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Lithic Resources, Workshops, and Consumption in Northwestern Belize

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Lithic Resources, Workshops, and Consumption in Northwestern Belize

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Abstract

Stone tools played an important role in the everyday life of the ancient Maya. Whether for ritual or domestic uses, stone tools were required to complete everyday tasks. Access to stone resources used to make tools, including chert, likely influenced the sociopolitical relationships between communities and cities across the ancient landscape. Through various methods including field survey, lab analysis, and statistical analysis, various chert resources in Northwestern Belize are identified and analyzed in order to recognize chert procurement locations and possible tool production sites or workshops. In addition, an overall analysis of chert quality is included to form a better understanding of how chert may have moved across the landscape. These chert materials are then compared to the bifacial chert tools from the site of Xnoha. A medium sized Maya city, Xnoha, appears to have been a consumer of these nearby chert resources and provided a large sample of bifaces dating to the Late Preclassic through the Classic periods. While this research is just a beginning for chert sourcing in Northwestern Belize, it identifies important resource locations across the landscape, provides information on the quality and makeup of the stone in this region, and points this topic towards methods of analysis that may increase our knowledge in the future.

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Chapter 1: Research Goals

The goal of this research is to understand the use of stone bifaces at the site of Xnoha. The research will proceed along three lines: (1) by providing a general description of the naturally occurring chert resources in the area to provide context for procurement; (2) an intra-site analysis of bifaces at Xnoha to examine the possibility of morphological standardization, and to make observations about chert material usage, (3) to assess the likelihood that the site of Xnoha was using local chert materials sourced from the identified and sampled locations. The following sections further elaborate on these themes.

In order to shed light on the availability or presence of chert resources across the landscape in relation to the site of Xnoha, multiple procedures seemed necessary. First, by collecting GPS coordinates at each resource location (any location which raw chert materials were present, whether utilized or non-utilized) included in this study and displaying these locations on the map, a better grasp on the spatial relationship of these resource to the site of Xnoha is gained. In addition, by describing the characteristics including visual difference and quality of material, a better understanding of the chert present at these locations is gained.
The ease of accessibility to chert resources for Xnoha likely played a role in establishing interdependent relationships between communities which could have been based on trade of goods, specifically those made of chert accessible by those individuals who lived and worked in or near Xnoha. Also, strong links between chert resource locations and how those resources were distributed throughout residential sites, eventually taking the shape of tools recovered at archaeological sites, have not yet been made in this region. The present belief is that the wide variation found within each chert deposit greatly inhibits an individual researcher from making

clear cut links between chert deposits, tool production locations, and consumed tools within archaeological contexts. This research should allow a more definitive statement to be made concerning this issue.

At the Maya site of Colha, workshops are identified by the presence of either isolated mounds, or sheet like deposits of chipped chert waste from the production of formal tools (Hester and Shafer 1983). This "workshop debris includes almost exclusively flaking debitage, discarded implements broken during the course of manufacture, or exhausted manufacturing tools," very little household debris such as ceramics are included in these deposits (Hester and Shafer 1983:523). In general, high volumes of debitage hint at a workshop locations (Barrett 2004). By striving to locate possible workshops based on standards from Colha and understanding how possible lithic workshops in this region interacted with local polities, it is hoped that a better understanding about how chert tool production and distribution in this region of Belize functioned will be gained. It is possible that links may exist between raw material attributes from chert resource locations mentioned above, to the workshops which produced tools out of stone from these locations, and the actual tools found at Xnoha. Establishing such links will provide a direct connection from raw material procurement through production, to use and discard, allowing for the documentation of the flow of this resource through the Mayan community centered at Xnoha. This information can then be compared to the site of Colha, which is currently the best-known example of large-scale production and distribution of chert tools in Northern Belize.

It is hoped that statistically analyzing all bifacial tools collected through excavations at various intra-site locations within the site of Xnoha will provide information that either supports or refutes the standardized production and distribution of common tools via craft specialization. These indicators may present themselves in the form of standardized tool dimensions. Analyzing standard metric attributes could also indicate patterns of use and damage, rather than craft specialization that account for any consistencies in shape. In this case, links between workshops and chert resources could still potentially be based purely upon strong correlates between material types and resource areas and workshops. If no associations can be made based upon material or metric variables, perhaps Xnoha was not the benefactor of distributed tools from nearby workshops, nor were they using the chert deposits addressed in this research.

The following chapters will include a summary of what we know about prehistoric northwestern Belize and the Maya that resided there, along with details about this region in Belize today. A detailed summary of previous chert-based studies in northwestern Belize will be followed by a description of the geological landscape and the general characteristics of chert in this region. A description of the methodology used to conduct this research is included prior to describing the locations of chert resources and possible workshops across the landscape and their characteristics. From there, an analysis of bifacial tools from the site of Xnoha will familiarize the reader with the overall sample size and summary statistics before revealing the patterns exposed during statistical and visual analysis. Finally, a discussion of these results and the conclusions that can be drawn from them is provided at the end. Three multi-paged charts are provided in the appendix for a comparison of colors and inclusions across resource locations and within the bifacial tool sample from Xnoha.

Chapter 2: Background Information

The Blue Creek Archaeological Project sponsored by the Maya Research Program (MRP) was established in 1992 and is a non-profit corporation that sponsors ethnographic and archaeological research in Middle America. In the summer of 2017, MRP began its 26th consecutive field season of excavations at archaeological sites in Northwestern Belize, Central America (Guderjan and Hanratty 2014). While the general size of Belize is small compared to other surrounding countries, it makes up a portion of the Yucatan Peninsula and is located within the Maya Lowlands cultural area (Hammond 2009:21). Today MRP continues to host a variety of researchers and students to participate in archaeological excavation in order to further our understanding of the ancient and modern landscape in this region.

Prehistoric Northwestern Belize

Figure 1: Major sites of relevance in northern Belize.

Via Dr. Guderjan's excavations at the site of Blue Creek (Figure 1), a date of 800-350 BC, or the Early Middle Preclassic time period appears to be the earliest cultural remains known at this time. This site is currently the most extensively studied site in MRP's research area and is generally used as a standard comparison for this region's archaeological research. The site of Blue Creek, situated in an assumedly prime location due to its close proximity to the Rio Hondo River (Figure 1), which extends to the eastern coastline of Belize, into the Caribbean Sea, would have provided a route greatly enabling trade possibilities to far distances.

While prehistoric peoples in this region survived by hunting and gathering, over time they manipulated their landscape in order to create an environment that would be highly productive agriculturally. Remnant ditched field agriculture litters this region and can be seen in aerial photos (Figure 2). It appears that agricultural exports became a great asset to this region throughout time.

Figure 2: Example of remnants of ancient ditched field style agriculture in northwestern Belize (Guderjan and Krause 2010:132).

As mentioned above, the Early Middle Preclassic time period is the earliest known datable materials located at the site of Blue Creek, located just above the escarpment in our work region. These dates are largely agreed upon based on strong ceramic seriation techniques developed for the region. As for the site of Xnoha (Figure 1), which my bifacial tool samples were taken from, currently the earliest date we have is the Late Preclassic. While massive efforts are still underway to understand this vast archaeological site, only two structures that have been excavated to date represent these earliest dates (Late Preclassic) at Xnoha; Structure 100, and the structures 79 and 80 patio group.

To provide a wider spread understanding of the ancient occupation of the Maya people, the following is a summary based upon Michael D. Coe's (2005) book, "*The Maya.*" The span of the Maya people's occupation across Central America has been split into regional domains: southern, central, and northern environments generally contrast each other via general cultural and geographical definitions. Some of the earliest occupations by people we consider to be of the "hunter-gatherer" period stem back to 13,000 years ago in some regions. As in other archaeological areas, this period is followed by an "Archaic" period where simple farmers, hunters, and horticulturists occupy the landscape. During this time, people begin to expand upon forest clearing for the cultivation of maize and manioc. These patches of tropical forest would present agriculturists with good soils via slash and burn techniques achieved with the lack of metals, by stone tools and other wood digging implements. These time periods or cultural ways of earlier life in this region are less known about due to the general lack of evidence found from these times. But eventually these people span into the "Preclassic or Formative" time period from 2,000 BC to AD 250. By this time, it is believed that small villages forming well established farming protocols provide for the conditions under which more intensive settlement can begin with increasing populations. During this time, wetter conditions were also influential in establishing farming abilities in some regions. These circumstances allowed for the coming of cities with denser occupation with more highly organized societies, pyramids and larger architecture than present before, stone monuments, and even murals within these built environments. Early versions of the elaborate Maya calendar, script on stone, and the vaulted architecture of the Maya may have begun during this time in some regions. The accomplishments of the Preclassic Maya lead way to the even greater accomplishments of the Classic Maya between AD 250 and 900. Stone monuments and pyramids were erected, with some dated via the long count system. Large villages or cities occupied year-round, with dominant powers ruled over even larger regions, or at least controlled regions by some sort of political systems based upon trade or other cultural and influential factors. More complex pottery, ceramic figurines, and true cooking vessels are well represented. Perhaps dryer conditions had a great impact upon people highly dependent on agriculture. In AD 585 a major dry event occurred which has been termed “the Great Hiatus” which is attached to some stela defacing and abandonment of settlement locations (Coe 2005). By the end of the classic period abandonment had begun to occur across most of the Maya lands, though not everywhere. During the Postclassic period (900-1542 AD) cities such as Coba, Lamanai, and Tayasal experienced growth and continued occupation. In some cases, like at Lamanai located on the New River (Figure 1) in Belize, occupation would continue through Spanish arrival and well into the Colonial era. Remnants of these interactions, such as language, religious practices, and Spanish architecture, can be seen across the Maya world

For more than a millennium, changes in settlement styles, environmental changes, and various construction periods existing across their vast territories coincided with shifts in political economies existing at various notable sites (Guderjan 2005). Key factors such as the ability for people to produce "exotic" goods at certain locations with greater abilities to distribute these goods allowed for expansion of trade, political relationships, and power. Playing a huge role in trade and social dynamics is the location of sites with access to the New River (Figure 1) and the Rio Hondo River, which both flow into the Chetumal Bay. This is the largest bay system on the Caribbean side of the Yucatan Peninsula, and Chetumal Bay and associated sites played a huge role in providing access to trade goods into the Petén region (Guderjan 2005).

Shifts in the rise and fall of political economies have been identified via construction times and styles, ceramic types, and the presence and absence of certain exotic goods throughout the Central Petén region to the coast of Belize, and eventually up to Central Mexico (Guderjan 2005). During the Preclassic, the sites of Santa Rita and Cerros (Figure 1) existed as nucleated villages (Carr 1985; Cliff 1982; Garber 1989; Lewenstein 1987; Robertson and Friedel 1986; Scarborough 1991; Schele and Fridel 1990; Walker 1990), quickly rising to dominant roles in trade due to their locations within Corazol Bay. Five large pyramids built quickly during this Preclassic at Cerros suggest close relationships with sites in the Peten and a rapid change from a nucleated village to an impressive ceremonial center (Freidel 1986). A set of masks on one of the buildings are closely resembling imagery at sites such as El Mirador and Uaxactun (Reese-Taylor and Walker 2002). Ceramic remains also link El Mirador and Uaxactun to Cerros (Reese-Taylor and Walker 2002). An increase in Maya urbanism is linked to this area, stemming from a site called Nakbe in the Mirador basin in this Central Peten region. When Nakbe was abandoned, the populations moved across the basin to El Mirador where,

> all the elements of Late Preclassic urbanism, architecture, and complexity come into play. From the Central Peten, these ideas spread rapidly across the Maya lowlands. Consequently, we see the origins of many of the region's ruling lineages in this time. (Guderjan 2005:189)

In the Early Classic, whether due to local climate changes and the rise of sea waters, or geopolitical factors, Cerros saw a large decline in population (Reese-Taylor and Walker 2002, 2001; Reese-Taylor, Walker, and Mitchum 1996; Walker 1990) allowing for Santa Rita and other northern sites within Chetumal Bay, such as Oxtankah, to rise. Both sites are Early Classic administrative sites on the bay shore, with larger populations and increased economic activities (Guderjan 2004). Likely associated with its location midway between the mouths of the Rio Hondo and New River, Santa Rita built larger monumental architecture and imported ceramics related to its central Peten allies, likely the site of Tikal, indicating its importance in the political climate of the times. Oxtankah (de Vega Nova 1995, 1996; de Vega Nova, Rosas Sanchez, and Ontiveros Ortiz 2000) also constructed monumental architecture linking its styles and influences to Blue Creek, indicating interactions with the inland areas located at the terminus of the Rio Hondo region (Guderjan 2004). Tikal style vessels reached the sites of Blue Creek (Guderjan 1988) and Dos Hombres (Durst 1998) just southwest of Blue Creek.

During the Late Classic, Tikal had lost power due to war with Calakmul and its allies. In addition, Tikal's central Mexico allies at Teotihuacan had also fallen which appears to lead to a disbursement of power throughout the Peten. Without the ability to rely on Tikal and its associated settlements as economic partners, the sites of Santa Rita and Oxtankah saw decrease in trade dominance and populations. This resulted in the dispersal of people and settlements on the bay, with the emergence of other sites such as Calderitas and Tamalcab (de Vega Nova 1995; Sanders 1960) on the northern portion of the bay, and Sarteneja on the south end of the bay (Boxt, 2005). An increase of monumental architecture construction at these locations and the increased presence of numerous other smaller centers in Chetumal Bay also indicate that powers had dispersed in the Late Classic. With dispersal of power along the bay, trade posts at sites on Ambergris Caye enlarged in the Late Classic (Guderjan 1988, 1998; Guderjan and Garber 1995) and significant construction was undertaken at some sites such as San Juan (Guderjan 1988, 1998; Guderjan and Garber 1995) and Marco Gonzalez (Graham and Pendergast 1989; Stemp & Graham, 2006). While these sites, again, never rose to be as dominant as Santa Rita, it is evident that the elites in these areas continued to build architecture, import ceramics and carry out practices largely linked in style and influence to their inland allies. While no single site stood out among others as a prominent influence, the distribution of costal goods including salt, textiles, and food items continued to be distributed (Guderjan 2004). Another indicator of these continuous relationships is the shift in procurement. For those in settlements located in northern Belize, obsidian had gone from an elite good to a household item everyone could obtain by the Late Classic (Guderjan 2004).

By the Postclassic period, dynamics were changing in the Maya lowlands and within the Chetumal Bay area. Most southern Maya lowland kingdoms had collapsed, and populations drastically decreased. In the northern lowlands, large centers such as Chichen Itza had formed new strong economic relationships with allies in central Mexico. Large populations at Chichen

Itza allowed for a new form of trade control along the Caribbean coast, causing expansion and development at Cozumel (Andrews and Robles Castellanos 1985; Sabloff 1977; Sabloff and Rathje 1975). Consequently, most of the smaller trade sites in Chetumal Bay and specifically on Ambergris Caye were abandoned. One of the few survivors was the Marco Gonzalez site which continued on in Early Postclassic times (Stemp & Graham, 2006), likely due to its close relationship with the site of Lamanai on the New River, which also continued to be occupied well into Postclassic periods (Graham and Pendergast 1989). Sites such as Cerros (Walker 1990) and Santa Rita (Chase and Chase 1988) which had played a significant role in distribution of goods in the past became reoccupied, but not to any significant extent and in general, populations at most sites on the bay diminished (Guderjan 2005). These people likely retreated to more centralized locations, specifically those that were defensible. For instance, sites located on small islands on the coast of southern Belize were abandoned for islands further off coast and out of view (MacKinnon 1989). Populations also increased at Ichpaatun, a walled site midway between the mouth of the Rio Hondo and the passage to Laguana Bacalar (Gann 1926), becoming a center of authority. Here, ceramics and architecture exhibit links to San Gervasio on Cozumel (Escalona Ramos 1946; Freidel and Sabloff 1984; Sanders 1960). Trade of exotic goods would always be profitable, but without the organized political economy once controlled by kings who had a vested interest in keeping the economy strong, it appeared that the trade business became more hostile and increased the need for defensible spaces to work from (Sabloff and Rathje 1975). Not only that, but the sites which were flourishing were doing so by way of newer influences. It appears that Santa Rita was much more influenced by the Mayapan at Chichen Itza. Mixtex-Puebla style murals (Chase and Chase 1988; Gann 1926) discovered at Santa Rita hint that relationships were linked more heavily towards the north during the Late Postclassic by way of copper, turquois, and green obsidian making its way from central Mexico (Chase and Chase 1988).

This is just scratching the surface of how broad sociopolitical changes may have taken place throughout Maya times and the vast Maya region. However, it is useful in understanding how the dynamics of political influence, populations changes, power realignments, stylistic construction patterns, flow of goods, changes in traditional practices, and settlement occupations cause and affect one another in this region of study.

Northwestern Belize, Today

The region in which MRP carries out excavations is currently occupied by Mennonite farmers who arrived in this region in the 1950s. While several individuals in the current local population find archaeology interesting and something worth preserving or researching, others do not find that it aligns with their current values or politics. Generally, Mennonite farming practices are highly obtrusive, which results in the destruction of ancient Maya structures via the flattening of jungle bush and the archaeological remains within them. Sometimes these structural remains are used as road fill, other times the remains of these structures are spread across the landscape and eventually trampled by cows or covered up again by natural vegetation or agricultural crops. Occasionally these generally destructive practices are aid to archaeologists much like forest fires in the Boundary Waters Canoe Area Wilderness can be both destructive and helpful to archaeologists. Removal of thick forests can reveal archaeological remains previously unidentified due to natural conditions. But the Mennonites have not always occupied these lands. Remnants of the ancient Maya are everywhere and several non-profit organizations currently operate in this region, making efforts to study and preserve archaeological landscapes. The Program for Belize (PfB), established in 1988, focuses its attention to the Rio Bravo Conservation Management Area, a 260,000-acre conservation area with a multitude of preservation and conservation goals. The Maya Research Program's (MRP) investigations began in 1990 with initial focus on the site of Blue Creek. While working at Blue Creek and getting to know the landscape and the local Mennonite community members, Dr. Guderjan began to expand efforts in mapping Maya sites around the region. Most of the research by MRP could have been carried out without the permission and support of Mennonite landowners. Other smaller projects have existed and currently exist, throughout the landscape. For instance, professor Norman Hammond (Boston University) and his excavations at La Milpa (Hammond 1991), Mary Nievens who mapped and excavated with El Pozito project in the 1970s (Guderjan et al. 1994), or Dr. Helen Haines and her current excavations at the Ka'Kabish Archaeological Research Project (Haines 2005). The list could go on, though it often seems that one or a group of archaeologists generally locate these sites, but cannot carry out all the work and research, so over time sites get passed on to further documentation. For instance, Dr. David Pendergast visited Ka'Kabish for the first time when working at the site of Lamanai. And, Dr. Guderjan initiated a pilot project which mapped significant sites located in northwestern Belize, but then these sites were divided among a team he had formed within the PfB members. All of these research members, plus an uncountable number of people, effort, and time, over the years have contributed to the knowledge we now have about the ancient Maya in the region.

Previous Chert-based Studies in Northern Belize and Why Chert was Important to the Ancient Maya

Throughout time, the development of occupational sites has been enabled by the presence of environmental factors surrounding them. Access to natural resources like food and water clearly play an important role in establishing settlement patterns. In *Water, Stone and Soil*, Gail Hammond (2009) argues that lithic resources, such as chert also play a very important role in the daily life of humans. Tools produced from lithic materials, whether of local or exotic types, enabled the Maya people to complete a wide variety of daily activities including food processing, hunting, construction, and other ritual activities (Hammond 2009:19). Without access to stone materials, these activities would be difficult to achieve, and would not allow people optimum living circumstances or the ability to function autonomously (Hammond 2009:32). In addition, Hammond calls for the identification of "lithic outcrops near [the site], and raw materials [within the site]…" in order to "evaluate the accessibility of lithic resources for individual sites" (Hammond 2009:55). She also notes that the site of Xnoha, with its close proximity to the Dumbbell Bajo, may have "had access to the high-quality lithic resources that the bajo had to offer" (Hammond 2009:55).

Other previous work associated with the Maya Research Program concerning lithic materials was completed by Jason Barrett. His main goal was to test whether or not these types of critical resources were monopolized and managed by Maya political elites (Barrett 2008). Lithic resources were in constant demand, considered necessary to maintain a way of life which involved both practical daily utility uses along with ritual ones (Kwoka 2017:54), and were therefore considered a commodity. Chert may also be considered a non-renewable resource in that not all rock materials are suitable for tool production (Barrett 2008). This is why the quality of the chert source is so important. Further while some areas across the Belizean landscape never felt strain upon their resource consumption habits, other areas completely lacked these types of resources. For instance, the site of Colha, the focus of well-known lithic research, was located in northern Belize's major chert-bearing zone (CBZ) and therefore had access to a major source of stone for tool production (Tobey 1986). The focus of Barrett's research was at the site of Blue Creek, which seems to have been a marginal cut off of the Colha interaction sphere. Here he identified two major chert resource types, one being Colha chert, characteristically dark brown to grey, and another chert type Barrett called "unidentified" (Barrett 2004:8). Additional archaeological sites assessed by Barrett include Bedrock, Bajo Vista, La Milpa, Nohol Naj, Northern, and Sotohab (Barrett 2006:40-74). Several of these sites lay nearby the Dumbbell Bajo, "where soils retain high water content, resulting in greater erosion of bedrock limestone" (Barrett 2004:78). Such environmental circumstances allow chert and chalcedony nodules to become more accessible due to erosion or quarrying of the limestone surroundings (Barrett 2004:78). His final conclusions lead him to believe that elites did have the authority to restrict accesses to certain chert resource locations and probably held them in reserve to control production and economics (Barrett 2008). Throughout the completion of his research, he identified and conducted excavations at several chert-bearing and tool production areas within the MRP permit area and deemed the quality of the chert located in the Dumbbell Bajo, not far in distance from Xnoha and further away from Blue Creek, to be of high quality and highly workable (Barrett 2004:113). In addition, based on the quantities of debitage present in some areas, it was likely that people were producing tools for export of some kind until resources became scarce (Barrett 2006:68).

