FORM AND FUNCTION OF BIPOLAR LITHIC ARTIFACTS FROM THE THREE DOG SITE, SAN SALVADOR, BAHAMAS

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The significance of a microlithic assemblage composed of imported, nonlocal materials is discussed for the Three Dog site, an early Lucayan site located on San Salvador, Bahamas. The Bahama archipelago is an interesting area in which to examine the organization of technology because the islands lack cherts and other suitable materials for chipped stone manufacture, suggesting that economizing strategies may have been practiced. The artifacts were manufactured by bipolar production and a few show evidence of recycling and reuse. Microwear analysis, undertaken to determine function, was inconclusive due to heavy weathering from the depositional environment. Traces of an organic adhesive suggest that some of the objects were used as hafted or composite tools. The presence of starch grains, most likely Xanthosoma sp., *and other plant residues on some artifacts suggests they were used in plant processing. The morphological similarities of the flakes produced through bipolar reduction with those from ethnographic sources suggest that most of them probably were used as grater chips to process root or tuber foods. The assemblage was compared to other bipolarly-produced microlithic assemblages from nearby islands.*

Este artículo trata de la importancia de la presencia de un conjunto microlítico compuesto de materiales importados en el sitio Three Dog, un sitio Lucayo temprano localizado en San Salvador, Bahamas. Las Bahamas es un área interesante para el estudio de la organización de la tecnología ya que las islas carecen de silex u otros materiales apropriados para la manufactura de piedra tallada. Numerosas evidencias de medidas de economizar inducidas por la escasez del material, tales como la técnica bipolar y el reuso y reciclaje de los artefactos, estan presente en el conjunto. Se llevó a cabo un análisis de microdesgastes para determinar el uso de los artefactos. El marcado deterioro de los artefactos líticos producidos por las pobres condiciones de deposición hace difícil la identificación de los patrones de lustre. Las semejanzas morfológicas entre las lascas producidas por la reducción bipolar y las descritas en las fuentes etnográficas sugieren que muchas de ellas fueron usadas como microlascas de ralladores de tubérculos. Tanto la función y el uso anticipado como la falta de buenas fuentes de lítica son consideraciones importantes en la determinación de la forma y la tecnología de artefactos.

The production, manufacture, maintenance, and use of tools are determined by factors such as mobility, anticipated function, projected needs, knowledge of the lithic landscape, nature of raw materials, distance and ease of transportation to raw material sources, and length and intensity of site occupation (Nelson 1991). Raw material availability is a particularly important determinant of stone tool-production strategies, design, and use (Andrefsky 1994; Kuhn 1991; Odell 1996). In areas where good stone tool material is absent or exists in small quantities, people employed lithic production strategies that made greatest use of their available supplies, often practicing economizing and conservatory measures in tool and toolkit design and manufacture (Goodyear 1993; Jeske 1992; Nelson 1991; and others). People in such areas often made maximal use of the tools produced from these supplies by resharpening, recycling, rejuvenating, and retooling existing chipped stone artifacts (Clark 1987; Holdaway et al. 1996:384; Johnson 1991:181; Kelly 1988; Nelson 1991; Parry and Kelly 1987; Rolland and Dibble 1990:484). Moreover, tools made from nonlocal materials tend to have been used for a wider range of functions than those manufactured from local materials (Bamforth 1986; Morrow and Jefferies 1989).

The frequency with which materials occur and the mode, regularity, and ease of transport to source areas also influence the acquisition of raw materials (Kuhn 1991). The geological environment determines the raw material types and characteristics. Andrefsky (1994) has shown that informal (i.e., expediently produced) tools are often made from low-quality raw

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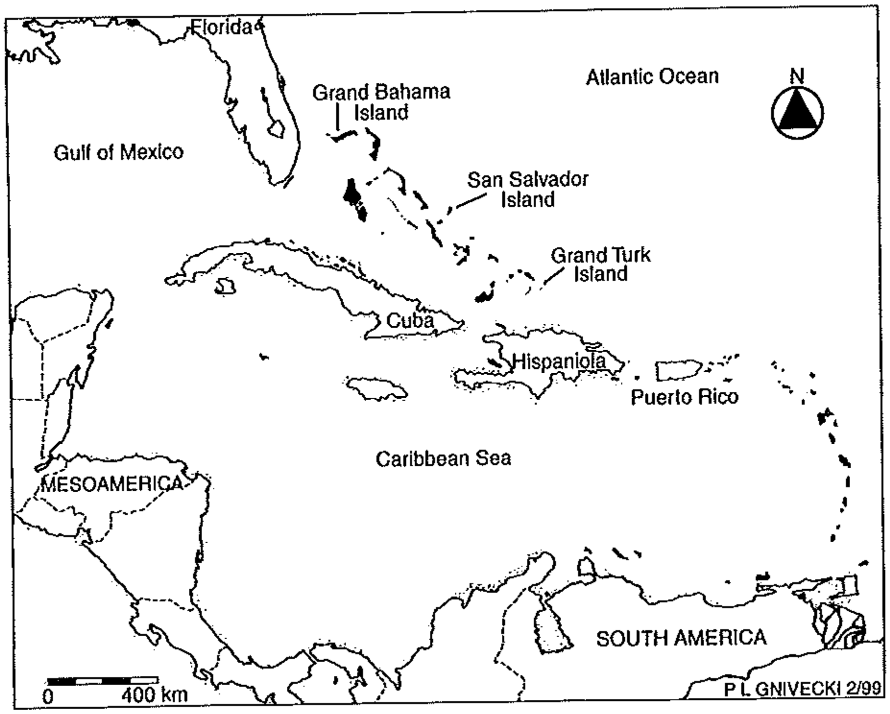

Figure 1. Map of the Caribbean showing the Bahama Archipelago.

material, while formal tools often are made from high-quality materials regardless of distance to source or local abundance. Moreover, trade relationships play an important role in facilitating or hindering lithic raw material procurement.

The chipped stone artifacts from the prehistoric Three Dog site on San Salvador, Bahamas, provide a unique opportunity to examine what factors affected artifact design and use, since no permanent, naturally-occurring siliceous cryptocrystalline materials suitable for chipped stone tool manufacture occur on the island. Moreover, the primary source for these lithic resources is located over 300 kilometers away. Direct acquisition or down-the-line procurement through interisland exchange over water would have been the means of obtaining raw materials or tools. In the following study, we set out to find if the kinds of responses to these conditions, which Odell (1996:75) has referred to as "scarcity-induced economizing activities" are evident in the assemblage and whether they resembled other assemblages produced by people in similar circumstances. We also want to assess the degree to which function influenced artifact design and technology (Torrence 1994) and whether they were conditioned by scarcity or the quality of raw materials. Moreover, we are curious to learn to what degree surrounding cultural traditions influenced artifact design and technology. The investigation raises questions about the nature of prehistoric Caribbean lithic production and use by examining what Nelson (1991) and others have called the organization of technology. This approach contrasts with the other Ceramic Age lithic analyses that look primarily at technology and style (Febles 1988; Pantel 1988) or technology and function (Bartone and Crock 1991; Crock and Bartone 1998; Walker 1980a,1980b, 1983). Finally, we want to identify how taphonomic processes attributable to the coastal environments in which many Caribbean sites are found might affect recognition of function and the organization of technology.

