BEYOND THE COMMONER/ELITE DIVIDE: ILLUMINATING CLASSIC MAYA MULTI-AGENT PRODUCTION SYSTEMS AT TAMARINDITO, PETÉN, GUATEMALA

By

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Dissertation

Submitted to the Faculty of the

Graduate School of Vanderbilt University

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

in

Anthropology

August 13, 2021

Nashville, TN

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ACKNOWLEDGEMENTS

People say that it takes a village to raise a child. I would argue that it also takes a village to write a dissertation, and my village has been vast, loving, and incredibly supportive in both respects. I want to be clear that this dissertation is far from perfect, and all mistakes and shortcomings (of which there are many) are entirely my own. Still, I am so proud of this dissertation. I wrote it while raising three children. I wrote it through a contentious adoption. I wrote it through multiple therapy sessions a week and daily tantrums with my youngest. I wrote it through mental and physical health issues. I wrote it through a pandemic. Without my village, any one of these would have been a devastating roadblock. So, to all those listed here and so many more I am sure I have forgotten, thank you, thank you, thank you. We wrote this.

I first want to thank my committee members for the years of mentorship. My doctoral advisor, Markus Eberl, has served as my biggest source of academic support. Even from my first year at Vanderbilt, he treated me more like a colleague than a student. His advice, encouragement, and mentorship have not only improved the contents of this dissertation but have also made me a better colleague and mentor to others. I also want to thank Steve Wernke, Carwil-Bjork James, and Isaac Ullah for providing advice and comments on numerous drafts of grant proposals and my dissertation, along with dozens of letters of recommendation. Each of you has contributed to my research and scholarship, while also teaching me how to be a better teacher and colleague.

I also want to thank several faculty members not on my committee but who provided support throughout this process. Norbert Ross was an integral part in helping me better understand the colonizing nature of anthropology and helping me to begin decolonizing my own work (though I still have an immense amount of learning and work to do in that respect). Tiffiny Tung was continuously supportive throughout both professional and personal struggles and someone that I knew I could always go to. Beth Conklin always made a point to check in with me and to keep an open door of communication. Larisa DeSantis taught me how to incorporate new methods into my research and was an amazing example of mentorship. I worked with Bill Fowler on Ancient Mesoamerica for two years, during which I gained invaluable insights into academic publishing. Jonathan Gilligan taught me about agent-based modeling and, more importantly, that family comes first. The work will always be there. I want to thank Sophie Bjork-James for assisting me with job applications and encouraging me to go for it even when I did not feel totally qualified. I want to thank Tom Dillehay for providing me with space in his lab to complete the microdebitage analysis for my dissertation and for being supportive of my work.

This research could not have been completed without the support assistance of friends and colleagues in Guatemala. I want to first and foremost thank my field crew at Tamarindito: Monica Santos was with me every day in the field, tolerated (and sometimes laughed at) my poor Spanglish, taught me the proper way to say words and phrases I was butchering, and translated between the other crew members and myself. Cesar Higinio Perez Mejia, Luis Crualdo Pop, Abelardo Deonicio Baqui Cho, and Romilio Baqui Caal were my primary field assistants, and I am forever grateful for their hard work and kindness. Abelardo, in particular, saved me from many ant nests once it became obvious that I was a magnet to them. I also want to thank Edgar Carpio of the Universidad San Carlos de Guatemala for providing me with multiple obsidian samples, books, and for being encouraging of my research. In the lab at Flores, I was grateful to have Adriana Beatriz Lopez Caseros, Fany Dely Lester Perez Mejia, and Meylin Odili Salazar Alvarez help me organize, catalog, and prepare all 480 samples for shipment to Vanderbilt. Most of all, I am grateful to my great friend and colleague, Mayra Alvarez, for assisting me on multiple occasions in Guatemala City and for her constant encouragement and friendship.

Once the soil samples were at Vanderbilt, Lexe Olexiuk was an invaluable asset in the lab. Thank you for helping me get organized and for cooking all my dirt. I appreciate you and your friendship. I would never have been able to navigate all the funding and paperwork issues (just to name a few) without the support of Sarah Nagy, Crystal Jackson, Jeannie Wagner, Shelley Darling, and Frank Midgely. Last but certainly not least, I want to thank Tammy Burgaleta for being a constant source of support and friendship from the very first day I arrived at Vanderbilt.

I want to thank my thesis advisor at the University of Tennessee, Boyce Driskell, for instilling in me an appreciation of all things lithic. To my ARL crew, Katherine McMillan Barry, Jessica Vavrasek, and Stephen Carmody, thank you for making lithic analysis so fun and for remaining supportive friends long after. I miss you all and appreciate you! I also want to thank my Brockington crew (Christy Pritchard, Jim Pritchard, Niki Mills, Michael Creswell, Allison Mangin, Heather Donnelly, Chris Lankford, and John Kerley) for always being incredible friends and colleagues and for telling me to go for it when I wanted to go back to school. Special thanks go to Kayce Humkey for introducing me to microartifact analysis. I also want to thank Lara Homsey-Messer for inviting me to present my microartifact research and then to publish it. Thank you for never giving up on that article and for supporting me long after!

My research was generously funded by several grants and fellowships. External funding includes grants from the Rust Family Archaeology Research Foundation, a Jacoby Bursary Grant from the Lithic Studies Society, the Humanities Institute for Learning Technology, and a travel grant from the CAA International Digital Archaeology Conference. Internal funding includes a

Mellon Digital Humanities Fellowship with the Vanderbilt Digital Humanities Center, research and professional development grants from the Department of Anthropology, the College of Art and Sciences, and the Graduate School, a Russell G. Hamilton Graduate Leadership Development Institute Dissertation Enhancement Grant, a Digital Humanities Summer Institute grant, and a Tarkington Archaeology Scholarship.

In no particular order, I want to thank my fellow graduate students for their unique gifts and contributions to my graduate career. No doubt I have left someone out, so my love and apologies if that was you! To Carla Hernandez for sharing all your job application resources and for always reminding me that I was good enough. To Eu Zavaleta for your kindness and generosity, for feeding Liam and I, and for always being a safe space to talk about anything. To Jenn Foley for showing me what an amazing academic mama looks like and for supporting me long after she received her PhD. To Kyle Harper for always being humble even though you are always a step or two ahead of the rest of us. To Kristina Lee for being the best carrel buddy ever and for listening to me vent about anything and everything. To Nathan Frisch for letting me complain without judgment. To Gabriela Ore for her badass computer skills, for being an amazing friend, and for being the rockstar I can only hope to be one day. To Scotti Norman for hugging me and telling me that I was enough on days when I felt like I never would be. To James Zimmer-Dauphinee for your brilliant assistance with all the things (yes, all the things) and for being someone I could always lean on for support with my sweet Liam. To Maya Krause for always brightening my spirits with your beautiful smile and for always inviting me to events that you knew I probably would not be able to attend. To Alex Korsunsky for always being a source of inspiration (i.e., making it look easy) and for always bringing a sense of calm that made me feel like everything was going to be okay. To Terren Proctor for your incredible support and friendship. Finally, I want to thank Kristin Benson for all the talks, movie nights, and personal support.

I want to give special thanks to a few ladies whose support has gone above and beyond the norm. To Kellie Cavagnaro for being a constant source of support starting long before I arrived at Vanderbilt and for making me a far better grant writer (though nowhere near as strong as you). To my fellow Virgo, Keitlyn Alcantara, for always reminding me of my worth and for hanging out with me and my children whenever I needed you to (and sometimes just because you wanted to). To Rosemary Lieske for making me feel like I was not alone (you know what I am talking about) and for always being an incredible friend. To Melinda González for always holding space for me and for being a virtual shoulder to lean on. Finally, I want to thank Chelsey Dyer for being my constant rock and commiseration partner throughout my entire graduate career. I cannot thank you enough for being that person. We may have been the blind leading the blind, but we got each other through, and I literally do not know how I could have done it without your support.

Many of my family members have been extremely supportive of my career goals since I was very young. To my father, Matthew, for always telling me that I could be whatever I wanted to be and to never let anyone tell me that I could not have something I wanted. To my Aunt Becky, who is my mother in all ways but biology: thank you does not even begin to cover it. I could write an entire dissertation on how you have supported me my entire life. Thank you for being the mother you never had to be. To my sisters, Amy and April: you may be twins, but it has always felt more like we were triplets. Thank you for rescuing me, housing me, feeding me, laughing and crying with me, and loving me. To my sister, Ariel: thank you for being one of the best friends I have ever known. I adore you. To my sister, Bethany: your journey is only just

beginning. Thank you for giving us another chance. To my sister, Danielle: thank you for making space for me in your life even when you plenty of reason not to. I appreciate you more than you know. I cannot imagine completing this degree without the neverending support of my amazing mother- and father-in-law, Bev and Ron Johnson. Thank you for loving my children and taking care of them when I needed to work, when I needed a break, and when you just wanted to see them. To my three wonderful children, Logan, Gideon, and Liam. Thank you for being patient when Mommy had to work instead of playing with you. Thank you for telling me how proud you are of me and bragging to people about how "My mommy is an archaeologist." Making you proud has easily been the greatest achievement of my life. I hope that each of you pursues whatever dreams come to you and that I can be as supportive of you as you have always been of me.

Last but not even close to least, I want to thank my husband, James, whose unwavering support has made this dissertation possible. You never flinched when I told him I wanted to leave my full-time job and move our family to a new city so that I could get a PhD that may or may not result in a better job. You understood that it was a dream of mine, and that was all you needed to know to sign off on it. When I needed to travel for fieldwork, conferences, or training, you made sure I had everything I needed before, during, and after those trips without question or complaint. Thank you for being a wonderful partner and an even better example to our children. They have seen you support me in ways that I never thought possible, and for that, I will always adore you. You always say that you would follow me anywhere, and you always have. To the next adventure, my love.

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CHAPTER 1

USING TINY ARTIFACTS TO ANSWER BIG QUESTIONS: INTRODUCING STONE TOOL PRODUCTION, SOCIAL DIFFERENTIATION, AND MULTI-AGENT SYSTEMS AT TAMARINDITO

Introduction

When most people think of the Maya, they imagine stunning, forest-filled horizons dense with gigantic pyramids, palaces adorned with beautifully carved images of Maya rulers and gods, stelae covered in detailed hieroglyphic texts, and most recently, depictions of the Maya calendar. Handheld artifacts recovered from these contexts, including intricately painted pottery, carved figurines made of ceramic and/or jade, and lifelike human masks, are also highly revered and coveted. Though these contexts and artifacts are of great importance to Maya archaeology and contribute a great deal to our understanding of the lives of Maya elites, religion, and political organization, these items reveal little about the activities associated with the daily lives of Maya residents living outside the royal palaces, who comprised the overwhelming majority of Classic Maya society. If we want to illuminate the activities of Maya non-elites, the materials used both within and outside residential households must also be carefully examined and analyzed to paint a fuller picture of Classic Maya society.

The humid tropical Maya climate limits our opportunities to engage with many of these materials, however. Due to their perishable nature, many household materials simply do not survive in the archaeological record, making it difficult to reconstruct residential activities. On the other hand, stone artifacts, such as obsidian and chert, are virtually indestructible and would have been used by nearly all members of Maya society for a plethora of activities, making these implements ideal for examining multiple facets of ancient Maya life. Moreover, because of the sheer number of lithics recovered at archaeological sites, the analysis of stone tools offers key advantages over other (often more popular) material culture, such as ceramics and grand architecture, including the ability to collect and analyze large quantities of lithic debitage. Thus, the analysis of stone tool production has the potential to elucidate not only the activities that were taking place within and outside non-elite households but can also lead to a deeper and more nuanced understanding of Classic Maya economies, including who controlled certain aspects of stone tool production, such as technical or ritual knowledge, and the motives and choices of producers and non-producers alike.

To effectively reconstruct Classic Maya economic systems, this study relies heavily on microdebitage as a representation of stone tool production. The Classic Maya manufactured stone tools for a variety of reasons, including daily domestic tasks, trade for needed goods, and ritual activities, and each of these types of production leaves a distinct trace in the archaeological record (though that trace may admittedly be difficult to identify). Maya archaeologists have typically relied solely on the presence of stone tools and macrodebitage (measuring > 6 mm) to identify areas where stone tools were manufactured. Though these artifacts are certainly the result of stone tool production, relying solely on these assemblages is problematic because these artifacts are large enough to be easily moved through cleaning, sweeping, and natural post-depositional processes, such as erosion, animal disturbance, and bioturbation (Bertran et al. 2012; Gifford-Gonzalez et al. 1985; Homsey-Messer et al. 2016; Stafford 1995).

Because microdebitage is more resistant to post-depositional movement than larger macroartifacts or tools, which are rarely recovered in their original location of deposition, microdebitage (measuring < 6 mm) is a much more appropriate spatial indicator of where stone tool production was taking place, especially when combined with the presence of macrodebitage and stone tools themselves. Examining living spaces within and outside of structures is also essential. Following Scott (1985, 1990), Robin asserts that household archaeology exposes so-called *hidden transcripts,* or "the social perspectives developed by members of society through their living experiences," invisible through *public transcripts*, "the overt and public representations in writing, art, and architecture of society's dominant groups, which may not "represent" the living experiences of all members of society." (Robin 2003:59). As such, these artifacts may identify areas of primary stone tool production that have traditionally been rendered archaeologically invisible, further uncovering invisible processes such as economic activities taking place within households, social and economic relationships between households, and networks of technical and/or ritual knowledge.

Thus, as the material product of lithic production remaining primarily in the location where that production first took place, the analysis of microdebitage allows for the identification of repeated production behaviors across space and time, thus rendering visible many of the types of production taking place within individual households and across the site of Tamarindito. In doing so, this dissertation illuminates multiple overlapping economic systems taking place simultaneously while contributing to the greater goal of maintaining the overall economic well-being of the residents living within Tamarindito. In this way, this research complements and expands upon previous studies concerning Maya social structure and the study of stone tool production by: 1) rethinking agency in multi-agent systems in which individuals interact, observe, and trust one other; 2) re-evaluating ritualized production as the result of multi-agent systems; 3) demonstrating the potential of microdebitage as an important resource in revealing site-wide and household dynamics that larger artifacts render invisible; and 4) providing the basis for a more robust future understanding of ancient Maya economies. In the following section, I provide background information for Tamarindito, previous archaeological studies that have been conducted there, and the rationale behind examining stone tool production at this site.

The Classic Maya Capital of Tamarindito

Overview of Investigations. Located in the Petén region of Guatemala (Figure 1.1), Tamarindito served as capital of a Classic Maya kingdom from 400-800 AD. Tamarindito was first discovered in 1958, and mapping of the site began in 1984. Excavations began in 1990 as part of the Vanderbilt Petexbatun Regional Project (Demarest 2006; Houston 1993; O'Mansky 2007). Fieldwork continued through 1994 in the site center and adjacent residential groups (Valdés et al. 1994). Excavations ceased until 2009 with the initiation of the Tamarindito Archaeological Project co-directed by Markus Eberl of Vanderbilt University and Claudia Vela of Colegio Evelyn Rogers in Guatemala. This project has focused on the Late and Terminal Classic non-elite residential groups (Eberl 2014; Eberl and Vela González 2016). The site includes two main plazas (A and B) situated atop adjacent hills (Figure 1.2).

Brief History of Tamarindito. Plaza A was constructed during the Early Classic period and includes seven plazas with palaces, a temple pyramid, and uncarved panels (Eberl 2014; Eberl and Vela González 2016). Studies of hieroglyphic inscriptions indicate that Plaza A was the seat of power during the fifth and sixth centuries, while Plaza B, located approximately 400 meters southwest of Group A, became prominent in the Late Classic Period (seventh and eighth centuries) and was likely the seat of the ruling lineage at Tamarindito that reigned until 762 AD (Eberl and Vela González 2016; Houston 1993). The extent to which Plaza A continued to be occupied during the Late Classic is not completely understood, though many of the residential groups to the northeast of Plaza A contain Late Classic components. All excavated residential groups west and southwest of Plaza B (including all locations sampled for this project) were occupied during the Late Classic Period, the height of occupation at Tamarindito.

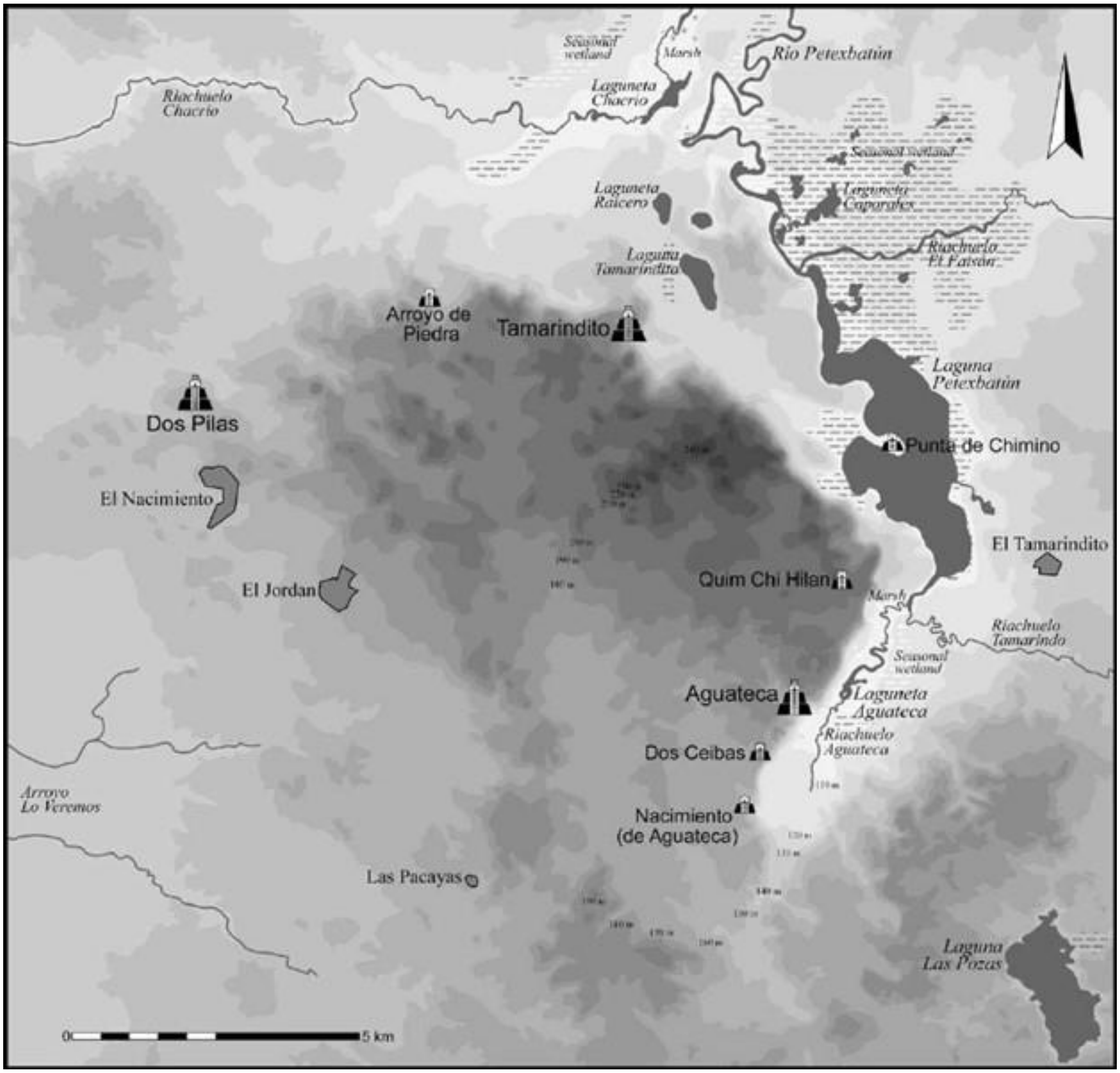

Figure 1.1 Regional Map showing Location of Tamarindito (map by Markus Eberl)

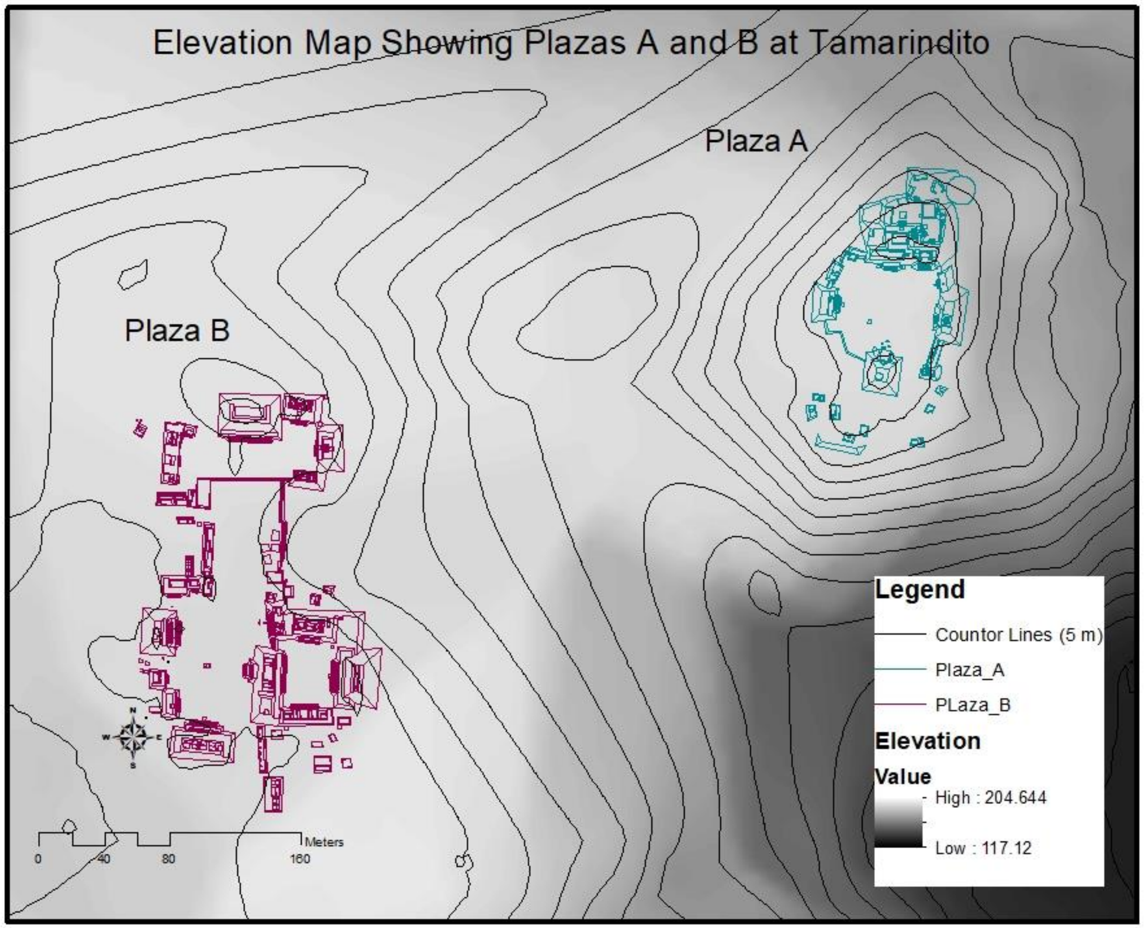

Figure 1.2 Elevation Map of Tamarindito showing Plazas A and B

Regional Importance. Tamarindito is located within the Petexbatun region, which comprises the portion of the Department of Petén that is situated between the Pasión River to the east and the Guatemala-Mexico border to the west. This area is rich with archaeological remains from throughout the Classic Maya period (600-800 AD) and was extensively surveyed between 1989 and 1996 by the Petexbatun Regional Archaeological Survey, directed by Arthur Demarest and Juan Antonio Valdés (Demarest 1997, 2006; O'Mansky 2007), resulting in the identification and mapping of several important Maya centers. Most of these date to the Late Classic period (ca. AD 600-800), which is widely considered to be the height of Maya political power. These sites primarily include Dos Pilas, Aguateca, Punta de Chimino, Nacimiento, Arroyo de Piedra, and Tamarindito.

The central location of Tamarindito in the Petexbatun region of the Maya lowlands allows for the regional comparison of intra- and intersite economic strategies between Tamarindito and other polities. This project is especially well-suited for comparisons with Aguateca and Ceibal (lying outside the Petexbatun region), where stone tool economies have been intensively studied (Aoyama 2009; Aoyama et al. 2017; Inomata 2001). For each of these sites, chert is ubiquitous within a few kilometers of the area (Aoyama 2009), while obsidian had to be imported from non-local sources hundreds of kilometers away, signaling at least partial elite control of this exchange. The proposed research will compare the interplay between chert and obsidian production on social structure and division of labor at Tamarindito, which can then be compared with these regional stone tool economies.

Socioeconomic Differentiation at Tamarindito

Because Tamarindito served as a royal capital during the Late Classic period, this site is ideal for examining social differentiation during the so-called height of Maya civilization. Late Classic Maya capitals are understood as having a hierarchical political system with Maya kings ruling over the entire polity and having control over numerous resources, while "commoners" have the very least amount of power and resources. Within Tamarindito itself, multiple lines of archaeological evidence demonstrate that the residents were socially and economically stratified, supported by the exceptional number of residential contexts that have been excavated within the site. Tamarindito is one of the few sites in Guatemala where non-elite households have been excavated on such a grand scale. Of the approximately 60 residential groups identified, 43 have been mapped and test-pitted, along with both plazas (Figure 1.3). Through these excavations and subsequent analyses (Eberl and Vela González 2016), the following data have been used to illuminate socioeconomic differentiation at Tamarindito: 1) the construction volumes of residential groups; 2) the distance of residential groups from the elite plazas; and 3) differences in the cutting edge-to-mass (CE/M) ratios of obsidian blades found within each context.

Architectural Representations of Wealth and Status. At Tamarindito, residential groups tend to be spatially separated from neighbors and to contain functionally differing buildings, including residences, shrines, and kitchens. Each likely contained a distinct household and – judging from similar patterns in ancient Mesoamerica – served as the basic social unit (Eberl 2014; Monaghan 1996; Robin 2003; Wilk and Ashmore 1988; Wilk 1983; Wilk and Netting 1984). As such, I regard residential groups at Tamarindito as discrete households, with each structure playing serving a specific function within that household. By measuring the volume of the construction materials used to manufacture these households, archaeologists have

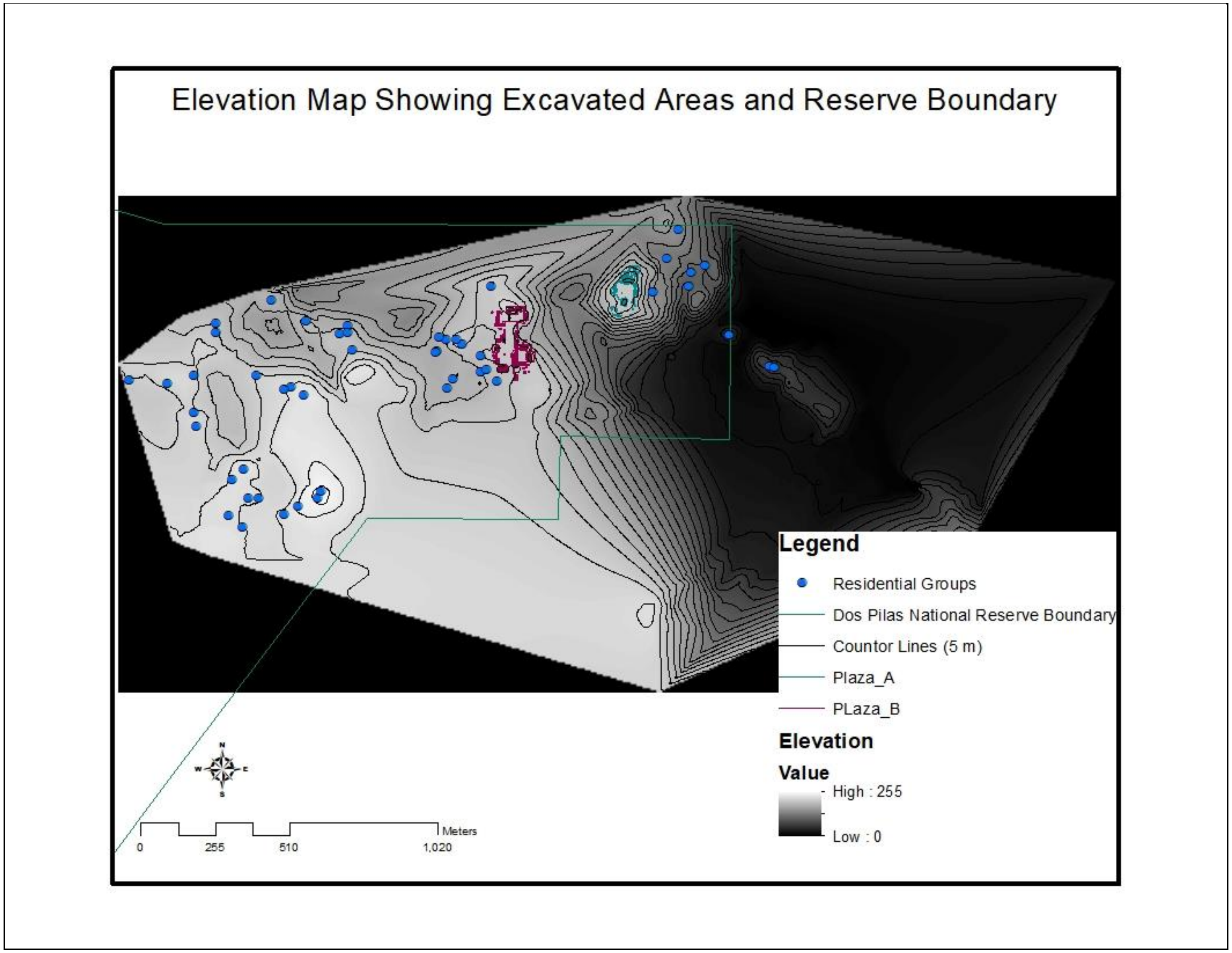

Figure 1.3 Elevation Map Showing the Locations of Plazas A and B, Excavated Residential Groups, and the Boundary of the Dos Pilas National Reserve

been able to measure the relative status and political power of individual households within Maya archaeological sites (Abrams 1994; Chase 2017; Eberl and Vela González 2016; Webster and Kirker 2015), and this has been deemed one of the simplest and most straight-forward methods for establishing wealth hierarchies. Architectural remains serve as a proxy for time and labor invested into procuring the materials needed, manufacturing any needed parts, and the construction of the building itself (Abrams 1994:2).

To establish the socioeconomic status of each residential group excavated at Tamarindito, construction volumes were measured for each group and compared to that of Plazas and B by the TAP (Eberl and Vela González 2016). Construction volumes for excavated groups at Tamarindito range from 4.9m^3 to 266m^3, while the construction volume for Plaza B (which would have been contemporaneous to the vast majority of household groups) measured 15,970m^3. This demonstrates that those residing in the plaza were able to commission greater amounts of materials and labor for building their residences, which equates to their status as elites. Conversely, the relatively small construction volumes of houses outside the plaza demonstrate that these residents did not have the same access to resources or labor. Further, there is also a large disparity between the households themselves, with the largest residential being 54 times larger than the smallest residential group, further stressing the increased access to resources, including building materials and potentially servants to assist in running the household. Living closest to the plaza also likely signaled high social status, as these households were closest to the royal residences.

Residential groups are also spatially dispersed along the landscape of Tamarindito, primarily to the southwest of Plaza B. Distances between these residences and Plaza B vary from 57.6 meters (5TQ-b) to as far away as 1.33 km (5OR-b). Both metrics (construction volume and distance-to-plaza) are considered to be measures of political status and wealth, and in order to test whether the volume of residential groups decreases as groups get further from the plaza, I conducted a Pearson correlation test using the statistical software R. The results indicate that these two variables are moderately negatively correlated, $r = -.35$ $p < 0.026$, and this correlation is statistically significant. This demonstrates that as residential groups at Tamarindito get further away from Plaza B, the construction volume tends to decrease. Further, though we only see a moderate correlation here, these distances do not represent the paths that may have been taken from the plaza to each residence, which may have made some of these distances even longer, thus increasing the correlation.

The Relationship between Social Differentiation and Stone Tool Production at Tamarindito

Tamarindito is uniquely suited for an analysis of Maya stone tools production for several reasons. In addition to having a large number of excavated households to pull data from, the construction of house floors at Tamarindito makes the site particularly amenable to microdebitage analysis. Unlike many other Maya sites where household and plaza floors were covered with stucco, little evidence of this has surfaced during excavations at Tamarindito (Eberl and Vela González 2016). For example, at the site La Trinidad (also located in the Petén), micromorphological analyses of stucco floors in both elite and sub-elite contexts revealed that no microartifacts had infiltrated the stucco floor (Spensley 2004:9). Instead, plaza floors at Tamarindito were likely made of gravel covered with smoothed soil (Eberl, personal communication, 2018). Because of this, microdebitage would have migrated more easily into floors (and preserving in the archaeological record), whereas in thick stucco floors, debitage would have become stuck at the surface, making it highly visible and more easily removed or swept away.

CE/M Ratios as Wealth Indicators. The TAP also calculated CE/M ratios for obsidian blades recovered from residential groups and averaged these ratios for each household (Eberl and Vela González 2016:134). Developed by Sheets and Muto (1972), greater CE/M ratios generally equate to a longer use-life for the tool and are also considered to demonstrate standardization of obsidian blade production. Basically, the longer the cutting edge, the greater the use life of the tool. In this way, wealth and status differences between households can also be gauged based on CE/M ratios such that wealthier households that had greater access to obsidian should have lower CE/M ratios because these households would have had less need for efficiency. Conversely, households that had limited access to obsidian would have needed to conserve these resources, leading to higher CE/M ratios.

During the Classic Period in Mesoamerica, average CE/M ratios from sites in the Maya Lowlands (5.73 cm) are significantly higher than average CE/M ratios for the Maya Highlands (3.52 cm) (Table 1.1) where the primary obsidian sources are located (Sidrys 1979:595). This difference has been attributed to the need for efficiency due to the long distances that obsidian had to be transported from sources located in the Maya Highlands to sites in the Maya Lowlands (Eberl and Vela González 2016; Inomata 2009; Sheets and Muto 1972). Because Tamarindito is located over 200 linear km from the nearest obsidian source, it is assumed that the CE/M ratios of blades recovered from the site would be relatively high.

Table 1.1 Cutting Edge/Mass Ratios Calculated at Classic Maya Sites

Site	CE/M Ratio (cm/g)	Citation
Cancuen	2.87	Kovacevich 2006
Ceibal	3.74	Sidrys 1978:150-152
Tikal	4.08	Sidrys 1978:150-152
Altar de Sacrificios	4.55	Sidrys 1978:150-152
Piedras Negras	5.15	Sidrys 1978:150-152
Aquateca	6.75	Inomata 1995:565
Tamarindito	6.8	Eberl and Vela Gonzalez 2017:134
Nacimiento and Dos Ceibas	7.42	Eberl 2014:249-253

For excavated residential groups at Tamarindito, the average CE/M ratio is 6.8 cm/g (Eberl and Vela González 2016:134), significantly higher the average reported for Lowland sites by Sidrys (1979). Compared to other Late Classic sites within and outside the Petexbatun region, CE/M ratios at Tamarindito are higher than at Altar de Sacrificios (4.55 cm/g), but match Aguateca (6.75 cm/g) almost perfectly (Eberl and Vela González 2016:134; Inomata 1995:565; Sidrys 1979:595). Two other small sites within the Petexbatun, Nacimiento and Dos Ceibas, report a higher CE/M ratio of 7.42 cm/g (Eberl 2014:249-253). These ratios are in stark comparison to the average CE/M ratio of 2.87 cm/g recorded for Cancuen, a Late Classic polity located just south of the Petexbatun region (Kovacevich 2006:301), whose strategic position between the highlands and the lowlands allowed for access (and at times, control of) obsidian trade routes (Demarest et al. 2014). Ceibal lies approximately 13 km north of Cancuen along the same river and produced an average CE/M ratio of 3.74 cm/g, meaning that Ceibal also likely benefited from the obsidian trade routes along this river. Thus, it would appear that Tamarindito's geographic position further from riverine trade routes made it more difficult to obtain obsidian resources during the Late Classic period and thus would have needed to make their obsidian resources last as long as possible.

CE/M ratios can also be used to examine intrasite obsidian distribution and patterns of wealth. For example, the majority of obsidian blades recovered at Tamarindito are from Residential Group 5PS-d. Even so, Figure 1.4 demonstrates that Residential Group 5PS-d did not average the highest CE/M ratios at Tamarindito, suggesting that this household had a lesser need for efficiency compared to many other residential groups. This is counterintuitive, however, this household, which is located over a kilometer from Plaza B, was a relatively low-status residence.

For excavated residential groups at Tamarindito, CE/M ratios range from 0 (at 5PR-b where no obsidian blades were recovered) to 14.7 cm/g (at 5PQ-a). Interestingly, a Pearson correlation test failed to demonstrate a correlation between CE/M ratios and either construction volume ($r = -.078$, $p < 0.63$) or distance to the plazas ($r = -.072$, $p < 0.066$). Thus, even though construction volumes and distances from residential groups to Plaza B demonstrate a negative correlation that likely represents decreasing wealth and status as residences get smaller and further away from the elite plaza, CE/M ratios at Tamarindito suggest that obsidian blades were not distributed according to political status or wealth, a supposition that is supported by the vast majority of obsidian blades being recovered from a non-elite residence located 1.1 km from Plaza B at Tamarindito. This raises interesting questions surrounding the relationship between stone tool production, status, wealth, and the agency of stone tool producers.

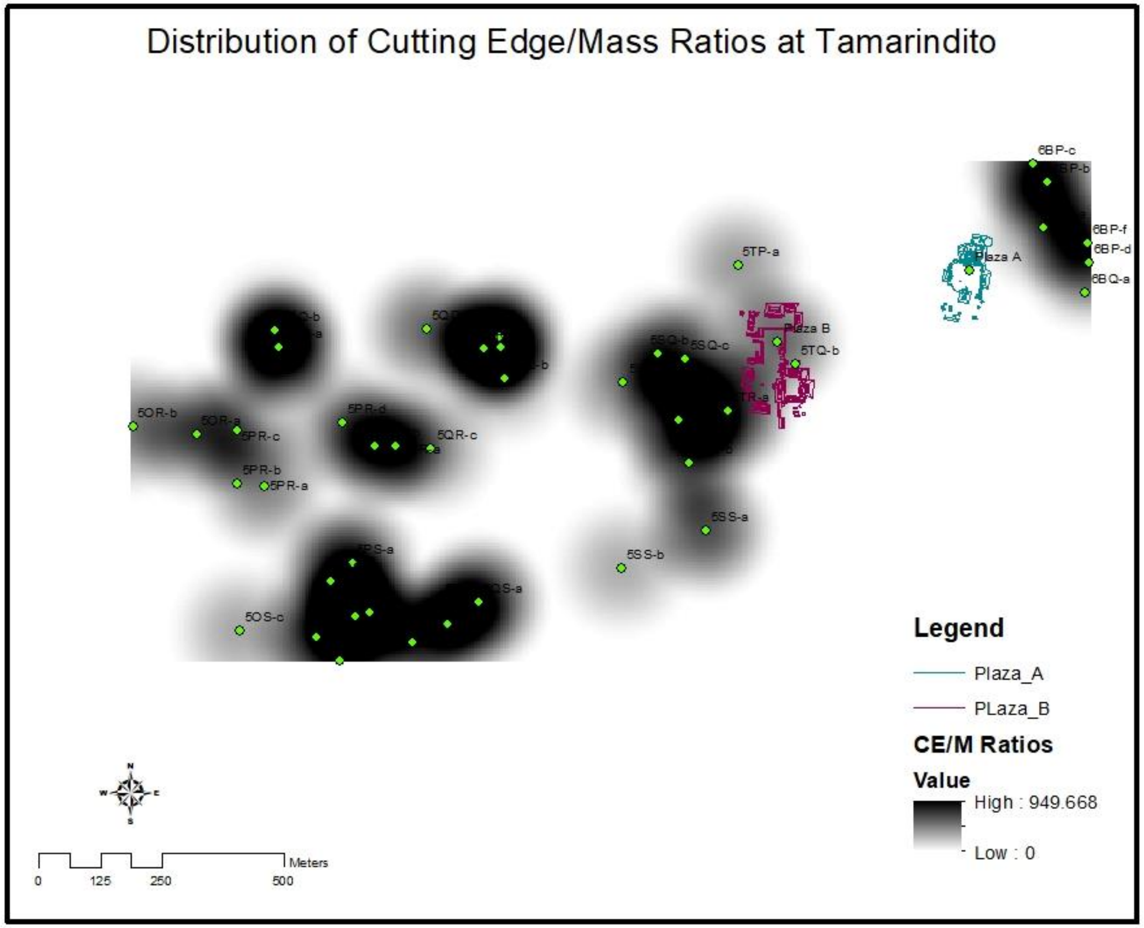

Figure 1.4 Density Map of Average Cutting Edge/Mass Ratios for Obsidian Blades Recovered at Tamarindito

Regional Understandings of Classic Maya Stone Tool Production

Though Maya stone tool production practices have traditionally been undervalued and understudied, more recent analyses at several Classic Maya polities have led archaeologists to agree that there is no standard protocol that explains how the Maya produced stone tools, as is true of many economic, social, and political aspects of Classic Maya life. "Even between communities lying only a few km apart, the historical trajectory, and the social, political, and economic organization of commoner settlements can be quite different (Robin 2003:61). Some sites boast extensive chert workshops, such as evidenced at Colha, while others appear to produce no significant chert tools outside those manufactured for immediate household use.