Research at Colha has been led by Thomas R. Hester and Harry J. Shafer. Colha thrived during the Late Preclassic (300 BC-AD 205) and into the Late Classic (AD 600-850) time periods. During this time period, settlement sizes and populations were increasing, and so did production at Colha's chert workshops (Hester and Shafer 1991:81). During the Late Preclassic the people who lived in this area controlled lithic production for most of northern Belize (Hester and Shafer 1989:6-14). They attained their resources from the chert-bearing zone between Colha and the archaeological site of Altun Ha. Chert tools that were produced at the site of Colha can often be identified by their distinct forms, colors, and material quality. For instance, mass-produced, small-stemmed blade points are one of these forms. Colha chert is characteristically high quality, fine-grained, banded chert with colors including brown, grey, and tan. Hester and Shafer (1991) state that outside of this northern region of Belize, chert resources were of poorer quality indicated by their color and composition.

Within Hester and Shafer's 1989 paper, distinctive characteristics of chert originating from specific locations were identified and linked to the site of Colha (Hester and Shafer 1989). By the Early and Middle Postclassic (AD 900- 1250), Colha's traditional tool forms such as the tranchet bit, stemmed macroblades are replaced by the production of side-notched, lenticular dart points, triangular bifaces, and tapered-end bifaces (Hester and Shafer 1984). While production continued, it appears to have decreased in comparison to the Classic period (Hester and Shafer 1984). Through the identification of these tool styles and chert types, lithic distribution and consumption patterns can be traced from Colha to a multitude of other sites. Cuello, Nohmul, San Estevan, Cerros, Sarteneja, Lamanai, Ambergris Caye, Hick's Caye, Moho Cay, and Wild Cane Cay, are just some of the sites Colha's lithic distribution patterns can be linked to (Hester and Shafer 1989). However, Colha’s distinctive chert type is not present in the current excavations taking place at Xnoha, nor present in mass quantities at any of the other site locations where MRP has lead excavations at (other than Blue Creek) (Guderjan, personal communication, 2014). It is thought that the Colha interaction sphere likely terminates with the site of Blue Creek on the edge of the Rio Bravo escarpment (Guderjan, personal communication, 2014). This leads to the belief that the people who resided at sites further west, which include Xnoha, and others within MRP’s permit area, relied heavily upon the local chert resources. Based on variables of procurement and manufacture proposed by Drollinger (1989) in his lithic reduction model presented in 1989, J. Dockall statistically compared bifaces from the sites of Colha and Santa Rita, Kichpanha, Pulltrouser Swamp, and Nohmul in Belize. The methodology used in this paper is the same that Drollinger applied to a sample from Operation 2024 at Colha. Drollinger created a 5-tiered classification system, which establishes the physical stages that a bifacial tool in this region goes through: procurement, production, exchange, consumption, and recycling or discarding (Dockall 1994:52). Here, bifacial flake patterning and wear is thought to not only be achieved during the procurement and initial manufacture of the biface, but also present when a tool has been used, maintained, and then discarded (Dockall 1994:53). Dockall classifies either recycling or discard as an effective end to the biface use life because in the former stage it is transformed into a different tool class and in the latter stage it enters the archaeological record. On page 56, the author provides us with a list of “correlates for craft specialization and cost minimization at Colha” which have been obtained from separate publications by Shafer (1982a) and Torrence (1986). A “high degree of consistency in the size and shape of products” (Dockall 1994:56) can be tested statistically. In addition, the expected outcome of his analysis–that used and refurbished bifaces would exhibit considerable variation, turned out to be false. Because of this, he believes that bifaces "nearing the end of their use" become statistically "normalized" (Dockall 1994:59-60). In addition, it appears that the residents did not use or retouch bifaces until a point at which they would normally be considered extremely 'exhausted' or overused. This is shown by not only the general lack of debitage evidence for retouching, but also by the state at which the bifaces were discarded. It appears that these people did not have much difficulty obtaining replacement tools (Dockall 1994:61) and therefore had the ability to discard tools without significantly re-sharpening them first.

The importance of chert stone as a resource to the Maya can be well understood through a quote from Diego de Landa, a Spanish bishop who recorded a fair amount of information about the Maya people around 1566. Diego de Landa states, "there are in Yucatan many edifices of great beauty, this being the most outstanding of all things discovered in the Indies; they are all built of stone finely ornamented, though there is not metal found in the country for this cutting" (Kwoka 2017:54). In *The Value of Things* (2017), Joshua Kwoka describes the importance of stone implements in the daily life of the Maya. Stone played several roles, whether economic, social, or cultural. Not only did chert implements contribute to every-day cultural practices, uses, and, social exchanges, but they also had exchange value that enabled economic interactions within and across communities. The author compares two distinct value systems: (a) value in use or usefulness related to quality for everyday tasks, and (b) value in worth or exchangeability and the human desire for some type of object (Kwoka 2017:3). Chert material in the form of implements or decorative objects can be valuable due to their symbolic and ritual uses, rather than just everyday uses. For example, chert objects are represented on stelae at archaeological sites, and can sometimes symbolize activities such as bloodletting and military uses (Kwoka 2017:5). And while the complex exchange and production systems taking place at the site of Colha cannot be ignored within this paper either, it is recognized as an outlier and not as a standard in relation to how chert tools were produced. "Outside of northern Belize, stone tool acquisition occurred on a smaller scale that was characterized by inter-household or local market exchange (Kwoka 2017:4)."

Perhaps one of Kwoka's (2017) most interesting sections is titled "Communities of Practice." It stems from Lave and Wenger's 1991 study on the "apprenticeship model of learning" (Kwoka 2017:6). A 'community of practice' is comprised of a group of individuals who "share a common concern or practice" (Kwoka 2017:6), and therefore they are more able to achieve community goals. According to Kwoka there are three characteristics that set a 'community of practice' apart from other types of social groups, while additionally help create the community as it comes to exist. By initially (a) sharing an interest, such as tool production or chert acquisition, and an expertise aimed at doing so, then, (b) mutual focus on a specific interest allows for social relationships resulting in a sense of community, and finally, (c) the actual practice, sharing of, and maintaining of knowledge related to the shared interest solidifies a group of people into a real community (Kwoka 2017:6). The idea of communities of practice has been studied and described by at least several other professionals, including Starzmann (2013), Wenger (1998), Herzfield (2002), and Philips (2010).

Landscape and Geology

Northwestern Belize is located on a karst landscape on the southeastern portion of the Yucatan platform (Lenè 1997:13). The eastern Petén also covers the modern states of Quintana

Roo, Campeche and Yucatan, Mexico and the Department of Peten in Guatemala. Much of the geological origins of this unique karst landscape can be associated with the late Precambrian Period, about 1 billion years ago (Lenè 1997). It is thought that the igneous and metamorphic substrates formed during that time. By the first half of the Mesozoic Era (about 65 to 245 million years ago), major alterations within the landscape occurred via a variety of erosional and depositional events that reduced this area to a fairly flat surface (Barrett 2004:75; Lenè 1997; Wilson 1980). Siltstones, sandstone, and layers of gravel were deposited over this region, causing highly oxidized "redbeds" associated with the Triassic and Jurassic geological periods (Lenè 1997:13). Through various separations and continental movements, the Yucatan Platform reached its current geological position, along with the opening of the Gulf of Mexico by the late Jurassic Period, about 200-145 million years ago (Lenè 1997:13).

During the Cretaceous period (about 140 million years ago), this landscape was covered by sea waters which resulted in the initial deposit of dolomite, limestone, and anhydrite mixed with bentonite and pyroclastics (Lenè 1997). The Yucatan Platform sat, mostly covered by shallow sea from the last half of the Cretaceous through a portion of the Cenozoic Era beginning about 65 million years ago through the present. These conditions caused the formation of a large carbonate bank and by the Paleocene and Eocene, limestones and dolomites had been distributed across the region we identify as modern-day Blue Creek in Belize. By the end of the Tertiary Period (about 1.8 million years ago), the Yucatan Platform emerged from sea waters (Lenè 1997:13), and resulted in the landscape we likely see today (Barrett 2004) (Figure 3).

The high platform littered with irregular karst sink holes and valleys has been shaped over time by erosion, fracturing, dissolution, and collapse of underlying carbonate rocks (Barrett

2004; Lenè 1997). Through these processes, chert and chalcedony deposits have had the ability to manifest from the surrounding rock in spherical and tabular forms including nodules, thin lenses, and thick beds of stone (Barrett 2004).

Barrett (2004) noted that some of the most productive deposits of chert are located on or near bajos where soils retain high water content which better enables erosion to expose the harder chert and chalcedony materials within (Barrett 2004:78). Incidentally, the majority of Maya cities and residential groups we explore for excavation and survey are located around the edge of either the Dumbbell or Alacranes Bajos. The site of Xnoha, which we are most concerned with for this research sits on a high point between the two bajos, while most of the chert sources located for this research are inside of, or near the edge of, this bajo. It would likely be profitable research to explore this region in Guatemala for lithic resources as well, especially since it is located on the same geological platform mentioned previously.

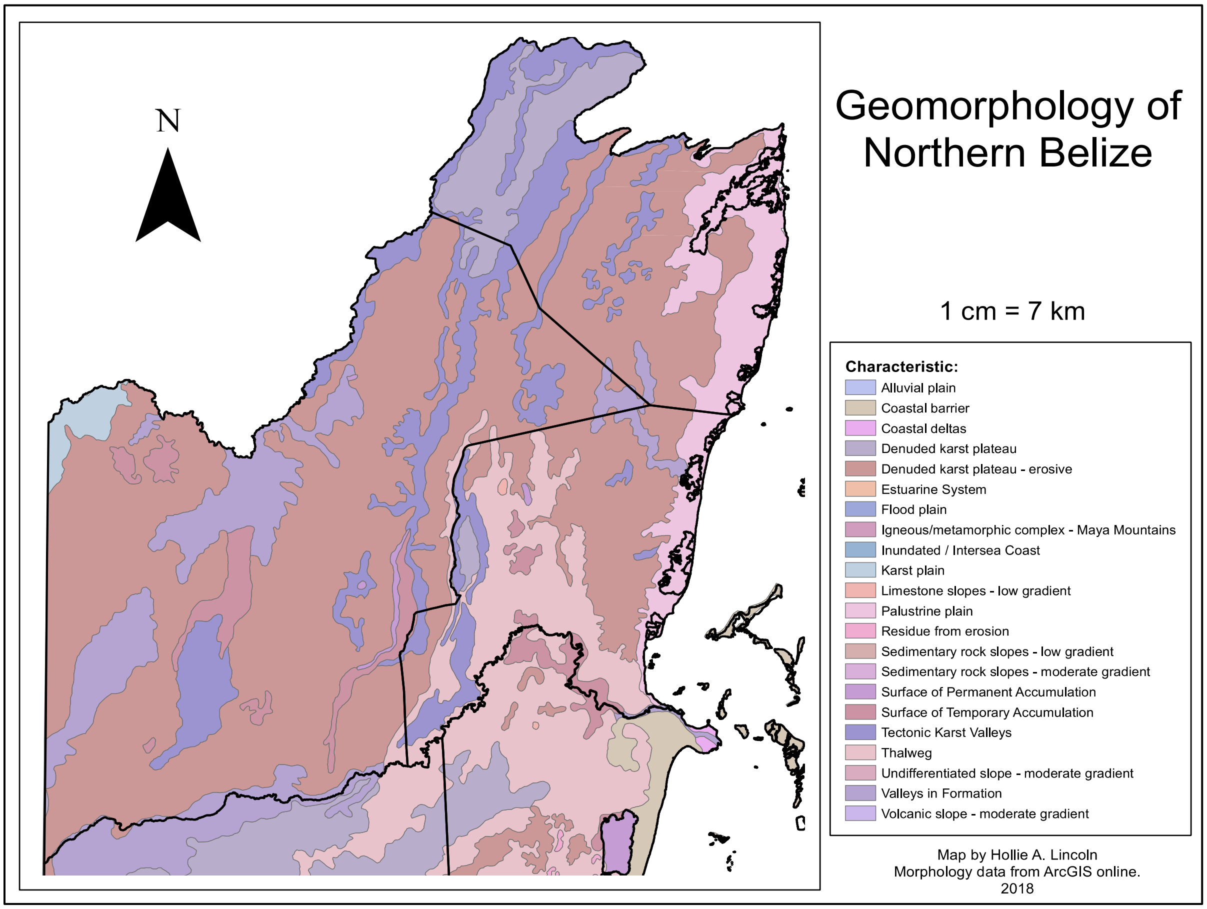

Figure 3: Geomorphology of northern Belize.

Chalcedony is included in this study not only due to the presence of stone tools with chalcedony content, but also because in general it is often present in the same geological environments as chert in this region, which can be witnessed when visiting one of the chert bearing locations mentioned later.

Barrett noted that in the Maya Lowlands, chert deposits are generally consisting of nodules that have eroded out of the parent material surrounding it, or were sometimes quarried out. In addition, he noted that chert also appears to be carried in river systems (Barrett 2004:78).

Characteristics of Chert and Chalcedony

Chert is comprised of a cryptocrystalline type of structure. And while most geologists might consider chert to be of a different nature than materials such as agate, jasper, flint, or chalcedony; all these materials are generally very similar compositionally (Odell 2003:19). For that reason, and due to the presence of chalcedony in some of the sourced locations in northern Belize, chalcedony is included in this study as a type of chert resource.

Chalcedony seems to be a bit less understood but is often found in the same environments that we find chert. This material exhibits a semi-crystalline structure and generally grows in bundles of radiating fibers. It appears fairly translucent in daylight, but sometimes exhibits some mineral impurities causing it to be colored, but not to the extent that chert is definitively colored. In fact, it was incredibly difficult to decide upon a Munsell color for a material sample that was chalcedony due to the light presence of color hues and its translucent nature. Chalcedony is also highly variable when it comes to grain size, micro and macro fossils, outcrop characteristics, and mineral impurities (Barrett 2004:78; Luedtke 1992:2).

Two different types of chert formations have been noted, including nodular, and bedded or tabular. Each type is made by different depositional events. For instance, nodular formations appear over time within limestone when calcium carbonate is replaced with infilling silica (Odell 2003:20). Tabular or bedded cherts form in sediments with high alkalinity, through accumulation. During these formation processes, it is often common to have visible shells of organisms, including diatoms, radiolarian, and sponge spicules (Odell 2003:20). Such organisms appear to be present within some of the samples in northern Belize.

While chert is a fine-grained rock (Odell 2003:19), archaeologists often discern between fine, medium, and coarse-grained cherts. These characteristics can become extremely important when considering how ancient populations were able to manipulate the stones to produce tools that functioned for various tasks in their daily lives.

Chert deposits located in the northwestern Belize research area are highly heterogeneous. In prior attempts to visually source chert at Blue Creek, the heterogeneous nature of these materials cause overlap in results and therefore still could not prove solid links between resources and tools.

Chapter 3: Xnoha and Bifacial Tool Samples

The site of Xnoha was effectively located in 1990 by Froyla Salam and Thomas Guderjan. The name Xnoha was chosen by Dr. Guderjan due to the site's close proximity to "Xnoha Creek," which eventually drains into the Rio Hondo Valley (Guderjan and Hanratty 2016:317). This site sits on top of a remnant hill of karstic materials which slopes down 40 or more meters on the southern, eastern, and western sides. The northern portion of the site sits on a precipitous cliff. Just below this cliff appears to be wetland areas. This wetland area appears to fill during the rainy season and overflows north into the Rio Hondo drainage. Xnoha, sitting on it's erosional, karstic hill also sits as the highest point between the Bajo Alacranes and the Bravo Escarpment (Guderjan and Hanratty 2016:318).

In an effort to learn more about the site of Xnoha as a whole (Figure 4), the Maya Research Program has focused its efforts in 2015, 2016, and 2017 towards the excavation of various structures within this ancient city. While minimal excavation had taken place in previous field seasons, it was never to the extent which has been completed in recent years.

The sample of bifacial tools included in this study recovered during more recent excavations were located within structures numbered 1, 3, 10, 16, 65, 77, 79, 80, 100, 102, 103, 104, and the patio surface situated adjacent to the "L" shaped group of structures 79, and 80 (Table 1). Each of these structures yielded bifacial stone tools during excavations. The following paragraphs are meant to familiarize the reader with the individual structure's locations, possible function, and general time-period which each structure was occupied (Table 1).

Table 1: Total bifaces included for analysis from each structure excavated at Xnoha, with approximate dates for the materials retrieved.

Biface Sample Totals		
Structure Number:	**Total # of Bifaces from Excavation:**	**Time Period:**
3	17	Late Preclassic- Early Classic
10	6	Preclassic
16	53	Early Classic- Late Classic
65	23	Late Classic
77	12	Late Preclassic
79	25	Late Preclassic
80	2	Late Preclassic
100	14	Late Preclassic
102	5	Early Classic- Late Classic
103	4	Early Classic- Late Classic
104	5	Terminal Classic
Patio	3	Late Preclassic

Figure 4: Map of Xnoha city center by Marc Wolf (personal communication). (Yellow circles indicate plazas and residential groups).

Structure 3 is a monumental structure in plaza A (Figure 4) with dates spanning from the Terminal Late Preclassic to Early Classic based upon ceramics found throughout architectural phases. It stands just over 8 meters tall and takes up at its base 24.231 meters by 22.326 meters on the western edge of the main plaza at Xnoha (Pastrana and McLellan 2015).

Multiple sets of stairs, construction risers, and plaster floor levels at the base of the structure and superstructure were located leading excavators to believe that at least three phases of construction occurred on this structure over time (Pastrana and McLellan 2015). Each additional construction phase added mass and height to the structure as a whole. In its functioning times, the superstructure would have had a perishable roof based upon the wall stones present (only a meter at most in width) indicating that they likely would have not been able to support a vaulted stone roof, along with the simple absence of such vaulted style stones that would have been used to create the corbel arches seen on some monumental structures (Pastrana and McLellan 2015). Two doorways were located on the superstructure of this building associated with a room (Figure 5). Each located along its eastern wall, one was located on the centerline, presumably the central door way and a second was located just to the south giving access to the associated room (Pastrana and McLellan 2015).

Figure 5: Super structure room on structure 3, with center and southern doorways.

No definitive purpose for this building has been established, though it does not appear to be residential, and likely used for more ritualistic types of activities on the western side of the main plaza at Xnoha (Pastrana and McLellan 2015:119-135).

Structure 10 is a monumental temple on the northeast side of the main plaza B (Figure 4). Its overall width is 22.04 meters long with its highest point reaching 15.97 meters above the plaza floor. In front, it has its own platform resting 9.81 meters above the main plaza floor and was initially built during the Preclassic time period based on ceramics located during excavation (Pastrana and Trowbridge 2016). Multiple phases of architecture were identified through several years of excavations at this structure. While it is thought that at least three phases have been recognized, additional excavations are necessary to solidify just how much remodeling took place on this massive structure (Pastrana and Trowbridge 2016).

Figure 6: View of structure 10 stair case.

A large concentration of ceramics, including the head of a figure, a whistle, and the remnants of possibly a whole pot, in addition to marine shell, a complete chert biface, 2 obsidian blades, a chert projectile point, and a large speleothem was located during excavations of the platform in front of this structure (Pastrana and Trowbridge 2016). What appears to be molded plaster was located next to the front stair case of this structure, which could be the remains of a mask that appears to have been covered by additional staircases built on top of the same area at a later time (Figure 6). A looter's trench on the western side of this building had exposed one layer of staircase. Upon further excavations of this area, a disarticulated and poorly preserved burial was discovered next to the stair case, likely representing at least two individuals in a secondary burial style deposit (Pastrana and Trowbridge 2016:63-81).

Structures 15 and 16, and **16A** excavated by Mead, Mastroprieto and LeMasters (2014), are located in the northwest portion of Xnoha. They consist of two parallel structures with a patio in between. Excavations prior to 2013 described the function of these structures to be a ball court. However, minimal or incomplete information about the previous excavations that took place here lead MRP to begin new excavations to shed light on the structures themselves, and remaining datable material within. Upon excavation of structure 16, another structure was located and called 16A. Currently being described as a hallway, a gap between structures 16 and 16A revealed a large ceramic deposit. Upon exposing the two rooms within 16A and the southern and western halves of structure 16, numerous special deposits consisting of mainly ceramics were located. In addition, two interior benches (Figure 7) were located. It was determined that these structures had no more than two different construction phases. Multiple re-plastering events occurred over a single construction phase of the associated platform. These structures, according to ceramics, date to the Late-Early Classic and Early-Late Classic period (Mead et al. 2014).