Chipped Stone Assemblages in the Bahamas

The Bahama archipelago (Figure 1) consists of a series of low-lying carbonate islands and shallow banks composed of Pleistocene and Holocene eolianite ridges, interdune swales, marine terraces, coastal cliffs, tidal flats, and coastal and sand plains located between 21º and 27º30' north latitude and 69º to 80º30' west longitude (Carew and Mylroie 1995; Sealey 1994). The islands lack siliceous cryptocrystalline rocks. Cuba and Hispaniola, located 325 and

480 km to the south, are the closest sources of these materials.

The presence of chert and other siliceous cryptocrystalline artifacts at the Three Dog site can be attributed to a number of factors related to settlement, direct procurement, and exchange. The material may have been brought by the island's colonizers. Exchange of objects and raw materials might have been components of an embedded exchange system (Morrow and Jefferies 1989). Numerous chroniclers reported that the Indians made regular trading expeditions to Cuba and Hispaniola from the Bahamas (Keegan 1992). Fifteenth-century Lucayans were apparently knowledgeable about the route to Cuba, as they guided Columbus there on October 25–28, 1492 (Dunn and Kelley 1989: 115, 117; Morison and Obregon 1964: 41–42, 45). Fifteenth- and sixteenth-century Lucayan toponyms for many of the islands suggest Hispaniola and Cuba as origin points for migration, colonization, trade, or exchange (Granberry 1991). Winter and Gilstrap's (1991) chemical analysis of nonlocal sherds from San Salvador and neighboring islands indicates Cuban and/or Hispaniolan origins, suggesting active prehistoric relations between them and the Bahamas.

Although interisland contact may have been common, procurement may have been impeded during certain times of the year by water currents, winds, and weather-related factors such as hurricanes that would have affected the timing and frequency of trips to obtain materials or the transport of such materials from source areas. During much of the year, return voyaging to procure resources would have been difficult, as the canoers would have been forced to go against the prevailing current (Berman and Gnivecki 1995; Keegan 1992).

Keegan (1992:60) and Keegan and Mitchell (1986) have found that nonlocal lithic materials could have been conveyed to the Bahamas through natural means. Rocks and pebbles found trapped in the root system of a palm tree that washed ashore on Great Inagua correspond to those found in the Cap Haitien area of northern Haiti. This raises the possibility that some nonlocal raw materials may have found their way to the Bahama islands in a similar manner.

Walker (1985) has noted that chipped stone artifacts often constitute a tiny proportion of Ceramic Age artifacts and food remains. While this might reflect the nature of site activities, the low frequency of excavated chipped stone artifacts can also be attributed to the types of research questions and recovery methods that investigators have employed. In the Bahamas (and elsewhere in the Caribbean), a preoccupation with ceramics deterred the recognition and collection of chipped stone artifacts (Pantel 1988, 1991). Moreover, mesh size used in archaeological recovery did not allow for the retention of small objects, such as microliths. Until 15 years ago, archaeologists working in the Bahamas routinely used ¼-inch (6.35 mm) mesh screen. Since the minimum measurements of many of the excavated chipped stone objects known from Bahamian sites are less than this size, numerous specimens have likely passed through the screen unnoticed (Shaffer 1992). It was only with the implementation of 1/16-inch screen (1.58 mm mesh) in the early 1980s that quantities of these and other small artifacts began to be noted.

Most chipped stone artifacts found on Bahamian sites are manufactured from limestone. These pieces are hard to recognize as tools and are often confused with fire-cracked rock or the blackened limestone fragments abundant in Bahamian archaeological sites. At the Three Dog Site and other sites on San Salvador, such tools were manufactured from micrite, a microcrystalline calcite, and calcarenite, a form of limestone with grains > 63 µm < 63 mm (Scoffin 1987:8). Our observations on San Salvador, Sullivan's (1974:41) work on Eleuthera, and Keegan's work on Grand Turk (Carlson 1993; Carlson 1995) indicate that such artifacts were manufactured by percussion flaking.

Chert artifacts have been recovered from Grand Turk and sites in the Caicos group, B.W.I., and San Salvador, The Bahamas. The thirteenth-century Governor's Beach (GT-2) site on Grand Turk yielded 567 bipolarly flaked pieces of chert (Carlson 1993, 1995; Keegan 1991, 1997:82). The Coralie site on Grand Turk, and the Palmetto Grove site (Hoffman 1967), the Long Bay site, and the Pigeon Creek site (Rose 1982, 1987) on San Salvador have produced a few chipped stone artifacts of varying siliceous materials. Flakes manufactured from chert and a chalcedony-like material have been found during recent surface collections and excavations at the Pigeon Creek site. De Booy (1912:104) reports flint artifacts from various sites in the Caicos group.

Due to infrequent recovery and lack of formal description of chipped stone assemblages, only a vague picture of regional lithic traditions, raw mate-

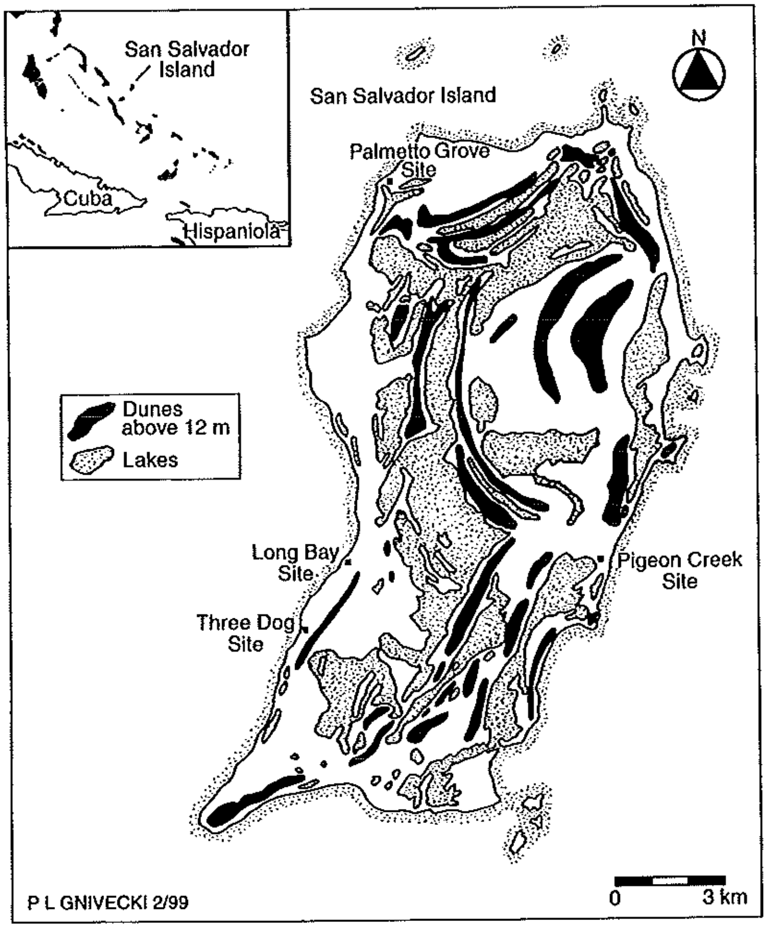

Figure 2. San Salvador Island, Commonwealth of the Bahamas.

rial procurement patterns, and technological strategies exists for the Bahama archipelago and adjacent islands. This study represents an initial effort to describe these and to discern the organization of technology that existed in this region during prehistory.

