THE MYSTERY OF THE GUANGALA OBSIDIAN: A FUNCTIONAL EXAMINATION THROUGH EXPERIMENTAL ARCHAEOLOGY

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ABSTRACT

The Guangala people of ancient Ecuador were farmers and hunters who traded with fishermen of the shores and peoples from the mountains. Among the thousands of artifacts found at Guangala sites, archaeologists have unearthed limited quantities of flakes of obsidian, a volcanic glass. However, obsidian is not native to the Guangala region of Ecuador. The flakes were probably obtained from mountain traders; their rarity and difficulty of procurement indicate obsidian may have been considered precious by the Guangala. In order to learn about the Guangala's use of obsidian, we made replicate obsidian flakes by flintknapping. We then tested the flakes on various contact materials of soft, medium, and hard consistency. Finally, we compared the resulting damage on the edges of the replicas to the damage found on the edges of Guangala artifacts using both reflecting light and scanning electron microscopes. The results led to the preliminary conclusion that the blades were used by the Guangala in some type of ritualistic butchering, providing new insight into the culture of these ancient people.

INTRODUCTION

The History of the Guangala

According to accounts from European explorers, the indigenous people living on the Ecuadorian coast at the time of the Spanish conquest formed a united group of diverse tribes, sharing common characteristics. They were animistic, believing in the sanctification of natural forces, places, objects, or animals. Their customs included animal sacrifice and the working of shells and gold into jewelry. Body art and face painting were also common practices and were used as clothing and decoration [1]. The Guangala were ancestors of these tribes. The Guangala Phase of Ecuadorian history, dated from 100 BC to AD 800, predates the arrival of the Spanish [2]. Most Guangala villages discovered from this period are located along or near streams and rivers, demonstrating the importance of a water source in a semi-arid environment. It is believed that the Guangala were farmers, fishers, hunters, or a combination of these, depending upon the location of the village. Agriculture was probably fairly widespread, the main crops being maize, manioc, squash, and peppers. The Guangala ate a variety of New World vegetables, and corn was a main ingredient in their diet. One European account states that in this region "...they make better maize-bread than they do in any other part of India" [1]. They also supplemented their diet with deer, fish, and *cui* (or guinea pigs).

Through the analysis of the artifacts and the surrounding soil from Guangala settlements, archaeologists have concluded that the Guangala society was organized in individual or extended households or farmsteads [2]. Tools that have been found are often made of shell, bone, copper and stone such as chert and also rarely, obsidian [3]. The Guangala used numerous stone tools, both polished and unpolished, for unknown purposes. Metal artifacts were almost completely ornamental with the exception of tweezers and needles. It is therefore assumed by archaeologists that the stone tools were used for all daily farming and food preparation activities such as cutting, chopping, skinning, and butchering. These conclusions have never been tested, however, by any type of experimental or analytical project. Chert is by far the most common material found in the Guangala region. Obsidian is much rarer at the sites, and it may have held special significance to the Guangala. Obsidian flakes, which originated from a source in the Ecuadorian highlands over 200 miles away, are strong evidence of trade over long distances. No studies have ever been conducted to determine the possible uses for these rare obsidian flakes.

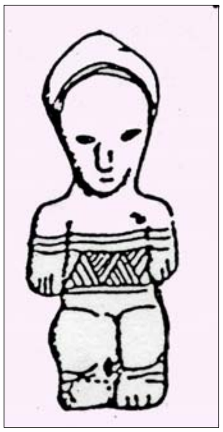

Figure 1. Picture of Guangala Ceramic Figurine.

After over one thousand years in existence, the Guangala culture disappeared sometime after AD 500. The causes of this collapse are not definitively known, but it is thought that neighboring peoples conquered the agriculturally-based Guangala. One such warlike people were the Caras, who came by sea on rafts in the sixth or seventh century and eventually came to rule the Ecuadorian highlands [4]. Another group was the Manteno, who were present on the coast at the time of the Spanish conquest. It is most likely that the Guangala civilization was incorporated into that of the Manteno [5]. The Spanish accounts of the Manteno culture include descriptions of their practice of human and animal sacrifice.

Explorations near the modern town of El Azúcar have revealed numerous ancient Guangala settlements [2]. Artifacts found at these sites include imported materials such as copper, gold and obsidian as well as marine vertebrates and invertebrates which indicate Guangala participation in the exchange of goods with neighboring cultures [2]. The most abundant artifacts are of pottery (Figure 1) which includes ceramic figurines which range from abstract bars of clay to posed human figures. These are commonly found in burial sites. Unlike those from other ancient societies in Ecuador, few of the Guangala figurines give any indication of the nature of daily life or rituals. However, there is reason to believe that they may have played a role in religion. Other artifacts discovered at the Guangala sites which may have played a part in rituals and ceremonies include painted ceramics, hollow figurine whistles, bead fragments, shell tools, and metal ornaments [3]. Obsidian, or volcanic glass, in the form of flakes has also been found at the El Azúcar Guangala sites, although it is a rare occurrence. This transparent stone is known to have been a sacred material for the ancient peoples of Latin America and played a prominent role in the rituals of all the major civilizations encountered by the Spanish.

<u>Location</u>

The modern town of El Azúcar (Figure 2) in southwestern Ecuador is located along the Río Azúcar about halfway between the Pacific Coast and the Colonche Hills, each about 20 kilometers from the village. The village is situated in a relatively narrow river valley surrounded by hills which reach heights of 250 meters. The valley is located in a border zone between the semi-arid coastal plain, which has only sparse vegetation and relatively dry soils, and the dry tropical forest which has moister soils and heavier vegetation. The climate generally consists of a rainy winter season and a dry summer season, with temperatures year-round about 25° C. The dry season is usually longer than the wet season, although the length and intensity of the rainy season varies.

There is almost no forest left in the river valley itself, but residents have reported that there has been much deforestation during the past thirty years [5]. The river flows only during a heavy rain season, and often dries up during the dry season. However, the river flowed more freely before a dam was constructed upstream from the village. Most of the ancient Guangala settlements near El Azúcar would have been agricultural in nature, as the sites are too far from the ocean to rely upon fishing. Lasting 7 to 8 months, the long dry seasons forced the people at this site to live on a combination of agricultural produce, hunted game such as deer and imported marine products from the coast.