Figure 7: Facing north-northeast, architecture at the end of 2013 field season.

Structure 15 revealed at least three construction phases, each dating to the Early Classic Period. The high volume of ceramics located on or around these structures seemed characteristic of termination rituals, likely occurring during the Late Classic Period. Eight separate human interments were identified consisting of at least 10 individuals within these structures (Mead et al. 2014). Other notable special finds included obsidian blade fragments, chert blade fragments, one jade bead, multiple whole obsidian blades, multiple bifaces and biface fragments (Mead et al. 2014:83-83). Of these artifacts, 53 bifaces were analyzed from this excavation. In the end, it was determined that the original idea that these structures functioned as a ball court appeared to be incorrect and a new determination of a habitation area was established (Mead 2015).

Patio Group 65 was excavated by H. Plumer in 2013 and appears to have been built within the Late Classic time period and is located about 100 meters south of the 77 shrine. Multiple human interments were located within the “L” shaped patio group. Twenty-three bifaces were analyzed from this group of structures. The report on this patio group is currently unpublished, but it is apparent that these structures represent a residential group of structures (Plumer 2014).

Structure 77 excavated by Quiroz, Deschenes, and Savoie is currently being interpreted as a shrine dating to the Late Preclassic, located in the eastern residential group (Figure 4). This single mound structure is located just 200 meters east of the main plaza at Xnoha, and sits just meters away from the elite residential structures 79 and 80 (Quiroz and Deschenes 2015) and (Quiroz, Deschenes and Savoie 2016). It has been determined that the residential patio associated with 79 and 80 shares the same platform, basically connecting structure 77 with those residential features (Quiroz, Deschenes and Savoie 2016:162). This structure exhibits sloped walls, rounded corners, stylistic outsets within wall construction features, and remnants of limestone floors forming two separate platforms on the structure (Figures 8 and 9). This structure also exhibits a staircase on the east-west orientation, which suggests that the main access point to the super structure on top of this building was from the west, facing the main plaza area at Xnoha (Quiroz et al. 2016). Twelve bifaces located during excavations at structure 77 were included for analysis in this research.

Figure 8: West side of structure 77.

This staircase was intentionally covered by compacted fill and large boulders, indicating that the use of this structure may have been terminated at some point. Continuation of excavations in 2015 revealed that a series of modifications took place on this structure over time, much like “shrine” structure 100. It is thought that structure 77 exhibits Preclassic architectural styles, which is solidified by the ceramics located during excavations (Quiroz and Deschenes 2015:147-169).

Figure 9: Structure 77 facing south-east at the end of 2015 excavations (Quiroz et al. 2015).

Previous excavations carried out by the Maya Research Program at the Kin Tan Group associated with the site of Blue Creek, completed by Hanratty, liken this structure stylistically to an ancestral shrine, which may indicate this structure may have functioned for similar purposes. However, at this point no significant artifacts or human remains can wholly support this theory (Quiroz et al. 2016:181). Though it can be stated that this structure does not in any way resemble a structure which would have been used for residential purposes (Quiroz et al. 2016:181).

Structures 79 and 80 are directly connected to a large patio surface, evidentially constructed during the Late-Preclassic time period (300 BC-250 AD) and located in the eastern elite residential group (Figure 4). This architectural group is defined as an “L” shaped patio group. The patio area is elevated and bound by the two structures (79, 80), forming an “L” shape and restricting access via the structures themselves, and the elevation increase in relation to the surrounding landscape (Figures 10 and 11). The group as a whole measures about 25 by 25 meters (Parmington 2014). Both structures consist of multiple rooms in the final architectural phases, both with evidence of structural modifications over time in previous phases of construction. Within these construction phases, multiple human individuals had been placed within the chert and limestone fill beneath the limestone plaster floors (Lincoln and LeMasters, 2016).

Twenty-five bifaces from structure 79, and two from structure 80 are included in the analysis for this research. Much more excavation was completed on structure 79 yielding a much higher amount of bifaces than for structure 80.

In addition, within the patio surface, multiple tombs with ornate grave goods were excavated, along with other ritualistic deposits including a lip-to-lip cache of Sierra Red vessels. These vessel’s phytoliths indicated the presence of extracted oils, sponge spicules, palm fruits, trees, shrubs, and leaves (Parmington 2015).

Figure 10: Structure 79 at the end of 2014 field season.

Figure 11: Structure 80 at the end of 2014 field season.

This complex is located only about 200 meters east of the main plaza, supporting the view that an elite group of people lived here (Parmington 2014). Not only its close proximity to the main plaza, but the sheer size and amount of labor it would have taken to build these residential structures implies a more elite residential context.

In addition to the energetics in construction, two tomb style burials were located within the patio. Large jade beads and a complete ceramic vessel shaped as a turkey hit at the importance of these individuals and hints at an established lineage of these individuals to this residence. (Parmington 2015: 17-81). Only three bifaces from within this patio surface were analyzed and included in this research.

Structure 102 is a single room residential structure located in the western residential group (Figure 4) with a large bench located in the western end of the structure. Upon excavations into this bench, no features were located (Figure 12). However, below the bench and beneath the floor it sat upon, a crypt was located in the southeastern corner, though nothing of particular significance was located within (Austin 2016). Two cuts in the plaster floor of this structure seemed to indicate deposits of some sort of significance, only to reveal upon excavation no remnants of any special finds or burials (Austin 2016). Artifacts found during excavation include ceramic fragments, lithic fragments and two shell beads within the construction fill beneath the floor (Austin 2016).

Figure 12: Sub-floor excavation view of structure 102.

A couple of replastering events were identified during excavations, one likely occurring just after the bench was built, but no major structural modifications appear to have taken place (Austin 2016). A total of five bifaces were located during the one season of excavation at this structure and are included in this bifacial tool sample.

Structure 103 is located in the western elite residential group (Figure 4). Excavations of this structure revealed a multi-roomed structure, likely used for residential purposes (Moodie 2016). Through excavations of a "central hallway" within this structure, it appeared that this building was constructed in one phase, directly on top of bedrock (Moodie 2016).

At least two benches were located during excavations, one at the southern end, and another in the central area of this structure. One individual burial was also located within the central bench, in addition to another human burial identified within the southern bench. A multitude of special finds including chert tools, obsidian blade fragments, ceramics, and other lithic debris were found during excavations (Moodie 2016:84-140). A total of four bifaces were recovered during the one season of excavations at this structure and are included in the analyzed sample within this research.

Structures 104 and 105, also located in the western residential group (Figure 4) were both constructed directly on top of the bedrock on the northern end of the Western Group Residential area, structure 104 laying directly southwest of 105 (Van den Notelaer et al. 2016). Construction dates based upon ceramics place these structures at the Terminal Classic. A large special deposit consisting of 2,109 ceramic pieces, 245 lithic remnants, 7 chert bifaces, 3 obsidian blade fragments, 1 chert tool 1 spindle whorl, and a granite metate fragment took up the majority of excavation time on these two structures. In addition, a Colha chert spear point was located *in situ* within structure 105's room block (Van den Notelaer etl al. 2016:157-160.). Only five of the seven chert bifaces were analyzed from this excavation for this research.

Chapter 4: Methodology

Between May and August of 2014, each chert resource area and possible workshop site that Jason Barrett included in his doctoral dissertation was visited. Additional survey work was also conducted, which allowed the documentation of other chert-bearing locations not previously explored by Barrett. At most of these new locations, there was no evidence of ancient use. It is possible that some of these chert deposits were not available during ancient Maya times and have more recently eroded out into the landscape. It could also be, that some of these locations were too small and therefore had less of the qualities an individual looks for when obtaining workable chert, and that these locations simply were not desirable.

In 2015 chert samples were collected during revisits to the identified and accessible chert resource locations identified in 2014. Additionally, GPS coordinate information, area measurements, and photos with detailed notes were taken while collecting samples of the chert materials present at each location. The goal was to collect a sample of about 400 chert pieces per site. This sample size was selected in order to establish a 95% confidence interval for population proportions at each site. A pre-fabricated 1x1 meter unit built from PVC piping with 10cm corresponding holes for string to be tightly strung across functioned to divide the square meter into one-hundred squares. If the ground surface allowed, one piece of chert could be selected from each ten by 10 centimeter square. After attempting to walk the whole perimeter of what appeared to be the whole resource zone, a sketch of the size and shape of the resource area could be rendered and an attempt to randomly place the pre-made unit to select samples. The estimated perimeter, which could only be based on what could be seen of the ground surface, was documented using the tracking feature on a Garmin Dakota 20 GPS unit. A random number generating chart was used to choose where within the boundaries the unit would be placed in most instances. However, the size and/or shape of some locations occasionally posed issues when trying to implement this method. The sampling strategies at each location will be discussed.

All samples were bagged based on the unit number and location defined by GPS point. Each sample was then taken back to the lab to be analyzed. Originally outlined in the thesis proposal was for the analysis to be carried out in the field. However, it quickly became evident that weather and climate conditions did not allow. Mainly it was difficult to endure long periods of time completely exposed to the sun in open fields for a full day, especially those that had been burnt recently. Also, our field season occurs during the rainy season, which did not help much either.

Once the samples were returned to the lab, they were sorted into groupings which most resembled each other. From there, characteristics including fossils, banding, mottling, speckles, veins, or vugs were documented as present or absent. A vug is a small cavity within stone sometimes filled with crystals of different minerals (Jackson and Bates 1984). Mottling can be recognized within stone as streaks or blotches of different colors or shades dispersed throughout the main color of the stone (Fletcher and Veneman 2018), while banding is indicated by alternating colors of dark and light materials approximately of the same thickness (Reeves 1966). Analysis of grain size was done visually and by feel. For instance, fine-grained chert is completely smooth and without detecting any coarse patches visually, or by feel. On the other hand, coarse-grained materials have a rough texture and the grains or the structures forming the chert can be seen visually. In the middle, medium-grained cherts are slightly coarse, yet have smaller grains than coarse chert but not as microscopic or as minimal as fine-grained materials. While this scale is not quantitative, it is internally consistent.

These distinctions play an important role when thinking about actual tool production. As explained earlier, fine-grained cherts, because of their compact microcrystalline structure, generally break in a more predictable way. This would allow the individual producing the tool to do so with more ease and greater control over the finished product. Larger grained cherts break along larger, coarser structure and therefore can be more difficult to work with. In some instances, the production of a certain type of tool, point, eccentric, or stone implement may require the chert to be of a certain quality. In some cases, though, such as in biface production, the quality of stone may not dictate the production of the tool so much, just as long as it can serve the general purpose of use. In other words, the tool's precision is not as necessary as crude functionality.

Primary and secondary coloring within the samples was documented based upon a Munsell Soil Color book. A color was considered primary when it made up 50% or more of the stone's color. If an additional color or colors were present, making up less than 50% of the stone's appearance, it was considered to be a secondary color. Most of these techniques are recommended by Odell (2003).

In addition, during the 2014 field season, time was spent analyzing all chert bifacial tools collected during 2013 excavations at Xnoha. To increase the sample size, permission was obtained to use metric attribute data on all chert bifaces from 2014 excavations at Xnoha, mainly completed by Dr. Alexander Parmington who is an archaeologist at the Wurundjeri Tribe and Land Council in Australia and staff archaeologist at the Maya Research Program.

Initially (in 2014) the documented attributes of these stone tools included length, width, thickness, portion present, color, and weight. Photos of each biface were taken for further reference. In 2015 additional excavations increased the bifacial tool sample size to the 169 included in the current study. All of the attributes listed above were collected on these newly obtained tools. In addition, other qualities such as outline shape, flake scar patterning, grain size, primary and secondary coloring, edge morphology, and inclusions were recorded. All metric measurements were obtained with a digital caliper in millimeters (mm) and a scale in grams (g).

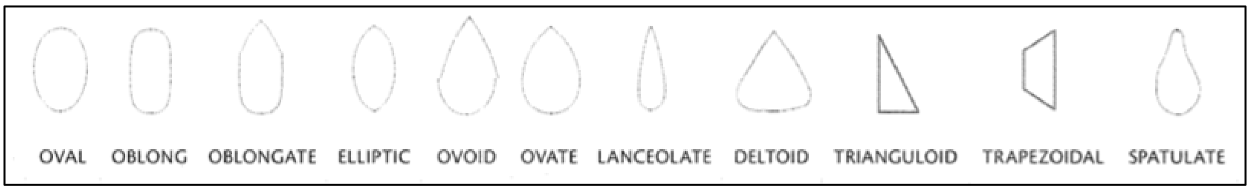

Figure 13: All bifaces were analyzed for shape based on standards defined by Muñiz. (These shapes are a combination of shapes found in the natural world along with geometrical types) (Muñiz 2014).

Standardized definitions of outline shape, flake scar patterning, and edge morphology were based on those used by Muñiz (2014). Possible outline shapes (Figure 13) include oval, oblong, oblongate, elliptic, ovoid, ovate, lanceolate, deltoid, trianguloid, trapezoidial, and spatulate (Muñiz 2014). Flake scar pattern possibilities (Figure 14) include cortex, convergent, comedial, transmedial, diagonal, longitudinal, edge retouch, outré passé, and square edge remnant (Muñiz 2014). When analyzing the edge morphology of bifaces, straight, wavy, sinuous, straight and wavy, straight and sinuous, wavy and sinuous, and irregular were the categories used to define them. Grain size was assessed visually and by feel, as described above.

Additional methodology was created in order to begin making connections between raw material sources and the bifacial tools found during excavations. By making these links we can begin to understand how chert resources across the landscape were consumed by the ancient Xnoha people. This methodology was devised post field season and completed without the artifacts present.

This analysis began with identifying which Munsell colors were only found to be present at only one location (Tables 3, 4, 5, 6). For instance, “bluish gray” is only present and Bajo Vista according to the samples. By isolating this color, only seven bifaces can be identified within the total sample of 169, as being made up of this color (Table 6). After selecting these seven bifaces, any additional colors present within the chert were noted. If these additional colors were not present at Bajo Vista, this biface was eliminated. After color characteristics were narrowed down, grain size and inclusions were focused on (Figures 35, 38, 45, and 46). If the inclusions within the biface matching Bajo vista colors also matched Bajo Vista’s inclusions, this biface would be considered a good match to this resource location.

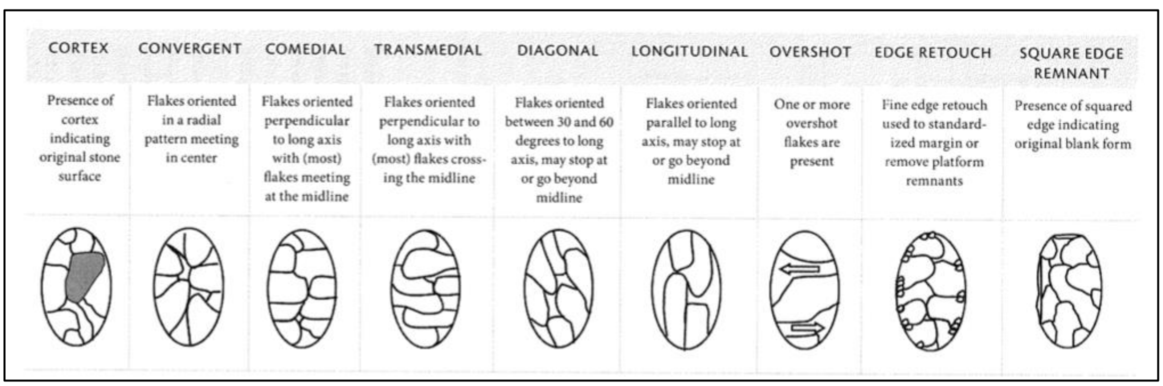

Figure 14: Flaking pattern definitions used to analyze bifaces from Xnoha.
(These definitions come from Muñiz 2014:121).

In order to identify any statistical patterns of importance, potentially hinting at standardized production within the biface sample from Xnoha, multiple steps were taken. First the decision was made to group the bifaces into three different categories based on the time periods associated with the structures they were found inside during excavation (Table 1). Therefore, bifaces dating to the Preclassic, Classic, and an intermediate period spanning between the Preclassic and Classic periods are how the batches of bifaces were compared to one another. Batches of metric attributes, including weight, length, width, and thickness were then statistically analyzed with respect to those three time periods (Table 2). Box and dot plots showing the median and midspread of data were compared to find any outliers, overlapping ranges, and to visualize the distribution of the batches. An analysis of variance (ANOVA) was used to determine if each type of metric attribute stood out in any statistically significant way. When necessary, a two-sample *t* Test was utilized in order to compare just two of the time periods, providing a better understanding of ANOVA results.

Chapter 5: Results

Chert Resource and Workshop Locations

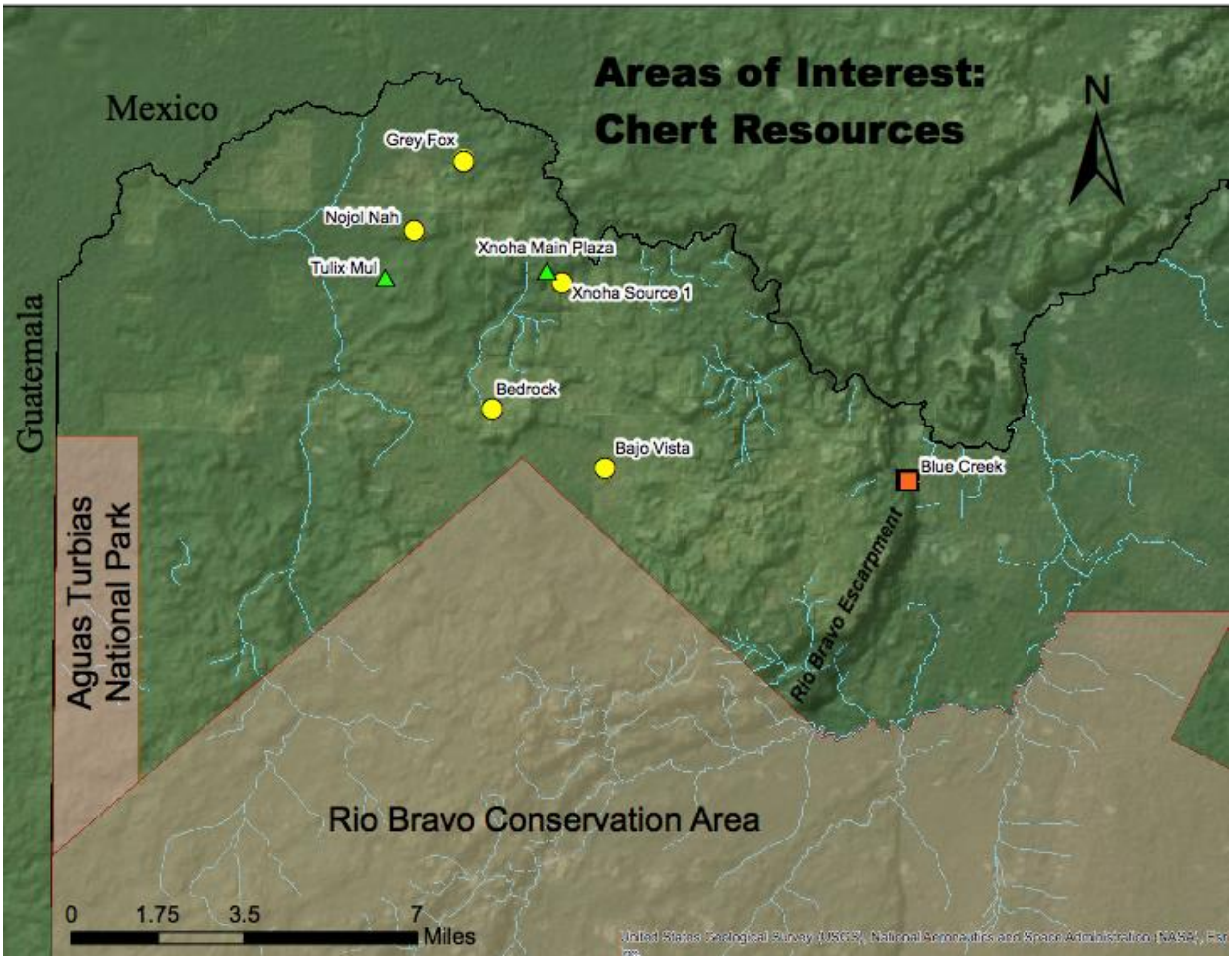

Figure 15: Map of chert resource areas assessed in this research study.

Determining whether or not one of the following locations is a lithic tool production workshop has been mainly based upon evidence Jason Barrett described in his dissertation. He states that typical characteristics of workshops include the presence of a high volume of lithic debitage. In most instances, a high percentage of this debitage will exist with the cortex still intact, hinting at the fact that raw pieces of chert were used in the beginning of tool production. In addition, production failures, or stone tools that were in the process of being completed but had something go wrong will be present (Barrett 2004). The hammer stones used to produce these tools may also be present. Several of these factors were witnessed at multiple of the following locations giving strong support to the idea that humans were in fact producing stone tools at these locations, or at least using the chert located at these locations for utilitarian uses. Other locations examined did not present all or any of the criteria for a workshop. In some instances the chert bearing location was not significant in size or quality, and therefore may not have been utilized whatsoever in ancient times. The samples retrieved from these locations can basically only serve as a resource aiding in the understanding of the chert materials present in this area.

