thinness, and plain, simple stamped, and check stamped surface treatments (Elliott and Sassaman 1995; Snow 1977:46). It has a limited geographic range and is generally encountered along the upper Satilla River, in the inter-riverine area between the Satilla and Ocmulgee Rivers, and southwest into the Gulf-draining Alapaha River (Elliott and Sassaman 1995:60). At present, little headway has been made regarding vessel reconstruction to suggest a general vessel form for Satilla Series wares and no absolute dates are available to definitively date it. Elliott and Sassaman (1995) place it temporally between 3000-2500 BP based on stylistic attributes.

The temporal and spatial distribution along with vessel forms listed above are notable when compared to the fiber-tempered pottery, such as the Squeaking Tree assemblage, from the Ocmulgee Big
The Bend region of the interior Coastal Plain of Georgia. The Ocmulgee Big Bend is well beyond the observed western most boundaries of both Stallings and Thom’s Creek series pottery. In comparison with eastern Georgia, the fiber-tempered pottery from the Ocmulgee Big Bend has a distinctively crude or rough appearance. Surfaces are coarse and can be pitted in contrast to the smoother wares of Stallings and Thom’s Creek. This is not to say that the people who made it lacked any sort of technological savvy, but rather that their pottery is easily discernible from wares to the east and along the coast of Georgia. It is also easily differentiated from Satilla pottery based on wall thickness and surface decoration.

Differences in surface treatment are also distinct because Stallings/St. Simons and Thom’s Creek pottery are known for being decorated with the drag and jab technique that produced intricate patterning on vessel surfaces. In contrast, almost the entire assemblage from Squeaking Tree is plain with the exception of a single rim sherd decorated with a punctated design (Figure 7). As opposed to the other sherds, however, it does not show a great deal of pitting or surface attrition. Similar forms also occur in the area and may fit the criteria of Stallings, St. Simons, or Orange types though they are rare (Elliott and Sassaman 1995:61). What this occurrence means from a socio-cultural perspective is not known at this time which is a problem that needs to be addressed by examining more site assemblages with fiber-tempered pottery from the Big Bend.

The pitted surfaces found on fiber-tempered pottery from Squeaking Tree are also an interesting point of discussion. Heavy surface attrition is likely the result of post-depositional processes as a number of physical, chemical, and biological agents may alter artifacts after they are buried (Schiffer 1987:148-150). Moisture in particular may have deleterious effects on low-fired earthen wares, especially when combined with cold air temperatures (Reid 1984:56; Schiffer 1987:161; Skibo et al. 1989:138). Squeaking Tree lies in the floodplain of the Ocmulgee and its close proximity to the river certainly impacted the preservation and condition of the assemblage due to exposure to moisture from periodic flooding. Many of the broken sherd edges are rounded and none were able to be refitted. Interestingly, surface pitting appears to be more restricted to the thicker sherds as opposed to rim sherds. As an alternative explanation, the pitting potentially resulted from wear that occurred over the use-life of the vessels. In this case, it may be a consequence of vessels being used directly over fire. This is difficult to prove based on materials from a single site and will ultimately need to be tested by comparing the Squeaking Tree pottery to assemblages from sites located outside of floodplain settings. However, other attributes associated with direct-heat cooking, such as internal wall oxidation thickness in relation to sherd thickness and unoxidated rims, are strong indicators that vessels were being used for direct-heat cooking.
Direct and Indirect-Heat Cooking Technology

Vessel use can be inferred based on overall form and paste composition. In this instance attributes can lend insight into whether vessels were used for direct or indirect-heat cooking. Heating effectiveness or the rate at which the temperature of vessel contents can be raised by the application of heat must be considered when thinking about either mode of cooking technology as it can be manipulated through vessel form and wall thickness (Sassaman 1993:141).

The heating effectiveness of vessels used for direct heat-cooking can be controlled through the application of thin walls to expedite heating and rounded bottoms to streamline airflow to and from the heat source (Hally 1983; Sassaman 1993:141). In contrast, pottery used for indirect-heat cooking usually has distinctive qualities to insure the insulation of vessel contents rather than the conductivity of heat (Reid 1989:173). This can be accomplished with thick vessel walls with flat, thick bottoms to help radiate heat inside the vessel. The inclusion of a heavy organic temper in the paste also helps to insulate heat because it makes vessel walls porous (Sassaman 1993:141).

Indirect-heat cooking is considered to be predominately used in the interior Coastal Plain as a means to cook food. Direct-heat cooking, on the other hand, evolved on the coast and was slowly adopted in the interior (Sassaman 1993; Sassaman et al. 1995:37). As previously mentioned the sherds from Squeaking Tree are thick and plain and in some instances display surface attrition. Therefore, differences between the fiber-tempered pottery assemblages of the South Atlantic Slope, like Squeaking Tree, and Coastal Zone cannot be explained as merely the result of aesthetics but are instead likely the result of differential use, an idea that is best explored through use-wear analysis.

Use-Wear Analysis

Use-wear analysis is a viable means to develop a general understanding of how pottery vessels were used over the course of their use-life (Hally 1983, 1986; Skibo 1992). Hally (1983) posits that the alteration of vessels through use is an indicator of their primary function. He notes several forms of use that tend to impact vessel surfaces such as the absorption of phosphorous and fatty acids, the accumulation of mineral salts and carbonized food residues, the general breakdown of vessel surfaces, and differential patterns of vessel breakage, discoloration, and sooting based on proximity to cooking fires (Hally 1983:4). For the purpose of this paper, the differential patterning of oxidation that results from vessels being used in direct association with open fire will be examined.

Oxidation and sooting are two forms of alteration that affect cooking vessels (Hally 1983:7). Soot is left on vessel surfaces as a by-product of fuel combustion and is easily identified by the presence of blackened areas on exterior surfaces. Oxidation is a physio-chemical change in the clay that has the potential to discolor surfaces. However, it may be restricted to the interior of the walls of vessels as a result of manufacture and not be as obvious as sooting (Hally 1983:11). Hally also points out that much of the pottery produced in traditional societies is fired at low temperatures, which when combined with the presence of organic matter in clays and free carbon, results in a pattern of black or gray coloration in post-fired pottery. Temperatures above 200 degrees Celsius will cause the organic matter to decompose which can in turn oxidize and dissipate if temperatures reach approximately 500 degrees Celsius (Hally 1983:11). Vessels subjected to this type of environment will display differential patterns of oxidation based on their orientation to fire and subsequent coloration will range from white though buff to red. The fiber-tempered sherds from the Squeaking Tree site are amenable to this type of analysis and the methodology used to implement it is developed in the following section.

Methodology

Differential oxidation results from the positioning of a vessel in relation to fire (Hally 1983:39). To clarify the terminology used here, interior and exterior “wall” oxidation refers to the inner portion of a sherd or vessel, while “surface”
refers to the interior and exterior faces of a sherd or vessel. Some oxidation will occur during firing, but additional oxidation will take place over the life of a vessel based on how it was used. Initial firing will result in somewhat uniform levels of oxidation near the interior and exterior of vessel walls. Subsequent use in fire will lead to increased levels of oxidation within pottery walls exposed directly to high levels of heat. Exposure to heat will also increase the porosity of vessel walls as organic materials burn up and carbonates decompose (Rice 1987:350). Porosity further facilitates the flow of heat into the interior of vessel walls.

Oxidation levels should be related to the overall thickness of sherds based on the portion of the vessel from which they originate. In this case, basal sherds are likely to be thicker than rim sherds. They should also display thicker levels of oxidation given their closer proximity to cooking fires over the course of a vessel's use life. Therefore, vessels used for indirect-heat cooking should be expected to display relatively uniform levels of oxidation throughout the vessel walls because they were not exposed to high levels of heat during use. Vessels used for direct-heat cooking should exhibit just the opposite with high levels of oxidation present as a result of differential exposure to fire. Basal sherds should have much higher levels of oxidation as opposed to rim sherds due to their positioning during use. Oxidation should also be primarily restricted toward the exterior portion of vessel walls.

Oxidation is often restricted to the interior of vessel walls and can only be examined through their exposure. After the Squeaking Tree artifacts were washed and prepared for analysis, sherds were divided into rim and body categories in an attempt to ascertain the minimum number of vessels in the sample. Sherds less than two mm in diameter were not used, which left 200 sherds to be examined. A sherd level of analysis is taken because many of the sherd edges are heavily worn and eroded, which coupled with the lack of surface decoration, made the prospect of cross-mending difficult.

Following sorting, a small break was made on each sherd to expose a clean cross-section. Each sherd was measured for thickness. Measurements were taken at the center of each sherd in order to insure consistency. Oxidation thickness was also measured based on the presence of an outer band located within the interior of the vessel wall. It was also noted whether it was oriented toward the interior or exterior. Rim thickness was measured to determine differences between rim and body sherds. Measurements were taken three centimeters below the lip of each rim. Four rims were not examined because they were less than three centimeters in length.

### Results

Approximately 32 vessels were present based on the occurrence of rims with distinctive characteristics such as thickness, or flat or folded edges. Maximum thickness of sherds ranged from 5.9 to 21.5 mm and the average sherd thickness measured 11 mm (Table 1). Thinner sherds, on average, had less or no oxidation present compared to thicker sherds in the assemblage. If sherds were oxidized, they tended to be thicker than those that were not. These results are also substantiated by a student t-test. Thicker sherds (n=116) had an average thickness of 11.6mm and greater thickness of oxidation compared to thinner sherds (n=84). (Test results are statistically significant at a 95% confidence interval.) Heavy oxidation on thicker sherds runs counter to what would be expected if vessels were being used for indirect-heat cooking. Oxidation thickness ranged from 0 (no oxidation present) to 18.9 mm thick and was oriented to the exterior wall of every sherd that showed evidence for it.

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Frequency</th>
<th>Percentage</th>
<th>Average Thickness of Oxidation</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.9 - 11.5</td>
<td>123</td>
<td>62%</td>
<td>2.3</td>
</tr>
<tr>
<td>11.6 - 14.9</td>
<td>60</td>
<td>30%</td>
<td>4.3</td>
</tr>
<tr>
<td>15 - 21.5</td>
<td>17</td>
<td>9%</td>
<td>8.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>200</strong></td>
<td><strong>100%</strong></td>
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single sherd possibly had interior wall oxidation though it is open to speculation because of the overall shape of the sherd made it difficult to determine its orientation.

A Chi-Square ($x^2$) test suggests that oxidation and sherd thickness are associated. Oxidized sherds ($n=110$) accounted for 57.5 percent of 200 sherds in the sample. The total number of oxidized sherds is greater than the expected value of 96.86. Conversely, 19.14 rims were expected to be oxidized to the actual count of six. Results indicate that oxidized sherds are thicker and therefore more likely to be body or basal sherds. Thicker sherds also have higher levels of oxidation when compared to rim sherds. The association yields a Chi-square ($x^2$) value of 25.72 with 1 degree of freedom at the 95% level of confidence.

Only one rim was oxidized out of the 32 examined, all of the others were reduced and had heavy amounts of dark organic matter on the vessel wall interior. Heavily reduced rim sherds are a strong indicator that the upper portions of vessels were not in direct proximity to open fire. This is also significant considering the vessels are heavily tempered with fiber. If the upper portions of vessels were exposed to the same levels of heat as their lower counterparts, the organic fibers within their walls would burn up, and lead to increased porosity and more direct exposure to heat and subsequent oxidation. This stands in contrast to the unoxidated rims in the Squeaking Tree assemblage.

A contrasting picture emerges when the overall vessel form and oxidation thickness of the sherds is compared. On one hand, overall oxidation thickness lends evidence to support the idea that the Squeaking Tree vessels were used for direct-heat cooking. There also appears to be a correlation between sherd and oxidation thickness with thicker sherds having greater levels of oxidation. However, the overall morphology of the vessels is more conducive to indirect-heat cooking; vessel walls are thick and heavily tempered while the vessels appear to be flat bottomed. Sooting is also notably absent from all of the sherds. An explanation of these seemingly divergent characteristics may lie in the total thickness of oxidation.

Oxidation is most prevalent on the thickest sherds. If vessels were being used for indirect-heat cooking, as suggested by vessel form, oxidation would be expected to be fairly uniform. Some sherds may display more than others because of differential exposure to heat when they were initially fired. However, this is not the case here because oxidation thickness increases as sherd thickness increases. The lack of oxidation on the rim sherds also indicates that the oxidation resulted from use after the vessels were made. Therefore, thicker oxidation levels are likely the result of differences in exposure to heat from use rather than initial firing.

Thick vessels were needed to overcome high levels of attrition that resulted from constant exposure to heat as the vessels were used directly in fire. Surface attrition is present on all of the sherds but particularly on thicker sherds. Almost all of the sherds in the sample are pitted and otherwise eroded. Pitting may be the result of continued heating and cooling while the vessels were used for cooking and the addition of moisture would only further exacerbate the effects of thermal stress (Skibo 1992:106). Pottery users at Squeaking Tree were in a sense fighting an uphill battle. Their pots were more conducive to insulating heat rather than conducting it but their size and shape was needed to insure that vessels could survive being subjected to the continued stress of direct heat cooking.

The absence of soot on sherds may also be explained through vessel use. If vessels were placed directly on coals and embers they would be exposed to heat but not the requisite flames needed for soot deposition. Flames must be present to physically and chemically combust properties in wood in order for soot deposition to occur (Hally 1983; Sassaman 1993:143; Skibo 1992). A lack of soot deposition suggests that the Squeaking Tree pots were used for direct-heat cooking though they were likely placed in coals as opposed to open flames. Pots placed in direct proximity to coals would be less likely to develop soot deposits because glowing coals with heat but little or no flame would not generate the requisite combustion for soot deposition to occur (Skibo 1992:154).
Conclusion

Examination of the artifact assemblage from the Squeaking Tree site provides evidence, based on spatial, temporal, and use-wear differences, that fiber-tempered pottery in the Ocmulgee Big Bend Region of the interior Coastal Plain of Georgia may warrant its own distinct type name to adequately differentiate it from wares further to the east. This will, of course, need to be substantiated by examining more assemblages of fiber-tempered pottery from the region.

Overall vessel forms at the site were likely short-walled and flat-bottomed but this will need to be corroborated by the analysis of materials from multiple sites. A techno-functional analysis of early pottery from the site demonstrates that it was used for direct-heat cooking as suggested by thick basal sherds with high levels of internal wall oxidation. Heavily reduced rims also indicate the upper portions of vessels were not exposed to the same levels of heat as the lower parts. At first glance, overall vessel morphology is similar to forms used for indirect cooking; walls are thick and heavily tempered, qualities that are conducive to insulating rather than conducting heat. Thick vessels, however, were needed to counter the detrimental effects that direct heat cooking had on vessels.

The findings here are noteworthy because the Ocmulgee Big Bend is well outside the range of the Stallings/St. Simons and Thom’s Creek pottery series. Aside from geographic dissimilarities, pottery types also differ with regard to surface treatment and use. The 3460 +/-60 BP AMS C-14 determination also indicates that soapstone vessels at Squeaking Tree post date the use of both Stallings/St. Simon’s and Thom’s Creek vessels in the Middle Savannah River Valley. The use-wear recorded from this analysis of the Squeaking Tree sherd assemblage is also important because it documents a new method for determining how cooking pots were used, i.e. whether they were used for direct versus indirect-heat cooking based on the presence and orientation of oxidation within vessel walls.

The co-occurrence of fiber-tempered pottery with soapstone vessels also points to a connection with the interior and their relationship in the Big Bend should be further explored. Evidence presented here shows that fiber-tempered vessels were used in a similar way to soapstone vessels. A complex relationship is suggested between them in other parts of the southeast, like the Savannah River Valley (Sassaman 1997). What part the Big Bend played in the social dynamic of areas known for distinctive concentrations of early pottery is not understood and needs to be addressed through further research. The presence of both Stallings and Orange fiber-tempered pottery in the area is also particularly interesting and needs much more attention. Late Archaic assemblages from the Ocmulgee Big Bend may represent the melding of disparate cultural traditions from distinct geographic areas. This is an important consideration regarding the utility of developing a new type name for fiber-tempered pottery from the Ocmulgee Big Bend. Our energies may be better spent working to establish a phase to account for the arrival of early pottery in the region rather than adding yet another name to an already long list of pottery types in Georgia. Certainly a divergent use of pottery, as suggested here, is a good direction for continued research. More studies like this one are needed to substantiate this claim and attempt to explain the social connectivity of people living in the Ocmulgee Big Bend region of the interior Coastal Plain of Georgia to those of the greater Southeast.

Acknowledgements

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Caught Knapping: A Modern Flintknapping Station in Greene County, Georgia

by Scott Jones and Jerald Ledbetter

During the spring of 2001, an archaeological survey crew located a “site” consisting of modern flintknapping debris within a camping area on the shoreline of Lake Oconee. The site was revisited by Ledbetter and myself in April 2001 and named the Boy Scout Site (Figures 1 and 2). The visits resulted in three collections of lithic material, two surface “grab samples” and one screened sample. These collections were analyzed in part for the uniqueness of this type of site, as well as to provide a prototype for the interpretation of modern lithic sites. As flintknapping becomes more popular as a recreational craft, such interpretations are increasingly necessary to distinguish prehistoric from modern activity. In the present case, this is accomplished by examining the technical approach of modern knappers and analysis of raw materials. With all the evidence viewed collectively, the Lake Oconee site demonstrates the degree to which modern lithic sites are interpretable.

Analytical Methods

The artifacts were analyzed according to the accepted conventions of lithic analysis. While generally successful, the standard categories of core, biface, and various grades of reduction debitage were inadequate for interpreting the strategy (or lack thereof) of the novice knapper. This will be elaborated later. Table 1 lists the artifacts by material and type.

Raw Materials

The raw materials present are representative of those used by many contemporary knappers, with natural stone from local and distant (commercial) sources, and man-made materials (Figure 3). The Coastal Plain chert is unmistakably from the Stony Bluff area of Burke and Screven Counties near the Savannah River. This locality is well known among knappers, and has long been a source of chert for prehistoric as well as modern flintknappers (Figure 4). Though sometimes found as large boulders, the material found at the Greene County site appears to be from small cobbles. This is the typical form of the material found along the dirt road at the source in southern Burke County.

The exotic materials are readily available from either rock shops or commercial purveyors of knapping stone (Figure 5). The obsidian debris consists of no less than 3 varieties, and possibly a fourth: black and very glassy; clear-streaked black, which may be part of the black type; opaque, matte-black; and silvery-gray. These are all common varieties, and thus a source cannot be confidently named, but much of the commercially available obsidian is from central Oregon.

Of the lesser varieties of raw materials, four have been identified. Novaculite is a distinctive white chert from Arkansas, and is popular among knappers. The unidentified chert is believed to be from Texas, a conclusion based on the chert itself and from the cortical surfaces on two of the bifacial
Figure 1. Photograph of the Boy Scout site taken in 2001. Photograph shows large granite boulders along the shoreline and various types of site furniture.

Figure 2. Plan map of the Boy Scout site (the primary lithic activity areas is shown just to the west of the turkey target).
Table 1. Artifact Totals from the Boy Scout Site.