Figure 2. Map of Southwest Ecuador. Arrow points to El Azúcar, the site from which the obsidian artifacts were retrieved..

<u>The Significance of Obsidian</u>

Obsidian, a natural volcanic glass, provides an extremely sharp edge when chipped. The material is preferred by many societies throughout the world for cutting activities. It was known as a sacred material to many of the ancient cultures of Latin America such as the Inca, Aztec, and Maya. It was the central material used in human and animal sacrifices by these peoples. Archaeological research in Ecuador shows that each ancient Guangala household had only one or two obsidian flakes, indicating that these were possibly used for special occasions such as rituals. Based on information from other Ecuadorian societies described by the Europeans, examples of ritual uses may have included bloodletting or human or animal sacrifice at ceremonies such as temple dedications, weddings, offerings, and burials. The actual uses of the obsidian by the Guangala is not currently known.

Project Goals and Hypotheses

Use wear analysis or the study of the damage on the edges of stone artifacts has been studied by archaeologists in other parts of the world to identify the uses of stone tools. The probable activity which caused a damage pattern can not, however, be determined without information on the damage different uses cause on stone edges. Experimental archaeology is commonly used to provide the necessary reference samples. Such a project produces replicas of ancient tools and through tests and trials creates and examines the wear on stone edges. These wear patterns are then compared with those on actual ancient stone tools to formulate hypotheses of possible uses.

The primary goal of this project was to determine possible uses of Guangala obsidian artifacts through use wear analyses and experimental archaeology. This experiment was designed to test several hypotheses. The first is that using obsidian on test materials would create characteristic edge damage that would be easily recognizable on a reflecting light or scanning electron microscope. The second is that due to its glass-like qualities, obsidian could be used without retouching and the damage would therefore be more suitable for comparison. The third is that insight into the use of the ancient obsidian artifacts could be gained by comparing the characteristic patterns of edge damage created by using obsidian on test materials to the damage visible on actual obsidian artifacts.

The function of the artifacts can give us insight into Guangala culture. Deposits of obsidian were not found near the excavation site, which signifies that obsidian was a rare material that would have to be imported and bartered for. This leads to the inference that it would only be used for special purposes, perhaps ritualistic or ceremonial rather than common, everyday tasks for which more abundant materials would function just as well. Discovering the special uses for the artifacts would provide information on beliefs and worldview of the Guangala.

METHODS AND MATERIALS

Procedure

Experimental archaeology tests the function and purpose of ancient artifacts through the production of replicas. It is important that the techniques used to create the replicas be similar to those used by the society in question [6]. Experimental archaeology deals primarily with the technology of ancient cultures and uses this as a basis for understanding the culture. Replication, the process used in this study, adheres as closely as possible to methods used in the past, while reproduction implies a certainty in the accuracy of the simulated artifact not present in this study.

In order to perform our experiment, replicas were created to approximate the obsidian flakes found at the archaeological sites. To do this, the first step was the production of obsidian flakes that could be used for microwear analysis. This was accomplished through the use of flintknapping, a method of creating blades that is believed to be similar to that of the ancient Guangala. Obsidian was used to create the replicas because our artifacts were made of obsidian.

The obsidian we used to make our replicas was from Wyoming. Although Wyoming is a great distance from the Ecuadorian highlands, the composition of the rocks did not differ enough to interfere with the experiment. Due to the absence of intentional flaking along the edges of the artifacts, only percussion flaking was used to create replicate flakes and no edge preparation was necessary. After producing numerous flakes, six with clean edges were selected. Each flake was used on a different material for a specified amount of time.

The selection of test materials was based on possible ancient uses of obsidian and was selected to encompass a wide range of hardness. Soft material that was chosen was plant matter, cut on a sandstone slab and chicken skin. Replica 1 was used on wood in a transverse shaving action for 17 minutes (approximately 70 strokes/min). Replica 2 was used on plant fiber on a sandstone slab in a longitudinal sawing motion for 15 minutes (approximately 45 strokes/min). These materials were chosen because plant matter would have been cut by the Guangala in farming and clearing land for agriculture, and skin might have been cut during hunting or for ritual bloodletting and sacrificial purposes. The materials of medium hardness were wood or bark and chicken cartilage. The Guangala might have cut cartilage after hunting game, particularly deer. The damage on replica 3 was created by means of longitudinal sawing of cartilage for twelve minutes with forty strokes per minute. Replica 4 was used for 10 minutes of longitudinal and transverse cutting actions (approximately 10-12 strokes/min). Its primary use was to separate the skin from the muscle, meat, and cartilage. The shaving of wood may have been necessary for building construction, tools, or in art. The hard materials included shell and bone. Replica 5 was used on dry, hollow bone from a cow. The replica was used in a longitudinal sawing motion on the rim of one end of the hollow bone. The sawing was carried on for approximately 3 minutes, after which the edge of the replica was noticeably worn. Replica 6 was utilized to saw the *Spondylus* in a longitudinal motion. The continuous vertical motion was conducted on the edge of the shell, as this portion displayed a purple hue which may have been used in jewelry making. The edge of this very hard material was jagged and sharp. The sawing was executed for approximately two minutes. Many Guangala villages depended on fishing as a source of food and income, and worked shell was a main export of the Guangala.

The original artifacts and flake replicas were photographed with a camera (Appendix A, B) and examined under a reflecting light microscope and a scanning electron microscope. Using the photographs and descriptions of the edge damage, each of the artifacts was compared to each of the replicas in an attempt to identify a possible use for the original artifacts.

<u>Flintknapping</u>

Flintknapping is the shaping of stone into sharp flakes using hammerstones or antlers. Tools such as hammerstones, abrading stones, and antler billets are used to strike the obsidian and thus drive off flakes. Obsidian fractures conchoidally as a result of a Hertzian cone of force caused by percussion flaking (Figure 3). An expert flintknapper can prepare a core of obsidian in order to obtain the type of flake which he needs. It is possible to create two types of flakes when flintknapping. The first, pressure flaking, is performed by applying pressure to small hammerstones or antler tines while the tool is positioned on the very edge of the obsidian until a small flake is removed. This results in a regular pattern of serrations. The second, percussion flaking, is done through the brisk striking of the platform of the obsidian with a larger hammerstone or antler, resulting in flake edges that can be as thin as two microns. These edges are easily lost when the blade is used, which provides a unique wear pattern that can be compared to artifacts found at archaeological sites.