The following sections attempt to explain each location's setting (Figure 15), the resources present, accompanied with photos of each location (Figures 16, 19, 20, 23, 26, 29, 45, and 46) and charts depicting general proportions of grain sizes, along with bar charts depicting the presence of each type of inclusion found within the samples. Both of the presence and absence charts depicting the Munsell colors present at each location can be found in the appendix of this document (Appendices A, B, C, D for Tables 3, 4, 5, 6).

Bajo Vista

Figure 16: Photos of chert resources present at Bajo Vista resource location.

The site of Bajo Vista is located in the low-lying center of the Dumbbell Bajo, which also sometimes functions as modern cattle pasture. Within this bajo, two locations nearby each other, totaling 24,544.38 square meters exhibit fine chert and chalcedony cobbles along with left behind flakes and stone tools (Figure 16). Identified by Barrett, it is easy to see why he claimed this resource procurement and potential workshop area contains the highest quality chert. He also claimed this location to be the most productive deposit of chert in relation to his research focused on the site of Blue Creek (Barrett 2004:78). Just upon initial visual inspection, this resource area contains very fine-grain cherts and chalcedony cobbles (Figure 16). This type of fine-grained, higher quality deposit (Figure 17) is not characteristic at any of the other resource procurement locations visited during this research. In addition to the high quality of this source, it also contains colors and inclusions which are not seen at other locations (Tables 3, 4, 5, and 6). Deep browns, purples, and shades of blue, along with large shell inclusions are present at this location only. At Bajo Visa, small (64 millimeters) to medium size (about 128 millimeters) chert cobbles lay on top of the ground surface, likely having eroded from within the limestone landscape all around. Complete or almost complete tools lie on the ground, along with a high volume of flakes and debitage pieces. This evidence clearly shows that production of tools to some extent took place here.

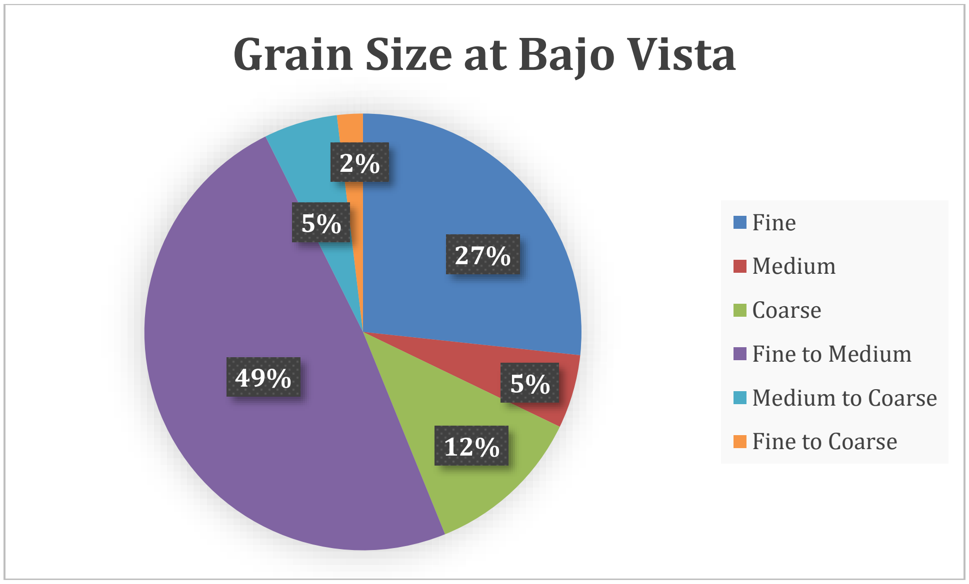

Figure 17: Pie chart of chert grain sizes by percentage, present in resource samples from Bajo Vista.

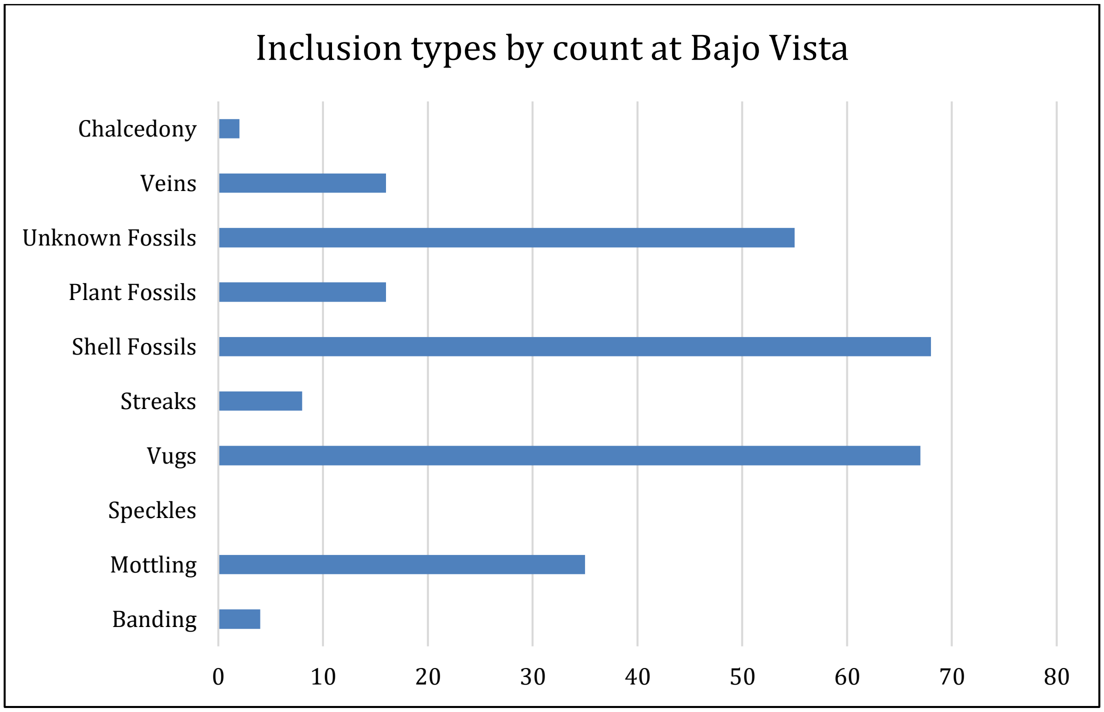

Figure 18: Graph showing visible inclusion counts within chert samples from Bajo Vista.

Of all resource locations included within this research, Bajo Vista has the highest percentage of fine-grained chert materials (Figure 17). In addition, this sample includes almost every inclusion type to some degree, excluding speckling (Figure 18).

Bedrock

Figure 19: Aerial photo of Bedrock courtesy of Kim Cox (personal communication).

Figure 20: Photos of archaeological mounds and chert resources present at Bedrock.

The site of Bedrock is massive in size (Figure 19), and so we were unable to walk a whole perimeter of this site in order to obtain complete information on the location of chert across it. Problems in obtaining the on-ground actual measurements made it difficult to obtain a truly random sample from across the site as a whole. During our survey work a 276,468.11 square meter area was walked. In addition, due to the size of the site, a sample size larger than four hundred might be more appropriate to illustrate true characteristics about the chert population located here as a whole. Less than four hundred pieces of chert were collected from this location in 2015 and the decision that Bedrock should be addressed on its own, perhaps in the future, was made by myself and Thomas Guderjan. Seasonal time constraints and my additional duties as part of the MRP team could not allow for excessive amounts of time to be spent at this site. However, from the minimal analysis completed, when considering the criteria for the presence of workshop activities to be taking place, it can be determined that the site of Bedrock in fact did take part in tool production based upon large amounts of debitage making up a possible production mound with production failures, hammer stones, and the presence of debitage with cortex remaining.

Currently this vast site functions as a pasture for several herds of cows, which also made it difficult to reach certain areas within the site perimeter. Numerous large structural mounds are easily viewable from a distance at this site. Several GPS points were taken at locations that appeared to be production mounds based on the large volume of chert debitage piled at each (Figure 20). Large (256 millimeters) to small chert cobbles (64 millimeters) are strewn about this site in many locations and appear to be eroding from the limestone rich hillside. In addition, whole tools can be easily found lying on top of the grass/soil. An aerial photo (Figure 19) obtained by Kim Cox and Jason Barrett begins to aid in understanding how large this site is.

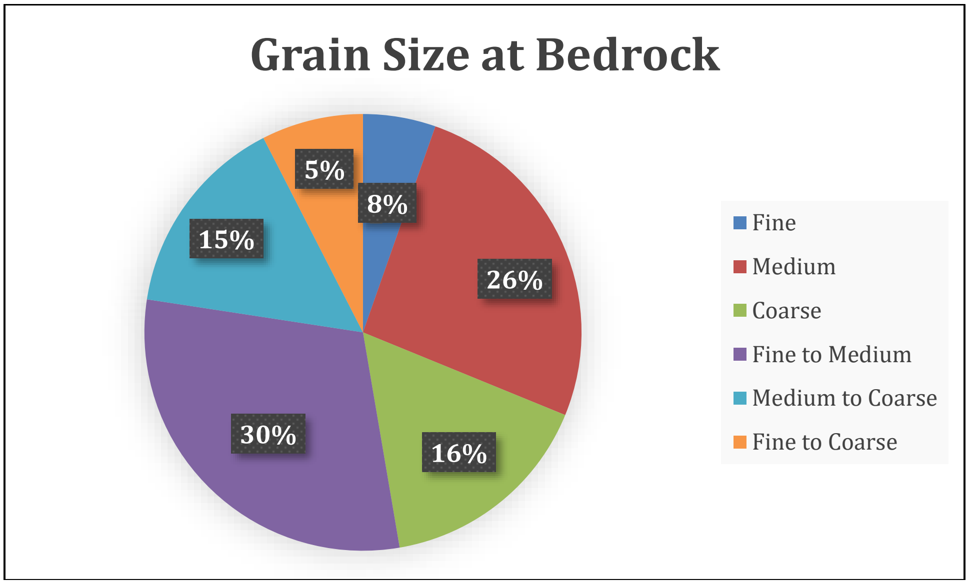

Figure 21: Pie chart showing chert grain sizes by percentage, present in resource samples from Bedrock.

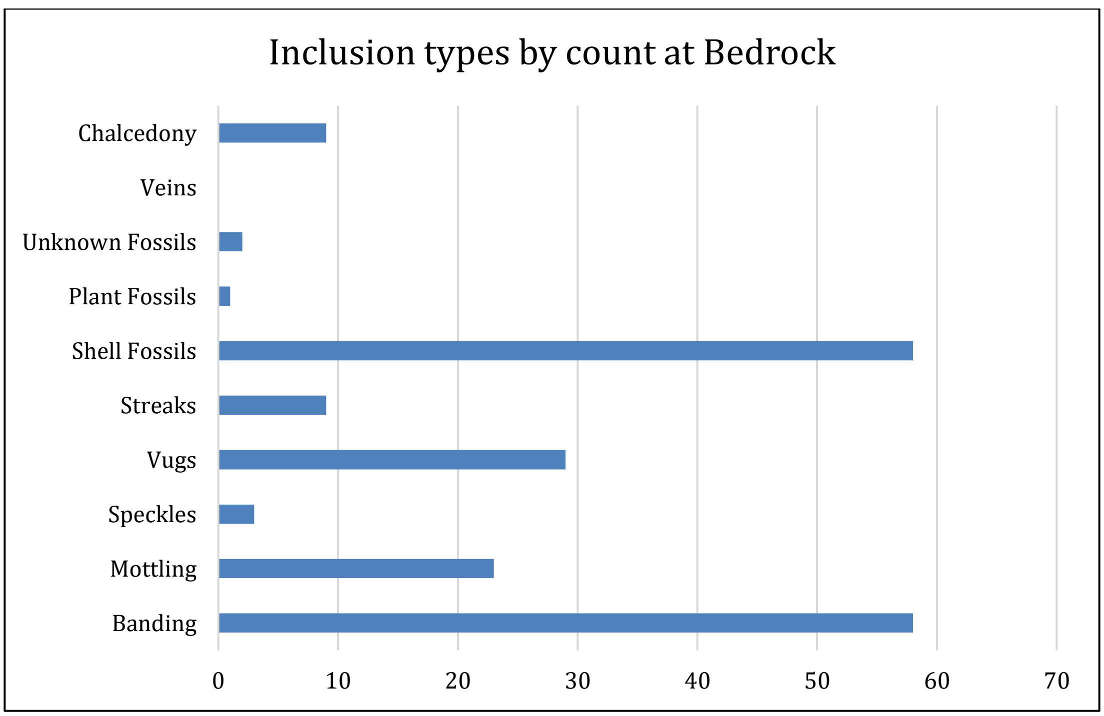

Figure 22: Graph showing visible inclusion counts within chert samples from Bedrock.

Bedrock's chert samples show a high amount of banding and again includes every type of inclusion, this time excluding veins (Figure 22). The presence of speckling appears to be unique to this location. Chert grain sizes vary much more than Bajo Vista and include a lot of mixed grain size samples (Figure 21).

Grey Fox

Figure 23: Chert resources at Grey Fox location.

The site of Grey Fox is a medium sized city center located further northwest than any of the other chert procurement zones visited (Figure 15). When first viewing this site in 2014 a small path through the jungle existed as a means to gain access to portions of this site. An exposed field for modern crop cultivation was present between the fully forested area to the north, which the main site was located within, and the dirt access road to the south. This field, consisting of fairly dark, highly silty and moist soil exhibited a plethora of smaller chert cobbles (Figure 23) and some potentially culturally modified flakes and debitage materials.

Upon returning to this location in 2015, even though the Maya Research Program had raised enough money to buy a large portion of this property, the area had been drastically modified. A massive logging road about the size of a two-lane road in the US had been cleared where the narrow forested path once was. While this demolition of forest was detrimental to the site of Grey Fox as a whole, it exposed a larger area of the ground revealing that the chert was dispersed over a larger area than originally understood, though some of this might be spread out due to the clearing activities and the possible destruction of smaller architectural structures within its path (Figure 23). In total, during survey we determined that chert resources were sparsely spread out over 53,481.9 square meters. The exposure of Grey Fox's landscape and chert materials allowed for easy set up four one by one-meter units for sample collection.

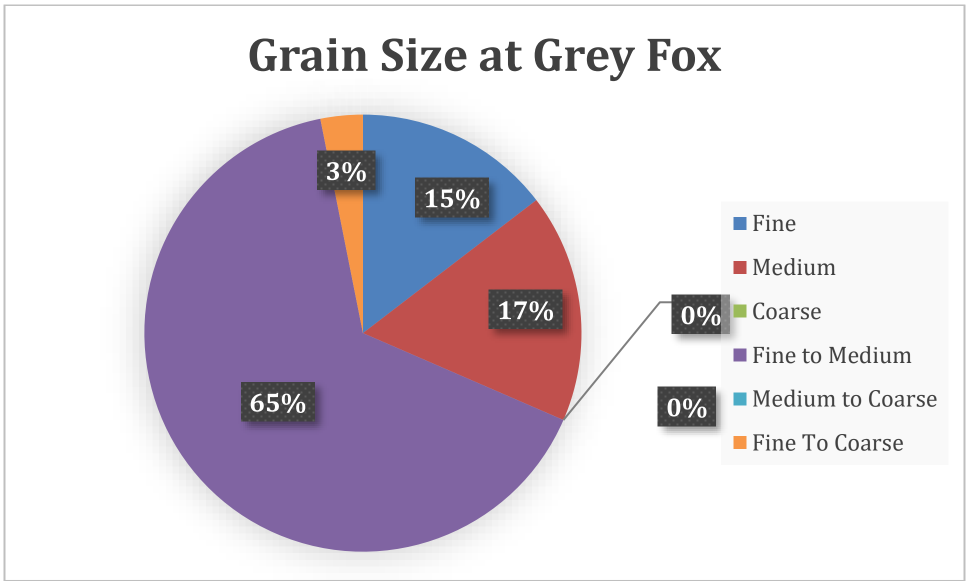

Figure 24: Pie chart showing grain sizes present in chert resource samples from Grey Fox.

Chert samples from Grey Fox include no coarse-grained materials whatsoever (Figure 24). Sixty-five percent of the sample from this location is made up of fine to medium grained chert, along with another fifteen percent of fine-grained materials (Figure 24).

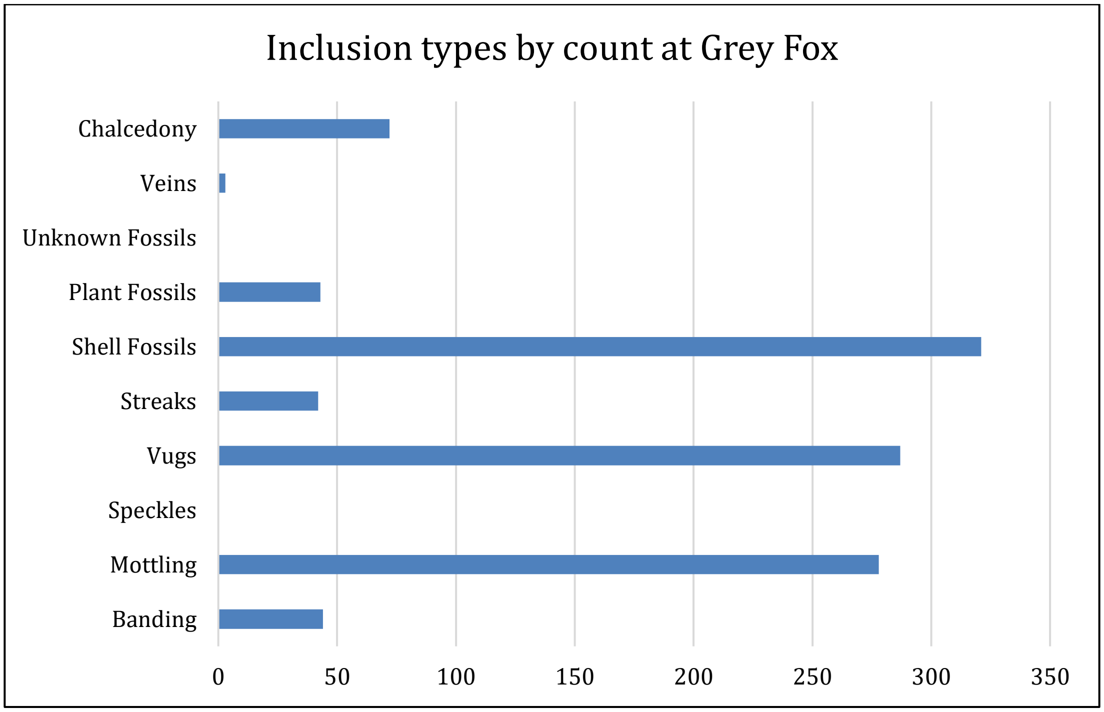

Figure 25: Graph showing visible inclusion counts within chert samples from Grey Fox.

Again, almost every inclusion is present at Grey Fox except speckling (Figure 25). The lack of "unknown fossils", possibly some type of small organism such as diatoms, radiolarian, or sponge spicules as discussed previously seem to be lacking at this location (Figure 25). This may be a unique characteristic inherent to Grey Fox.

Nojol Nah

Figure 26: Four images showing chert resources and deforestation at Nojol Nah.

In 2014 the production site of Nojol Nah was completely covered by forest and tall grasses. The only evidence obtained during that 2014 visit was the presence of chert debitage and small cobbles located along the access road into the pasture which lead us to the location where MRP had carried out excavations for several years in the past. The chert sample obtained in 2014, while not substantial in amount, may be a better representation of the quality of chert located at this location for the following reasons. In 2015, when returning to the site, a major portion of what was once covered by forest had since been bulldozed and burnt by the modern Mennonite farmers (Figure 26). These modern disturbances revealed highly evident production mounds exhibiting high volumes of lithic debitage which could not previously been seen. These debitage mounds are so far the most impressive when considering the sheer volume of these mounds. At this point it is unclear if there are chert procurement locations at or near this production location, or if the chert used to produce tools here was brought from another location. Due to the random sampling strategy, a large portion of the chert samples retrieved in 2015 appear to be burnt and probably do not represent the material population properly. These burnt materials could very well cause accuracy issues. This issue should probably be considered when attempting to visually analyze stone materials all over this region. It seems highly plausible that an excavation into these high debitage volume areas would yield useful information on the large amounts of chert being consumed here. Nonetheless, four randomly placed units defined with GPS coordinates within the 44,510.89 square meters which contained all the chert debitage mounds, displaced debris chert debitage and other chert and limestone debris possibly from now non-existent structures due to the recent slash and burn activities were sampled.