Obsidian tool production becomes even more complicated, with sites such as Cancuen producing massive amounts of blade cores to be distributed across the region. Still, no regional analyses of Maya stone tool production have been undertaken. In the present section, I review the most significant analyses of Classic Maya stone tool production conducted at a handful of Classic Maya centers. Though this discussion is from from comprehensive, these examples represent many of the most significant undertakings concerning Maya stone tool production and illustrate the vast differences between these studies. The contexts in which stone tool production was examined varies greatly between elite and non-elite contexts, obsidian and chert production, and other factors, but what is most evident is that none of these examinations consider sitewide lithic production strategies.

Currently, the best evidence for household stone tool production comes from the rapidly abandoned Maya sites of Cerén, in El Salvador, and Aguateca, in Guatemala. Cerén was buried circa 600 AD by the eruption of the nearby Loma Valdera volcano (Sheets 1992), while Aguateca was burned to the ground during a Military attack in circa 810 AD (Aoyama 2009;

Inomata and Triadan 2014; Sheets 2000, 1992). Because of these sudden catastrophic events, evidence regarding daily activities was preserved within households at both sites as the cities were rapidly abandoned. Even so, only a handful of households have been examined at each site.

Cerén. At Cerén, Sheets (2000) examined household production at only four households (three non-elite and one elite). Sheets divides household economic activities at Cerén into three categories: 1) items produced for household consumption; 2) items produced to be traded with other households; and 3) exchange of surplus items for items controlled by the elite. Interestingly, the third of these is the only category that involves any sort of elite control. "Every household excavated so far at Cerén produced at least one commodity in excess of what they needed within the household, and presumably that surplus was exchanged within the village for the commodities other households over-produced from their part-time specializations" (Sheets 2000:218). Obsidian was procured from this type of exchange and, even though it has traditionally been considered a luxury good, was recovered two of the three non-elite households excavated. Though these analyses provided crucial insights regarding daily activities and the general economy, this small sample is not necessarily representative of all potential household economic situations.

Aguateca. In contrast to the research at Cerén, which focused primarily on non-elite households, Aoyama (2009) examined elite contexts at Aguateca. Chemical composition of obsidian from Aguateca demonstrates that residents imported 96 percent of obsidian from the El Chayal geological source. Obsidian was imported primarily as polyhedral cores, which would have been knapped into prismatic blades on site. Aoyama suggested that elite craftspeople may have manufactured prismatic blades near their residences. Interestingly, however, no workshops or workshop dumps indicative of obsidian blade production have been recovered at Aguateca.

This may suggest that these activities occurred primarily in non-elite contexts, but further research, especially involving microdebitage analysis, is necessary to test this theory.

Evidence for Stone Tool Production at Tamarindito

Since the initial excavations began in the 1990s with the Vanderbilt Petexbatun Regional Archaeological Project, little evidence of intensive stone tool production has been recovered at Tamarindito. Most household excavations have uncovered a handful of chert and obsidian tools, most of which are considered to have been common utilitarian objects required to complete household tasks. Investigations undertaken primarily by Juan Antonio Valdés uncovered evidence for a potential exception. A possible lithic workshop was uncovered at Residential Group Q6-2 (as named during the Petexbatun Regional Archaeological Project), located northeast of Plaza A. Because this group was not reinvestigated by the TAP, the following description is based on descriptions provided by (Emery et al. 1994:53–58) and (Valdés 1997:329).

Ceramics found during the 1994 excavations date this group firmly to the Late Classic period. This group consists of three structures located on the north, west, and south sides of a rectangular plaza. The westernmost structure (Q6-8) was built slightly into the hillside and opens up to the horizon and scenic views of the Lagunas Tamarindito and Petexbatun to the east. Because of this, Emery and her co-authors suggested that this was the most important of the three structures. Within this structure, a burial was uncovered of a male, aged 20-35, covered in a layer of obsidian and chert flakes. The teeth are reported to have been in excellent condition with no caries observed. This discovery, combined with the proximity of this group to Plaza A and the panoramic view associated with the location of this structure, suggest that this occupant was likely of an elite status (Emery et al. 1994:54). The only other known burial at Tamarindito to have included a similar layer of lithic debris is that of *Aj Ihk' Wolok*, the last independent King of Tamarindito, buried in Plaza B (Eberl et al. 2019; Eberl and Vela González 2016; Gronemeyer et al. 2013:329; Valdés 1997).

Though Emery and her colleagues do not suggest that a workshop existed in Group Q6-2, Valdés (1997) suggests that the inclusion of lithic debris within Burial 4 may indicate that this group was occupied by lithic artisans who manufactured lithic tools for the elites of Tamarindito. Lithics of this quantity have only been observed in royal tombs in the Maya Lowlands, such as at Dos Pilas, Tikal, Uaxactun, Caracol, and Altar de Sacrificios (Valdés 1994). Valdés seems to suggest that perhaps the occupant of this burial was actually a high-status lithic specialist and was thus buried with these lithics to honor his occupation in life.

TAP excavations conducted between 2009 and 2014 produced a total of 7,814 obsidian (n=688; 1771.5g) and chert (n=6,730; 396.3kg) artifacts. Obsidian artifacts include prismatic blades (n=536; 77.9 percent), debitage (n=87; 12.6 percent), cores (n=36; 5.2 percent), and unidentifiable obsidian artifacts (n=29; 4.3 percent). The overwhelming majority of these were recovered from Residential Group 5PS-d, where excavations produced 75.7 percent of all obsidian (Eberl and González 2016:135) and 15.4 percent of all chert recovered during TAP excavations at Tamarindito.

Research Questions

This project will explore the effects and outcomes of stone tool production in multi-agent social systems by exploring the following two questions: **1) How are power differentials produced within multi-agent production systems?** and **2) Who was involved in the**

production of stone tools, and how were these relations structured? Question 1 will elucidate sitewide exchange systems, while Question 2 will elucidate ritualized knowledge within households.

Question 1. This question focuses on site-wide differential production by examining how power structures emerge with and alongside household-organized production, which results in particular systems of labor division. To address this question, I will compare construction volumes and distances of households from the plazas to artifactual data collected during excavations at Tamarindito and microdebitage data collected during the current project. I propose three production scenarios (self-sufficiency, community exchange, elite control) at Tamarindito. These scenarios are similar to those identified at Cerén by Sheets (2000) and loosely follow Braudel's (1992b) three-level model of the economy. I expand on the Cerén study, however, by substantially increasing the sample size (39 households at Tamarindito vs. four households at Cerén) and by examining how agency, choice, and dependency factored into each of these scenarios. For this question, I proposed three hypotheses:

Hypothesis 1) Households become self-sufficient.

Hypothesis 2) Egalitarian household relationships result in community production and exchange.

Hypothesis 3) Unequal power relationships result in elite control of production. In this scenario, specialists are controlled by elites who consume and distribute the surplus of goods produced by specialist households.

Question 2. Who was involved in the production of stone tools, and how were these relations structured? Building off Question 1, this research question asks whether the technical expertise required to manufacture stone tools was available to all social groups of society. Depending on the structure of the household economy (self-sufficient, egalitarian, elite-driven), social constraints may have affected producers differently. If technical knowledge was not equally distributed, competition may have driven producers, especially obsidian blade specialists, to hide their technical knowledge from competitors. To address this question, I will compare spatial distributions of chert and obsidian microdebitage among households at Tamarindito. For this question, I have two hypotheses:

Hypothesis 1) Competition for technical expertise required for obsidian blade production led to secret knowledge and the development of ritualized production.

Hypothesis 2) Technical knowledge required to manufacture obsidian blades was not secret.

Theoretical and Methodological Contributions

Theoretical Significance. Historically speaking, archaeologists studying Classic Maya economies have focused on Western ideas of economy that center linear, capitalist trajectories of goods, flowing neatly from acquisition to consumption (Aoyama 1994, 2009; Clark 1987; Gaxiola and Clark 1989; González Arratia and Mirambell 2005; Hester and Shafer 1991; Hirth and Andrews 2002; Hirth 2003, 2006; Hruby 2011; Mcfarlane and Schortman 2017; Spence 1981). Because this model assumes a top-down approach that centers elite control over these processes, however, parallel economies that are likely taking place within other socioeconomic levels of Maya society are overshadowed. In order to make room for multiple economies powered through the agency and strategies of producers at all levels of Maya society, we must begin to rethink Maya economies as dynamic and non-linear.

By examining the motivations involved in choosing where different types of production take place, this dissertation demonstrates that ritualized production cannot be explained entirely by cultural norms. Instead, I argue that ritualized production is the logical outcome of a multi-agent production system wherein multiple agents compete for the technical knowledge required to specialize in the manufacture of specific goods. In this way, production cannot be separated from ritual (Monoghan 1998), thereby illuminating how competition for technical knowledge requires producers to involve seemingly unnecessary steps, such as chants, prayers, etc., in the production chain to further distance the means of production from their neighbors.

Methodological Significance. Excavations at Classic Maya sites have focused largely on elite contexts, such as plazas, palaces, and elite residences. The few research programs that have excavated households suggest that residents curated and removed most of the durable goods prior to abandonment, leaving little obvious evidence of lithic production (Aoyama 2007; Feinman and Nicholas 2004; Healan 1986; Hirth 2006; Santley and Hirth 1993). The cleaning of floors, which might include putting down a sheet prior to stone tool production or sweeping the floors after, removes the majority of microartifacts created during these processes. As such, the presence of these artifacts in a specific location is not an accurate representation of in-situ activities that may have occurred there (Clark 1986, 1991; Deal 1985; Manzanilla and Barba 1990; Schiffer 1972, 1976; Seymour and Schiffer 1987). As such, microdebitage has a marked advantage over other artifact classes to identify primary areas of stone tool production, which has the potential to reveal otherwise invisible social contexts.

Though the potential for microdebitage analysis to contribute to theoretical models of stone tool production has been well demonstrated, microdebitage remains a relatively untapped data source in archaeological research, especially in Mesoamerica. This is primarily due to the extensive time and labor associated with collecting, identifying, sorting, and counting microdebitage (Johnson et al. 2021; Metcalfe and Heath 1990; Sherwood et al. 1995). Though I only analyzed 50 samples from a single residential group, this ranks among the largest studies of microdebitage in archaeological research to date. To alleviate many of these issues, I apply Dynamic Image Analysis (DIA), an innovative method for analyzing soil and stone particles, to the analysis of soil samples taken from Residential Group 5PS-d at Tamarindito. In our pilot study (Johnson et al. 2021), my colleagues and I demonstrated that DIA is capable of differentiating between soil and lithic particles using three-dimensional measurements taken using a PartAn 3D analyzer. Most importantly, DIA reduces the time needed to count and sort microdebitage from soil samples by up to 98 percent while also taking 40 additional variable measurements that are virtually impossible to take manually. Thus, not only does this dissertation expand applications of microdebitage analysis in examinations of stone tool production, but it also exemplifies the potential to significantly expedite the analysis of microdebitage while also increasing the accuracy and robusticity of the data.

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Organization of Dissertation

My dissertation is divided into seven chapters. Chapter 1 sets up my research questions by describing previous archaeological work completed at Tamarindito and situating that work within a methodological and theoretical context. Chapter 2 defines the theoretical framework of the dissertation, wherein I expand upon the concept of multi-agent systems through an analysis of how this model can be applied to Classic Maya economies. Chapter 3 details the contributions of lithic analysis, primarily microdebitage, to our understanding of Classic Maya economies and, more specifically, agent-based production systems. Chapter 4 discusses my methodological approach with a focus on the collection and analysis of soil samples and microdebitage from a range of socioeconomic contexts at Tamarindito. Chapter 5 present the results of the microdebitage analysis, including a comparison of traditional methods with Digital Image Analysis. Chapter 6 discusses the implications of the results, detailing how the analysis of stone tool production across the site contributes to our understanding of a multi-agent production system at Tamarindito, how that differs from previous understandings of Maya economies, and comparing these results and interpretations with those from similar polities in the Petexbatun region and beyond. Chapter 7 summarizes the research questions, results, implications, and limitations of the study and presents potential pathways for future research.

Conclusion

In sum, this dissertation contributes an innovative and interdisciplinary approach to the study of stone tool production, social structure, and ancient economies. Through the incorporation of traditional and innovative archaeological methods, this study offers novel theoretical and cutting-edge methodological approaches to our understanding of Classic Maya production system and advances archaeological knowledge of the ways that multiple agents influence social structures while simultaneously being constructed by them.

CHAPTER 2

(MORE THAN) ONE ECONOMY TO RULE THEM ALL: MULTI-AGENT PRODUCTION SYSTEMS IN CLASSIC MAYA ECONOMIES

Introduction

Traditional analyses of Classic Maya economies have often employed singular models that flow linearly through acquisition, production, consumption, and distribution. These models are largely born from modern, Western notions (related to the idea of the nation and top-down government of society) that assume one overarching economy without acknowledging economic models that incorporate multiple economies. Focus on Maya economies has increased dramatically since the 1950s, and this work has demonstrated unique economic strategies were employed between polities, meaning that there was not one single overarching economic model that can explain the production and flow of goods at all sites across the Maya region. Though intersite economic variation has been established, little research has been done to examine intrasite economic variation during the Classic period. This can be primarily attributed to the lack of extensive household and sitewide excavations covering the entirety of the site. Instead, most Maya research programs have instead focused heavily on specific areas within the site, such as elite plazas and structures or a handful of non-elite residences. Because of this, few Classic Maya research programs have enough excavation coverage across multiple socioeconomic contexts, making it difficult for Maya archaeologists to understand the totality and multiplicity of Maya economies within a single site. As stated by Freidel (2020:12), “we are working, for the most part, with very difficult and incomplete data sets in Maya archaeology."

In the present chapter, I propose using a multi-agent systems model for examining Maya economies that critiques previous assumptions that primarily assume a single economic strategy wherein one group was in control of decisions concerning who manufactured goods and how they were distributed. To view Maya economies as multi-agent systems, however, it is imperative that we abandon Western notions of economy that foreground monolithic paradigms. Instead, it is more advantageous to view Maya economies through the lens of multi-agent frameworks so that multiple nodes of agency and power may be uncovered across the socioeconomic spectrum at Tamarindito. In this way, multiple overlapping economies may be made visible within a single overarching community.

What Makes an Economic System?

Before we examine the idea of multi-agent systems, it is important to first define the concept of an “economic system.” Systems are broadly defined as interrelated or connected pieces working collaboratively towards a similar goal. One commonly used example is the human body, which is made up of multiple parts all working together to keep the body alive and functioning properly. The body is not just one singular system, however, but instead contains multiple smaller systems (muscular, respiratory, nervous, etc.) that each have more specific, local goals, such as keeping the lungs breathing or the heart beating, all of which contribute to the overall goal of a thriving body.

Like the human body, an economic system functions to preserve society and keep it functioning by providing a means for obtaining needed resources and sustaining the lifeways of its members. Several different types of economic models have been defined, such as capitalist, socialist, market-based, and traditional economies, most of which are centered around present-day understandings of economic systems that tend to foreground the notion that only one overarching economic model can exist within a particular society. For example, the United States currently operates within a capitalist economic system, wherein the means of production is privately-owned, and goods are consumed primarily for individual profit (Marx 1964). Within socialist economic systems, on the other hand, the means of production is owned by the community at-large (such as the state, for example), and profits from the sale of goods are redistributed among that community.

These two examples may appear to be in stark contrast to one another, and in many ways, that is certainly the case. In many aspects, these two examples illustrate the dichotomies between the formalist and substantivist economic schools. As defined by Polanyi (1957), the former defines the economy as the allocation of limited resources, whereas the latter views economy as a provisioning of society (Smith 2004). Those who have followed the formalist model argue that ancient and non-Western economies are quite similar to modern capitalist economies. The substantivist school argues against this, however, by asserting that non-capitalist economies (both ancient and modern) are substantially different (Smith 2004:75). Polanyi tended to take a substantivist view, as asserted in the following excerpt:

> "The latter [formal meaning] derives from logic, the former [substantive meaning] from fact. The formal meaning implies a set of rules referring to choice between the alternative uses of insufficient means. The substantive meaning implies neither choice nor insufficiency of means; man's livelihood may or may not involve the necessity of choice and, if choice there be, it need not be induced by the limiting effect of a 'scarcity' of the means" (Polanyi 1957:243).

Choice is an important factor to consider here. In the case of ancient economies, I agree with Polanyi's assertion that livelihoods may or may not involve choice and that this choice does not need to depend on the availability of resources. Instead, I argue that the economic choices of agents may reflect social, cultural, and/or religious factors. Thus, while my research does follow a substantivist view of Maya economies, broadly speaking, I deviate from the "this or that" mentality wherein an economy is either similar to capitalist economies or it is something else altogether. Alternatively, I contend that it was more likely "this" *and* "that" with multiple overlapping economic systems simultaneously at play within a single site or political center. By centering the agency of households that are socially positioned across multiple socioeconomic stations and physically positioned across the site of Tamarindito, this overlap may become apparent.

Centering Actors in Overlapping Economies: A Multi-Agent Theoretical Framework

Moving away from the idea of operating within one singular "economy," multi-agent systems allow for multiple economic systems to co-exist, and possibly even interact without competition, within a single community. The concept of the multi-agent systems within archaeological research stems from agent-based modeling (ABM), originally developed in the field of artificial intelligence. Within ABM, the behavior and reasoning of goal-oriented agents occupying and making decisions within a specific environment is simulated in order to better understand responses to specific environmental changes and stimuli or agent-based actions (Epstein and Axtell 1996; Ferber 1999; Lake 2014). In this way, the wants, needs, and/or motives of individual actors or groups of agents can be simulated to assess human or environmental responses to these choices.

Defining Multi-Agent Systems Archaeologically. Though it can be difficult to see past our modern notions of economy, in many times and places throughout prehistory, there was likely more than one type of production happening within a single community, or archaeological site, at a given time, and these different types of production may be missed when looking through the lens of a unidirectional theoretical framework. Thus, the use of a multi-agent paradigm allows researchers to shift the focus away from identifying singular economic categories and to examine production from the viewpoint of the various actors involved within all levels of society, leading to a fuller picture of Classic Maya production systems, and in turn, Classic Maya economies as a whole.

Though the concept of multi-agent systems is a direct product of computational modeling, many of the same laws that regulate these computational systems may be applied to real-world systems and agents. This is evident through Wooldridge's (2002) delineation of multi-agent systems, described as following three primary rules:

1) agents are autonomous and at least partially independent;

2) agents have a limited view and understanding of their environment; and

3) no single agent is in complete control of the entire environment.

Although Wooldridge attributes these rules to computational agents within virtual environments, the same logic may be applied to human agents in the real world, or in this case, the ancient past. In the present chapter, I envision how a multi-agent framework might be operationalized for the purpose of envisioning Classic Maya economies as dynamic and multidirectional. This framework moves beyond singular, static approaches through the examination of not only the "assigned" roles of multiple actors, but also the role that agency played in actors defining roles for themselves, from across the socioeconomic spectrum in

Classic Maya society. In the following sections, I use Wooldridge's rules to critique previous theoretical frameworks that impose either unilinear models of Maya economy or focus primarily on only a portion of the population.

Autonomous Agents: Households and the Role of Choice

Agents are autonomous and at least partially independent (Wooldridge 2002). As such, agents can identify and recognize their own self-interests and make decisions that do or do not support those interests. In this way, agents are active, meaning that they either choose to act or choose not to act. This line of thinking does not align with many previous theories, however. For example, the debate between structure and agency questions whether individual agency or structure is of greater importance in the development of societies. Many archaeologists have adopted this theory of structuration to better understand the social complexity of ancient societies, and most of these examples examine how individual agents are shaped by social structures (Barrett 2000, 2001; Dobres and Robb 2000; Dornan 2002; Gardner 2004; Joyce and Lopiparo 2005).

Moving Beyond the Structure-Agency Debate. This structure-agency debate is important, but it neglects to conceptualize the role of interactions between individual agents or how the choices made by agents affect these interactions. Instead, this framework suggests that social structure primarily directs the actions and decisions of individual agents. In contrast, multi-agent systems center the interrelationships between the division of labor, structure, and agency and focus on how these elements work congruously in the development of societies, and in the present case, economies. This aligns strongly with Giddens (1984), who argued that individual agency and social structure (or the organization of human beings living and interacting with one another) act as a dialectic, with each bearing equal weight in shaping society. Rather than focusing on who has more control over the outcome, the focus is on the role of social and economic relationships in the creation and maintenance of societal systems.

Between individual agents, economic relationships especially require mutual trust that other agents within the social group will produce goods that you do not, creating a specific type of division of labor that is based largely on the decisions or choices of agents. "Humans are knowledgeable agents. This means that they are not only capable of acting, but that they also reflect on their own behavior and the behavior of others" (Eberl 2017:11). For example, if an agent chooses not to specialize in stone tool production in lieu of another form of production (such as weaving or ceramic production), this agent trusts surrounding households to produce and exchange stone tools necessary to sustain the household. If the other household fails to do so, the agent may choose to act differently. Giddens argues that this knowledge is engaged by actors who "then reflect on the consequences of their actions as they understand them—for they may be at odds with intentions and expectations—thereby reproducing or changing the knowledge and conditions that originally enabled their actions" (as cited by Gillespie 2001:79). Agency in this context then means having the power to decide whether to participate in the manufacture of goods or to decide not to participate, thus becoming dependent on other producers to provide those goods not being made in one's own household.

The Household as Agent. In the present study, I equate individual agents to individual households wherein the members of each household have similar economic motives and interests. Although many definitions for archaeological households have been proposed (Monaghan 1995; Wilk and Ashmore 1988), here I employ Hendon's practice-based definition that describes a household as "a setting in which many groups of men and women not only lived but engaged in activities that affirmed the importance of their household identity and contributed to the social reproduction of the group" (2002:78). This concept of household recognizes that households are not passive, but active members of the community, contributing to and shaping communal identity, social change, and political transformations (Kovacevich 2015). As such, households act as agents when making economic decisions for all members therein. It is critical to acknowledge, however, that economic decisions made on behalf of the entire household may cause unequal benefit or harm to its members, depending on the individual roles of each person. These roles may be defined by factors such as age, gender, and/or occupation, for example. As such, intra-household diversity would have been as significant as the diversity between households, and by interpreting individual households as agents, I do not intend to flatten or render invisible the socioeconomic diversity taking place within each of these households.

Though Maya archaeologists began realizing the potential of household research beginning with Wauchope's work on household groups at Uaxactun in 1938, it would be 50 years later, before household research would begin making a serious foothold, with the publication of "Household Remains of the Humblest Maya" (Webster and Gonlin 1988). From that point forward, Maya archaeologists began to recognize "household archaeology" as a pathway towards understanding the daily lives of the Maya and the contribution this research brings to the overall interpretation of Maya communities (Robin 2002). "As household units are often involved in production, consumption, and/or reproduction, and may have significant symbolic meaning in a society, a household perspective can help archaeologists understand people, their everyday lives, and the external socioeconomic and political roles, impact, integration, and independence in the broader arena of ancient societies" (Robin 2003:51). Over the past three decades, household studies have increasingly focused on revealing the active lives and potentials of commoners (Robin 2003) by focusing on the activities occurring within and outside individual households and the relationships between neighboring households.

Though household research has opened many archaeological doors (both physically and metaphorically) into our understanding of the social, economic, and political similarities and differences between the daily lives of non-elites (Robin 2003; Yaeger and Robin 2004), archaeologists are still not fully accessing the intricate web of social and economic relationships that exist between all members of Classic Maya societies by looking at the differences between households within a single polity. Alternatively, multi-agent frameworks approach Maya economies from multiple socioeconomic angles while focusing on the role of choice among agents, which allows for a more holistic understanding of the role of social structure in the development, elasticity, and sustainability of economic processes.

Looking Beyond the Household: The Limited Worldview of Agents

Agents have a limited view and understanding of their environment (Wooldridge 2002). While agents have the choice to act or not act, these decisions are largely affected by how the agent views and understands their environment. Households are most likely to collaborate and work economically with those households with the least geographical and familial distance, partly because social relationships have already been established and may be easier to maintain, but also because the economic success of nearby households will directly reflect and positively affect the agents within the primary household. Further, the economic decisions of neighboring households are most visible, and the reasoning behind these decisions is most easily understood. In turn, when the familial and geographic distance between households increases, economic decisions become more difficult to discern and eventually become invisible to outsiders. Thus, it becomes impossible for any single agent to have a complete understanding of all the economic decisions and actions taking place across the community.

Ritualized Production. Though this limited worldview may be perceived as an economic disadvantage for most, one way in which households may use this as a social and economic advantage is through ritualized production. Hruby (2007:71) defines “ritualized production” as the method of production, regardless of the ritual meaning (or lack thereof) placed on the end product. Thus, agents can introduce particular methods into the production process that may become required (even if they are unnecessary). In this way, ritualized production differs from non-ritual production in that steps, such as prayers, chants, gestures, or bodily movements, are introduced into the production process that go beyond the “basic necessities” of production (Hruby 2007:70).

These steps then become a critical component of the production process by instilling the objects being created with special properties. By following these steps, this process may then serve as a form of social exclusion wherein certain people are imbued with the knowledge necessary to carry out specific forms of production while others are intentionally not (Hruby 2007). As such, producers may have specific motivations for wanting to not only learn this technical knowledge, but to hide it from others. “The degree to which ritualized production becomes a conscious and politicized act has implications for social and economic organization” (Hruby 2007:72). Thus, having such secret knowledge may come with not only a competitive advantage on the market, but also special status or social privilege.

Thus, agents may inadvertently create a “ritual economy,” described as a hybrid of political economy and agency approaches that combine the analysis of agency, worldview, economy, and power (McAnany and Wells 2008; Wells 2006; Wells and Davis-Salazar 2007).

According to Wells, ritual economy "strikes a balance between formalist and substantivist views by considering the ways that belief systems articulate with economic systems in the management of meanings and the shaping of interpretations" (2006:265). This framework is inclusive of multiple viewpoints, making it useful for understanding and interpreting multiple facets of ancient economies, including the roles of agents from differing socioeconomic backgrounds.

This is especially applicable in multi-agent networks wherein multiple producers may choose to specialize in the same skill or trade. An agent's choice to act (by specializing) can leave the producer vulnerable to exploitation of the technical knowledge required for that specialty or skill. Technical knowledge is a valuable asset that can be transcribed into social power and capital (Dobres 1995, 1999, 2000; Dobres and Robb 2000; Inomata 2001; Kovacevich 2015; Schiffer and Skibo 1987). If several agents choose to specialize in the same skill or trade, this creates competition and potentially limits the possibilities for exchange. In other words, the market may become oversaturated by one product while other products become scarce. This does not necessarily mean that there can only be one household producing each class of goods within a single site, but there should be some physical distance between these producers. In this way, there may be clusters of households, or neighborhoods, where households are supporting one another by specializing in specific industries.

Thus, instead of being primarily governed by universal economic logics/rationality, Maya economies are at least partially constituted by ritual practices. As such, I argue that in multi-agent systems, it becomes advantageous and even necessary for producers to hide specialized knowledge to avoid having it become a liability. In doing so, producers limit competing producers' access to this technical knowledge, thus creating "secret knowledge," many examples of which are found throughout the world (Eberl 2017; Foster 1965; Glover et al. 2018;

Guengerich 2014; Hruby et al. 2007; Knuttson 1999; de Landa 1937; Neupert 2000; Nicklin 1971; Skeaping 1953; Tozzer 1941). As a result, I further argue that the use of ritualized production is not merely the result of cultural norms, but instead is the logical outcome of a multi-agent production system in which multiple households are simultaneously in competition with and dependent upon one another as a result of the limited access each agent or household has economic decision-making taking place across the site.

No One Agent to Rule Them All

No single agent is in complete control of the entire environment (Wooldridge 2002). Because individual agents have a limited worldview, it is not possible for one agent or even a group of agents to have ultimate control over all of the economies operating within a socioeconomically hierarchical society such as the polities of the Classic Maya. As such, previous theoretical models that impose a unilinear ideology of power wherein one group holds all the power, leaving the groups powerless and without agency or choice, simply do not work because it becomes impossible to observe all the economic decisions, interactions, and transactions taking place.

Let us return to the analogy of the human body. In contrast to Spencer (1864), no one system keeps the human body alive. Instead, the body flourishes because all systems work collaboratively. For example, the brain controls the heart by sending signals that tell it to keep beating, but the brain would not be able to do so if the heart were not continuously and simultaneously pumping blood back to the brain. In short, the nervous system cannot control the body's functions all by itself. Instead, each system is kept alive through the collaboration of the other systems. As such, political economy approaches that center the role of elites in controlling the economy, thereby assuming a singular economy within Classic Maya societies no longer makes sense. Such a paradigm creates a commoner/elite dichotomy that distinguishes between those with power (elites) and those without (commoners), and more importantly, ignores the socioeconomic complexity existing within those two groups and across the site.

According to Levine (2014), the vast majority of research devoted to Mesoamerican economies has addressed questions either directly or indirectly related to political economy (Aoyama 1994, 2009; Clark 1987; Gaxiola and Clark 1989; González Arratia and Mirambell 2005; Hester and Shafer 1991; Hirth and Andrews 2002; Hirth 2003, 2006; Hruby 2011; Levine 2014; Mcfarlane and Schortman 2017; Spence 1981). Political economic approaches to ancient Maya economies began to get traction during the 1970s, stemming mainly from Marx (1964), who was interested in understanding and explaining human society through economic relations. Marx viewed class struggle as the result of the exploitation of labor as capital (Marx and Engels 1972). In this view, laborers have little or no control over the means of production or how the end product is distributed. Instead, the bourgeoise hold the power and control production, distribution, and consumption of all goods manufactured (Marx 1964). As a result, elites also hold all wealth produced through these economies, while producers are left with little to show for their efforts. In other words, economic production can be understood by examining 1) those who own the means of production and 2) those who contribute to production with their labor.

Political Economy vs. Household Approaches. While scholarship focusing on political economy has made significant contributions to our understanding of the role of elites in Maya economies, problems with this framework were brought to the forefront once household archaeology become a stronghold in Maya archaeology. Not only does this framework ignore the agency and choice of an estimated 95 percent of the population, but it also assumes that households were able and willing to produce a “surplus” of material goods for the elite to collect and redistribute afterwards. Sahlins (2017) critiques this idea of surplus by suggesting that the production of goods beyond the use of the household or for immediate exchange with neighboring households assumes that households had a viable reason to produce more than needed to sustain their own livelihoods. "Production is under no compulsion to proceed to the physical or gainful capacity, but inclined rather to break off for the time being when livelihood is assured for the time being” (Sahlins 2017:43). Sahlins’ arguments are in alignment with those of Chayanov, who argued against the idea that peasant families would pursue high-yield (and therefore, high-risk) economic strategies unless compelled, or even forced, by the state or in response to changes in the market. Instead, peasant economies are more likely to follow a low-risk strategy that produces consistent returns, thus satisfying subsistence needs (Chai͡anov and Čajanov 1986).

Following this logic, though households at Tamarindito likely did produce the occasional surplus during years when crops were thriving, for example, this would not have been commonplace for most non-elite households (Freidel 2020; Garraty 2010; King 2015; Sahlins 2017) Put simply, households are simply not organized to be consistent, continuous producers of surplus when the primary purpose of a household is to sustain the needs of its own members. Thus, a political economy framework assumes that one group of people controls the economy, while the remaining majority are prisoner to those decisions.

The problematic nature of this paradigm has prompted archaeologists to challenge the use of political economy, recognizing that this framework represents only a small aspect of Maya economies (Clark 1995; Costin 1991; Feinman 2004; Hirth 1996; Hruby 2011; McAnany 2010; Schortman and Urban 2004), emphasizing “single dimensions of resource accumulation rather than identification of the mix of strategies employed by prehistoric economies" (Hirth 1996:220). Wells (2006:278) suggests that political economy approaches (especially those with a Marxist orientation) "allow for the concept of agency but only to the point of examining how people manipulate economic processes for personal gain." In contrast, multi-agent frameworks trace the social and economic connections between household groups through an analysis of economic processes occurring both within and outside an inclusive range of households across the site. Instead of looking at socioeconomic strata as concrete, fixed categories that contain static actors with primarily equal statuses, multi-agent systems may be used to instead envision Maya socioeconomic status as a matrix of social, economic, and political positions wherein a multitude of factors, including agential choice, affect where a household falls on the X, Y, and Z axes.

Conclusions

Though elite control was definitely a component of Classic Maya economies, political economy frameworks leave no room for the idea that multiple economic systems were operating simultaneously within Maya communities such as Tamarindito that allowed for, and perhaps even encouraged, greater non-elite access to social and economic power. Envisioning Maya economies as multi-agent systems deviates from previous theoretical paradigms, including political economy and household approaches, by viewing Maya economic systems as composed of multiple individual agents living and working independently while also depending on one another for the resources needed to manage their everyday lives. This perspective also assumes that individual agents are at least partially independent, have a limited worldview, and do not have the capacity for complete control over economic systems (Wooldridge 2002). Thus, operationalizing a multi-agent economic system for reconstructing Classic Maya economies means examining the needs and motives (which may be transformed into decisions of action or inaction) of agents situated within a broad range of socioeconomic situations.

Though the rise of household archaeology deviated from political economy approaches by opening windows into the lives of non-elites and the roles played in Classic Maya economies, the agency involved at all levels of society can be better disentangled through a perspective that approaches production through the role of choice and motive that accounts for the agency of all actors. Furthermore, whereas much of the previous research on production in Maya economies is based on diachronic perspectives that seek to understand changes in the division of labor through time that do not typically allow for overlap of multiple types of production, this dissertation takes a synchronous perspective that assumes that more than one type division of labor or production can exist at a given point in time within the same society (Mcfarlane and Schortman 2017; Palka 1995; Sheets 2000)

“Top Down” versus “Bottom-up.” Through the application of a multi-agent framework, we have the opportunity to think beyond the dichotomy of political economic perspectives (focusing on elite control) while also expanding on the deficiencies of “bottom-up” approaches that focus exclusively on commoners. Applying such unidirectional foci centers one group over another and may deflate the role of larger hierarchical schemes that are involved in site-wide economic systems. As Hruby (2011:170) suggests, top-down approaches that focus on elite control “may serve to obfuscate rather than clarify ancient Maya economies.” The same may be said for “bottom-up” approaches that focus primarily on the lowest ranks of Maya society through the archaeological examination of a limited number of households. By ignoring specific communities of Maya society, the complex interrelationships between producers and consumers may become obfuscated, which lends researchers to misinterpret representations of economic cooperation, interdependence, and/or competition. As such, theoretical frameworks focusing on the social and economic relationships between actors across the complex spectrum of socioeconomic strata may be a more useful means for examining the social context of stone tool economies than previous approaches. Using this multi-actor framework, archaeologists can better illuminate both broad-scale and fine-grained analyses of these processes.

Identifying the Decision to Act in the Archaeological Record. In most cases, when agents decide to "act" and thus participate in the economy by producing goods, these practices tend to leave material traces behind for archaeologists to capture, thus allowing for the reconstruction of these practices. This has been especially useful in the examination of individual households within Classic Maya polities, which has illuminated many of the activities that took place within these households. Agents' decisions not to act, however, pose a dilemma for archaeologists because these decisions rarely leave behind a material trace, rendering them invisible to present-day archaeologists.

To combat this, this dissertation employs a site-wide approach that moves beyond the individual household to examine the interrelationships between households across the site of Tamarindito. In doing so, the social and economic connections between agents of different socioeconomic strata become visible, which may further illuminate the decisions of individual agents. These socially "long-distance" connections are valuable because individual households are only fully cognizant of their own decisions and motives, while those of neighboring and/or relatives' households may only become partially apparent based on their actions and economic activities. Beyond that, the decisions of agents and households become less attainable. Thus, no single household can fully know the economic decisions being made and put into action beyond throughout the entire community.

In conclusion, the study of Maya economies in archaeological research was in many ways developed in conjunction with the introduction of political economy as a theoretical framework, thus centering the role of elites and creating a linear, top-down economic structure. Due to its conceptual ties to modern-day capitalism, I argue that political economy approaches were comfortable and easily relatable for early generations of archaeologists trying to tease out the rules and norms of ancient economies, especially when excavations focused heavily on elite contexts and artifacts while almost completely ignoring the non-elite. Though several Maya scholars have since asserted that Classic Maya society had greater social, economic, and political complexity than simply "elite" and "commoner" classes through the rise of household archaeology (Palka 1997, 1995; Robin 2001, 2002, 2003a; Wesson 2008; Yaeger and Robin 2004), the present study recognizes not only that elite and commoner contexts are obviously linked, but also provides a novel framework for identifying those links in the archaeological record.

In the following chapter, I elaborate on the role of stone tool research in our understanding of Classic Maya economies and focus specifically on the contribution of lithic debitage and microdebitage, which I argue is the most underutilized artifact class with possibly the greatest potential for illuminating stone tool production practices, which will further illuminate household agency, division of labor, and intrasite economic relationships.

CHAPTER 3

USING STONE TOOLS TO ILLUMINATE MULTI-AGENT PRODUCTION SYSTEMS IN CLASSIC MAYA ECONOMIES

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Introduction

Widely considered one of the oldest artifacts of human behaviors, stone tools are recovered virtually ubiquitously in nearly all times and places in which humans lived around the world. Because of this, stone tools are one of the primary indicators of human habitat and behavior at archaeological sites in which other artifact types, including food remains, ancient fabrics, and even ceramics, have long since perished. Further, whereas other artifact classes of material culture, such as hieroglyphic texts, are only found within elite contexts, stone tools were used to complete daily tasks at all levels of Classic Maya society. Thus, lithic artifacts are likely to be recovered within socioeconomic contexts where stone tools were manufactured, making these artifacts ideal for tracing production practices and identifying economic processes taking place within a single site. In the present chapter, I first defend the rationale behind using microdebitage analysis for identifying areas where stone tools were manufactured and/or maintained at archaeological sites. Next, I outline how mapping primary stone tool production areas aids in the identification of multiple economies, thus revealing a multi-agent economic system.

Where Have all the Stone Tools Gone?

During the Classic Maya period, the majority of Maya society used stone tools, typically in the form of obsidian or chert, to complete their daily activities, including hunting/butchering animals, food preparation, and the manufacture of pottery, clothing, and other household items. As such, stone tools should be recovered in nearly all contexts where domestic activities took place. The limited research that has been completed in most domestic contexts at Maya sites, however, has proven it difficult to locate areas where stone tools were initially manufactured (primary lithic production areas) and then later maintained (through resharpening and reshaping for differential use). This is most often attributed to one of four processes: 1) site maintenance, such as cleaning and sweeping (Clark 1986, 1991; Homsey-Messer and Humkey 2016; Sherwood et al. 1995) ; 2) the versatile nature of production spaces that were used for multiple functions, potentially masking traces of stone tool manufacture (Aoyama 2017; Levine 2014; Mixter et al. 2011; Moholy-Nagy 1997; Tourtellot et al. 1992); 3) the removal of stone tools during abandonment of the structure or site by its original occupants (Aoyama 2009, 2017; Hirth 2006; Inomata 2001; Santley and Hirth 1993); and 4) post-abandonment reuse of production areas (Chase and Chase 2000; Deal 1985; Inomata 2001). Therefore, unless the site has been very well-preserved at a specific period in time (such as at Aguateca or Cerén), stone tools found on the present-day surfaces of archaeological sites cannot solely be relied on for reconstructions of stone tool production.

How then can archaeologists identify where stone tools were made and used in Classic Maya economies, thus potentially revealing a multi-agent production system? Instead of focusing on larger artifacts that are easily displaced from their location of manufacture and/or use, microdebitage (measuring less than 6 mm) recovered in situ is a much more reliable indicator of stone tool production and maintenance because, unlike their larger counterparts, microartifacts tend to be more resistant to post-depositional movement via human or natural causes, such as cleaning/sweeping, bioturbation, and/or erosion (Dempsey and Mandel 2017; Gifford-Gonzalez et al. 1985; Mandel et al. 2017; Sherwood 2001; Sherwood et al. 1995; Nielsen 1991). This is especially true for lithic microdebitage, which along with some metals, are classified as the most stable post-depositionally, while other microartifact classes, such as ceramics, shell, bone, charcoal, daub, are considered unstable and less likely to remain preserved and in situ (Sherwood 2001; Sherwood et al. 1995). As such, even when larger tools are debitage are intentionally removed, microdebitage is more likely to remain at the location of stone tool reduction, serving as markers of these areas during present-day archaeological investigations.