The Three Dog Site

Excavation of 102 one-x-one m^2 units from the Three Dog site, a Ceramic Age settlement on the western (leeward) coast of San Salvador Island, Bahamas (Figure 2), yielded 58 chipped stone artifacts made from cryptocrystalline materials. Cultural deposits were screened in window screen (1/16 inch or 1.58 mm), and noncultural sediments were sieved through 1/4-inch (6.35 mm) mesh screen. Excavations were carried down to the sterile zone in 10-cm intervals, where fine screening continued for 20 cm. The majority of microliths were recovered through screening; several were found *in situ* and in flotation samples. Each excavated chipped stone artifact was wrapped in a thin layer of ethafoam and placed in a plastic box for protection, storage, and transport.

Two occupations are evident (Berman and Gnivecki 1995). The later component dates to the Spanish Contact period, while the earlier one, which yielded the microliths, dates to the A.D. 800s–900s (Berman and Gnivecki 1995). The site represents the earliest systematically excavated site in the Commonwealth of the Bahamas and one of the earliest sites excavated in the Bahama archipelago (Berman and Gnivecki 1995; Keegan 1997).

The early component is composed of two activity areas probably representing the interior of a house, and a midden reflecting the domestic activities of one or two extended or joint families (Berman and Gnivecki 1999). The occupation was short-lived. Evidence for shell tool manufacture, pottery production, food preparation, cooking, microlith manufacture and use, and activities requiring the use of limestone flakes, coral abraders, rasps, and scrapers are present in Activity Area #1. Food preparation, work requiring the use of shell tools, shell tool manufacture, and activities involving the production and use of microliths took place in Activity Area #2. Sweeping, accidental loss of objects, and discard took place at each of these loci. Numerous shell disc beads in various stages of production suggest that shell bead manufacture occurred. The ceramic assemblage includes sherds from cooking and serving vessels and griddles. While stone tools were found in each of the activity areas, the midden and Activity Area #2 contained the highest densities of the microlith assemblage discussed here.

One limestone hammerstone was found in association with several pieces of microlith shatter, several chert microliths, two carved figurines, two quartz sandstone abraders, and a coral abrader. Shell hammers, also found in association with shatter, might have been used to produce chipped stone artifacts. No anvils were recovered.

Methods

Classification of rock types was based largely on macroscopic characteristics. Due to the small size of the artifacts, we did not undertake any destructive analyses that might have allowed us to identify source areas. However, Grenville Draper of Florida International University performed a non-destructive compositional analysis of five specimens with the use of an energy dispersive spectrometer (EDS) attached to a Joel 5410E scanning electron microscope run in low vacuum mode at 15 kV. We hoped that this procedure would provide data to assist with provenience identification.

The technological analysis considered the following attributes: raw material, overall geometric shape, ventral and dorsal surfaces, fracture initiation points, fracture directionality (unidirectional vs. bidirectional), ventral surface morphology (bulb of percussion, compression rings), condition (breakage and weathering), presence/absence of retouch or edge damage, and presence/absence of cortex. Length, width, and thickness were measured for each artifact to the nearest .1 mm using a digital caliper. Because the specimens were small (Figure 3) and their proximal-distal orientations often difficult to recognize, the measurements were taken without regard for the orientation of the fracture. In other words, length is equal to the specimen's maximum dimension, while the width is the maximum dimension perpendicular to maximum length.

Specimens identified as compression flakes exhibited collapsed or crushed fracture initiation points (Figure 4). Unidirectional or bidirectional dorsal flake scars were recognized as possessing ventral compression rings and lacking ventral bulbs. Bifacial thinning flakes were identified as exhibiting wide, faceted, and ground fracture initiation points ("true" striking platforms), a platform "lip," low ventral bulbs, and unidirectional dorsal scars. Soft hammer percussion most often produces flakes possessing these attributes. Pieces classified as core flakes or fragments from bipolar production (Figure 5) were characterized by a crushed platform, bidirectional flake scars, a wedge-shaped cross-section produced by hard hammer reduction on an anvil, and lacking a bulb of percussion. (Core flakes from non bipolar reduction have unidirectional flake scars and a bulb of percussion.) Fragmentary specimens lacking definable characteristics were classified as indeterminate flake fragments.

Macroscopic examination suggested that use-wear was present and could be observed more completely by examining the objects at higher magnifications. Use-wear studies on Caribbean assemblages have followed the low-power (10×-60×) approach. Several investigators, including Walker (1980a, 1980b, 1983) and Bartone and Crock (1991), used the low-power approach advocated by Odell (1981; Odell and Odell-Vereecken 1980) on assemblages from St. Kitts and Montserrat. Febles (1988 and elsewhere) employed a different low-power method to study microwear from Cuba. Because polishes and other forms of microwear are not observable through the low-power approach, we decided to analyze the assemblage under higher magnifications.

High-power (50×-200×) microwear analysis customarily combines information on edge damage, striation patterns, edge rounding, polishes, and residue (see Shea 1992, and Yerkes and Kardulias 1993 for a review of techniques). We used an Olympus BHM series metallurgical microscope and a stereomicroscope to examine edge damage at Indiana University's Lithic Microwear Laboratory. The optics associated with stereomicroscopes make them ideal for examining edge damage, while the metallurgical microscope is better suited for the identification of striations and polishes.