<table>
<thead>
<tr>
<th>Coastal Plain (Briar Creek/Stony Bluff)</th>
<th>Orthoquartzite (Tallahatta quartzite):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chert:</td>
<td>1 bifaclal thinning flake</td>
</tr>
<tr>
<td>2 cores/fragments (1 thermally altered)</td>
<td>Unidentified chert:</td>
</tr>
<tr>
<td>3 biface fragments (2 thermally altered)</td>
<td>1 tertiary flake (thermally altered)</td>
</tr>
<tr>
<td>1 cross-mended biface (thermally altered)</td>
<td>5 biface thinning flakes (4 thermally altered; two with cortex)</td>
</tr>
<tr>
<td>1 primary flake</td>
<td>Unidentified agate:</td>
</tr>
<tr>
<td>1 secondary flake (from patinated original artifact; thermally altered)</td>
<td>1 core-like chunk</td>
</tr>
<tr>
<td>3 early reduction flake fragment (1 thermally altered)</td>
<td>1 primary flake</td>
</tr>
<tr>
<td>1 tertiary flake</td>
<td>3 late reduction fragments</td>
</tr>
<tr>
<td>7 bicaclal thinning flakes (two struck from patinated original artifacts; 3 thermally altered)</td>
<td>Red glass slag:</td>
</tr>
<tr>
<td>8 late reduction flake fragments (3 thermally altered)</td>
<td>1 multi-platform core</td>
</tr>
<tr>
<td>1 angular reduction fragment</td>
<td>2 core fragments</td>
</tr>
<tr>
<td>8 thermally shattered chunks</td>
<td>1 tabular biface/core fragment</td>
</tr>
<tr>
<td><strong>Obsidian:</strong></td>
<td>3 tertiary flakes (1 retrofit to core; 1 blade-like flake)</td>
</tr>
<tr>
<td>2 core fragments</td>
<td>1 angular reduction fragment</td>
</tr>
<tr>
<td>2 biface fragments</td>
<td>Yellow/green/pink glass slag:</td>
</tr>
<tr>
<td>1 preform</td>
<td>1 modified piece</td>
</tr>
<tr>
<td>2 bifacially modified flake fragments</td>
<td>2 tertiary flakes</td>
</tr>
<tr>
<td>2 primary flakes</td>
<td>7 bicaclal thinning flakes</td>
</tr>
<tr>
<td>2 early reduction flake fragments</td>
<td>14 late reduction fragments</td>
</tr>
<tr>
<td>3 tertiary flake</td>
<td>3 angular reduction fragments</td>
</tr>
<tr>
<td>46 bicaclal thinning flakes</td>
<td>Blue glass:</td>
</tr>
<tr>
<td>20 retouch flakes</td>
<td>2 angular flake fragments</td>
</tr>
<tr>
<td>51 late reduction flake fragments</td>
<td>Toilet tank ceramic:</td>
</tr>
<tr>
<td>8 angular reduction fragments</td>
<td>2 bifacially modified, angular slabs</td>
</tr>
<tr>
<td><strong>Novaculite:</strong></td>
<td>2 bicaclal thinning flakes</td>
</tr>
<tr>
<td>1 biface fragment</td>
<td>1 late reduction flake</td>
</tr>
<tr>
<td>2 bicaclal thinning flakes</td>
<td>Brown bottle glass:</td>
</tr>
<tr>
<td>1 late reduction flake fragment</td>
<td>4 small sherds (&lt;2cm.)</td>
</tr>
<tr>
<td></td>
<td>2 retouch flakes</td>
</tr>
<tr>
<td></td>
<td>Clear bottle glass:</td>
</tr>
<tr>
<td></td>
<td>1 small sherd (15x8 mm; with embossed numbers “0297”)</td>
</tr>
</tbody>
</table>
Figure 3. Graph showing percentages of various raw materials collected from the site.

Figure 4. Examples of prehistoric artifacts made from Coastal Plain chert used as raw material by the modern knapper.
Figure 5. Examples of exotic lithic raw materials collected from the site.

thinning flakes. The orthoquartzite flake is the classic silvery-gray Tallahatta quartzite, from southern Alabama and Mississippi. The presence of this flake, taken in consideration along with other factors, may provide clues to the time during which the mystery knapper worked at the site. The unidentified agate has a smooth cortex that appears to be wind—or water-worn. In overall appearance, it is most similar to commercial agates from Brazil, and may have been purchased from a rock shop. It is unheated and very tough. Although Brazilian agates are sometimes sold through knapping suppliers, it is generally sawn into thin slabs and thermally altered prior to sale.

The man-made (Figure 6) materials are likewise consistent with modern knapping practices, with glass slag, bottle glass, and toilet tank ceramic (a.k.a. johnstone or thunderchert) represented (Waldorf 1984). It may be inferred that the bottle glass and toilet ceramic were obtained more or less locally. Chunks of brightly colored slag glass are readily available at roadside rock shops and pet stores where it is sold for decorative use in aquaria. As presented below, however, the slag glass from this site, when viewed in the context of the overall assemblage, provides clues to the date of the site and the origin of much of the raw material.

Analysis of Flintknapping Technique

In order to discuss the raw materials fully, they must be interpreted in light of the technique(s) applied to them. While the knapper was aware of, and had access to, a wide range of acceptable materials, the skill level reveals shortcomings in the quality and/or extent of training. As mentioned above, the conventional categories of lithic analysis were forced into use, but this effort was complicated by the lack of strategy applied by the knapper to biface manufacture. The few bifacial thinning flakes of novaculite, Texas chert and Tallahatta quartzite are well formed, generally with good platform remnants, and appear to have been struck from spalls or bifaces. These are forms in which such commercial materials are often sold. The small amount
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Manufactured Materials

Figure 6. Examples of man-made raw materials collected from the site. Red Glass Slag (upper left, first and second from left), White Glass Slag (lower left, first and second from left), Blue Glass Slag (lower left, third from left), Conjoined "Johnston" Biface (upper and lower right).

of these relatively expensive materials also indicates a conservative attitude towards them.

Obsidian is the most extensively used and abundant material (by count) from the site. The obsidian debitage also contained many good examples of bifacial thinning flakes. It is an excellent material for amateur knappers; it is easily worked, yields a high rate of success, and is relatively inexpensive even when mail-ordered. Also, rock shops often carry obsidian in large chunks, and despite the greater cost commanded for obsidian in the lapidary trade, the size of available pieces would serve to increase the visibility and use of this material. Judging from the multiple varieties present, the tabular nature of the core fragments, and the well-structured thinning flakes, I suspect that the obsidian was purchased from the same commercial dealer that supplied the novaculite, Texas chert, Tallahatta quartzite, and slag glass.

By contrast, proximate (relatively speaking) Coastal Plain chert provided a source of abundant stone free for the gathering. This material was readily identified as the type found in the Stony Bluff area along the Burke/Screven County line. An effort was made to thermally alter much of this chert to improve workability. While two bifaces (a fragment and the conjoined artifact) were of thermally altered chert, the presence of much thermally shattered chert in the immediate vicinity of the knapping station suggests an imperfect of knowledge of heat-treating. Unlike the novaculite and Texas chert that are typically heated in a kiln by the dealer, the chunks of Coastal plain chert presented special challenges to our knapper. Scavenged prehistoric blanks (Figure 6) represented in the assemblage (as evidenced from the patinated surfaces, commonly found as artifacts throughout the Stony Bluff area) provide some of the same advantages (tabular or relatively thin pieces) as commercial
spalls and blanks. To the novice knapper unschooled in the preparation of bifacial edges and the subsequent execution of thinning, pre-prepared spalls and preforms with thin edges bypass much of the learning required for core reduction and biface manufacture. Among the three Coastal Plain chert biface fragments recovered, the two largest show unsuccessful attempts to remove subsequent flakes from square, broken edges. This is likewise evident in the largely unsuccessful efforts to “thin” the angular slabs of toilet porcelain by striking unmodified 90 degree edges.

The glass slag presents some of the same reduction problems as other blocky natural materials. Without knowledge of systematic core reduction, chunks of material (either natural or manmade) are often of little use to the amateur knapper. With the exception of a thick, core-like bifacial fragment of red glass, only one of the glass pieces (a long, narrow angular fragment of the yellow/green/pink material) shows signs of a strategic effort to create a bifacial tool. Though not bifacial in execution, this piece exhibits modification along one edge in an aborted effort to shape the piece.

A cursory examination of flake scars and platform remnants reveals little about the type of percussors used; prior to the early 1990s, either wooden batons or copper billets were relatively scarce among knappers in the region, and it is likely that stone hammers and antler billets were utilized. Copper-tipped pressure flakers, however, have long been in service among modern knappers, and the obsidian retouch flakes consistently show either heavy bulbs of force and/or crushed platform remnants, both of which indicate the use of copper pressure tools. No copper residues were noted on the artifacts.

Discussion

In light of the foregoing discussion, the modern knapping station may be interpreted as follows: With regard to temporal setting, the range of commercial raw materials reflects availability prior to the early 1990’s. This is likewise reflected in the types of tools possibly used. In terms of skill, a novice knapper (or knappers) during this time would have had limited resources for instruction as well, depending perhaps on only one of the available publications. The most widely available of these at the time is Waldorf’s *The Art of Flincknapping* (1984).

During the time that the knapping station is believed to have been in use, one of the few suppliers (actually the only supplier, to my knowledge) of commercial materials was Homochito Replication and Supply of Natchez, Mississippi. This enterprise, co-operated by Wilkie Collins (since about 1991 operating solo under the name of Native Way, Washington, Mississippi), offered a variety of raw materials for sale. My initial suspicions about the date of the site were reinforced by a review of the Homochito supply list from 1986. The catalog advertises obsidian, Texas chert, novaculite, Tallahatta quartzite, and chunks of slag glass. Except for the glass, lithic materials are also offered as spalls and preforms. Of special interest is the advertisement for “#2 mixed spalls and preforms” containing an assortment of materials including “some of all our varieties...heated cherts and novaculites, and unheated flint and obsidian.” The catalog also advertises flintknapping tools and kits featuring antler billets as well as copper and antler pressure flakers.

In addition to a wider range of obsidian and Texas chert being available by the early 1990s (various advertisements by Craig Ratzatt, “Neolithics,” Springfield, Oregon, ca. 1990; Butch Nemec, Nemec Stone Co., Jarrell, TX, ca. 1994), two other materials are conspicuous by their absence. By the early to mid 1990s, high-quality rhyolites from the Uwharrie Mountains of North Carolina became widely available. Also, in 1993 a drainage canal was opened in Albany, Georgia, and made the Flint River a destination for commercial knappers/suppliers seeking the distinctive high-quality butter-scotch-colored chert found there. Though inconclusive, the absence of either of these materials points to a time before they were widely available, further bracketing the temporal range for the site. The absence of Flint River chert is of significance since the presence of Stony Bluff chert indicates an awareness of Coastal Plain chert in Georgia.

Two other materials are absent from the collection. Quartz, a locally abundant material, is not
represented. Quartz is difficult to work, and even today most knappers prefer to avoid it unless they are involved in archaeological replication. Also missing is the dark chert from the Ridge and Valley province of northwestern Georgia. This material is often high in quality, but because it occurs most often in small pieces and has limited range of occurrence in the state, it enjoys little popularity except among knappers living in that part of the state, and a few veteran knappers.

Excepting the Stony Bluff/Brier Creek chert, the natural lithic materials present at the site and slag glass were offered for sale by Homochito Replication and Supply in the mid- to late 1980s. By spring of 1991, Collins had begun advertising as Native Way in the first edition of the Bulletin of Primitive Technology. A review of the 1993 Native Way price list offers only obsidian and novaculite. The entire suite of exotic raw materials including Texas cherts, novaculite, Tallahatta quartzite, obsidian, and slag glass was available from a single dealer (Homochito) until about 1991. It is postulated that these materials at the knapping station came from this source.

The Stony Bluff area on the Burke/Screven County line was one of the few widely known sources of Coastal Plain chert in Georgia for a number of years. In addition to being known to archaeologists, the accessibility of the site and disturbed context of the dirt county road that cuts through the outcrop made it one of the few sources to which they were willing to direct flintknappers.

The absence of Flint River chert or North Carolina rhyolite reinforces the argument for a date prior to about 1993. In light of the fact that the knapper was well informed enough to have learned about Stony Bluff and have contact with Homochito Replication and Supply, it is doubtful that the widespread availability of other local/regional materials would have gone unnoticed.

The flintknapper was a novice. Except for a few well-formed flakes resulting from further modification of previously shaped material (presumably aboriginal artifacts and commercial preforms), biface manufacture show violations of several cardinal rules. The broken bifaces indicate that flake removal was attempted by striking above the centerline platform; attempted shaping by striking square edges without prior edging and preparation is also telling. Little if any platform or edge preparation prior to flake removal is evident, and crushed and step-fractured platforms are common.

**Interpretation**

The interpretation is thus: In the late 1980s or early 1990s, a neophyte flintknapper (or flintknappers) engaged his hobby for recreation or demonstration (perhaps both) at a deer hunting camp. Much of the stone used is believed to have originated as mixed stone from Homochito Replication and Supply, and possibly a flintknapping kit ordered from the same. These commercially acquired materials were supplemented with others of local provenience, including Coastal Plain chert from the well-known Stony Bluff locale, toilet tank ceramic, and bottle glass. Though probably ordered from Homochito, the glass slag may also be of local origin.

Few people were teaching flintknapping at this time. Instruction was available through a few obscure publications or, rarely, from individuals. During this time the senior author taught a few sessions in flintknapping through the Georgia Center for Continuing Education. The assemblage echoes much of Jones' teaching at that time, including commercial and local sources, and man-made materials. While the assemblage may have arisen from an entirely different set of circumstances, it may well be that the flintknapper in question endured one of Jones' early teaching efforts.

**Conclusion**

While some would question the importance of interpreting modern knapping sites, flintknapping for recreation, commerce, and research is a reality. The potential exists for muddling the archaeological record, and as the craft gains in popularity, raw material sources are being overtaxed (for a discussion of the effects of modern flintknapping see Whittaker and Stafford 1999). Nevertheless, sites such as the one examined here are likely to be increasingly encountered by archae-
ologists. Successful efforts to instill in the public an active interest in prehistory will no doubt generate desirable as well as undesirable effects. The identification, analysis, and interpretation of these sites is the responsibility of archaeologists and primitive technologists alike.

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Quartz Tool Technology in the Northeast Georgia Piedmont

by Scott Jones

In this paper, I use data from surface collections made in Oglethorpe and adjacent portions of Wilkes Counties of northeast central Georgia to show the potential of surface surveys to contribute to archaeological knowledge and research in the region. From within a framework of geographical and geological background, culture history, and technical evaluation of quartz, I examine and interpret the various strategies for prehistoric quartz tool production in the study area. Additionally, I attempt to reproduce a number of reduction strategies, core forms, bifaces, and specialized tools identified in the analysis in an effort to aid in the interpretation of archaeological materials.

Before presenting my analyses, replication efforts and ultimate interpretations based on those surface collections, I attempt to contextualize the use of quartz as a stone tool raw material source in northeastern Georgia. In the following sections I examine the problematic nature of quartz, present a working classification of quartz varieties and discuss several important issues relating to quartz as a tool, its distribution and quarrying, and its use in understanding the past.

Thinking Quartz

Quartz, the macrocrystalline form of silica, is a material that often elicits derisive remarks from archaeologists and frustrates lithic analysts. Among lithic materials, quartz is poorly understood, and strategies for quartz tool production are all too often misinterpreted. It is frequently derided as an inferior material, and analyses of quartz artifacts are often grossly simplistic. Working in a region where quartz is the dominant lithic material, I have long been a proponent of rigorous analysis based on experimentation and comparison. My earliest efforts at flintknapping were conducted with quartz, and I have since worked to decipher the mystery surrounding its use in Georgia and other parts of the southeastern United States.

For several years I tried to make sense of the seeming chaos of quartz tool production in the east Georgia Piedmont. In addition to the overwhelming use of a material fraught with interpretive problems, the hodgepodge of highly variable lithic resources available in the Piedmont of eastern Georgia has made a cogent interpretation of lithic technology in the region difficult. Early on, I was inspired by Flenniken's (1981) Hoko River work that combined quartz tool technology, bipolar flaking, and the prospect of the identification of gender in stone tool assemblages. Facing an overwhelming prejudice against quartz that teetered on the brink of superstition, I persisted in my pursuit. In 1996, an excerpt from Errett Callahan's An Evaluation of the Lithic Technology in Middle Sweden During the Mesolithic and Neolithic (1987) was reprinted in the Bulletin of Primitive Technology (1996). The excerpt showed drawings of bipolar cores of quartz and quartzite, with illustrations and explanations of anvil and bipolar
flaking. That the study was conducted by an accomplished replicator with an eye towards demonstrating the technology through replication was of significance to me, and resonated with my growing interest in quartz lithic extractive strategies.

Though based on lithic technology from another continent, I recognized immediately this as the template I sought. I contacted Callahan and borrowed a copy of the original 1987 publication, and, since it was out of print, secured his permission and promptly copied it. In 1997 I drafted the quartz material typology, and began in earnest to direct my work towards compiling a cogent reconstruction and interpretation of quartz tool technology. I have since located others who, even if not involved in the replicative aspect, nonetheless recognize the importance to regional archaeology of an understanding of quartz tool technology.

My participation in archeological testing at Lake Oconee in nearby Greene County, Georgia (Ledbetter 2000; Ledbetter et al. 2003) has been influential in the refinement of my interpretations of quartz tool technology. While artifacts from the designated project area provided the necessary data for this article, systematic testing at Lake Oconee provided screened samples that (among other things) helped counteract the biases inherent in surface collections. The availability of controlled samples and raw materials allowed me to test and refine the vague suspicions inferred from my surface collections.

The prejudice against quartz tool technology in North America results in part from the limited distribution of the material. Ironically, this prejudice is sustained because of the ubiquity of quartz within its range of occurrence. Also, artifact assemblages are dominated by bifacial tools and projectile points, the result of which is a pervasive over-emphasis on the archaeological significance of biface production that I call the biface bias (Jones 2001a; Ledbetter et al. 2003). Hence, the identification and recognition of specific strategies for tool production have gone largely unexplored. Only recently have North American archaeologists begun to recognize and define a broader set of technological imperatives for quartz tool extraction, reduction, and use (Flenniken 1981; Barber 1981; Neumann and Polglase 1992; Webb et al. 1993; Webb 1998; Cantley et al. 2000).

Such is not the case in the Old World, where long expanses of time include a vast array of tools and tool-making strategies. This is particularly evident in Africa, a large and geologically diverse continent with millions of years of lithic technology. The diversity of Old World tool types has forced archaeologists to consider a wide range of possible production strategies. This is well illustrated in the microlithic traditions of the Late Stone Age in Africa and Neolithic Europe. In addition to recognizing specific non-bifacial techniques for tool production, African archaeologists have been more accepting of quartz as a lithic material, and more objective in their interpretations of the use of quartz in prehistoric assemblages (Phillipson and Phillipson 1970; Phillipson 1976; Gramly 1981; Sussman 1985, Casey 2000).

This article is an interpretive assessment of quartz lithic assemblages in a restricted geographical area within a major geophysical region. Its purpose is, in the broadest sense, twofold. The primary goal is to use archaeological data to dissect the dominant strategies for quartz tool production and present them in an organized way. This functional/typological approach necessarily entails a number of heuristic assumptions. Apart from a brief exploration of the possibility of gender identification, it is beyond the scope of this work to address topics of social organization or ethnic identity in lithic assemblages. The second purpose is to use replication to demonstrate these techniques and reinforce the interpretations. My intent is not to embark on a mission of self-gratification by showcasing skills cultivated over many years—five-centimeter bifaces are scarcely the stuff of flintknapping dreams (Jones 2005a). Overtly, my goals are directed at the demystification of quartz tool production and to inspire others to reinforce lithic analyses with sound replicative and comparative work. Less obvious, perhaps, is the desire to encourage future research into the broader sociocultural implications of Piedmont lithic assemblages.
The Quartz Problem

Quartz is defined by some researchers as all forms of nearly pure macrocrystalline and cryptocrystalline silica (cf. Andre'sky 1998: 23). While Andre'sky defines as quartz all varieties of "cherts, flints, or chalcedonies," he scarcely mentions the use of macrocrystalline quartz as a lithic material, referencing only the work with crystal quartz by Reher and Frison (1991). Quartz, as used in this study, denotes exclusively massive macrocrystalline silica. Variety and/or area of geographical origin (Coastal Plain chert, for example) distinguish other lithic materials.

As with other lithic materials, the physical limitations of raw material package size play a role in interpretive problems. Apart from flake scar definition, small package size of much of the available quartz material must be taken into account. Large chunks of quartz often contain multiple fractures, and when finally broken into intact constituent pieces, the actual size is rather small. Reduction strategies must be adjusted to permit the production of desired types of cores and flakes. Quartz artifacts reduced by conventional means are difficult enough to translate. With anvil flaking and bipolar flaking the difficulty in identification is compounded.