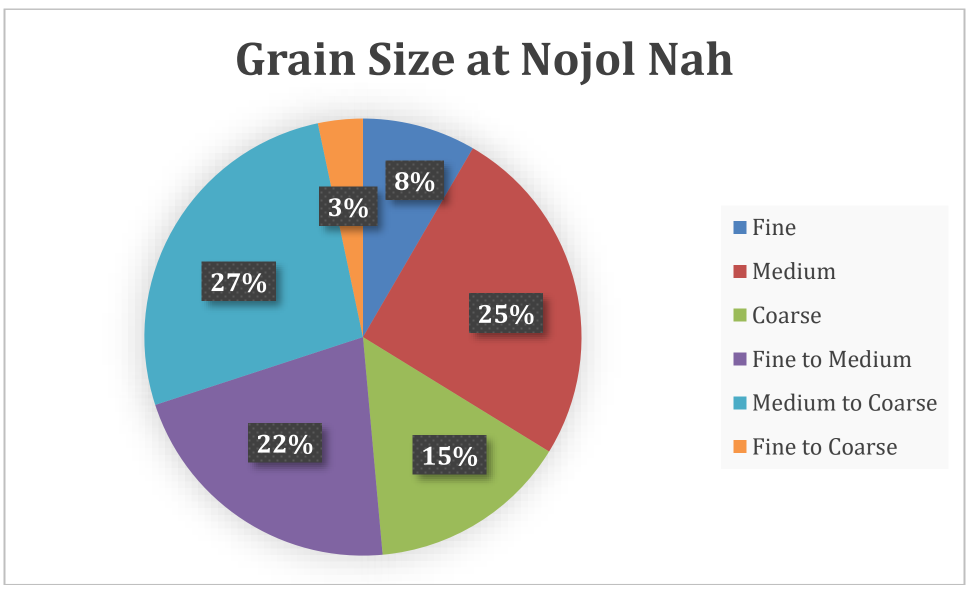

Figure 27: Pie chart showing grain sizes present within chert samples from Nojol Nah.

Nojol Nah also shows a wide variety of grain sizes along with a lot of mixed grain materials. A relatively low percent of materials are composed of purely fine grains (Figure 27). Based on the knowledge that larger scale tool production was taking place at this location, it is interesting to note that fine-grained materials, generally accepted as the desired quality of stone for flint knapping, make up only eight percent of the total sample. All inclusions except speckles are present within the Nojol Nah samples (Figure 28).

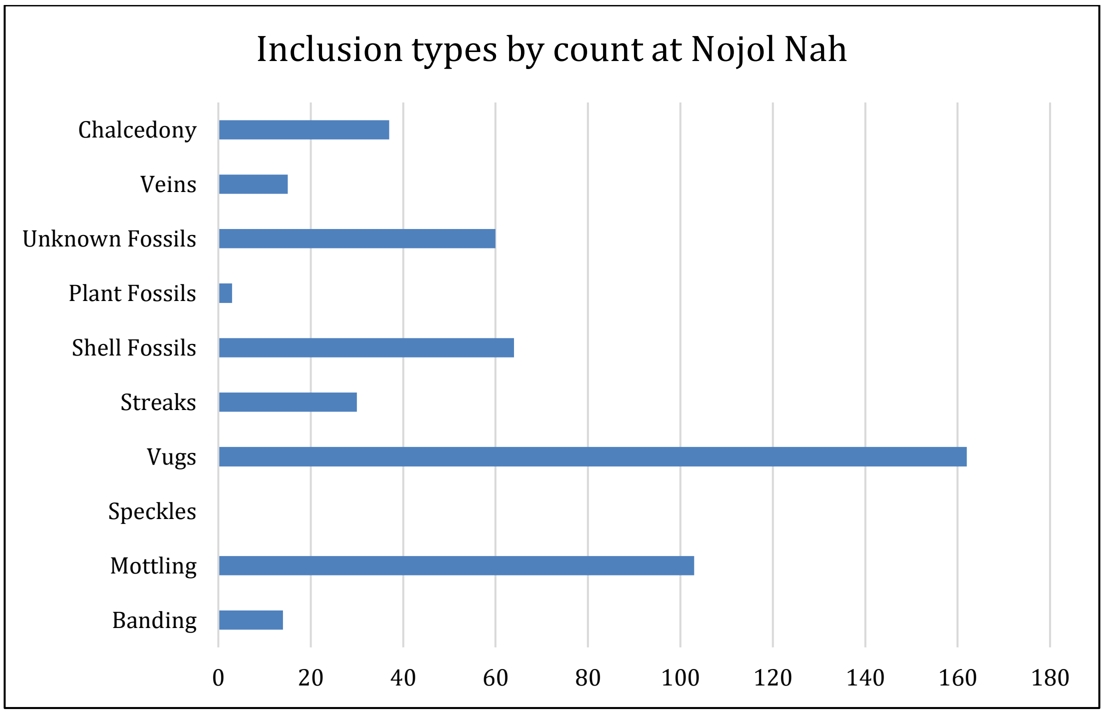

Figure 28: Graph showing visible inclusions within chert samples form Nojol Nah.

Xnoha Source 1

Figure 29: Photos of Xnoha Source 1 chert resources.

This small but potential source of chert is located very near the site core of Xnoha. It sits only about 619 meters to the southeast of the main plaza and consists of large boulder sized to small chert cobbles. This potential resource location is also located in a cattle pasture and is identifiable along a makeshift road used to access not only the large forested portion of Xnoha, but also a private property northeast of the main plaza (Figure 29).

The main difficulty with this chert bearing location was that, as it currently sits, the amount of chert present is minimal. In addition to overall size of the deposit, much of it is made up of very large boulders, 256 millimeters in diameter and greater, which for obvious reasons could not be collected. In addition, this deposit is very narrow and linear, totaling 129 meters in length and no more than five meters wide. For this location, we identified four spots, about evenly spaced along the side of the road to collect whatever pieces of chert we could find. This location does not appear to have any indicators whatsoever of stone tool production, even with its extremely close proximity to the main plaza of Xnoha, and to other structures surrounding this city-site. This continues to be considered a possible resource location due to the possibility that modern farming and road building activities could have changed or reduced the amount of chert located here, and because of its close proximity to not only the location of Xnoha's main plaza, but also a plethora of other Maya structural remnants spread all around this area. In addition, it can provide a general idea about the type of chert present here.

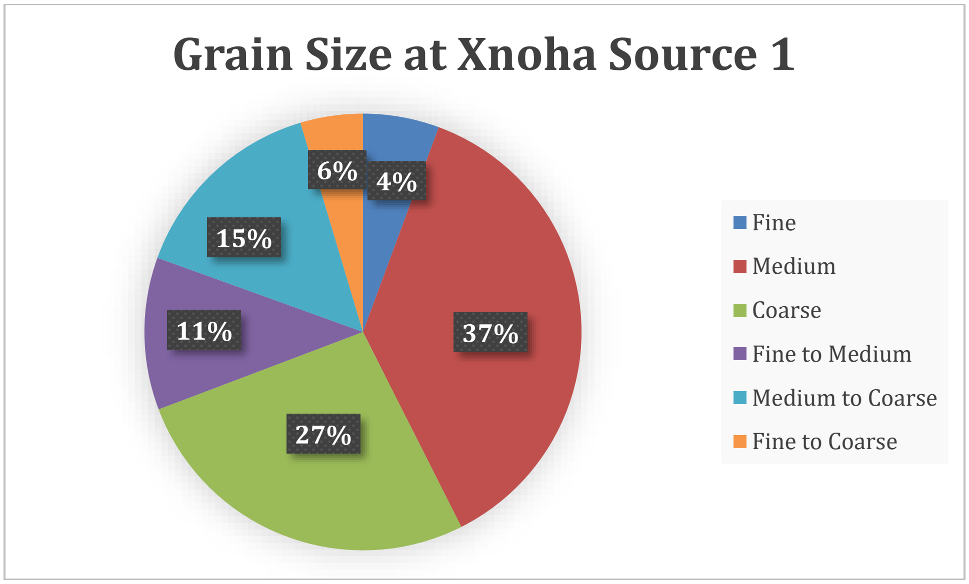

Figure 30: Pie chart showing grain sizes present in chert samples from Xnoha 1.

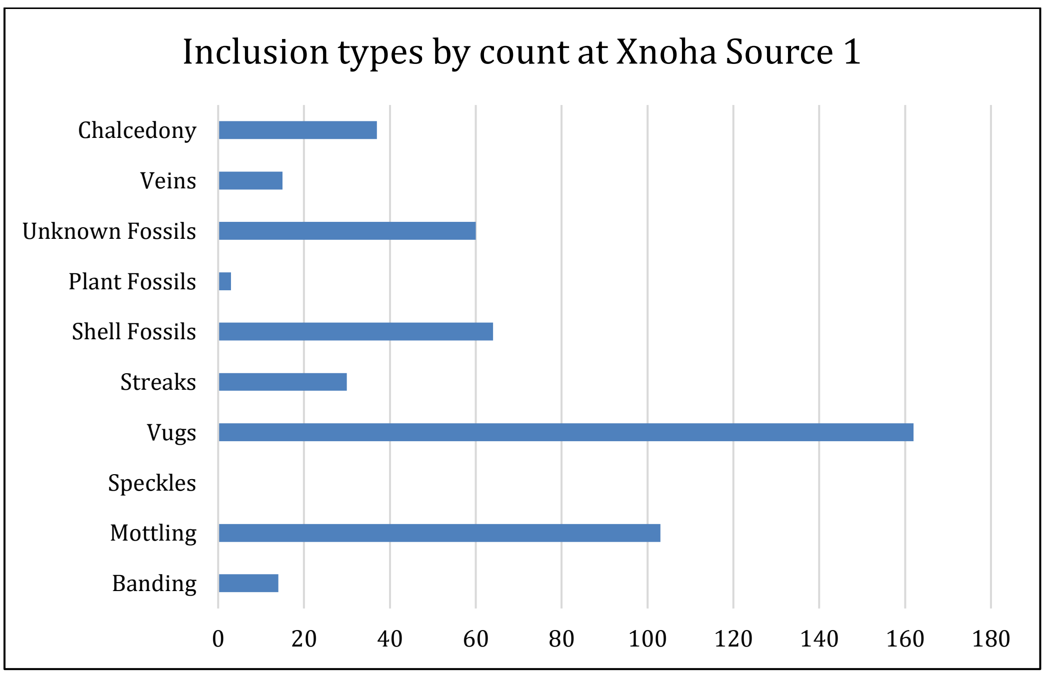

Figure 31: Graph showing visible inclusions within chert samples from Xnoha 1 resource area.

Again, all inclusion types are present at Xnoha Source 1, except speckles (Figure 31). Very little material at this small chert deposit is of fine-grained quality (Figure 30), with 37 percent of the sample falling into the "medium" category.

Patterns Exposed During Raw Material Analysis

The presence or absence of specific Munsell colors within chert and chalcedony resource zones are represented by three multi-paged figures at the end of this document. Table 3 simply documents the presence of each primary Munsell color within a piece of raw material or lithic debitage, depending on what was collected during the random sampling at each chert bearing location. Table 4 documents the presence of all secondary Munsell colors within the same types of chert pieces listed above. On numerous occasions, a piece of material may have more than one, even up to five, secondary colors present within a single piece. For that reason, a third figure (Table 5) was created, which shows the specific combinations of secondary colors present and whether or not those same combinations show up at other locations across the survey area. The decision to use "presence/absence" charts as opposed to more complex statistical methods of showing the varieties of chert at each location was intentional. Personal issues with forcing data into categories did not seem very transferable or comparable to other similar resource studies, nor specifically helpful when continuing this research topic in the future. It was also the preferred method of examining information in other studies, such as the one detailed in "*Transport Costs, Consumer Demand, and Patterns of Intraregional Exchange: A Perspective on Commodity Production and Distribution from Northern Belize"* (Santone 1997). The author states that this method is "least biased of the alternatives, and given the limitations of the data available, yet still provides significant information" (Santone 1997:75-77). The discrepancies she describes are the same that have been identified here. These issues are derived from the types of sampling strategies possible when excavating individual structures at Maya sites. In some cases the excavations are focused mainly on ceremonial structures. Regardless of the assumed purpose a structure had, available samples can easily be lacking due to excavation techniques and the complications of the structure itself based on how it was constructed, remodeled, and whether or not we have time and resources to actually get to all phases of architecture (Santone 1997). In addition to sampling bias at structures during excavation, biases are also present at the chert resource areas which were randomly sampled due to modern day farming practices, and slash and burn agriculture. Areas are often cleared and pushed around by heavy machinery, trampled by animals, and burned.

An overall theme within the raw material locations surveyed is that the site of Bajo Vista has a wider variety of colors in general, as well as color combinations. Additionally, this source exhibits the largest proportion of fine-grained chert and chalcedony materials. Other identifiers including a dark reddish plant-like inclusion appears in some of the sample pieces and can be witnessed when visiting the site. Not only does this location have a high variety of colors, it also includes colors that other locations surveyed in northern Belize simply do not have, such as bluish GLEY colors on the Munsell Soil Charts. Overall this location exhibits higher quality materials comparably.

Similar charts, as listed above, were created to understand the presence of additional features within the samples. Those variables were listed earlier in the methods section, but include whether chalcedony is present and whether or not samples exhibited traits such as vugs, speckles, veins, bands, fossils, or mottling.

After assessment of the wide variety of colors located at each location, it became apparent that most colors appear to be present at almost every, or all resource locations. Occasionally a location exhibited an individual color that was not found anywhere else, though this was rare. While this could potentially be due to sampling techniques, it could potentially aid in identifying where specific stone tools originated from. For instance, as described earlier in the methods section, it appears that the Munsell color Bluish Gray (GLEY 5/5PB) is only present at the Bajo Vista location. Dark red (10R 3/6), dark yellowish brown (10YR 4/6), dusky red (10R 3/4), grayish brown (2.5Y 5/2), strong brown (7.5YR 5/6), and very dark grayish brown (10YR 3/2) appear to all be unique to Bajo Vista. Meanwhile, Light pink (7.5R 8/2) and reddish black (10R 2.5/1) are the only two stand out colors at the site of Bedrock. Light reddish gray (2.5YR 7/1) appears to only be present at Nojol Nah. All other colors presented and documented on the provided charts appear at almost all of the resource locations currently known and documented.

Characteristics and Patterns of Bifaces

As previously mentioned, only a handful of Munsell colors are present at one resource location. In some instances, individual colors may be present at only two or more locations. It makes sense to think that a bifacial tool consisting of one or possibly more colors, which are only found at one resource location, has a greater likelihood of originating from that source. It could also be useful to narrow the possibility of a bifacial tool to only two, three, or even just four of the locations in order to rule out where it could not have come from. However, considering the nature of random sampling, the sample sizes that were obtained at each location based on various environmental and time factors, and the fact that there are many more resource locations we don’t yet know about, along with resource locations that have not been tested yet, we cannot

100% accurately make links between tool consumption and resource areas. All that being said, we can carefully consider whether specific biface tools included in these samples originated from the destinations they currently seem to match based on Munsell Soil Color Charts, as well as grain size analysis, and inclusion analysis.

Based on the elimination strategy for matching bifaces to resource areas described in the methodology section earlier, some "good matches" could be made and can be seen below. Bifaces 15-7117 (Figure 32) from structure 10, 14-7005 and 13-478 from structure 65 (Figures 33 and 34) are good matches for the Bajo Vista resource area based on the Munsell colors, bluish grey and light bluish grey, along with other stone characteristics. While this process provides some interesting results, there are not a high volume of bifaces that fall into the "rare" color and matching inclusion schemes present at any one resource zone. Colors considered to be unique to a resource location can be identifies in appendices 1, 2, 3, 4 for tables 3, 4, 5, 6.

Figure 32: Special find (SF) 15-7117. Biface from structure 10 exhibiting bluish grey (GLEY 5/5PB) Munsell color code.

Figure 33: SF 13-478, biface from structure 65 exhibiting light bluish grey Munsell color code (GLEY 8/5PB).

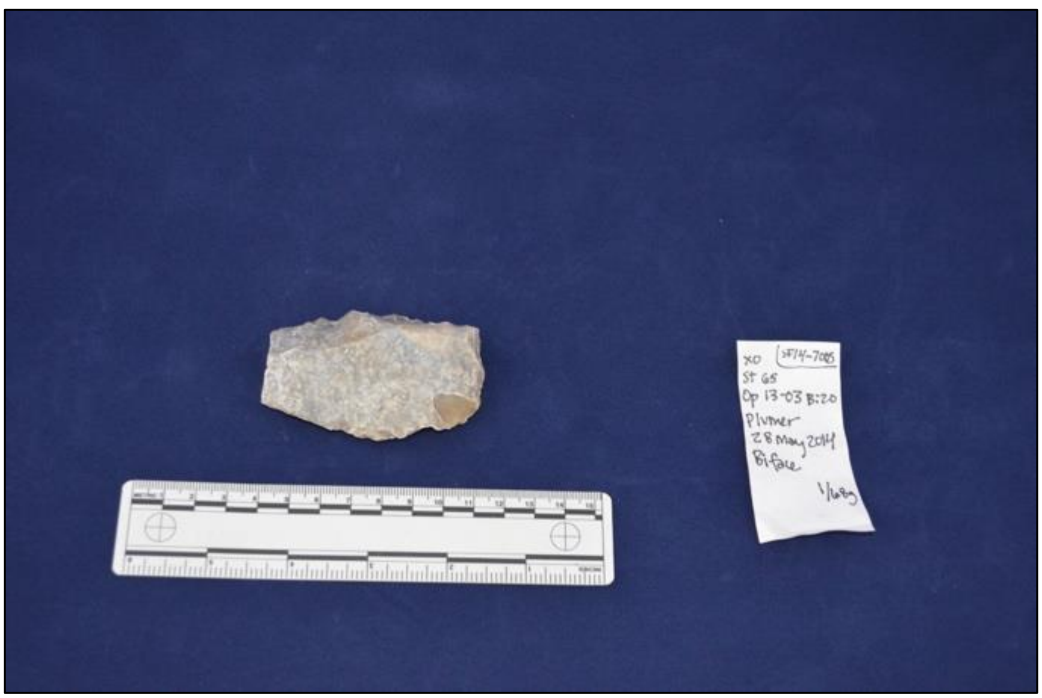

Figure 34: SF 14-7005 from structure 65, exhibiting Munsell color code GLEY 6/10B for bluish grey.

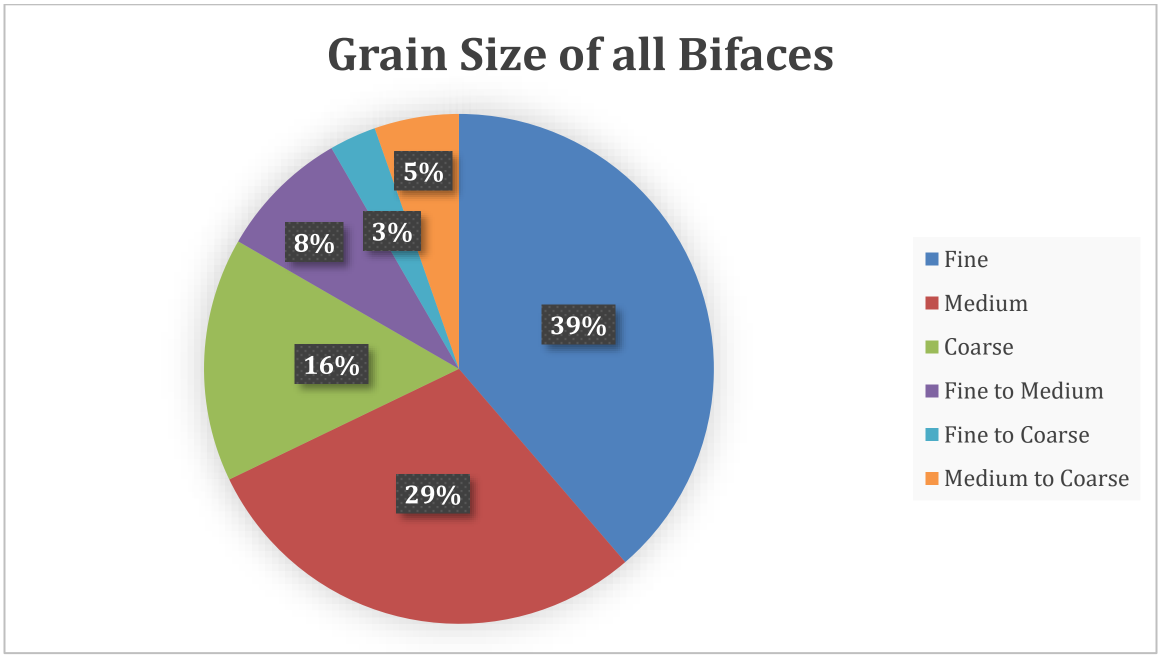

Figure 35: Chart depicting grain size of all bifaces recovered from Xnoha.

As with the raw material sources, bifaces were also analyzed for their grain size. While a fairly large amount, 39 percent, of the bifaces in this study are made of fine-grained cherts, a decent amount of bifaces are also made of medium (29 percent) and coarse (16 percent) materials (Figure 35). It seems there was definitely a preference for the good quality materials, but less quality didn't mean that tool production was not an option or possibility.