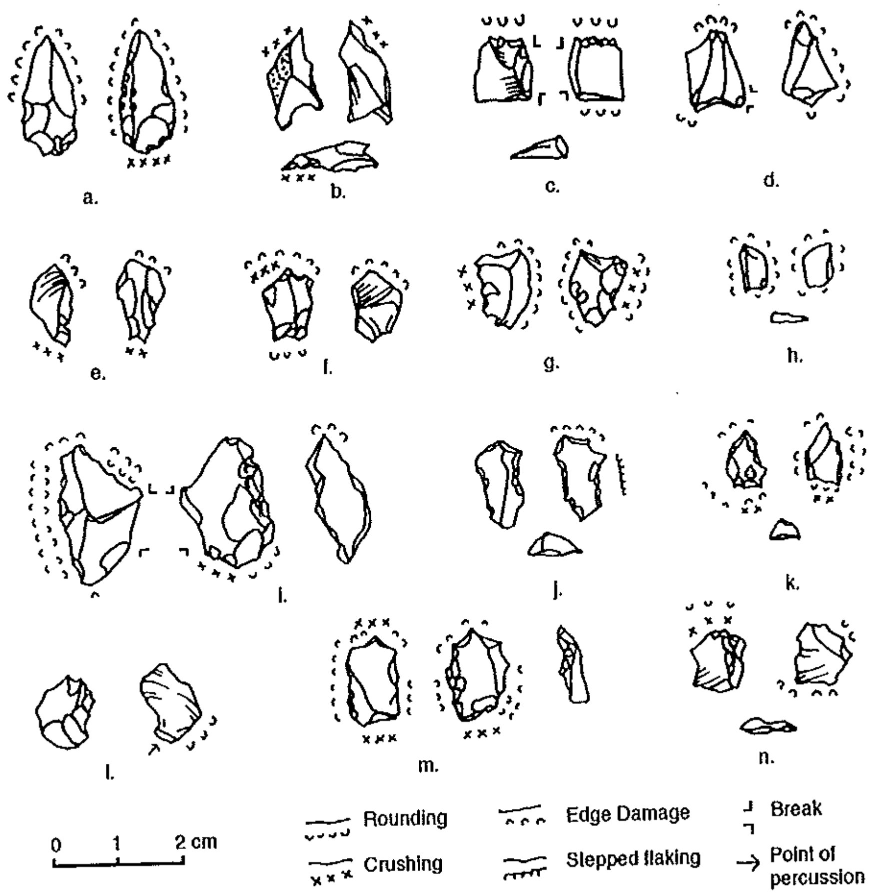

Figure 3. Sample of Microlithic Artifacts from the Three Dog Site (a) retouch flake (3207), (b) typical compression flake (5324), (c) core flake (5490), (d) compression flake with resinous residue (10187), (e–g) compression flakes (6225, 6226, 7430), (h) distal flake fragment (11391), (I) compression flake (11393), (j–k) retouched shatter with projections (16836, 16841), (l) thinning flake (16843), (m) retouched compression flake with projection (16848), (n) compression flake (16842).

First, all the artifacts were scanned for residues that could have a prehistoric, cultural origin, such as adhesives or plant remains. Following this, 35 were cleaned in detergent and then in a 10-percent HCl solution. The artifacts were examined for traces of use-related wear. Interpretations of microwear traces were based on the microwear present on a collection of replicas used in a series of experiments in which use-wear was produced from actions on wood, shell, bone, butchery, stone, herbaceous plants, and root crops. Previous studies (Aldenderfer et al. 1989; Sievert 1992a) indicate that a distinctive wear trace, characterized by extreme edge rounding and a moderately bright, rough polish, is produced on stone tools used to grate manioc and other roots and tubers.

Finally, Deborah Pearsall of the University of Missouri-Columbia examined six microliths for evidence of phytoliths, plant opal silica bodies. This aspect of the study sought to ascertain if plant remains, not discernible through the microwear analysis, could be identified. Furthermore, if phytoliths were present, we were anxious to identify them. The artifacts, three compression flakes, one thinning flake, one distal flake, and one retouch flake were chosen for study because they represented a range of artifact types from the assemblage. Moreover, they were found in each of the activity areas and the midden.

Analysis

Raw Materials

Most of the chipped stone artifacts are manufactured from a white fossiliferous chert similar to that found

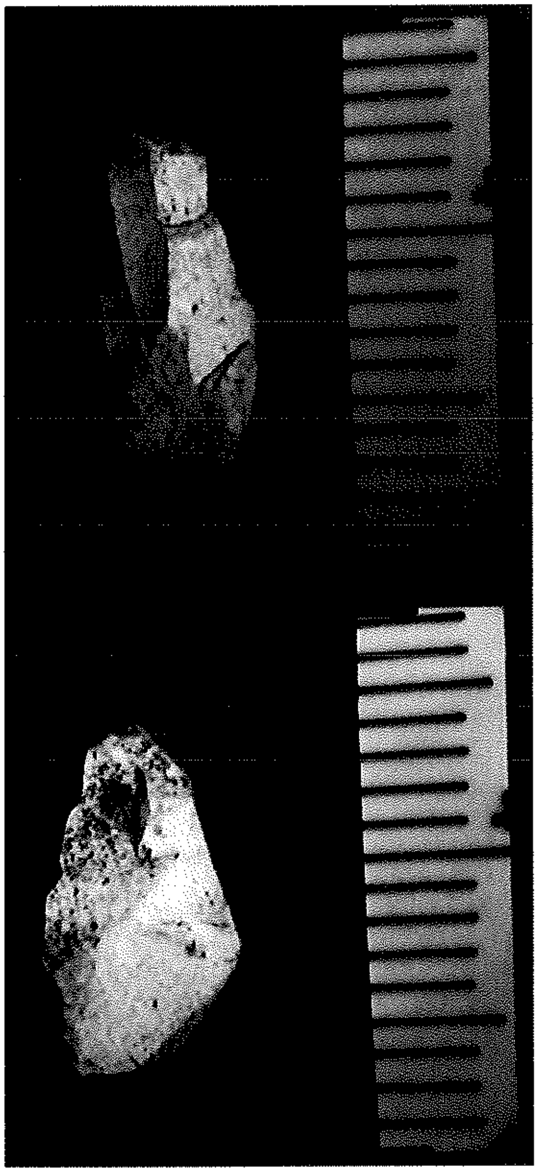

Figure 4. Compression Flake (5665).

on the north central and northeastern coasts of Cuba and the north coast of Hispaniola (Draper and Barros 1994; Draper et al. 1994). Keegan (1997:26) notes that it is identical to white chert from Hispaniola, while Cuban archaeologist Jorge Febles observes it resembles small nodules found on Cuba's north coast. Two of the specimens are a fine-grained green stone with small, scattered grains of chalco-pyrite. The EDS/SEM microscopic work revealed that these could be aplite vein rocks or chert (Grenville Draper, personal communication 1999). Two of the white

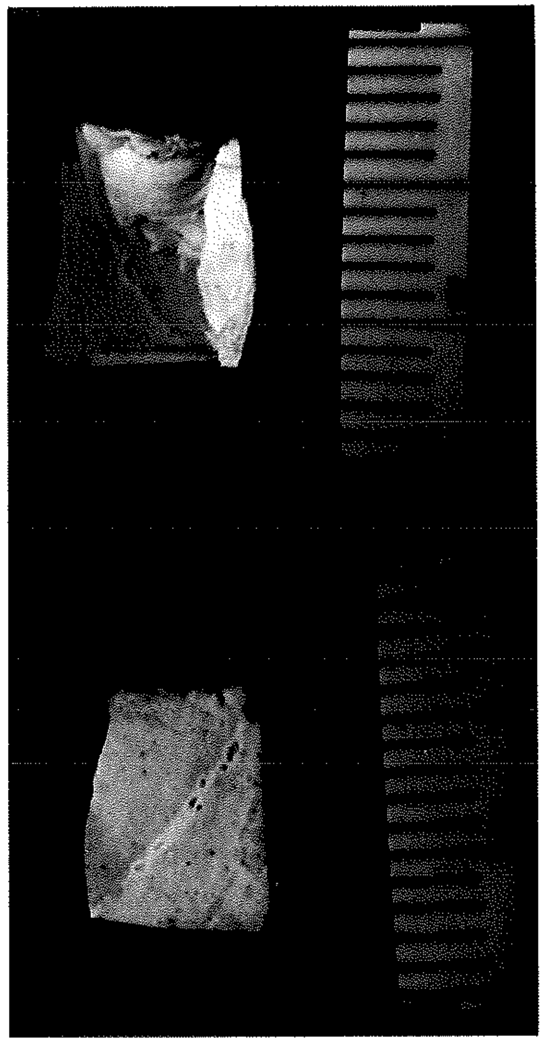

Figure 5. Core Flake (5490).

specimens may be fine-grained aplite. The third specimen was identified as white porcellenous chert with unidentified ghost microfossils. Aplite and the kinds of chert observed in the specimens are common throughout Cuba and Hispaniola.