Another persistent difficulty with quartz is the entrenched notion that, as a raw material, it is ubiquitous, and as a tool it is used almost exclusively as an expedient. Although it is true that small package size and proximate availability of quartz allows for routine replacement of tools, collections generally show a preference for better grades. On non-quarry sites, it is often noted that surface artifacts contrast sharply against the soil background, and are of better quality than quartz present on the site (Tippitt and Marquardt 1984: 6-12; Canitt and Goodyear 1985: 188). It has been observed that certain types and qualities of quartz were specifically selected for use. This is aptly expressed by Benson (1995, also quoted in Cantley 2000):

...not all quartz was "expediently" procured for tool production. Since quality varies between different types of quartz, it follows that certain quartz sources were probably valued more than others and thus exploited more often than others throughout prehistory. The value of quartz, both technologically and sociopolitically, is likely to have changed from one prehistoric time period to the next.

Although quartz is ubiquitous throughout the Piedmont, the most desirable types best suited to tool manufacture are not. Yet if a selective preference for high-quality quartz can be demonstrated, local/regional logistical planning need not entirely exclude expediency.

Rethinking Quartz

It is clear to me that there is room to rethink quartz and how it is used as a stone tool raw material. In this section, I deal with a variety of issues ranging from descriptive categories of quartz raw material to ways of understanding its use in tool production.

Quartz Raw Material Categories

Quartz artifacts from the survey were divided into one of the six following categories during the analysis. I originally devised this system in 1997, with only minor changes since then. It is based (however subjectively) on translucence and fracture surface texture, and approximates the intuitive ranking of desirability. In short, Types 1-3 and high-quality Type 4 are glassy, and average Type 4 and Types 5-6 are grainy. Other efforts have been made to classify quartz raw material (Abbott et al. 1987; Blanton 1983), and Dickson (1977: 102) mentions color and opacity as indicators of quality.

Translucence is used to distinguish the first four types. Surface fracture texture, on the other hand, is an important indicator of quartz quality for all types. The quality of fracture is directly linked to 1) the amount of detail visible in flake scars and 2) the quality of a fresh flake edge. The more detail available in flake scars, the more accurate may be the interpretation of a tool's manufacture, use, and overall life history. The most common system currently in use consists of "crystal" and "other". If a
program of more detailed analysis can be established, it may then be possible to demonstrate that prehistoric stone-workers showed a selective preference for certain types of quartz. Different types of quartz also have specific technical characteristics that are of particular relevance to lithic function.

The following six groups constitute a continuum, with one type grading into one or more of another. They represent culturally usable (if not always the most desirable) quartz. There are many avenues for intergradation, and the ones noted are most commonly seen. A single outcrop of quartz will often contain several types; a hand sample or artifact may even contain two distinct types. Quartz displaying intermediate characteristics of two defined types is sometimes encountered, and it may be described as such. For example, much of the quartz encountered in the Lake Oconee/Wallace Reservoir area has a marble-like quality that falls between Types 4 and 6. Consequently, it was dubbed Type 4/6.

Fresh fracture surfaces on some types of quartz (especially Types 2, 4, and 6) differ in appearance from weathered surfaces of artifacts of the same material. Raw material samples should be washed before comparing them to artifacts. Short of actual weathering, this permits a more accurate basis for comparison of recent samples to prehistoric artifacts.

**Type 1) Crystal:** Clear, glass-like. Flake scars visible in great detail, fresh edges are smooth and sharp. Minute use-wear is readily evident. Crystalline quartz may be distinguished from glass by the presence of fissures and hackles in the flake scars, and it is harder; crystal quartz will readily scratch glass. In massive form, crystal quartz may show color (i.e., amethyst, rose, or smoky), but thin pieces are virtually colorless. This type ranges from perfectly clear to slightly cloudy, and may grade into Types 2 or high-quality 5.

**Type 2) Ice:** Few to many streaks of white mixed with clear. Fracture varies from glassy to slightly irregular or frosty, with edge quality and flake scar detail following. With decreasing flake scar resolution, it typically grades into Type 4.

**Type 3) Milk Glass:** Smooth, nearly opaque to translucent, glass-like. Better grades have a "greasy" feel. Extremely detailed flake scars, with smooth, sharp edges. As with Type 1, this quartz can be distinguished from white glass by hardness and the presence of hackles in flake scars. Grades into Types 4 or 5; with increased streakiness grades into Type 2.

**Type 4) Milky:** Fracture surfaces are bumpy to slightly grainy. Edges are sharp but sometimes ragged; flake scars are discernible with varying degrees of difficulty, but lack the flake scar detail of Types 1 and 3. Use-wear is difficult to detect, but retouch is often apparent. This category defines much of the common vein quartz, and by virtue of availability, is the most widely utilized type in many areas. Most examples of this type are white, translucent to nearly opaque. Streaked varieties are common, representing the lower end of Type 2. This type intergrades most commonly with Type 3, and occasionally with Type 5. This is the most common type of quartz in the study area.

**Type 5) Frosty:** Increasing graininess of Types 1 or 3 results in this type. Very homogeneous with relatively obvious flake scars and correspondingly uniform edge quality, this quartz has the appearance of frosted or sandblasted glass. Texture varies from grainy with a "greasy" feel (approaching Types 1 and 3) to minutely sugary (approaching Type 6). The slight graininess of surface and edge yield less visible flake scars and use-wear by comparison to Types 1 and 3, but better grades are comparable to the lower grades of Type 2 and 3. Type 5 Grades into Types 3, 4 or 6. Color is usually white, buff, pale green, or pink (heat altered). Translucence varies with texture.

**Type 6) Grainy/Sugary:** Details of flake scars indistinct, but depending upon the coarseness, large individual scars are readily visible. Use-wear is difficult to detect. This type is similar to, and in some instances is indistinguishable from, quartzite. From a technological and analytical standpoint, this type of quartz is functionally similar to quartzite. Colors range from buff to tan, pink, and red (in heat altered specimens). Pale green varieties are sometimes seen.
The analysis of over 4,000 artifacts into raw material categories was cumbersome and tedious, especially in light of the amount of useful information obtained. Over time, though, it has proven to be a useful shorthand for describing sources of raw material or characterizing artifact assemblages. In retrospect, I would broaden the qualifications for Types 2 and 3 to include better grades of Type 4 quartz.

With respect to tool function, the following observations are drawn from experience, and relate functional characteristics to particular types of quartz: Most quartz can be used for general cutting tasks. Glass-like quartz (Types 1-3) is useful in situations requiring a clean cutting edge (butchery or scarification, for example). Crystal types (Types 1 and 2) hold up well for cutting/scraping/smoothing hard materials like bone, antler, and wood. Milk-glass (Type 3) quartz, while extremely sharp, seems to dull rather quickly and does not hold up well when cutting/scraping hard materials. Type 4 quartz is an intermediate material with a wide range of variation. It is useful for many tasks, and is abundant. While Types 4-6 can be used for most purposes, these rough-textured types (especially Type 6) have a rasp-like quality that is advantageous for sawing hard materials. Thus, given the expected range of variation in raw material in an outcrop or region, it is possible to assemble a tool kit consisting of a variety of quartz types selected for different (and probably overlapping) purposes. Throughout the Piedmont of Georgia, tool kits are further augmented by the use of chert from the Coastal Plain and Ridge and Valley regions, metavolcanics, and other local silicates.

Quartz as a Tool: Some Functional Considerations

One aspect of quartz tool technology that receives little attention beyond casual notation is the quality of a particular type of quartz and the associated functional characteristics. Thermal alteration of chert helps extend the qualitative range of this material, thus rendering tough, utilitarian varieties into easily workable, glassy material. The natural variation of quartz fulfills a similar role without the need for heat alteration. Although glassy types of quartz are generally recognized as the most desirable forms, grainy types are highly utilitarian in less obvious ways. Glassy quartz (crystal, milk-glass like, or icy) yields an extremely sharp edge similar to obsidian (Callahan 1987: 57). Such edge quality is unarguably desirable, especially in operations that require clean slicing action. Also, these types are readily knapped into formal tools and bifaces.

As with most other high-quality lithic materials, vitreous types of quartz are not equally suited to all tasks. For sawing and grooving hard materials (like bone, antler, and wood), a smooth, sharp edge and the vitreous flake surfaces create excessive friction. For these uses, tools must be modified (by serration or burination, for instance) into specialized forms. By contrast, grainy types of quartz with less aesthetic appeal can be used as-is to accomplish such tasks. Rough flake surfaces rasp the sides of a cut as the ragged edge deepens it. As applied to lithic material, desirability is often synonymous with vitreousness. Yet this is not entirely accurate, and it should be recognized that quartz assemblages vary widely in quality and utilitarian properties.

Tool Edge Angle

In addition to the intentional selection of quartz raw material for particular qualities, tool edge angle is an important consideration for tool function. Regarding stone tools generally, a sharp acute-angle flake edge, like a modern steel knife, tends to part masses of material cleanly; bifacial edges are well suited to a variety of tasks, including scraping and slicing, but are particularly suited to sawing through material. Flakes are often used unidirectionally, the motion typically either a knife-like slicing action with the ventral surface nearly parallel to the work piece, or in a scraping action in which the edge is held perpendicular to the direction of use. When used perpendicular to a work surface, even relatively soft material like dry hide eventually take a toll on flake edges by shearing small flakes from the surface opposite the direction of motion (use-wear). Hard materials impart greater damage to flake edges, but this consequential steepening of edges renders them more durable for the
task at hand. Archaeologically, many expedient flake tools show this sort of use-wear, and some are evidently flaked intentionally for use as scrapers, concave scrapers ("shaft scrapers," "spokeshaves"), and other tools. By changing the angle (steepness of bevel) of the working edge of a tool, much can be learned about the breadth of tasks for which stone is suited. Hence, with any given lithic material, an acute, sharp edge will be effective and durable in cutting cleanly through soft material (flesh, hide, vegetation, etc.), but this edge may be damaged if it comes into contact with hard material (e.g., wood or bone). A steep-edged tool of the same material, by contrast, may not perform well as a slicing tool, but will be more durable as a planing/scraping tool for working hard materials. Obtuse edges and dorsal flake ridges up to 130 degrees (Crabtree 1974: 46) are surprisingly useful for controlled shaping and smoothing of hard materials, and are very durable.

Redefining "Quarry"

Lithic quarries are often perceived only as sources for bifaces and other tools that will be removed prior to use. The "arrowhead factory" view of quarries in the eastern U.S. is often applied equally to all lithic materials, quartz included, regardless of the presumed degree of curation of bifaces thus produced. This view contrasts with the use of quartz for expedient tools and as a material with which to supplement curated tools. The apparent contradiction disappears if certain types of quartz are identified with curated tools, while other forms (i.e., small package size or less desirable types) are allied with expedient and/or supplemental tools. If this seems to complicate the otherwise simple notion of lithic quarry, bear in mind that the interpretation of quarries (especially quartz) is oversimplified through lack of functional understanding. Conventional notions of quarry must be redefined, and quartz quarries must be interpreted in light of the particular properties of quartz (Canouts and Goodyear 1985: 188).

In some instances, large quarries may supply raw material to outlying workshop and habitation sites. Alternatively, an area containing a large outcrop of quartz frequently includes other secondary outcrops that are subject to exploitation. Both situations are plausible and likely depend on the availability and manner of occurrence of raw material.

It is logical to think that ancient peoples would have utilized vast amounts of expendable, pristine edge for a variety of purposes in a setting that did not require that the lithic material be transported beyond the immediate area. While some tool-like cores may exhibit edge or platform preparation that in some instances is misinterpreted as use-wear, others are obviously and deliberately formed as tools. Just as mobile groups were accustomed to logistical planning for stone tool procurement, they would be equally aware of the potential for non-lithic production at lithic quarries. In other words, it is easier to bring a project to the workshop than it is to transport the workshop to the project. Thus the interpretation of quarry function should be expanded to include not only curated or supplemental bifaces and tools, but also to incorporate an alternative interpretation as a workshop for non-lithic goods.

To illustrate this by example, consider the production of an appropriate composite implement. From my background, the production of an atlatl is one such example. From our understanding of this weapon, it may be made entirely of wood, or may be a composite of wood, antler, stone, sinew, and other fiber goods (Webb 1946; Hester et al. 1974). In a situation where only curated tools are available, the wooden blank would be procured by cutting a small tree with a heavy hafted tool or hand-held core tool. This blank would be further processed perhaps by splitting with a wedge of bone, antler, or stone. It is then shaped by cutting and scraping with a variety of tools from within a curated system, including flakes, bifaces, and unifacial tools. If an antler hook is desired, the antler would be soaked in water until soft, and then shaped with the same suite of tools. Hard wood (even when green) and antler (even soaked) take a significant toll on tool edges, requiring considerable resharpening and maintenance. While entirely
plausible, this approach is expensive in terms of tool cost.

Consider next the production of the same weapon under other circumstances: At a quarry, core-like chunks of lithic material with extremely sharp edges are available in large numbers. Where lithic raw material is abundant, a dull tool may be resharpened, or discarded and replaced with little regard for conservation. Such tools may be customized and effectively used to cut and split wooden blanks, and to hew and plane the blank into the desired shape. The antler piece would be processed through a similar strategy. Specialized tools would be needed for drilling the stone weight and possibly an antler hook, and are likely present in the curated tool kit. Heavy, generalized tools produced expeditiously at the quarry would remain more or less where they were made and used. While curated tools were designed to be used in situations away from the quarry as described in the preceding paragraph, the use of the quarry as a non-lithic workshop eliminates the need to transport excessive numbers of cumbersome core tools.

**Raw Material Distribution and Manner of Occurrence**

Though quartz is often regarded as a ubiquitous resource in the Piedmont, high-quality material is not so widespread as is commonly believed. This further complicated by the high degree of variability in the size of quartz exposures and the patchy distribution of this material. While quartz is known to form under well-defined geological conditions, the complex geology of the Piedmont restricts any meaningful predictive model for distribution.

The manner in which quartz occurs is likewise significant. Natural outcroppings of quartz vary widely in size, as do the individual pebbles, cobbles, and boulders that make up the outcrop. In some instances, large pieces of quartz occur as fairly solid masses. This is especially true for hydrothermal quartz arising from the southern Little River series of the Carolina Slate Belt in east central Georgia. In the study area, the northern Little River series yields patchy yet abundant quartz float in the form of angular to sub-angular chunks. Quartz availability is variable in parts of the study area outside the Slate Belt. This variation in manner of occurrence leaves abundant room for selective decision-making on behalf of ancient toolmakers, mitigated by material quality and size, and desired tool dimensions. A large exposure of quartz regarded as low quality may be entirely ignored in favor of a lesser amount of high-quality material. Seemingly large natural pieces of quartz often consist of fractured pieces weakly bound together. These require reduction to their smallest intact constituent fragments to accommodate tool production.

Similarly, a relationship exists between raw material quality, exploitable package size, and minimum acceptable tools dimensions. High quality quartz tools are highly utilitarian through all stages of manufacture, maintenance, and recycling. With increasingly glass-like properties (especially as raw material approaches Types 1 and 2), ever-smaller package sizes are subject to exploitation. Massive, coarse quartz may be used for a variety of tool forms, but cores and bifaces must have sufficient size to provide stability for controlled flaking.

**Reading Quartz**

While it is tempting to dismiss quartz reduction as little more than a regional manifestation of “nodule smashing” (Boksembaum 1980), the archaeological record suggests that there is a detectable (if sometimes subtle) order to quartz reduction and utilization. Quartz is a highly variable, brittle material that ranges from readily readable glassy types to grainy, bumpy types on which flake scars are barely discernible. Depending on the quality and the flaking technique used, normal flake signatures (bulb of force, curvature) may or may not be present, or may be present in unfamiliar forms (Baker 1976. Anvil and bipolar flaking frequently generate shearing forces within a core, resulting in flat ventral flake surfaces (Cotterell and Kaminga 1987; also cf. Dickson 1977: 97). Qualitative variability often makes use-wear difficult to detect. Lacking reference materials and low-power magnification equipment, tools often go unnoticed. Faced with a quartz assemblage, a lab worker accustomed to chert or other uniform lithic materials is immediately at a loss.
Quartz analysis is dominated by the debris category commonly called *shatter*. This category often functions as a catchall for ambiguous debris. Although the terminology is deeply entrenched in lithic analysis, a more specific alternative term is *angular reduction fragments*. Angular fragments ("shatter") are the frequent by-products of quartz reduction, and yields potentially useful information about reduction techniques. For this category to be useful it is necessary to differentiate (insofar as is possible) true shatter from flake fragments. Common patterns of quartz flake fragmentation (Figure 1) are noted by Knutsson and Lindgren (*under tryckning*), and Callahan (1992). These patterns are representative of those noted by myself, and their experiment need not be replicated in the present study to demonstrate the effect of flake fragmentation on quartz analysis and interpretation.

It is clear from Knutsson and Lindgren's experiments that flake fragmentation in quartz follows some general patterns. Flake fragments are generally derived from radial/longitudinal fractures arising from forces originating at the point of initiation, and transverse fractures arising from tension/compression failure. In analytical procedure, both processes yield angular fragments and triangular (trihedral) fragments. Though the mass of flake debris is confusing enough, the later of these (trihedral fragments) and faceted cone fragments often mimic the products of bipolar flaking. Understanding flake formation processes, identifying small but critical amounts of unambiguous debitage (specifically anvil/bipolar and bipolar cores), and the critical assessment of entire assemblages (including shatter) are important aspects of effective quartz analysis. As Whittaker (1994: 276) notes, "Analyzing 10,000 flakes is a laborious job, but necessary to confirm or deny the vague impressions formed by casual observation."

Further regarding flake formation and fragmentation, it should be noted that rough types of quartz often yield few of the regular flake signatures of textbook lithic analysis (cf. Baker 1976). The shearing property noted earlier often produces few ripples or other standard marks of directionality. The propensity for flake to break apart means that, for a given flake, the bulb of force will be found on only one of several fragments. Taken together, this means that the larger number of flake fragments will possess little information regarding origin or directionality. Yet even on flake fragments, enough information often remains to permit the analyst to distinguish dorsal and ventral flake surfaces. Ridges on the dorsal surface and curvature (concave on the ventral surface) are useful indicators. Lacking

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**Figure 1. Experimental quartz flake fragmentation patterns.** After Knutsson and Lindgren (*under tryckning*). As described by Knutsson and Lindgren, “Types of fractures observed in quartz flakes in two series of experiments in which quartz cores were broken up in accordance with a 'prehistoric' schedule.”

A shows Lateral fragment, middle fragment, proximal part of lateral fragment, medial part of lateral fragment, and distal part of lateral fragment; B shows lateral fragment (splinter), and proximal, medial, and distal lateral fragment; C shows proximal, medial, and distal middle fragments; D shows conical fragment and distal anvil fragment; E shows secondary high-velocity fracture; F shows proximal, medial, and distal transverse flake fragments; G shows triangular transverse fragment (anvil flake). English translations adapted from personal communication from Kjel Knutsson, 2002.
these, flake directionality can be determined by the subtle lines that converge towards the point of initiation. In quartz (especially the intermediate and poor grades), these are not neat, straight fissures described by Crabtree (1972) and Andrefsky (1998). Though used synonymously with fissure, force line, and grooved shatter line by these writers, I use hackle in reference to the irregular directional fracture of quartz. As applied to quartz,hackles are radiating lines that often intersect with other short lines at approximately right angles. This forms a low, relatively smooth (depending on the quality of quartz) network of bumps or plate-like structures ("chatter") on flake surfaces. When viewed at a low angle, the shadow of the radiating hackles gives a fair indication of the orientation of the flake fragment with respect to the point of initiation and position within the whole flake. This greatly increases the number of identified flake fragments, while reducing the number of artifacts relegated to the shatter category. This is especially when augmented with experience in making and examining quartz flakes, cores, and resulting fragments.

A Multimodal Approach

In the foregoing discussion, I address several approaches towards reinterpreting quartz lithic technology. While these views challenge the various viewpoints of quartz as strictly expedient or supplemental material, I am in reality contending that each potential use—expedient, supplemental, and logistical—is correct to a greater or lesser degree, often occurring simultaneously. In a general reference to lithic technology, Tomka (2001: 209) hints at this in saying "Overall, I see tool manufacture varying along a continuum from expedient to formal," but does not further develop this theme. Drawing from Torrence's (1989) redefinition of variables of Bleed's (1986) maintainability/reliability types, the supplemental and expedient use of quartz is posited as a maintainable means of reducing risk among hunter/gatherers throughout the Archaic. As a logistical material, quartz also fits the criteria for reliability. The concept of optimal quartz tools is elaborated in the biface replicative section, with particular regard to metric attributes.