Using Microdebitage to Identify Lithic Production in the Archaeological Record

Since the late 1970s, archaeologists have increasingly recognized the importance of microartifacts to questions of site structure, site formation processes, site integrity, and identifying activity areas (Ahler 1989; Andrefsky 2007; Baumler and Downum 1989; Clark 1986; Dunnell and Stein 1989; Hassan 1978; Homsey-Messer and Humkey 2016; Hull 1987; Johnson et al. 2016; Metcalfe and Heath 1990; Parker and Sharratt 2017; Sherwood 2001; Sherwood et al. 1995; Sherwood and Kocis 2006; Tani 1995). The term “microdebitage” was first introduced by Fladmark (1982) to describe the category of microartifacts that consists specifically of lithic debitage measuring less than 1.0 mm in size. Regarding the role of microdebitage in archaeological research, Fladmark concluded that "as a stable and long-lasting signature of past cultural activity imprinted on the sedimentary environment, and not subject to some biases inherent in macroscopic cultural material (such as selective collecting, re-use, etc.), it represents a useful means of site verification" (Fladmark 1982:215). In the nearly 40 years since this publication, microdebitage has been analyzed at sites throughout the world, primarily in North America (Cyr et al. 2016; Homsey-Messer and Humkey 2016; Homsey-Messer and Ortmann 2016; Johnson et al. 2016; Ortmann and Schmidt 2016; Peacock 2004; Peacock et al. 2008; Sherwood et al. 1995; Sherwood and Kocis 2006) and the Near East (Alperson-Afil et al. 2007; Goren-Inbar et al. 2004; Nadel 2001; Rainville 2005; Stepka et al. 2018; Ullah 2012) and the examined sites date from as long ago as 790,000 years ago at ancient hominin sites in the Near East to as recent as only 400 years ago in what is now the United States.

According to Sherwood (2001:341), “a lithic reduction area is identified by the concentration of microdebitage.” As such, the importance of analyzing microdebitage in tandem with macrodebitage has been strongly stressed (Hull 1987; Johnson et al. 2016; Sherwood 2001). “These small artifacts must be collected and analyzed in conjunction with their larger counterparts, and only then can the primary context or activity areas be discovered and interpreted within the complex combination of site formation processes” (Sherwood 2001:340) Furthermore, if microdebitage analysis is to be a worthwhile means of investigation of archaeological interpretation, then discernible patterns in the deposition and recovery of microdebitage should be readily identifiable. Archaeologists continue to disagree, however, on exactly how assemblages of microartifacts represent specific activities, such as primary reduction loci.

Schiffer (1983) describes three primary types of artifactual refuse: primary refuse, secondary refuse, and de facto refuse. Primary refuse describes debris that remains in the area where the activity first took place. Secondary refuse refers to debris that has been relocated from its primary location. Finally, de facto refuse describes an area where primary activities took place, but larger artifacts are left in place due to rapid abandonment. Applying this model to stone tool production, Hull (1987:773) interprets the correspondence or lack thereof between microdebitage and macrodebitage distributions using the following definitions:

> 1) Primary refuse is identified by a cluster of macrodebitage corresponding to a cluster of microdebitage and is associated with activity areas.
>
> 2) Secondary refuse consists of macrodebitage with no corresponding cluster of microdebitage and is associated with discard areas.
>
> 3) Defacto refuse, although difficult to distinguish from primary refuse, should correspond to a microdebitage high density area while containing relatively large macroflakes and, possibly, more tools or tool fragments.

Following this model, primary lithic production loci would fall under "primary refuse" at most archaeological sites. As such, a high frequency of microdebitage in association with a high frequency of macrodebitage should be expected within lithic production loci, using Hull's model. Given that residents of Maya households would have removed larger microartifacts during sweeping and/or cleaning of the house floors (Inomata and Stiver 1998; Robin 2003), however, this pattern would not hold true at most Maya sites. Furthermore, at sites such as Cerén and Aguateca that were rapidly abandoned, primary activity areas would remain associated with larger artifacts as producers quickly left these areas, constituting these areas as de facto refuse. As such, these definitions prove to be problematic and not all-encompassing.

Sherwood et al. (1995:432) reinterpret Hull's classification scheme to include four general principles regarding the relationship between micro- and microartifacts:

1) Spatial concentrations of microartifacts can coincide with concentrations of large artifacts;

2) Macroartifact concentrations may occur in areas where microartifacts are rare (the first two relationships correspond to Hull's first two model conditions);

3) Microartifacts can concentrate in locations where large artifacts are few; and

4) Neither large nor small artifact concentrations are present in a given location.

These principles allow for greater flexibility for the ratios between macro- and microartifacts and are, therefore, much more applicable to Maya archaeological sites. In Mesoamerica, the ratio of macrodebitage and stone tools to microdebitage is site- and context-specific and will vary based on culturally and temporally-specific conditions.

Microdebitage Research in Mesoamerica

Though microartifact studies have been conducted since the 1970s, Mesoamerican archaeologists have been reluctant to include microartifact analysis in their research. These studies include a handful of doctoral dissertations with relatively small microartifact components (De Lucia 2011; Fulton 2015; Mixter 2016), all of which have been produced within the last decade. Each of these studies used microartifacts in addition to other methods to identify and assess activity areas within both public and household spaces. De Lucia (2011) analyzed microartifacts from house floors at the Early Postclassic site of Xaltocan in Mexico in order to better understand household activities. Fulton (2015) employed microartifact analysis to identify activity areas both within and between household groups at the Terminal Classic period site of

Actuncan in Belize. Also at Actuncan, Mixter (2016) used microartifacts to examine the use of public space during the Terminal Classic period. Though these investigations are few, the results have shown that microartifact studies can contribute to our understanding of how spaced was utilized within different socially constructed spaces across Mesoamerican sites. Though the previous studies all examined various types of microartifacts, including lithics, ceramics, bone, and botanical remains, even fewer studies have focused exclusively on using microdebitage to uncover areas where stone tools were produced in Mesoamerica.

Microdebitage and Lithic "Workshops." Much of the research concerning Maya stone tool production has relied heavily on a handful of lithic "workshops," which have been a topic of interest in Mesoamerica for the past 30 years (Aldenderfer et al. 1989; Black and Suhler 1986; Clark 1987; Clark and Bryant 1997; Hay 1978; Kelly 1980; Mallory 1984, 1986; Parry 1987; Pires-Ferreira 1975; Sanders 1977; Santley 1984; Shafer 1982; Shafer and Hester 1986). Lithic workshops have typically been defined simply as concentrations of stone debitage. This definition has been criticized by many researchers who have since hypothesized that these areas actually describe "workshop dumps" instead of actual workshops (Clark 1989, 1991; Moholy-Nagy 1990). The difference being described here is one of primary (areas where the stone tools were actually made) versus secondary deposits (areas where stone tool debris was deposited after manufacture, such as middens). These parameters are highly problematic for sedentary societies given that refuse from stone tool production rarely remains in the location of primary reduction, an assumption that has been demonstrated through ethnoarchaeological observations (Clark 1991; Moholy-Nagy 1990).

Moholy-Nagy (1990) was one the first Mesoamerican archaeologists to recognize and argue for the important contribution that microartifacts (specifically microdebitage) could make in identifying lithic production loci. Moholy-Nagy argued that microdebitage was not just useful but was absolutely essential in distinguishing between a lithic “workshop” and a workshop “dump.” Reminiscent of Hull (1987), Moholy-Nagy (1990:270) defined a workshop “by the behavior associated with a given locus,” while a workshop dump is defined “as a deposit composed mostly or entirely of the durable waste materials—the debitage—generated by workshop activity.” The primary difference between these is that a workshop remains in its primary context, while a workshop dump is located elsewhere in a secondary context.

According to Costin (1991:4), craft specialization should be readily visible in the archaeological record because “differences in productive activities should translate into differential distributions of the materials and artifacts associated with production.” This aligns well with the traditional definitions of lithic workshops as concentrations of stone debitage. Moholy-Nagy (1990:270-272) describes six types of stone tool debitage deposits recorded in Mesoamerica: debitage mounds, other unincorporated debitage concentrations, microdebitage incorporated into floors, debitage incorporated into construction fill, debitage included in special deposits, and random scatters. Of these, Moholy-Nagy concludes that only microdebitage incorporated into floors “can be regarded as an unequivocal indicator of an activity locus or workshop” (1990:272). Thus, if microdebitage clusters are recovered from within Maya households, this should be a reliable indicator that stone tool production was taking place in these areas.

Moholy-Nagy was heavily criticized for this initial microdebitage research, and the September 1992 issue of Latin American Antiquity was dedicated almost entirely to this debate. Healan (1992) suggests that the interpretations made by Moholy-Nagy concerning workshops and workshops dumps are overly simplistic. At least part of this argument seems to stem from

Moholy-Nagy's criticism of the analysis of a possible obsidian workshop at the Toltec site of Tula in Mexico (Healan et al. 1983; Moholy-Nagy 1990). Healan (1992) argues that while Moholy-Nagy criticized the failure of Healan et al. (1983) to make a concrete conclusion as to whether or not the debitage concentrations at Tula represented primary areas of lithic reduction, Healan (1992) offers a critical rebuttal of Moholy-Nagy with the following statement:

> "Considering the positive contributions of our work to the substantive and methodological tenets of her paper, I am surprised that Moholy-Nagy would focus criticism upon a cautiously phrased statement about a few anomalous strata that constitutes neither the confusion of workshop and workshop dump with which she is concerned nor an uncertainty on our part about the nature of refuse deposits, as she implies. Equally surprising is her apparent unwillingness to consider the possibility that lithic reduction can occur in workshop dumps, a position I find indefensible" (Healan 1992:241).

Following Healan (1992), Hester and Shafer (1992) argue in the same issue that the Moholy-Nagy is not completely correct in her assumptions concerning microdebitage as indicators of dumps and workshops. Particularly, Hester and Shafer argue that her conclusions that the concentrations of chipped-stone debitage from Colha (and other sites) are not representative of workshops, but instead, workshop dumps. This is in direct opposition of conclusions drawn by Shafer and Hester regarding the concentrations of debitage at Colha (Shafer and Hester 1983, 1986). In addition, while Shafer and Hester support her assertion that that microdebitage is an indicator of primary lithic reduction, they argue that microdebitage is not the most reliable indicator. Instead, the authors argue that microdebitage is only one of several criteria for identifying these loci. Moholy-Nagy (1992), however, maintains that microdebitage is the best and most reliable indicator of past primary lithic reduction loci, though she also agrees that it is important to note the context in which microdebitage is embedded.

Concurrent to these discussions, Clark (1991) conducted ethnoarchaeological research of stone tool production among modern Lacandon Maya of Highland Guatemala. Clark examined whether material and artifactual evidence of stone tool production remained in contexts where knappers systematically dispose of the lithic debris either by putting down a sheet of fabric beforehand to catch the debitage, by sweeping the floors afterwards, or a combination of these. Clark found that even in these situations, microdebitage was still abundantly embedded into the earthen workshop floors. Clark also found that the resultant stone tools (blades and projectile points) were not typically found in these workshop locations. Not only does this support Moholy-Nagy's suppositions regarding microdebitage, but this research also demonstrates that microdebitage clusters may be recovered without any associated tools in areas of primary stone tool production at archaeological sites.

Nearly 20 years later, Whittaker et al. (2009) used the analysis of microdebitage at the site of El Pilar in Belize to uncover the sequence of production for a locus of Late Classic period chert axe production. Near the ceremonial center of Pilar, chert axes were first prepared on a cleared limestone shelf followed by further preparation on a prepared cobble platform. Large proportions of microdebitage comprising approximately 40 percent of the total debitage were recovered from column samples from the limestone shelf, while microdebitage comprised only between 2-7 percent of the debitage recovered from samples taken from the midden below the shelf. Archaeologists at El Pilar concluded that microdebitage remained in situ after the larger debris was swept away into the midden once it had piled up and become cumbersome. These massive proportions of microdebitage have been interpreted as evidence of large-scale production of axes during the Late Classic period at El Pilar.

Most recently, Widmer (2019) examined microdebitage in the Tlajinga District at Teotihuacan in order to examine whether lithic production was taking place in this area. Though there were no signs of craft production based on the presence of macroartifacts in this portion of the site, 84 two-liter samples were taken, making this one of the largest examinations of microdebitage undertaken in Mesoamerica to date. The results indicate that multiple types of lapidary production (including ceramic, slate, shell, and mica) were taking place. Perhaps more importantly, an obsidian blade workshop was also identified in this area based solely on the presence of obsidian microdebitage recovered from soil samples.

Microdebitage and Maya Marketplaces. Cap (2016, 2019) has used microartifact clusters to assist in the identification and spatial orientation of activity areas within marketplaces at the Classic Maya sites of Buenavista del Cayo and Xunantunich in Belize. At Buenavista del Cayo, Cap used the collection of macroartifacts, microartifacts, and soil chemistry analysis to identify a marketplace and reconstruct its spatial activities. Cap found that chert knapping areas had higher densities in the marketplace area than in household contexts but were less dense than those found at locales identified as workshops. Cap argues the debitage remains signal an emphasis on final stages of production, which meets the requirements of marketplace reduction (Hirth 2009; King and Shaw 2016). Moreover, an obsidian production locale was identified that appears to suggest that small or pre-worked cores were brought to the plaza, signaling late-stage obsidian production likely took place in this area (Cap 2016:129-130). At Xunantunich (2019), Cap recover microdebitage indicative of the in situ production and rejuvenation of chert bifaces. Further research into Maya marketplaces will illuminate the methods that producers of stone tools used for manufacturing and distributing these goods, which will in turn reveal the level of control that elites had over production and the role that the marketplace played in the development and reproduction of social structures within Maya society.

Microdebitage and Raw Material Sourcing. Kovacevich et al. (2010) use Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) to chemically source microdebitage recovered from two archaeological sites (Chiquiuitan and El Baul) in the Pacific coast region of Guatemala. Unlike most of the other microartifact research discussed in this chapter, the authors of this study do not use microdebitage to identify activity areas at these sites, but instead use it to identify the source from which the obsidian at these two sites was procured. At Chiquiuitan (dating to the Early and Middle Formative periods), 38 microdebitage pieces were recovered from four mounds representative of domestic residences. At the Late Classic site of El Baul, 14,489 pieces of obsidian microdebitage were recovered from what appears to have been a single event deposition of obsidian debitage. From this large assemblage, 172 pieces of microdebitage were selected randomly to be analyzed. The authors verify that LA-ICP-MS is an appropriate tool for sourcing obsidian debitage smaller than 1mm, for which accurate visual sourcing is often impossible. In addition, this research shows that obsidian recovered from Chiquiuitan was sourced almost entirely from El Chayal, while the vast majority of obsidian recovered from El Baul was sourced from San Martin Jilotepeque. The results indicate that different obsidian sources were in use during different time periods in this region.

Stone Tool Production and Multi-Agent Economic Systems

Now that we have established using microdebitage analysis as an appropriate method for identifying where stone tools were made and maintained, how do we use these investigations to illuminate multi-agent economic systems? Identifying the contexts where stone tools were manufactured is imperative for illuminating multi-agent systems for multiple reasons. First and foremost, knowing where stone tools were made tells us who was making these implements. This, in turn, reveals which households had access to local (chert) and non-local materials (obsidian), which may illuminate socioeconomic access to various materials. Second, these areas may reveal who had access to the technical and/or ritual knowledge necessary to complete tool manufacture. Finally, this may illuminate who had control over various forms of production.

Who Manufactured Stone Tools? When combined with other measures of socioeconomic status, including the construction volume of households and the distance between households and the elite plazas, the spatial analyses of chert and obsidian microdebitage may aid in disentangling how households situated at different nodes across the socioeconomic spectrum contributed to the overlapping economies operating within the site. Following Sheets (2000), three primary scenarios may be identified: 1) Households are sufficient and produced stone tools primarily for themselves; 2) Households are egalitarian and trade goods either household-to-household, through marketplace exchange, or through a combination of both; and 3) Households are required to produce stone tools for the elite, who then control redistribution of these implements. In multi-agent economic systems, I expect to find a combination of these three operating simultaneously and, perhaps, cooperatively at a given time.

Further, mapping the differences between where local and non-local materials (chert vs. obsidian) were manufactured reveals differential access to these materials between households. Chert is ubiquitous within a few kilometers of all sites within the Petexbatun region (Aoyama 2009), while obsidian had to be imported from non-local sources between 300-500 km away depending on the trade route taken. Because chert would have been readily available, most if not all households would have had access to this material for stone tool production, and most households may have had members who could easily knap chert into an acceptable tool for daily tasks. As such, knowledge of chert tool manufacture is more likely to have been widespread and accessible to most, if not all, members of society. Obsidian, however, would have been less abundant (and may have been under some extent of elite control), suggesting that there may have been differential access to this material. Moreover, knapping chert and obsidian requires different technical skillsets, with the production of obsidian tools potentially requiring also ritual knowledge.

Who had Access to Technical and/or Ritual Knowledge? Ethnohistoric and archaeological evidence suggests that ritualized production of many different types of artifacts often took place in secluded places (de Landa and Gates 1937; Eberl 2017; Glover et al. 2018; Guengerich 2014; Neupert 2000; Tozzer 1941) most likely to produce esoteric or ritual knowledge that was only accessible by certain craft specialists (as described in Chapter 2). At Copan in Honduras, for example, microartifacts were collected from within a large household complex (Group 9N-8) dating to the Late Classic period (Widmer 2009) in order to examine the organization of elite craft production. Though several rooms within this structure were linked to different types of craft production (including shell gorget production, ceramic production, and clothing production), two rooms, in particular, appear to have been linked to sacred activities. Unlike the 14 other rooms, the entrances to these two rooms do not open onto the patio. As such, activities within this room would not have been visible to the outside. “The secluded nature of the rooms with restricted access suggests that secretive activities took place inside them that might relate to esoteric, religious behavior, even restricted from other elites” (Widmer 2009:177). Though non-elites oversaw this group, it is likely that non-elites lived and worked in this location and may have been involved in this production.

Thus, ritual production of stone tools may be evident by identifying rooms within households that 1) were not easily accessible to the rest of the household; and/or 2) were not easily visible to the household or surrounding community. Working in rooms such as these would have allowed for privacy from the rest of the household and from surrounding households so that physical and vocal actions would not be observed or overheard. Further, artifactual evidence of stone tool production within these rooms would primarily include significant deposits of obsidian microdebitage. Macrodebitage and tools themselves may also be recovered from these contexts, but in many instances, macrodebitage would have been removed during cleaning to keep from being stepped on. Obsidian is virtually a natural glass, so stepping on these tiny glass-like artifacts would have been extremely undesirable and even dangerous. These larger pieces of debitage also may have been repurposed as expedient tools, and the tools that were manufactured here would have likely been removed for trade or use elsewhere.

Who had Control Over Production? Maya archaeologists have put heavy emphasis on theories of production that focus on elite control. This is especially true for the procurement of obsidian, which only occurs naturally in a handful of volcanic zones throughout Mesoamerica. Because of the need to travel long distances (often hundreds of kilometers) to access these geologic sources, it has been theorized that political elites often controlled and managed the procurement and distribution of these materials, which would have been delivered to Maya polities via specific trade routes (Brumfiel and Earle 1987; Clark 1987; Demarest et al. 2014; Hirth 1996; Smith 2004). Further, elite control of production may have been associated with “palace” schools identified in the Maya region, wherein producers are trained in the specialized production of specific goods, typically ceramics (Healy and Blainey 2011; Houston and Stuart 2001; Inomata 2001; Reents-Budet and Ball 1994; Reents-Budet et al. 2000). Though no palace schools to produce obsidian goods have been identified thus far in the Maya region, identification of households near the plaza that appear to have exclusively produced obsidian tools would be strong evidence of these schools having existed.

Thus, to identify multi-agent production systems archaeologically, it is imperative to employ a sitewide approach involving households and other contexts that span the site both geographically and socioeconomically. Stone tool production is the most appropriate process for illuminating multi-agent systems because stone tools are the least perishable of all goods that would have been manufactured. As such, using microdebitage recovered from multiple households to identify areas where stone tools were manufactured and/or maintained has the greatest potential for illuminating Classic Maya multi-agent production systems.

Lingering Questions Regarding Microdebitage Analysis

Micro- vs. Macroartifacts. Even though multiple experimental studies using microdebitage and other microartifacts have been conducted, archaeologists remain uncertain about many principles of microdebitage form, including size, shape, and density. Many archaeologists still question whether microdebitage mirrors macrodebitage in shape, angularity, retention of the bulb of percussion, and many other factors. Though a handful of studies have examined the volume of microdebitage in different size classes based on reduction type (Behm 1983; Fladmark 1982; Henry et al. 1976), these studies remain problematic for many reasons. For example, using ratios between different size-grades may identify specific lithic reduction schemes if only one tool type was being created. This protocol does not account for multiple tool types being manufactured in the same area, varying skill levels of the knappers, or potential ritual processes that may produce specific types of microdebitage. Furthermore, archaeologists have yet to intensively examine whether the form (shape, angularity, roundness, bulb of percussion) are comparable between macro- and microdebitage.

Post-Depositional Movement. Another problem is that archaeologists still do not have all the answers for how microartifacts behave in different substrates and within varying post-depositional processes. Though experiments have been conducted, Homsey-Messer and colleagues point out some of the variables that must be taken into consideration prior to experimentation. “The types of scenarios replicated by the grid, the length of time the experiment lasts and the sampling and/or artifact seeding strategy may all vary depending on the research question asked” (Homsey-Messer et al. 2016:68). As such, archaeologists wishing to use microartifacts should have a thorough understanding of the soils and potential post-depositional activities taking place within the archaeological context being sampled. Further, microartifacts are not completely immune to relocation (Hilton 2003), especially “downward gravitational displacement” caused by insects, burrowing animals, and uprooted trees (Mandel et al. 2017:805). Dempsey and Mendel (2017:489) demonstrate, however, that “though activity-specific remains may not occur as discrete units, analysis of microartifacts, microstratigraphy, and careful site mapping may reveal significant patterns of site use.”

Accuracy of Data Analysis. Further, many researchers have questioned the accuracy and replicability of this method. Unlike macrodebitage, which are identified by specific attributes (such as bulbs of force, for example), objective criteria for defining microdebitage have not been standardized in archaeological research. As such, it is not clear whether the sheer presence of obsidian or chert microdebitage sufficient for identifying areas of primary reduction. Finally, there is the problem of fatigue when looking through a microscope for long intervals and manually sorting microdebitage, causing the analyst to become less accurate over longer periods of analysis (Ullah 2012; Ullah et al. 2015).

Time-, Cost-, and Labor Efficiency. The analysis of microdebitage requires an intensive investment of time and, as a result, money (Johnson et al. 2016). Collecting soil samples during archaeological excavations requires advanced planning as to where and how samples will be taken, sample volumes, and the total number of samples required. Moreover, significant additional time and expenses are often associated with the processing of soil samples and the analysis and quantification of microdebitage recovered from within each sample. As stated by (Johnson et al. 2021), "corresponding studies are limited in their number of soil samples and fractions: 33 samples/156 fractions in Rosen (1986), 16 samples/80 fractions in Rosen (1989), 87 samples and fractions in (Hull (1987), 45 samples and fractions in Metcalfe and Heath (1990), 69 samples/138 fractions in Cap (2016)." Because of this, researchers who have chosen to implement this methodology have typically focused on relatively small portions of archaeological sites, such as specific households (or even single rooms within households) (Homsey-Messer and Humkey 2016; Metcalfe and Heath 1990; Sherwood et al. 1995; Widmer 2009) or have restricted their analysis to smaller units within archaeological excavations (Johnson et al. 2016).

To address many of these issues, a handful of archaeologists have proposed various methods to expedite the analysis of microartifacts (Peacock and Ryan 2018; Sherwood and Ousley 1995; Ullah et al. 2015). For example, Sherwood and Ousley (1995) created and employed a computer program called MMCount to estimate the number of microartifacts within a single sample in as little as 25 minutes. Ullah et al. (2015) propose a method wherein multiple analysts count the microartifacts from each sample, which produces a much more accurate count of microartifacts, but takes significantly longer (approximately 10-20 person hours per sample). Most recently, Peacock and Ryan (2018) have proposed a methodology using High-Resolution Computed Tomography (HRCT) to scan soil cores taken from archaeological sites in order to manually identify microartifacts. Each scan, depending on the machine used, takes between 30 to 90 minutes. Though each of these studies has produced positive results, these protocols have not yet been more widely adopted in archaeological research.

Conclusion

Though microartifacts, and microdebitage more specifically, have repeatedly proven to be a reliable data source for identifying primary activity areas, examining site formation processes, and assessing the post-depositional integrity of archaeological sites, multiple unanswered questions and concerns remain that have led archaeologists away from applying microdebitage analysis to their investigations of stone tool production, even though these artifacts remain the most accurate proxy for identifying areas were stone tools were manufactured at archaeological sites. In order to alleviate many of these issues and thus, make microdebitage analysis more appealing to a broader audience of researchers, I apply innovative methodologies to this dissertation for expediting the analysis, increasing the reproducibility, and producing a more robust dataset. In the following chapter, traditional methods of microdebitage analysis are compared to a method using Dynamic Image Analysis (DIA), recently developed by Johnson et al. (2021), for analyzing microdebitage and thus illuminating multi-agent production systems across the site of Tamarindito.

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

Introduction

The methodology and research questions employed in this dissertation were designed to best reconstruct multi-agent production systems by teasing out the relationships between stone tool production, status, wealth, and agency. Identifying where stone tools were produced at Tamarindito will provide at least a portion of the data needed to interpret: 1) the socioeconomic status of stone tool producers; 2) the purpose of stone tool production within each household; and 3) potential economic relationships between producers and non-producers. Unlike previous studies that have focused on who controls stone tool production, this investigation seeks to illuminate multiple economies functioning simultaneously while uncovering different levels of agency operating between different socioeconomic levels of society. Further, this study also advances the methodological approaches used to analyze microdebitage from archaeological contexts by introducing Dynamic Image Analysis (DIA) as a novel method for discerning microdebitage from natural soils in archaeological soil samples.

Research Questions

This project explores the effects and outcomes of stone tool production in multi-agent social systems by exploring the following two overarching theoretical research questions: 1**) How are power differentials produced within multi-agent production systems?** and **2) Who was involved in the production of stone tools, and how were these relations structured?**

Question 1 will elucidate sitewide exchange systems, while Question 2 will elucidate ritualized knowledge within households. These research questions are based on the analysis of all 480 soil samples taken from across Tamarindito. Because I am only able to examine Residential Group 5PS-d at this time, inferences will be made regarding Question 1, but this question will likely require further investigation.

Question 1: How are power differentials produced within multi-agent production systems? This question focuses on site-wide differential production by examining how power structures emerge with and alongside household-organized production, which results in particular systems of labor division. To address this question, I will compare data previously collected during excavations completed during the Tamarindito Archaeological Project (Eberl and Vela González 2016), including construction volumes, distances of households from the plazas, and artifactual data at Tamarindito to microdebitage data collected by myself for the current project. Within multi-agent-systems, I propose that three primary production scenarios may be taking place at any given time (self-sufficiency, community exchange, elite control). These scenarios are similar to those identified at Cerén by Sheets (2000), but I expand on the Cerén study by examining how agency, choice, and dependency factored into each of these scenarios. For this question, I proposed three hypotheses and assume than any or all three may be in process simultaneously within the same site: 1) Households become self-sufficient; 2) Egalitarian household relationships result in community production and exchange; and 3) Unequal power relationships result in elite control of production.

Hypothesis 1. Households become self-sufficient. In this scenario, households produce most of the goods necessary to maintain their own household for themselves. I will identify this scenario within my data using the following two test implications: **1a)** Households with the smallest construction volume are self-sufficient. Because house size is considered one of the best indicators of household status and wealth (Abrams 1994; Eberl 2007; Inomata 2009; Palka 1995, 1997; Rapoport 1969; Tourtellot, et al. 1992; Turner, et al. 1981; Wilk 1983), I expect self-sufficiency to be linked to the poorest households, which will be measured through construction volume as a proxy for wealth. Based on how sizes were clustered among all excavated residential groups, Eberl and Vela González (2016) categorized residential groups as small (average = 12.2m3), medium (average = 64.3m3), and large (average = 189.6 m3). Using these classes, I expect self-sufficient households to fall within the "small" size category. **Test Implication 1b)** Households will use locally available chert instead of non-local obsidian. Because poorer households had less access to resources and specialized production knowledge, these self-sufficient households would have relied heavily on locally available chert for tool production. As such, I expect soil samples taken from households falling within the "small" size category to produce predominantly chert microdebitage.

Hypothesis 2) Egalitarian household relationships result in community production and exchange. Households may choose to specialize in a particular trade that they then exchange with other households, either directly, through marketplaces, or a combination of both. In this scenario, a division of labor is developed wherein each household specializes in a different craft (stone tools, ceramics, weaving, etc.), and goods are exchanged between households. This division of labor often makes it disadvantageous for agents to produce the same goods being produced by other households in the local community because specializing in a unique skillset allows individuals to trade crafts or service for needed goods. For example, in the case of stone tools, agents may decide not to learn knapping and instead learn to weave, which would result in dependency on other households for stone tools. I will identify this scenario within my data using the following test implication: **Test Implication 2a)** A small number of households with microdebitage clusters will be dispersed across the site. In this scenario, not every household is manufacturing stone tools. As such, I expect that only soil samples from certain households will contain microdebitage. In this way, those specializing in stone tool production are accessible to the greatest number of households without overlapping with other specialists of the same craft (for example, two stone tool specialists would likely not be situated adjacent to one another). The position of these households also facilitates exchange with households specializing in other trades.

Hypothesis 3) Unequal power relationships result in the elite control of production. In this scenario, specialists are controlled by elites who consume and distribute the surplus of goods produced by specialist households. I will identify this scenario within my data using the following two test implications: **Test Implication 3a)** "Palace" schools will be located in close proximity to the plazas. Elite control of production may be associated with these "palace" schools identified in the Maya region, wherein producers are trained in the specialized production of specific goods, typically ceramics (Healy and Blainey 2011; Houston and Stuart 2001; Inomata 2001; Reents-Budet and Ball 1994; Reents-Budet et al. 2000). Thus far, however, no palace schools for the production of obsidian goods have been identified. **Test Implication 3b)** Obsidian microdebitage clusters will be recovered primarily from these locations. Scholars have assumed that elites had control over the exchange of obsidian, but it is not clear if the production of obsidian was also tightly controlled. If so, I expect to find the majority of obsidian microdebitage in these palace schools, but little to no chert.

Addressing Question 1 is crucial to understanding the social structure of production systems at Tamarindito and throughout the Maya lowlands. These three hypotheses are not exclusive, however, and I expect to find evidence for each scenario coexisting throughout Tamarindito. I will disentangle these coexisting production systems through the spatial analyses of chert and obsidian microdebitage, construction volume, and distance to the plazas in order to sort out how households of different socioeconomic status are situated in both the vertical and horizontal economies. Ranging in distance from 40 to 1979 meters from Plaza B and varying in construction volume from 4.9 to 266 cubic meters, these residential groups are excellent indicators of socioeconomic differences in production strategies, which can be used to elucidate how power differences affected agent choices in production (Figure 4.1).

Question 2: Who was involved in the production of stone tools, and how were these relations structured? Building off my first research question, this question asks whether the technical expertise required to manufacture stone tools was available to all social groups of society. Depending on the structure of the household economy (self-sufficient, egalitarian, elite-driven), social constraints may have affected producers differently. If technical knowledge was not equally distributed, competition may have driven producers, especially obsidian blade specialists, to hide their technical knowledge from competitors. To address this question, I will compare spatial distributions of chert and obsidian microdebitage within Residential Group 5PS-d at Tamarindito. For this question, I have two hypotheses:

Hypothesis 1) Competition for technical expertise required for obsidian blade production led to secret knowledge and the development of ritualized production. Evidence from sites throughout the Petexbatun demonstrates that obsidian blades and cores found in households were typically manufactured from the El Chayal source (Aoyama 2017; Eberl 2014), and the CE/M ratios suggest that producers attempted to conserve materials. As such, a great

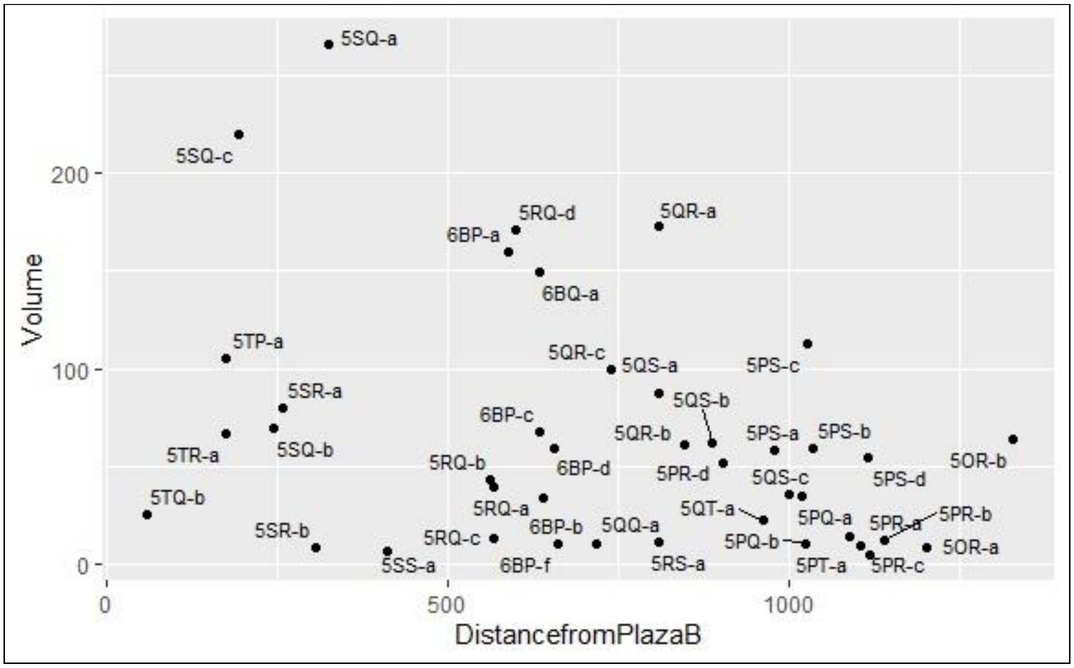

Figure 4.1 Construction Volumes and Distance from Plaza B of Residential Groups (modified from Eberl and Vela Gonzaléz 2016:145)

deal of technical knowledge would have been required in order to manufacture blades with the greatest use-life. Knapping out in the open would have made obsidian specialists vulnerable to copying, causing producers to move the production of obsidian tools to secluded spaces within the household. In addition, producers may have developed ritual production as a method for increasing the knowledge gap between producers and non-producers, thus making it more difficult for competitors to acquire these skills. I will identify this scenario within my data using the following test implication: **Test Implication 1a)** Clusters of obsidian microdebitage will be found in separate and discrete locales than chert microdebitage. Ethnohistoric and archaeological evidence suggests that production took place in secluded places (de Landa and Gates 1937; Eberl 2017; Glover et al. 2018; Guengerich 2014; Neupert 2000; Tozzer 1941), and microdebitage has been employed to show that obsidian production took place in an interior room in at least one household at Copan (Widmer 2009; Widmer and Storey 2016).

Hypothesis 2) Technical knowledge required to manufacture obsidian blades was not secret. If competition for the technical expertise required to produce obsidian blades was not necessary, then I expect to find obsidian microdebitage clusters in areas that are not restricted from the public. I will identify this scenario within my data using the following test implication: **Test Implication 2a)** Obsidian and chert microdebitage will be found in similar non-discrete contexts. If obsidian was equally available to all producers, then there would be no competition and no need to hide technical knowledge.

Addressing Question 2 is crucial to understanding how social constraints affect the decisions agents made and how these decisions resulted in differential production strategies within Maya households. Hruby (2007) suggests that blade-core technology may be linked to ritualized production and social structure at Piedras Negras, but as Hruby et al. (2007) suggest, more detailed descriptions of production debitage and other artifacts are needed from archaeological sites in the Maya Lowlands to fully support this claim (Hruby et al. 2007). As such, the proposed research will contribute to elucidating the relationship between ritualized production and social structure in the Maya lowlands.

Methods

The primary methodology used in this dissertation involves the collection and analysis of microdebitage, which consists of the smallest pieces of obsidian or chert (measuring < 4mm) that are knocked off during stone tool production. Spatial analysis of microdebitage can elucidate where and how stone tools were being made at archaeological sites (Cyr et al. 2016; Homsey-Messer and Humkey 2016; Johnson et al. 2016; Ortmann and Schmidt 2016; Parker and Sharratt 2017; Sherwood et al. 1995). Without analyzing the microdebitage, these activity areas cannot be located, and important information regarding the utilization of space, intra-household activities, and intra-site relationships is lost. For every stone tool that is produced, thousands of pieces of microdebitage may be removed from the core, meaning that tens of thousands of pieces of microdebitage likely exist in any archaeological context where stone tools were manufactured, and millions of pieces may exist across a single archaeological site.

Moreover, as discussed in depth in the previous chapter, microdebitage is less affected by post-depositional processes, such as cleaning, soil erosion, or animal/human disturbance, than are macroartifacts (measuring > 6 mm). This is the result of microartifacts becoming embedded into the floors of houses, plazas, and other work areas through trampling and sweeping, forcing these tiny, sharp artifacts to penetrate into the occupation surface (Clark 1986, 1991; Dempsey and Mandel 2017; Gifford-Gonzalez et al. 1985; Mandel et al. 2017; Moholy-Nagy 1990; Nielsen 1991; Sherwood 2001; Ullah 2012). As such, microdebitage is considered the best material indicator for identifying the locations of stone tool production.

Sampling Strategy for Residential Group 5PS-d

In the present section, I describe the size and layout of Residential Group 5PS-d, the number of structures, the location of soil samples, and a brief overview of investigations conducted previously, including TAP excavations between 2009 and 2014 (Eberl and Vela González 2016). Residential Group 5PS-d measures 54.7m^3 (placing it within the medium size category) and consists of four structures (5PS-12, 5PS-13, 5PS-14, 5PS-15) surrounding a central rectangular plaza (Figure 4.2). Situated 1.12 km southeast of Plaza B, this residential group is one of the furthest from the royal palace. The largest structure (5PS-14) lies south of the plaza and consists of three rooms and a central staircase facing the courtyard. The easternmost structure (5PS-15) contains two rooms, and the westernmost structure (5PS-13) consists of only a single room. Finally, the northernmost structure (5PS-12) consists of a central rectangular room, a bench, and an annex that opens to the north of the structure, facing away from the rest of the residential group (Eberl and Vela González 2016:88-89).

TAP excavations at 5PS-d took place between 2011 and 2012 and consisted of two 1x1-meter test units within a potential midden west of structure 5PS-12, one 2x2-meter test unit within structure 5PS-13, and one 7x1-meter trench within structure 5PS-12. Excavations within this trench initially revealed a small cache consisting of two obsidian cores and 104 obsidian blades. Because of this, TAP decided to excavate the entire structure with an additional 26 excavation units (Eberl and Vela González 2016:93-97). Lithic artifacts recovered during these excavations included 20 obsidian cores and 220 obsidian blades.

No excavations were undertaken in Structures 5PS-14 or 5PS-15, as the layout of Structure 5PS-14 is very typical of Classic Maya residences excavated in the Petexbatun region (Inomata 1995), and the e-shaped structures (Structure 5PS-15) are also very common. Instead, excavations were focused on the less common structure types, or in the case of Structure 5PS-12, completely unique. Excavations within Structure 5PS-13 uncovered a burial shrine that likely contained the remains of earlier inhabitants of the group (Markus Eberl, personal communication, 2021).