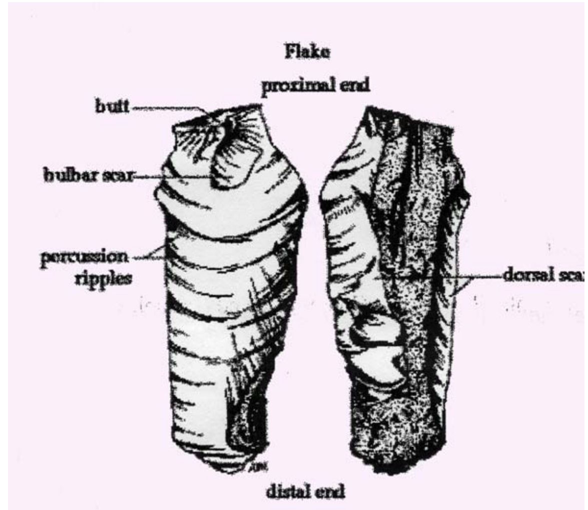

Figure 3. Image of obsidian flakes created through the process of flintknapping.

Scanning Electron and Reflecting Light Microscopy

The two types of microscopes employed in this project were the reflecting light microscope and the scanning electron microscope (SEM). The reflecting light microscope consists of a series of glass lenses which reflect and refract a beam of light from an external source and can be adjusted to focus and magnify the object. The SEM functions by using a beam of electrons produced by a high powered electron gun. This beam is attracted by an anode and condensed by a condenser lens, then focused into a fine point by an objective lens. The SEM uses voltage from a generator to create a magnetic field which is necessary to deflect the beam.

Use Wear Studies

Microwear analysis uses microscopy to examine damage caused by the various materials on the obsidian. Most examination is focused on microscars which form on the edge of the material. In *Use Wear Analysis of Flaked Tools,* specific criteria are used to compare simulated wear on artifacts [7]. These criteria include the type of action, such as longitudinal or transverse, and hardness of the test material. We used similar criteria in our study.

Experimental archaeology is generally believed to be inconclusive when used exclusively to determine the function of a particular artifact. However, we are able to get a general idea of which actions produce certain types of wear. Through this type of detailed observation, Semenov was able to ascertain the function of a tool [7]. With appropriate standardization and the sharing of information between tests and research teams, a general consensus can be reached regarding probable use of an artifact.

RESULTS

Use wear or microwear analysis uses microscopy to examine damage caused by use on the edges of stone tools such as those on obsidian. Most examination is focused on microscars which are left when tiny flakes are struck off the edge through use. Our study also found other types of edge damage which was visible and distinctive on both artifacts and replica edges. The characteristics noted on edges were of three main types which are summarized in Appendix C. These characteristics are 1) flake scars – shape and depth; 2) edge characteristics – shape, sharpness and angle; and 3) other – surface pitting, and striations. These attributes were examined on the artifacts and then the range of patterns compared between the artifacts and replicas. Results for individual specimens are summarized below and in Appendix C.

Artifact 1 displays three separate and distinct patterns of wear. In Section 1, deep crevices with rounded fracture peaks appear alongside shallow, jagged fractures. This damage is not accompanied by flake scars. These marks neither mar the surface of the flake nor disrupt the smoothness of the edge. This damage extends to Section 2, a raised section in the center of the edge characterized by flake scars leaving a thick, blunted edge (Figure 4). Striations continue to the edge and in some small areas form very shallow ridges in the edge (Figure 5). However, they do not affect the flake scars. Section 3 contains a large flake scar between the smaller flake scars of Section 2 and the very thick right corner of the analyzed edge. This large flake scar, which is composed of nine or ten shallower individual flake scars, is bisected by a dull peak. Though the top right corner also has a small flake scar, it was not considered for this project.

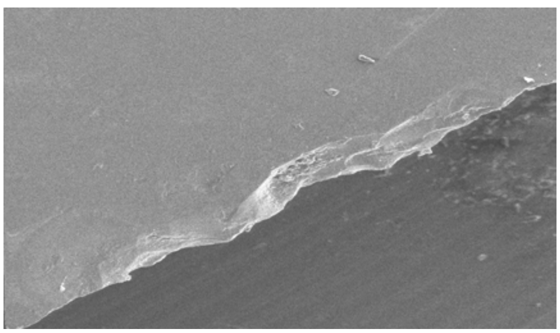

Figure 4. SEM – taken originally at 100x. Deep, irregular flake scarring of the edge on Artifact 1.

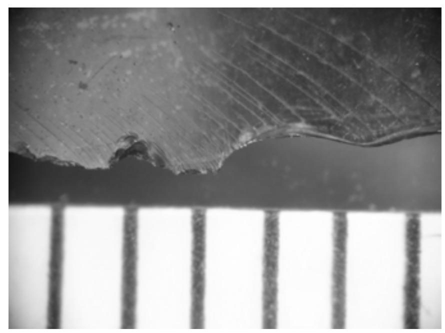

Figure 5. Light Microscope (scale in millimeters). Striations extend from two jagged chips in the edge of Artifact 1.

Artifact 2 has many shallow yet well-defined flake scars along the analyzed edge. It also has many deep, pronounced striations that radiate from the flake scars. The edge of the artifact is jagged but with rounded peaks between flake scars (Figure 6, 7). The artifact also contains damage areas where it appears some portion of the stone had crumbled off during its use.

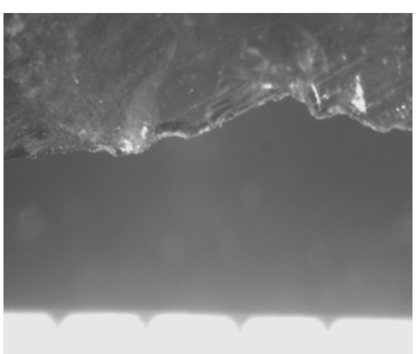

Figure 6. Light Microscope (scale in millimeters) The uneven edge with somewhat smoothed, rounded peaks of Artifact 2 is shown.