Many of the artifacts are extremely fragile, chalky, and grainy due to chemical weathering, factors that impeded microwear analysis. Several of the artifacts have been reduced to a chalky-like substance, suggesting that the silica present in the chert had been removed through leaching. Two objects exhibit what appears to be cortex on one or more surfaces. Light-colored cherts often develop a light rind as a result of the loss of silica and the leaching of other materials (Luedtke 1992:109). The rind may be confused with cortex. It is also possible that these specimens

Table 1. Metric Measurements for Three Dog Site Chipped Stone Assemblage.

	Minimum	Maximum	Mean	Standard Deviation
Length	4.04 mm	37.79 mm	11.00 mm	5.3439
Width	3.56 mm	18.77 mm	6.98 mm	2.8112
Thickness	1.45 mm	10.54 mm	3.52 mm	1.6232
Weight	.05 g	7.30 g	.32 g	.9576

came from a different colored chert, possibly a darker chert, which had changed color due to weathering.

Morphology

The artifacts (Table 1) range in length from 4.04 to 37.79 mm with a mean of 11 mm; width ranges from 3.56 to 18.77 mm with a mean of 6.98 mm; and thickness varies from 1.45 to 10.54 mm with a mean of 3.52 mm. Weight ranges from .05 to 7.3 g with a mean of .324 g. The specimens include 32 (55 percent) compression flakes, 3 (5 percent) core flakes, 1 (2 percent) bifacial thinning flake, 1 (2 percent) retouch flake, 9 (15 percent) flake fragments, and 11 (19 percent) pieces of shatter (Table 2). The flake fragments include distal flakes, medial flakes, and an indeterminate flake fragment. Most of the assemblage consists of flakes (79 percent), which appear to have been produced by the bipolar technique of core reduction. It is likely that most of the shatter also was produced through bipolar technology. Bipolar products occasionally exhibit striking platforms and bulbs of percussion reminiscent of other reduction methods (Ahler 1989; Jeske and Lurie 1993; Magne 1985; Walker 1980a, 1980b; Whyte 1984). More often, bipolar reduction results in flakes without identifiable flake characteristics, no bulbs of percussion, or flat and diffuse bulbs if they are present, and a flake angle near 90º (Jeske and Lurie 1993:140). Bipolar reduction results in a relatively large amount of shatter and blocky fragments.

The compression flakes exhibit considerable variation in shape, including specimens that are thin and flat and ones that are relatively thick. Many of the pieces are polyhedral when viewed from the top. Crushing (collapsed platforms), present at either or both ends on numerous specimens, is typical of bipolar generation.

Table 2. Counts and Relative Frequencies by Artifact Category.

Type	Number	Percentage
Compression flake	32	55
Core flake	3	5
Bifacial thinning flake	1	2
Flake fragments	9	15
Retouch flake	1	2
Shatter	11	19
Potlid	1	2

Macroscopic observation identified retouch on two compression flakes, three pieces of shatter, and one distal flake fragment. On three tools, the retouch was present on one or more edges to form graver-like projections. The other retouched tools are retouched along lateral edges. In all cases, the retouch is shallow; it does not extend deeply onto the tool faces. Generally, it is steep, creating blunt and sturdy edges on otherwise thin flakes and fragments.

Microwear

Unfortunately, most distinct wear patterns were obscured or obliterated by chemical and mechanical weathering. Weathering could have even produced the faint traces of wear that were observed on several of the artifacts. Weathering results in microfractures, scratches, and glosses, while mechanical damage produces retouch on the edges of thinner flakes and tools (Stapert 1976). Chemical weathering often results in patination, pitting, and the removal of a thin layer of material from surfaces and edges. The chemical weathering of chert occurs in its most extreme form in warm, humid climates and in coastal deposits where alkaline soils with a high pH and high rainfall allow for the concentration of salt (NaCl) (Sheppard and Pavlish 1992). These factors, characteristic of the study area, likely accelerated the rate of chemical weathering and patination. Furthermore, Luedtke (1992:108) notes that the rate of reactions doubles for each 10 degree C rise in temperature. In the Bahamas, beach surfaces are known to exceed 38º C (100º F) Sealey (1994:51). The site's highly alkaline soils (pH = 11) contributed to the formation of the highly patinated surfaces present on most of the artifacts. As pH rises above 9, silica's solubility is accelerated (Sheppard and Pavlish 1992; Siever 1962); salt concentrations contribute to this process (Sheppard and Pavlish 1992:51). Schmalz (1960: 49) has noted that a deep patina might form in less than a year in sodium or calcium-rich groundwater, such as that found in this environment. In these specimens, patination has affected the entire matrix of the artifacts, not just the surface. Finally, chemical weathering might have been responsible for the rounding and altering of artifact luster.

In spite of the deteriorated surfaces, we were able to differentiate three types of edge modification: edge modification deemed cultural and prehistoric, but not related to use; edge modification judged to be postdepositional; and edge modification possibly attributable to use-wear. Table 3 shows the incidence of these different types of modification and damage for each causation group. The most prevalent form of edge damage is crushing. Crushing is to be expected in cases of bipolar reduction and usually appears on opposite poles of the artifacts. Although crushing also occurs on striking platforms in free-hand percussion, it is generally less severe and more isolated. Such patterns also can be due to wedging (Le Blanc 1992) or hafting; therefore, caution must be exercised in attributing this attribute to bipolar production. Such action is used when inserting microliths into manioc-grater boards. Walker (1980b) and Sievert (1992a) have observed the production of similar bipolar attributes when replica flakes were inserted into a grater board, not when they were used. Crushing is present in 48 percent of the assemblage (N=28).

Postdepositional processes contribute other forms of alteration, including edge rounding, pitting, and excavation damage. Although edge rounding is characteristic of use on materials such as hide, meat, and tubers, it also derives from chemical and mechanical weathering. In cases where rounding was ubiquitous on the piece, it was assumed to derive from weathering. In cases where it affected only selected edges, edge rounding was attributed to wear. Twelve observations could be attributed to wear, and even so, tentatively. In two cases, a polish was visible, but given the physical alteration and optical characteristics of the chert, we cannot unequivocally discern its origin.