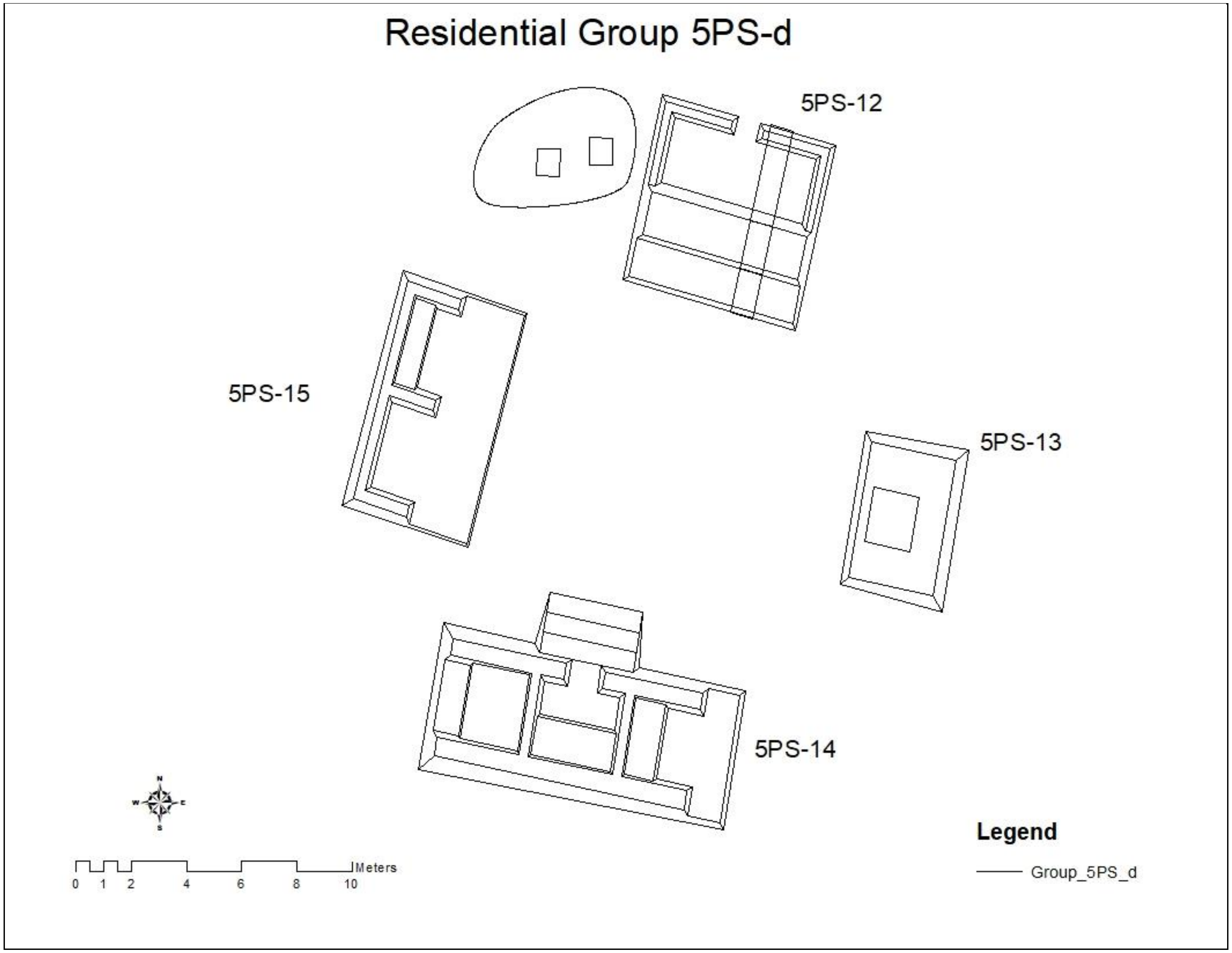

Figure 4.2 Plan Map of Group 5PS-d

Within the northern annex, under the original location of the bench, sixteen of these cores were aligned in three overlapping rows measuring approximately $30cm^2$, demonstrating that these implements were placed here purposefully. In total, the obsidian recovered from structure 5PS-12 comprised the vast majority of obsidian (75.7 percent by weight) recovered from all of Tamarindito (Eberl and González 2016:135), while the chert recovered from 5PS-d (2475.5g) comprises 15.4 percent of all chert artifacts recovered during TAP excavations at Tamarindito.

As a result of the overwhelming amount of lithic material recovered, Eberl and Vela González (2016) interpreted this structure as a potential lithic workshop. To test this assumption, I designed a strategy for collecting soil samples to capture microdebitage that would reveal locations within Residential Group 5PS-d where stone tool production was taking place. Because of the meager material remains left in situ, archaeologists often focus excavations on middens, which normally house a plethora of artifacts representative of daily life. Unfortunately, due to the mixed nature of middens as "palimpsests of diverse practices by various individuals at different moments" (Aoyama 2007:4), archaeologists continue to struggle against serious limitations when reconstructing agency and the role of stone tools in the daily lives of Maya commoners.

During the 2017 field season, I collected soil samples in 2-meter intervals across the entire residential group (Figure 4.3). Samples were collected using posthole diggers in order to maintain uniformity in the diameter of each sample, and excavations were ceased once bedrock was reached for each individual sample (Figure 4.4). The grid used within each context was independent of other sampled contexts and the grid employed by the TAP excavations. The location of samples was based on the interpreted function of each structure, whether that structure had previously been excavated, and the presence of modern debris and/or vegetation.

Figure 4.3 Looking Northwest across Residential Group 5PS-d during 2017 Investigations

Soil samples were not taken from previously excavated contexts (such as units from the TAP excavations) to avoid the cross-contamination of soils and artifact assemblages, and certain portions of the residential group could not be sampled due to the density of debris (including building materials, tree cover, or dense vegetation) on the ground surface at the time of this investigation. A Garmin eTrex 10 handheld GPS was used to record the locations of soil samples. The locations of soil samples were also hand-drawn onto printed map of Residential Group 5PS-d (from Eberl and Vela González 2016).

Figure 4.4 Cesar Higinio Perez Mejia Taking Samples with a Posthole Digger at Group 5PS-d

Using this methodology, a total of 239 soil samples (weighing 67,855.4g) were taken from this residential group, with special attention being paid to the central plaza. Sample depths ranged from 15 to 80 cms, and the mean weights for these 239 samples is 283.9 g. (See Appendix A). or the present study, I subsampled 50 of these soil samples primarily from the plaza area (Figure 4.5). With this strategy, this dissertation is uniquely suited to make significant progress in reconstructing where stone tools were manufactured along with the spatial organization of stone tool production throughout the entire site.

Microdebitage Analysis

Once fieldwork was completed at Tamarindito, I transported the 239 soil samples from Residential Group 5PS-d, along with 241 additional samples taken from across Tamarindito, to a field lab in Flores, Guatemala where all soil samples were carefully labeled and catalogued. To decrease the weight for shipment to Vanderbilt University, each soil sample was air-dried using a camping oven before shipment (Figure 4.6). Once at Vanderbilt, all soil samples were dried again in a closed oven per USDA guidelines to eliminate biological contaminants (Figure 4.7). At a given time, 3-4 samples were placed in the oven, and each sample remained in the oven for between 20-30 minutes until reaching a temperature of 200 degrees Celcius. Once that temperature was reached, soils remained in the oven another five minutes to ensure all biological contaminants were destroyed. All 480 soil samples were decontaminated between June and August 2017. Of these 480 samples, I selected a subsample of 50 soil samples from Residential Group 5PS-d to be analyzed manually and via DIA to allow for a direct comparison of the two methods.

Manual Microdebitage Analysis. First, I manually analyzed the 50 selected soil samples from Residential Group 5PS-d, primarily following the methods for “spatial microarchaeology” outlined by Ullah et al. (2015). Spatial Microarchaeology focuses on overcoming challenges in identifying and explaining “habitus” in the archaeological record and on providing a user-friendly methodology for analyzing microartifacts that is neither time-consuming nor expensive,

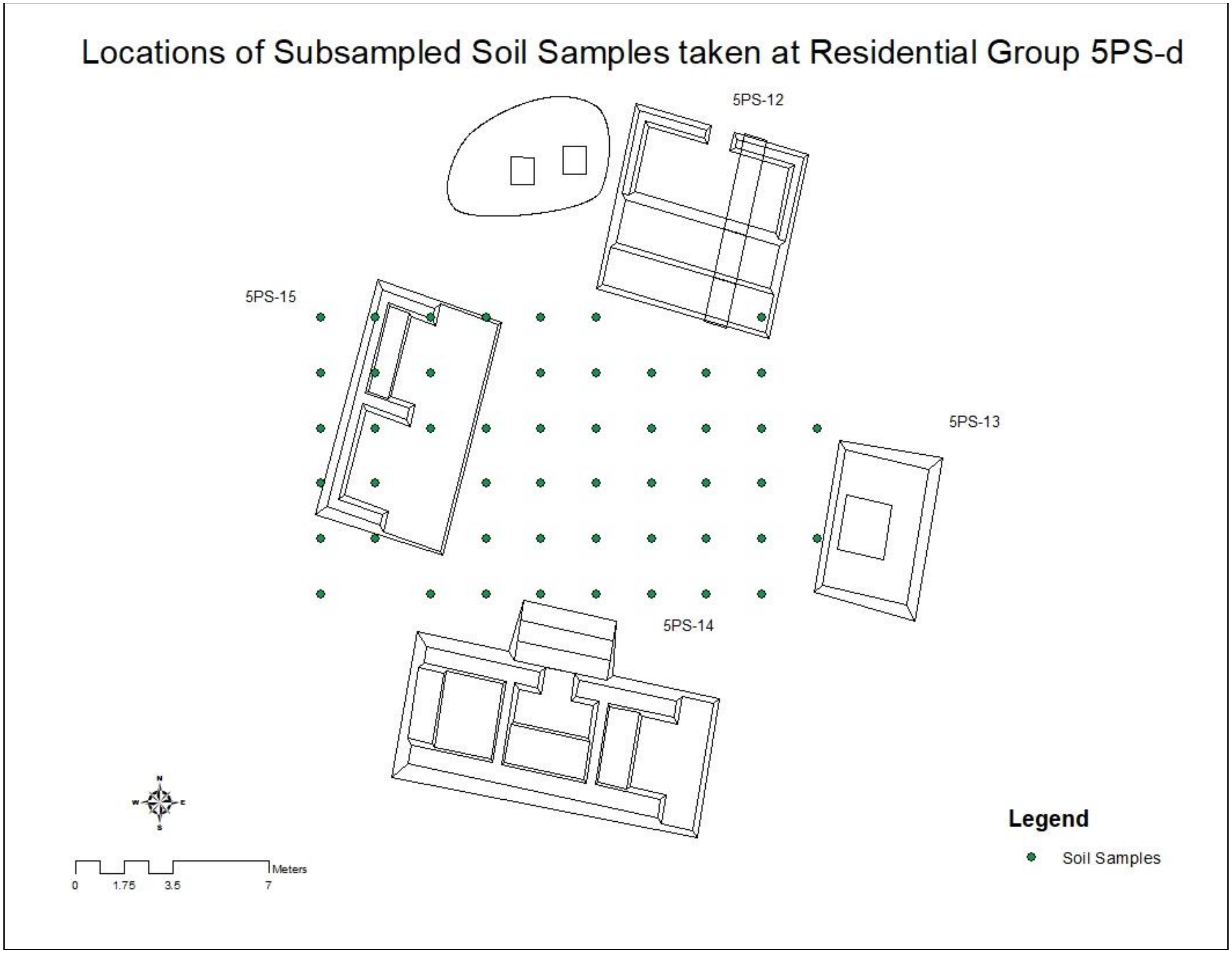

Figure 4.5 Plan Map Showing the Locations of Subsampled Shovel Tests at Residential Group 5PS

Figure 4.6 Soil Samples Prior to Heating at Lab in Café Yaxha, Flores, Guatemala

Figure 4.7 Soil Samples in Dry Oven in the Mesoamerican Archaeology Lab at Vanderbilt

which has been a common reason that archaeologists have shied away from this type of analysis (Johnson et al. 2016). In order to make a direct comparison between manual analysis and Dynamic Image Analysis (DIA), I removed subsamples measuring 50g from each of the 50 soil samples for manual analysis and an additional 50g was subsampled for DIA.

Soil samples were first soaked in a 5-percent solution of distilled white vinegar overnight in order to break up the heavy clay content of the soils. Because this investigation focuses only on microdebitage and does not seek to recover other microartifact classes, each soil sample was water-sieved using 0.063 mm mesh so that all microdebitage measuring greater than 0.063 mm would be captured. Once samples were dry, each sample was manually sieved to separate each soil sample into size grades. Following the Udden-Wentworth (North American) clast-size divisions (Wentworth 1922), all recovered microdebitage was size-graded using standard geologic screens with graduated sizes of 6.3 mm, 4.0 mm, 2.0 mm, 1.0 mm, 0.5 mm, and 0.25 mm using the mass analysis technique outlined by Ahler (1989) and recommended by Ullah et al. (2015).

Next, each size grade was sorted by raw material type. Using a low-power boom microscope with magnifications up to 250x (Figure 4.8), microdebitage was separated from natural (versus culturally produced) chert and obsidian debris based on the assumption that microdebitage generally displays angularity, sharp edges, and flat sides (Dunnell and Stein 1989; Fladmark 1982; Nicholson 1983; Peacock 2004; Peacock et al. 2008). Other diagnostic attributes used to separate out microdebitage included transparent or translucent appearance under light, regular geometric shape, and retention of some aspect of conchoidal fracture or bulb of percussion ((Fladmark 1982; Nadel 2001; Susino 2007). Further, microdebitage specimens were compared to experimental chert and microdebitage samples knapped by Mike McBride in

Figure 4.8 Microdebitage Particles Under the Boom Microscope

October 2019. Finally, counts and weights for each category of raw material within each size class were recorded and entered into the project database.

Dynamic Image Analysis. In our pilot study, my colleagues and I used the Multivariate Analysis of Variance (MANOVA) test to identify significant differences ($p < 0.001$) between lithic and soil particles, indicating that DIA is a viable and promising method for differentiating between microdebitage and natural soils within archaeological soil samples (Johnson et al. 2021). This study used only one sample of lithic debitage and one sample of archaeological soils, however, and because this is the only archaeological research completed to date using DIA, it is important to test this method on larger datasets. As such, I apply DIA to the analysis of the same subsample of soil samples (n=50) selected from manual analysis. In addition, I also conduct DIA on 15 soil samples collected from within the northern annex of Structure 5PS-d by Markus Eberl during TAP excavations.

DIA was conducted at Vanderbilt University using the PartAn 3D particle analyzer (Figure 4.9). Each sample was individually poured into a funnel at the top of this analyzer and then passed through a vibrating tray until each particle was dropped individually into the measurement area (Figure 4.10). Next, digital photos were taken of each individual particle from multiple angles, and measurements of each particle were calculated for up to 40 different variables (Figure 4.11). This process took between 3-5 minutes for each sample. Most of the variables measured are dependent on one another, and some even use the exact same measurements. Currently, Markus Eberl and I are collaborating with the Data Science Institute at Vanderbilt to develop a machine learning model that uses the DIA data to differentiate between microdebitage and soil. Our investigation has revealed that transparency is overwhelmingly the most significant variable for differentiating between these two particle types. Modified from the

Figure 4.9 PartAn 3D Analyzer in the Ancient Artifacts Lab at Vanderbilt University

Figure 4.10 Soil Particles Passing through the Vibrating Tray into the Analyzer to be Photographed

Figure 4.11 Photographed Particles Passing through the PartAn 3D Analyzer

protocol developed by Johnson et al. (2021) to reflect this, I chose two variables that use independent measurements that do not overlap: length/width ratio and transparency (measure of light intensity). Table 4.1 presents descriptions and value ranges for each of these variables.

Spatial Analysis

Spatial analysis was used to visually assess differences in 1) household wealth and status across Tamarindito, 2) areas where stone tools were being manufactured, and 3) areas where resultant stone tools were found during excavations. Comparing these three categories of data creates a visual representation of where stone tool production was located both geographically and socioeconomically. Density raster maps included the following data: microdebitage densities, artifact data from previous excavations, household construction volumes, and distances of households from the plaza. Artifact information from TAP excavations was supplied by Markus Eberl via the project database. Using ArcGIS 10.7, I added artifactual data to shape files previously created by Markus Eberl and Sarah Levithol-Eckhardt of the TAP to create raster density maps of microdebitage locations (including size classes and material types) at Residential Group 5PS-d to visualize the spatial distribution of these artifacts. To visualize stone tool densities across the site of Tamarindito, obsidian and chert densities, along with CE/M ratios for obsidian blades recovered from each household, are also mapped to assess each the access to obsidian and chert for each household. Spatial variation based on household wealth, status, and power was mapped via metrics from household construction volumes and distances.

Summary

In this chapter, I have reviewed the methodologies employed to collect and analyze soil samples for the current dissertation research. This methodology builds from microdebitage and microartifact analyses taking place worldwide since the 1970s (Baumler and Downum 1989; Clark 1986; Dunnell and Stein 1989; Hassan 1978; Homsey-Messer and Humkey 2016; Hull 1987; Johnson et al. 2016; Metcalfe and Heath 1990; Parker and Sharratt 2017; Sherwood 2001; Sherwood and Kocis 2006; Sherwood et al. 1995; Tani 1995) but have yet to be seriously employed in Mesoamerica. Further, I expand on the methodologies used to analyze microdebitage by adding DIA. I employed both manual analysis and DIA of archaeological soil samples in order to compare the time and effort required for each method and also the accuracy and robustness of the data produced. In the following chapter, I present the results of these analyses.

Table 4.1 Variable Descriptions (modified from MicroTrac MRB Imaging Parameters Reference Table)

Variable	Description	Value Range	Meaning of Value
Length/Width Ratio	Measure of length divided by width	1 to infinity	Value of 1 represents a perfect square
Transparency	Mean intensity of light passing through particle	0 to 1	Value of 0 equals opaque; 1 equals completely transparent;

CHAPTER 5

RESULTS OF INVESTIGATIONS AT RESIDENTIAL GROUP 5PS-D

Introduction

In this chapter, I present the results of artifact analyses undertaken with stone tool remains recovered at Residential Group 5PS-d to uncover spatial evidence of stone tool production. Residential Group 5PS-d is located in the southwest corner of Tamarindito, over a kilometer away from Plaza B, making it one of the furthest removed residential groups from the royal center. This residential group differs significantly from other excavated groups for many resasons. First, the northernmost structure (5PS-12) contains an annexed room that can only be accessed from an outer opening that faces away from the group's central plaza and other structures. Second, 2011-12 TAP excavations conducted within structure 5PS-12 revealed the highest frequency of obsidian artifacts ever recorded at the site, tripling the total number found within all other excavated areas during TAP excavations. Further, the vast majority of these artifacts were recovered from within the annexed room of 5PS-12.

The present investigation included the collection and analysis of soil samples to identify microdebitage; the spatial analysis of microdebitage recovered from these soil samples; and the morphometric analysis of obsidian cores and blades. By comparing the results of these analyses, specific areas where stone tools were manufactured and/or maintained may be illuminated within this residential group, which allows for a glimpse into the agency and choice of Classic Maya stone tool producers at Tamarindito. In addition, the soil samples were analyzed using two contrasting methods (manual analysis and Dynamic Image Analysis) in order to compare the time and labor costs, accuracy, and results of the two methods.

Results of Manual Microdebitage Analysis

Of the 239 total soil samples taken from across Residential Group 5PS-d, I examined a subsample of 50 to analyze manually for the present study (see Chapter 4 for complete details). Fifty grams of soil were taken from each sample in order to maintain a consistent frequency of microdebitage and to preserve soil for future analyses. The manual analysis resulted in a total of 780 microdebitage weighing 3.837 g (Table 5.1). Obsidian comprised 62.5 percent (n=488), while chert comprised the remaining 37.5 (n=292) percent of the overall assemblage by count. Conversely, chert dominates the weight category with 66.6 percent (2.555 g) of all lithic microdebitage recovered, and obsidian measuring 1.282 total grams.

Size Grades. Microdebitage recovered from these soil samples was manually size-graded using nested sieves into the following size-grade categories: 0.5-1.0 mm, 1.0-2.0 mm, 2.0-4.0 mm, and 4.0-6.3 mm. Visual recognition of microdebitage measuring less than 0.5 mm proved unreliable. As such, though there are likely microdebitage present, the 0.5 mm size-grade category was not included in order to maintain the integrity of the results. Figure 5.1 provides an

Table 5.1 Microdebitage Totals by Size Grade

Raw Material	Size Grade (mm)								Totals	
	4.0-6.3		2.0-4.0		1.0-2.0		0.5-1.0		Count	Weight
	Count	Weight	Count	Weight	Count	Weight	Count	Weight		
Chert	6	0.706	19	1.096	115	0.571	152	0.182	**292**	**2.555**
Obsidian	1	0.71	2	0.065	63	0.202	422	0.305	**488**	**1.282**
Totals	**7**	**1.416**	**21**	**1.161**	**178**	**0.773**	**574**	**0.487**	**780**	**3.837**

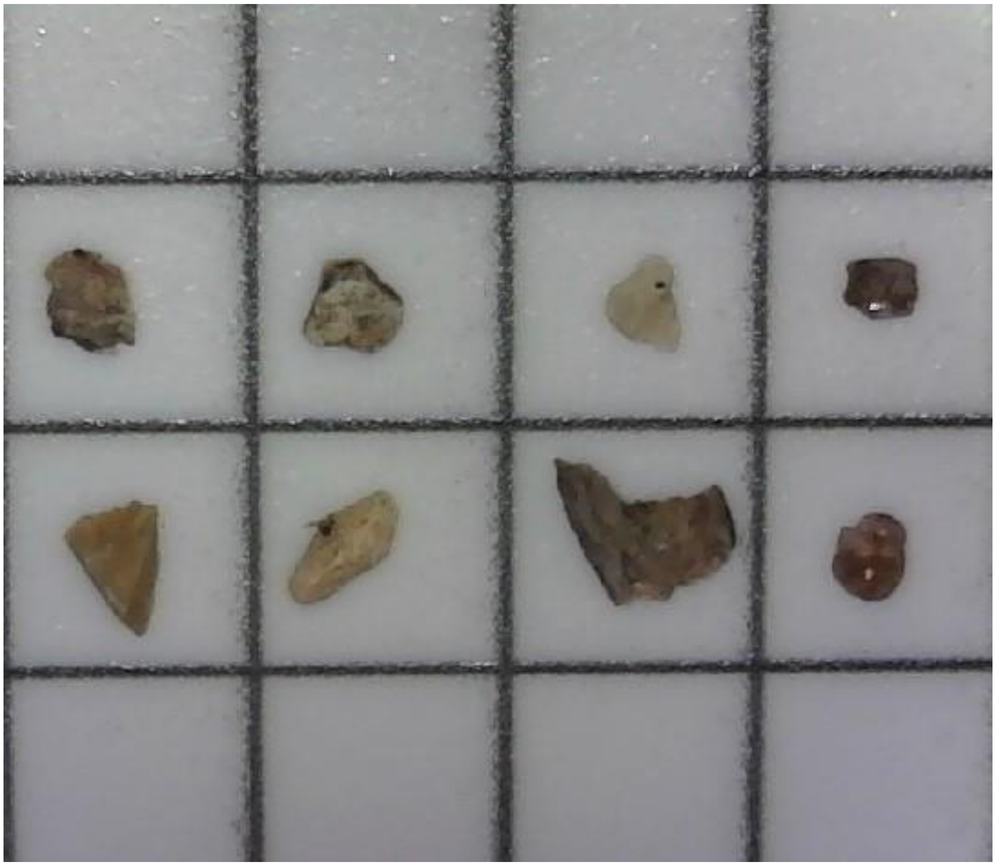

Figure 5.1 Sample of Chert Microdebitage Measuring 1.0 - 2.0 mm from Residential Group 5PS-d (each square = 5 mm^2)

example of chert microdebitage within the 1.0-2.0 mm size-grade from Residential Group 5PS-d. The smallest size-grade (0.5-1.0 mm) dominates both the chert and obsidian microdebitage assemblages, comprising 52 and 86.5 percent of the respective microdebitage counts.

Density Mapping of Manually-Identified Microdebitage

In order to visualize the distributions of microdebitage recovered from 5PS-d, I created density, or heat maps, using ArcMap 10.7.1. To do this, I overlaid point data containing weights and counts for microdebitage onto a raster map showing the plan view of Residential Group 5PSd (see Chapter 4 for complete details). These shovel tests were placed two meters apart and measured approximately 30 cm in diameter, meaning that the microdebitage counts and weights between each excavated shovel test are unknown. To fill in these gaps, I used regularized spline-tension interpolation (Mitášová and Mitáš 1993) to estimate the weights and counts of microdebitage between excavated shovel tests. Ullah et al. (2015) recommend this method as a highly accurate and easily tunable method for visualizing the distribution of microartifacts at archaeological sites. This method produces clear density maps with smooth, continuously colored surfaces with the darkest "hot spots" reflecting the highest weights or counts of microdebitage data recovered from specific shovel tests across the residential group, while the lightest areas reflect the lowest weights or counts.

Total Microdebitage Densities (3.837 grams). Figure 5.2 displays the combined weight densities. Because microdebitage can be broken post-depositionally, weights are considered a more accurate reflection of the density of microdebitage recovered and are described in the present section, while counts of microdebitage are described at the end of this section. In this way, the manual counts and estimated counts from DIA can be compared. As a whole, microdebitage is clustered roughly in a semicircle around the southern edge of the plaza, with the highest total concentration situated directly west and in front of Structure 5PS-13. The remaining clusters are located directly north of the steps of Structure 5PS-14, to the south of Structure 5PS-15, and also within the southernmost room of Structure 5PS-15. Within this structure, the cluster is densest at the northwest corner of the room. The central portion of the plaza appears relatively clean.

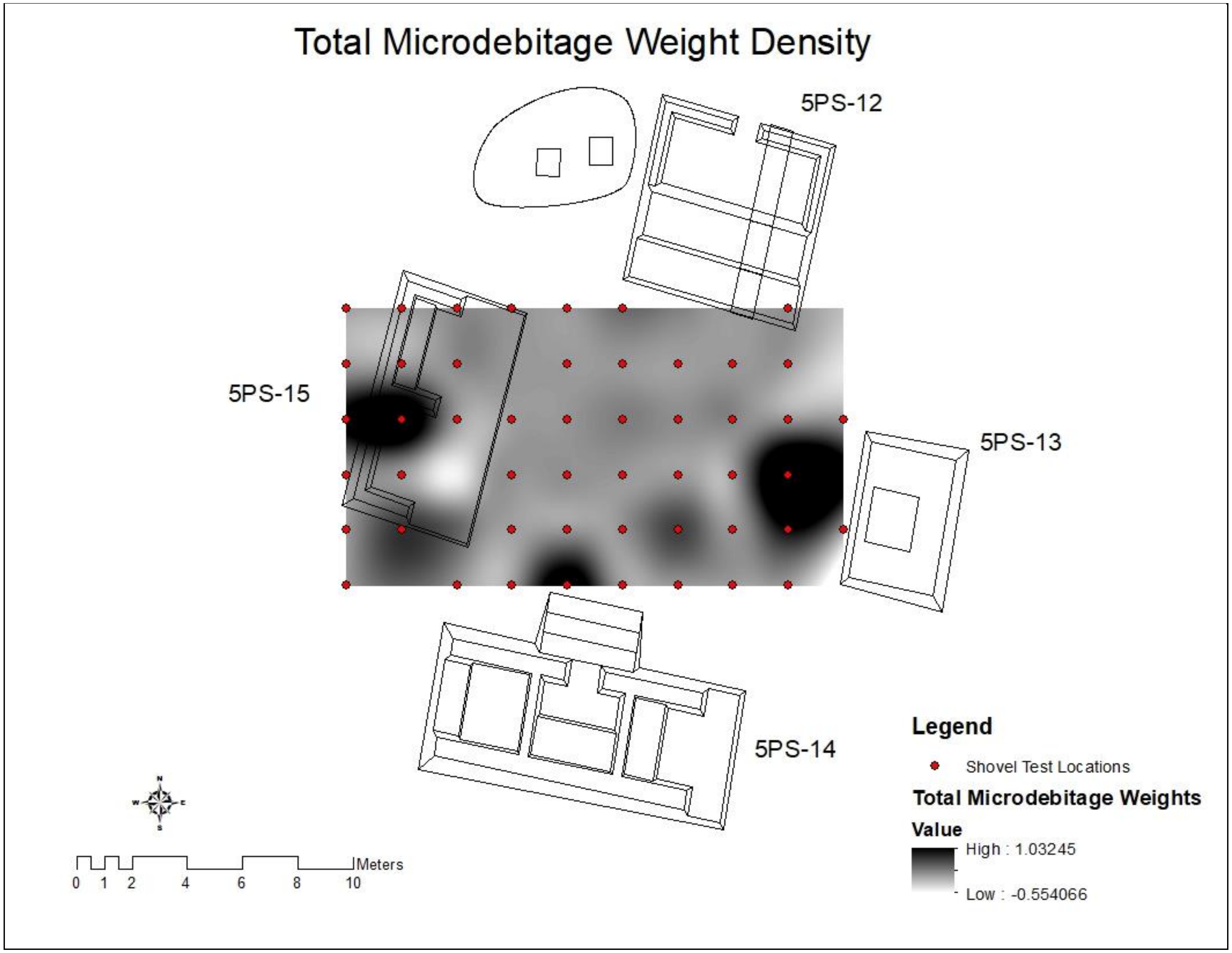

Figure 5.2 Density Map Showing Combined Weights of Chert and Obsidian Microdebitage Measuring 0.5 - 6.3 mm Recovered from Soil Samples at Residential Group 5PS-d using Manual Analysis

Total Chert Microdebitage Densities (2.555 grams). The overall chert microdebitage assemblage (spanning all size grades) is clustered in an almost identical pattern to that of the overall microdebitage densities (Figure 5.3), with concentrations of chert microdebitage clustered roughly in a semicircle around the southern edge of the plaza. Hot spots are located in front of Structure 5PS-13, directly north of the steps of Structure 5PS-14, to the south of Structure 5PS-15, and also within the southernmost room of Structure 5PS-15. Once again, the central portion of the plaza appears relatively clean.

Chert Microdebitage Measuring 0.5-1.0 mm (0.182 grams). The chert microdebitage measuring 0.5-1.0 mm is similarly clustered in a circular fashion around the plaza with the central most plaza remaining relatively clear (Figure 5.4). In contrast, however, a cluster now appears spreading across southeast corner of Structure 5PS-15. Further, a secondary cluster now appears directly south of the southeast corner of Structure 5PS-12.

Chert Microdebitage Measuring 1.0-2.0 mm (0.571 grams). A significant decrease in chert microdebitage clustering is evident within the 1.0-2.0 size grade. The most significant cluster lies directly south of the southwest corner of Structure 5PS-12, while a secondary cluster may exist at the northwest corner of Structure 5PS-15 (Figure 5.5). Similar to the previous density maps, the central portion of the plaza is relatively clear of microdebitage.

Chert Microdebitage Measuring 2.0-4.0 mm (1.096 grams). Only one significant cluster is evident within the 2.0-4.0 size grade of chert microdebitage (Figure 5.6). This cluster appears at the northwest corner of the southernmost room in Structure 5PS-12. The remaining area remains uniform, which can be attributed to the paucity of microdebitage recovered from within this size grade.

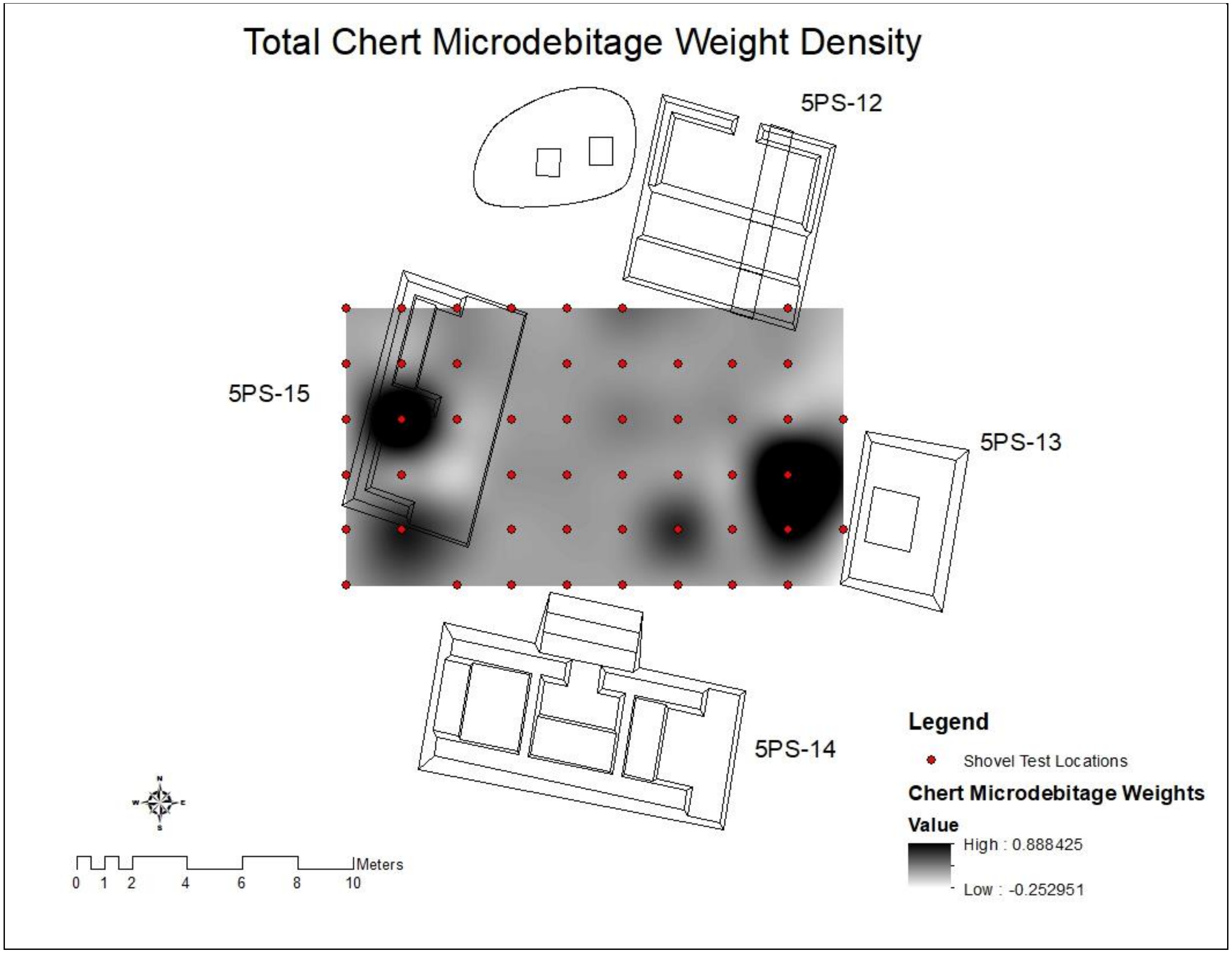

Figure 5.3 Density Map Showing Weights of All Chert Microdebitage Recovered from Soil Samples at Residential Group 5PS-d

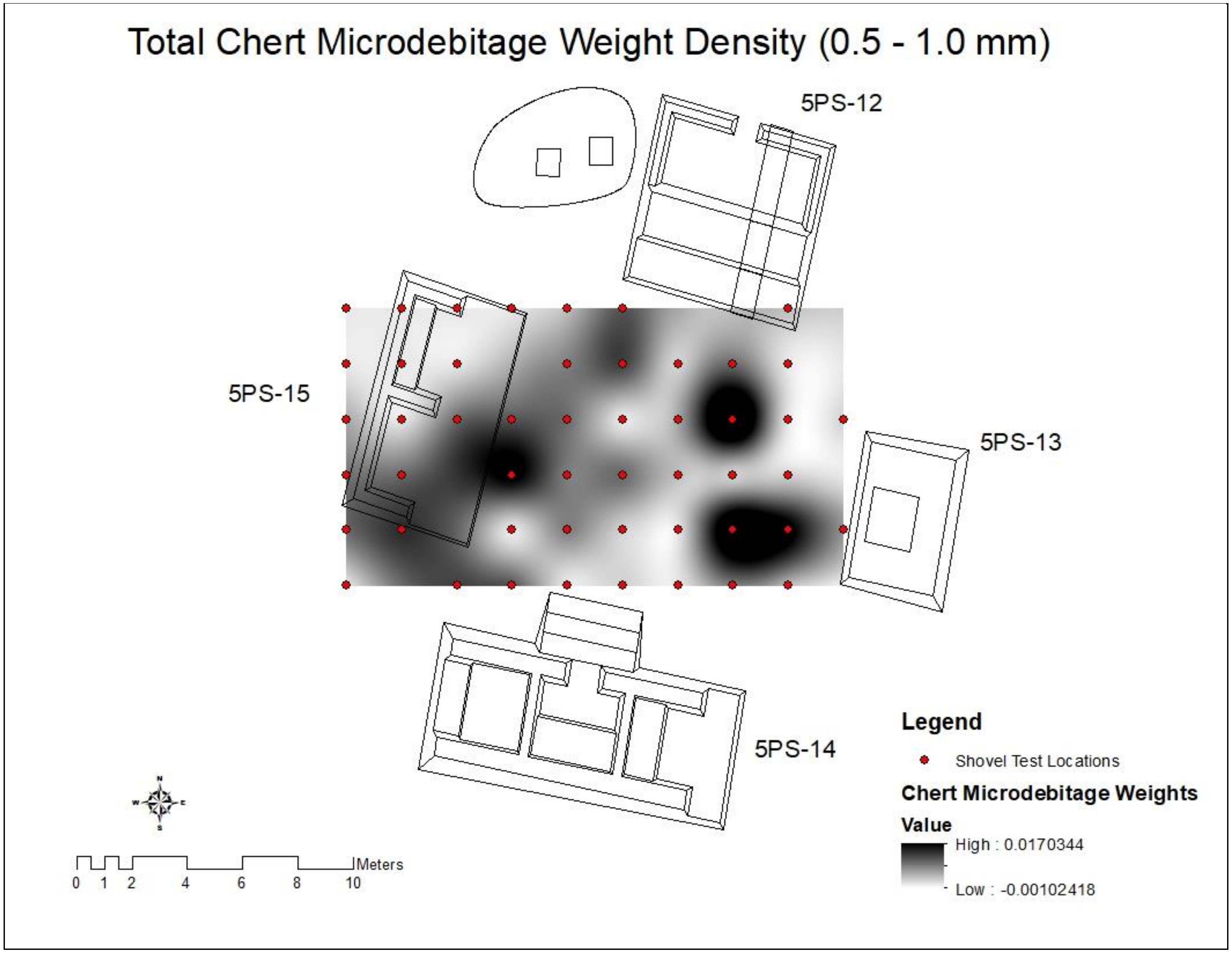

Figure 5.4 Density Map Showing Weights of Chert Microdebitage Measuring 0.5 - 1.0 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

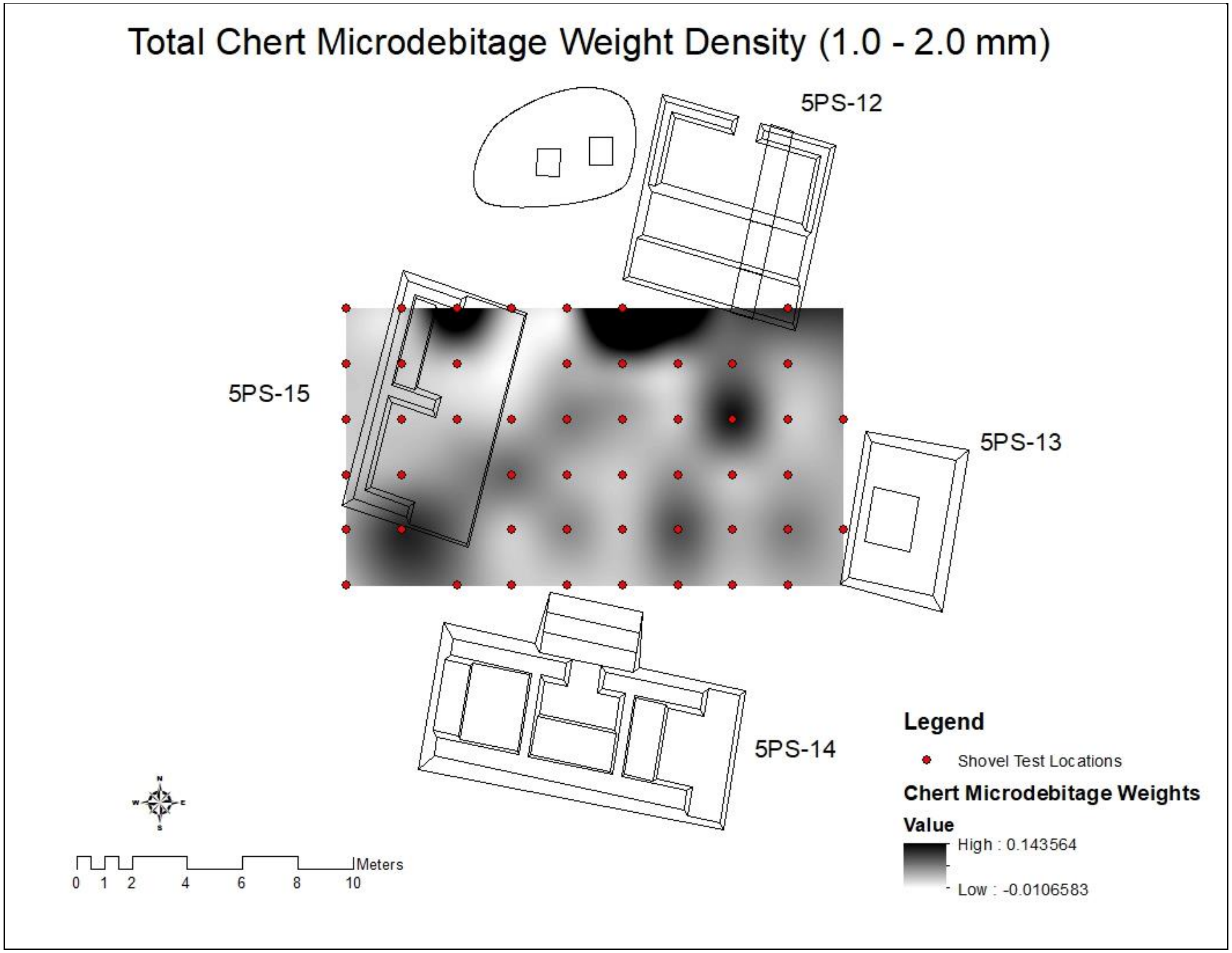

Figure 5.5 Density Map Showing Weights of Chert Microdebitage Measuring 1.0 - 2.0 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

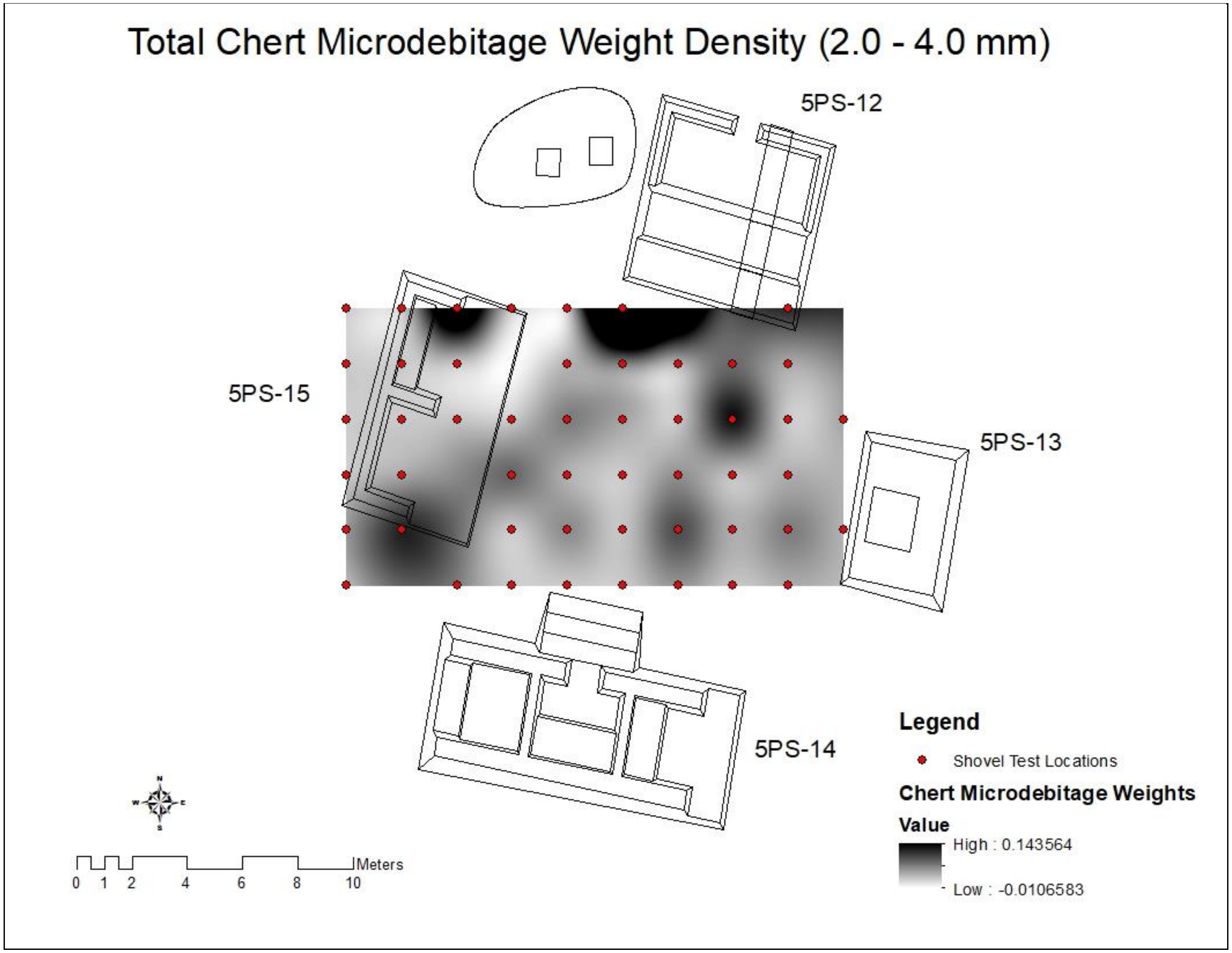

Figure 5.6 Density Map Showing Weights of Chert Microdebitage Measuring 2.0 - 4.0 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

Chert Microdebitage Measuring 4.0-6.3 mm (0.706 grams). Departing from previous density maps of chert microdebitage, the 4.0-6.3 mm size grade displays a significant cluster directly west of Structure 5PS-13, while a secondary cluster is evident directly in the center of the plaza (Figure 5.7). Similar to the results of the 2.0-4.0 mm size grade, this is likely an artifact of the low density of chert microdebitage recovered from this size grade.