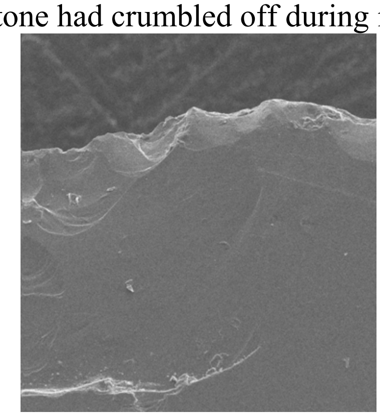

Figure 7. SEM – taken originally at 100x. The deep flake scarring of Artifact 2 is evident as well as the jagged edges and the scar's fractures.

The analyzed edge on Artifact 3 contains edge damage that is irregular, uneven, and jagged although the damaged edges appear to be worn-down, with no distinct peaks (Figure 8, 9). There are very small flake scars of varying size along the edge. The percussion ripples extend away from the edge to about one-third of the artifact's width. Striations diagonal to the edge are visible. Beneath the bulb of percussion is an erailleur scar. The edge appears smooth to the naked eye, but reveals some shallow micro-scars when magnified. The flake scars are mostly cylindrically shaped and extremely small. There is no regular pattern or distribution to the scarring.

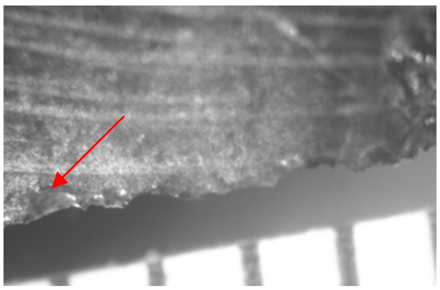

Figure 8. Light Microscope (scale in millimeters). The irregular worn-down edges of Artifact 3 are exhibited, as well as small flake scarring (see arrow).

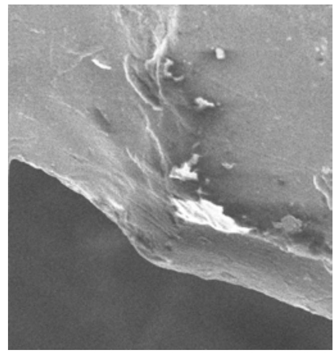

Figure 9. SEM – taken originally at 500x. At a closer look, the edges of Artifact 3 appear more rounded, but the actual scarring shows much serration and sharpness.

Replica 1 was used to shave bark off twigs. Its edge suffered very little damage, with only minor irregular, shallow edge chipping. There was a complete lack of flake scars. It showed frequent irregular pitting, which covered the entire used edge up to a noticeable distance inward on the surface of the stone (Figure 10). Though the shapes of the edges were very similar to those of Artifact 1 and 3, the lack of pitting on the artifacts leads to the conclusion that the artifact was not used to shave wood. Replica 1 had little or no flake scars, unlike Artifacts 2 and 3 (Figure 11). Shaving wood did not cause any visible striations. The replica also had much smaller peaks than those observed on the artifacts.

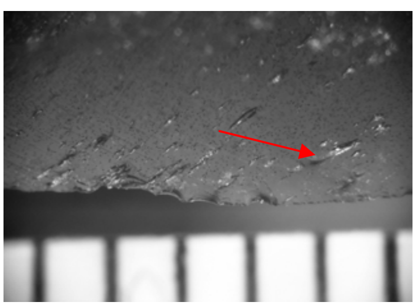

Figure 10. Light Microscope (scale in millimeters). At this magnification, the rounded edges of Replica 1 are apparent, as well as the pitting (arrow).

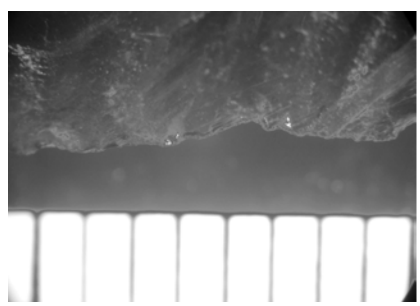

Figure 11. Light Microscope (scale in millimeters). Artifact 2 shows many more jagged edges, scarring, and sharper peaks and no pitting (no match).

Replica 2 was used to cut plants in a longitudinal action against a sandstone grinding stone, producing a very roughly rounded edge. This dulling of the edge was caused by the use of the replica on the sandstone rather than on the plants. There were no peaks but flake scarring was visible under the SEM (Figure 12). The conclusion was then that none of the artifacts were used to cut plants in this manner. Because of the lack of deep scarring visible to the eye using a light microscope, it was unlikely that Artifact 2 or 3 was used to cut plants (Figure 13). No striations were visible on this replica. Replica 2 did not have peaks, but simply looked like it had been dulled.

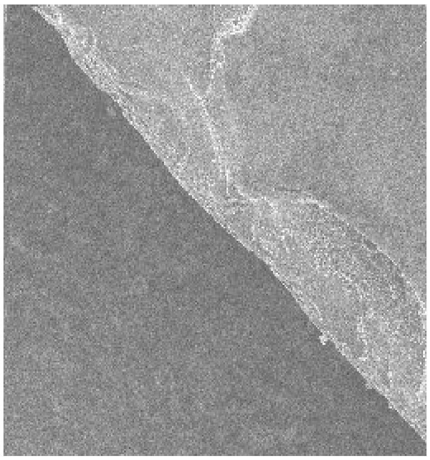

Figure 12. SEM – taken originally at 100x. Flake scarring is revealed under the SEM. The image also demonstrates the lack of peaks or a sharp edge.

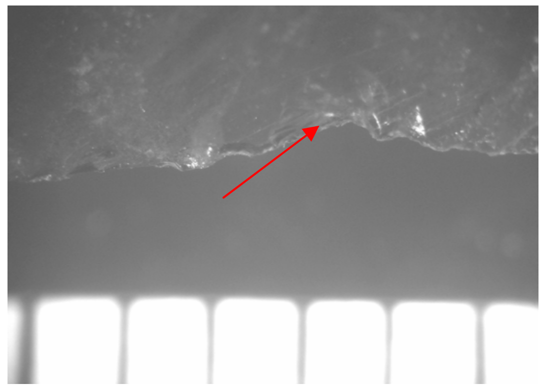

Figure 13. Light Microscope (scale in millimeters). On Artifact 2, the flake scars are visible at a much lower magnification.