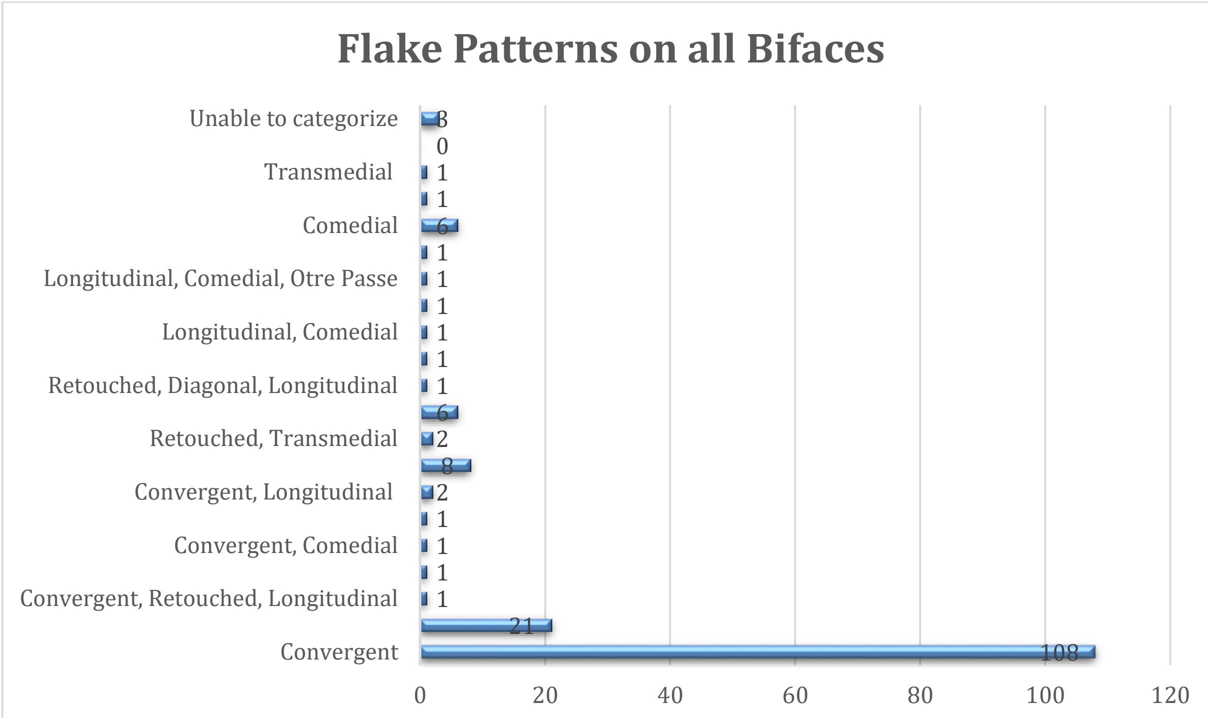

Figure 36: Total count of bifaces exhibiting each type of flaking pattern style from production (Figure 14).

Over half of the bifaces in this research, sixty-four percent or 108 total, had flake patterns considered to be convergent (Figure 36) in nature (Figure 14). This means that the final tool product which was analyzed exhibited flaking patterns which indicate that the tool-maker removed flakes from the outside inward, in a circular motion. The volume of bifaces produced using this pattern of flaking indicates that this was a favored procedure for the ancient Maya at Xnoha. It could also hint that a smaller group of individuals were producing tools that were dispersed within the site of Xnoha.

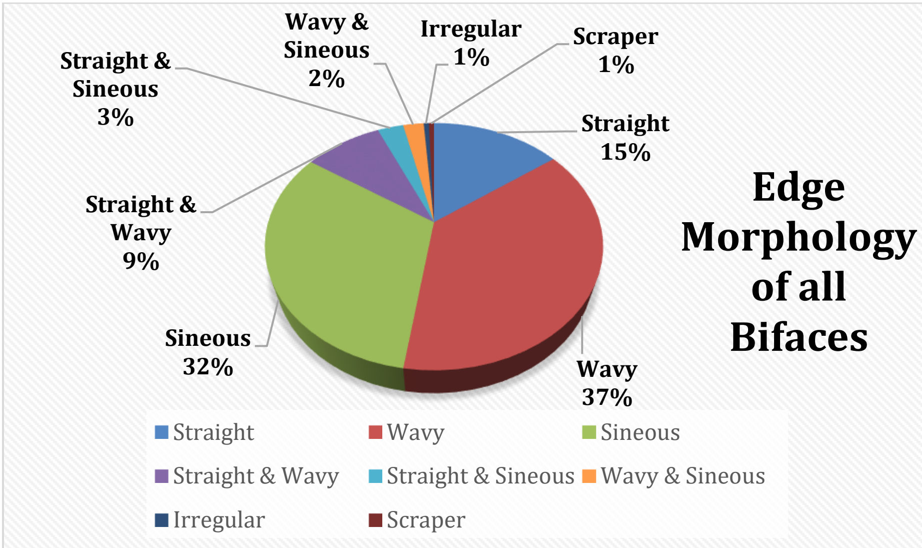

Figure 37: Percentage of bifaces exhibiting each type of edge morphology identified during analysis.

Together, wavy and sinuous make up sixty-nine percent of the edge patterns of all the bifaces analyzed from Xnoha (Figure 37). Overall, 117 of 168 bifaces make up these two categories, again pointing to a favored type of production pattern, as these edge morphologies are very similar.

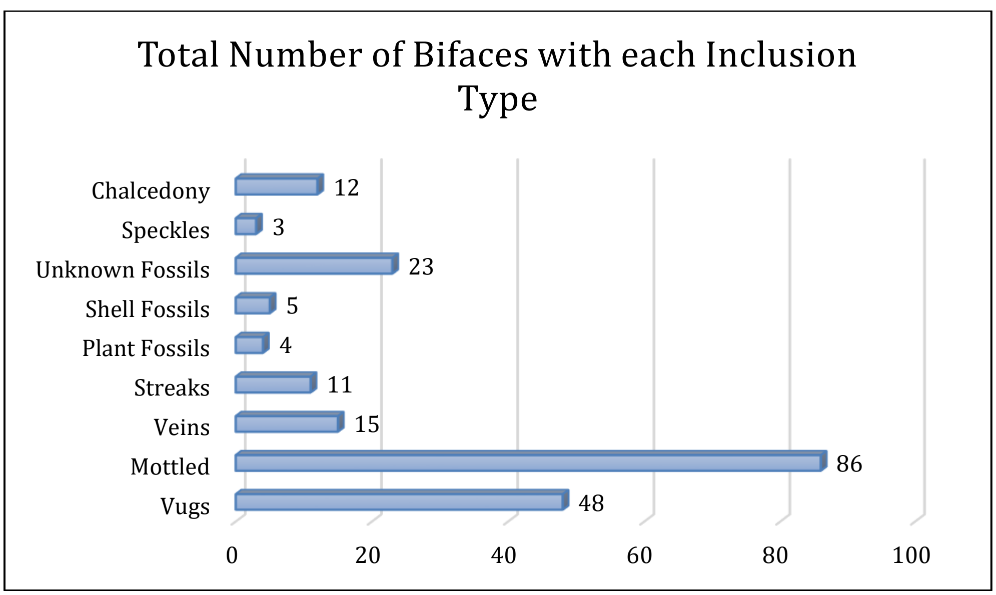

Figure 38: Total number of bifaces with each type of inclusion or feature.

A total of 51 percent of the 169 bifaces are made of mottled chert materials, while twenty-seven percent of all the bifaces in this research have vugs, many bifaces exhibit a combination of multiple inclusions or features within their chert composition. Figure 38 shows how many times each of these qualities appeared within the sample. All other inclusions within the biface materials are much more minimal. This information seems to correspond well to most of the chert resource areas. Of the total 1,491 pieces of raw chert, 685 showed mottling and 663 pieces included vugs. While some combination of fossils (shell, plant, and other unknown types) were highly present in raw materials (n = 1,018; 68.3 percent) and found at every raw material location to some extent, they are present in only a very small amount (n = 32; 18.9 percent) of bifaces. This may indicate that chert materials with fossils, especially larger ones like shell would not work well for flint knapping activities and were probably avoided.

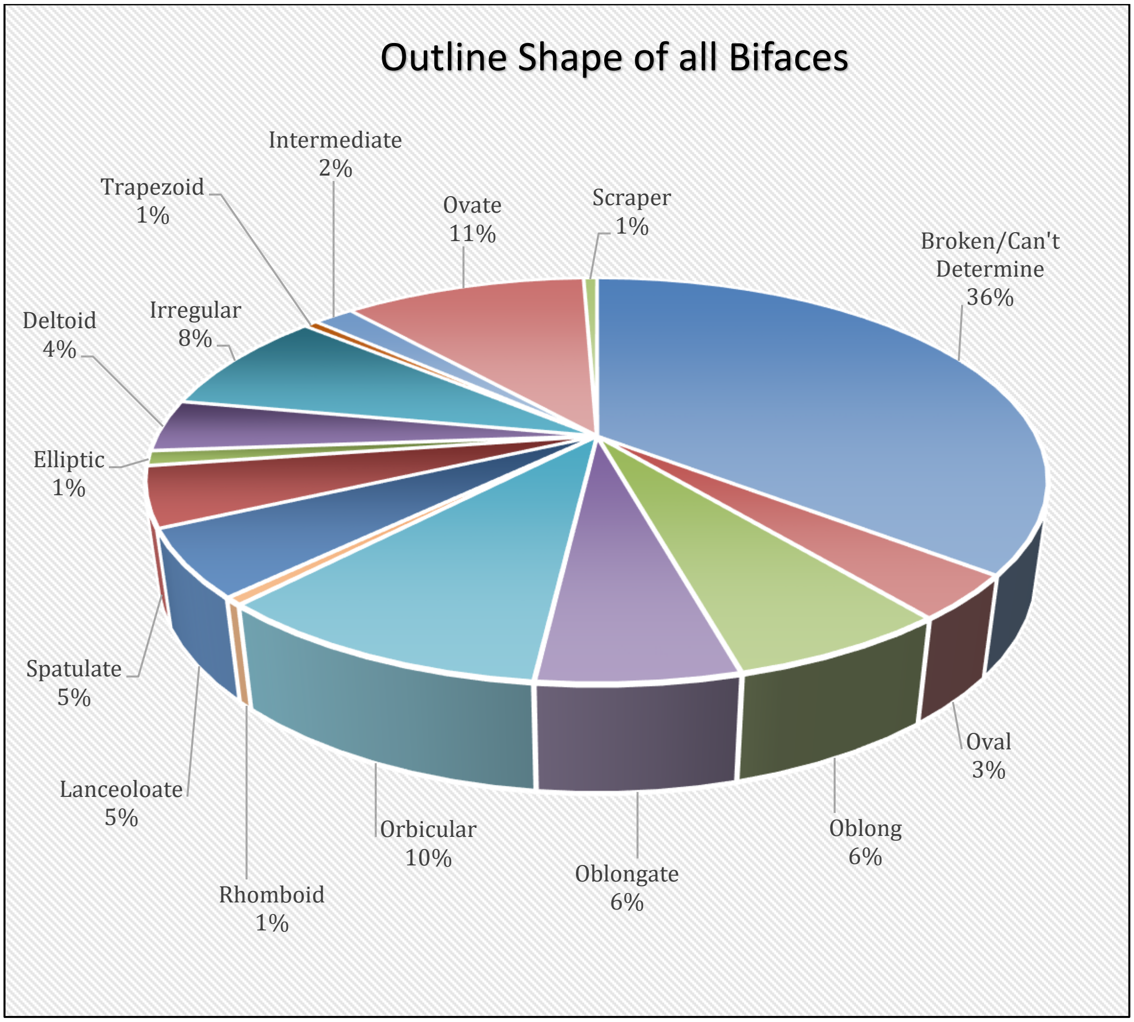

Figure 39: Outline shape of all bifaces by percentage of total sample. (See Figure 13 for descriptions.)

Overall, 36 percent of all bifaces included in this study are broken in a way that made it difficult to determine outline shape (Figure 39). On occasion the shape of a broken biface could be interpreted from the remaining portion. However, in this case, more often the 'broken biface' had been utilized again, making it difficult to determine the original shape.

Figure 40: Examples of ovate (left) and orbicular (right) bifaces from Xnoha.

All other bifaces shapes including oval, oblong, oblongate, orbicular, rhomboid, lanceolate, spatulate, elliptic, deltoid, irregular, trapezoid, intermediate, ovate, and one biface-like scraper make up anywhere from one to eleven percent of the total sample. The two most prominent shapes (Figures 39 and 40) are ovate (11 percent), and orbicular (10 percent), totaling 35 bifaces. Combined with the broken bifaces (n = 60), these make up the majority of the biface sample leaving only 73 bifaces to fall into all other shape categories.

Biface Statistical Analysis

In order to assess whether patterns pointing towards standardized production exist within the metric attribute data collected on the biface sample from Xnoha, exploratory statistics were conducted. Bifaces were separated into three groups (Tables 1 and 2) based on time periods associated with the structures they were excavated from. Preclassic, classic, and a “transitional” group including bifaces falling within the Late Preclassic to Early Classic time periods were parameters by which the bifaces have been grouped.

Table 2: Summary of batches used to conduct the following analyses in order to identify statistically significant differences within biface metric attributes. “CI” stands for confidence interval.

Summary Statistics	
Preclassic weight has a mean of 111.3 g +/- 16.2 g at 95% CI	Standard Deviation: 63.9
Preclassic length has a mean of 75.2 g +/- 5.2 g at 95% CI	Standard Deviation: 20.4
Preclassic width has a mean of 53.1 g +/- 3.2 g at 95% CI	Standard Deviation: 12.5
Preclassic thickness has a mean of 25.7 g +/- 1.8 g at 95% CI	Standard Deviation: 7.2
Transitional weight has a mean of 125.3 g +/- 60.5 g at a 95% CI	Standard Deviation: 117.6
Transitional length has a mean of 79 g +/- 15.2 g at a 95% CI	Standard Deviation: 29.6
Transitional width has a mean of 51.8 g +/- 4.7 g at a 95% CI	Standard Deviation: 9.2
Transitional thickness has a mean of 25.5 g +/- 5.0 g at a 95% CI	Standard Deviation: 9.7
Classic period weight has a mean of 142.3 g +/- 18.4 g at a 95% CI	Standard Deviation: 87.9
Classic period length has a mean of 83.9 g +/- 5.4 g at a 95% CI	Standard Deviation: 25.5
Classic period width has a mean of 56.2 g +/- 2.7 g at a 95% CI	Standard Deviation: 12.8
Classic period thickness has a mean of 28 g +/- 3.6 g at a 95% CI	Standard Deviation: 17.1

Weight Analyses

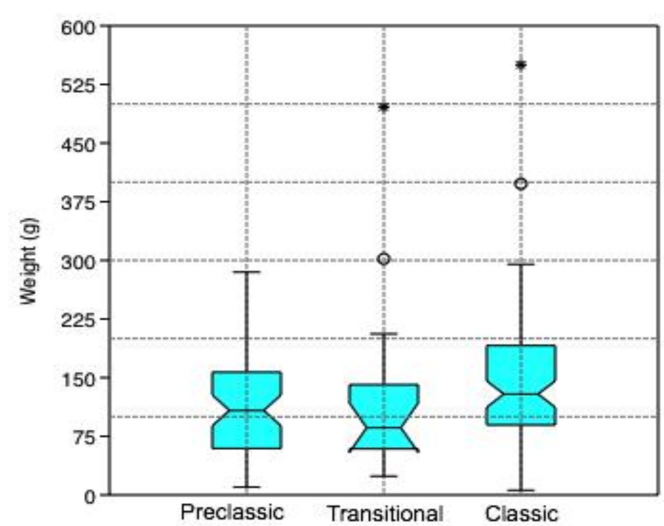

Figure 41: Notched box-and-dot plot of median (at 95% confidence interval) and midspread values for biface weight (g) for each period.

Because each batch of numbers representing the weights of each biface was skewed, the samples were normalized using a 20% trim and Winsorized. The above graph (Figure 41) showing non-overlapping medians, and potentially non-overlapping means lead to the conclusion that the weights of bifaces may change, or increase over time.

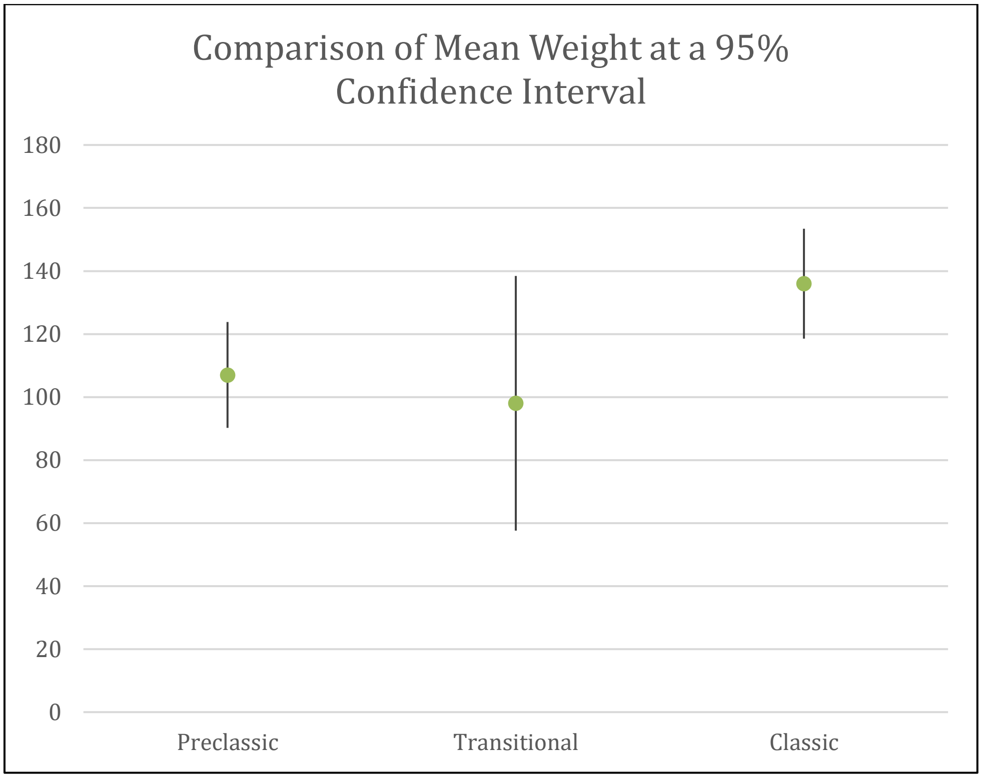

Figure 42: Graphed comparison of trimmed (20%) samples for weight in grams at a 95% confidence interval.

In another attempt to visualize this same data, the Winsorized and trimmed weights are depicted above (Figure 42). While the Preclassic and transitional batches are not significantly different at a 95% CI, it is clear that the Preclassic and Classic samples do not overlap. Again, this suggests significant differences in biface weights between the Preclassic and Classic samples.

Using these same trimmed and Winsorized batches for weight, an ANOVA resulted in $p = 0.00525$, and $F = 5.419$. This probability result strongly suggests that the difference in means seen across these batches is not simply due to the vagaries of sampling. With a fair amount of confidence, we can say that biface weight in fact does increase from the Preclassic to the Classic time period, while the transitional period falls close in line with the weights of the Preclassic batch. By using Tukey's post-hoc pairwise comparison, it is again confirmed that the differences between Preclassic and Classic weights are the driving factor for the significance result obtained by ANOVA.

Length Analyses

Because it has been identified that the weight of bifaces increases over time, additional assessment to understand which other metric attributes within the bifaces are contributing to a weight increase have been conducted. After evaluating the normality of each batch, it was decided that no alterations were necessary, as the attributes for length already exhibited normal shaped curves within each batch. While the transitional batch does include one outlier, it has been determined to not be significant enough to alter the data.

Results from ANOVA including all three batches (Preclassic, transitional, and Classic) provide a p value of 0.09329, with an F ratio of 2.406. This initial result suggests that the length of bifaces did not change over time. However, when using a two-sample t Test for equal means with the Preclassic and Classic batches only we see a different result. By eliminating the transitional period lengths from the analysis, we now see $t = 2.2$ and $p = 0.03$. This suggests that there actually is a significant difference between Preclassic and Classic lengths.

Width Analyses

As with weight, each batch of width measurements needed to be normalized to correct for skew. In this analysis, the batches were trimmed by 10% to create normally distributed batches and Winsorized.