The widespread availability of quartz in the Piedmont and the apparent degree of non-lithic production at quarry sites suggests that quartz tool procurement conforms to Binford's (1979) definition of embeddedness. Further following Binford's (1980) reasoning, low site density, raw material selection, and high degree of tool formality and curation that characterize Early Archaic assemblages roughly approximates a mixed forager-collector strategy (Sassaman 1996: 71). Abundant Middle Archaic sites consisting of a broad range of quartz material types and expedient tools corresponds loosely to the forager strategy for exploiting relatively homogeneous environments.

The Northeast Georgia Quartz Survey

The data I use in this paper derives from a survey I have conducted of archaeological sites in northeastern Georgia. The survey is the cumulative result of over ten years of non-systematic recording of surface sites in northern Oglethorpe County and adjacent portions of Wilkes County, Georgia. Data is recorded for 42 lithic sites (see Table 1), most of which were located during forays into the rural countryside investigating lithic sources and other materials for experimental archaeology projects. In some cases, information was available for whole sites. Others are known only from exposures along narrow swaths of unpaved county roads.

Sites with known boundaries vary from large quarries sites to small lithic scatters. The majority of Oglethorpe County sites are located in the uplands, the nearest drainages being small tertiary streams. The Wilkes County sites are along a section of Long Creek, a second order stream that empties into the Broad River a few kilometers downstream. This difference in the remote uplands of Oglethorpe County sites and the intermediate uplands of Wilkes County sites provides an interesting comparison.

The survey provided a large enough sample of quartz artifacts to permit a plausible reconstruction of quartz tool reduction and use in the area. Settlement pattern studies for this and surrounding areas are reported by Freer (1991) and Pluckhahn (1994). It should be noted that the cumulative ef-
Table 1. Table showing the artifact data for the sites within the North Georgia Quartz Survey area.

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fect of all site reporting contributes to the overall body of knowledge of prehistoric and historic land use.

Of the 42 sites reported, 4 are quarry or quarry/workshop sites where quartz was processed from raw material. Seven are habitation/workshop sites with abundant evidence of quartz tool manufacture and reduction. Twelve are identified as habitation sites containing tools and domestic debris (and ceramics in many cases). Fourteen lithic scatters and 6 artifact scatters (lithics and ceramics) were recorded. The limited amount of information available for some sites may reflect limited surface exposure.

The Physical Environment

The study area lies in the Piedmont geophysical province of northeast Georgia, in the Broad River drainage. The Piedmont is a region of gently rolling hills underlain by crystalline rocks that form the eastern flank of the Appalachian Mountains. Like most of the major geophysical features of the eastern U.S., the Piedmont extends well to the north, terminating in New Jersey (Godfrey 1997). In the study area, maximum elevations of upland areas are about 600 feet (183 meters), with changes in local relief (to adjacent drainages) seldom exceeding 100 feet (30 meters). Stream generally follow a dendritic pattern, although faulting influences drainage patterns drain the area. The natural vegetation is mixed hardwood (oak/hickory) forest, with mesic species dominating. Xeric species are sometimes found on elevated ridges and rock outcrops (Wharton 1978). Much of the area is now in commercial timber (pine) plantations.

The Piedmont is bounded to the south and east by the Coastal Plain (see Figure 2). The Coastal Plain is characterized by marine deposits (including chert) of Tertiary age and later, and extends to the present Atlantic Ocean. It is separated from the Piedmont by the Fall Line, an abrupt demarcation between the crystalline Piedmont rocks and marine sediments. As the name suggests, rivers crossing the Fall Line contain numerous rocky shoals as their waters drop towards the flat, meandering expanse of the Coastal Plain.

To the north and west of the Piedmont lies the Blue Ridge Mountains, the southern extension of the Appalachians. Like the Piedmont, the Blue Ridge is a region of very old crystalline rocks. Though heavily eroded, the Appalachians in Georgia attain elevations of over 4,000 feet (1219 meters).

Further to the northwest, the western edge of the Blue Ridge abuts sedimentary Paleozoic rocks of the Ridge and Valley province. Like much of the southeast, geologic forces exerted from the south and east have affected the area, the result being that these sedimentary rocks have been uniformly folded into northeast-trending bands.

Geological Overview

Piedmont geology is notoriously complex, and contains evidence of multiple episodes of metamorphism, faulting, and folding. Many of the rock formations and structural features of the southern Piedmont exhibit a northeast-southwest orientation. This pattern is the result of the convergence of the African and North American plates about 350 million years ago, and the subsequent decoupling of the continents by about 250 million years ago (Whitney et al 1978). Stresses induced on the continental fabric during both events resulted in numerous faults. Some of these faults represent the sutures between the original continent and volcanic islands and small parts of the African plate.

The Middleton-Lowndesville fault is one such fault (Figure 3). It traverses the study area from the southwest to the northeast, effectively dividing it into two distinct geological zones (Turner 1986). To the northwest of the fault, the Inner Piedmont flank is characterized by gneisses and the massive Elberton granite batholith. Southeast of the fault are found metavolcanic rocks of the Carolina Slate belt. Slate Belt rocks have undergone varying degrees of metamorphism, and some originated from sediments of volcanic origin. Some of the felsic metavolcanics are sufficiently glassy and homogeneous to permit their use for stone tools.
Figure 2. Map of Georgia showing geophysical regions and project area.
Granite batholiths and metavolcanic rocks also have a direct connection to the formation of quartz in the study area. One of the final major geological events in the southeast was the emplacement of a number of granite plutons into the central and outer Piedmont. In the Slate Belt, the heat and water generated by local granite intrusions reacted with silica-rich volcanic sediments, creating a moderate amount of high-quality milky quartz of hydrothermal origin. In the gneiss-dominated Inner Piedmont (i.e., to the northwest of the Middleton-Lowndesville fault zone), hydrothermal activity produced varying amounts of quartz, depending upon local conditions. Some granite plutons generate more water than others, which condition affects the formation of quartz (James Whitney, personal communication 2001). Though residual felsic magma can be injected into fissures to form coarse pegmatites containing good quality quartz, these do not form a significant part of the usable quartz lithic resources in the study area.

Other Lithic Resources

Piedmont lithic assemblages are overwhelmingly dominated by quartz. Other lithic resources are present within the region, and still others are found in adjoining geophysical provinces. Small amounts of these materials are frequent constituents of archaeological sites in the Piedmont, attesting to the potential for human movement and exchange in prehistoric times. Some are geographically and temporally limited enough to be diagnostic for certain time periods in the absence of diagnostic projectile points.

Metavolcanics: Among the principal non-quartz lithic resources of proximate origin to the
study area are felsic metavolcanic rocks of the Carolina Slate Belt. The Slate Belt is a discontinuous series of metavolcanic and metasedimentary rocks of volcanic origin that extends northward to (and includes) the Uwharrie Mountains of North Carolina. Southward through South Carolina and into Georgia, the composition changes from rhyolitic to dacitic, and is believed to have undergone a higher degree of metamorphism than have rocks of the northern extension (Whitney et al. 1978). In Georgia, the Slate Belt bifurcates where it enters the state at the border with South Carolina. The two arms are called the Northern Little River series and the Southern Little River series, and extend to the southwest almost to central Georgia.

Slate Belt rocks in Georgia are relatively coarse, occasionally cherty rocks that range in color from silvery gray to dull black. They weather quickly, and artifacts are often weathered to the degree that flake scars are obliterated. Meta basalts, fine-grained amphibolites, and porphyritic volcanics of variable composition are also found in the Slate Belt and were employed for ground stone tools. Felsic metavolcanics were used extensively in the Late Archaic for biface production.

Coastal Plain Chert: Tertiary-age marine cherts are found in the Coastal Plain just below the Fall Line. These cherts occur in a broad band that extends from Allendale County in western South Carolina westward through Georgia. In west central Georgia the band turns south and can be traced along the Flint River into Florida and adjacent parts of southeastern Alabama. Coastal Plain cherts range from translucent butterscotch and brown mottled varieties to coarse, opaque buff colored types. Artifacts of this material are often thermally altered.

Cryptocrystalline Rocks of Piedmont Origin: Within Georgia, Piedmont sources of chert, jasper, and chalcedony have been increasingly recognized as culturally important (i.e., Ledbetter et al. 1981). Piedmont cherts and jaspers are the infrequent product of hydrothermal action, a process that most often yields milky quartz. In Georgia, fault zones appear to be the operative force in the production of these cherts. They range in color from dark brown to pale, translucent chalcedonic varieties. These cherts often consist of aggregates of small, spherical botrydial structures (Jones, in Gresham 2000). Though superficially resembling Coastal Plain chert, Piedmont chert/jasper contains no fossils. Botrydial structures, boxwork, or other residual structures may be mistaken for fossils in some specimens.

Quartzite: As used here, quartzite (metaquartzite) is defined as a tough, grainy metamorphic rock consisting mainly of quartz. A Piedmont lithic resource, quartzite is typically formed from the fusing of quartz sandstone through metamorphism, but for analytical purposes it is sometimes difficult to distinguish true quartzite from a grainy or sugary Type 6 quartz. Technologically, they function similarly. Orthoquartzite is formed when sand grains are cemented with soluble or cryptocrystalline silica. This sedimentary rock is found in the upper Coastal Plain, but because of the poor quality of orthoquartzite found in Georgia, it is not a widely used lithic material.

Ridge and Valley Chert: Paleozoic cherts are found in northwestern Georgia and adjacent portions of Alabama and Tennessee. The characteristic dark cherts of this region were widely utilized and transported during the Early Archaic (Sassaman 1996:65).

Daltonite: Daltonite is a compact siliceous rock consisting of poorly sorted angular quartz grains cemented by amorphous silica. This gives the impression of an orthoquartzite, and it has often been identified as such. It is a Fall Line area resource, and appears to be the composite product of fault activity and sedimentary processes. Only one source is presently recorded, this from a locality in Washington County in central Georgia (Jones 1998; Waggoner and Jones 2002). Within the area of occurrence, daltonite is utilized sporadically throughout prehistory. Away from the source area, however, the mere presence of daltonite is practically diagnostic for late Paleoindian and Early Archaic occupation. It often occurs on lithic sites as formal tools (pp/ks and endscrapers). This material was first dubbed daltonite by Elliot (1979) during
the Wallace reservoir project, suggesting a commonly associated biface type (the Dalton point).

**Soapstone (also steatite and serpentine):** is an extremely soft rock of ultramafic composition. It is used for vessels, cooking stones, atlatl weights, pipes, gorgets, and other objects, especially during the Late Archaic. It ranges from silvery gray to dark green in color, with other colors (mostly reds and browns) occasionally seen. Scattered soapstone outcrops are relatively common in the study area. These outcrops are part of the Lake Russell allochthon and have been the subject of geological study in east central Georgia (Legato 1986; McFarland 1992). The relationship among the various soapstone manifestations in Georgia is poorly understood. They are thought to be the highly metamorphosed remnants of a massive thrust-sheet of sea floor basalt. In eastern Georgia, a discontinuous series of these small outcrops are located immediately to the south of the Middleton-Lowndesville fault (Georgia Geological Survey 1976). Despite the overall importance of soapstone in prehistoric assemblages, very few artifacts of this material were recovered in the survey. This likely reflects the minor Late Archaic presence in upland areas.

**Diabase.** With respect to Piedmont lithic technology, this form of gabbro deserves special mention. Decoupling of the North American and African plates during the Triassic induced tectonic stresses on the continental fabric. These stresses produced numerous cracks and fissure, which, contrary to much of the geology of the southeast, are oriented in a northwesterly direction. Basalt magma filled the fissures and formed the numerous diabase dikes that crosscut the region. Some diabase dikes can be traced for several kilometers, and in thickness they range from a few centimeters to several meters. The dikes are visible on the surface as lines or linear arrangements of rounded, gray boulders and cobbles (recently unearthed diabase sometimes has an orange or yellow clayey rind resulting from the weathering of iron-rich pyroxene). Weathered surfaces of coarse-grained diabase often clearly show the unique (ophitic) texture of interlocking laths of feldspar that distinguish diabase from other mafic (iron-rich) crystalline rocks. The high iron content and interlocking texture make diabase very heavy and tough. Fresh surfaces are dark gray-green to black, with texture varying with the coarseness of grain size.

Diabase is common throughout the Piedmont, and was used for items ranging from hammer stones and anvils to core tools, axes, food processing gear, site furniture, cooking rock and hearth material (cf. Webb 1998: 74). Bifaces are occasionally made from exceptionally fine-grained diabase. Although many of these items are not highly curated or easily transportable (with the exception of hammer stones, formal ground stone tools, and bifaces), diabase is a common constituent of site assemblages.

The natural processes of jointing and fracturing and subsequent weathering of diabase typically produces rounded boulders and cobbles. Other forms occur, including exfoliation spalls and split cobbles. These forms may also result from heating of cobbles. With regard to quartz tool technology, diabase artifacts of non-specific form (i.e., cobbles and chunks) are common on sites, and in some instances it is difficult to determine if such artifacts are fire-cracked rock or tools. Nonetheless, hemispherical cobbles of diabase (and other tough stone) are frequently seen on archaeological sites. Along with hammer stones, these artifacts are believed to play a role in the production of flaked stone tools.

**Quartz and Coastal Plain Chert: A Comparison**

To illustrate differences in exploitation of lithic materials that differ significantly in their physical properties and manner of occurrence of quartz differ considerably from other lithic resources in the southeast. It is helpful to compare and contrast these differences with a lithic material with familiar characteristics. The nearest major source of cryptocrystalline material to the study area will be considered. The Coastal Plain is a broad, flat area of Tertiary sediments that extend from the outer Piedmont to the Atlantic Ocean. Within sediments of the upper Coastal Plain are found outcrops of Tertiary cherts. Roughly paralleling the boundary separating the Piedmont and Coastal Plain (the Fall Line) these cherts extend across the state in a southwest-
erly arc from Allendale County, South Carolina to southeastern Alabama.

Coastal Plain chert outcrops are discrete. Though plentiful in the upper Coastal Plain, chert disappears quickly to the south and east. Inland, the Fall Line marks the dramatic change from sedimentary geology to that of igneous and metamorphic Piedmont rocks. While this chert is a common constituent of diverse Piedmont lithic assemblages, the discrete quality of these chert sources compelled Archaic peoples to plan carefully for seasonal excursions into the lower Coastal Plain. To the south and east, the lower Coastal Plain is largely lacking in lithic resources. Away from the outcrops, supplemental lithic material is practically non-existent.

Coastal Plain cherts are variable in quality, yet good material is relatively common. Natural qualitative variation was combined with thermal alteration to achieve a technologically and logistically flexible tool kit for forays into the lithically impoverished outer Coastal Plain. Although specific applications of thermal alteration change through time, it is nonetheless evident for the entire Archaic period (see Jones 2001b).

Quartz, by contrast, has a patchy yet more or less continuous distribution throughout the crystalline rocks of the Piedmont and Blue Ridge. While high-quality quartz is rarer than less desirable forms, it is nevertheless present across much of the landscape. Heat treatment yields little or no effect on the workability of quartz (Flenniken 1981: 20-27; Leveillee and Souza 1981), but this is compensated by the wide qualitative variability and ready availability of utilitarian grades. The availability of quartz is in part responsible for the pervasive view of it as an expedient and supplemental material. This is partially true, but the evidence suggests that particular types of high-quality quartz served a role as curated tool material. Callahan's (1987: 61) observation of lithic technology in Middle Sweden is relevant to the present study: "[T]his system allowed virtual freedom of movement across the landscape, with any size and kind of lithic material being suitable for use. The evolution of a system dependent upon...predominantly local material...may have been a master stroke of wisdom unappreciated by the makers of large, formal tools to the south."

White Rock Site, 9LC1005, Lincoln County, Georgia

This article focuses primarily on small-package lithic resources. There are, however, a few areas where quartz raw material packages are far larger than is common in the Oglethorpe/Wilkes County project area. To provide a balanced picture of quartz exploitation in northeastern Georgia, I am including a brief overview of one such site that is possibly the single largest quartz outcrop in the state.

The site is the White Rock site (9LC1005) in Lincoln County, Georgia (Figure 4). It is on the shore of Lake Strom Thurmond (formerly Clark Hill Lake), a man-made reservoir on the Savannah River. The site is situated around the end of a small landform dominated by a cliff of hydrothermal milky quartz. The outcrop stretches across the landform for about 80 meters. The lakeshore along the flanks of the outcrop is littered with prehistoric quarry debris. The extent to which the area has been disturbed by gold prospecting (Hurst 1990) or hydraulic action is not known. Similarly, the extent to which the outcrop was exposed prehistorically is unknown, but the prominence of the landform and the volume of quarry debris suggest that it was heavily exploited.

I first saw the site in the early 1990's while investigating sources of metavolcanic rocks in the area. This was my first conscious inkling that the volume of quartz present in Slate Belt rocks of the southern Little River series vastly exceeds that of the northern Little River series and adjacent areas. Subsequent to my initial visit it was recorded in the Georgia Archaeological Site File. It is notable that the site and associated expanse of high-quality lithic material was overlooked during previous archaeological surveys of the reservoir. Artifacts and raw material samples were collected from the site in 1999 under permit from the U.S Army Corps of Engineers.

Collections from the lake shore contain many large artifacts including bifaces, biface fragments, cores, flakes, core tools, expedient tools,
hammer stones, and a small number of gabbro artifacts (the later are probably quarry tools; cf. Gresham and Neumann 1995). Other areas of the shore contain large amounts of smaller debris, this evidently the result of sorting by wave action. Despite the presence of large biface blanks, the only late-stage bifaces are two relatively small aborted preforms of unknown cultural affiliation (Jones 2000a). The temporal relationship between materials at 9LC1005 is uncertain, but it is probable that many of the bifaces are of Archaic affiliation. Unlike the Oglethorpe/Wilkes County project area, the Savannah River valley was heavily occupied during the Late Archaic. Large quartz and metavolcanic bifaces of this period are common.

Despite the large size of both outcrop and raw material at White Rock, other smaller quartz exposures in the immediate vicinity were heavily exploited. Although the volume of quartz available on these sites is impressive, package size of typically small. Artifacts from these outlying sites are correspondingly small. The impression is that debris and tools from the area appear to be larger on average than those from the main study area, yet tool size rapidly diminishes with distance from large outcrops.

This opens up some possibilities for interpretation. One is that the need for large raw material/tool size is temporally defined (Early or Late Archaic). Alternatively, there is perhaps a maximum size limit for quartz tools with respect to utility. These possibilities may reflect differences in attitudes towards tool procurement/curation through time, geographical distribution of cultural groups, and the distribution of raw material across the landscape. Further studies in northeast/east central Georgia would be productive for determining the significance of large quartz resource such as 9LC1005.

Metric data from selected sites across the region

Figure 4. White Rock (9LC1005). View to the southeast along outcrop. Photo by Jerald Ledbetter.
would be informative for determining the relationship between these sites and small upland lithic sites.

A Brief Culture History of the Study Area

Sites from the survey are assigned to one or more time periods based on the presence of diagnostic artifacts. The following section is divided into 5 periods to provide a culture historic context for this study. The survey includes very few Woodland period sites with diagnostic lithics. Mississippian sites, while abundant, often contain few lithics consisting mostly of small triangular projectiles/knives (pp/ks). Consequently, the lithic technology of these two periods (as represented in the survey) forms a small part of the study, and they are grouped together as ceramic sites. The Middle Archaic is subdivided to include the late Middle Archaic to reflect recent work defining this period in the Piedmont (Jones, in Ledbetter et al. 2003). Lithic sites yielding no diagnostic artifacts are identified as unidentified lithic (10 sites). The chronology is based on Ledbetter et al. (2003) and Stanyard (2002).

Because many of the sites considered here are multicomponent sites know only from surface finds, the chronology of quartz lithic technologies is largely speculative. Apart from the small number of recognized lithics from ceramic period sites, the bulk of material can be reasonably presumed to date to the Archaic period. While the number of Late Archaic sites would indicate a significant occupation during this period, these sites are not well defined in the uplands of the survey area. Most are identified by low numbers of non-quartz artifacts on multicomponent sites. By default, this study focuses predominantly on the Early and Middle Archaic, with the near-exclusive use of quartz in the Middle Archaic being of particular interest.