The edge of Replica 3 (used on cartilage) was characterized by very deep crevices interspersed with steep fracture peaks and shallow jagged edge fractures (Figure 14). This replica also had well-defined flake scars, which varied from very wide and smooth to very deep and narrow, including multiple flake scars in one area. A similar set of characteristics was observed on Artifact 1. This replica also had damage striations, though they were not as precise and defined as the striations on Artifact 2. It also had much sharper peaks than Artifact 2 (Figure 15). Even though the edges of Artifacts 1 and 2 were more eroded with softer peaks, this may have been a result of variables due to the age and care of the obsidian.

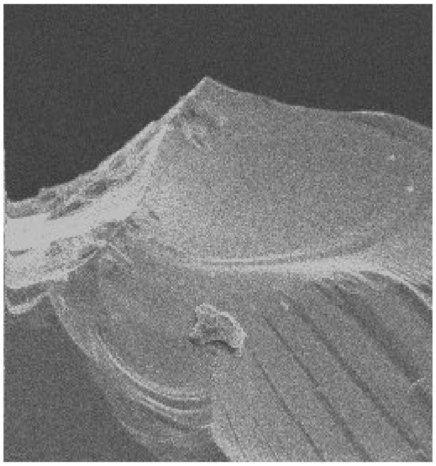

Figure 14. SEM – taken originally at 500x. The very sharp edge of Replica 3 is exposed, as well as the regular round flake scars and fractures.

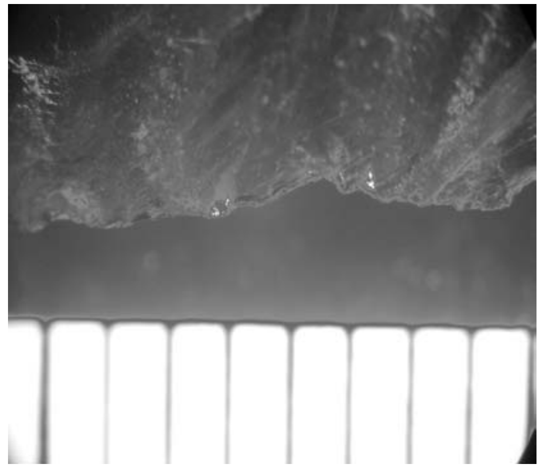

Figure 15. Light Microscope (scale in millimeters). Artifact 2 edges are much more rounded than Replica 3 (no match).

Replica 4 was used to cut skin on raw chicken wings using a transverse motion. The replica edges showed tiny, shallow irregular flake scars consistent with the middle portion of Artifact 2. Using the replica on skin also produced jagged edged sections with flattened peaks (Figure 16). These characteristics are similar to sections of Artifact 1. Surface pitting, edge crumbling and small striations were also observed on Replica 4 but are not present on any artifact (Figure 17). The significance of pitted surfaces needs further experimental analysis since this was observed on a number of the replicas but not on any of the artifacts.

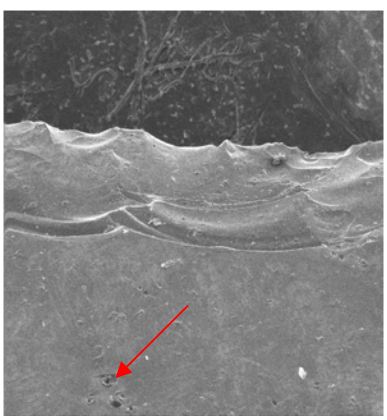

Figure 16. SEM – taken originally at 200x. The image of Replica 4 confirms the presence of flat peaks, irregular (rounded and flat) edges, and pitting (arrow).

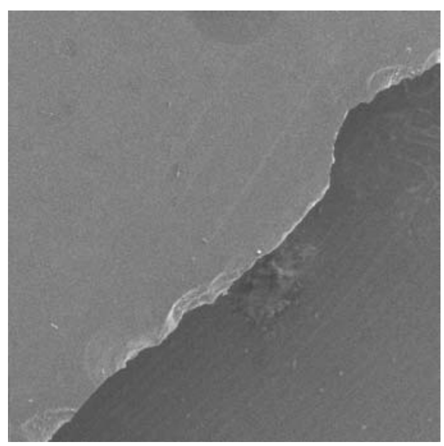

Figure 17. SEM – taken originally at 45x. The image of Artifact 1 shows its jagged edge-line but lack of pitting.

Replica 5 was used on dry, cow bone in a sawing motion. This action produced irregular, shallow flake scarring, low jagged edges and deep striations (Figure 18). The relatively minor flake scarring is distinct from that observed on Artifacts 1 and 2. The edge is more similar to portions of Artifact 3 (Figure 19). The striations on Replica 5 are similar to those on Artifact 2.

Some of these striations were visible, however, on the replica blade before use. Therefore, striations on the faces of artifacts may actually be a result of production of the tool rather than from its use.

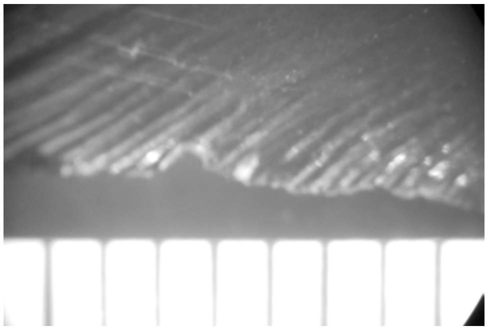

Figure 18. Light Microscope (scale in millimeters). Replica 5 does not have regular flake scarring; although the deep striations are apparent.

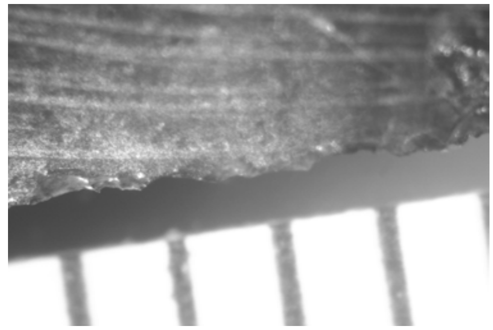

Figure 19. Light Microscope (scale in millimeters). Striations and irregular, sharper edges of Artifact 3 are similar to Replica 5.