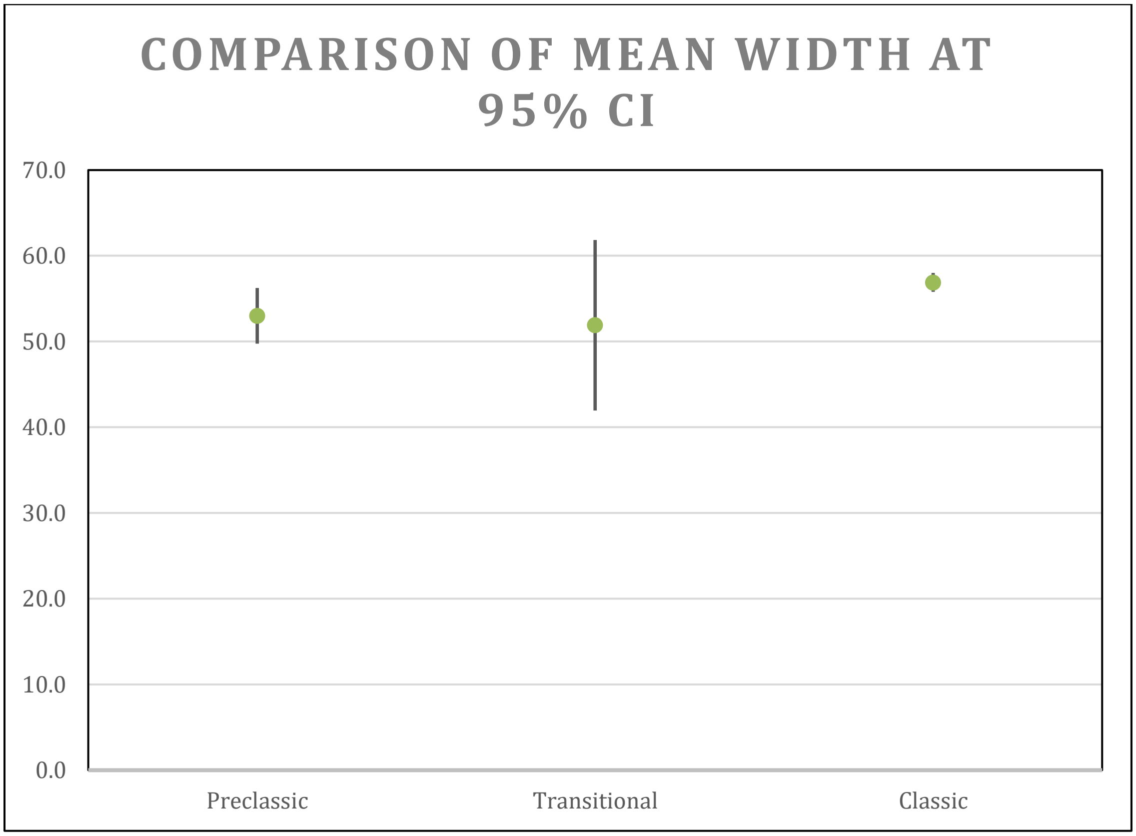

Figure 43: Winsorized comparison of mean width (cm) at 95% confidence interval.

The visual comparison (Figure 43) suggests a significant difference between means at a 95% CI. This observation appears true when comparing the Preclassic and Classic batches, and the transitional and Classic batches, but not for the Preclassic to transitional comparison. While the above graph appears to show Winsorized means for the Preclassic and Classic as not overlapping at a 95% CI, along with non-overlapping Winsorized means for the Preclassic and transitional batches, other analytical methods do not give this result. An ANOVA including all three batches results in $p = 0.1216$, $F = 2.134$, while a two-sample t test between the Preclassic and Classic batches results in $p = 0.08$ and $t = 1.75$.

Biface Thickness

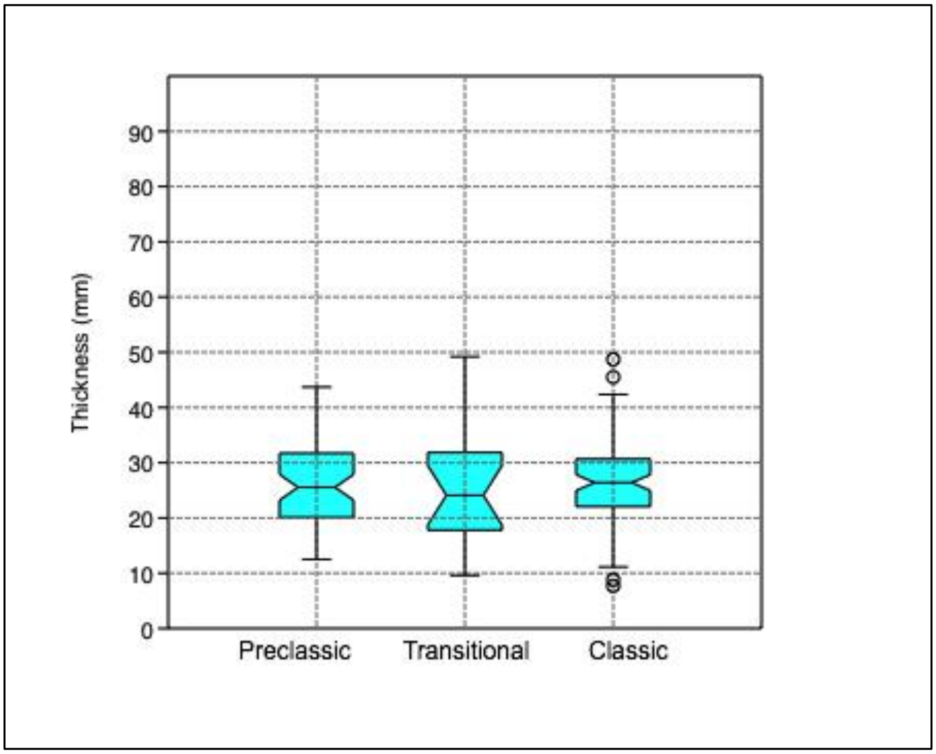

Figure 44: Notched box plot of median (at 95% confidence interval) and midspread of thickness measurements (mm) of each period.

The above chart (Figure 44) suggests that the disbursement of each batch of thickness measurements are similar to one another. Not only do the means appear to overlap, but in general the midspreads of each batch are quite similar. This result has determined that it is not likely that the thickness of bifaces has changed in a significant way over time, and results in the decision to not explore this attribute any further.

Through the above statistical tests, it appears that the weight and length of bifaces at Xnoha increase over time, specifically from the Preclassic to the Classic periods. These tests also indicate that no significant change occurs over time in relation to the width and thickness of bifaces. In the next chapter, possible factors relating to these metric changes over time will be considered.

Chapter 6: Discussion and Conclusions

Through the identification of chert resource areas across the northwestern Belize landscape and the analysis of these resources, a better understanding of raw chert materials has been gained. This information paired with the analysis of bifaces from the site of Xnoha provides a better understanding of how chert stone materials were utilized across the landscape. The results of this research now allow for a more robust conversation about ancient Maya tool production, use, and distribution. By carefully identifying patterns within raw chert material and the chert materials used to produce bifaces, along with biface attributes, theoretical ideas can begin to take shape and aid a larger discussion about how the Maya functioned as consumers of chert.

As previously mentioned, only a handful of Munsell colors are present at one resource location. In some instances, individual colors may be present at only two or more locations. It makes sense to think that a bifacial tool consisting of one or possibly more colors, which are only found at one resource location, has a greater likelihood of originating from that source. In addition, the chert resources at Bedrock are the only ones included in this study that exhibit a high amount of banded chert. All other resource locations exhibit only 10 to 45 pieces of chert total with banding, while Bedrock has 58 banded pieces of chert, even though the full projected sample of 400 pieces was not collected here. In relation to the chert collected from the Grey Fox location, it may be useful to point out that none of the raw materials here are made up of any amount of coarse-grained materials.

Another observation can be made in regard to fossil content in both raw material resources and the bifaces from Xnoha. Raw chert materials collected from the identified resource locations exhibit a rather high volume of fossils, including plant, shell, and microfossils. However comparatively, these fossils are found less frequently within the bifaces from Xnoha. Only four bifaces include plant fossils, five bifaces include shell fossils, while 23 include microfossils. Perhaps it should be taken into consideration that larger fossils such as plant and shell may have an impact on an individual’s ability to work the stone into the intended tool form, leaving raw materials with these types of inclusions less utilized, while microfossils may not have made much of an impact. These sorts of observations could begin to lend a hand in sourcing materials across the landscape.

While it could also be useful to narrow the possibility of a bifacial tool to only two, three, or even just four of the locations in order to rule out where it could not have come from. However, there is hesitation to insist that this information is 100 percent accurate considering the nature of random sampling, the actual sample sizes that were obtained at each location based on various factors, and the fact that there may be many more resource locations we don’t yet know about as well as sources that have been located within the last field season (2017 and 2018) that have not yet been tested. All that being said, we can carefully consider whether specific biface tools included within this sample originated from the resource areas they currently seem to match based on Munsell Soil Color, as well as grain size analysis, and inclusion analysis.

In addition, based on findings throughout this research, narrowing down a single biface down to one or even a few resource location areas through the information we currently have on the resources themselves, or the tools themselves, serves as a strong indicator in proving resource area use patterns among the ancient Maya at Xnoha. While the samples that were obtained from each resource area exhibit great amounts of color variation (Tables 3, 4, 5), along with grain size

(Figure 45) and inclusion (Figure 46) variants these samples still do not compare to the actual variation seen on the ground. If an individual were to pick up a sample of every color seen at a resource location, it seems that the variation within that zone would appear even greater than is already displayed in the presence and absence charts within this document. And while visual sourcing can provide a great amount of data and understanding, it is difficult to ensure that the field and laboratory conditions in the tropical environment of Belize are stable in such a way which would allow for accurate and completely similar analysis conditions on a daily basis. Things like sunlight, moisture, and humidity cannot be controlled to the same extent each day to allow Munsell color judgements to always be precisely accurate. While this research has contributed to the understanding of chert resources used by the ancient Maya in Northwestern Belize, it is obvious that this research needs to be expanded upon. By using other analysis methods, perhaps by documenting the chemical makeup of stone resources in order to compare them to stone tools recovered during excavations, we will have a much more substantial and definitive idea of how resources traveled across the landscape.

Tool Production, Craft Specialization, and Workshops

Based on the evidence presented above showing the close relationship between chert resource locations to various known ancient Maya sites, it is clear that these resources were used to produce stone tools to some extent. To better understand the extent to which these resources were being used and relied upon and how they played a role in sociopolitical relationships throughout this region, several factors need to be taken into consideration. It could be that a resource area was being used by a small community producing tools only for domestic consumption as needed, while larger scale production and distribution has been documented at sites, such as Colha (Figure 1). In the case of large-scale production and specialization in the Maya world, Colha has basically set the standards with known distribution to consumer centers where large percentages of debitage and tools found at these locations indicate that their main source of chert tools stem from Colha. For instance, 87% of the formal tools found at Ambergis Caye excavations were made from Colha chert (Hult and Hester 1993:37). At other sites such as Pulltrouser Swamp- 94 percent (McAnany 1987, 1989b:337), El Pozito- 82 percent (Hester et al. 1991:68), Kichpanha- 76 percent (Shafer 1982b:175), and Cerros- 87 percent (Mitchum 1994:139), Colha chert also made up a significant amount of formal tools. These consumer sites clearly depended heavily upon imported types of stone and stone tools to achieve daily tasks. Even debitage, probably created from the reworking of imported Colha tools at some sites can clearly establish some sort of dependence upon Colha's resources. At Santa Rita 74.8 percent (McAnany 1989:337), Pulltrowser 75.7 percent (McAnany 1989:337), and at Laguna de On- 21.6 percent (Mason 1993) of debitage located during work at these sites proved to be of Colha-like character and generally accepted to be imported material (Santone 1997). Proof of dependence on importation of stone materials can also be indicated by lack of cortex present on debitage. Such information indicates that "full production" of tools, wasn't taking place at sites like Pulltrouser, Santa Rita, and Ambergris, meaning that primary flaking and manufacture failures are generally not present at these locations (Santone 1997). A predominance of later stage edge reduction or edge maintenance debitage is more likely in these situations (Santone 1997). When considering Colha's role in production and distribution of tools, not only for their communities' personal use, but for various other ancient Maya communities too, we cannot ignore the presence of large quantities of debitage located at the site of Colha which is also a major indication of specialized craft production. At Colha mounds of debitage ranging from 20 to 30 centimeters thick spanning up to 15 square-meters to mounds 2 meters thick covering spaces up to 350 square-meters are thought to establish a location as a "workshop". Researchers at the site of Colha have firmly established that Colha was in fact a location where formal specialized workshops were active in specialized production, "on a massive scale (Mallory 1986:154)."

While the importance of Colha chert, or even just chert generally retrieved from the Belize Chert Bering Zone was clearly important to many communities in this Maya region, this is not the only region with chert resources suitable for producing artifacts (Moholy-Nagy 1992). But how do we correctly grasp the scale or degree to which other locations in the Maya world were producing tools? John K. Mallory acknowledges that Hester and Schafer, authors of most Colha data have failed to elaborate on the idea that "degrees of craft specialization vary" (Mallory 1986:154). For instance, the sheer presence of volumes of debitage does not necessarily indicate a workshop, nor can we be sure the extent or nature of exchange of these goods (Mallory 1986:154). Moholy-Nagy brings up concerns for the "frequent confusion of manufacturing loci with the waste products generated at them" (Moholy-Nagy 1992:249)" Apparent use of baskets and ground cloths to capture manufacture waste could lead to less clear identification of actual production locations (Moholy-Nagy 1992). To better understand where the potential chert tool workshops in this study fit into the whole scheme of things, multiple definitions and "indicators" of specialized or craft production and workshops need to be considered.

Hester and Schafer (1991:79) have chosen to define craft specialization using criteria established by Roemer (1984).

> …an individual who repeatedly manufactures a craft product for exchange. Production in craft-specialized communities exceeds that needed for household use. The degree of specialization depends upon the amount of time devoted to the craft and to the quantity of production. Production efficiency and standardization are other criteria that have been used to define craft specialization. (Roemer 1984:67, 68)

In chapter 6 of *"Stone Tools: Theoretical Insights into Human Prehistory,"* Jay K. Johnson lists and describes three indicators for craft specialization at workshops. The *first* to consider is the volume of debitage present. While it is acknowledged that high volumes of debitage can be present at quarry sites due to repeated visits by "non-specialists," designated workshops at Colha have created "more that 100 mounds measuring up to 30 meters in diameter and more that 1 meter in depth, whose primary constituents are flakes and production rejects" (Johnson 1996:163). *Second* is the presence of standardized production styles and tool forms. That is, a tool type or shape is distinct and can be recognized based upon its standard from (Johnson 1996). And *third*, by somehow establishing that individuals were producing more goods than necessary for local consumption, would indicate that specialization was taking place (Johnson 1996). On page 171, Johnson (1996) concluded that in order to understand and model production activities, understanding what is being produced including the tools, flakes, and rejects is essential.

In an article called *"Testing the Producer-Consumer Model for Santa Rita Corozal, Belize,"* authors J. Dockall and H. Shafer reproduce a list first suggested by McAnany (1982, 1986) which suggests the qualities of large-scale stone tool production at a site which has access to large quantities of raw material (Dockall and Shafer 1993:166-167).

> (1) Biface preforms and manufacturing failures from all states of reduction;
> (2) polyhedral chert cores from the production of blades and macroblades;
> (3) plunging blades and core-rejuvination flakes resulting from manufacturing failures of chert blades;
> (4) a high percentage of cortical debitage, and

> (5) debitage that reflects the production of large bifaces averaging 14 cm in length and 6 cm in width. This would include outrepasse (overshot) flakes and a low percentage of flakes with damage at the junction of the dorsal surface and the striking platform. (Dockall and Shafer, 1993:167)

An in-depth analysis of debitage at production locations is required to use this model, along with portions of all three of these models. These types of data are not currently available within this research study, and makes it difficult to determine whether the site of Xnoha was in fact producing tools via craft specialization. Definitive statements about the range of debitage produced at the resource locations described in this study cannot be made either.

As mentioned above, standardized production of tool forms can be an indicator of craft specialization. And in some instances, the resource bearing areas and possible workshop areas which have been explored by Barrett and myself indicate tool production, and in some instances possible large scale production based only on the presence of some amount of debitage and the presence of various tool forms. Of all the resource areas included in this research, the Nojol Nah resource zone has generally been accepted as a “workshop” due to the sheer volume of debitage present, consistent with all three production and specialization definitions above. The amount of debitage at Nojol Nah likely exceeds the amount of tools that would be necessary for an individual household. However, it needs to be taken into consideration that “large scale production” could mean different things depending on who a workshop was supplying tools to. While the ancient Maya may not have been distributing tools and chert materials long and far distances in northwestern Belize, they may have been supplying the many communities that are scattered around the Dunbell Bajo. Generally, the stone tools found at most of the excavations taking place in the MRP permitted work area in northwestern Belize do not appear to be made of foreign or imported cherts, but very closely resemble the native chert materials. Does this mean we can say that some sort of specialization was taking place, or only that these communities were using the resources they had?

While it was not included within this research proposal to do close analysis of the debitage at these resource locations, it is now clear that this information would have been incredibly useful in identifying specialized production indicators and should be something of focus in the future. Perhaps we need to put away the term “craft specialization” and consider what it means to have a “local market exchange” system in place at locations such as ancient cities being excavated in northwestern Belize.

The bottom line with these bifaces is that they tend to be either broken, which makes sense since they were a highly used tool, or of ovate or orbicular shape. While the condition of the bifaces analyzed needs to be taken into consideration, the statistical results they returned provided for some interesting results. When split up into three groups based on associated time periods derived from ceramic analysis dating, multiple patterns appear. Over time, from the Preclassic time period to the Classic, it appears that bifaces get heavier while a transitional group of bifaces falling in between the Preclassic and Classic time periods more closely resembles bifaces from the Preclassic (Figure 46) in regards to weight. This conclusion could be due to multiple factors including the possibility that the chert resources being used over time changed and the raw materials were larger in size. It could also be that over time, individuals preferred larger, heavier tools for different purposes.

While the transitional group of bifaces shows no significant signs of length increase, a significant increase in length does appear to happen when comparing the Preclassic and Classic bifaces. Statistical differences in length may be related to the stage of reduction a tool is in

(Dockall 1994). After statistical analysis of oval bifaces from Colha, it was concluded that a clear difference is visible between bifaces that are complete versus those that have been resharpened and maintained during use (Dockall 1994). Perhaps the Preclassic Maya were more concerned about over use of chert resources, using their bifaces much longer than the Classic Maya. Potential shifts over time in resource accessibility could have allowed later populations to discard their bifacial tools sooner, resulting in longer and heavier bifaces appearing in the archaeological record during the Classic period.

After multiple attempts to statistically identify a difference in biface width over time which could also contribute to the increase in biface weight, this could not be confirmed (Figure 47). The metric data for thickness quite clearly shows no change whatsoever through time (Figure 48).

In addition to the popularity of ovate and orbicular shapes (Figures 13 and 39) and statistical results based on documented metric data, bifaces predominantly exhibit convergent flaking (Figures 14 and 36) patterns, with either wavy or sinuous edge morphologies (Figure 37). On the other hand, Dockall (1994) suggested the possibility of standardized metrics and shapes, in relation to bifaces found during excavations, due to utilization processes, leaving bifaces in similar forms once exhausted and no longer useable (Dockall 1994).

A majority of the chert material used to produce these bifaces included mottling and/or vugs (Figure 38), and appears to be from local sources that resemble the raw material resources analyzed rather than being made from other “exotic” materials. All other inclusions were less likely to be present within materials used to make the bifaces at Xnoha. And while the grain size of composing these bifaces tended to lean towards fine to medium grained cherts (Figure 35), all other combinations of chert grain sizes were also present.

The presumed use of local chert materials, some locations exhibiting large amounts of debitage and evidence of production to some extent, a general trend towards similar flaking patterns and edge morphology, and clear statistical trends in metric data perhaps hint at some sort of standardized production of tools. Unless every individual making or using tools at the site of Xnoha produced a tool using very similar flaking patterns and all individuals happened or agreed upon increasing certain dimensions of bifaces from the Preclassic to the Classic, these observations hint at a smaller population producing some amount of bifacial tools for some sort of distribution that included the site of Xnoha.

Future Research Possibilities

Through this research, it became quite apparent that visual sourcing comes with its difficulties. While it can provide us with some useful information about chert across the landscape, it does not produce the types of results initially hoped for. However, as technologies improve and become more available, it may be possible to achieve more accurate results. Various geochemical methods have been tested in attempts to recognize trace elements within stone. Neutron Activation Analysis (NAA) has been recognized as an effective method of analyzing stone sources. Unfortunately, the cost and availability of this type of testing makes it fairly inaccessible for many archaeologist, it also is fairly damaging to the materials being tested (Odell 2003). Another up-and-coming analysis type may actually be available in continuing this research is called X-Ray Fluorescence Analysis (XRF). This nondestructive and often portable technique has the ability to detect concentrations of specific elements within stone materials

(Odell 2003). It may be possible to differentiate stone from one spatial region to another using this technique in the future.

In addition to the analysis of chemical signatures within chert resource, it may be possible to increase the sample size of stone resource areas by using Light Detection and Ranging (Lidar). This technology is currently making its presence well-known in the field of archaeology. While one Lidary survey has been completed in northwestern Belize, it is hoped that this information with be built upon. With increasing Lidar survey work, we may be able to identify outcrops of raw chert materials across the landscape by recognizing what kind of signature such materials leave within the resulting data. In addition, larger quarry sites may be easily recognizable using the precision within the imagery Lidar can produce.

As technology becomes more available and increases the possibilities of chemical and landscape analysis, the accuracy of this research can only become better. With time, archaeologists can achieve a better understanding of the distribution of stone resources across ancient landscapes, how those resources fluctuated over time, and how they influenced populations.

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Appendix A: Tables 3 and 4

Table 3: Primary Munsell colors located at each raw resource area.