The preponderance of quartz artifacts in the uplands of Georgia led Caldwell (1954, 1958) to coin the term Old Quartz Industry to define assemblages he believed were contemporaneous. Subsequent work by Coe (1964), Dickens (1964), and others showed Old Quartz Industry assemblages to encompass much of the Archaic, and the term has fallen into disuse (Johnson 1981; Canouts and Goodyear 1985:181). Though obsolete, it is important to the development and history of Piedmont archaeology. It remains approximately synonymous with the Middle Archaic.

Paleoindian Period

A growing body of evidence suggests that eastern North America was inhabited by humans prior to the established threshold of 12000 BP (Carlisle and Adovasio 1984; McAvoy and McAvoy 1997; Adovasio et al. 1999, Goodyear 2000, 2001; Chandler 2001a, Marshall 2001). At present, however, the first definable, widespread culture appears around 12,000 years ago at the end of the last ice age. Paleoindian period sites are rare, and characterized by the presence of fluted and unfluted lanceolate projectile points and formal tools including endscrapers and blades. A high degree of mobility allowed Paleoindian hunter/gatherers to select good quality stone for tools, and the tool kit often contains exotic lithic materials. Paleoindian period projectile weaponry is the subject of much speculation. The modest size of many projectile point/knives (pp/ks) in the Piedmont indicates the use of the spear-thrower (or atlatl), although thrusting spears were possibly used. Only one late Paleoindian site was identified in the survey by a Dalton projectile point. Another small isolated point has been tentatively identified as Paleoindian.

Early Archaic (8 sites)

By 10,000 years ago, the shift to a temperate post-glacial climate brought about changes in the material culture of hunting and gathering peoples of the region. Lanceolate points gave way to smaller side- and corner-notched varieties. Early Archaic tools continue to be made from a variety of good quality materials and are heavily curated, but an increase in the use of local materials is evident. Bifacial tools and formal unifaces remain major parts of the tool kit. Towards the end of the Early Archaic a variety of stemmed projectile points emerge. As with the remainder of the Archaic, the spear-thrower (atlatl) was the principal projectile weapon.
Middle Archaic (19 sites)

By about 8,000 years ago, climatic change heralds further change in the material culture. The Hypisthermal climatic event created drier and warmer conditions throughout much of the region (Delcourt 1979). While this interpretation has been repeated by many researchers, significant differences in Middle Archaic settlement patterns across the southeast have caused some to question the application of this interpretation to the entire region (Sassaman 2001). In brief, Middle Archaic sites to the west of the Appalachian Mountains are river-oriented, lending support to the argument that the climate was drier. To the south and east of the Appalachians (including the study area), settlement patterns reflect a strong upland focus, implying that the climate was wet (Neumann 1998). Middle Archaic material culture is dominated by contracting stem bifaces and informal flake tools, with an almost exclusive reliance on local lithic materials.

Late Middle Archaic (16 sites)

This trend towards tool kit redundancy continues into the late Middle Archaic (16 sites), with contracting stem pp/ks giving way to small, stemmed lanceolate types (Whatley 2002). In previous work, it was noted that non-ceramic sites yielding small stemmed points were found consistently in upland contexts (in Ledbetter et al 2003). Such points are frequently identified as Woodland types, but in addition to the lack of ceramics on specific sites, they are often found in areas with little Woodland occupation. Workmanship is generally better than for Woodland types (for instance, the Coosa type). The late Middle Archaic is characterized in the Carolinas by Guilford point types, in western Georgia and Alabama by Sykes/White Springs, and in middle and southern Georgia by MALA/Allendale point types. While dates for these point types vary somewhat, the overall trend indicates that contracting stem types (e.g., Morrow Mountain) give way to stemmed varieties. Few of these named point types are found in the east and central Georgia Piedmont. It was observed that these “stubby stem” or “Piedmont Allendale” points are consistent with late Middle Archaic site location, context, and technology. A calibrated radiocarbon date of 5670-5470 BP from a feature containing a similar point type have been reported by Charles and Ferguson (2005) in the Piedmont of South Carolina.

Late Archaic (14 sites)

Further changes in material culture are evident by about 5,000 years ago. Increased sedentism and incipient horticulture gave rise to pottery in the form of fiber-tempered ceramics and soapstone vessels, and an increased use of ground stone tools. Projectile points of the period are large stemmed types, decreasing in size through time. In addition to quartz, a wide variety of local materials were utilized for the production of projectile points during the Late Archaic. The number of Late Archaic sites in the survey is somewhat misleading. Few large or heavily occupied sites for this period were recorded. Diagnostic artifacts typically occur in small numbers on large (often multicomponent) sites, or are represented by small, low-density sites.

Ceramic Periods (Woodland and Mississippian, 19 sites)

Agriculture, refinement and widespread use of ceramics, and use of the bow and arrow are defining features of these periods. In the survey, the ceramic component is often identified by small numbers of residual sherds that cannot be confidently identified as Woodland or Mississippian. In the uplands, these small ceramic sites are often part of larger multicomponent sites. An exception to this is the late prehistoric Lamar period, represented in the upland by large, almost exclusively ceramic sites.

The Woodland period (3,000-1,100 years ago, or 1,000 B.C.-A.D 900) is identified by increased ceremonialism, long-distance exchange, and the construction of burial mounds. The bow was adopted during the Woodland period, and lithics remain a significant part of the material culture. Freer's (1992: 52-55) observation that Woodland occupation shifts toward the Broad River is supported by the survey data. No conclusively diagnostic Woodland lithics were recorded. Typical early Woodland projectile points include smaller versions of Late Archaic stemmed types and large
triangular (Yadkin) types. By the Middle Wood-
land, these give way to large and medium trian-
gular and stemmed types. Triangular points decrease
in size through time.

The Mississippian period (AD 900-1540) is
the apex of social and political organization in the
southeast. Intensified maize agriculture is initially
focused on river floodplains, and populations are
concentrated in fortified municipal centers. Resi-
dences of headmen are constructed on the tops of
large earthen mounds within the towns. Small tri-
angular arrow points are diagnostic of the early and
middle Mississippian. The present survey supports
Freer's observation that upland areas of the study
area contain few early and middle Mississippian
ceramic sites, while contemporaneous diagnostic
lithic sites are present. Late Mississippian settlement
shifts to upland areas, and is repre-
sented by small,
dispersed farmsteads. Lithics are virtually absent from
late Mississippian and protohistoric sites (Williams
and Jones 2001). A number of such sites were
recorded in the study area, but were excluded be-
cause of the lack of lithic artifacts.

Artifact Analysis

Analytical Categories

During analysis, artifacts were divided into
five groups (flakes, bifaces, cores, tools, and miscel-
naneous) that were considered broad enough to
encompass most of the artifact types encountered.
These groups were further divided into specific arti-
facts types. For each site, maximum quartz artifact
size was recorded, as were maximum core and flake
size. Metric data were recorded for a sample of
bifaces since these artifacts possess consistent at-
tributes of length, width, and thickness. Metric data
and other relevant information are summarized for
each artifact type under the specific heading. Sum-
mary data for bifacial preforms, cores, flake tools,
and projectile points are found in Table 2. Metric
data for quartz artifacts and debitage are summa-
rized in Table 3.

Flakes: Flakes are grouped into early and
late reduction flakes depending on the amount of
cortical surface present on flake dorsal surfaces.
Because quartz cortex is not chalky (as in the case
of cherts and metavolcanics) it has no bearing on
technological performance. It is used as an indica-
tor of reduction stage. Because the survey focused
on upland areas, cortex is potentially useful in iden-
tifying the source of raw material. This is especially
true in the case of alluvial pebbles and cobbles
(Goodyear et al 1979; Tippitt and Marquardt 1984:
9-2). In addition to early and late flakes, flake de-
bris also includes flake fragments and unidentified
reduction fragments ("shatter"). Flake debris was
sorted into debris larger than 2.5 cm, and debris
less than 2.5 cm.

A wide range of flake forms were identified,
including freehand, anvil, bipolar and bifacial thin-
ing flakes. In general, flakes and flake debris ex-
ceeding 2.5 cm. predominate on quarry sites. Oth-
erwise, debitage less than 2.5 cm. is more abun-
dant.

Bifaces: Bifaces are categorized as early
biface/core type, early preform, mid/late preform,
or fragment (projectile points are treated under
Tools). Biface fragments are those that are too frag-
mentary to yield useful technological or metric data.
Bifaces, as used here, are relatively large, ovate to
ovate-pointed formal artifacts in various stages of
reduction. With some exceptions, these are pre-
dominantly Archaic in age.

Metric data for a sample of bifaces are found
in Table 4. As is evident in Table 4, bifaces show a
consistent change in proportion for all attributes
through each reduction stage. While this is not sur-
prising, it is noteworthy in light of the overall lack
of temporal segregation of nondiagnostic Archaic
bifaces in the survey. Width-to-thickness ratios are
expressed as a single number, which is the width in
relationship to thickness with an implied value of
1. For instance, a biface with w/t value of 2 is twice
as wide as it is thick. Expressed in conventional
terms, this would be 2:1.

Core/early preform bifaces: Generally, core/
early preform bifaces are large and thick with bifi-
cial modification around much of the perimeter.
They exhibit core-like characteristics with little
refinement in outline. Despite the small measur-
able sample size (n=4), the core bifaces from the
Table 2. Summary table for bifaces and cores in project area.

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<th>Single-platform anvil cores</th>
<th>Multi-platform freehand cores</th>
<th>Single-platform freehand cores</th>
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project fit the metric pattern for other bifaces sufficiently well to include them for reference purposes. They have an average width/thickness of 1.6, and an average length just under 80 mm. Of the large number of total bifaces found, the small number of early/core bifaces is perplexing. One possibility is that these bifaces were successfully reduced to a later stage. Another is that, when broken, these cores were still massive enough to reduce by other means (i.e., as another type of core, as discussed below). An alternative explanation is that these cores appear to be made from tabular or chunky raw material. Other bifaces in later stages of reduction are made from thinner raw material (though of similar form), or from thick flakes. This would place them at a later reduction stage early in the process.

Early stage bifaces: These bifaces are roughly ovate to ovate-pointed in outline, with bold flake scars. Refinement in outline is evident and proximate/distal ends are frequently evident. They are thick, with an average width/thickness of 1.9. The length averages just over 56 mm.

Mid- and late-stage bifaces have a width/thickness ratio around or exceeding 2:1, with evident edge and outline refinement and proximal/distal end delineation.

Bifaces on flakes are, as the name suggests, bifaces or identifiable fragments that retain evidence of the original flake blank.

Bifaces occur on 38 sites. The greatest numbers of bifaces are found on quarry, quarry/workshop, and habitation/workshop sites. One quarry site (90G464) yielded 103 bifacial preforms, including 65 early preforms and fragments. The largest bifaces are 9 cm. long, one each from 90G467 and 90G486. Most are smaller, averaging from 5.5-8 cm. Although bifaces are a common constituent of multicomponent sites, the number of bifaces is greater on sites with an Early Archaic component. One exception in the survey is site 90G467, which is strongly Middle Archaic.

Bifaces are important throughout the Archaic of the southeast, although the nature of biface production seems to change over time. The Early Archaic emphasis on core-type bifaces (Sassaman 1996: 78) gives way to a Middle Archaic trend towards multifunctional, late-stage bifaces. Late Archaic bifaces are made from a variety of raw materials with an emphasis on size and raw material diversity. In general, quartz bifaces are made from chunks, cores, or tabular pieces of raw material, or from large flakes or splinters removed from cores. Bifaces are also produced by minimal modification of thin flakes of suitable size.

Plano-convex bifacial cores: A second type of core biface encountered in the survey warrants discussion. Only a small number were identified (n=3), including two whole specimens and a fragment. One is an isolated artifact, and the other two are from low-density lithic scatters consisting ex-
clusively of quartz. This suggests a Middle Archaic association, but the formality of the core form is inconsistent with the usual redundancy of tool kits from this period. In form, these resemble nothing more than humpback cores and are ovate-pointed in plan view. The form and execution suggest that they are fall within the scheme of bifacial tool reduction. The planar surface is crowned slightly by marginal flaking, apparently from a thick flake blank. The edge is steeply beveled around the perimeter to provide striking platforms for flakes removed from the convex surface.

**Cores:** In the original analytical design, the difference between single and multi-platform cores was believed to be significant, in the sense of Johnson's (1991) comparison of patterned and amorphous cores. Through the analysis and replication I became aware of the flexibility of core form as it relates to the difficulty of maintaining a specific (i.e., formal) core type. Thought aware of anvil flaking techniques prior to this project, I had lapsed into the common practice of viewing core reduction as either freehand or formal bipolar. Consequently, many core forms remained enigmatic. Only during the analysis of non-bifacial quarry material from the Lake Oconee site 9GE1829 (Ledbetter 2000; Ledbetter et al 2003) did I seriously begin to consider anvil flaking as a viable reduction strategy in the Piedmont of Georgia. Hence, platform configuration became less important as the freehand/anvil/bipolar reduction continuum became increasingly evident.

Platform configuration is thus overshadowed by platform edge angle. Virtually all flaked stone tool production is predicated on hertzian cone mechanics, requiring that core edges necessarily exhibit an overhang of less than 90 degrees. Anvil and bipolar techniques generate shearing forces, which often result in flake removals at approximately 90 degrees to the platform. This change in core geometry is a key diagnostic feature as reduction shifts from freehand to anvil-supported.

Single platform cores are cores with a single relatively flat striking surface, with flakes struck more or less exclusively from this surface. Multi-platform cores are cores with flakes removed from different directions. This is often dependent upon the shape of the raw material. These range from polyhedral cores to tabular and sub-bifacial types.

Depending on core shape, material, and degree of use, anvil cores often exhibit distal crushing, pitting, or other evidence of being supported on an anvil to facilitate flaking. Anvil cores may be single or multi-platform, but in the analysis multi-platform cores are more numerous. Core fragments are those that retain no diagnostic evidence of their original core type. Cores were re-analyzed to segregate them into multi-platform freehand cores, single platform freehand cores, and single-platform anvil cores, and multi-platform anvil cores. Though present elsewhere in the region, only a small number (n=2) of fragmentary chopper-like cores with bifacially worked edges were identified in the survey. These do not appear to be part of the biface production trajectory. To avoid confusion with early preform/bifacial cores from within the biface reduction sequence, I follow Andrefsky’s (1998) suggestion in calling these bimarginal cores. For the present, this core type will be included with the multi-platform cores.

Bipolar cores appear to be associated with specialized flake and tool production, and are treated separately from other core types. Bipolar cores show crushing at one or both ends, in conjunction with shearing (splitting) or multiple faceting along the long axis. No effort was made to further divide bipolar cores into recognized subtypes (Binford and Quimby 1963; Forsman 1974). As an analytical note, formal bipolar cores often split into pieces of more or less equal size, effectively blurring the distinction between core and flake. It is both convenient and acceptable to refer to these ambiguous artifacts as bipolar pieces or bipolar material.

**Tools:** Tools include projectile point/knives: whole or base diagnostic, unidentified, and fragmentary; and other bifaces (non-pp/k bifaces, special purpose tools). Unifaces, flake tools and utilized flakes and microtools were also included as tools.

**Projectile points:** this category includes all identifiable finished bifacial projectile/knife tips and fragments thereof in all stages of reduction. Apart
from established diagnostic criteria, these bifaces have a defined proximal haft area, distal tip, lateral blade edges, and a broad suggestion of bilateral symmetry. Site component information is largely predicated on the presence of diagnostic types (n=131).

Other bifaces: All bifacial tools that do not have attributes of projectile points. In this category are included bifacial scrapers, small discoid bifaces, small ovate or bi-pointed plano-convex bifaces (limaces), adze-like tools, and other forms that do not conform to the definitions of other tool types. This group contains a small number of artifacts, but this is perhaps the result of misidentification.

Adze-like tools are of special interest. With few exceptions (Goodyear 1974; Gramly 1981; Webb 1998; Ledbetter et al 2001; Jones 2001c), these tools are poorly identified in the region, especially in quartz. These are typically bifacial tools (a thick early reduction flake, in one instance), with visible abrasion on the surfaces, and grinding along the lateral edges. One artifact of this type is flaked to produce a constriction on the lateral edges, evidently to facilitate hafting.

Other tools: These include unifaces, flake tools, microtools and perforators. A small number of formal unifaces were identified, but this is obfuscated by the presence of an unexpectedly large number of unifacially modified quartz flake tools. In many cases, the distinction between formal and informal unifaces is unclear. Among flake tools, lateral edge and distal use are represented. Microtools were identified on a few sites. These were made on small flakes of quartz and Ridge and Valley chert. Perforators are tools on flakes or biface fragments with an extreme amount of polish on one or more protrusions indicating a use for drilling in hard materials. While a small number of perforators were identified in this project, the Big Creek site (9MF38), a multicomponent site in nearby McDuffie County yielded a substantial number of this tool type (Pluckhahn and Jones 2002). Only tools with evident use-wear or retouch were identified as tools.

Miscellaneous: This category includes other artifacts that do not fall into one of the above groups. It contains non-flaked stone artifacts, including hammer stones, anvils, groundstone, and soapstone. It also includes heavy flaked stone core tools of local non-quartz lithic material (diabase, diorite, metavolcanics, and epidote). Ceramics from the Woodland, Mississippian, and Historic periods were also recorded. With the exception of hammerstones and anvils, most of the artifacts in this broad group do not relate directly to quartz tool technology and are not further considered.

Synopsis of the Analysis
This study focuses primarily on core forms, and is a conscious decision arising from the need for expediency. Beyond rudimentary metric data, flakes have not received as much attention as they deserve in a study that purports to reconstruct and replicate a lithic reduction sequence (Andrefsky 1998). The replication of core forms will, however, give rise to specific flake forms. It is my hope that this will be sufficient to support the premises of this study.

The following overview is supplied to give a sense of scale for quartz tool technology as represented in the study, and gives the distribution of certain artifact groups and rough metric sketches. Measurements for artifacts are given in centimeters unless otherwise noted, and denote the longest dimension of the artifact.

Bifacial versus Non-bifacial Reduction
Biface production is the most prolific and visible lithic reduction technique in the study (38 sites). Other reduction strategies are evident, and non-bifacial core forms occur in significant numbers in the survey. Many sites are multicomponent, and it is thus difficult to correlate specific reduction strategies with particular time periods. The significance of non-bifacial artifacts and techniques will be explored in a later section. Single and multi-platform cores (combined) occur on 22 sites. Anvil cores were found on 13 sites, and bipolar material on 19 sites.

Quartz Raw Material Overview
The application of the raw material categories outlined above is a subjective exercise. Never-
theless, some generalizations can be made about quartz raw material use based on findings from the project (see Table 5). Of 4225 artifacts, 3785 (89.5%) are quartz. Twenty five percent of quartz artifacts are Types 1-3. Of the 75% of Type 4-6 quartz artifacts, they are overwhelmingly Type 4 quartz. Several small and low-density sites have high percentages of Types 1-3. While this may simply reflect raw material availability, it is potentially indicative of an active selection for certain types of quartz. Early Archaic sites contain higher amounts of Types 1-3. Some of these are quarries, and probably reflects the availability or choice of raw material, and overlaps somewhat with Middle Archaic raw material preferences. Archaic projectile points from the study are predominantly Type 4 quartz (about 70%). This is followed by Type 3 quartz (about 17%) and Type 2 (8%). The remainder are Types 1, 5, and 6 quartz.

**Table 5. Summary of quartz artifact types in the project area.**

<table>
<thead>
<tr>
<th>Site #</th>
<th>No. of artifacts type 1-3 quartz</th>
<th>No. of artifacts type 4-6 quartz</th>
<th>% of type 1-3 quartz</th>
<th>Total quartz artifacts</th>
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<tr>
<td>Total</td>
<td>945</td>
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A similar distribution for flake debris is apparent. Flakes greater than 2.5 cm in length are more numerous on quarry and workshop sites than on other types of sites. The largest flakes are in the 7 to 8 cm range, but these appear to be flake blanks that were brought to the site from elsewhere. The average maximum debitage size is 5.2 cm. Large quartz cobbles and boulders are occasionally seen, but these are exceptional. In many cases massive intact pieces appear to be unused by prehistoric
peoples. The general trend towards cores and core tools of less than 11 cm suggests a preference for stone of manageable size. This also reflects the size of available quartz in much of the study area.