Replica 6 was used to saw shell. The use produced regular, multiple, shallow flake scars with jagged peaks (Figure 20). Crumbling was also noted on the edge of this replica. The damage observed did not match the pattern on any of the artifact edges.

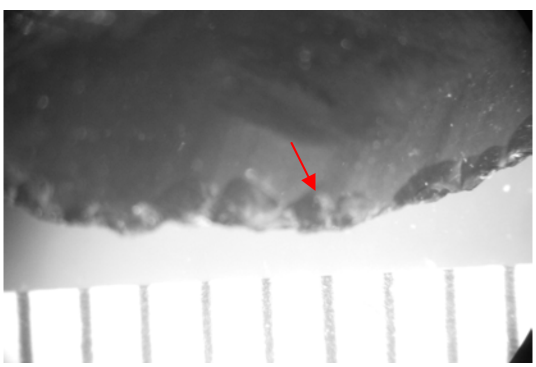

Figure 20. Light Microscope (scale in millimeters). The regular, multiple flake scars of Replica 6 are illustrated.

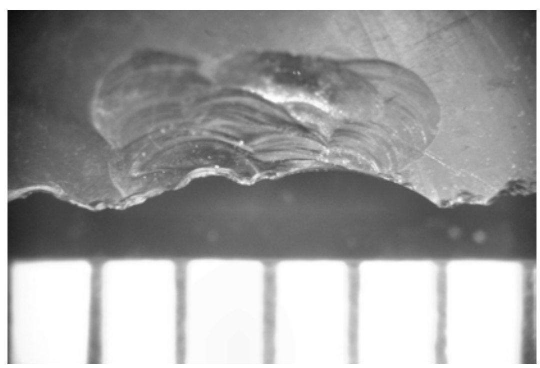

Figure 21. Light Microscope (scale in millimeters). Similar multiple rounded scarring is seen in Artifact 1.

Six distinct patterns of wear were created through the processes of sawing and scraping a range of soft, medium and hard contact materials. Even though none of the artifacts matched all attributes found on any one replica there were correlations between individual characteristics on replicates and artifacts. Of all the samples in the experiment, the damage produced in cutting cartilage and skin and in sawing bone was most similar to the damage found on the three artifacts. Specifically, Artifacts 1 and 2 exhibited patterns similar to those found on Replicas 3 and 4 used on cartilage and skin, respectively, and Artifact 3 exhibited patterns similar to those found on Replica 5 used to saw bone. From the results it can be concluded that Artifact 3 was most likely used on a harder surface than Artifact 1 and 2. If that surface was bone, its function was probably not to saw at the bone, since the obsidian did not prove useful for that job. Only a small notch was formed after 3 minutes of sawing, and the edge was heavily worn down. So if it was used for bone, it would have more likely been an activity such as scraping meat off a bone, severing tendons and flesh, or engraving patterns. This idea can also be concluded by examining the scanning electron microscope images of Replicas 4 and 5 (skin and bone, respectively). The rough, pointy scarring of these two specimens was very similar (Figure 22, 23). Therefore, the Guangala obsidian blades may have been used on a range of butchering activities involving cutting skin, bone, flesh, and cartilage.

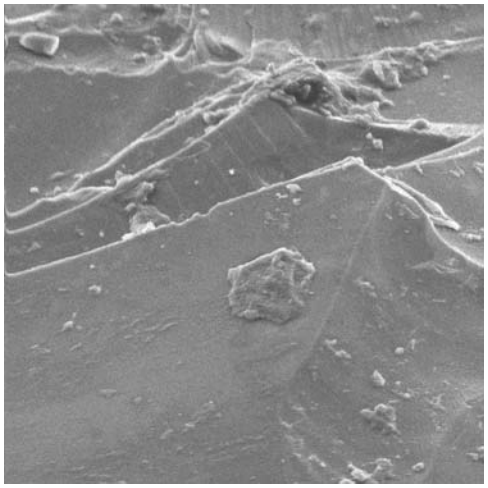

Figure 22. SEM – taken originally at 500x. The irregular sharp, scarring of Replica 4 is exhibited by this image; Replica 4 was used to cut through skin of a chicken appendage.

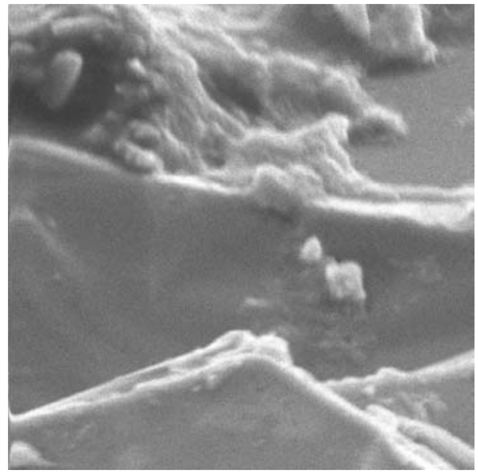

Figure 23. SEM – taken originally at 2000x. Seen at an even greater magnification, the scarring of Replica 5, used on bone, is very similar to the jagged flake scars of Replica 4.

DISCUSSION

Effectiveness of the Scanning Electron Microscope

Some problems were encountered in the project, which are typical of reflecting light microscopy. These include "decreasing depth of field with increasing magnification, glare, poor contrast, and difficulty with surface recognition using translucent materials" [8]. The scanning electron microscope (SEM) provides an effective solution to these problems. Its depth of field is much greater than that of the reflecting light microscope at any magnification, and it produces a grayscale relief image, which can be adjusted for brightness and contrast, instead of the colored flat image of a reflecting light microscope. The SEM also has higher resolution, a much greater range of magnification and a field of focus 400 times greater than that of the reflective microscope. However, the SEM did not provide a view of the entire edge of a flake, and the preparation of the flakes required in order to view them under the SEM made it difficult to examine edges other than those which had originally been marked. While the SEM did allow for a more detailed comparison of peaks and flake scars, the frame of reference was often lost, and overall the reflecting light microscope is more effective for comparison. Used in conjunction with the reflecting light microscope, the SEM can be a very useful tool; however, it can not be used alone to provide a complete and accurate comparison.