Total Obsidian Microdebitage Densities (1.282 grams). The overall obsidian microdebitage assemblage (spanning all size grades) is clustered in a similar fashion to the overall microdebitage densities (Figure 5.8). The highest concentrations lie directly north of the steps of Structure 5PS-14 and directly behind Structure 5PS-15, with smaller concentrations located to the west of Structure 5PS-13 and between Structures 5PS-12 and 5PS-15. Once again, the central portion of the plaza appears relatively clean.

Obsidian Microdebitage Measuring 0.5-1.0 mm (0.305 grams). In contrast to the overall microdebitage densities for obsidian, the 0.5-1.0 mm range displays a more dispersed pattern of clustering with the most significant clusters situated directly at the center of the plaza, with additional clusters directly west of Structure 5PS-15 and west of the northwest corner of Structure 5PS-13, and south of the southwest corner of Structure 5PS-12 (Figure 5.9).

Obsidian Microdebitage Measuring 1.0-2.0 mm (0.202 grams). Similar to the 0.5-1.0 mm size grade, the obsidian microdebitage recovered from within the 1.0-2.0 mm displays a scattered pattern of clustering (Figure 5.10), with the highest concentrations situated between Structures 5PS-12 and 5PS-13, at the northwest and southwest corners of Structure 5PS-15, and directly west of Structure 5PS-15. Lighter concentrations are apparent throughout the central portion of the plaza.

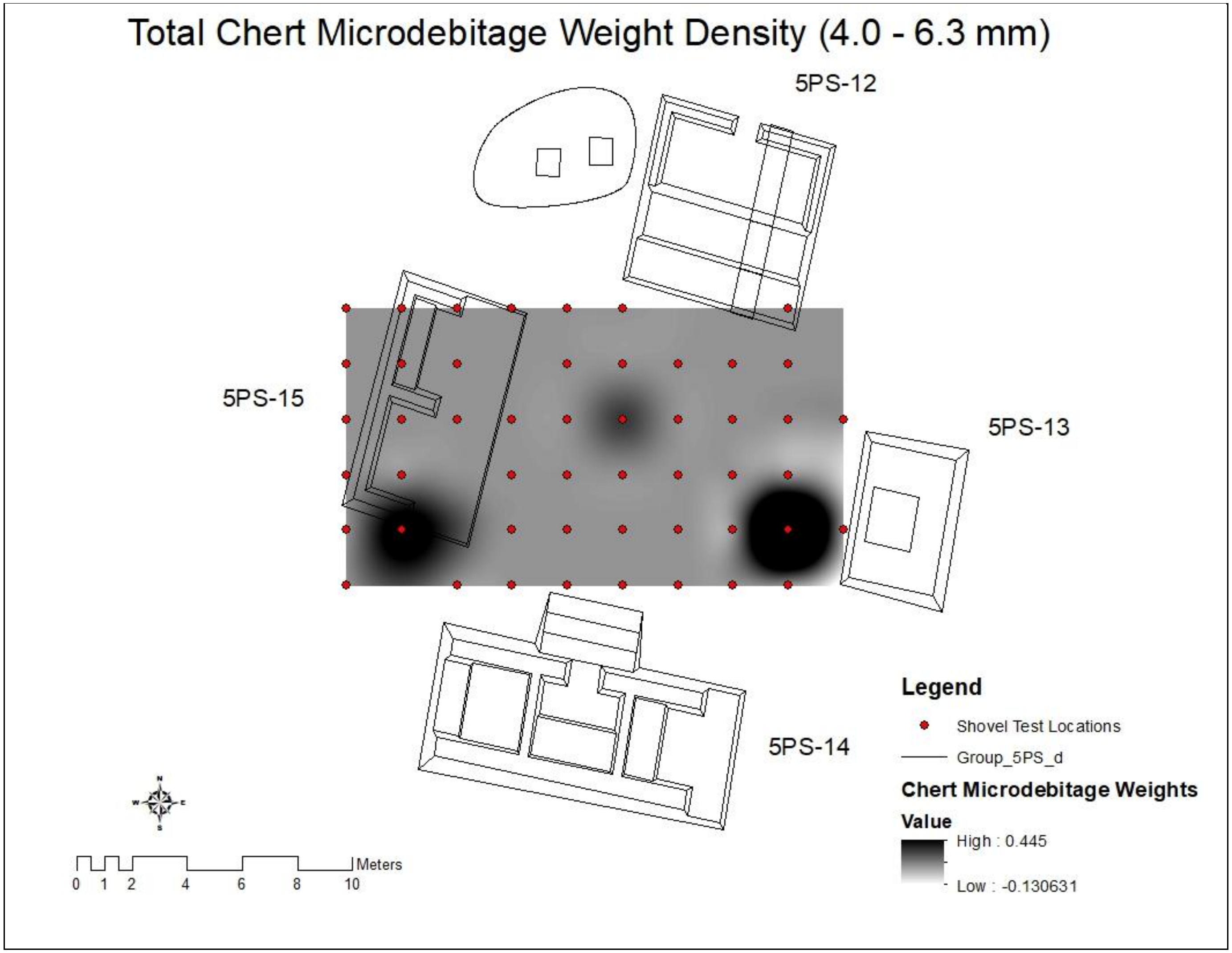

Figure 5.7 Density Map Showing Weights of Chert Microdebitage Measuring 4.0 - 6.3 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

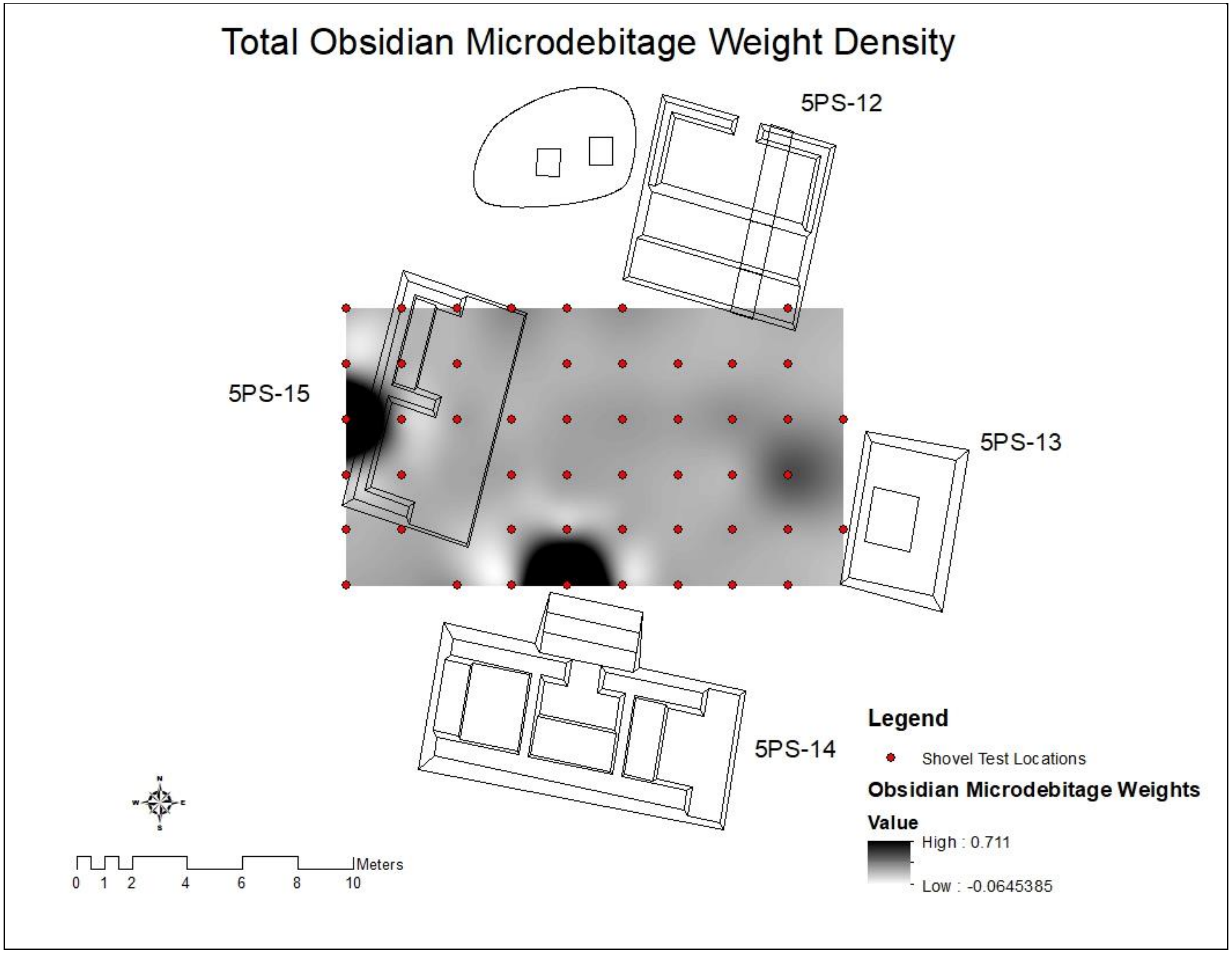

Figure 5.8 Density map Showing Total Weights of Obsidian Microdebitage Measuring 0.5 - 6.3 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

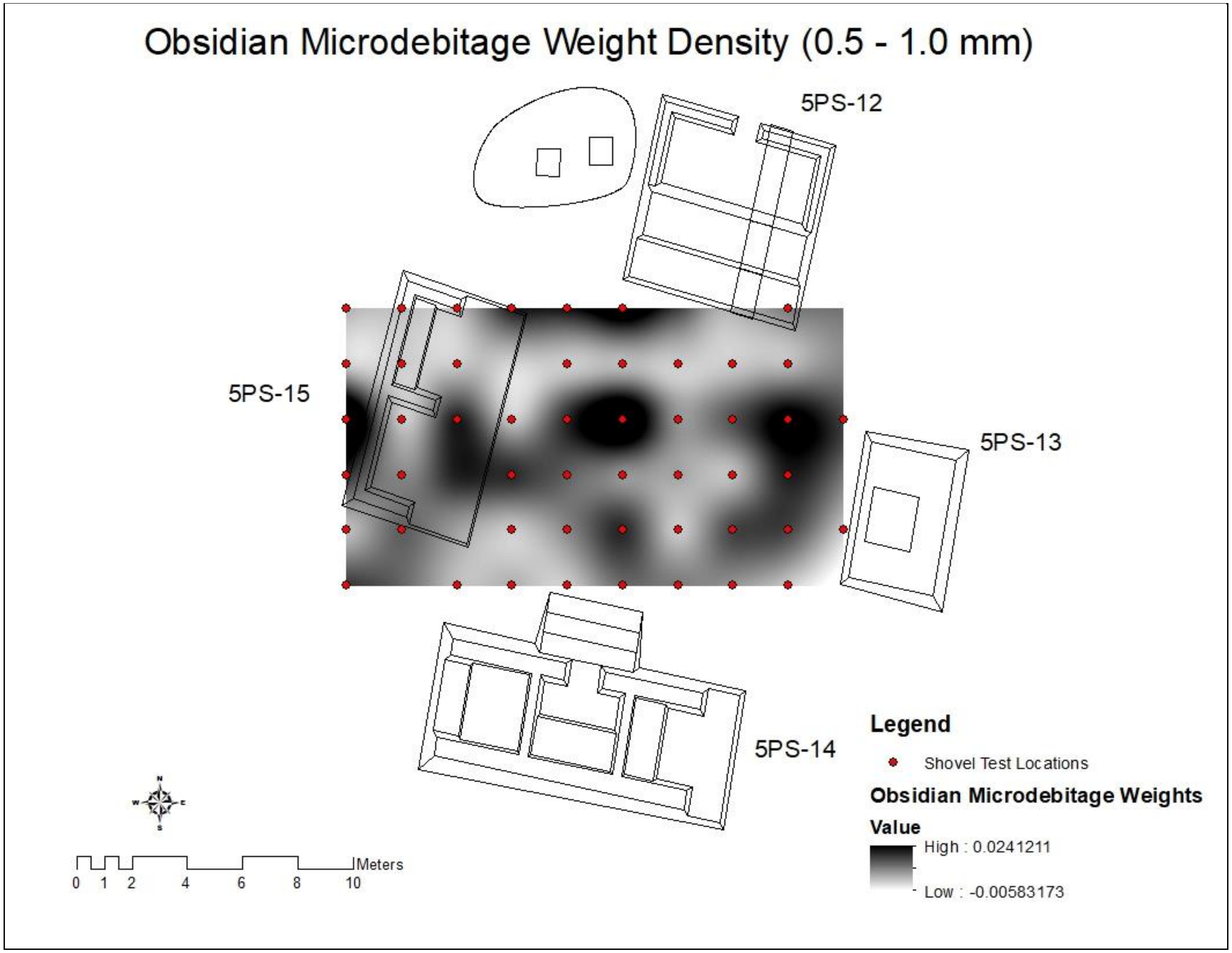

Figure 5.9 Density Map Showing Weights of Obsidian Microdebitage Measuring 0.5 - 1.0 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

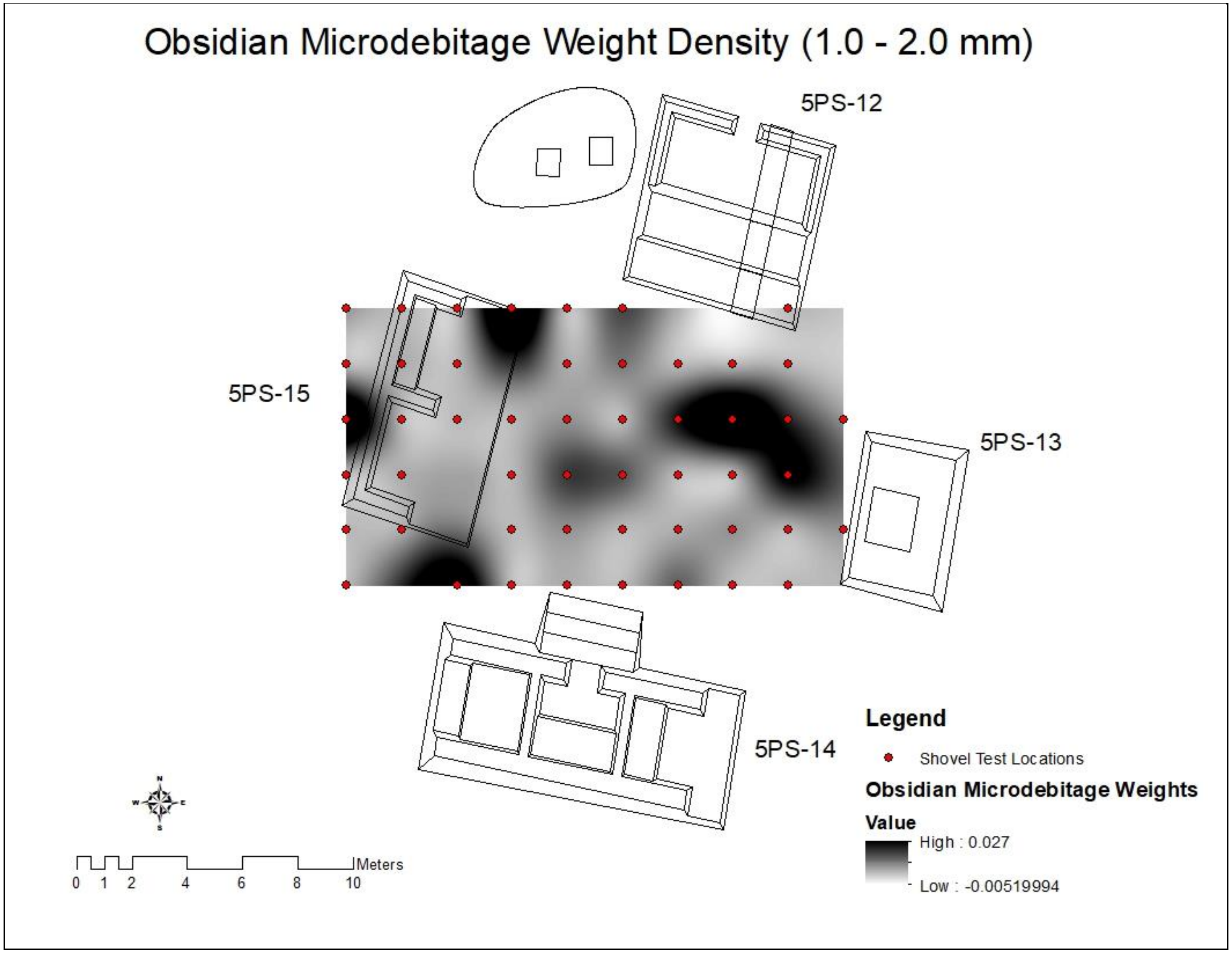

Figure 5.10 Density Map Showing Weights of Obsidian Microdebitage Measuring 1.0 - 2.0 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

Obsidian Microdebitage Measuring 2.0-4.0 mm (0.065 grams). The only concentration of obsidian microdebitage recovered from within the 2.0-4.0 mm size grade is situated directly west of Structure 5PS-13 (Figure 5.11). This result is directly attributed to the paucity of artifacts recovered.

Obsidian Microdebitage Measuring 4.0-6.3 mm (0.71 grams). The single specimen of obsidian microdebitage recovered from within the 4.0-6.3 mm size grade is situated directly north of the steps of Structure 5PS-14 (Figure 5.12). Once again, this result is directly attributed to the paucity of artifacts recovered.

Total Microdebitage Count Densities (n=780). Because DIA cannot yet calculate the weights of particles, microdebitage counts are included here as a comparison with the DIA results that are included below. The distributions of combined chert and obsidian microdebitage counts are patterned somewhat differently than that of the weights for chert and obsidian microdebitage (see Figure 5.8). Instead of being clustered in a semicircular pattern with clusters positioned around the outside of the plaza and relatively close to the structures, microdebitage counts appear clustered throughout the plaza (Figure 5.13). The most significant similarity is that a cluster remains at the southwest corner of Structure 5PS-15.

Total Microdebitage Measuring 0.5-1.0 mm (n=574). The densities of the combined totals of obsidian and chert microdebitage measuring between 0.5- and 1.0-mm mirrors almost exactly the densities of the weights for obsidian microdebitage within the same size grade (see Figure 5.9). This can be attributed to the fact that obsidian microdebitage comprises 73.5 percent of all microdebitage within this size grade. In contrast to the overall microdebitage count densities, the 0.5-1.0 mm range displays a more dispersed pattern of clustering with the most significant clusters situated directly at the center of the plaza (Figure 5.14), with additional

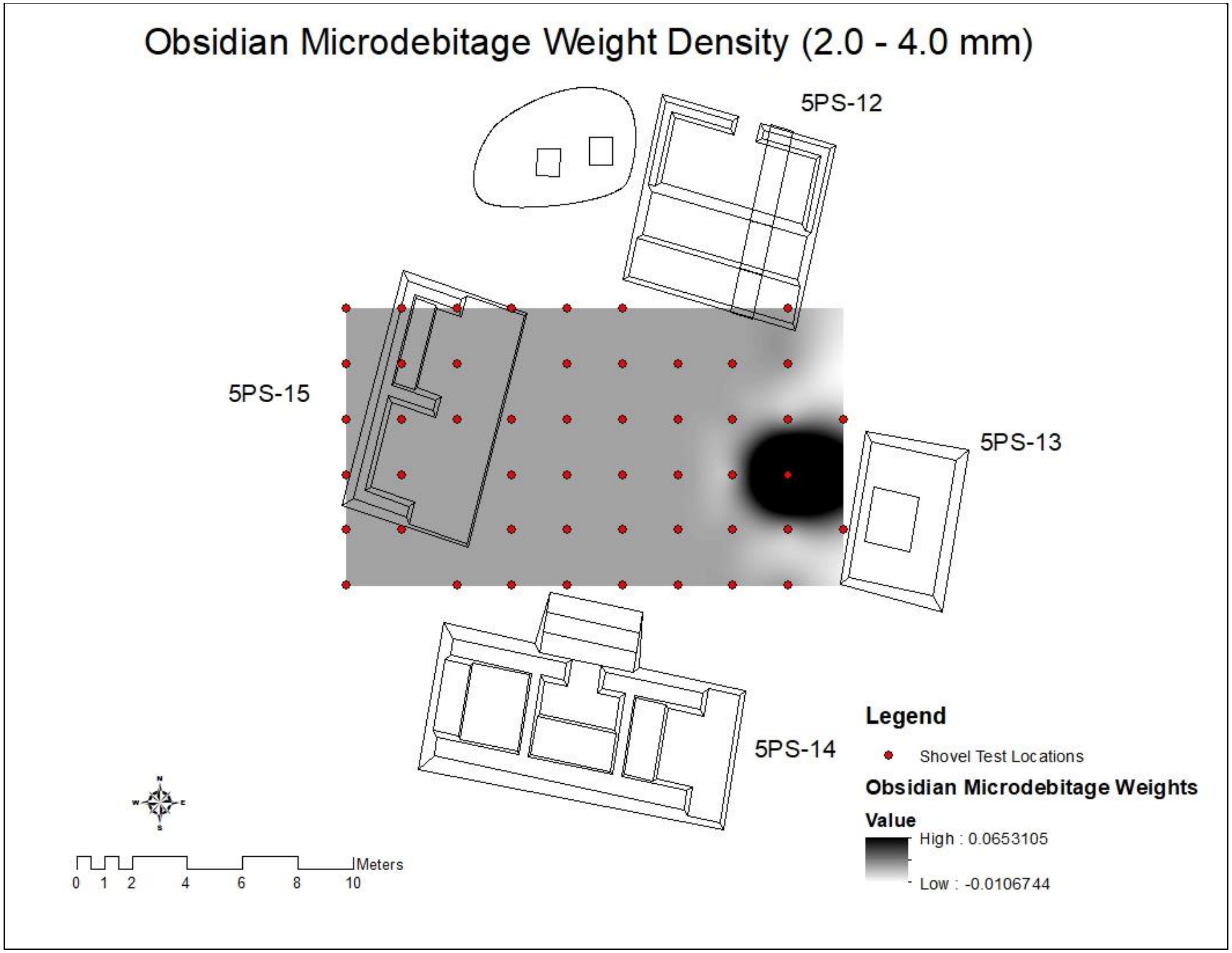

Figure 5.11 Density Map Showing Weights of Obsidian Microdebitage Measuring 2.0 - 4.0 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

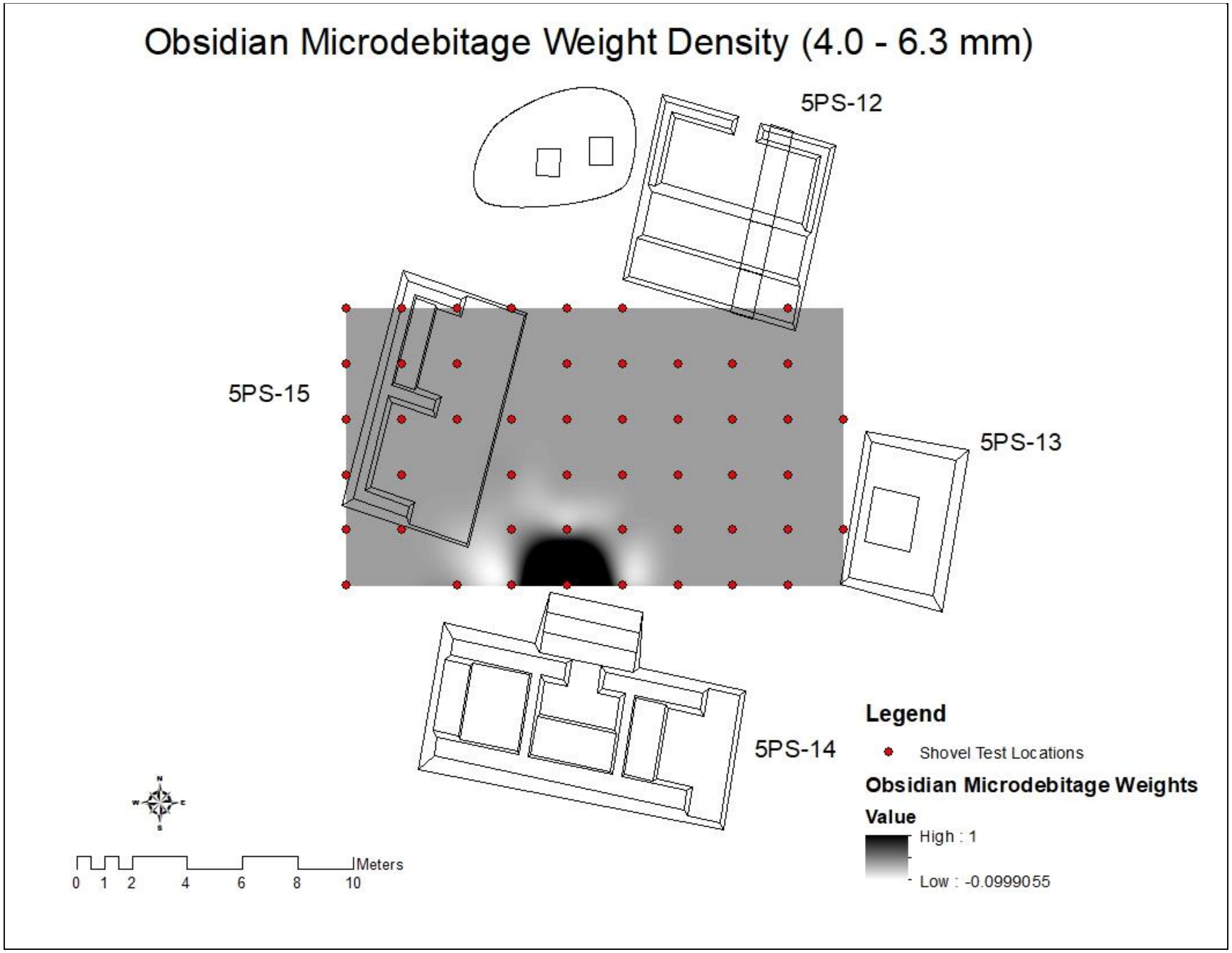

Figure 5.12 Density Map Showing Weights of Obsidian Microdebitage Measuring 4.0 - 6.3 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

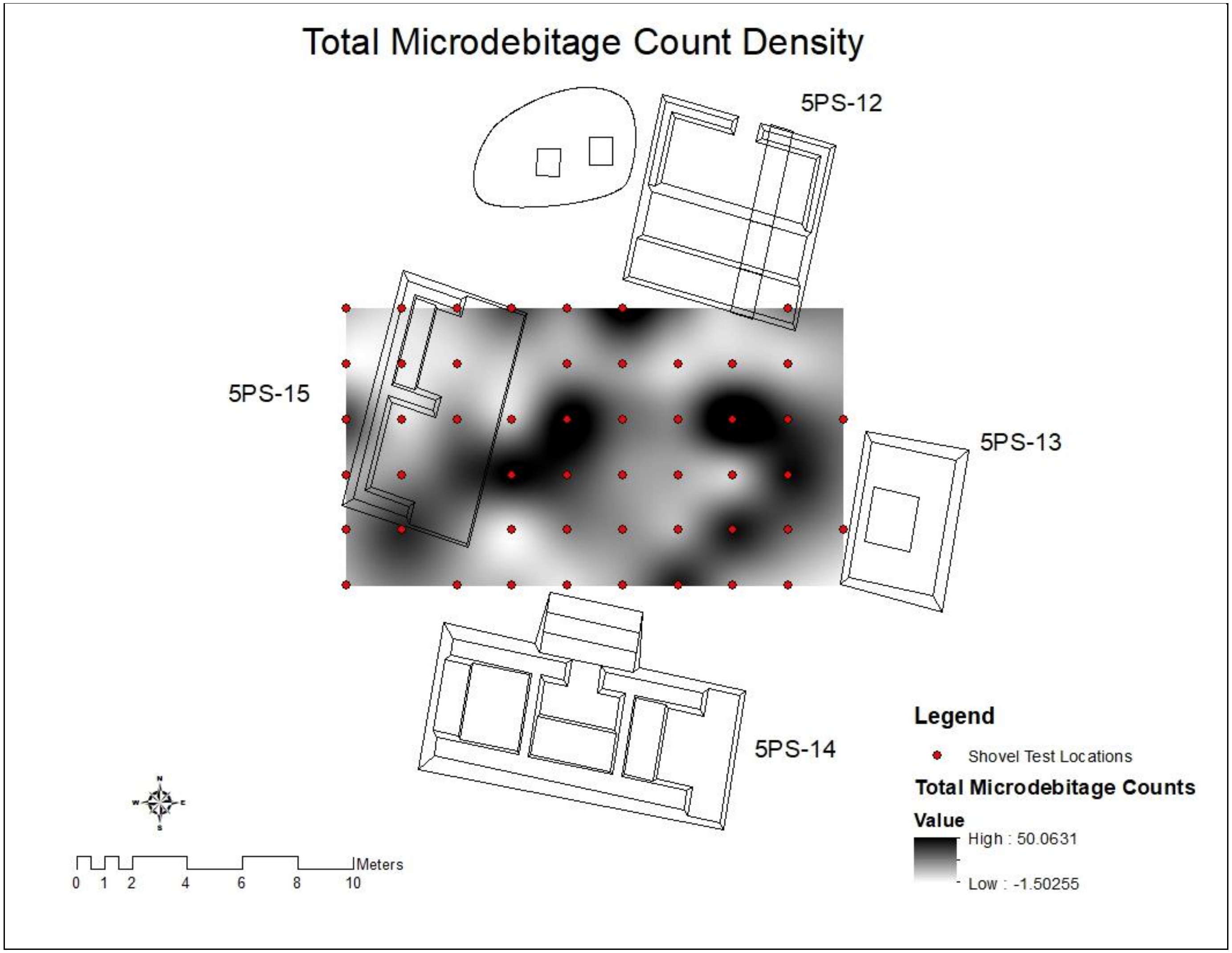

Figure 5.13 Density Map Showing Combined Totals of Chert and Obsidian Microdebitage Recovered from Soil Samples at 5PS-d using Manual Analysis

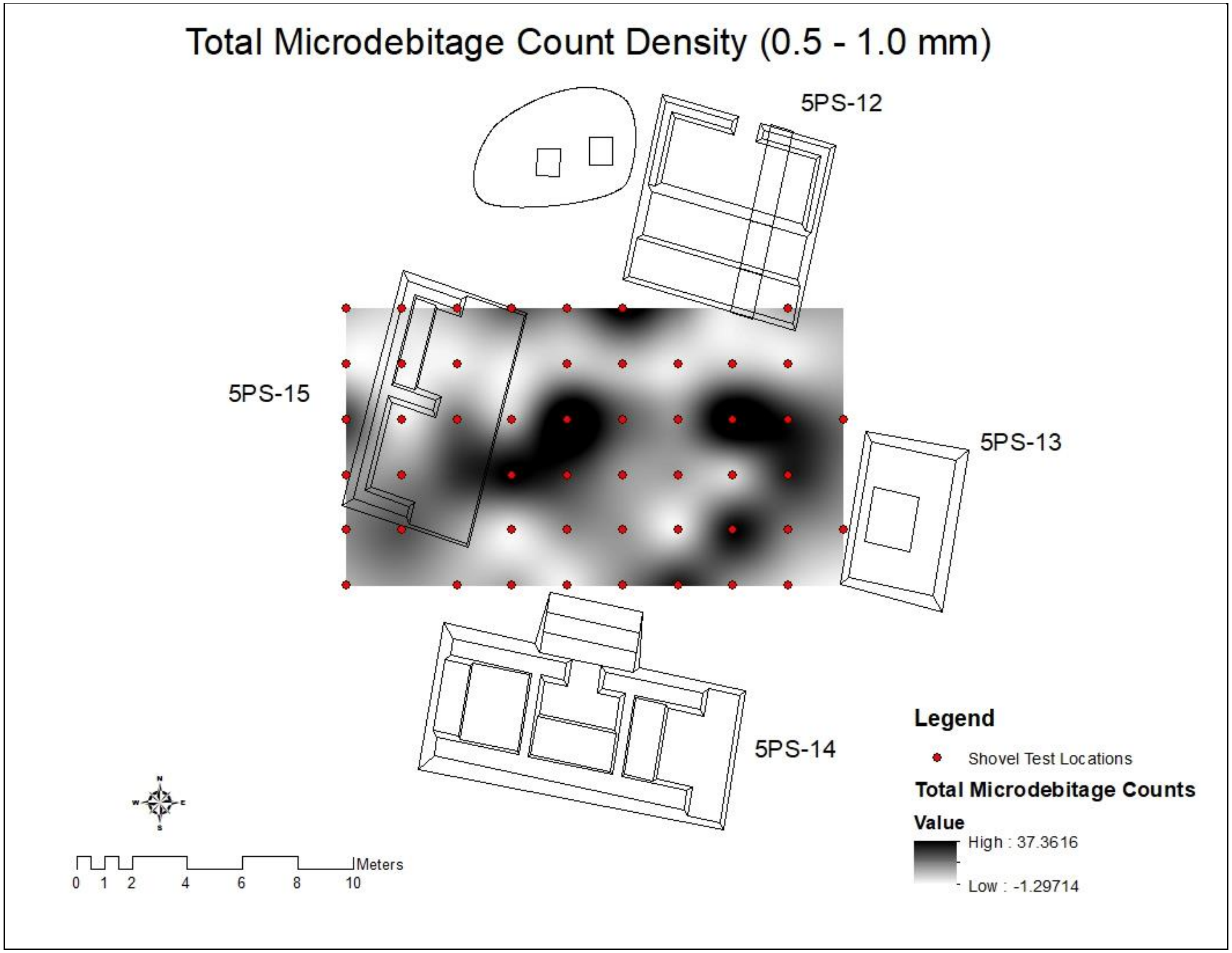

Figure 5.14 Density Map Showing Combined Totals of Chert and Obsidian Microdebitage Measuring 0.5 - 1.0 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

clusters directly west of Structure 5PS-15 and west of the northwest corner of Structure 5PS-13, and south of the southwest corner of Structure 5PS-12.

Total Microdebitage Measuring 1.0-2.0 mm (n=178). Similar to the 0.5-1.0 mm size grade (and again mirroring the patterns for obsidian microdebitage (see Figure 5.10)), the total counts of microdebitage recovered from within the 1.0-2.0 mm display a scattered pattern of clustering (Figure 5.15), with the highest concentrations situated between Structures 5PS-12 and 5PS-13, at the northeast and southeast corners of Structure 5PS-15, and directly west of Structure 5PS-15. Lighter concentrations are apparent throughout the central portion of the plaza.

Total Microdebitage Measuring 2.0-4.0 mm (n=21). The only concentration of obsidian microdebitage recovered from within the 2.0-4.0 mm size grade is situated directly west of Structure 5PS-13 (Figure 5.16). This result is directly attributed to the paucity of artifacts recovered. As with the previous two size grades, this mirrors almost exactly the pattern for obsidian microdebitage within the same size grade (see Figure 5.11).

Total Microdebitage Measuring 4.0-6.3 mm (n=7). Unlike the previous three size grades that mirror patterns for obsidian microdebitage, the 4.0-6.3 mm size grade follows a nearly exact pattern to that of the chert microdebitage within the same size grade (see Figure 5.7), displaying a significant cluster directly west of Structure 5PS-13, while a secondary cluster is evident directly in the center of the plaza (Figure 5.17). Similar to the results of the 2.0-4.0 mm size grade, this is likely an artifact of the low density of chert microdebitage recovered from this size grade.