Residue

During the microwear analysis, three types of residues were observed on the artifacts: a thin to thick layer of gray or brown soil particles, a black, crusty resinous material, and brown fibers. The fibers, believed to be root hairs, are very fine and adhere to the edges of the microscars or the crevices within crushed or battered areas. In several cases, they survived cleaning. The black resinous material, present in the crevices and flake scars of five compression flakes (one with retouch), was not eliminated with cleaning. Rostain (1997:235) observed a black resinous material on numerous microliths from the Tanki Flip site, a Dabajuroid settlement dating mainly to the A.D. 900s–1200s on Aruba (Versteeg and Rostain 1997:1, 110–111). He notes that numerous modern Amazonian people use a latex or resin-based adhesive to bind stone teeth to a wooden manioc-grater board. Moreover, the Wai Wai create decorative patterns on their manioc-grater boards by applying an adhesive colored with *Bixa orellana* (Rostain 1997: 235; Roth 1924; Yde 1965:82, 267–269). Sievert (1992b) notes a visual similarity between the substance present on the Three Dog site microliths and the resinous compounds used as hafting materials by the Postclassic Maya of the Yucatan. Thus, the Three Dog site objects may have functioned as parts of hafted implements or components of composite tools that required adhesion.

Plant Remains

While looking for phytoliths, we did not expect to observe evidence of manioc, as it leaves few or otherwise unidentifiable phytoliths (Pearsall 1989; Piperno and Holst 1998:765). In fact, no silica bodies were observed. Smooth spherical bodies adhering to the surfaces of the microliths, however, were noted in several instances (Berman and Pearsall 1999; Deborah Pearsall, personal communication 1999). These bodies tended to fracture in the condensing electron beam. Organic signals were obtained before several of the spheres exploded. The spheres ranged in size from 6 to 10 microns, with a few smaller bodies. The grains conform in size and shape to the starch grains produced by *Xanthosoma* sp. (cocoyam, yautia, malanga), a native Caribbean aroid (Loy 1994:106; Piperno and Holst 1998:775).

Discussion

Some authors (Goodyear 1993; Shott 1989) have argued that the use of the bipolar technique is evidence of economic use of rare or dwindling resources. Jeske (1992) suggests that bipolar reduction is a means to increase energetic efficiency, arguing that the lack of good raw materials encourages people to engage in economizing practices like bipolar reduction. The difficulties encountered in the use of bipolar products are outweighed by costs of obtaining higher quality material. Some researchers have proposed that bipolar reduction is the only means by which small, rounded lithic materials can be reduced (Geier 1990; Hayden 1980; Honea 1965; Jeske and Lurie 1993; Shafer 1976). Cuban archaeologist Jorge Febles observed similarities between the Three Dog site assemblage and that of Cayo Jorajoría and other contemporaneous sites located along Cuba's northern coast in which microliths were derived from small, rounded nodules. Since chert does not occur naturally in the Bahamas, it is argued that the assemblage, particularly the compression flakes, resulted from efforts to maximize the utility of rare and small lithic materials that had been brought with the site's occupants or traded to them. Alternatively, bipolar reduction allowed for useable flakes to have been produced from cores that had been trimmed of their cortex, exhausted or broken stone tools such as adzes or scrapers, or a combination of these sources. Bipolar reduction allowed for objects of useable shapes and sizes to be produced from these parent materials. Flakes also could have been parts of composite tools such as grater boards that were brought to the site or manufactured there. Numerous South American groups such as the Taruma, Maiongkong, Guinau, and Wai Wai produced manioc-grater boards that were traded great distances throughout lowland Amazonia (Chernela 1992; Lathrap 1973:172; Roth 1924:635; Yde 1965:34).

Although heavy weathering impeded recognition of microwear patterns, some evidence of retouch, use, and reuse was observed. Retouch often is associated with recycling and reuse of tools and raw materials because it extends their use-lives (Unger-Hamilton 1989:95). Retouch and resharpening are also interpreted as forms of economizing behavior in situations of low resource availability (Holdaway et al. 1996; Rolland and Dibble 1990). It has been suggested that reuse occurs more frequently at sites where raw material is scarce (Holdaway et al. 1996). Scavenging and recycling of tools and debitage are other means of making maximum use of scarce materials (Close 1996). At least one retouch flake appears to have resulted from the rejuvenation of the working edge of a large bifacial tool, such as an adze, by means of impacting the lateral/distal edge of the tool to create a transverse fracture. More significantly, in a few cases, several types of wear were present on one specimen, suggesting it had been used for numerous tasks (Table 3). Microwear analysis revealed that retouch was present on three pieces of shatter, indicating use was not limited to flakes and that materials of varying shape and size were selected for use.

In the case of the Three Dog site assemblage, anticipated function and raw material scarcity might have worked together in the generation of microliths, since both are known to influence artifact design, means of manufacture, and function. Kimball (1992), Le Blanc (1992), Walker (1980b), and others argue that the bipolar technique alone produces objects of a size and shape suitable for certain economic purposes that cannot be produced readily by other means. According to Flenniken (1981), these tasks include precision cutting, slotting, scraping, perforating, and grating, while Shott (1989) has observed that artifacts produced through bipolar reduction were used for circumcision and body scarification.

Table 3. Microwear Patterns and Modification Observed in the Three Dog Site Assemblage.

Cultural	Incidence
Crushing	25
Retouch	2
Retouch and crushing	1
Stepping	1
Edge damage and crushing	2
Edge damage	1
Postdepositional	**Incidence**
Erosion	8
Pitting	1
Pitting and rounding	5
Pitting, rounding, and recent damage	2
Rounding	26
Rounding and patination	2
Rounding, patination, and erosion	1
Rounding and recent damage	2
Edge damage	1
None	2
Unknown	2
Patination	1
Patination and recent damage	1
Recent damage	4
Wear trace	**Incidence**
Rounding	7
Polish	2
Edge damage	2
Striations	1
Indeterminate	6
None	40

Like numerous investigators in South and Central America (Acuña 1985), Caribbeanists often assume, on the basis of size, shape, and technology, that microliths were used as chips for insertion into manioc-grater boards. For example, in a preliminary analysis of the Three Dog site assemblage, Berman (1995) suggested that some of the pieces might have been used as manioc-grater chips. Similarly, Versteeg and Schinkel (1992) interpret an assemblage of pointed, triangular shaped flakes from the Golden Rock site on St. Eustatius measuring less than 10 mm in length, "as stones that were inserted in cassava graters" (Versteeg and Schinkel 1992:139). Small stone flakes recovered from fine-screened sediment samples at the Greenland and Shell Oil Depot sites on Barbados "may have been used in grater-boards to shred cassava" (Hackenberger 1991:166). Versteeg and Rostain (1997:235) classify 126 small (length ranges from 4 to 15 mm), flat, narrow, rectangular, or square-shaped chert and quartz flakes found at the Tanki Flip site on Aruba as manioc-grater chips. Like the Bahamas, Aruba lacks naturally occurring chert.