Efficacy of the Replicas on the Test Materials

Replica 1 was very useful for shaving thin bark from tree twigs. A single stroke removed all of the bark from the area of use. However, it seems unlikely that the delicate blades could be used to remove thicker tree bark. Replica 2 was able to cut through grass and plant matter, but several strokes were required to cut through completely. A similar task may have been accomplished more effectively manually or through the use of other tools. Replica 3 was inefficient for cutting chicken skin. The edge was difficult to use and slippery, but the corners proved much more effective. Replica 4 was used to cut through cartilage in the joints of a chicken. It was effective and able to cut through the cartilage quickly, but the flake wore down very quickly. It would be possible to cut through the joint of a larger animal such as a deer fairly easily, but would probably require several flakes or a larger flake. Replica 5 was able to make a small notch in a bone, but it also wore down very quickly. In order to do more intricate carving, many such flakes would be required. The blade was losing its efficacy in sawing at the bone. The replica was ineffective if the purpose was to cut the bone, because the only visible evidence was a small notch in the bone. However, the flake could be used to engrave the bone, although it does not leave a mark easily. Replica 6 was used on shell. This use had no discernable impact on the shell, but caused considerable damage to the blade. It is unlikely that obsidian flakes were used to work shells in this manner. In this period of time, it was noted that no visible mark was made on the shell. Nonetheless, the sawing on this rigid contact material caused much deep, jagged flake-scarring of the obsidian.

Possible Sources of Error

The most significant source of error during any project based on experimental archaeology is in creating the replicas. While modern flintknapping closely resembles the technique of ancient people, it is impossible to know exactly how a particular culture created a particular item. Another problem encountered is that that many different methods might lead to the same or similar product. This is referred to as equifinality. It is incorrect to assume that the methods are the same because the replicated flakes appear similar in nature to ancient artifacts. This is true in the creation of the replicas as well as in their use. Regardless, the degree of skill at flintknapping of an ancient culture highly successful in this field is incomparably higher than that of modern students or even most professional archaeologists. It is always possible that some edges of these artifacts were not used at all, or that they were used for a variety of purposes on a variety of materials. It can not be determined in full whether the Guangala would have used the obsidian on the same materials in the same manner.

Ideas for Future Research

The most useful work that could most likely be done to follow up these experiments would be more experiments, mostly based on using different test materials. Because the results of this experiment were not completely conclusive, obsidian flakes could be used on materials that are more specific to the area where the original artifacts were found—materials obtained from or in the vicinity of the site itself would provide the most accurate results. Other variables that could be changed in future experiments would include the type of motion used on the test materials and the number of strokes applied to the materials. In this experiment, mostly longitudinal (cutting and sawing) motion with respect to the materials was used, while in other experiments the focus could be placed on transverse or scraping motions, used on some of the same materials. Also, a greater number of strokes or a longer use period on some of the materials could produce more regular wear patterns on the edge of the replicas, and would probably also simulate better the use of the original artifacts themselves—it is likely that the Guangala people would have used such valuable obsidian tools to their fullest potential. Besides future experiments, obtaining the results of other use wear tests of obsidian flakes could be useful for comparison with our results and getting ideas for future tests that could be done to determine conclusively the function of these obsidian artifacts.

CONCLUSION

This project in experimental archaeology provided new information on the uses of obsidian blades by the ancient Guangala people of Ecuador. First, in agreement with our initial hypothesis, we discovered that using obsidian on different contact materials did create characteristic patterns of wear. For example, sawing cartilage creates deep crevices, steep fracture peaks and shallow, jagged fractures on the edge of the blade. These results demonstrated the potential of a "library" of type samples of wear patterns that could be created using many different replica materials and contact materials. Such a library could be used to bypass the replication and testing phases for future trials in experimental archaeology and allow analysis to advance immediately to the comparison phase.

Second, we demonstrated that retouching is not required to maintain a sharp edge on an obsidian blade, in accord with our second hypothesis. The three artifacts chosen for comparison lacked damage patterns that would suggest intentional serration by flintknapping; they all had "clean" edges which appeared to have been simply used and then discarded. In addition, several of the replicas were tested for extended periods of time (fifteen minutes or more) without need for retouching to maintain their efficiency at the task. This suggests obsidian is well suited to use wear analyses because it is unlikely any edge damage due to use on a specific material would have been erased by later retouching. Such alteration would make comparison between artifacts and replicas impossible.

Finally, we hypothesized that we could determine possible uses of obsidian artifacts through comparison of their edge damage to the damage on replicas. This was the central goal of the project. Although we demonstrated that specific contact materials leave distinctive damage patterns on stone edges, none of the patterns on the replicas were an exact match to those on the artifacts. Therefore, the exact function of the Guangala obsidian blades remains a mystery. We were able, however, to rule out the soft materials (wood and grass) and the hard materials (shell and dry bone) as the source of the edge damage on the artifacts. This implies that the blades were not used for activities involving these types of materials, such as carving wood and bone. The artifacts' damage most resembles the damage on the replicas tested on medium materials—raw skin and cartilage. The damaged edges were not complete matches since the patterns on both the replicas and the artifacts were complex. In all cases there was a set of patterns and so not all characteristics observed on the replicas appeared exactly on the artifacts. Individual characteristics do, however, match. Therefore, based on our experiments, the obsidian blades were most likely used for some type of butchering activity. We can not determine at this point whether this involved skinning, slicing meat, or cutting cartilage. In addition, although we tested Replica 3 solely on skin and Replica 4 solely on cartilage, it is more probable the artifacts were used on a range of animal material within the process of butchering explaining the complex combination of patterns found on the artifacts.