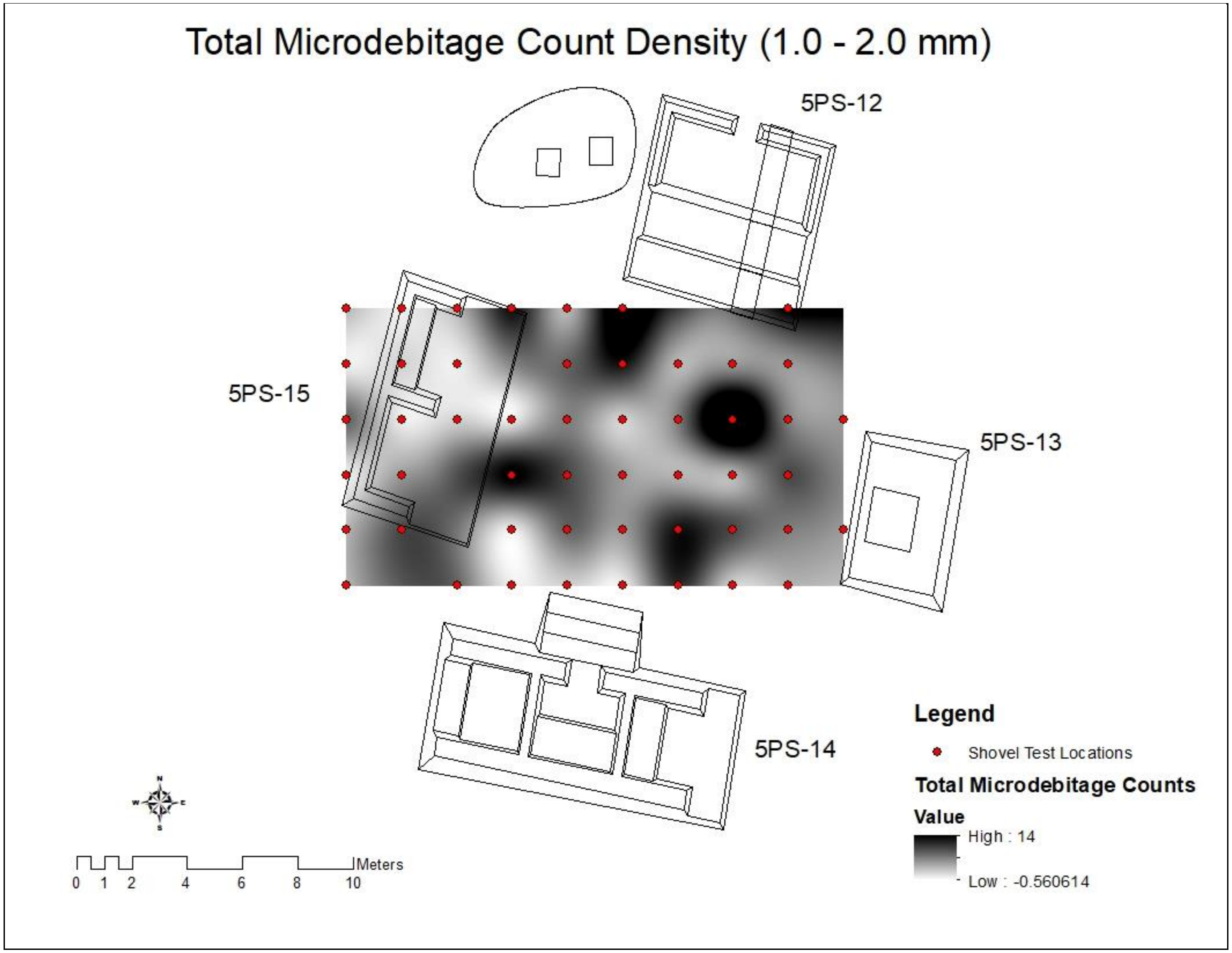

Figure 5.15 Density Map Showing Combined Totals of Chert and Obsidian Microdebitage Measuring 1.0 – 2.0 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

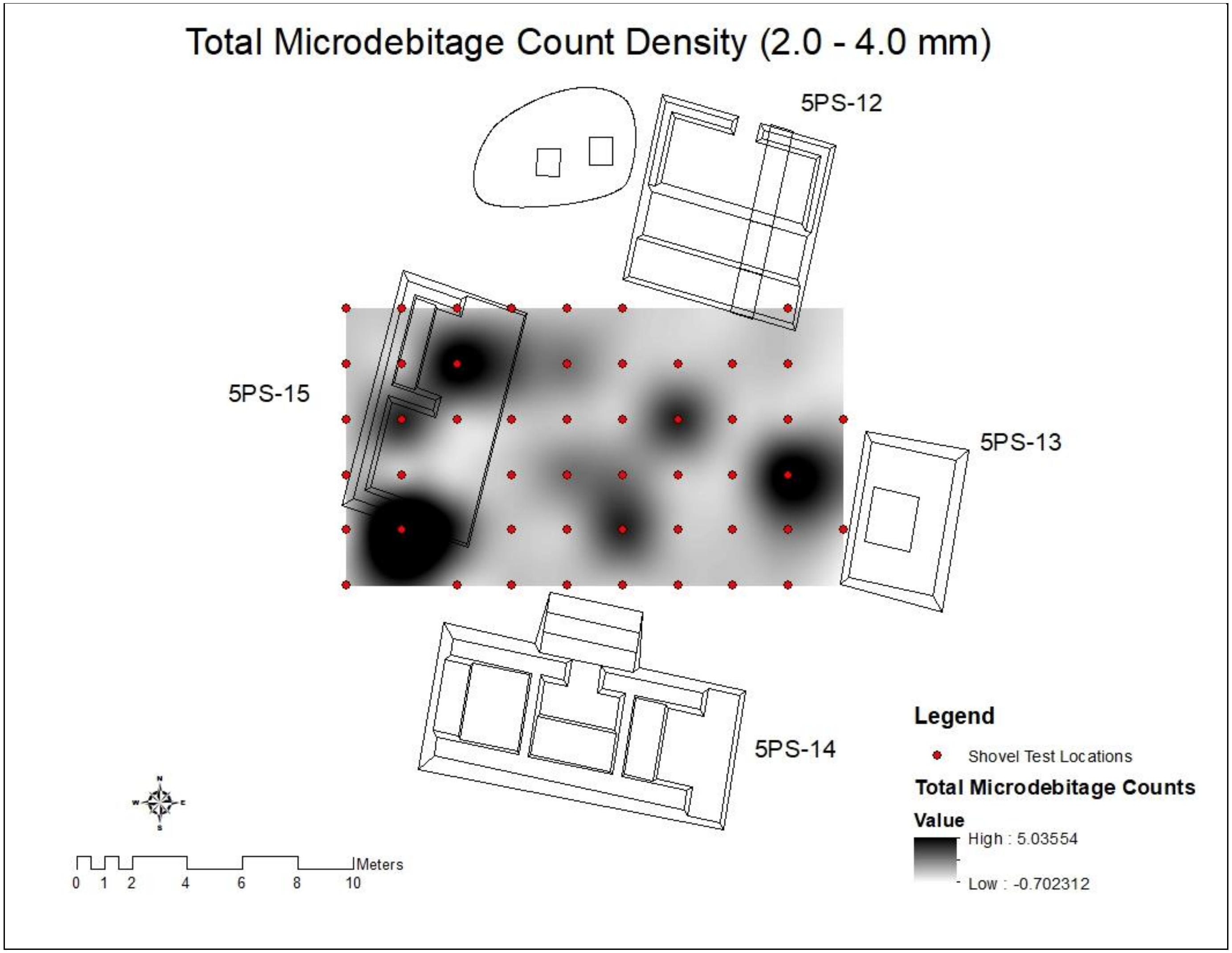

Figure 5.16 Density Map Showing Combined Totals of Chert and Obsidian Microdebitage Measuring 2.0 - 4.0 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

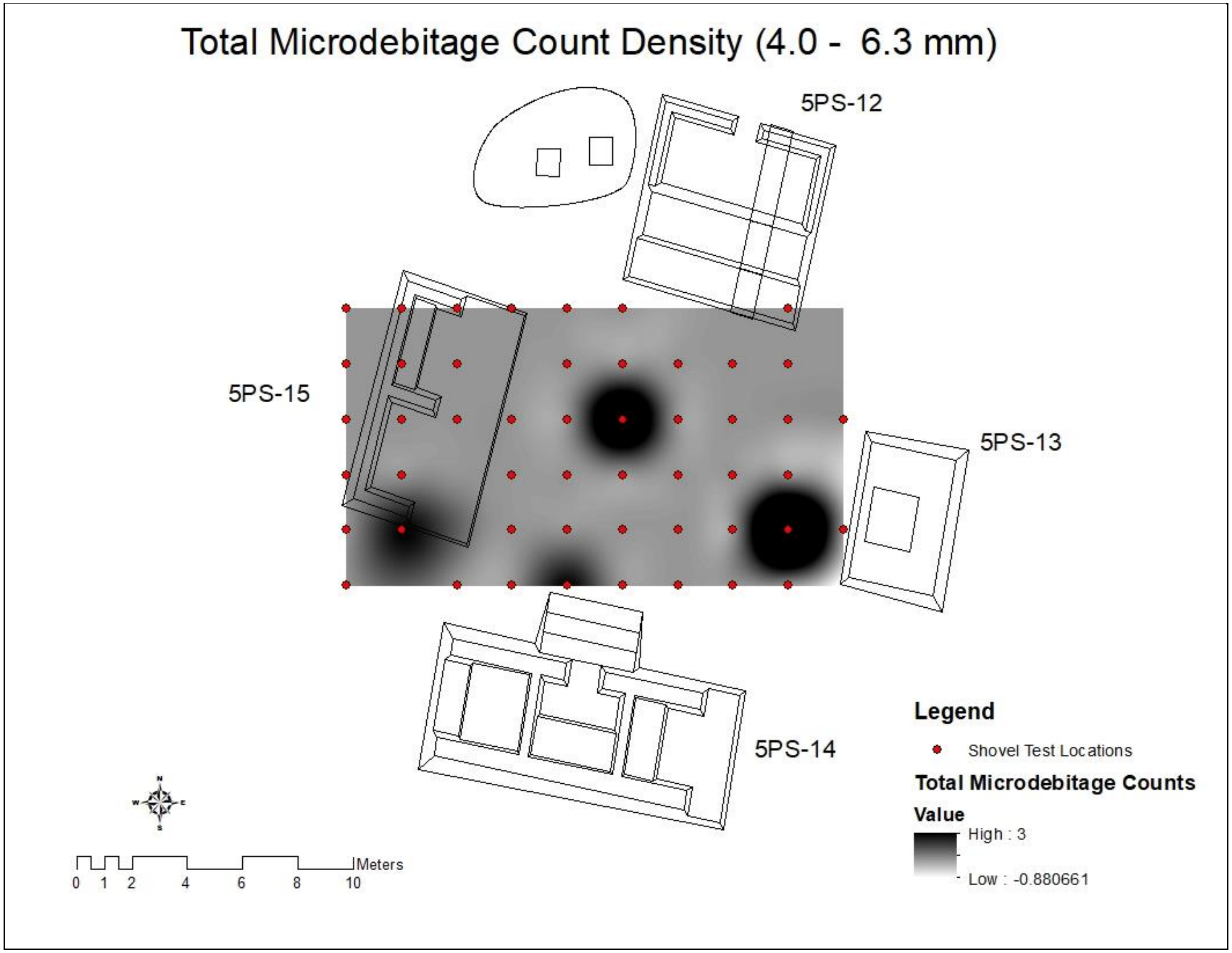

Figure 5.17 Density Map Showing Combined Totals of Chert and Obsidian Microdebitage Measuring 4.0 - 6.3 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

Results of Dynamic Image Analysis

DIA was conducted using the PartAn 3D particle analyzer in the Anthropology Department at Vanderbilt University. As with the manual analysis, 50 grams of soil were subsampled from the same 50 soil samples in order to maintain a direct comparison with the manual analysis. In addition to the 50 samples I collected from 5PS-d, I also include here the results of DIA completed on 15 soil samples collected by Markus Eberl during TAP excavations of Structure 5PS-12. As described in greater detail in Chapter 4, most of the samples taken by Markus weigh less than 50 grams. To make accurate comparisons between the two sets of samples, I have weighted the totals for all 65 samples in order to directly compare the estimated microdebitage results from each. Further, the collection strategy used to collect samples from 5PS-12 resulted in only two comparable size grades (0.5-1.0 mm and 1.0-2.0 mm). As such, the density maps for the 2.0-4.0 mm and 4.0-6.3 mm size grades do not include results for Structure 5PS-12.

Unlike with manual analysis, the ability for DIA to distinguish between chert and obsidian microdebitage has not yet been tested. As such, all microdebitage is counted as one undifferentiated category. In addition, the PartAn 3D analyzer does not calculate weights for particles, so only estimated counts are presented here. The DIA resulted in an estimated total of 462 microdebitage between my samples (n=422) and the TAP samples (n=40).

Size Grades. As part of the DIA, the PartAn 3D analyzer sorted each particle into a size-grade category equivalent to those used with the manual analysis, and these results are included as a direct comparison to the results of the manual analysis, using the same four size-grade categories as above. Counts for each size-grade category are as follows: 0.5-1.0 mm (n=262), 1.0-2.0 mm (n=144), 2.0-4.0 mm (n=46), and 4.0-6.3 mm (n=10). Though not to the same extent as with the manual analysis, the smallest size-grade (0.5-1.0 mm) continues to dominate the microdebitage assemblage, comprising 56.6 percent of the microdebitage counts.

Density Mapping of Microdebitage Identified through Dynamic Image Analysis

Total Estimated Microdebitage Counts (n=462). As discussed in detail in Chapter 4, DIA was completed using the PartAn 3D analyzer, and the results provided are estimated values of microdebitage for all 65 soil samples from both datasets. As seen in Figure 5.18, the densities of the total counts of estimated microdebitage demonstrate both similarities and differences to those of the total counts of microdebitage identified using manual analysis. As with the manual analysis, DIA densities reveal a significant cluster of microdebitage at the southwest corner of Structure 5PS-15. There is also a less dense cluster along the northern steps of Structure 5PS-14 and the beginnings of a cluster at the southeast edge of Structure 5PS-12. This is similar to the results of the manual analysis, but the concentrations are far less intense. With the addition of the 15 soil samples from TAP excavations, a dense concentration also appears in the northern annex of Structure 5PS-12.

Microdebitage Measuring 0.5-1.0 mm (n=262). As with the overall densities for estimated microdebitage counts, the results of the DIA reveal a significant cluster of microdebitage measuring 0.5-1.0 mm at the southwest corner of Structure 5PS-15. There is also a less dense cluster along the northern steps of Structure 5PS-14 and the beginnings of a cluster at the southeast edge of Structure 5PS-12 (Figure 5.19). This differs significantly from the results of the manual analysis that display a more dispersed pattern of microdebitage clusters (see Figure 5.14). As with the densities seen in Figure 5.18, there is also a dense concentration in the northern annex of Structure 5PS-12.

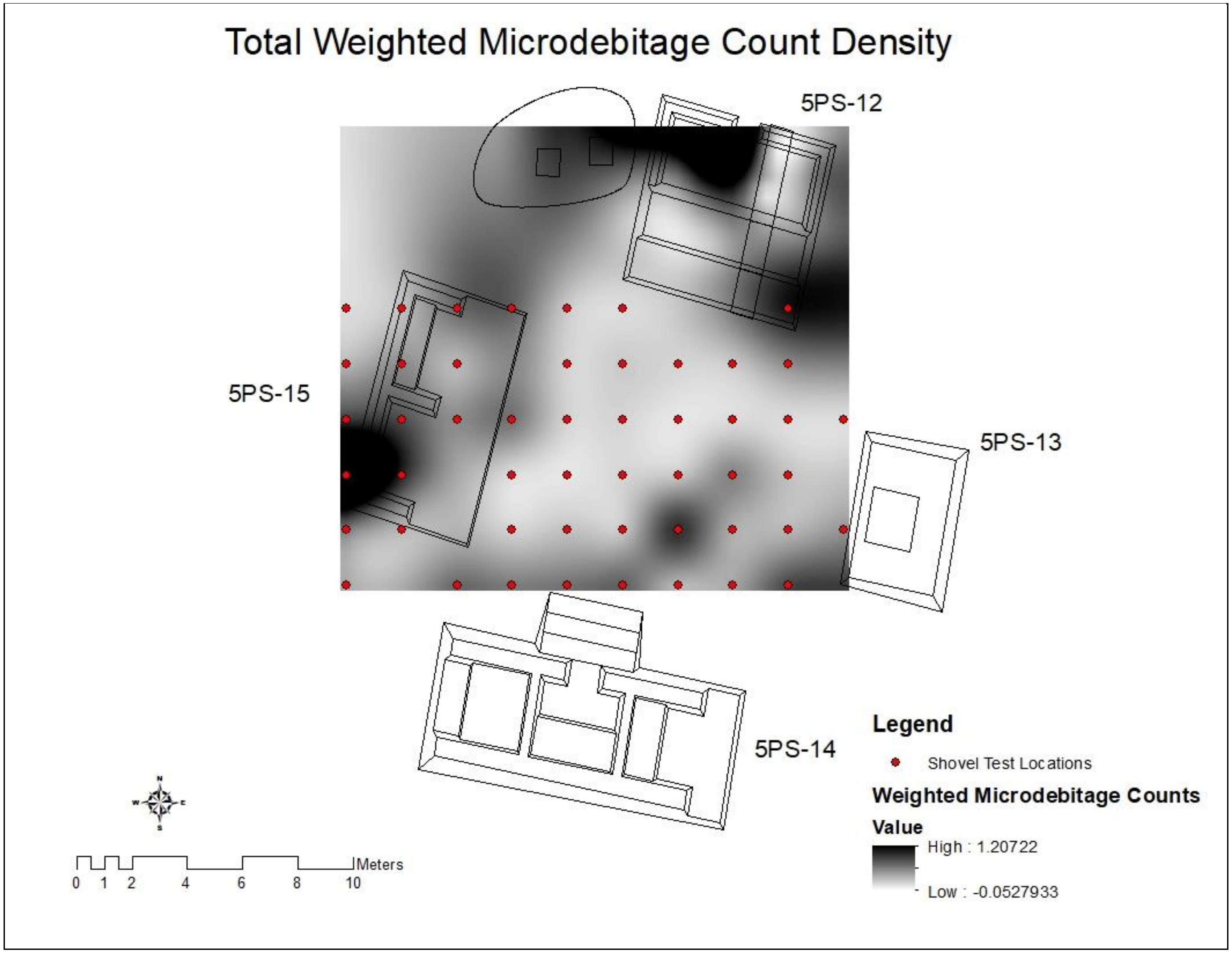

Figure 5.18 Density Map Showing Weighted Estimated Counts of Microdebitage from All Size Grades Recovered from Soil Samples at 5PS-d using Dynamic Image Analysis

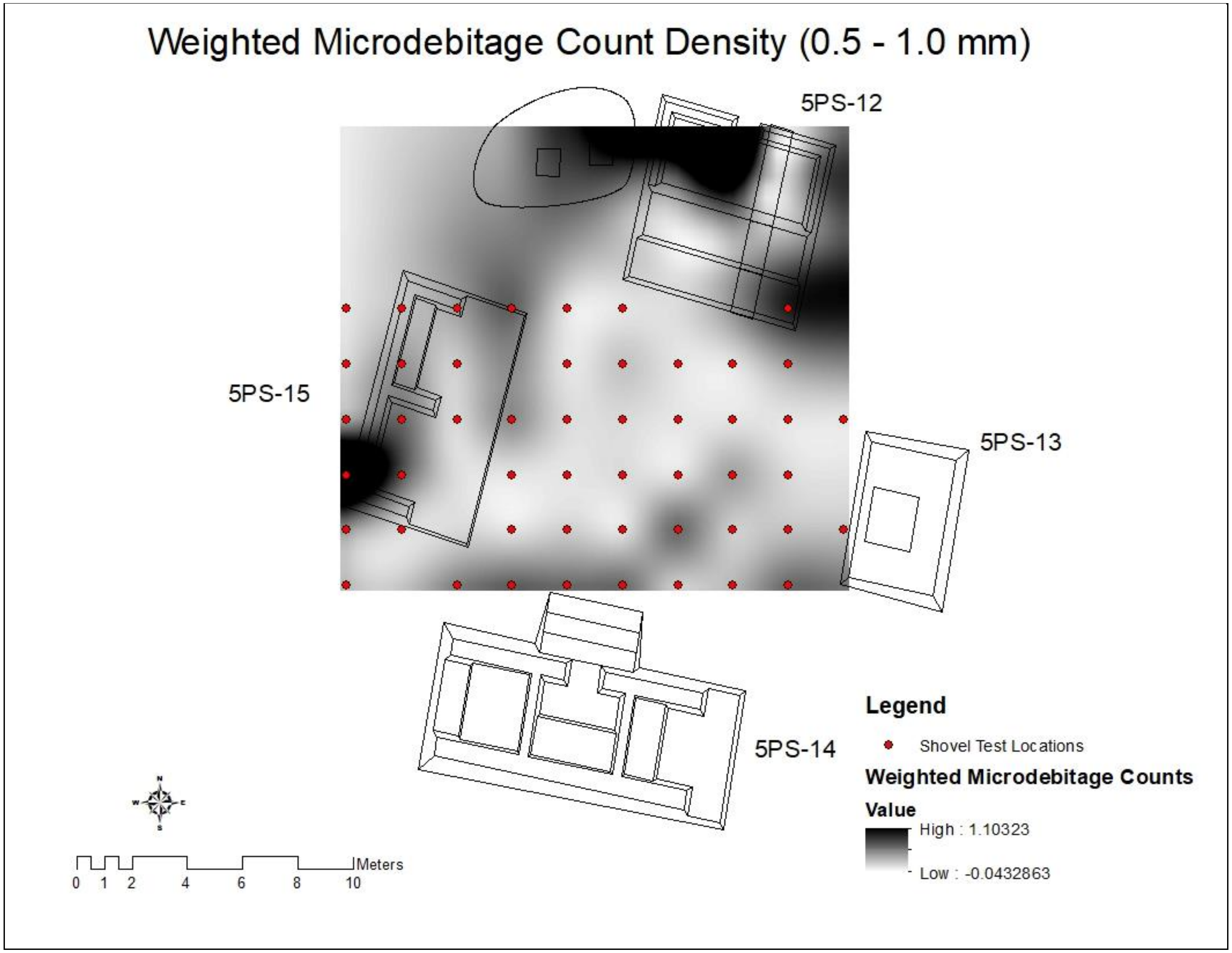

Figure 5.19 Density Map Showing Weighted Estimated Counts of Microdebitage Measuring 0.5 - 1.0 mm Recovered from Soil Samples at 5PS-d using Dynamic Image Analysis

Microdebitage Measuring 1.0-2.0 mm (n=144). Though the patterns are not exactly mirrored, the density patterns for the 1.0-2.0 mm size grade of overall microdebitage counts completed using manual analysis are very similar to those of the estimated microdebitage recovered from within the 1.0-2.0 mm using DIA. Both groups display a scattered pattern of clustering (see Figure 5.15), with dense concentrations situated between Structures 5PS-12 and 5PS-13. Whereas the manual results display microdebitage clusters at the northeast and southeast corners of Structure 5PS-15, the DIA results reveal one large cluster directly west of Structure 5PS-15 and bleeding over into the southernmost room of that structure (Figure 5.20). Unlike the overall densities (Figure 5.18) and the 0.5-1.0 mm size grade (Figure 5.19), there is not a significant microdebitage concentration in the northern annex of Structure 5PS-12.

Microdebitage Measuring 2.0-4.0 mm (n=46). Unlike the results of the manual analysis which show only a single cluster of microdebitage directly in front of Structure 5PS-13 (see Figure 5.16), the DIA results for the 2.0-4.0 mm size grade show a dispersed pattern of microdebitage clustering, with the most significant cluster situated directly in the middle of Structure 5PS-15 between the two rooms (Figure 5.21). Secondary clusters are situated directly south of Structure 5PS-12 and between Structures 5PS-13 and 5PS-14. The central most portion of the plaza appears as clean of microdebitage.

Microdebitage Measuring 4.0-6.3 mm (n=10). Though with different intensities, the pattern of estimated microdebitage clusters within the 4.0-6.3 mm size grade follows that of the manual analysis (see Figure 5.17) in that there are microdebitage concentrations directly west of Structure 5PS-13 and north of Structure 5PS-14. There is also a similar concentration in the center of the plaza, though slightly southwest of what is displayed for the manual analysis. There

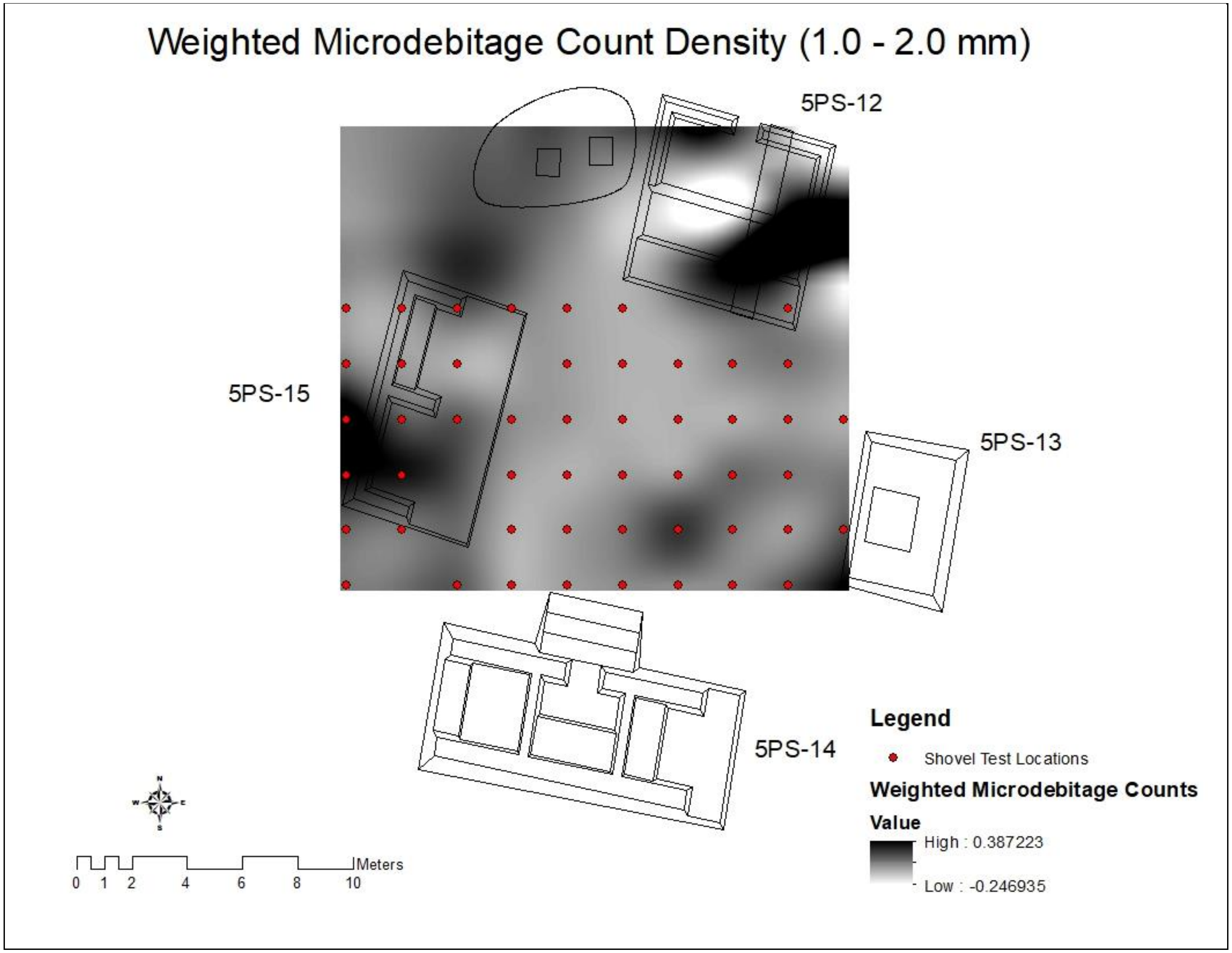

Figure 5.20 Density Map Showing Weighted Estimated Counts of Microdebitage Measuring 1.0-2.0 mm Recovered from Soil Samples at 5PS-d using Dynamic Image Analysis

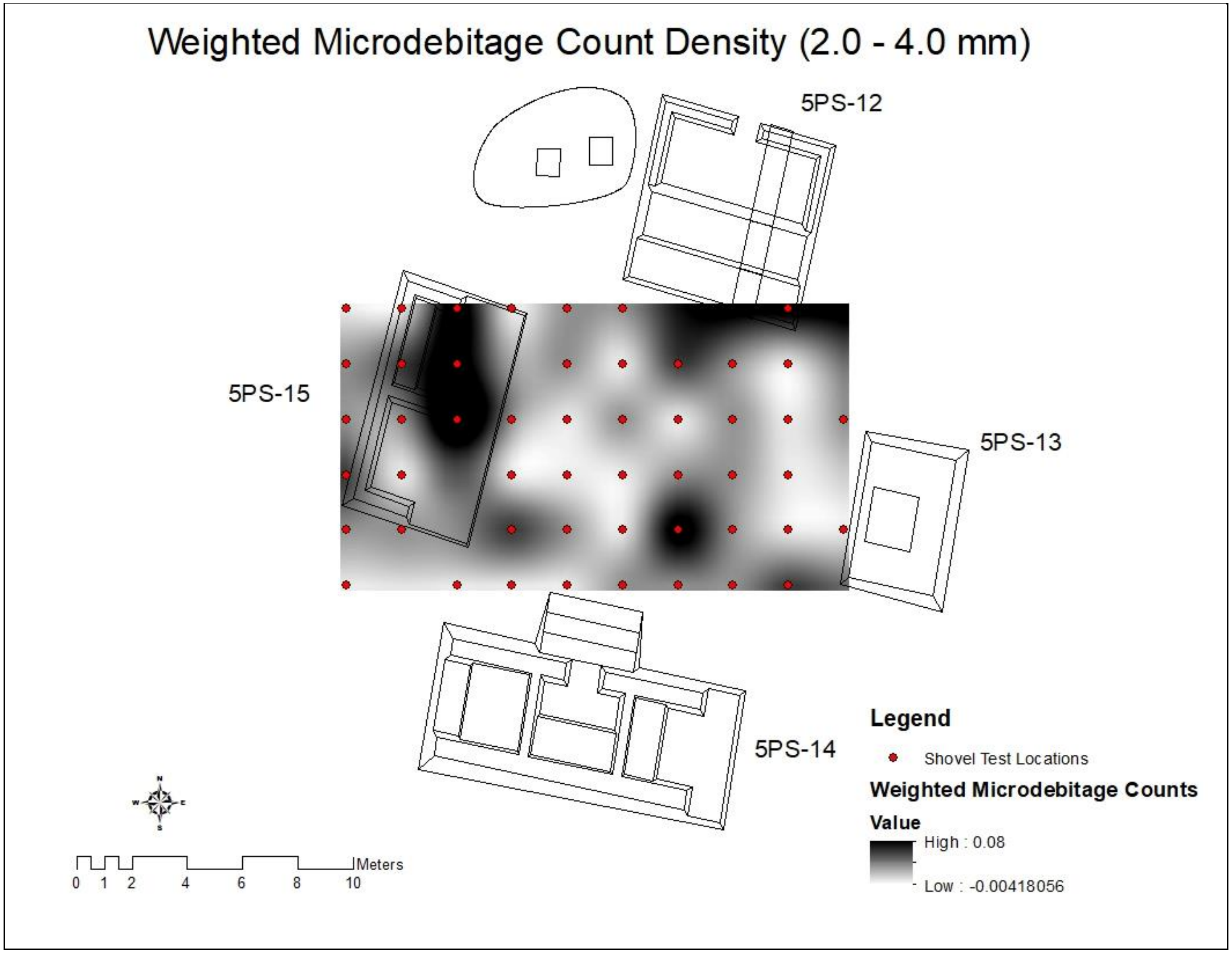

Figure 5.21 Density Map Showing Estimated Counts of Microdebitage Measuring 2.0-4.0 mm Recovered from Soil Samples at 5PS-d using Dynamic Image Analysis

is also a dense concentration directly east of Structure 5PS-15 that was not evident for the manual analysis (Figure 5.22).

Morphometric Analyses of Lithic Macroartifacts recovered from Residential Group 5PS-d

In July 2019, I spent one week working at the Instituto de Antropología e Historia (IDAEH, Institute of Anthropology and History) examining obsidian cores and chert artifacts collected from Residential Group 5PS-d during TAP excavations. By comparing the macroartifacts (measuring greater than 6 mm) to the microdebitage (measuring less than 6 mm), a comprehensive understanding of the stone tool production activities that took place within Residental Group 5PS-d can be achieved. In the following section, I describe the measurements taken by Markus Eberl, Sarah Levithol, and myself.

Obsidian Blades. A total of 220 obsidian prismatic blades, weighing 176 grams, were recovered from excavations within Structure 5PS-12 during TAP excavations. Of these, only eight percent (n=18) of the blades are complete, exhibiting intact proximal (platform-end) and distal (termination-end) while typically exhibiting a bulb of force on the ventral surface of the blade. Conversely, 92 percent of the blades recovered from Residential Group 5PS-d are fragmentary and include primarily the proximal portion of blades (n=107), but also include 72 medial sections (the midsection between the distal and proximal ends), 20 distal ends of blades, and one lateral side of a blade (broken more or less in half). The lengths of the blades varied between 0.53 and 6.35 cm with a mean length of 2.35 cm. Blade widths varied between 0.56 to 2.16 cm, with a mean width of 1.08 cm. Finally, overall blade thickness varied between 0.01 and 0.71 cm, with a mean thickness of 0.68 grams.

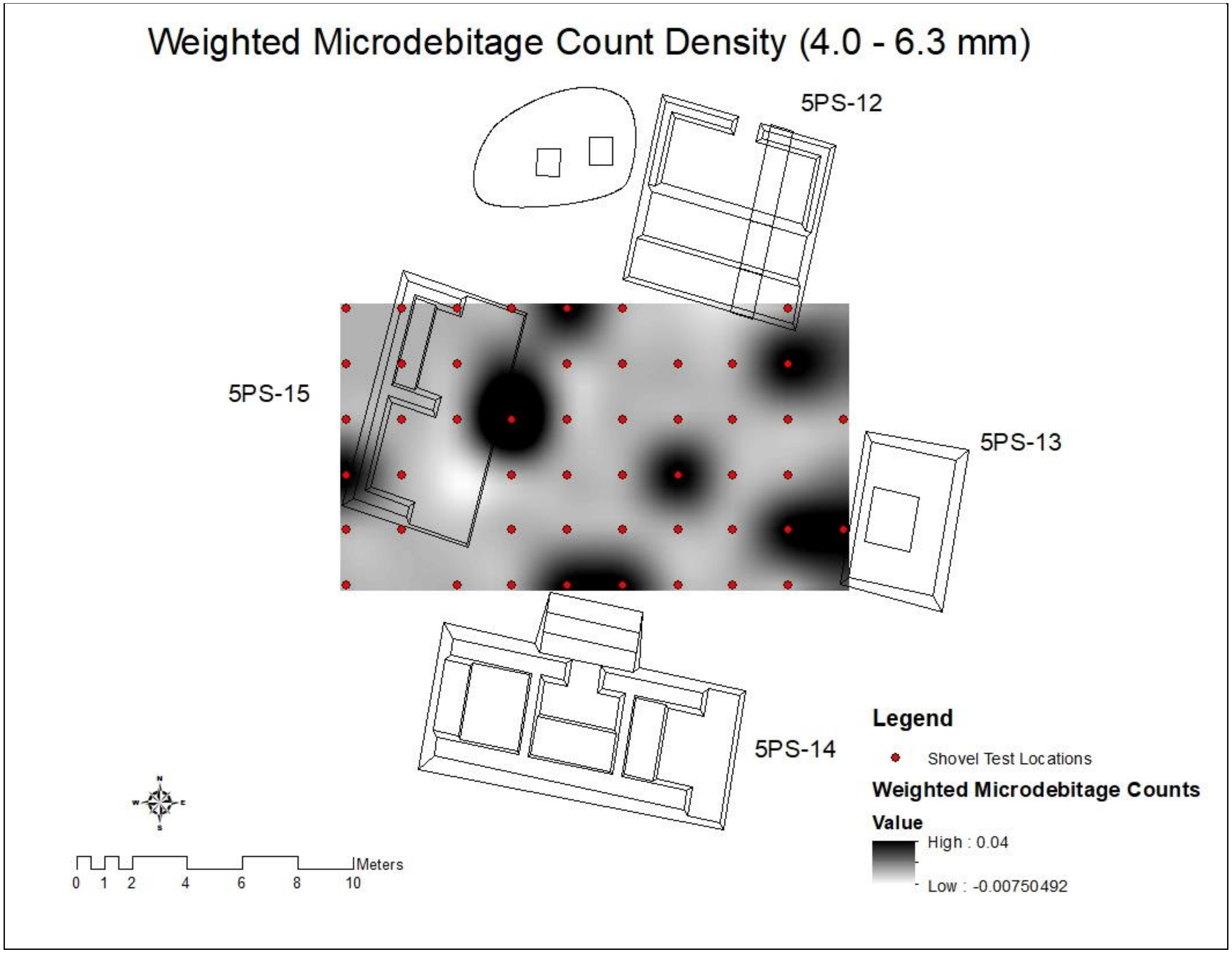

Figure 5.22 Density Map Showing Weights of Obsidian Chert Microdebitage Measuring 4.0-6.3 mm Recovered from Soil Samples at 5PS-d using Manual Analysis

I also compared the average metrics (length, width, thickness, weight) for the four primary portion types (complete, proximal, medial, distal) recovered from 5PS-d to those recovered throughout the remainder of Tamarindito in order to examine whether the blades at 5PS-d may have been produced with a different function in mind than those found elsewhere. No significant differences were found between the two sets of blades (Table 5.2).

Obsidian Blade Cores. In total, 29 obsidian cores were recovered from Tamarindito during TAP excavations. Of these, 20 obsidian cores were recovered from within Structure 5PS-12 of Group 5PS-d, accounting for 69 percent of the obsidian cores recovered from all TAP excavations at Tamarindito. Further, 18 of these cores were recovered from the annex room of 5PS-12 (Figure 5.23). Markus Eberl provided me with the following measurements of the obsidian cores (length, width, thickness, weight, platform length, and platform width) (Table 5.3). The results demonstrate a difference of less than 2.5 cm between 19 of the 20 blade cores in terms of length, width, and thickness. With a length of 2.79 cm, a width of 0.96 cm, and a weight of 0.8 grams, the one remaining blade core was shown to be an outlier and is significantly

Table 5.2 Comparative Metrics for Obsidian Blade Portions

Portion	Provenience	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)
Complete	**5PS-d**	3.32	1.27	0.35	1.27
	Tamarindito	3.49	1.01	0.33	1.2
Proximal	**5PS-d**	2.52	1.13	0.32	0.97
	Tamarindito	2.51	1.19	0.31	1.02
Medial	**5PS-d**	1.87	1.02	0.23	0.55
	Tamarindito	2.06	1.06	0.25	0.7
Distal	**5PS-d**	2.42	0.9	0.23	0.51
	Tamarindito	2.39	0.98	0.25	0.62

Figure 5.23 Obsidian Blades Recovered from the Northern Annex of Structure 5PS-12

Table 5.3 Descriptive Statistics for Obsidian Blades and Cores Recovered from 5PS-d

	Mean Length (cm)	Mean Width (cm)	Mean Thickness (cm)
Blades	2.35	1.08	0.68
Blade Cores	0.4	2.74	2.8

smaller than the remaining 19 among all measurements taken. The lengths of the 19 remaining blade cores measured between 5.46 and 8.29 cm, with a mean of 7.4 cm. The widths measured between 2.02 and 3.76 cm, with a mean of 2.67 cm. The resultant length-to-width ratios measured between 2.04 cm and 3.9 mm, with a mean of 2.93 cm. Thickness of blade cores measured between 1.34 cm and 3.78 mm, with a mean of 2.8 cm. The lengths and widths of the platforms were also measured for all but three of the obsidian cores, each of which had flaked-off or unclear platforms. Platform lengths varied between 0.42 and 4.0 cm (mean 1.69 mm), while platform width measured between 0.23 to 4.0 cm (mean 1.26 cm), with a difference of less than 3 cm between the 17 blade cores with identifiable platforms.