The presence of small, angular flakes is not sufficient evidence that the objects were used for manioc grating. This common assumption, Crock and Bartone (1998: 212) note, has obscured our understanding of other kinds of chipped stone and their functions found at Ceramic Age sites. Other sources of evidence such as microwear analysis, experimental replication, ethnographic analogy, and botanical analyses must be used to support functional inferences.

Walker's (1980a, 1980b, 1983) review of the ethnographic literature points to the use of bipolarly produced microliths as manioc-grater chips by various Central American and lowland South American groups, where bitter manioc (*Manihot esculenta*) was a widely eaten root crop. Processing bitter manioc for consumption is a multistage process involving peeling, grating, squeezing, drying, and cooking to neutralize and leach out alkali toxins present in the roots (Simpson and Conner-Ogorzaly 1986:245). Peeling and grating help to remove the toxins that are present in the outer cortical cells, flesh, and greens. After the outer peel is removed, the manioc tuber is shredded on a grater that consists of a wooden board into which small stone flakes, teeth, or wood chips have been embedded. Manioc-grater boards containing stone chips have been recovered from prehistoric contexts in Hispaniola and Cuba (Fewkes 1907; Harrington 1921). Newsom (1993:248) reports manioc remains from the Taíno occupation of the En Bas Saline site in northern Haiti.

DeBoer (1975) and Walker (1980a,1980b,1983) recognize that the morphological characteristics of the microflakes reported from numerous archaeological sites as manioc-grater chips resemble those reported from the Wai Wai (DeBoer 1975), early twentieth-century Taruma (Roth 1924), and Black Carib (Garifuna) (Taylor 1938; Walker 1980b, 1983). In his literature review of a sample of ethnographic groups, Walker (1980b:111–112, 1983:243) found that manioc-grater teeth range from 2 to 10 mm in length. DeBoer (1975:430) reports that the Wai Wai manioc-grater chips in the American Museum of Natural History are characterized by a modal length of 8 mm, a width of 6 mm, and modal thickness of 2–3 mm. Sievert (1992a:58) notes a mean length of 8 mm for chips in grater boards at the Field Museum of Natural History. The mean length of the microliths from the Three Dog site is 11 mm, while the modal length measures 9–10.9 mm, the modal width is 7–8 mm, and the modal thickness is 3–3.9 mm.

Roth's (1924:278–280) description of Taruma production of manioc-grater chips yields further insights into the morphological characteristics of final tool form and associated debitage. His descriptions of how Taruma women manufactured grater chips suggest they used the bipolar technique (Walker 1980b). Roth notes that when the flakes were first detached from their parent material "great care is taken to get uniformity in thickness, but width and length do not matter" (Roth 1924:279). Varying flake shapes, including ones that are circular, semilunar, lanceolate, and foliate in form, were produced. To attain the desired flake length and width the women "smash the flake into a varying number of pieces" (Roth 1924:279). They then selected a few and modified the remainder by reducing their width or creating a pointed end.

Some similarities of the Three Dog site specimens to the Taruma example can be drawn. First, over three quarters of the Three Dog site assemblage was produced through bipolar reduction. Second, the Three Dog site assemblage consists of flakes of varying shapes and sizes.

Many of the compression flakes in the Three Dog assemblage resemble manioc-grater chips produced by the Wai Wai (DeBoer 1975) and several other

South and Central American groups. The flakes also look like those that were derived experimentally by Lewenstein and Walker (1984:Figure 6) and Walker (1980b:79, 1983) for use as manioc-grater chips. They are similar in size, shape, and scarring. Like the ethnographic and experimental examples, they exhibit battering on the end, and in some cases, pointed ridges instead of striking platforms. A resinous substance is present on a number of specimens, suggesting that they were affixed to another surface.

Morphological characteristics and comparison with ethnographic data suggest that the Three Dog site microliths could have been used in the processing other roots or tubers known to have been consumed by the prehistoric occupants of the Caribbean, however. Many of these plants also involved the removal of toxins through grating, straining, and pounding (Sturtevant 1969). Newsom (1993:248) has tentatively identified sweet potato (*Ipomoea batatas*) from the Taíno occupation of En Bas Saline. The native populations also are believed to have consumed zamia (*Zamia sp.)* a member of the Cycadacae family. Las Casas noted that the Taíno of the Higuey region regarded zamia as an important food and prepared it by grating the roots "on some rocks rough like rasps" (Sturtevant 1969:190). Most germane to this study is the presence of possible *Xanthosoma* sp. grains on several of the Three Dog site microliths. This suggests that the stone tools were used to process *Xanthosoma* sp., which, too, was cultivated in the Caribbean at the time of European contact (Piperno and Pearsall 1998:116). Its tubers are prepared by roasting or boiling, while the starch is removed by grating and boiling (Piperno and Pearsall 1998:116).

Finally, a few of the flakes exhibit graver-like projections. These could have been used unidirectionally to groove shell or some other hard material, such as wood. A well-developed woodworking complex existed in the northern Greater Antilles during prehistoric times. Numerous wooden objects manufactured from tropical hardwoods have been recovered from Cuba and Hispaniola (Dacal Moure and Rivero de la Calle 1996; Fewkes 1907; Harrington 1921). Wooden *duhos*, canoes, mortars, statues, and implements have been found throughout the Bahama archipelago. It is not unreasonable to assume that woodworking might have occurred at the Three Dog site; microlithic tools would have been suitable for some stages.

Regional Comparisons

The Governor's Beach Site Assemblage

Studies show that as distance to the source increases, flake size (weight) decreases (Feder 1980; Jefferies 1982; Newman 1994). Therefore, we should expect that flake size at the Three Dog site should be less than that observed where lithic resources can be more readily acquired. In fact, average flake size at the Three Dog site is smaller than that of microliths found at several sites in northern Cuba (Berman 1995:115) where raw material is abundant. Although this could reflect an economizing tendency or distance decay pattern, it also could reflect functional considerations. A different pattern is observed at the Governor's Beach site on Grand Turk (Figure 6), another island in the archipelago, like San Salvador, lacking suitable cryptocrystalline materials for chipped stone manufacture. Here, 567 chert artifacts, produced by bipolar means, were recovered from nearly 100 m^2 units (Carlson 1993:7), an area equivalent to that excavated at the Three Dog site. The artifacts, consisting of 52 drills, 5 cores, and 393 flakes, including primary reduction flakes (Carlson 1993:22), have a mean weight of .1068 g (Carlson 1995:21). The average length of flakes and drills is 6.5 mm and 7.5 mm respectively (Carlson 1995:21). In contrast, the mean weight of the Three Dog site material is .32 g, while the mean flake length is 10.63 mm. Due to its proximity to Hispaniola, transport costs were lower at the Governor's Beach site. Thus, it was expected that the mean weight and mean size of the Governor Beach site assemblage would be larger than that found on San Salvador, which is further away from chert sources. Yet, the mean weight of the Three Dog site assemblage is almost three times greater than that of the Governor's Beach site.