Primary Munsell Colors located at each site within sample. **Primary Definition:** Each individual raw stone sample is made up of 50% or more of this color.	Xnoha Field	Grey Fox	Bajo Vista	Bedrock	Nojol Nah (2015)	Nojol Nah (2014)
Black			x			
Brown		x	x			
Brownish Yellow			x		x	
Dark Brown			x			x
Dark Gray			x		x	
Dark Grayish Brown			x			
Dark Red			x			
Dark Red, Very Pale Brown			x			
Dark Reddish Brown			x			
Dark Reddish Gray	x		x			x
Dark Yellowish Brown			x			
Gray				x	x	x
Gray to Very Dark Gray	x					
Grayish Brown			x			
Light Bluish Gray			x			
Light Brownish Gray						x
Light Gray	x	x	x	x		x
Light Gray to Light Yellowish Brown	x					
Light Gray to Reddish Gray						x
Light Olive Brown						x
Light Pink				x		
Light Pink, Weak Red				x		
Light Reddish Brown	x	x		x	x	x
Light Reddish Gray						x
Light Yellowish Brown	x				x	
Olive Brown	x					
Pale Brown			x			
Pale Red		x		x	x	x
Pale Red, White			x			
Pale Yellow	x	x	x	x		x
Pink	x		x	x	x	x
Pink, Very Pale Brown			x			
Pinkish Gray			x	x		x
Pinkish Gray to Pinkish White	x					
Pinkish White	x		x	x	x	x
Pinkish White, Reddish Yellow					x	
Red	x		x	x		x

Reddish Brown						x
Reddish Brown to Pale Red	x					
Reddish Gray			x			x
Reddish Yellow		x				x
Strong Brown			x			
Very Dark Gray			x			
Very Pale Brown	x	x	x	x	x	x
Weak Red		x				x
White	x	x	x	x	x	x
White to Light Gray						x
White to Pale Yellow	x					
White to Pink						x
White to Pinkish White	x					x
White to Very Pale Brown	x					x
Yellow	x				x	x
Yellowish Brown			x			x
Yellowish Red			x			x

Table 4: Secondary colors present at raw resource locations.

Secondary Munsell Colors make up less than 50% of a stones color. Can be more than one secondary color within one piece of stone.	Xno'ha Field	Grey Fox	Bajo Vista	Bedrock	Nojol Nah (2015)	Nojol Nah (2014)
Black	x				x	x
Bluish Black						
Bluish Gray			x			
Brown	x		x		x	x
Brownish Yellow	x	x	x			x
Dark Bluish Gray						
Dark Brown			x			
Dark Gray	x	x	x	x	x	x
Dark Grayish Brown	x			x		
Dark Greenish Gray						
Dark Olive Brown						
Dark Olive Gray						
Dark Red						
Dark Reddish Brown						x
Dark Reddish Gray						x
Dark Yellowish Brown						
Dusky Red			x			
Gray	x	x	x		x	x
Grayish Brown			x			
Grayish Green						
Greenish Black						
Greenish Gray	x					
Light Bluish Gray						
Light Brown						
Light Brownish Gray	x		x			x
Light Gray	x	x	x	x	x	x
Light Greenish Gray						
Light Olive Brown	x		x	x		
Light Olive Gray						
Light Pink				x		
Light Red			x		x	x
Light Reddish Brown	x				x	
Light Reddish Gray						
Light Yellowish Brown	x					x
Olive						
Olive Brown			x			
Olive Gray						
Olive Yellow			x	x		

Pale Brown	x	x	x			x
Pale Green						
Pale Olive						
Pale Red	x	x		x		x
Pale Yellow	x	x	x	x	x	x
Pink	x			x	x	x
Pinkish Gray	x				x	x
Pinkish White	x		x		x	
Red	x			x	x	x
Reddish Black					x	
Reddish Brown	x		x		x	
Reddish Gray				x		x
Reddish Yellow	x			x	x	x
Strong Brown			x			x
Very Dark Bluish Gray						
Very Dark Brown						
Very Dark Gray	x				x	
Very Dark Grayish Brown			x			
Very Dark Grayish Green						
Very Dark Greenish Gray						
Very Dusky Red						
Very Pale Brown	x	x	x	x	x	x
Very Pale Yellow					x	x
Weak Red		x		x		x
White	x	x	x	x	x	x
Yellow	x		x	x	x	x
Yellowish Brown			x	x	x	x
Yellowish Red	x			x	x	x

Appendix B: Table 5

Table 5: Secondary color combinations on raw materials.

Secondary Munsell Colors located at each site within sample. **Secondary Definition**: Less that 50% of each stone sample piece is made up of this color. In some cases each raw stone sample is made up of multiple "secondary" colors.	Xnoha Field	Grey Fox	Bajo Vista	Bedrock	Nojol Nah (2015)	Nojol Nah (2014)
Black						x
Black, Pale Red	x					
Black, Pinkish White, Reddish Yellow					x	
Bluish Gray, Gray, Olive Brown, White			x			
Bluish Gray, Light Brownish Gray, Very Dark Grayish Brown, Yellowish Brown			x			
Brown					x	
Brown, Brownish Yellow, Very Pale Brown			x			
Brown, Grayish Brown			x			
Brown, Pale Brown, Gray	x					
Brown, Pinkish White, Red, White			x			
Brown, Pinkish White, Yellowish Brown			x			
Brown, Reddish Gray						x
Brown, Strong Brown			x			
Brownish Yellow						x
Brownish Yellow, Light Olive Brown			x			
Brownish Yellow, Light Red, Reddish Brown			x			
Brownish Yellow, Red, White						x
Brownish Yellow, Very Pale Brown, Yellowish Red	x					
Brownish Yellow, White, Yellow, Yellowish Red						x
Dark Brown, Pale Brown, Very Pale Brown, Yellowish Brown			x			
Dark Gray			x		x	x
Dark Gray, Dark Yellowish Brown, Reddish Brown, Very Pale Brown			x			
Dark Gray, Gray						x
Dark Gray, Gray, White			x			
Dark Gray, Light Brownish Gray	x					
Dark Gray, Light Gray	x					
Dark Gray, Light Olive Brown			x			
Dark Gray, Yellowish Brown				x		
Dark Grayish Brown, Light Brownish Gray, White	x					
Dark Grayish Brown, Light Gray, Reddish Yellow,	x					
Dark Grayish Brown, Red, Very Pale Brown				x		
Dark Grayish Brown, Weak Red, White				x		
Dark Red, Gray, White			x			
Dark Reddish Brown, Reddish Yellow						x
Dark Reddish Gray						x
Dark Reddish Gray, Weak Red		x				
Dusky Red			x			

Dusky Red, Pale Brown, Pale Yellow			x			
Dusky Red, Reddish Brown, Strong Brown			x			
Gray		x	x			x
Gray to Brownish Yellow		x				
Gray, Greenish Gray	x					
Gray, Light Gray			x			
Gray, Light Gray, Light Yellowish Brown						x
Gray, Light Gray, Olive Yellow						x
Gray, Olive Yellow, Pale Yellow						x
Gray, Olive Yellow, Yellow			x			
Gray, Pale Red, Very Pale Brown	x					
Gray, Strong Brown, White			x			
Gray, Very Pale Brown		x			x	
Grayish Brown, Light Gray, Very Dark Gray			x			
Grayish Brown, Reddish Brown, Weak Red			x			
Light Bluish Gray, Yellow			x			
Light Brownish Gray						x
Light Brownish Gray, Light Gray	x					
Light Brownish Gray, Pale Red, Very Pale Brown			x			
Light Brownish Gray, Pinkish Gray			x			
Light Brownish Gray, Very Pale Brown						x
Light Brownish Gray, White	x					
Light Gray	x	x	x	x		x
Light Gray, Light Olive Brown			x			
Light Gray, Light Olive Brown, White	x					
Light Gray, Light Reddish Brown, White, Yellow	x					
Light Gray, Light Yellowish Brown, Reddish Yellow	x					
Light Gray, Pale Brown						x
Light Gray, Pale Yellow			x			
Light Gray, Pinkish Gray			x			
Light Gray, Pinkish White			x			
Light Gray, Reddish Brown					x	
Light Gray, Strong Brown, White			x			
Light Gray, Very Pale Brown			x			
Light Gray, Yellow				x		
Light Gray, Yellowish Brown			x			
Light Olive Brown				x		
Light Pink, Weak Red				x		
Light Red					x	
Light Red, Light Reddish Gray						x
Light Red, Red						x
Light Red, Reddish Brown, White					x	
Light Red, Reddish Yellow						x
Light Red, Very Dark Gray, Very Pale Brown, White					x	
Light Reddish Brown, Pale Yellow, White	x					

Light Reddish Brown, Pink					x	
Light Reddish Brown, Pinkish Gray, Red, Reddish			x			
Light Reddish Brown, Reddish Yellow, Strong Brown			x			
Light Reddish Brown, Weak Red			x			
Light Reddish Brown, Yellow, White	x					
Light Reddish Brown, Yellowish Red	x					
Light Yellowish Brown			x			
Light Yellowish Brown, Pale Yellow, Yellow, Yellowish Red	x					
Light Yellowish Brown, White	x					
Olive Yellow	x					
Olive Yellow, Reddish Yellow				x		
Pale Brown		x	x			
Pale Brown, Yellow, Yellowish Brown			x			
Pale Red		x		x		
Pale Red, Pink	x					
Pale Red, Red						x
Pale Red, Strong Brown			x			x
Pale Red, White			x			
Pale Red, Yellowish Red						x
Pale Yellow		x		x	x	
Pale Yellow, Red, White				x		
Pale Yellow, Reddish Brown	x					
Pale Yellow, Weak Red			x			
Pale Yellow, Yellow	x					
Pink	x			x	x	x
Pink, Reddish Gray				x		x
Pink, Weak Red, White						x
Pink, White				x	x	
Pinkish Gray					x	x
Pinkish White					x	
Pinkish White, White, Pinkish Gray	x					
Red						x
Red, Reddish Black, Reddish Brown, White					x	
Red, Reddish Black, White					x	
Red, Reddish Yellow	x					
Red, White	x					x
Red, Yellowish Brown					x	
Reddish Brown					x	
Reddish Gray, Very Pale Brown				x		
Reddish Gray, White				x		
Reddish Yellow			x	x		
Reddish Yellow, Very Dark Gray	x					
Reddish Yellow, Very Pale Brown					x	
Reddish Yellow, White			x	x		

Strong Brown			x			
Strong Brown, Yellow						x
Strong Brown, Yellowish Red			x			
Very Dark Gray	x				x	
Very Dark Gray, Very Pale Brown					x	
Very Pale Brown					x	x
Very Pale Brown, White						x
Very Pale Brown, White, Yellow						x
Very Pale Yellow, White						x
Weak Red						x
White	x	x		x	x	
White, Yellow			x			x
Yellow			x		x	x
Yellow, Very Pale Brown	x					
Yellow, Very Pale Yellow					x	
Yellowish Brown			x			x
Yellowish Red				x		
Yellowish Red, Reddish Yellow, White					x	

Appendix C: Table 6, Figure 45 and 46

Table 6: Colors present within biface samples.

Light blue color indicates a color appearing to be unique to a resource area.

Munsell Color	**# of Times Each Color Appears.** (Primary and Secondary instances among all bifaces.)	**# of Bifaces with Color as Primary Color.**	**# of Bifaces with Color as a Secondary Color.** (Many Bifaces have more than one secondary color.)	Resource Locations which each color are present via random samples.	Xnoha Field	Grey Fox	Bajo Vista	Bedrock	Nojol Nah
Black	3	2	1		x		x		x
Bluish Gray	7	6	1				x		
Brown	8	3	5		x	x	x		
Brownish Yellow	7		7				x		x
Dark Bluish Gray	2		2						
Dark Brown	0						x		x
Dark Gray	14	6	8		x	x	x	x	x
Dark Grayish Brown	5	4	1		x		x	x	
Dark Olive Brown	1		1						
Dark Red	0						x		
Dark Reddish Brown	1		1				x		x
Dark Reddish Gray	4	2	2		x		x		x
Dark Yellowish Brown	6	4	2				x		
Dusky Red	1		1				x		
Gray	36	7	29		x	x	x	x	x
Grayish Brown	5	2	3				x		
Light Bluish Gray	8	6	2				x		
Light Brown	3		3						
Light Brownish Gray	9	4	5		x		x		x
Light Gray	34	10	24		x	x	x	x	x
Light Gray to Reddish Gray	1	1							x
Light Olive Brown	8	4	4		x		x	x	x
Light Pink	2	1	1					x	
Light Reddish Brown	3	1	2		x	x	x	x	x
Light Reddish Gray	1	1							x

Light Yellowish Brown	10	3	7			x				x
Olive Brown	0					x		x		
Olive Gray	1		1							
Olive Yellow	9	1	8					x	x	
Pale Brown	8	2	6			x	x	x		x
Pale Red	19	9	10			x	x	x	x	x
Pale Yellow	26	6	20			x	x	x	x	x
Pink	2		2			x		x	x	x
Pinkish Brown	1		1							
Pinkish Gray	13	8	5			x		x	x	x
Pinkish White	7	5	2			x		x	x	x
Red	3		3			x		x	x	x
Reddish Black	2		2						x	
Reddish Brown	2	1	1			x		x		x
Reddish Gray	7	3	4					x	x	x
Reddish Yellow	4		4			x	x		x	x
Strong Brown	3		3					x		
Very Dark Bluish Gray	3	1	2							
Very Dark Gray	8	1	7			x		x		x
Very Dark Grayish Brown	3	2	1					x		
Very Dusky Red	1		1							
Very Pale Brown	29	15	14			x	x	x	x	x
Weak Red	9	2	7				x		x	x
White	78	36	42			x	x	x	x	x
Yellow	7		7			x		x	x	x
Yellowish Brown	15	4	11					x	x	x
Yellowish Red	2		2			x		x	x	x
	441	163	278							

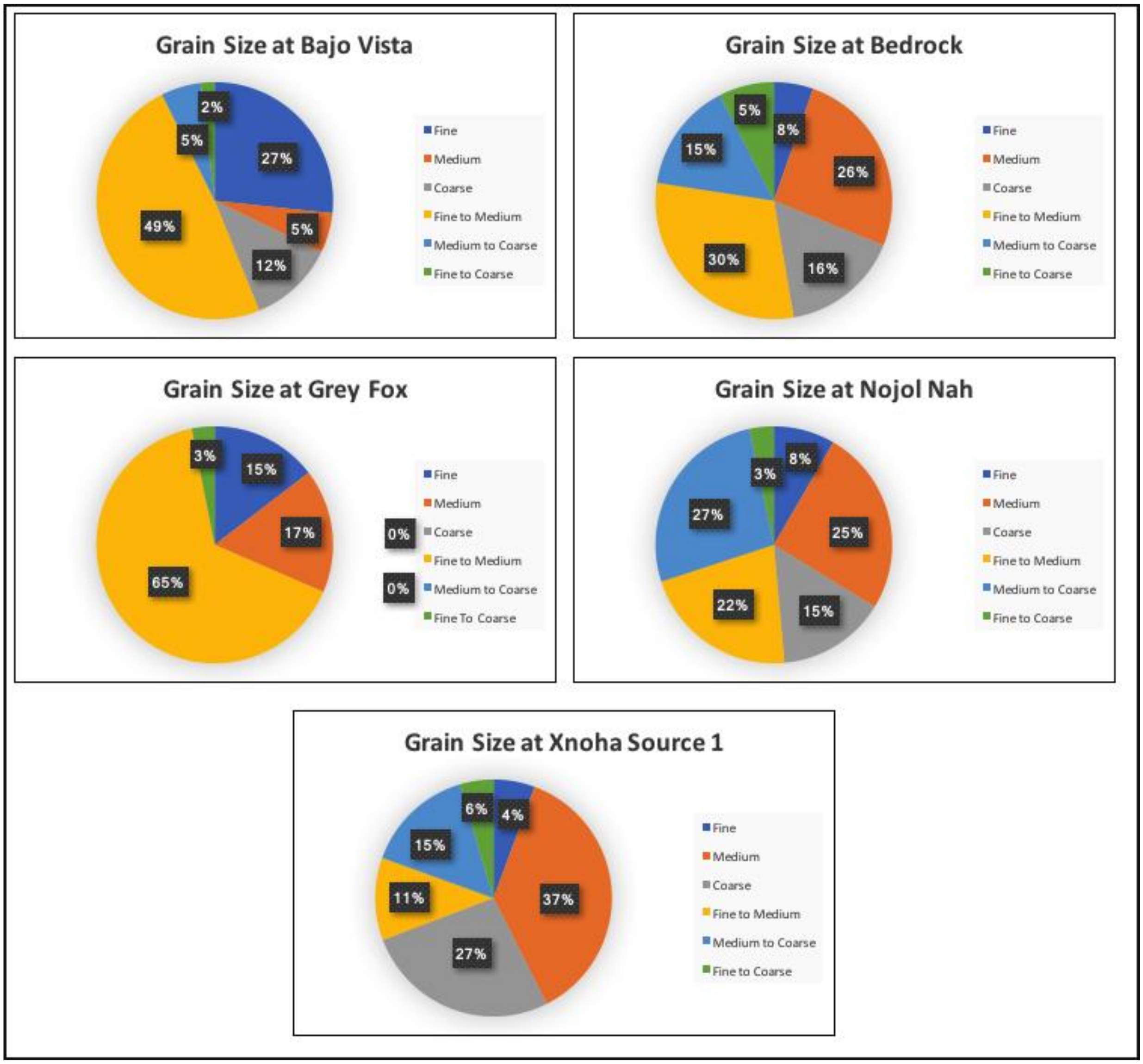

Figure 45: Side by side comparison of grain size pie charts at all resource locations.

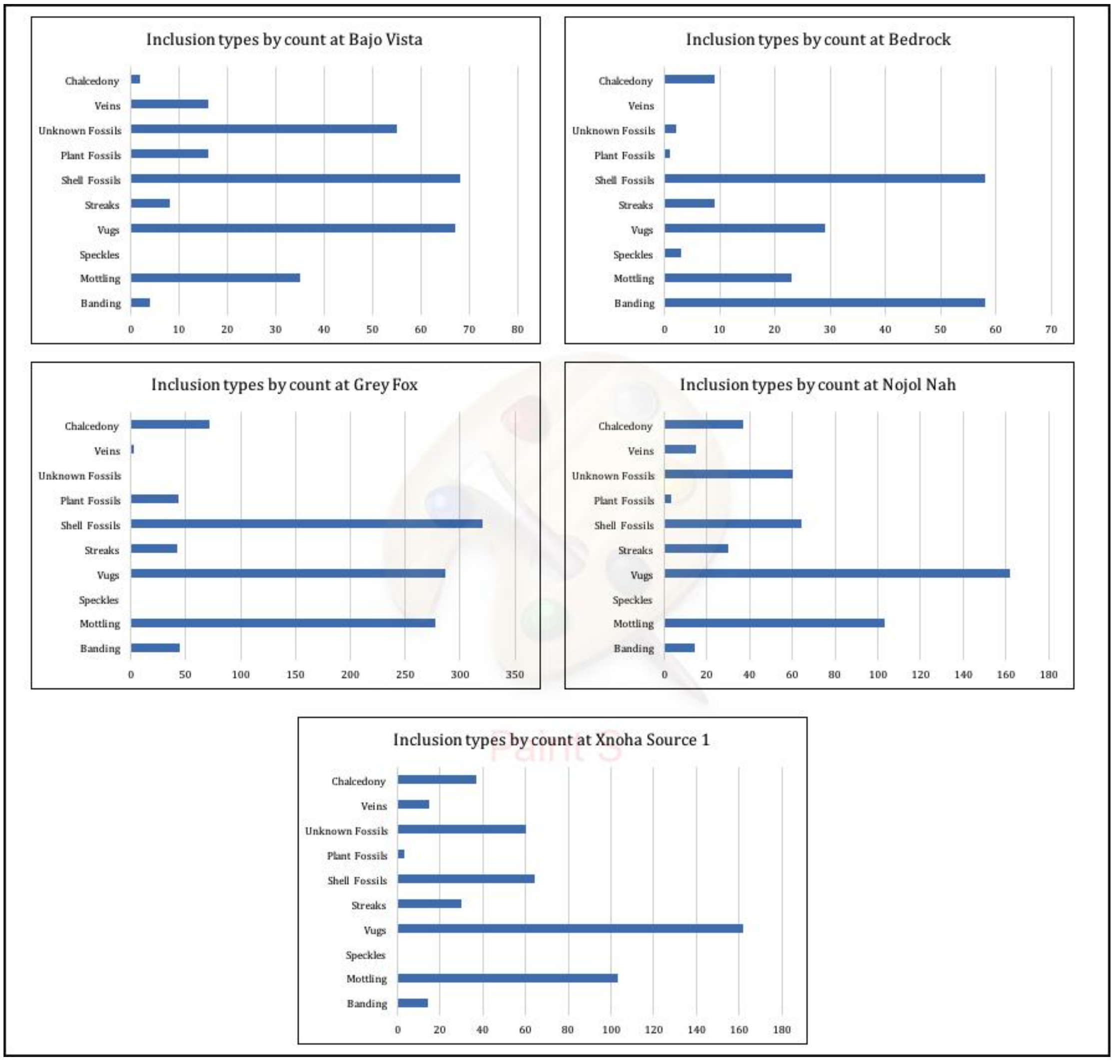

Figure 46: Side by side comparison of inclusion count graphs for all resource locations.