In addition to the TAP measurements, I also measured the number of blade scars, maximum width of each blade scar, and minimum width of each blade scar for each of the 20 blade cores from Group 5PS-d. Similar to the overall measurements of the blade cores, the blade scar measurements demonstrated strong similarities among all three variables. The total number of blade scars varied from 9 to 19, but three of these counts are outliers (9, 16, and 19) (Figure 5.24). Of the remaining 17 blades cores, one core (five percent) had 11 blade scars, seven cores (35 percent) had 12 blade scars, five (25 percent) had 13 blade scars, and the remaining four cores (20 percent) had 14 blade scars. Thus, 17 (or 85 percent) of the 20 blade cores had between 12 and 14 blade scars, demonstrating immense uniformity among the assemblage. The measurements of the individual blade scars themselves support this uniformity, with an average

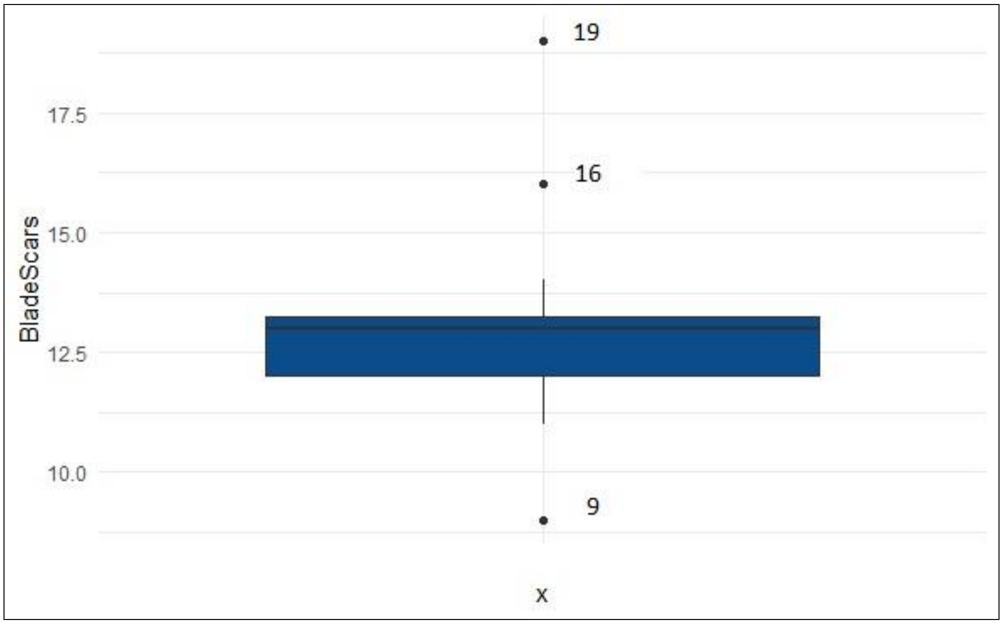

Figure 5.24 Box and Whisker Plot of Blade Scar Counts for Obsidian Cores from 5PS-d

minimum blade scar width for all 20 obsidian cores of 3.23 cm, while the average maximum width is 15.36 cm.

I also recorded the type of termination associated with each blade scar, which develop in three primary forms: feather, hinge, and step terminations (Figure 5.25). Feather terminations are considered the most “natural” termination and are defined by Andrefsky (2005:20) as smooth terminations with sharp edges. Hinge terminations are smooth, like feather terminations, but turn inward at the very end. These occur when the force of impact turns or rolls away from the objective piece (Andrefsky 2005:20). Finally, step terminations are caused when flakes or blades snap or break during removal. Cotterell and Kamminga (1979:104–105) note that while feather and hinge terminations lack discontinuities in their slope, step terminations terminate abruptly, resulting in right angles. Of the 259 blade scars recorded across the 20 blade cores, 228 (or 88 percent) of the terminations were comprised of feather terminations, while the remaining 27 (or

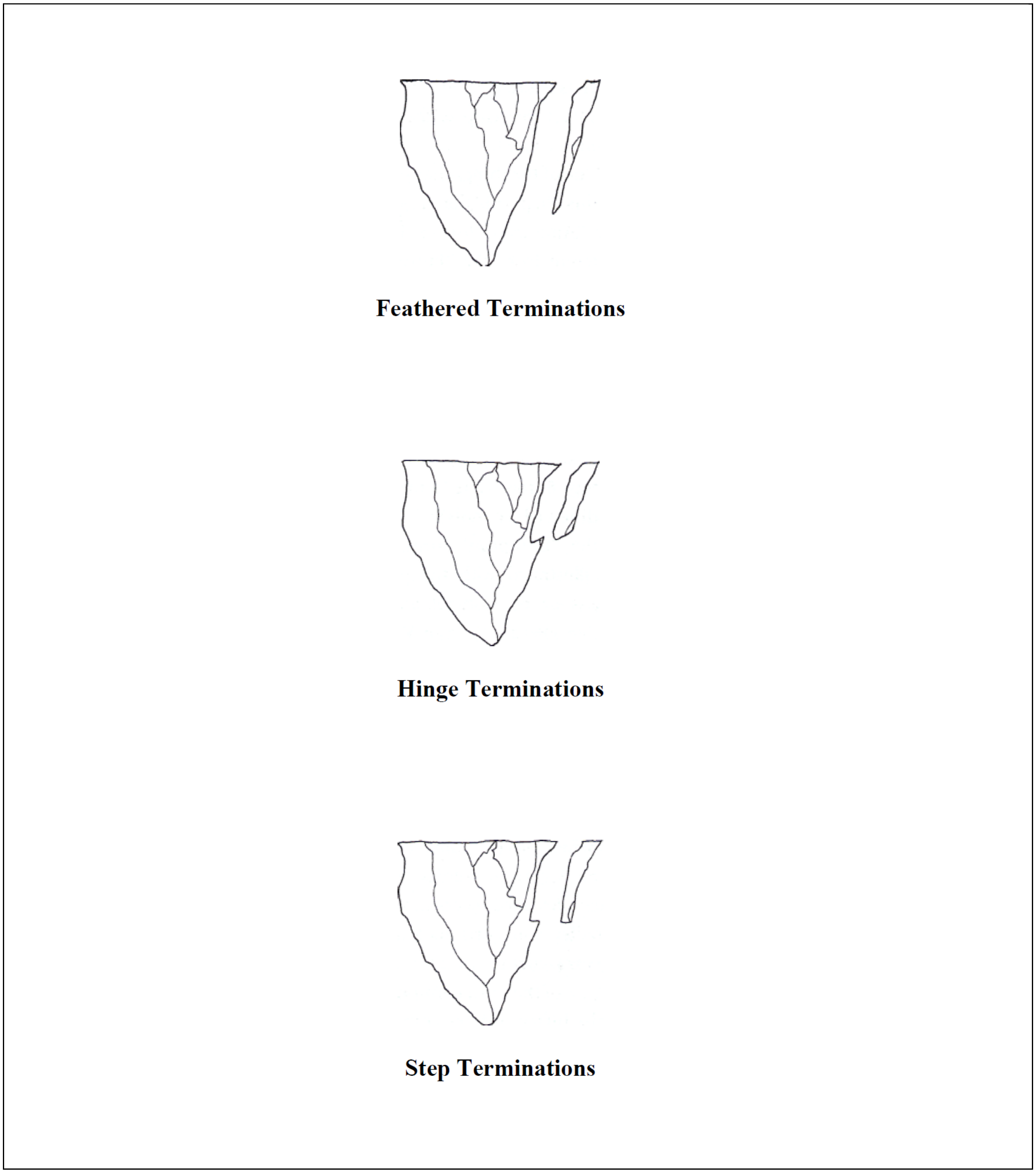

Figure 5.25 Types of Flake Terminations (adapted from (Kooyman 2000:21)

11 percent) were comprised of hinge terminations. No step terminations were identified.

Chert Artifacts

In total, TAP excavations at Residential Group 5PS-d uncovered 657 chert artifacts (weighing 14,928 grams), including cores (n=2), tools (n=56), and debitage (n=595) (Table 5.4). As with the obsidian assemblage, the majority of these measurements were taken by Markus Eberl and members of the TAP. The core assemblage is comprised entirely of simple cores (n=2), while the tool assemblage consists of hammerstones (n=29), bifacial points (n=15), scrapers (n=5), choppers (n=5), one unifacial point, and one oval biface. The debitage assemblage includes primarily general debitage (n=393) but also includes bifacial thinning flakes (n=105), flakes (n=89), and notched flakes (n=8). Of these, 233 chert artifacts were evaluated for chert quality and placed into one of five categories: very fine (n=58), very good (n=37), good (n=58), fair (n=51), and poor (n=29). Exluding the general debitage category, 196 chert artifacts

Table 5.4 Chert Artifacts Recovered from Residential Group 5PS-d

Artifact Class	Artifact Type	Total
Cores	Simple Cores	2
Tools	Hammerstones	29
	Bifacial Points	15
	Scrapers	5
	Choppers	5
	Oval Biface	1
	Unifacial Point	1
Debitage	Bifacial Thinning Flakes	105
	Flakes (with clear bulb of force)	89
	Notched Flakes	8
	General Debitage	393

were categorized according to the ratio of cortex remaining on the exterior of the artifact (Table 5.5). Of these, only 2.6 percent (n=5) have the cortex complete removed, while the remaining 97.4 percent of artifacts have at least 0-25 percent of the artifact surface covered in chert.

Conclusion

In the present chapter, I have presented the results of the analysis of microdebitage (completed via manual analysis and DIA), obsidian tools, and obsidian cores recovered from Residential Group 5PS-d at Tamarindito. Three primary patterns have emerged through the density mapping of locations where microdebitage were identified within the 50 subsampled soil samples examined in the current study: 1) Significant microdebitage clusters are prominent within or just outside Structure 5PS-15 and within the northern annex of Structure 5PS-12; 2) Smaller concentrations of microdebitage tend to cluster around the front side (or the sides facing towards the plaza) of each structure; 3) The results of the DIA on all 65 soil samples from both

Table 5.5 Ratios of Cortex Recorded on Chert Tools from Tamarindito

Artifact Class	Artifact Type	0	0-25	25-50	50-100	Unknown
Cores	Simple Cores	0	1	1	0	0
Tools	Hammerstones	0	2	0	13	0
	Bifacial Points	1	3	0	0	1
	Scrapers	0	0	2	3	0
	Choppers	0	3	1	1	0
	Oval Biface	1	0	0	0	0
	Unifacial Point	0	1	0	0	0
Debitage	Bifacial Thinning Flakes	3	39	14	8	1
	Flakes (with clear bulb of force)	0	43	30	16	0
	Notched Flakes	0	6	2	0	0

datasets demonstrate expected patterns of microdebitage, suggesting an effective level of accuracy, especially for the smallest two size-grades (0.5-1.0 mm and 1.0-2.0 mm) included in this study; and 4) the morphometric analyses of blades and blade cores demonstrate uniformity between the reduction of cores and production of blades. In the following chapter, I will discuss my interpretations of these results and potential contributions to archaeological understandings of multi-agent production systems.

CHAPTER 6

IDENTIFYING CLASSIC MAYA MULTI-AGENT PRODUCTION SYSTEMS AT TAMARINDITO

Introduction

Before introducing interpretations and inferences based on the results of this study, I will first discuss the implications of the two methods used to examine the spatial organization of microdebitage: manual analysis and Dynamic Image Analysis. Essentially, three different methods were applied to the analysis of microdebitage: 1) weights via manual analysis; 2) counts via manual analysis; and 3) estimated counts via DIA; and different inferences can be made from each. When examined manually, microdebitage weights are the most accurate assessment of the quantity of microdebitage recovered archaeologically due to the fragile nature of these artifacts and the likelihood of post-depositional breakage. Thus, when only manual methods are available, weight data should be considered more accurate than tabulated counts.

The data from the manually-tabulated counts of microdebitage, however, was essential for comparing the results of the manual analysis to the results of the DIA, which only produces estimated counts of microdebitage. MANOVA results demonstrate no significant differences between the results of these two methods ($p = 0.4343$). As such, this methodological comparison supports the conclusions made by Johnson et al. (2021) that DIA is an accurate and efficient method for estimating the number of microdebitage recovered from archaeological soil samples. Further, the results of the DIA include the greatest number of soil samples and living areas within Residential Group 5PS-d. Thus, to make the most holistic interpretations of stone tool production activities taking place within Residential Group 5PS-d, I will apply and compare the results from both the manual analysis and DIA to reconstruct the roles of stone tools in the multi-agent production economies of Tamarindito.

Stone Tool Production at Residential Group 5PS-12

In this study, I have examined data from macroartifacts (tools, cores, and debitage) and microdebitage (lithic debitage measuring less than 6mm) to identify areas where stone tools were produced within Residential Group 5PS-d, a potential Classic Maya workshop at Tamarindito. The results of these analyses indicate that the northern annex of Structure 5PS-12 served as a primary activity area for both chert and obsidian stone tool production, based on the presence of discrete concentrations of both chert and obsidian tools, macrodebitage, and microdebitage. This assumption is supported by evidence from TAP excavations (Eberl and Vela González 2016), including the recovery of 20 obsidian cores and 220 obsidian blades; and microdebitage analyses, which revealed the highest concentrations of microdebitage as compared to the rest of the residential group. The paucity of stone tools, cores, and microdebitage recovered throughout the remainder of this residential group suggest that production took place primarily within this structure and, more specifically, within the northern annex. The remaining microdebitage clusters reflect areas where stone tools were used, maintained, and/or areas where stone tool debitage was discarded.

Because the northern annex of Structure 5PS-12 opens to the outside of the group and would not have been visible from any of the group’s structures or the central plaza, chert and obsidian production taking place in this area likely reflects differential forms of ritual production that was hidden from the rest of the group and surrounding residential groups. Conversely, Structure 5PS-15 was completely open to the plaza and visible from the other three structures. As such, this indicates that chert and obsidian use and/or maintenance taking place within this structure (and within the plaza) was related to domestic activities that did not need to be hidden from other members of the group or other nearby households.

Domestic Stone Tool Production

Plaza Activities. The plaza was not excavated during TAP investigations (Eberl and Vela González 2016:89–96), and as such, no activity areas had been previously identified in this area. Stone tools were not observed on the surface of the plaza either during TAP investigations or during the current investigation, however. The results of the microdebitage analysis indicate that neither obsidian nor chert tools were being manufactured in significant quantities within the central plaza of Residential Group 5PS-d. The counts and weights of microdebitage recovered from this area are simply too low to account for such activities. Even considering that a portion of the microdebitage may have been swept away or relocated through various forms of post-depositional movement (Hilton 2003; Howard 2017; Howard and Orlicki 2016), these microdebitage totals account for less than what would be produced through the manufacture of a single stone tool. Instead, the microdebitage recovered from the plaza are likely the result of 1) domestic activities that involved the use of stone tools, which caused flaking along the edges; 2) maintenance activities, such as intentional resharpening of tool edges and/or rejuvenation of stone tools; and/or 3) cleaning activities, wherein microdebitage was swept from the inside of structures and out towards the plaza, accumulating near the entrances of the structures.

In the limited set of microdebitage studies that have been completed in Mesoamerica, it is not uncommon to see microdebitage clustered around the entrances of structures facing inward toward the plaza. For example, at Copan in Honduras, Widmer (2009:191) recorded dense concentrations of microdebitage just outside the entrances of several structures and spilling into the plaza within Patio H at Residential Group N9-8, a Late Classic period elite compound. Microdebitage in this area included not only chert and microdebitage, but also other stone materials, such as mica, basalt, pyrite, slate, and schist, as well as shell microartifacts, and these materials are differentially clustered around the entrances of different buildings, pointing to specific production activities taking place within each of these areas. Though Widmer does not specify what materials comprised the floors within this compound, it is likely that much of these microdebitage accumulations are the result of sweeping debris out of the residences and/or workspaces and into the plaza, where the microdebitage became embedded.

Structure 5PS-15 and Possible Midden. Like the plaza, Structure 5PS-15 (the westernmost structure of Residential Group 5PS-d) was not investigated during TAP investigations (Eberl and Vela González 2016:89–96). As such, the true function of this structure is unknown. Based on the density of chert and obsidian microdebitage recovered from within this structure, stone tool maintenance, such as resharpening and rejuvenation, and utilitarian activities involving chert and obsidian tools, likely caused the accumulation of microdebitage in that structure. There appear to be discrete microdebitage clusters within the southern room of this structure, with obsidian accumulating at the southwest corner and chert accumulating in the northwest corner of the open room (Figures 6.1 and 6.2). This room is open to the plaza, and the activities therein would have been easily visible to the entire residential group. As such, there is little potential for ritual production in this structure.

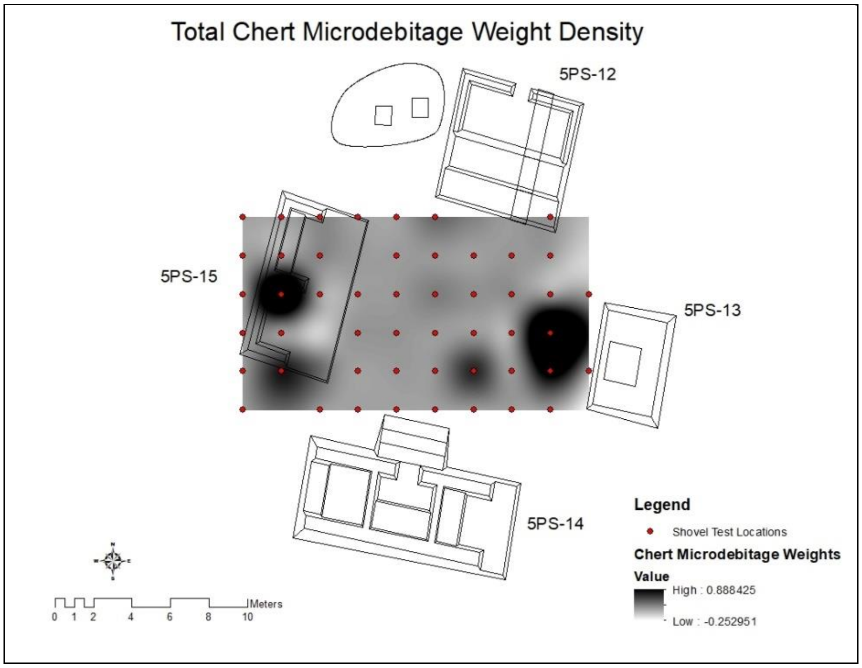

Figure 6.1 Density Map showing Chert Concentration in Structure 5PS-15

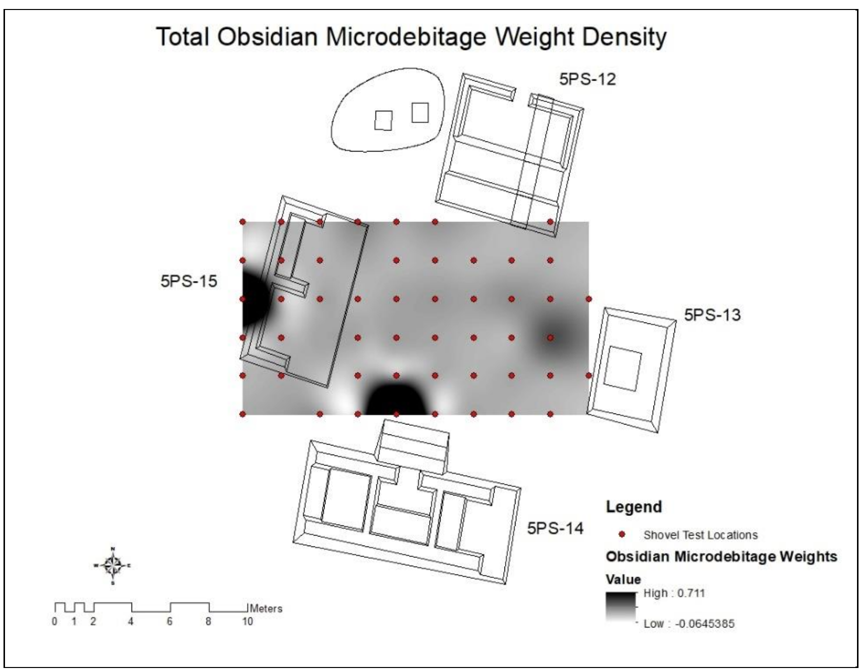

Figure 6.2 Density Map showing Obsidian Concentration in Structure 5PS-15

This pattern can be partially attributed to cleaning activities in this room. Sweeping would have likely pushed microdebitage from the center of the room into those crevices while simultaneously missing microdebitage in these hard-to-reach corners, thus producing an accumulation of debris in these areas. Given that obsidian and chert microdebitage are clustered in opposite corners, however, it is very likely that utilitarian and/or maintenance activities using obsidian tools took place near the northern wall of the room, while those that required chert were primarily taking place at the southern end. There is also a concentration of obsidian microdebitage directly west of this room to the outside of the structure, which may represent a midden where stone tool debris and other refuse were dumped.

During his ethnoarchaeological examination of modern Lacandon knappers, Clark (1991) observed household chert tool production was often completed close to interior house walls, and a small cloth was often laid down to catch debitage and microdebitage. When knapping was completed, the debris on the cloth was poured into a gourd and stored in this same area until taken away for discard. This minimized the accumulation of debris in the open, walking areas of the room so that sharp debitage would not cut the feet of those walking over it. Debitage produced during the rejuvenation and retouch of stone tools, however, was so small that knappers did not bother to clean it up, and Clark observed that these flakes were trampled into the floor before his visit had even concluded.

Ritual Production at Structure 5PS-12

Three distinct attributes of the archaeological materials examined from Structure 5PS-12 support the assertion that ritual production of stone tools was taking place here. First, the unique architectural elements of Structure 5PS-12 that would have been ideal for performing ritual activities away from the visibility of those, both within and outside the 5PS-d household, who did not have access to this knowledge. Second, the dense deposit of chert and obsidian tools and debitage representative of stone production were identified within the northern annex of 5PS-d. In particular, the obsidian artifacts comprise nearly 80 percent of all the obsidian recovered at Tamarindito. Finally, microdebitage was identified in higher estimated densities in the northern annex than in all other contexts sampled at Residential Group 5PS-d. While individually, none of these three attributes conclusively identifies ritual production, this combined evidence strongly supports the assertion Structure 5PS-12 was a ritualized space.

The Space and Place of Ritual Production. Structure 5PS-12 is unique among all non-elite structures excavated at Tamarindito and throughout the Petexbatun Region in that it has two unconnected rooms that open to the north and south. The northern room, or annex, includes a bench that runs the length of the adjoining wall. Because of this layout, the only way to enter the northern annex, is to walk around to the outside of the entire group and enter from the north. As such, this room was not visible to other structures or the plaza of this residential group. Thus, we can assume that not all members of this household were allowed access to the northern annex.

The northern annex was also not easily visible to nearby residential groups. First, the door likely would have been covered by a sheet or other material, limiting visibility inside the room. Even if that were not the case, however, the closest residential groups facing that direction are situated 115 meters (5PS-b) and 90 meters (5PS-c) away (Figure 6.3). At that distance, even with a clear line of sight into the northern annex, it would have been very difficult to ascertain the specific activities taking place within that room, especially if the producer was working in the furthest corners of the room, which would have been much more probable, especially if the

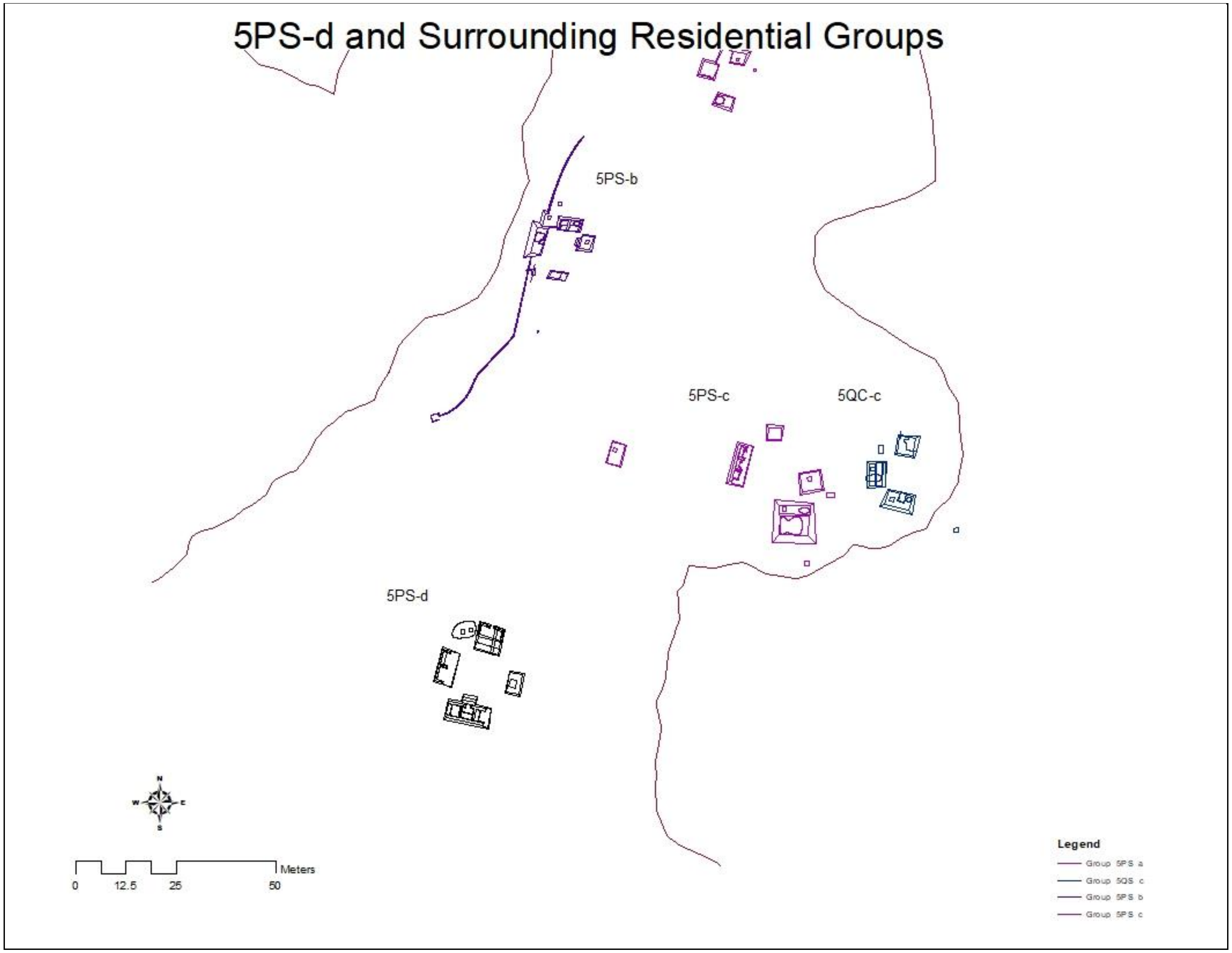

Figure 6.3 Plan Map of Southwest Corner of Tamarindito, showing 5PS-d, 5PS-c, 5QS-c, and 5PS-b

Moreover, no portion of Residential Group 5PS-d would have been visible from Plaza B. A viewshed analysis completed by Sarah Levithol and colleagues (Levithol et al. 2016) indicates that, although the residents of Residential Group 5PS-d would have been able to see the pyramid in Plaza B, the view of Residential Group 5PS-d from the pyramid at Plaza B (specifically Structure 5TQ-13) would have been obstructed by the distance (over 1 km), the terrain, and the numerous buildings and residential groups between the plaza and 5PS-d. As such, the interior space of the northern annex within Structure 5PS-12 would have been easily hidden from the residents of the group itself, surrounding residential groups, and the nearest elite plaza.

The Products of Ritual Production. Though the southern room of Structure 5PS-12 was relatively clean and devoid of artifacts, which according to Eberl et al. (2019:652), was typical of Maya households that were routinely swept and kept clean, the northern annex contained the remains of 18 obsidian cores (Figure 6.4) and hundreds of obsidian blades and associated debitage. Though the DIA cannot yet differentiate between obsidian and chert microdebitage, the spike in densities of overall microdebitage in the northern annex suggests that obsidian production was taking place in this room and likely involved the manufactured of the very blades recovered therein.

Morphometric analysis of the blades and blade cores supports the ritual production theory. Blade terminations on the 20 cores recovered from this structure demonstrate that blades were knapped with great uniformity and precision. Feather terminations comprise 88 percent of all blade terminations, meaning that 88 percent of the time, the knapper achieved the desired outcome of a smooth, continuous blade. Thus, the measurements taken from the blade cores suggest that blades were manufactured from all or most of these cores by a single, highly-skilled knapper with the intent to produce blades of a uniform length and width. Further, the knapper

Figure 6.4 Recently Excavated Obsidian Cores Recovered from the Northern Annex of Structure 5PS-12 (photo by Markus Eberl)

discontinued knapping at approximately the same time with each core, regardless of whether more blades could be produced, meaning that uniformity in the expended cores themselves may have also been a desired outcome of blade production.

Finally, locating assemblages of obsidian microdebitage at Tamarindito allows for the identification of locations where obsidian blades were being manufactured and/or rejuvenated. Within the northern annex, estimated counts of microdebitage equate to 2.54 microdebitage particles per gram of soil. These microdebitage estimates represent a 38 percent increase over the total estimated counts of microdebitage (1.84 microdebitage per gram of soil) recovered from the southern room of Structure 5PS-15 (where the second highest density of microdebitage is observed).

Chert Production within Structure 5PS-12. Of the 653 chert artifacts recovered from Residential Group 5PS-d, 569 of these were recovered from Structure 5PS-12. Further, the majority of these came specifically from the northern annex, including 10 hammerstones, six manos, five scrapers, three bifaces, and one chopper (Eberl et al. 2019:653). The recovery of 105 bifacial thinning flakes also strongly suggests that the reduction of chert tools occurred here, and the majority of all chert debitage was also recovered from the northern annex. Further, of the 569 artifacts recovered from Structure 5PS-12, 232 were assessed for cortex removal, and 97 percent of the assemblage retains at least a portion (0-25 percent) of the cortex. The presence of tools for reducing chert cores into tools (hammerstones), chert tools, cores, and a dense assemblage of debitage is consistent with chert production activities associated with the reduction of low- to high-quality chert likely acquired within a few kilometers of Tamarindito. The chert artifact assemblage, however, is not diagnostic of ritual activities but is instead typical of household, domestic activities (Stemp et al. 2010). With all evidence pointing to the northern annex serving a ritual function, what purpose do these artifacts serve?

The Role of Termination Rituals

Termination rituals were commonly used during the Classic period when elite houses were abandoned (Aimers et al. 2020; Clayton et al. 2005; Harrison-Buck et al. 2007; Newman 2019; Tsukamoto 2017), but evidence of non-elite termination rituals are more obscure. Stanton et al. (2008:237–238) describe six primary characteristics defining Maya termination rituals, including intentionally damaged buildings, scattered pottery, rapidly deposited artifacts, dense artifact assemblages, exotic artifacts, burnt artifacts, and white marl covers (Eberl et al. 2019:681). Though not an elite residence, Eberl et al. (2019) propose that Structure 5PS-12 was the site of a termination ritual wherein the non-elite residence was intentionally destroyed at the time of abandonment around 750 AD, near the fall of the royal lineage at Tamarindito. In addition to a plethora of chert and obsidian artifacts, a dense concentration of broken ceramics was also recovered, which through refit analysis was demonstrated to have been intentionally broken and scattered across the floor of the northern annex.

According to Eberl et al. (2019:681), Structure 5PS-12 is missing only the last two attributes. Instead of covering the structure with white marl, the residents of Residential Group 5PS-d used stones taken from the disassembled walls. Further, the structure does not show signs of having been burned, minus a few flecks of charcoal. Eberl and his colleagues suggest that these differences demonstrate the differences in wealth and status between elites and non-elites, wherein the residents of 5PS-d used the materials they had access to in order to best replicate elite termination rituals observed at Tamarindito, such as the fire ritual initiated by the last King of Tamarindito, *Chanal Bahlam*, that burned a royal burial in Plaza B in 762 AD (Eberl et al. 2019:680).

Though a termination ritual goes far to explain the significant quantities of chert and obsidian deposited within Structure 5PS-12, it does not explain the architectural origins and the need for the northern annex. The annex was not built specifically for the termination ritual, but was instead constructed prior to 650 AD (Eberl 2019:679), while Eberl and his colleagues place the abandonment of this structure at around 750 AD. That means that this structure was built with the annex in mind approximately 100 years before the termination ritual would have taken place. This suggests that, at the time of construction, Structure 5PS-12 was built with ritual purposes in mind and was likely used for that purpose at least for some duration of the next 100 years.

Taking this into consideration, I build on Eberl and colleague's assertion that Structure 5PS-12 was ritually terminated by proposing that this structure was specifically chosen for termination because of the ritual function it served during its use life. If the residents of Residential Group 5PS-d were, in fact, mimicking termination rituals that they had observed in elite contexts at Tamarindito, they would have understood that ritual terminations are reserved for structures that have a particular meaning. In the example of the fire termination in Plaza B, Gronemeyer et al. (2013) suggest that King *Chanal Bahlam* set fire to the burial of the most recent independent king of Tamarindito, *Aj Ihk' Wolok*, in order to honor the polity's return to independence following the forceful removal of Dos Pilas' fourth king, *K'awil Chan K'inich*, from power. In this way, *Chanal Bahlam*'s fire ritual may have served to reinstate Tamarindito as an independent polity.

Mimicking elite ritual activities was not confined to the household members of Residential Group 5PS-d, however. Another example is that of Residential Group Q6-2, excavated by the Petexbatun Regional Archaeological Project. As discussed in Chapter 1, this residential group was extensively excavated under the direction of Juan Antonio Valdés and Kitty Emery (Emery et al. 1994; Valdés 1997) and was not reinvestigated during TAP investigations at Tamarindito. Located northeast of Plaza A, this group is situated at the side of a steep hillslope facing the edge of the escarpment. Within the western structure that overlooks Laguna Tamarindito, excavations uncovered a burial covered in a layer of lithic debris. Though this practice was not uncommon within royal tombs throughout the Maya lowlands, only one other burial at Tamarindito was revealed to follow as similar pattern: that of King *Aj Ihk' Wolok*, the very tomb where *Chanal Bahlam* completed the fire termination ritual (Eberl et al. 2019; Gronemeyer et al. 2013; Valdés 1994).

Similar to the actions taken at Residential Group 5PS-d to mimic termination rituals such as that undertaken at Plaza B, I propose that the burial ritual undertaken at Residential Group Q6-2 mimicked the burial routines of royals within Plaza B and potentially elsewhere. Further, Valdés (1997) suggests that this burial may have been intended to honor the stone tool artisans who occupied and/or produced stone tools in this residential group. Ancestor veneration was a common practice for the Classic Maya, both among elites and non-elites (Geller 2012; McAnany 2002, 2013). In the case of Maya non-elites, the dead were often buried under house floors or in specific locations, such as the burial shrine located within Structure 5PS-13 at Residential Group 5PS-12.

Thus, this may not have been an uncommon practice among non-elites, at least at Tamarindito, wherein the bodies, homes, and/or workshops of stone tool producers (and potentially other types of specialists) were honored through burial and termination rituals. This explains the occurrence of both obsidian and chert production within the northern annex. I propose that the obsidian artifacts deposited within the annex reflect ritual activities that occurred during the occupancy of Structure 5PS-12, while the chert artifacts were deposited at the time of the termination ritual. The copious amounts of debitage suggest that at least a portion of the chert tools were knapped within the annex specifically for the termination, while a portion of the artifacts may have been collected from surrounding residential groups and deposited as a ritual offering.

Multi-Agent Production Systems at Tamarindito

Now that I have explained the presence of the dense chert and obsidian concentrations recovered from within Structure 5PS-12 of Residential Group 5PS-d, I now consider how this may play into multi-agent economies at Tamarindito. Understanding Maya economies as multi-agent production systems allows for the illumination of multiple economies co-existing and interacting with or without competition within a single community. Here, I revisit Wooldridge's (2002) delineation of multi-agent systems (as laid out in Chapter 1), described as following three primary rules:

1) agents are autonomous and at least partially independent;

2) agents have a limited view and understanding of their environment; and

3) no single agent is in complete control of the entire environment.

Autonomous Agents and Independent Households. Applying Wooldridge’s first rule stating that *agents are autonomous and at least partially independent*, the archaeological evidence recovered from Residential Group 5PS-d reflects three primary ways that household members were able to express their autonomy and independence both within the household itself and within the larger community: 1) select members were authorized to engage in ritualized blade production in the northern annex of Structure 5PS-12; 2) producers within Residential Group 5PS-d set themselves apart from surrounding households by potentially monopolizing stone tool production southeast of the royal center; and 3) household members elected to engage in termination rituals that were typically undertaken by elite members of society. Here, I reiterate Hendon’s definition of household as “a setting in which many groups of men and women not only lived but engaged in activities that affirmed the importance of their household identity and contributed to the social reproduction of the group” (2002:78). The identity of the 5PS-d house was reproduced through the architectural design of Structure 5PS-12, the process of ritual production taking place within that structure, and the support of that production, as evidenced through the termination ritual honoring those activities.

As previously discussed, the original construction of Structure 5PS-12 reflects the two-room design wherein the north and south rooms are not connected, and the northern annex can only be accessed from outside the group. As such, this structure was likely designed with ritualized activities in mind. Even more, the annex is not visible to the remaining structures of the group, signaling that only some members of the household were permitted access to the annex and, thus, the ritualized activities occurring therein. By recognizing ritualized stone tool production as an important self-interest of all household members (even those not participating in this production), the decisions of non-producing household members reflect their dedication to support and honor that household identity as blade producers through the termination of the structure wherein this production took place. In this way, household members were empowered through individual and household agency associated with ritualized blade production.

This highlights questions of non-elite power in ways that have not been previously illuminated in the Maya lowlands. At Aguateca, elite household activities have been examined in great detail due to the burning and subsequent rapid abandonment of the site, which left most household artifacts in situ (Aoyama 2007, 2009; Inomata 1995, 2009; Inomata et al. 2002; Inomata and Stiver 1998; Inomata and Triadan 2014). At Aguateca, elites served as highly-skilled artisans, which reveals much about artisan competition, social status, socioeconomic relations, and “the allocation of resources of production, including knowledge, labor, materials, facilities, and land" (Inomata 2001:323). At Tamarindito, however, there is little evidence for elite artisanship, especially where obsidian production is concerned. Instead, at least one non-elite household (Group 5PS-d) situated far from the royal center appears to have, at the very least, had partial control over the production of obsidian blades. Assuming that this would have allowed the residents of Residential Group 5PS-d a certain amount of social, economic, and political power, this further illuminates the socioeconomic diversity among Maya non-elites, all of whom were likely not simple peasants, but instead held a multitude of different statuses, affording them differential access to resources.

Secret Knowledge and Limited Worldviews. To better understand the relationship between secret knowledge and multi-agent systems, I apply Woodridge's second rule: *Agents have a limited view and understanding of their environment*. Wooldridge's (2002) interpretation of this rule (as it applies to agent-based modeling) is that each agent's lack of knowledge about the surrounding world affects their decision-making. This is also true of Tamarindito, where social and economic relationships are highly dependent upon the physical and social proximity of other households. In this way, agents will have a better perspective, both literally and ontologically, of their immediate physical and larger socioeconomic surroundings. In this way, economic relationships are likely to be strongest between members of the same household, family members residing within other households, and neighbors situated within a socially- and physically delineated proximity to their own household.

In contrast to Wooldridge's view, wherein the decisions made by agents are affected by what they do not know and therefore cannot control, I propose that members of Residential Group 5PS-d took advantage of the limited worldview of others by making the conscious decision to elevate their own status (and potentially wealth) above those of surrounding residential groups. As discussed in detail in Chapter 2, all household members within Residential Group 5PS-d, whether directly or indirectly involved in the ritual production of blades, likely shared in the household identity as blade producers and thus would have had specific motivations for wanting to hoard not only the knowledge needed to perform the ritual aspects of blade production (i.e., chants, body movements) but also the technical knowledge required to knap prismatic blades from obsidian cores. If obsidian blades are a desirable commodity within the community, having few households with the required ritual and technical knowledge for their production then increases the social and economic power of those households (Dobres 1995, 1999, 2000; Dobres and Robb 2000; Kovacevich 2015; Schiffer and Skibo 1987) and decreases the competition between other blade-producing households.

Looking at Figure 6.5, the volume of obsidian recovered from surrounding households at Tamarindito suggests that Residential Group 5PS-d, with an obsidian volume of 28 grams/square meter, monopolized obsidian production in the southwest region of the site and likely comprised the only production locus in that area of the site. Interestingly, however, there are at least two other residential groups that exhibit high obsidian volumes. Residential Groups 5QQ-a and 5RS-a produced obsidian volumes of 22.2 and 13.9 grams/square meter, respectively. Though the obsidian artifact assemblages from each of these, do not exhibit the same robustness as that of Residential Group 5PS-d, the excavation volumes are also much lighter, and more extensive excavations may uncover stone tool remains in greater densities.