A cursory metric survey of hammer stones provides potentially useful information for interpreting the processing of raw material. Hammer stones are notoriously scarce on lithic sites, indicating they were heavily curated. In the present study, the largest positively identified hammer stone is an elongate quartz cobble 10.5 cm long. Excepting a number of ambiguous cobbles of weathered diabase and diorite(?), most are much smaller. Prehistoric quartz quarries in Greene and Lincoln Counties have produced hammer stones on spent quartz cores up to 12 cm in diameter (Jones 2000a; Ledbetter et al 2003). The maximum dimension of these hammer stones is only slightly greater than those from the study area, yet their blocky or spherical shape renders them several times more massive.

**Discussion and Replication**

One of the attractive aspects of Callahan's (1987) work is his recognition of a broad range of reduction techniques. While any study has the potential to contribute to our understanding of lithic technology, many such studies are plagued by the lack of technical skill on behalf of the replicator; or the lack of ability to recognize specific reduction strategies. Though of potential use, these studies are often overly simplistic and have the potential to distort archaeological interpretations. To cite an example, I will use a study that I greatly admire for its objectivity (Baker 1976). Baker's experimental data compares hard hammer and soft hammer percussion flakes, and contains some useful observations. The assumption that quartz flakes are all produced essentially the same way (freehand percussion) fails to accommodate other strategies (anvil, bipolar) and variations in use of similar percusors (hammer stones of varying hardness, angle of applied force). This oversight causes the study to break down when his experimental findings are compared statistically with prehistoric artifacts. Different reduction techniques produce debitage that can mimic that of other techniques. Whole assemblages must be considered in light of positively identified diagnostic core and flake forms. Considered thus, an informed interpretation can be offered for lithic reduction sequences. While the present study doubtless contains methodological flaws, the diversity of identified core types indicate that a range of strategies were employed for extracting and utilizing quartz.

Virtually any replicative exercise is subject to criticism for its shortcomings, and a potential source of bias lies in the experience of the replicator. An experimenter of marginal skill cannot be expected reasonably to reproduce quantitative or qualitative efforts of a prehistoric knapper who spent a lifetime honing a limited repertoire of techniques. Likewise, in addition to his skills an experienced modern flintknapper brings to a project his own deeply ingrained biases. Over time, one develops preferences for certain flaking strategies, tools types, and methods of tool use. For both veteran and novice, success (and failure) rates are likely to differ from those of prehistoric stoneworkers. Also, single replicator, regardless of skill level, cannot accurately represent over 10000 years of technology; nor can 50 such replicators. Also, modern flintknapping is largely an individual pursuit. Prehistoric stone tool production was embedded in tightly knit traditional social structures (i.e., Binford 1986; Schick and Toth 1993) that are rarely reproduced by modern experimenters.

For the replication, quartz raw material from local sources was used when practical. Quartz from other areas is represented, especially in the case of documented pre-existing tools. Some of the replicated material is from this collection, and reflect minority core or tool types or are used to help flesh out the range of possible variation (especially bilateral material).

**Initial Reduction**

For those who are accustomed to conventional core and flake techniques for cherts and other well-behaved lithic materials, the processing of blocky chunks of quartz requires a slightly different approach. Much of the quartz in the Piedmont is riddled with internal fractures, unbonded crystal
interfaces, and other features that weaken the rock and affect its solidarity. The initial approach uses an appropriately sized hammer stone to strike the area of poorest quality material, typically an area containing the most cracks and obvious flaws. Because a visual appraisal of a quartz piece is sometimes deceiving, percussive blows to the low-quality area are executed at first in the same manner as they would be for a better quality of raw material. This sometimes yields usable flakes and chunks (see photos). Yet with a correct reading of the stone's quality, the selected area begins to crumble, and the shock from the blows weakens the bond along cracks and other flaws throughout the stone. Blows from the hammer stone begin to sound hollow (the "cracked baseball bat" sound) and cracks often open up visibly. Further gentle tapping with the hammer stone will cause the rock to fall apart along the cracks, yielding the most intact parts of the original stone. The large number of internal fractures present in much of the raw material make this method more productive than trying to spall out the quartz into large flakes from the outset. Also, heavy percussion sometimes causes flakes to fragment.

Once the original piece has been reduced to solid constituents, these angular pieces may then be graded. Within a quartz chunk, "windows" or "ice cubes" of better quality material are often visible (a useful criteria for field collection of raw material), and the process described above will frequently liberate these pieces for further processing. During the initial break-up, large flakes and flake fragments may be produced. These are used as-is for tools, or modified into cores, bifaces, and other tools.

**Percussors:** Quartz is a brittle lithic material (Boudreau 1981: 23), and the shape, material, and mode of application of hammer stones is critical to the successful replication and interpretation quartz assemblages. For reduction oriented towards the production of intact flakes (freehand, anvil, and bifacial cores), a relatively soft stone percussor is preferred. Fine-grained gneiss, amphibolite, and diabase are examples of suitable materials. Lacking these, harder materials (including quartz) may be used with similar effect so long as special care is exercised in selection and application. A hard hammer stone with a broad contact surface will distribute the force of the blow along a wider area of the core platform, resulting in an effect similar to that produced by a soft hammer stone. This results in less crushing and flake fragmentation, and fewer radiating fractures than a hammer stone applied forcefully to a concentrated spot on the platform.

The velocity with which the flake is struck is likewise important. Experience has shown that a heavy hammer stone applied at a low speed will produce desirable flakes more consistently than a smaller hammer stone delivered forcefully at high speed. The tendency among amateur knappers to strike a core with the most acute end of a hammer stone with excessive speed is often detrimental to the exercise, especially in quartz replication.

These observations regarding percussor hardness, velocity, and contact area apply to a greater or lesser extent to all lithic materials. A working knowledge of these relationships is extremely valuable in correctly interpreting quartz lithics.

On a related note, most types of quartz, while brittle, are glassy and behave like glass or obsidian. This has been noted by a small number of quartz replicators (Jack Cresson, personal communication; cf. Callahan 1987:57). Quartz is often regarded as a "tough" lithic material, in the company of rhyolites, coarse basalts, and quartzites. Quartz is brittle and often fickle. The better varieties (Types 1-4) are not tough, and should be treated as glass.

**Bifaces**

**Bifacial core/early preforms** represent the earliest stage of bifacial reduction. Intact examples of this type of core/bifaces are few in number, suggesting that they were either successfully reduced, or were recycled into other core types. Alternatively, this core form was perhaps not the preferred starting point for biface manufacture. Approximately symmetrical in cross section, these cores were evidently used as tools, and it may be reasonably assumed that they were also used for the production of flakes.
Further successful reduction of bifacial core/early preforms yields early stage bifaces. These retain some of the core-like attributes of the earlier form. The thickness of early stage bifaces allows further flake removals (for the production of flake tools) while still permitting use of the core tool itself (Kelly 1988:719).

The final stages of initial bifacial reduction results in a mid/late stage biface. Depending on the quality of the raw material, these reduction stages can be accomplished by percussion using a moderately soft hammer stone. An antler or wood baton can also be used. The curved shape of bifacial thinning flakes makes them vulnerable to breakage under the compressive strain of percussion. This is especially true in the case of quartz. Consequently, thin flakes removed with wood or antler are more likely to break than thick flakes generated by a hard percussor, rendering them less useful for flake tools.

**Metric comparison of biface width and thickness**

Bifacial reduction is often defined by width/thickness ratios, and modern flintknapping literature focuses disproportionately on this attribute. While exceptional examples of thinned bifaces are present in archaeological assemblages, late-stage prehistoric quartz bifaces often do not exhibit extreme width/thickness ratios extolled by modern stone-working dogma. In the sample of Early and Middle Archaic quartz projectile points (Table 4), this tendency towards thick bifaces is indicated by the average width/thickness ratio of 2.7. This is further supported by metric data from 11 Late Archaic pp/ks from Big Creek site (9MF38). These have an average width/thickness of 2.7 (Pluckhahn and Jones 2002). In a sample of over 500 quartz Early Archaic points, the 2.7 width/thickness ratio is again repeated (Jones et al. nd). By contrast, a small sample (n=5) of Late Archaic chert points from Big Creek (9MF38) and over 300 Early Archaic chert points from the previously cited work (Jones et al. nd.) show a consistent average ratio of 3.4. Despite the cavalier crosscutting of Archaic time periods in this comparison, a compelling level of consistency is evident in width/thickness ratios of quartz projectile points, especially when compared to contemporaneous chert examples.

These data do not take into account the effect on bifaces of resharpening. A sample of replicated quartz bifaces were measured for comparison to the width/thickness data for prehistoric bifaces (Table 6). Measurements were taken for bifaces in the pre-existing inventory as well as those that were produced specifically for this paper, and are grouped according to type. Some of the biface types used here differ from the prehistoric sample, and reflect the focus of various past projects. No replicated Early Archaic pp/ks were included, while 7 large stemmed Late Archaic replicas were measured. In the analysis, mid- and late-stage preforms were not distinguished; the only replicated preforms on hand were considered to be late-stage, requiring no further thinning prior to use. Otherwise, replicated small stemmed and contracting stem pp/ks are consistent with the content of the prehistoric analysis. Replicated bifaces were chosen for measurement if they were deemed to represent the earliest stages of manufacture and use. Doubtless, this is strongly biased by familiarity with prehistoric points in various stages of utilization, but it is partially offset by an understanding of the function and utility of quartz tools. Consequently, preforms are perhaps the best indicator of original proportions, assuming that they have undergone minimal reduction through resharpening. Other tools measured include hafted and unhafted bifaces that are unresharpened or retain the widest part of the blade in unmodified form. Aberrant forms were rejected, this consisting largely of marginal bifaces that could be argued to represent the later stages of use.

Of 10 late-stage preforms, the average width/thickness is 3. This is also true for the 7 large stemmed projectile points of Late Archaic type. In the sample of 16 small-stemmed bifaces, width/thick-

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<th>Replicated bifaces type</th>
<th>Average</th>
<th>Range</th>
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<td>Large stemmed pp/ks (n=7)</td>
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</tr>
<tr>
<td>Small stemmed pp/ks (n=16)</td>
<td>2.9</td>
<td>3.5-2.5</td>
</tr>
<tr>
<td>Contracting stem (Morrow Mountain) pp/ks (n=10)</td>
<td>2.8</td>
<td>3.3-2.4</td>
</tr>
<tr>
<td>All pp/ks and late preforms (n=43)</td>
<td>2.9</td>
<td>3.6-2.4</td>
</tr>
</tbody>
</table>
ness is 2.9, and for contracting stem/Morrow Mountain types the figure is 2.8. Of a total of 43 similar items (late preforms and pristine projectile point/knives), the average width/thickness ratio is 2.9.

Two possibilities are offered to explain the consistency of manufacture in quartz preforms and finished bifaces. The first concerns the relative predictability of quartz across the Piedmont. While many Archaic quartz points were evidently curated, the initial expenditure of time to produce extremely thin bifaces is tempered by the availability of more quartz suitable for the replacement of worn or exhausted tools. Second, the brittleness of quartz renders thin tools (whether bifaces or flakes) vulnerable to breakage. With regard to bifaces of any lithic material, an optimal tool is one that balances edge quality with durability. For quartz bifacial tools, archaeological and experimental findings suggest that a width/thickness value of about 3 represents an optimal balance between tool function and durability.

Replication of bifaces: Bifacial reduction is relatively straightforward, and is well represented in modern flintknapping literature (Callahan 1979; Hellweg 1984; Waldorf 1984; Whittaker 1994; Patten 1999). The use of quartz bifaces as portable cores differs somewhat from the model posited for Coastal Plain chert bifaces (Sassaman 1996: 78). This is attributed in part to the proximate or local availability of quartz across the region.

Bifaces were replicated in three modes: core bifaces (i.e., a tool that has undergone complete bifacial reduction), bifaces on flakes, and plano-convex bifacial cores. The distinction between thick flakes for the production of core-type bifaces and flake-blank preforms is idealized here for illustrative purposes. In practice, a range of flake types may be used, with corresponding degrees of modification. Plano-convex bifaces constitute a small but visible component of tool technology in the region. Consequently, the replicative data for this artifact type are excluded for the sake of brevity.

Bifacial reduction of quartz can be accomplished in large measure with hard-hammer percussion. Hammer stones include various size pebbles of quartz, diabase, and granite gneiss. The wide range of hardness of these materials allows differing amounts of control in flaking, with the greatest control in bifacial reduction possible with the softest stone. In this study, the granite gneiss is the softest. As noted earlier, however, the effect of a soft hammer stone can be achieved by striking with a broad (i.e., flat) area of a harder stone. The quality of the quartz being used is also important in the selection of percussor. The highest quality material (Types 1 through high-quality 4) can often be thinned with a hammer stone to realistic proportions. An antler billet provides an added level of control, giving the final preform a smooth surface. The replicated formal bifaces (projectile point/knives) shown (Figure 11) are from archival material. They were made by either bifacial reduction (of cores or thick flakes) or by minimal percussion and/or pressure retouch of flakes. In all cases, the points were finished by pressure flaking with antler, bone, or wood. Recent experiments (Callahan 1999; Jones 2001d) have shown that hard wood can be used with good effect for pressure flaking. I have found this to be especially true for heavy retouch of quartz tools.

**Core-type Biface**

As a point of clarification, core-type biface (as used here) represents the several stages of manufacture of a tool that has undergone complete or nearly complete bifacial reduction. This is distinct from the previously defined early preform/core biface, a core tool in the earliest stage of bifacial reduction. The present category also includes core-type bifaces made on thick flakes that must (by definition) undergo considerable modification. Those made on thin flakes requiring minimal modification are treated under *flake-blank preforms*.

The procedure: The production of core-type bifaces presented here is a composite of Archaic techniques. Early Archaic bifaces are postulated to have served as portable cores (Sassaman 1996: 78, and others) and were progressively reduced to preforms and projectile points. Middle Archaic forms seem to be initially smaller and perhaps destined for almost immediate use as projectile point/knives.
Nonetheless, the procedure appears to proceed along similar lines.

The starting point for Archaic core biface production is either a natural pebble or cobble, an angular piece from the initial breakdown of a large chunk, or a thick flake. Natural pebbles and cobbles in the 10-15 cm range are the most common in the study area, and were used for much of the replication.

In the present study, an early preform/core biface was replicated. The raw material consisted of a blocky chunk of good Type 4 quartz with a number of cracks and visible parallel fractures. It measured approximately 15 cm long. Using a gneiss hammerstone, about 5 minutes were spent trimming and edging the piece. The fractures predictably gave way, thus reducing the size potential for the tool. Once the chunk was pared down to the most solid constituent piece, a few large flakes were removed in an effort to begin shaping. Bifacial trimming of the piece produced several well-formed flakes in the 2.5 cm range. Once the exterior surfaces were removed, the resulting edges were prepared by grinding prior to flaking. This was helpful, but was possibly unnecessary because of the thickness of the core and the quality of the raw material. One surprising aspect of this sort of early-stage flaking is the size of the early flakes in relationship to the resulting cores.

Three early preforms were replicated. The descriptions are combined. One was from a blocky pebble, another from a lens-shaped spall from an eroding quartz vein, and another was a chunk from the breakdown of a large cobble. All were in the 10-15 cm range. Reduction was done with diabase and gneiss hammerstones. As in the previous example, the pieces were bifacially edged. Because a greater degree of refinement was desired, greater attention was given to edge preparation and beveling prior to flaking. Consequently, the most numerous flakes were relatively small (generally around 2 cm), with straight or curved profiles.

**Flake-blank Preforms**

Quartz bifaces were also made by minimal modification of flakes of appropriate size, and retain evidence of this origin. In general these are elongated, relatively thin flakes. The bulb of percussion often forms the proximal (haft) end of the biface/projectile point, with the striking platform remnant sometimes remaining intact at the base. In the case of Middle Archaic Morrow Mountain points, this is detectable as a slightly thickened or beveled basal tang. In Late Middle Archaic examples, the stem end retains the flat striking platform (giving the appearance of being steeply beveled), with the bulb of force still visible on the former ventral flake surface.

Replication: Flakes derived from any of the three principal core techniques (freehand, anvil, or bipolar) may be used for flake-blank bifaces. Robust freehand flakes with little curvature are best suited to the production of this type of biface. Large anvil flakes with similar characteristics are also usable. The tendency for quartz flakes to break apart makes difficult the consistent production of intact flake blanks. However, flake-blank biface production makes good use of solid material.

For this project, an 8-cm long percussion flake of good Type 4 quartz was used. Much of the original flake outline was altered as a result of heavy abrasion (bordering on light percussion) of the edges. The prominent bulb of force was thinned and effectively removed by percussion with a small gneiss hammer stone. Cracks were evident near the distal end. Heavy pressure flaking was used to shape the piece in an effort to prevent the failure of the cracks. The cracks caused the end of the preform to break off, but the remaining piece was deemed large enough to continue. A small antler billet was successfully used to reshape the broken preform end and further flatten the dorsal ridge. Final shaping was accomplished with an antler pressure flaker, and a fine-pointed bone flaker was employed for final edge sharpening.

**Bifaces in the Overall Scheme of Quartz Tool Technology**

Though the quartz used in the study was not all equally suited to the manufacture of bifacial tools, virtually all of it is suitable for expedient tools. Indeed, while the exercise reported here was geared towards the manufacture of bifaces, many useful
prospects for expedient cores, flakes, and other tools were left among the debitage. This brings us to several observations.

First, the few large, intact pieces of quartz found in the study area are often poor quality, with better material occurring in smaller packages. While it is sometimes possible to extract large bifaces from rough, grainy quartz, the toughness and unpredictability of this type of quartz makes it less suitable for portable core/curated tool applications. Hence, smaller bifaces of better quality quartz are easier to manufacture initially, and are more easily and predictably maintained. For long-term use, these may be preferable to bifaces of rougher material.

This, then, calls into question the ubiquity of quartz in the project area, and across the entire Piedmont. Conventional wisdom asserts that quartz—a mineral—is ubiquitous throughout the Piedmont, so by logical extension the human use of quartz should be equally distributed. Both experiment and archaeology demonstrate the refinement of this viewpoint. Experiment shows that quartz material is highly variable within a single outcrop, even within a single piece of stone. While much quartz has marginal utility as an expedient resource, not all quartz is equally suited to the predictable production of bifaces, formal tools, and flakes. Archaeologically, not all quartz outcrops show signs of prehistoric use, and not all quarry sites are used equally. The axiom may be re-stated: Quartz is ubiquitous across the Piedmont, but the occurrence of desirable tool-grade quartz is not so distributed.

The third observation is one of purely practical means. Quartz is a common mineral that varies widely in the technical properties sought by prehistoric peoples. With regard to the body of knowledge built around experimental flintknapping, quartz is unlike other lithic materials. Experience has shown that, when compared to other lithic materials, quartz is best approached with a “quit while you’re ahead” attitude. If the correction of a botched platform or crushed edge jeopardizes the finished product, it is better to leave it rather than destroy the point in an effort to achieve an idealized form.

Tool-making peoples of the past doubtless had defined limits of tool size that reflected the degree of curation and incidence of re-visititation of the quarry site. One need only look at the large broken biface fragments scattered about some of the Coastal Plain chert quarries to get a sense of size as a determining factor in tool production for Archaic natives. Quartz, on the other hand, has the distinction of being spread across an entire geophysical region. All of it is not useful tool material, but the likelihood of encountering an exploitable quartz outcrop in the Piedmont is much better than finding a chert outcrop in the lower Coastal Plain. Because quartz is a relatively common and predictable resource, a different strategy could be employed.

It is suggested that the production of quartz bifaces was a more flexible enterprise than with other lithic materials. Bifaces were evidently subject to minimum size limits, as evidenced by broken bifaces showing no sign of an attempt at salvage or remanufacture. Yet given the constraints of quartz tool production, it is plausible that the knapper set his sights on the largest possible biface from a given piece of stone. Even if a particular tool-making session yielded bifaces smaller than the optimal size, the quality of quartz from which they are made is modulated by the potential (or known) availability of quartz elsewhere within the region. If the raw material was of exceptional quality, a small biface could, by dint of quality, be viewed as highly utilitarian. Also, if other sources of quartz (regardless of quality, more or less) were known to exist nearby, these sources could be viewed as a means of augmenting the tool kit. Depending upon the quality and quantity of other sources, augmentation could take the form of supplemental/expedient tools or biface production.