Function, not economizing strategies, may have played a primary role in determining artifact form and design at the Governor's Beach site. Several studies (Carlson 1993, 1995; Keegan 1991, 1997; Littman and Keegan 1991) argue that the drills were used in bead production, while the chert cores and primary flakes were used in the manufacture of drill bits (Carlson 1993: 21). According to Carlson (1993:67), the small flakes were produced by resharpening the drill bits to make them more workable. Furthermore a portion of the assemblage, consisting of hard to identify short, bulky flakes, may

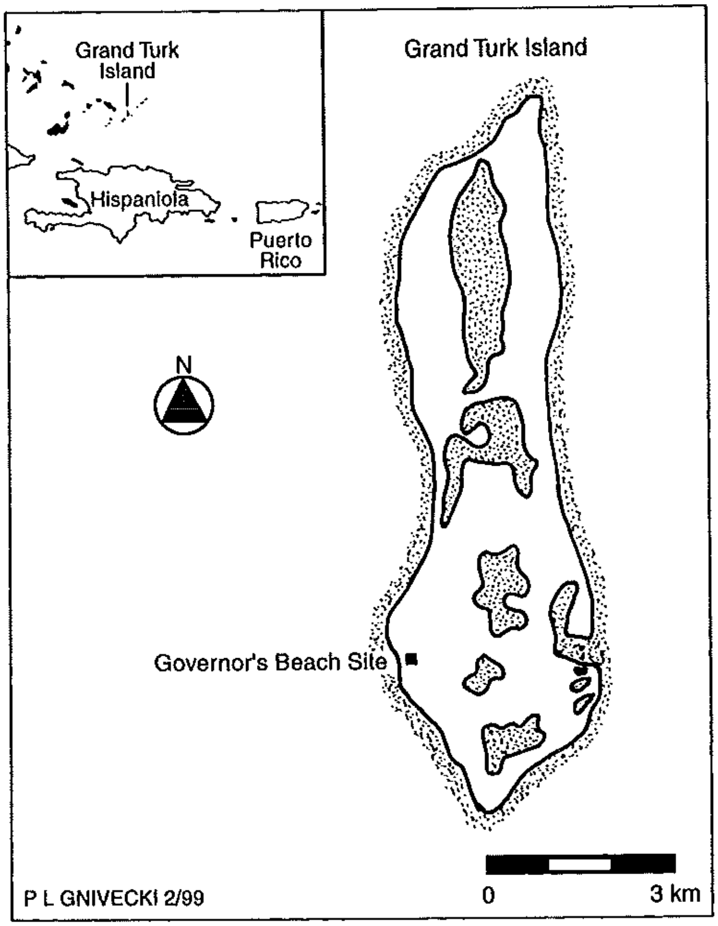

Figure 6. Grand Turk, B.W. I.

have been exhausted drill bits. A specialized lithics industry seems to have existed here.

The Aguas Verdes–Canímar Tradition

Microlith tools can also be attributed to the introduction, maintenance, and modification of various technologies and cultural traditions from the Greater Antilles. The Bahamas was settled from Hispaniola and/or Cuba and close relations between them and the Bahama archipelago existed up until the Spanish Contact period (Keegan 1992, 1997). A tradition of producing and using microliths existed in Cuba (Febles 1988; Dacal Moure and Rivero de la Calle 1996) at the time that the Three Dog site was occupied. The Canímar-Aguas Verdes lithic complex of Cuba (A.D. 450–950) (Dacal Moure and Rivero de la Calle 1996; Febles 1991a,1991b,1991c; Tabio 1991:6–7) has been reported from sites in Matanzas Province in north-central Cuba and in Guantánamo Province in northeastern Cuba. At Aguas Verdes in northeastern Cuba, tools were manufactured by a variety of means including the bipolar technique (Febles 1991b: Figures 9–14). Dacal Moure and Rivero de la Calle (1996:17) suggest that the Aguas Verdes assemblage was used to perform a variety of tasks. At Playita, a site located along the Canímar River in Matanzas, the microlith assemblage is characterized by a high incidence of perforators. Dacal Moure and Rivero de la Calle (1996:17) argue that these tools were used to perform specialized activities.

Conclusion and Summary

The 58 cryptocrystalline chipped stone artifacts from the Three Dog site consist of a unique assemblage for a number of reasons. Such artifacts rarely are recovered from prehistoric sites in the Bahamas, probably because they are small and because previous recovery techniques were inappropriate. This study represents an attempt to explain why such an assemblage was produced in terms of local and regional patterns of lithic production and use.

The assemblage, composed of artifacts of lithic materials originating in Cuba or Hispaniola, is dominated by flakes and shatter produced by the bipolar technique of percussion. The site's settlers may have brought the raw material used to produce the assemblage from their homeland. Alternatively, the raw materials and/or composite tools such as manioc-grater boards arrived as trade items in the Caribbean's far-reaching prehistoric interisland exchange networks.

Site data from nearby islands suggest that bipolar microliths were produced throughout the Caribbean. At some sites, bipolar-produced microliths were used to perform numerous functions, while at others, they were used for specialized purposes. As Nelson (1991) has noted, a variety of conditions in different settings may combine to shape specific lithic production technologies and uses. Availability of suitable resources and anticipated function likely played important roles in determining artifact form, function, and production methods. In the examples from northeastern Cuba, bipolarly produced microliths were used to perform numerous tasks. In contrast, a specialized microlith assemblage was found on the Governor's Beach site on Grand Turk, located closer to chert sources than the Three Dog site on San Salvador. At the Governor's Beach site, the bipolarly produced microliths were used for the production of drills. Proximity to cryptocrystalline materials on nearby Hispaniola may have been an important factor in determining the organization of technology. At the Three Dog site, it was expected that conservation measures would play a major role in determining the organization of technology due to the distance from the raw material sources. However, wholesale proof of conservation such as reuse and recycling was not present. Evidence for specialized production and use also is indeterminate since microwear analysis failed to produce unambiguous results and the flakes could not be assigned a functional classification. Microscopic studies revealed evidence of extreme weathering that obscured or destroyed most traces of use. Our research revealed many of the limitations encountered in performing microwear analysis recovered from tropical, coastal marine environments.

Evidence of edge rounding and retouch indicate that a portion of the assemblage functioned as tools and traces of adhesive suggest that some of the objects were used as hafted or composite tools. The presence of plant residues and starch grains (*Xanthosoma* sp.) on the working edges and crevices of some of the artifacts indicates they were used in plant processing. The bipolar flakes and shatter resemble those identified ethnographically as manioc-grater board chips and other artifacts used to process root and tuber foods. While it has not been demonstrated that all these small chipped stone artifacts functioned as grater chips, they represent an additional example of a bipolar microlith assemblage from a region where root and tuber processing technology was a focal aspect of the subsistence economy. Until similar artifacts characterized by plant remains and identifiable microwear are found, this regular association of bipolar microliths and tuber and root crop processing only can serve to support a hypothesis. Other microliths may have been used in tasks requiring incising or graving. Finally, we suggest that in some parts of the Bahama archipelago, bipolarly produced microlith technology may derive from the functional requirements placed on stone tools, while in others, economizing strategies and function may have influenced the organization of technology.

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