Following this conclusion we can then ask: what exactly were the Guangala butchering with these artifacts? Although this experiment does not directly address this question, other evidence from the site, on the Guangala culture and on the nature and importance of obsidian to ancient Latin American cultures suggests the artifacts were used for ritualistic purposes. Obsidian blades were very rare at the site and were imported from the Ecuadorian highlands, hundreds of miles away. In addition, the blades had not been used intensively. The rarity, cost of procurement, and lack of heavy use seem to indicate the artifacts were not used for everyday butchering, but for some special function. (Blades made from cheaper and more abundant materials, such as chert, were more likely used for daily food preparation.) Although the artifacts were found in a midden, or garbage pile, their unceremonious disposal does not necessarily discount them as ritualistic artifacts. In similar cultures, ritualistic objects must be of the proper material (e.g., *spondylus* shells, jade, obsidian), but their importance is defined by the ritual itself. The raw materials have no special significance after the religious action is completed and therefore require no special disposal.

If the artifacts are indeed ceremonial objects, their scarcity may indicate they were used for a specific type of ritualistic butchering. The most common modern day use of similar blades is in ritual sacrifice such as divination using guinea pig entrails. Further experimentation accounting for the numerous possible variables in butchering (i.e., type of action, type of animal, butchering location on the animal's body, etc.) is required to draw more definitive conclusions. With this experiment, however, we have been able to shed some light on the enigmatic Guangala and their obsidian blades.

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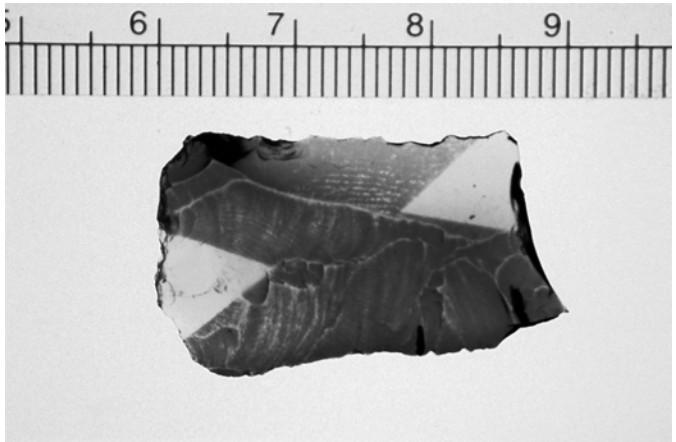
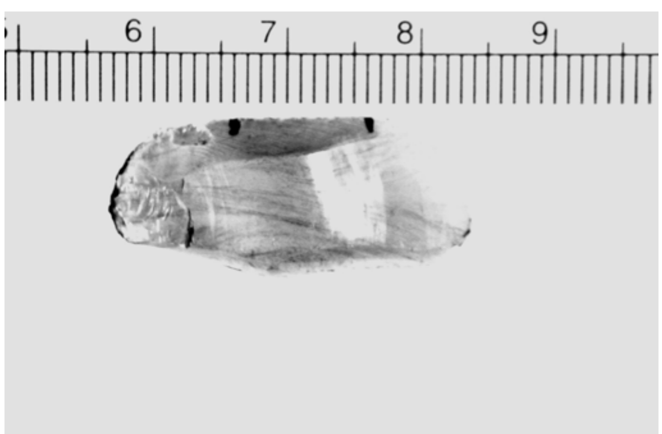
APPENDIX A

The following are images of the entire artifacts taken with a digital camera (scale in centimeters).



Artifact 1

Artifact 2.

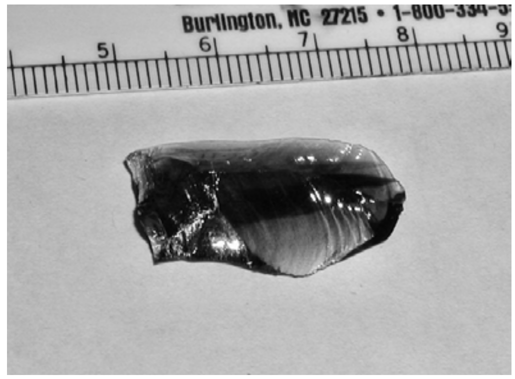


Artifact 3.

APPENDIX B

For a better understanding of the different edges which resulted from the work on the contact materials, below are the pre-worn images of the entire replicas. Notice the smooth edges in comparison to the resulting edges.

Replica 1 (used on wood)



Replica 2 (used on grass)

Replica 3 (used on cartilage)

Replica 4 (used on skin)

Replica 5 (used on bone)

Replica 6 (used on shell)

APPENDIX C

These two charts summarize the results of our experiment, by describing the artifacts and the replicas, respectively.

Artifacts	**Flake Scarring** Shape/Depth	**Edge Characteristics** Sharpness/Angle/Shape	**Other Characteristics** Striations, Pitting, Etc.
1	- two shallow smooth chips - large flake scar (composed of approx. ten shallower scars) bisected by peak - small, thick, irregular flake scars - shallow scars and ridges	- deep crevices with rounded fracture peaks - shallow, jagged fractures - thick, blunted edge - shallow ridges - dull peaks	- striations evident - no pitting
2	- shallow, yet well-defined flake scars	- jagged edge - rounded peaks between flake scars	- deep striations radiate from flake scars - some portion of the stone crumbled off
3	- shallow micro-scars when magnified - cylindrically shaped and extremely small - no regular pattern or distribution	- irregular, uneven, jagged edge damage - damaged edges worn down with no distinct peaks	- percussion ripples extend inward one-third of width - striations diagonal to edge visible

Replicas	**Flake Scarring** Shape/Depth	**Edge Characteristics** Sharpness/Angle/Shape	**Other Characteristics** Striations, Pitting, Etc.
1	- extremely small micro-scars only visible on SEM	- very little edge damage - minor, irregular shallow chipping - small, rounded peaks	- frequent, irregular pitting - no visible striations
2	- extremely small micro-scars only visible on SEM	- roughly, rounded dull edge - no peaks	- no striations
3	- well-defined flake scars - varied from very wide and smooth to deep and narrow - multiple flake scars in one area	- very deep crevices interspersed with steep fracture peaks - shallow jagged edge fractures - sharper peaks	- damage striations
4	- tiny, shallow irregular flake scars	- jagged edged sections with flattened peaks	- surface pitting - edge crumbling - small striations
5	- irregular, shallow flake scars	- low jagged edges - mostly rounded peaks	- deep striations
6	- regular, multiple, shallow flake scars	- jagged peaks - very deep ridges (surface uneven – SEM) - rounded edges - irregular wear	- crumbling noted