**Mississippian Small Triangular Arrow Points**

While the discussion and replication of bifaces focuses primarily on Archaic forms, this small biface type deserves mention by virtue of numerical visibility (n=31). Of this sample 23 are from Wilkes County sites. Three sites (9WS323,
9WS324, and 9WS328) yielded evidence for the stages of manufacture, including blanks, preforms and finished points (Figure 5). The form of this point type is a small isosceles triangle, sometimes with a slightly indented base. Basal width ranges from 15-21 mm.

**Replication:** The process begins with thick flakes or flake fragments, or thin flakes (Figure 6). In replication, the small size of the blanks favors hard-hammer percussion for initial reduction. The extent of reduction is dependent upon the size and thickness of the raw material. As with other small projectile point types, small triangular points are easily made from flakes and debris from earlier time periods. Since quartz does not patinate, this cannot be conclusively demonstrated. Yet given the sparse and diminutive nature of Mississippian lithics in northeast Georgia, this possibility cannot be disregarded. A number of the replicated small triangular points were made from flakes scavenged from the debitage of my previous activities. Also, prehistoric examples in the survey are typically made of high-quality Type 3 or 4 quartz. This preferential selection of good lithic material for small points is consistent with the conventions modern flintknapping.

Thick pieces were thinned by bold percussion flaking, and thin pieces were trimmed and edges straightened. Unlike ovate Archaic bifaces, Mississippian preforms are given a triangular shape early in the reduction sequence. This shape becomes more pronounced as the piece is further shaped. In the final stages of shaping, a basal concavity is formed. This is evidently a strategy that helps thin the base. Failure to accomplish this results in a thick, step-fractured concavity at the base of the blank, as is evident on artifacts from the survey. Though not represented in the survey, reduction techniques for triangular projectile point manufacture changes little from Woodland to Mississippian times. Despite the difference in size, large triangular Yadkin points of the early/middle Woodland period are similar in execution to smaller, temporally later forms.

Small triangular points are finished with pressure flaking. Some of the middle stage preforms show series of uniform, bold flake scars that are probably from pressure flaking. The final shaping of the edges and tip is done with fine pressure. Antler can be used, but sharpened slivers of sound bone also give good results for fine pressure flaking (cf. Swanton 1946:572-573).

**Non-bifacial Cores**

While flake production and reduction of cores often contribute to the production of bifaces, the process of core reduction deserves mention in its own right. Frequently in the analysis of quartz artifacts, the lesser-known aspects of quartz reduction go unnoticed by those unschooled in comparative replication. Non-bifacial core reduction in quartz is a discontinuous sequence. Ideally, it goes from the percussion reduction of non-supported cores (single and multi-platform) to anvil-supported but not anvil-interactive flaking, to anvil-supported and interactive flaking (the "outside in" bipolar approach) to formal bipolar flaking (inside-out bipolar, or splitting). In reality, a pebble may be split by formal bipolar flaking, and then be reduced further by freehand, anvil, or bifacial techniques. In the analysis, many of the small cores were produced on thick flakes, with the relatively flat ventral flake surface used as a striking platform.

Cores discussed below were replicated specifically for this study to illustrate the techniques (see accompanying photos). Of 10 cores attempted, 3 were aborted as a result of poor or badly flawed raw material. Other experimental cores are illustrated separately. These are from archival material, and were selected for their convenient size. Diabase and granite gneiss hammer stones were used for freehand core reduction, as specified. For all anvil and bipolar flaking, diabase hammer stones and anvil were used.

**Freehand percussion cores:** Freehand cores are, as the name suggests, cores that are reduced without the use of a solid support (Figure 7). This definition is necessarily broad, and encompasses techniques in which the core is supported in the hand, on the ground, or, in the convention of modern flintknapping, on the leg. These methods do
Figure 5. Mississippian Small Triangular Point Manufacturing Stages. Top: Early preforms, 9WS324. Second row: Mid-stage preforms, 9WS325 (left two); 9WS328 (right two). Third row: Late-stage preforms, 9WS325, 9WS324, 9WS328. Bottom: Finished points, 9WS328; 9WS324; 9OG474; 9WS325 (right two).
The terminology for anvil cores requires some qualification. In Callahan’s (1987) original work, he distinguishes freehand and anvil techniques by the use of an anvil support in the later case. Bipolar flaking is considered by him to be either “outside-in” or “inside-out.” I take no issue with this categorization, but I would like to divide the techniques in a slightly different way for the present study. As noted earlier, core reduction strategies have an implied linearity that suggests a tidy progression from freehand, to anvil, and finally to bipolar types. This is not entirely correct, noting that factors including the type of tool desired and package size of available material dictate the starting point for reduction. Yet drawing from experience with the progressive reduction model, I will consider all anvil-supported cores that are flaked on the periphery to be anvil cores. By so doing, the continuity of all “outside-in” techniques will be demonstrated. This includes initial stage anvil flaking, in which the anvil does not interact directly with the detached flake. Intermediate anvil flaking, a variation not addressed by Callahan (1987), bridges the technological gap between the extremes of anvil techniques, is introduced here. Because the stages of anvil flaking grades into each another, intermediate anvil flaking is more a conceptual stage than a specific technique; consequently, it is difficult to demonstrate clearly. Also included is late-stage outside-in bipolar flaking. I have chosen to use the term anvil/bipolar to describe this last method and distinguish it from formal bipolar technique.

**Initial stage anvil flaking:** In this technique the core is supported on an anvil, and flakes are removed without direct interaction with the anvil (Figure 9). Conversely, flakes (and often the cores) are practically indistinguishable from freehand percussion material. The core is placed on an anvil and struck so that the force is directed outward and away from the platform, thus removing a flake in essentially the same way as in freehand percussion. The impact of the hammer stone on the upper surface of the core can cause pitting and/or minor crushing where the core contacts the anvil. This is most pronounced in single platform anvil cores because the same end of the core is constantly in con-
Figure 8a. Freehand percussion replication; preparation for initial reduction.

Figure 8b. Freehand percussion replication; successful first flake removal.
tact with the anvil. On multiplatform anvil cores, the telltale signs of anvil contact are more subtle, and are found at the distal end of a given flake scar.

Flakes tend to be flat or have significantly less curvature than freehand percussion flakes, but morphological overlap is common.

Initial Stage Anvil Core Replication (Figure 10a-b): Of three replicated initial stage anvil cores, the first was produced from a piece of good Type 4 raw material measuring 12x10x7 cm. Several large flakes were removed, but the flake surfaces had a hackly quality despite the overall good raw material quality. Freehand percussion with a gneiss hammer stone was employed to rejuvenate the core. This resulted in a roughly bimarginal core remnant and several good percussion flakes.

The second core was from an angular, odd-shaped piece of quartz measuring 19x11x9 cm. The raw material was a marginal Type 4 quartz of glassy/granular texture. Several large flakes were removed before the failure of a crack caused a chunk to fall off the bottom of the core. Several more flakes were removed after this, but the core was not reduced further because of the poor quality of the material.
Figure 10a. Initial stage anvil flaking replication; preparation for flaking.

Figure 10b. Initial stage anvil flaking replication; the flake removed.
The third anvil core was made from high-quality Type 4 (bordering on Type 3) quartz. Raw material was slightly angular chunk measuring 12x6.5x6 cm. One good primary flake was removed. This core and flake were retained as examples, with no further modification.

**Intermediate anvil flaking:** As a core is reduced, it becomes increasingly difficult to remove flakes without interaction with the anvil (Figure 11). The core is struck using the same low-angle percussion blow of freehand and initial-stage anvil flaking, but is positioned so that the bottom of the core (at the distal end of the anticipated flake) is in contact with the anvil. This results in a flat, sheared flake with only minor distal damage, while avoiding the excessive crushing and splintering of bipolar techniques. The degree of interaction of the anvil with the flake is poorly understood. In this technique, the proximity of the anvil to the distal flake end may lend extra support, or it possibly serves as a hinge for flake detachment (Figure 12a-b). By recognizing and including the intermediate form, technological continuity is demonstrated for anvil flaking (as defined by Callahan) and early stage (outside-in) bipolar.

**Anvil/bipolar:** As the core becomes smaller or a different type of flake is desired, the direction of applied force changes to a higher angle (Figure 13). In the late stages of anvil flaking, the periphery of the core is struck with a vertical blow from the hammer stone, thus pinching core between anvil and hammer stone. Instead of a single-point flake initiation, the bipolar wedging phenomenon described for bipolar flaking by Cotterell and Kamminga (1987) removes a flake from the periphery of the core. Direct pounding of the core causes pitting and crushing at the point where it contacts the anvil. Callahan refers to this as “outside-in bipolar.” The method of execution is similar to the formal bipolar technique described below. It is included here with anvil techniques as the end member of a group of related reduction strategies for removal of flakes from the periphery of a core.

This method produces a range of flake forms similar to that of formal (inside-out) bipolar, including relatively thick flakes that are good blanks for small bifaces or flakes tools. Given the evident presence of anvil flaking in the study area (and elsewhere in the southeast), the relatively low numbers of cores probably indicate a conservatism in identification. Many of the anvil cores so identified are likely late-stage cores with readily apparent distal crushing. Indistinct or ambiguous evidence for contact with the anvil doubtless caused some minimally used cores to be counted among the freehand cores.

**Intermediate anvil-anvil/bipolar replication** (Figures 12a-b and 14a-c): Because of the overlap of these techniques, the replication was conducted as a single exercise. Raw material consisted of a sub-angular piece of good Type 4 quartz measuring 10x5x4.5 cm. A protrusion on one end of the raw piece was initially anvil flaked to establish core geometry for intermediate anvil reduction. This yielded several small, curved intact flakes. As reduction continued, intermediate anvil flaking produced several relatively flat, thick flakes. As the core face steepened and began to intersect the platform at an angle of about 90 degrees, the percussive force was increasingly directed downwards. This produced a number of anvil/bipolar flakes. At this stage, the top and bottom of the core showed distinctive crushing, with radial fractures evident in the flake scars on the core face. Some of the flakes from this stage are thick and splinter-like, with lon-
Figure 12a. Intermediate anvil flaking replication; preparation for flaking.

Figure 12b. Intermediate anvil flaking replication; after several flake removals. Note previous flakes in foreground.
Bipolar: Late-stage anvil flaking as described above is a form of bipolar flaking. But for technological purposes, bipolar flaking is here defined as the flaking or splitting of a core along the long axis. Since it was first described for New World assemblages by Binford and Quimby (1963; however, see Mason and Perino 1961), this technique has been only reluctantly and sporadically recognized. Conversely, some view quartz reduction (however erroneously) as being synonymous with bipolar flaking (Breuil and Lantier 1965: 63; Dickson 1977: 98; Troeng 1993: 39). This study will not concern itself with the largely semantic arguments about bipolar flaking that characterize the infamous exchanges of the late 1970s (Sollberger and Patterson 1976; Haynes 1977; Patterson and Sollberger 1977; White 1977; Cresson 1979; Patterson 1979; Rondeau 1979; Stafford 1979). Regardless of the mechanics responsible for the effect, this “inside-out” approach produces a small amount of distinctive debris contained within the greater volume of ambiguous reduction debris. As noted by Callahan (1987:13), bipolar flaking is a process, and is best identified through the analysis of entire assemblages (Joslin-Jeske and Lurie 1983). A large amount of space is devoted here to this “formal” type of bipolar reduction because of what it represents in the larger context of a tool technology that has been historically regarded as strongly bifacial.

Bipolar reduction is seen on a few relatively large cores (in the study, up to 6.5 cm), but the presence of small (even tiny) bipolar cores of classic form indicate a purpose beyond mere convenience in the reduction of small raw material. Bipolar cores in the study are smaller, with one classic form from 9OG482 measuring just 19 mm long (a similar formal bipolar core measuring 16 mm was recovered in the Lake Oconee survey). These bipolar cores do not appear to be themselves utilized, and they are unlikely to have been formed accidentally either prehistorically or historically. The presence of small flakes with apparent utilization and retouch at several sites in the Piedmont of Georgia strongly hint at a tradition of small tool use.

Chronologically, bipolar materials occur during all time periods, but they correlate most con-
Figure 14b. Anvil/bipolar flaking replication; flake shown with core.

Figure 14c. Anvil/bipolar flaking replication; core takes on bipolar characteristics after several flake removals.
vincingly with sites containing a Middle Archaic component. In the study 13 of 19 sites with a Middle Archaic component yielded bipolar cores. This finding hints at Neumann’s (1998) suggestion that Middle Archaic lithic technology focused on flake and microtool utilization.

Formal bipolar flaking is executed by holding the core upright on a stationary anvil and striking with a hammer stone (Figure 15). This exerts force along the long axis of the core, much like cracking a nut. While the classic example shows an oval pebble split neatly in half, or into thirds, the practical applications are quite varied. Cotterell and Kamminga (1987) have adequately discussed the mechanics of bipolar flaking, with specific reference to the splitting of the [hertzian] cone during fracture initiation. Although conchoidal fracture is observed in all grades of quartz, it is well developed in the highest grades (Types 1-3). Under certain conditions, all types of quartz show a propensity to fracture in such a way as to produce flat, sheared flake surfaces. This is noted by Flenniken (1981:29-32) in description of quartz bipolar flaking as shearing. Andrefsky (1998: 120) contrasts Flenniken’s assessment of shearing (of quartz) with Cotterell and Kamminga’s (1987) split cone theory (lithics in general). One of the characteristic attributes of quartz is the frequent lack of well-developed bulb(s) of force, compression rings, and other signature features of other lithic materials. As noted above, the bulk of literature on lithic technology and flintknapping fail to mention macrocrystalline quartz (excepting the occasional reference to crystal) as a lithic material. While quartz generally follows the rules of conchoidal fracture mechanics, the brittle quality and crystal structure contribute to occasional idiosyncratic fracture patterns. This is nowhere better exemplified than during bipolar flaking, which produces distinctive flake and core forms often exhibiting surfaces that are best described as sheared.

In the analysis, numerous artifacts were circumstantially identified as bipolar reduction debris. Yet because other methods of core reduction can (and often do) yield debris that closely resembles bipolar material, a conservative approach was taken. Consequently, the actual number of bipolar artifacts is probably underrepresented. Bipolar flakes were identified in the analysis, but bipolar cores are more easily distinguished. Consequently, the interpretations are based largely on core data. Unambiguous bipolar cores and flakes provide direct evidence for anvil-supported (and generally non-bifacial) reduction. This is significant in the present study for several reasons.

The significance of formal bipolar: Bipolar artifacts (cores) range in size from 1.9 to 6.5 cm. Bipolar products from the larger cores are suitable for the manufacture of small bifaces. Because of their small size and often columnar form, these cores do not appear to be part of a biface manufacturing sequence. None of the cores showed obvious use-wear. The small size (1.9 cm) of a bipolar core from 9OG482 is intriguing. Even if this core was exhausted and discarded, it was evidently useful until quite small. A small number of small flake tools (microtools) were identified in the study, and it is postulated that bipolar flaking is one possible avenue for the production of small tools. Elsewhere in Georgia, quartz microtools were identified by the author in the Lake Strom Thurmond (Clark Hill) survey (Braley 1999), and in the Reynolds Plantation survey (Ledbetter et al 2002). Neumann and Polglase (1992) suggest that the presence of microtools in the middle Atlantic region is indica-
tive of composite tools. A clear case for composite microtools has not been demonstrated for the study area. Cresson's (1988-1997) work in the northeast has demonstrated the utility of hafted single microtools and microbifaces, as has Flenniken's (1981) replication of Hoko River knives.

Because bipolar flaking is part of the nonbifacial reduction sequence (with the provision that small bifaces may be made from flakes produced within the sequence), recognition of formal bipolar reduction may prove useful for studies of gender within lithic assemblages. The relationship of specific lithic reduction techniques to gender has been suggested by Flenniken (1981), Gero (1991), Neumann (1998), and Ledbetter et al (2002).

As noted by Casey (2000: 87-88), fundamental misunderstandings of bipolar technique have arisen through the overly stringent definitions of "core," the disproportionate focus on flake end-products, and the erroneous presumption to know the intent of the knapper. With practice, bipolar flaking is predictable and controllable through technique, yet it produces a wide range of flake and debris forms. This appears to be wasteful, but once the focus has shifted from end products to the integration of those products into a larger process, bipolar products are highly utilitarian. The many flake forms and edge angles resulting from bipolar reduction frequently find use for a variety of tools including small bifaces (Boudreau 1981: 26), scrapers (Forsman 1974), and microdrills (Mason and Perino 1961; Yerkes 1983; Jones 2000b; for a related ethnographic item, see McCarthy 1967). The wide range of contexts in which bipolar materials are found (including quarries) suggests that this is a technique for producing specific tool forms, not an act of desperation.

A category of tools called wedges (approximately synonymous with pieces esquillees, pieces écaillées, and outils écaillées) is common in modern analyses, deriving momentum largely from MacDonald's (1968) description. An informal poll of other primitive technologist conducted over a period of years has shown that flake wedges are commonly used, but these seldom begin or end in the classic "splintered" or "scaled" forms. The typically flake wedge has a thick back that tapers to a sharp edge. Biface fragments may also be used, but the preferred form for these has a steep mid-section break that provides a wide, sturdy striking surface. Experimental flake wedge damage generally takes the form of semi-lunar bending fractures along the working edge, resulting in a tool that most closely resembles a denticulate (while still accounting for stone fragments embedded in worked bone artifacts). Recent replicative studies generally support the view that pieces esquillees have minimum utility as wedges, and that they represent an aspect of tabular bipolar core morphology (Hayden 1980; Flenniken 1981; Casey 2000). Scale- and step-like fractures are common on late-stage and abortive bipolar cores. Casey (2000) presents a detailed discussion of this problem. Nonetheless, I remain open to the possibility that certain tool forms may be shaped by bipolar flaking, but the specific function of such tools deserves in-depth experimentation.

Pitted anvils are often presumed to be associated with bipolar reduction. While these are useful in some bipolar operations, they are more likely to be a by-product rather than an intentional form. For columnar bipolar cores, the pitted anvil is acceptable. For tabular material, however, the pit provides two contact points for the bottom of the core, resulting in unpredictable/uncontrollable flaking.

Bipolar replication (Figure 16a-c): The first bipolar replication utilized a piece of raw material from survey site 9W5321. Consisting of good Type 4 quartz, it was slightly wedge-shaped, and measured 6x3x2.5 cm. Beyond some initial crushing of the thin end, the first flake removed was a curved flake showing a bulb of force on the upper end. This is believed to be the result flake initiation from the upper end, but lacking direct interaction with the anvil (similar to anvil flaking). Subsequent efforts to flake the core resulted in significant crushing, reducing the height of the core. This is believed to be the result flake initiation from the upper end, but lacking direct interaction with the anvil (similar to anvil flaking). Subsequent efforts to flake the core resulted in significant crushing, reducing the height of the core. The small, ultimately block piece eventually split into two classic barrel-shaped core pieces, and several flat and angular flakes. No further reduction was done to this sample, and the cores and flakes were retained.

The second bipolar experiment was conducted with raw material from survey site 9OG487.
Figure 16a. Formal bipolar replication; preparation for flaking.

This was blocky piece of good Type 4 quartz measuring 6x6x5 cm. The blocky shape of the raw material provides good contrast to the elongate shape of the previous example. Working from the periphery of the core, anvil/bipolar flaking was used to initiate reduction. This resulted in several thick, flat and splinter-like flakes. This continued, and yielded abundant crushing of the core top and bottom, and a variety of flake forms. As the core became smaller, force was (by necessity) directed increasingly towards the center of the core. The final few blows produced numerous long splinter-like flake forms and flat flake-like fragments. Many of these show radial cracks. Among the resulting pieces, a significant fragment of the core remains. Like many of the flakes, it clearly shows end-crushing, radial cracks, and flat, sheared flake scars. It was reduced no further, and was retained along with the flakes.

Other Tools

A number of tools were replicated specifically for this project, and others are from my reference collection of utilized and documented pieces. Some observations on quartz tool use that are of potential use for analysts are included. This group includes a variety of flake and bifacial tools of both formal and informal nature, generally reflects the makeup of tools from the survey. Some artifacts from the survey, such as unifaces, appear to be informal tools yet display a high degree of standardization. Others are unique, and perhaps reflect personal choice or situational need. Replication of these items is largely a conceptual matter, and interpretations are based on informed experience and inference. So long as the design and function of a given tool is understood, a precise replica is not strictly necessary. In many instances the additional effort spent on creating an exact replica is impractical, and risks spoiling the tool. My choice in tools for specific tasks has been influenced by long reflection upon archaeological examples as well as practical experience, and many of the tools shown are both visually and functionally similar to artifacts from the survey. Some of the replicated tools are not represented in the survey material, but reflect my interest in quartz tools beyond the immediate bounds of the project.

Flake Tool Replication and Utilization Exercise

The completion of this paper coincided with the yearly primitive technology studies week with the fifth grade class of a private elementary school. My previous participation in this program has allowed me to assemble a sizeable reference collection of used flake tools of various lithic materials. Burn-and-scrapewoodworking emerged as the most popular activity for this program, and the various associated tasks present the opportunity to conduct experiments in use-wear while collecting reference material.

The students involved with the program had little or no prior experience with stone tools. Each day's session consisted of a new group of approximately 10 students. This provided a relatively unbiased pool of tool-users. This would seem to
Figure 16b. Formal bipolar replication; split core.

Figure 16c. Formal bipolar replication; final reduction into typical end-stage bipolar material.
contradict my earlier statement regarding the novice bias in replicative studies. It should be noted, however, that my objection to conclusions drawn by inexperienced replicators is aimed at the production of stone tools. It is entirely reasonable to assume that stone tool manufacture is governed by sociocultural protocols (i.e., Binford 1986), even in circumstances where trans-gender tool production is inferred. On the other hand, tool use may be presumed to encompass a broad segment of a given population (Binford 1986: 553).

Flakes for the exercise were made by hand, generally from high-quality Type 4 quartz. Most were produced by freehand percussion. A minority of anvil and bipolar flakes were also included. Flakes with long edges were singled out for use as saws, and a variety of rounded and irregularly shaped flakes were set aside for scrapers. Beyond initial selection and instructions for use, no other biases were introduced.

The burn-and-scrape project consists of making a small mortar from a piece of pre-cut wood. The wood used is Sweetgum (*Liquidambar styraciflua*), a deciduous tree native to the eastern U.S. with medium-soft wood. Blowpipes are made from hollow sections of Rivercane (*Arundinaria gigantea*). Though of no immediate consequence to the replication study, pestles were made from unmodified alluvial pebbles.

Although the project does not include a comprehensive set of tool-use imperatives, the prescribed tasks include two primary actions that are important in the creation of wear patterns. They are executed upon moderately hard materials, and yield good examples of use-wear. **Sawing** motion is used to make the cane blowpipes. The cane is girdled by sawing with a flake, with tool movement paralleling the edge. **Scraping** motion is used for the periodic removal of burned wood residue from the mortar. This involves uni- or bi-directional motion perpendicular to the tool edge. Approximately 20 flakes were set aside for the sawing task, and about 30 flakes were reserved for scraping. Two flakes from the scraper group were re-used as saws, and were recorded as composite-use tools.

In a small number of instances, wet clay was applied to areas of the wooden mortar to prevent over-burning. The effect of residual clay on tool wear is not known, but should be taken into account in assessing scraping tools. As noted for the utilized mixed lithics from previous sessions, tool use is seldom limited to a single activity. Indeed, practical experience indicates that multiple uses of tools is routine.

Stresses on the tools quickly revealed pre-existing flaws and fractures in the flakes. Tool breakage and attrition were greatest during the first two days. Breakage of about one tool per day occurred on the third and fourth days, and none on the fifth.

One of the most interesting results of the exercise is the attitude towards tools with regard to experience and pre-conceived ideas of tool use. In demonstrating the various techniques to be used, I employed a limited set of tools for the entire week. Owing to my preconceptions, these tools (especially one bipolar flake scraper) show highly formalized "textbook" use-wear. Students and participating teachers brought to the project no such preconceptions, and therefore used the flakes opportunistically. For example, if a striking platform remnant at the proximal end of a flake provided an acceptable scraping edge, it was used without regard for tool "formality".

**Observations on tool use:** In actual use, quartz tools develop certain key characteristics that are useful in detecting use-wear. The high rate of attrition of tool edges used on hard materials results in wear that is readily apparent on good grades of quartz. On grainier varieties, wear is often present but difficult to detect. A good reference collection is beneficial in these situations.

In addition to visible use-wear, quartz tool edges often exhibit rounding that seems to correspond to unifacial use. Depending on factors including degree and intensity of use, hardness of the material being worked, and the quality of quartz, the tool edge becomes steep. Greater steepness causes the rounding to appear to extend slightly onto the ventral surface. Once identified, this type of wear can be confirmed by feel and visual inspection under magnification.
Another characteristic of utilized quartz tools is the noticeable smoothing of edges. This holds true for edge rounding described above, but is also evident for other patterns of tool usage (sawing and slicing, for example). Fresh or unused tool edges, while sharp, are minutely jagged. This gives the edge a certain amount of “grab.” Vigorous use wears down the edge, and even an irregular edge develops a “smoothed” feel over time. Again, comparative specimens are useful in identifying use-wear on prehistoric tools.

The use of tools on soft material leaves little macroscopically diagnostic wear. In many instances, ergonomic factors influence the subjective identification of possible tools. In a given assemblage, exceptionally large flakes, flakes of specific shape, or unusually regular edge shapes (blade-like, for example) are possible candidates. Also, fragmentation of quartz flakes results in a wide variety of non-standard flake and debris forms that are suitable for expedient tools. A certain amount of ingenuity is required to utilize these as tools; they provide a wide range of edge angles and possible tools forms. This is potentially advantageous for production and use of expedient or informal tools. This approach stands in contrast to the higher degree of predictability of flake forms from other lithic materials. Owing to ergonomic factors, raw material size, and the high degree of flake fragmentation, quartz tools vary widely in their potential for use. Use-wear may be detectable along an entire edge, or only along a small portion of an edge. A single flake scar on an aborted biface may be utilized, owing to a small but extremely sharp edge on an otherwise bulky tool that requires no hafting. Small tools may be used unhafted, but simple haft mechanisms provide greater leverage and relieve finger strain. Micrtoools are the most obvious tool type in this category.

**Experimental Hafting of Quartz Tools**

In the intervening years since the publication of Keeley’s (1982) missive *Hafting and Retooling: The Effects on the Archaeological Record*, experimental archaeology has contributed much to the body of knowledge concerning the hafting and use of stone tools. Although Keeley’s three basic types (jam, wrapped, and mastic) remain valid, these can be expanded to include haft types of relevance to replicative and interpretive studies. Hafting methods presented here still fall into three basic categories: compression, socket, and notch. Keeley’s types are contained within these types, but the correlation is not exact. The categories presented here allow for considerable variation that encompasses many types of haft strategies.

In addition to the three basic methods, hafted tools generally fall into endhafted types and side-hafted types. Notched hafts are most often associated with endhafted tools (projectile points, for instance). Because of the natural hollow of bone and cane drifts, and the relative ease with which wood and antler are hollowed on a crosscut end, socket hafts are also associated with end hafts. Sockets cut into the side of hafts are useful for making effective scraping and spokeshave-like tools (Jones 2001a). The simple split-stick compression haft is versatile, and can be adapted for a wide variety of tool configurations.

Most of the haft configurations detailed below are based on archaeological or ethnographic examples. Others are conjectural, the haft being adapted from modern woodworking tools (as in the example of the socket-hafted block plane).

**Notch:** notch hafting is conceptually appealing to most archaeologists and experimenters. It is a straightforward approach, the greatest obstacle being the labor-intensive job of making the notch. It is archaeologically documented, with many examples found in dry caves of the American west (Cosgrove 1947; Gunnerson 1962; Aikens 1970; Jennings 1978). Notched elements are useful for hafting projectile points, bifacial knives, and flake tools.

To simplify the notching of wooden hafts, Cosgrove’s (1947: 53-54) description of archaeological examples is useful. By using the splitting properties of the wood and four cuts, a notch of any desired depth can be made in a fraction of the time it takes to carve a similar notch with a stone knife. Once split out, the notch can be cleaned, widened, or deepened by sawing with a flake. The
stone point or other tool is affixed with fiber (sinew or plant fiber), often in combination with pitch or animal glue.

**Compression:** At its simplest, this type of haft consists of a split element with the tool inserted. A means of compression is necessary to secure the tool. It is familiar to most of us who tried as kids to haft tools “Indian style.” This method of hafting can be frustrating if not properly executed. Practice is the best remedy, but a few practical tips are helpful.

It is recommended that the haft be made of wood that is stiff yet splits easily. Seasoned wood is best. Avoid excessive splitting of the haft by securely wrapping the haft with cordage just below the point where the split should terminate. For end hafting, the ends of the split can be hollowed slightly to better accommodate the tool. This gives the haft more “bite” around the tool and helps prevent the tool from slipping sideways in the haft.

By leaving (or replacing) the split-stop wrapping in place around the midsection of the haft, a tighter grip on the tool becomes possible. This, however, makes the split harder to open in order to insert the tool. A bone awl can be used to wedge open the split by carefully pushing it into the split on the side of the haft. Once the blade is inserted, the awl is removed. The cleft springs shut, gripping the tool tightly. The haft is completed by securely wrapping the end of the split containing the tool with cordage. Simple friction knots that can be easily undone are best. Overhand knots work well, but must be re-tightened often during use. Also, side-hafted tools can be adapted to compression hafts. Flenniken’s (1982) Hoko knife replications are good examples of this.

Alternatively, slip rings can be used to secure compression end-hafted tools (Cresson 1988 1997; Holladay 2001). Though not based directly on archaeological finds, this method uses appropriate tools forms based on functional wear and experimentation. It is highly utilitarian and very adaptable for experimentation. A hollow section of antler, bone, wood, or cane is placed over the split end of a haft. The tool is inserted into the split, and the ring is slid up over or just below the tool (which

**Socket:** Socket hafting utilizes natural or fabricated hollows to hold tools. Often the portion of the tool to be secured must be slightly modified to fit the haft. Many naturally hollow handles are round, and thus are well-suited to tools with thick tangs. Otherwise, additional mastic is needed to fill the voids.

Antler and varieties of wood with pithy centers may be hollowed with relative ease. Socket hafting of Late Archaic knives is supported by the find of a Savannah River point in close association with a socketed antler drift handle at 9ED5 in South Carolina (Ken Sassaman, personal communication 1997). Holladay (1994) has replicated and demonstrated the utility of Basketmaker period knives from Utah featuring stemmed bifaces set into a socketed handle.

Sockets may also be fabricated from solid wood. Soft woods may be used with good results, since the stone blade is apt to break before the handle. Artificially hollowing a haft can be done with stone tools, but I find a bone awl quite useful. Being more flexible than stone, bone can be used to drill, gouge, and pry with less risk of breakage. Fabricated sockets are more labor-intensive, but result in custom fitted hafts for a variety of tool forms.

It is advisable to secure socket-hafted tools with pitch or other mastic. For hafts made from soft or weak wood, a fiber wrap may be added prior to the application of pitch (Jones 2005b).

**Conclusions and Directions for Further Research:**

Despite the difficulties inherent in quartz tool analysis, this material often dominates lithic assemblages in areas where it occurs naturally. Such is the case in the Piedmont of the southeastern United States. In this region (as elsewhere), a coherent understanding of quartz assemblages has fallen behind that of other, more easily interpreted lithic materials. This is believed to be largely the result of a reluctance to experiment with quartz. Consequently, this has resulted in the lack of an
effective strategy for systematic interpretation. This study is an initial attempt to rectify this shortfall.

This study is by no means comprehensive. The non-systematic nature of the survey, the almost exclusive upland focus, and the absence of sites from key time periods are limiting factors for this project. Nevertheless, it is my hope that others will be inspired to continue working towards an informed understanding the lithic geography of a poorly studied region.

The metric data are helpful in understanding regional lithic technology. No quartz artifact exceeds 11 cm. in length, with most well under 9 cm. This reflects (in part) the package size of the available raw material. Comparison of metric data from prehistoric and replicated bifaces is also telling: Within upland Piedmont lithic systems, an optimal late-stage preform/projectile point of the Archaic period is postulated to be a modest-sized tool with a width/thickness value of approximately 3. Optimization is probable for curated tools, but within a system containing widely available lithic material, optimization varies with respect to raw material package size and quality.

Because the information is derived from surface collections only, temporal associations are based on the presence of diagnostic artifacts. Many of the sites contain multiple components, but some broad generalizations can be made: (1) Sites with an Early Archaic component show a strong, if arguable, trend towards biface production. The frequency of good quality quartz (Types 1-3) is high on these sites, overlapping somewhat with Middle Archaic sites. The movement of core-type bifaces away from quarry sites is only weakly supported by the findings of this study, especially in association with the Early Archaic period. Non-diagnostic lithic scatters, despite frequently low numbers of artifacts, contain high percentages of high-quality quartz. This may be related to Early Archaic lithic use, but remains speculative. (2) Sites with Middle/Late Middle Archaic components contain numerous bifaces. These often occur as late-stage preforms or diagnostic forms, indicating that Middle Archaic biface production focused the production of late-stage non-core bifaces. Also, these sites show a marked presence of bipolar reduction, and less obviously, anvil reduction. A broad-based scheme of lithic use that includes bifaces in combination with considerable numbers of supplemental/expedient tools is postulated for the Middle Archaic. Despite this impression, the minor ceramic presence on some of these sites cannot be dismissed.

One of the most significant findings is the degree to which non-bifacial reduction techniques were practiced. The abundance of anvil and bipolar cores attest to a healthy pattern of non-bifacial tool production and use. Despite many long-standing biases concerning the function of prehistoric quartz quarries, it is evident that these sites, too, functioned as something other than biface factories. This study, in concert with other work in the Georgia Piedmont, even suggests the presence of a small tool industry. The extent that this was practiced is not presently known. In his discussion of bifaces as cores/variable-use tools Kelly's (1988: 719) observation is apt:

> When raw material is abundant and of adequate sharpness there is no temporal or spatial difference in the location of raw material and the location of stone tool use; in effect, stone tools have no role to play, and we can expect groups living under such circumstances to employ an expedient flake technology, with little use of bifaces as cores.

The first step in deciphering Piedmont upland lithic systems is to escape the pervasive bias that favors the manufacture of bifaces. In large measure, this can only be accomplished through experimentation, or at the very least, through stringent comparative analyses. By recognizing both bifacial non-bifacial tool production trajectories (Figure 17), the mosaic of site function, lithic distribution, and patterns of temporal usage will begin to come into focus.

Perhaps the most intriguing possibility raised by the recognition of an integrated scheme of lithic exploitation is the differentiation of gender roles in lithic assemblages. The topic of women in conjunction with the manufacture of stone tools
Utilization of cores is implied. The starting point (left side) is understood to be raw material from cobbles, pebbles, or tabular pieces in various stages of reduction.

Figure 17. Flow chart showing proposed sequence for quartz tool production.

appears sporadically in the ethnographic literature. Nonetheless, a few reference exist, establishing a clear if tenuous connection. An early and oft-cited reference to this topic is Man's (1883) ethnographic description of the manufacture of quartz tools by women in the Andaman Islands. While male imagery has dominated the sphere of stone tool manufacture and use, the potential for recognition of gender in lithic assemblages has gathered momentum in recent decades. Flenniken (1981: 171) suggests the possibility that the Hoko River assemblage (consisting of hafted bipolar quartz flake tools) reflects a female-dominated technology. Callahan hints at this as well (1987: 24) with regard to small bipolar cores in middle Sweden. Whittaker (1994: 294-298) states with conviction the probability that women engaged in stone tool production. Patten (1999: 13), in reference to an archaeological site in New Mexico, states succinctly an observation that could apply equally to the Piedmont of Georgia: "[E]ven within the same culture, two distinct technologies may have existed side by side: one for hunting (presumably men) another for tools used within the camp (presumably women)."

By “elucidating the bare minimum level of female participation in stone tools production” Gero (1991: 176) provides further motivation for looking in the upland of the southeast for gender in lithic assemblages. She goes on (Gero 1991: 176) to “suggest we look at lithic assemblages that are (1) from dwelling or habitation areas where, because of occupation over many days, weeks, or months, we are likely to find evidence of maintenance tasks related to food, clothing, or child-rearing; (2) made of locally available raw materials, to avoid arguments for or against differential male/female mobility; and (3) of “expedient” flake tools, leaving aside the highly retouched tools which, from our cultural perspective, conform to formal standards of tools morphology and are granted high social value” (emphasis added).

Following these criteria, studies in the Piedmont (or any other area fulfilling these qualifications), the topic of gender in lithic assemblages may be pursued on two levels. One level is the regional or intra-site, based on survey data. If experimental work can differentiate tool technologies well enough to determine modes of production (formal
tools/bifaces from expedient non-bifacial tools), significant progress can be made in interpreting site function, gender notwithstanding (in the sense of Binford and Binford 1969). In the present study, the identification of small anvil and bipolar cores and small, perhaps hafted, tools are believed to be a major indicator of alternative site function. The second level concerns inter-site assemblages. The delineation of male/female areas within domestic structures in secure archaeological contexts in the Piedmont would provide a better basis for interpretation of the larger intra-site pattern.

These goals (identification of divergent/concurrent lithic techniques and intra-site assemblage segregation) are attainable through structured analyses. Sites ranging from quarries to small lithic scatters require detailed study to determine spatial, temporal, and technological patterns. Because quartz artifacts are difficult to interpret, replicative and comparative studies are crucial to meaningful interpretation. Lithic assemblages generally contain material exhibiting considerable morphological overlap and ambiguity. Hence, analyses of entire assemblages (or significant samples thereof) are necessary to distinguish different reduction strategies.

A Note About Safety Past and Present

Flintknapping entails a number of health risks to flesh, eyes, and lungs. Most of these risks are treated in the literature, and need not be repeated here. One risk peculiar to quartz deserves mention. All lithic materials yield small fragments and splinters when knapped, but quartz produces a disproportionately large amount of very small splinters. More so than with any other material I have worked, these minute razor-like fragments have a propensity to become embedded in the fingers, especially during freehand knapping of cores and bifaces. While the long-term risk from quartz splinters is probably quite low, in the short term they cause excruciating pain and must be dug out or surgically removed. Excepting the earliest stages of reduction, controlled knapping is difficult to perform while wearing gloves or other hand protection. This raises questions about how prehistoric peoples dealt with the potential hazards of quartz. One wonders:

Does this contribute to the widespread use of anvil and bipolar techniques?

**Postscript: The Future of Experimental Archaeology**

In the decades since the beginning of the recent experimental archaeology movement, it has been embraced reluctantly by traditional archaeology. The relationship has been difficult at times, even drawing criticism from among the “new” archaeologists (Thomas 1986). Yet the persistence of experimentalists has resulted in increased recognition of the importance of experimental and replicative work. This has brought about a growing appreciation for well-organized experimental research among the current generation of archaeologists.

Despite waning criticism and an increased appreciation for experimental work within professional archaeology, lithic technology is still subject to many of the old attitudes. While the lithic replicator/analyst would say that lithic analysis cannot be conducted without experimental verification, this is simply not true. Analysis is done daily in the labs of universities and cultural resource management (CRM) firms. Much of this analysis, however, is artifact inventorying with little or no emphasis on reductive strategies. Consequently, for the intended purpose, this type of analysis is acceptable.

Analyses that purport to reconstruct lithic reduction strategies are another matter. Inasmuch as the hard sciences rely on reproducible experiments for the verification of hypotheses, replicative experiments are necessary for the coherent reconstruction of lithic systems (and by extension, all reductive paradigms of ancient technology). Otherwise, errors of perception or flawed “intuition” will be evident (or not!) in the final interpretation. One never escapes the possibility of interpretive error, but the risk can be minimized. Even as an experienced replicator and analyst, I find it necessary to confirm my intuitions by experiment. It remains the domain of experimental archaeology to present a range of possibilities (Jones 2001c) rather than a definitive (and potentially incorrect) answer.
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