Residential Group 5QQ-a measures $11m^3$ and consists of three relatively small structures (5QQ-1 to 5QQ-3) situated irregularly around a large central plaza that opens to the north (Figure 6.6). Four 1x1-meter test units were previously excavated by the TAP in the southwestern portion of this group to identify potential middens and to determine construction phases for structures 5QQ-1 and 5QQ-2 (Eberl and González 2016:43-44). Excavations at this group produced only a single obsidian blade from Structure 5QQ-3 (which had been previously looted) and a massive obsidian core from within Structure 5QQ-2, weighing 48 grams and

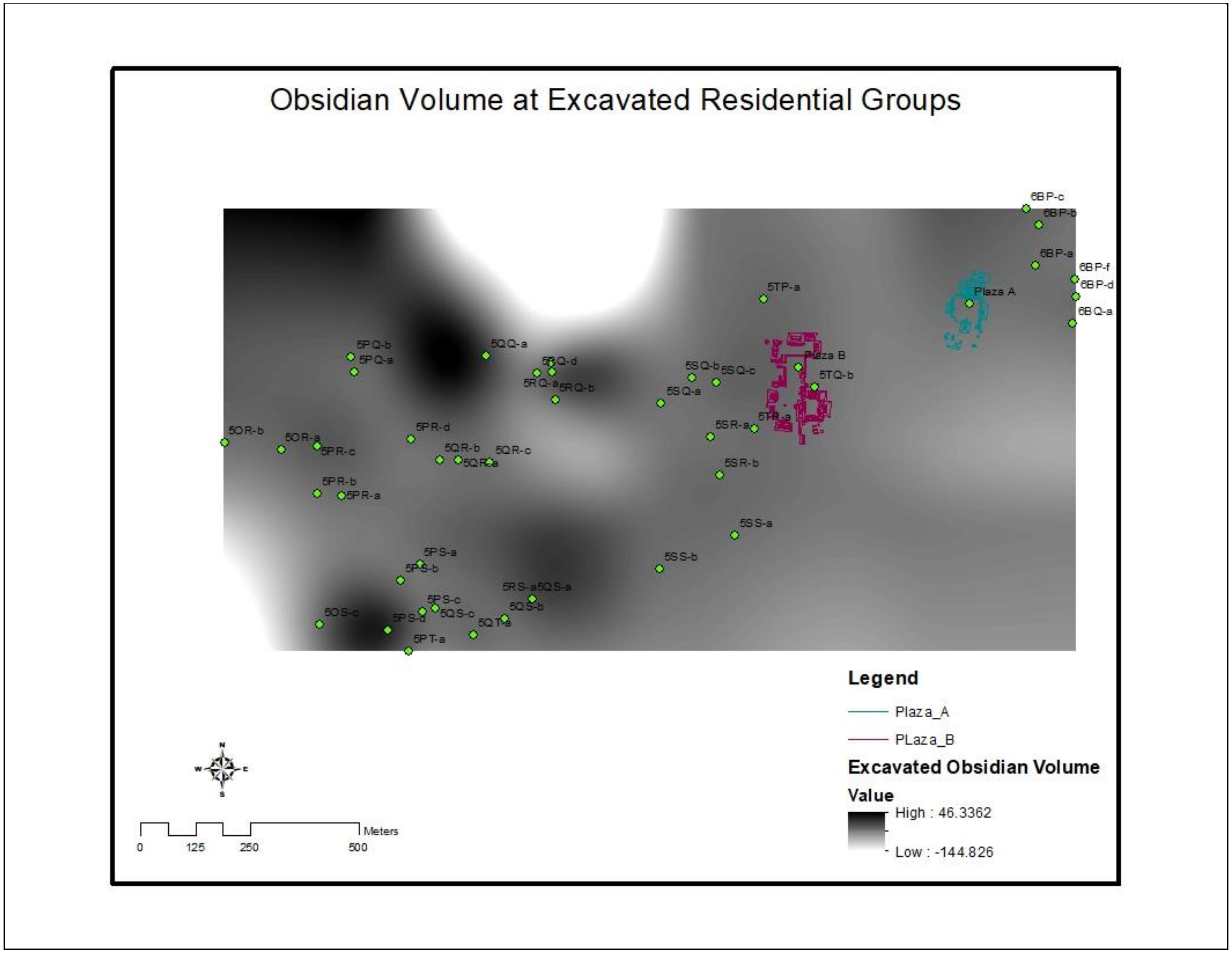

Figure 6.5 Density Map showing Obsidian Volume at Excavated Residential Groups at Tamarindito

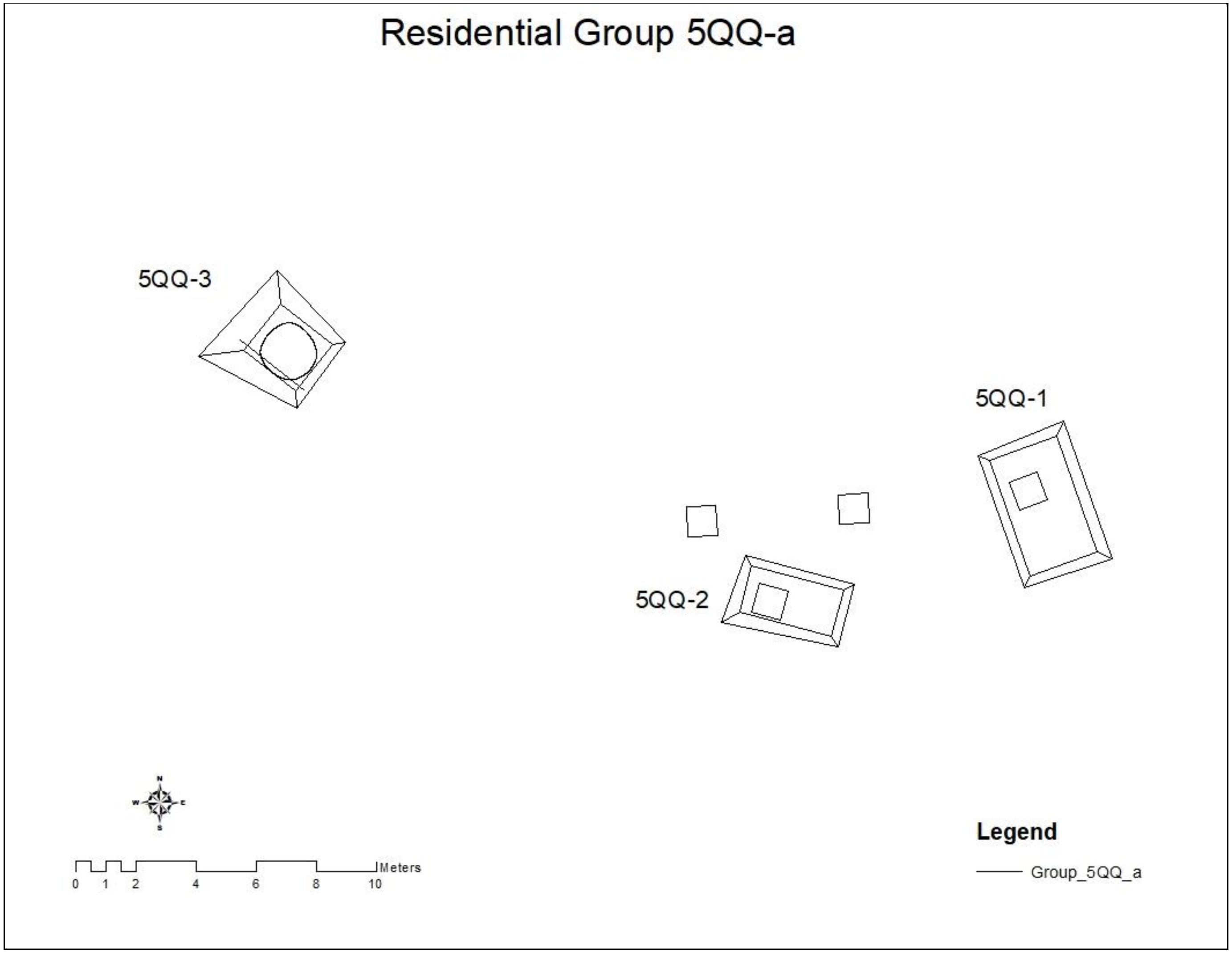

Figure 6.6 Plan View of Residential Group 5QQ-a, Showing TAP Excavations

accounting for the spike in obsidian volume at this residential group. Sixty-three chert artifacts were also recovered, all of which consisted of debitage.

Residential Group 5RS-a measures 11.4m^3 and consists of one visible structure (5RS-1) and two other structures (not yet mapped) still obscured by vegetation at the time of excavations (Figure 6.7). A midden was also identified to the northwest of Structure 5RS-1. TAP excavations consisted of a single 1x1-meter unit within the western portion of Structure 5RS-1 and another unit of the same size within the midden. This group produced 16 obsidian blades (four from Structure 5RS-1 and 12 from the midden) and one piece of obsidian debitage. Seventy-five chert artifacts were recovered, consisting entirely of debitage, almost all of which (n=52, 69 percent) came from the midden.

Though microdebitage analysis will need to be completed at these groups to confirm this proposition, based on the available data, it appears that Residential Group 5PS-d was the most significant obsidian workshop at Tamarindito. It is possible, however, that higher densities of obsidian recovered from excavations at both Residential Groups 5QQ-a and 5RS-a may reflect neighborhood clusters, with each also producing obsidian, but in smaller proportions to that of clustering around them. Further, groups 5QQ-a and 5RS-a are virtually identical in size, and both are characterized by atypical layouts. While no other dense concentrations are visible, it is important to note that these densities are based solely upon the volume of obsidian recovered during TAP excavations and do not include data from previous excavations. Thus, residential groups such as Q6-2 (discussed previously in this chapter) are not included.

Multi-Agent Production Systems and Economic Control. *No single agent is in complete control of the entire environment*. Residential Group 5PS-d is situated in the far

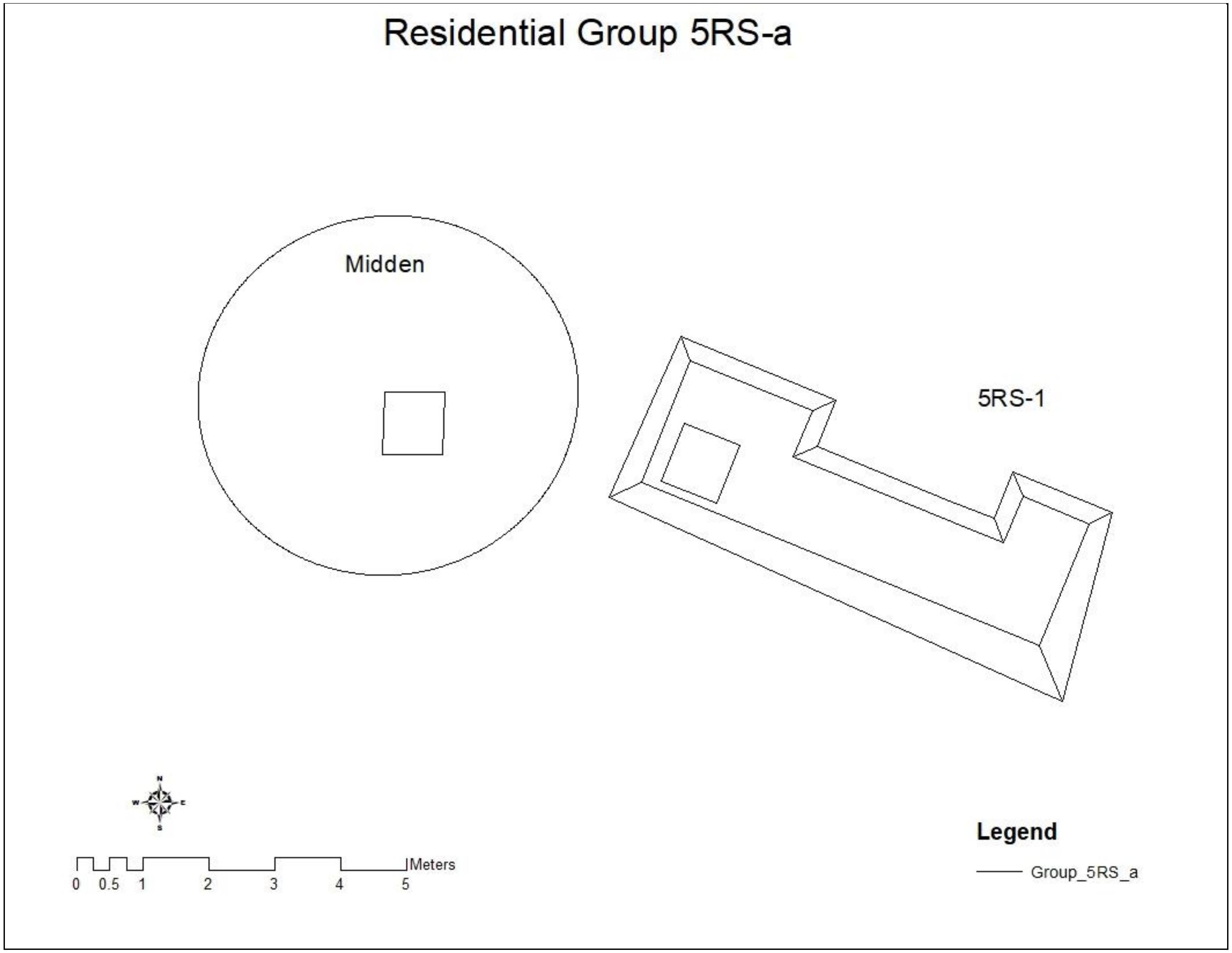

Figure 6.7 Plan View of Residential Group 5RS-a, Showing TAP Excavations

southwest corner of the site, over one kilometer from Plaza B, making it one of the furthest households from the royal center. As such, the residents of this group were potentially some of the most disconnected from the rest of the polity, which could have resulted in both positive and negative consequences for the residents of this group. On the one hand, the location of this group may have granted its members the greatest independence from the direct oversight of the royal center and surrounding elites. On the other hand, being so far removed may have made it difficult to interact with greater Tamarindito, and they may have been one of the last to receive distributions of any goods that were handed down from the royal center.

The latter does not hold true in the case of obsidian, however, which has long been thought to have been a highly exotic commodity controlled by the elites. Though it is commonly assumed that Maya elites controlled the production of obsidian blades (Aoyama et al. 2014; Brumfiel 1987; Brumfiel and Earle 1987; Earle 1982), the distance between 5PS-d and the royal center makes it highly unlikely that household members were manufacturing stone tools exclusively for the elites. Similarly, the members of Residential Group 5PS-d were not manufacturing these blades entirely for themselves, meaning that some method of exchange was likely in place. Further, given the relatively low status of this household, it is doubtful that its members were in complete control of the distribution of these blades. That being said, if the cores recovered from within Structure 5PS-12 were knapped at Residential Group 5PS-12 (or another context at Tamarindito), then not all the blades produced from these cores are accounted for, meaning that these blades were being somehow distributed outside of Residential Group 5PS-d.

The 20 cores recovered from Structure 5PS-12 weigh a combined 1,094 grams. Assuming the starting objective pieces consisted of prismatic blade cores, we can also assume that between

80 and 90 percent of the core material was removed during blade production (Sheets and Muto 1972). This means that the total amount of obsidian flakes and debitage produced from these cores would weigh between 4,376 and 9,846 grams. The 220 obsidian blades recovered from Residential Group 5PS-d weigh 176 grams combined, and the additional obsidian debitage recovered from 5PS-d measured 55.2 grams, for a total of 231.2 grams. Assuming 4,376 is the minimum weight of debitage and blades that would have been produced from the 20 cores recovered, this accounts for only 5.3 percent of the total weight of the obsidian cores. leaving the remaining estimated minimum of 4144.8 grams unaccounted for. Thus, though Residential Group 5PS-d certainly retained some element of control over the obsidian produced therein, outside stakeholders may have been involved, as well.

Conclusions

In tandem with the architectural and artifactual data gathered by the Tamarindito Archaeological Project, the data gleaned from microdebitage and macroartifact analyses of obsidian and chert artifacts recovered from Residential Group 5PS-d demonstrates that no single economic strategy dominated the production of stone tools at Tamarindito. Instead, this investigation illuminates multiple ways that Maya non-elites were intentional about elevating their own socioeconomic status by, quite literally, creating space for themselves along multiple economic trajectories. In the same vein, the residents of 5PS-d also invoked their agency with the decision to terminate Structure 5PS-12 as a way to honor the ritual production that had taken place, or perhaps more specifically, the producers themselves who worked and/or resided within that space. Further, the differential access to resources, especially obsidian, reveals the socioeconomic diversity that must have existed within the so-called commoner class.

The evidence presented here elucidates multiple overlapping and interconnected ritual activities taking place at Residential Group 5PS-d, all of which are connected to stone tool production. First, the architecture of the residential group appears to have been designed with the intention that ritual production would take place within Structure 5PS-d, as the disconnected northern annex was part of the original phase of construction. Second, the spatial patterning of obsidian cores, tools, debitage, and microdebitage indicates that ritual obsidian production likely took place within that annex. Finally, at the time of abandonment, a termination ritual was conducted at Structure 5PS-d wherein the entire structure was dismantled. As part of that ritual, chert tools, including bifaces, choppers, and scrapers, along with the hammerstones used to knap them and the resultant debitage, were scattered across the northern annex. In doing so, the ritual activities and/or those performing them were honored.

The Maya imbued objects with meaning and, at times, may have even viewed them as living objects. In the case of obsidian blade production, the residents of Group 5PS-d may have gone so far as to imbue not only the blades themselves with ritual power, but also the structure within which the rituals were performed and the people conducting the rituals. Knowing that Structure 5PS-12 was built with ritual activities in mind, this structure may have also been ritually imbued with the qualities required to perform ritual tasks within its walls. Thus, the construction of this building represents its birth; the occupation and use, its life; and the termination ritual marked its death.

CHAPTER 7

CONCLUSION

The present investigation into stone tool production at Residential Group 5PS-d has illuminated primary locations of stone tool production within Structure 5PS-12. This evidence indicates that this structure was designed and built for the purpose of conducting ritual activities within the northern annex of this structure, and the macro- and microartifact data elucidate production activities taking place during the Late Classic occupation of Residential Group 5PS-d. Additionally, the termination ritual identified by Markus Eberl and colleagues (2019) suggests that at the time of abandonment, the inhabitants of Residential Group 5PS-12 ritually "killed" the structure, thus removing the ritual power that had previously been imbued within that structure while simultaneously honoring the production practices and/or producers that lived and worked in Residential Group 5PS-d.

In the following section, I discuss how the findings presented in Chapter 6 to address the following two overarching theoretical research questions: 1) How are power differentials produced within multi-agent production systems? and 2) Who was involved in the production of stone tools, and how were these relations structured?

How are Power Differentials Produced within Multi-Agent Production Systems? For this question, which focuses on site-wide differential production, I proposed three hypotheses and assume than any or all three may be in process simultaneously within Tamarindito: 1) Households become self-sufficient; 2) Egalitarian household relationships result in community production and exchange; and 3) Unequal power relationships result in elite control of production. These overlapping hypotheses coincide with the concept of multi-agent production systems, which assume that multiple intersecting economies may be functioning contemporaneously.

Households become self-sufficient.

Test Implication 1a) Households with the smallest construction volume are self-sufficient. Construction volumes for excavated groups at Tamarindito range from 4.9m^3 to 266m,^{3} and Eberl and Vela González (2016) sorted all the excavated residential groups into three socioeconomic groups: small (mean = 12.2m3), medium (mean = 64.3m3), and large (mean = 189.6 m3). Because Residential Group 5PS-d falls within the medium size category (measuring 54.7m^3), this test implication will require the analysis of stone tool production at households falling within the small size group.

Test Implication 1b) Households will use locally available chert instead of non-local obsidian. This test implication is based on the concept that poorer households had less access to resources and specialized production knowledge, thus, they would have relied heavily on locally available chert for tool production. Thus, if Residential Group 5PS-d was self-sufficient, soil samples taken from this household would have produced predominantly chert microdebitage. Instead, obsidian microdebitage comprised two-thirds of all the manually-counted microdebitage recovered from the 50 analyzed soil samples (see Chapter 5). Though it is possible that the residents were self-supplying chert, the recovery of the highest concentration of obsidian tools, cores, and macrodebitage at Tamarindito demonstrates that Residential Group 5PS-d was not entirely a self-sufficient household.

Hypothesis 2) Egalitarian household relationships result in community production and exchange.

Test Implication 2a) A small number of households with microdebitage clusters will be dispersed across the site. As with 1a above, the present investigation did not produce the data required to address this test implication. As such, additional microdebitage analyses of soil samples from additional residential groups are required to sufficiently answer this research question.

Hypothesis 3) Unequal power relationships result in the elite control of production.

Test Implication 3a) "Palace" schools will be located in close proximity to the plazas. If only one singular economy was functioning at Tamarindito during the Late Classic period, I would expect to find obsidian production in the same locations as ceramic production (i.e., palace schools), where both of which could be overseen by elites. The only potential evidence for a palace school located close to the plaza is Residential Group Q6-2 where archaeologists from the Petexbatun Archaeological Research Project uncovered a potential lithic workshop, evidenced by the dense layer of lithic debris included in a burial located in the central structure of that group (Emery et al. 1994; Valdés 1997). I have not analyzed the materials from that context myself, however, and no microdebitage samples have been taken. Residential Group 5PS-d, however, is located too far from either plaza (1.1 km) to have served as a palace school. As discussed in Chapter 6, it would not have made sense to place a palace school at the furthest outskirts of the site, as elite oversight would have proven very difficult. Further, in neither residential groups 5PS-d or previously excavated Q6-2 was evidence of intensive ceramic production recovered. As such, elite control over production could not have been the only economy taking place at Tamarindito.

Test Implication 3b) Obsidian microdebitage clusters will be recovered primarily from these locations**.** Because no palace schools were identified during the present investigation, this test implication cannot be adequately addressed. That being said, the evidence presented in Chapters 5 and 6 demonstrate that elites could not have had exclusive control over obsidian production at Tamarindito. The obsidian artifacts recovered at Residential Group 5PS-d comprise the vast majority of obsidian recovered from all of Tamarindito, and no other contexts have demonstrated evidence of extensive obsidian production. Moreover, the manner in which ritual blade production likely took place with Structure 5PS-12 would have required elites (or potentially guards assigned by the elites) to stand watch within the northern annex while ritual production was taking place in order to maintain control over the production process. It would have been much more efficient to have blade producers located closer to the plaza.

Who was involved in the production of stone tools, and how were these relations structured?

The spatial distributions of chert and obsidian microdebitage within Residential Group 5PS-d addresses this question by illuminating the physical locations of stone tool production, and potentially, the socioeconomic relationships between the members of that household and the rest of Tamarindito. I proposed two hypotheses for this question.

Hypothesis 1) Competition for technical expertise required for obsidian blade production led to secret knowledge and the development of ritualized production.

Test Implication 1a) Clusters of obsidian microdebitage will be found in separate and discrete locales from chert microdebitage**.** Within Residential Groups 5PS-d, microdebitage clusters were identified in two primary locations: Structures 5PS-12 and Structure 5PS-15.

Within the former, DIA was conducted on 15 soils samples collected from the northern annex. Though the DIA performed on these samples does not yet differentiate between chert and obsidian, I assume that the estimated microdebitage identified therein is comprised of both materials, based on the presence of both chert and obsidian tools and debitage. The architectural and artifactual evidence further suggest that ritual blade production was the primary activity assigned to that space, while chert production took place within the annex as part of the termination ritual. As such, I propose that this hypothesis is correct and that, for the household members of Residential Group 5PS-d, ritualized production was the solution to competition for wealth and status among non-elites at Tamarindito.

Hypothesis 2) Technical knowledge required to manufacture obsidian blades was not secret.

Test Implication 2a) Obsidian and chert microdebitage will be found in similar non-discrete contexts**.** If it was not necessary to hide the technical and ritual knowledge required to produce obsidian blades, then there would little advantage to having an annexed room that is not accessible from the inside of the residential group (assuming that ritual activities involving other material classes were not taking place). Further, the termination ritual identified by Eberl et al. (2019) that completed the life cycle of Structure 5PS-12 may not have been required.

Lingering Questions and Future Research

Stone Tool Production at Tamarindito. Though the investigation of stone tool production practices at Residential Group 5PS-d has provided crucial insights into inner workings of multi-agent production systems at Tamarindito, there are several questions that remain unanswered. I have identified areas of ritual obsidian and chert production, along with domestic chert and obsidian use and/or maintenance within Residential Group 5PS-d, but analysis of additional soil samples taken from this group may uncover greater differentiation (or conversely, greater uniformity) in the spatial organization of production activities. For the present study, I only analyzed 50 of the 239 soils samples taken from Residential Group 5PS-d, but I plan to analyze the remaining 189 samples using Dynamic Image Analysis in the very near future.

The analysis of these samples will also answer additional questions that have arisen during the current study. First, if Structure 5PS-12 was designed and built prior to 650 AD with the intended purpose of serving as a space for ritual stone tool production, then it is possible that production was occurring in this space for 100 years or more. If that is the case, I would expect to have identified greater concentrations of microdebitage within the northern annex. There are several potential explanations for this perceived paucity, however. First, ethnoarchaeological studies of modern Maya flintknappers have shown that knappers often lay out a cloth in the knapping area in order to keep the floor clean of sharp debris (Clark 1991). Clark observed Lacandon Maya knappers disposing of their stone tool debitage over 100 meters from the knapping location, in areas such as riverbanks and hollowed-out tree trunks, where the debris would not cause harm to people, animals, or future agricultural uses of the land. Thus, it is possible that the knappers of Residential Group 5PS-d followed a similar protocol, and the dumping site has yet to be identified. This is corroborated by the lack of obsidian debitage recovered from excavations in the midden located just northwest of Structure 5PS-12.

Post-depositional processes comprise another potential explanation. Though microdebitage is less likely to be disturbed by these processes, such as bioturbation and erosion, Tamarindito has suffered from rapid deforestation since 2009, resulting in the loss of approximately 90 percent of the forest cover (Eberl et al. 2019:671) . Though Tamarindito is situated within the Dos Pilas National Reserve and, as such, is technically protected, local farmers have been moved to illegally log within the reserve in order to plant crops necessary to survive. This deforestation may be contributing to the erosion of already shallow soils at Tamarindito, causing microdebitage and other microartifacts to erode far away from the original location of deposition.

Another emergent question concerns the distribution of obsidian blades at Tamarindito. As discussed in Chapter 6, the blades and debitage produced from the obsidian cores recovered from Structure 5PS-12 are estimated to have weighed a minimum of 4,376 grams. Only 1771.5 grams of obsidian have been recovered from all of Tamarindito during TAP excavations. Several elite and non-elite structures and remain unexcavated, so there may be additional contexts containing obsidian artifacts. Further, these totals do not account for the obsidian artifacts recovered prior to excavations led by the Tamarindito Archaeological Project.

The role of market exchange in the distribution of obsidian blades at Tamarindito has not yet been explored. In addition to the soil samples taken from 39 residential groups (including 5PS-d) at Tamarindito, I also took samples from a potential marketplace located in Plaza A. The analysis of these samples may illuminate whether stone tool production and/or maintenance may have taken place in this area. Further, Plaza A lies approximately 1.5 km from Residential Group 5PS-d. Though this distance does not conclusively rule out market exchance, once again, it would make more sense for blade producers to be situated closer to the plazas if market exchange was a regular method of blade distribution.

One final suggestion regarding blade distribution concerns intersite exchange. As previously discussed, Residential Group 5PS-d lies near the southwest edge of Tamarindito.

During the eighth century, Dos Pilas has significant power and influence over Tamarindito as the royal lineages from each sites began to intermarry, and Tamarindito became integrated into the Dos Pilas kingdom (Eberl et al. 2019:671; Eberl and Vela González 2016:iii). Dos Pilas is lies approximately five km southeast of the royal center of Tamarindito, equating to less than four km from Residential Group 5PS-d. Thus, it is possible that obsidian blade exchange between Tamarindito and Dos Pilas was more easily facilitated by having producers situated in this more accessible portion of the site.

Future Microartifact Analysis. In addition to answering questions regarding stone tool production, this project sets up a framework for examining types of production beyond that of stone tools at Tamarindito that could not be addressed in the current project. By comparing the spatial distribution of microdebitage with other material correlates of production (such as ceramics, basketry, botanical remains, etc.), exchange systems within Tamarindito will become even more explicit in future studies. Dynamic Image Analysis via the PartAn 3D analyzer has the potential to contribute to this research in the same way that this method has begun to alleviate many of the issues concerning microdebitage analysis.

Applying Machine Learning Methods to the Analysis of Microdebitage. Though the protocol used in the present study applies statistical analyses to the data produced through DIA, thus producing reliable estimates of microdebitage within soil samples, machine learning may allow for even greater accuracy. Between January and May 2021, Markus Eberl and I have collaborated with Vanderbilt undergraduate students and data scientists at the Data Science Institute to develop a machine learning model capable of discerning between microdebitage and soil particles. The model then calculates probabilities for each particle within an analyzed soil sample, allowing the archaeologist to calculate microdebitage estimates with great accuracy.

Further, because the PartAn 3D analyzer takes multiple two- and three-dimensional photos of each particle, it may also be possible to apply a machine learning model to these photographs.

Methodological and Theoretical Significance

Theoretical Contributions. This research bridges the divide between top-down and bottom-up approaches by including agents that span the breadth of socioeconomic situations and locating these agents within both the vertical and horizontal spectrums of Maya economy. In doing so, this research builds on and expands practice theory by borrowing the concept of the multi-agent system from agent-based modeling studies in order to better understand the relationship between agency, choice, decision-making, and production in Classic Maya society. Practice theory is the idea that past agents had goals and intentions that affected the social structure, but who were also affected by their social context (Bourdieu 1977; de Certeau 1984; Giddens 1984). Bourdieu (1977) suggests that the actions of people in the world reflect their "habitus," or their internalized social dispositions and practical knowledge of the world. For Bourdieu, the locus of agency lies between the "habitus" and individual action (Dobres and Robb 2000:209). As such, uncovering the locations where production took place is essential to our understanding of the Maya "habitus," thus allowing for insight into the ontologies, worldviews, and possibly even intentions and motives of Maya people within multiple social strata.

According to Giddens (1984), understanding social order requires an understanding of the shifting relations between the production and reproduction of social life by its constituent actors. Because stone tools are ubiquitous at archaeological sites, and the majority of actors in Maya society would have required stone tools to complete their daily activities, analyzing stone tool production is particularly suitable for this analysis, as it provides evidence that supports the maintenance of social order through the creation of trust implied in the division of labor. Simultaneously, this research highlights the fragility of the social order, which requires protection through the creation of esoteric knowledge.

Methodological Contributions. One of the most significant advantages that DIA has in comparison to manual analysis of microdebitage is the dramatic increase in efficiency. The manual analysis of soil samples (measuring approximately 50 grams each) took approximately 30 hours each to complete, including 24 hours of soaking; 3-4 hours of rinsing and drying samples; and 1-2 hours to size-grade, identify, count, and weigh microdebitage particles. I soaked between six and 10 samples at a time, totaling approximately 150 total hours of soaking time. I dried the same amount of samples at a time, totaling approximately 25 total hours of drying. Finally, each sample had to be analyzed separately, adding up to approximately 75 hours of analysis time. Thus, the total time required to complete the processing and analysis of 50 soil samples totals approximately 250 hours (or an average of five hours per sample). Conversely, the PartAn 3D analyzer takes between 5-7 minutes to run a single sample measuring 50 grams. Thus, to run all 50 samples through the analyzer took approximately five hours, a 98 percent decrease in time, demonstrating that DIA is a more efficient method than traditional microdebitage analysis conducted by hand, even though the microdebitage counts produced are estimated.

Following Johnson et al. (2021), let us compare the current investigation using DIA to the Sherwood and Ousley (1995) study using MMCount, one of the most efficient methods for counting microartifacts to date. Though the time allotted for flotation and size-grading was not discussed, Sherwood and Ousley report an average time of 25 minutes required to count a microartifact sample using MMCount (1995:427). In the present study, each soil sample took less than 10 minutes to pass through the analyzer, including data output. Further, I did not have to use flotation to separate microartifacts from the soil matrix within each sample. Moreover, for each archaeological soil sample, the particle analyzer calculates up to 40 measurements per particle. With soil samples containing hundreds of thousands of particles, DIA produces millions of data points per sample, which is a marked advantage over any previous method for analyzing microdebitage (Johnson et al. 2021:115-116).

Finally, as the first intensive microdebitage study conducted in the Maya lowlands (and one of only a few in the entire Maya region) and one of the largest microdebitage studies ever conducted, this research has the potential to transform the way archaeologists use lithic artifacts to reveal complex relationships between multiple agents across a breadth of socioeconomic strata. Furthermore, no microdebitage studies have been completed on such a large scale anywhere in the world. As such, this project sheds a bright light on the contributions of microdebitage to archaeological research worldwide.

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APPENDIX A: RESULTS OF MANUAL ANALYSIS FOR CHERT MICRODEBITAGE

Northing	Easting	Latitude	Longitude	6.3mm Count	4.0mm Count	2.0mm Count	1.0mm Count	0.5mm Count	Total Counts	6.3mm Weight	4.0mm Weight	2.0mm Weight	1.0mm Weight	0.5mm Weight	Total Weights
504	508	1820219	793868	0	0	0	0	0	0	0	0	0	0	0	0
506	506	1820221	793866	0	0	0	0	0	0	0	0	0	0	0	0
508	500	1820223	793860	0	0	0	0	0	0	0	0	0	0		0
510	516	1820225	793876	0	0	0	0	0	0	0	0	0	0	0	0
512	500	1820227	793860	0	0	0	0	0	0	0	0	0	0	0	0
512	502	1820227	793862	0	0	0	0	0	0	0	0	0	0	0	0
514	500	1820229	793860	0	0	0	0	0	0	0	0	0	0	0	0
514	502	1820229	793862	0	0	0	0	0	0	0	0	0	0	0	0
514	506	1820229	793866	0	0	0	0	0	0	0	0	0	0	0	0
512	504	1820227	793864	0	0	3	0	0	3	0	0	0.072	0	0	0.072
510	502	1820225	793862	0	0	2	0	0	2	0	0	0.76	0	0	0.76
504	510	1820219	793870	0	0	0	0	2	2	0	0	0	0	0.001	0.001
506	510	1820221	793870	0	0	2	3	2	7	0	0	0.03	0.001	0.001	0.032
504	500	1820219	793860	0	0	0	2	0	2	0	0	0	0.003	0	0.003
508	514	1820223	793874	0	0	0	2	2	4	0	0	0	0.002	0.001	0.003
510	500	1820225	793860	0	0	0	0	1	1	0	0	0	0	0.003	0.003
514	508	1820229	793868	0	0	0	2	3	5	0	0	0	0.001	0.002	0.003
510	512	1820225	793872	0	0	2	0	5	7	0	0	0.043	0	0.003	0.046
504	514	1820219	793874	0	0	0	1	3	4	0	0	0	0.001	0.005	0.006
512	512	1820227	793872	0	0	0	2	1	3	0	0	0	0.005	0.001	0.006
508	510	1820223	793870	0	0	1	0	5	6	0	0	0.01	0	0.006	0.016
504	506	1820219	793866	0	0	0	0	4	4	0	0	0	0	0.007	0.007
510	504	1820225	793864	0	0	0	1	5	6	0	0	0	0.001	0.006	0.007
510	506	1820225	793866	0	0	0	0	5	5	0	0	0	0	0.007	0.007
512	516	1820227	793876	0	0	0	3	0	3	0	0	0	0.007	0	0.007
508	516	1820223	793876	1	0	1	2	1	5	0.868	0	0.001	0.006	0.001	0.876
504	516	1820219	793876	0	0	0	2	3	5	0	0	0	0.006	0.002	0.008
510	510	1820225	793870	0	2	0	1	0	3	0	0.083	0	0.008	0	0.091
506	518	1820221	793878	0	0	0	2	8	10	0	0	0	0.005	0.004	0.009
510	518	1820225	793878	0	0	0	2	1	3	0	0	0	0.008	0.001	0.009
512	508	1820227	793868	0	0	1	3	4	8	0	0	0.01	0.005	0.005	0.02
508	508	1820223	793868	0	0	1	3	5	9	0	0	0.024	0.005	0.005	0.034
504	512	1820219	793872	0	0	0	4	0	4	0	0	0	0.011	0	0.011
508	502	1820223	793862	0	0	0	2	5	7	0	0	0	0.007	0.006	0.013
508	512	1820223	793872	0	0	0	2	3	5	0	0	0	0.012	0.002	0.014

506	500	1820221	793860	0	0	0	2	4	6	0	0	0	0.01	0.006	0.016
506	508	1820221	793868	0	0	0	4	3	7	0	0	0	0.013	0.005	0.018
506	514	1820221	793874	0	0	0	5	7	12	0	0	0	0.006	0.015	0.021
510	508	1820225	793868	0	0	0	3	4	7	0	0	0	0.016	0.006	0.022
512	510	1820227	793870	0	0	0	6	3	9	0	0	0	0.015	0.008	0.023
504	504	1820219	793864	0	0	0	2	5	7	0	0	0	0.016	0.008	0.024
506	512	1820221	793872	1	0	0	7	0	8	0.286	0	0	0.026	0	0.312
512	514	1820227	793874	0	0	0	3	4	7	0	0	0	0.02	0.006	0.026
506	516	1820221	793876	0	3	1	4	3	11	0	0.445	0.014	0.016	0.012	0.487
508	506	1820223	793866	0	0	0	8	10	18	0	0	0	0.021	0.012	0.033
514	516	1820229	793876	0	0	0	9	3	12	0	0	0	0.034	0.002	0.036
506	502	1820221	793862	0	1	5	5	8	19	0	0.178	0.132	0.035	0.009	0.354
510	514	1820225	793874	0	0	0	9	19	28	0	0	0	0.039	0.017	0.056
514	504	1820229	793864	0	0	0	2	0	2	0	0	0	0.07	0	0.07
514	510	1820229	793870	0	0	0	7	11	18	0	0	0	0.14	0.007	0.147

APPENDIX B: RESULTS OF MANUAL ANALYSIS FOR OBSIDIAN MICRODEBITAGE

Easting	Latitude	Longitude	6.3mm Count	4.0mm Count	2.0mm Count	1.0mm Count	0.5mm Count	Total Counts	6.3mm Weight	4.0mm Weight	2.0mm Weight	1.0mm Weight	0.5mm Weight	Total Weights
516	1820219	793876	0	0	0	0	0	0	0	0	0	0	0	0
506	1820221	793866	0	0	0	0	0	0	0	0	0	0	0	0
502	1820225	793862	0	0	0	0	0	0	0	0	0	0	0	0
506	1820225	793866	0	0	0	0	0	0	0	0	0	0	0	0
500	1820227	793860	0	0	0	0	0	0	0	0	0	0	0	0
504	1820227	793864	0	0	0	0	0	0	0	0	0	0	0	0
512	1820227	793872	0	0	0	0	0	0	0	0	0	0	0	0
514	1820227	793874	0	0	0	0	0	0	0	0	0	0	0	0
500	1820221	793860	0	0	0	0	8	8	0	0	0	0	0.001	0.001
512	1820221	793872	0	0	0	1	0	1	0	0	0	0.001	0	0.001
514	1820223	793874	0	0	0	0	1	1	0	0	0	0	0.001	0.001
502	1820227	793862	0	0	0	1	0	1	0	0	0	0.001	0	0.001
508	1820227	793868	0	0	0	2	0	2	0	0	0	0.001	0	0.001
516	1820227	793876	0	0	0	0	1	1	0	0	0	0	0.001	0.001
502	1820229	793862	0	0	0	0	3	3	0	0	0	0	0.001	0.001
504	1820229	793864	0	0	0	0	8	8	0	0	0	0	0.001	0.001
508	1820219	793868	0	1	0	1	0	2	0	0.71	0	0.001	0	0.711
506	1820219	793866	0	0	0	0	4	4	0	0	0	0	0.002	0.002
518	1820221	793878	0	0	0	1	0	1	0	0	0	0.003	0	0.003
512	1820223	793872	0	0	0	0	6	6	0	0	0	0	0.003	0.003
514	1820219	793874	0	0	0	0	8	8	0	0	0	0	0.004	0.004
500	1820229	793860	0	0	0	2	6	8	0	0	0	0.003	0.002	0.005
502	1820223	793862	0	0	0	1	6	7	0	0	0	0.001	0.005	0.006
510	1820227	793870	0	0	0	2	2	4	0	0	0	0.005	0.001	0.006
516	1820229	793876	0	0	0	0	5	5	0	0	0	0	0.006	0.006
510	1820219	793870	0	0	0	0	10	10	0	0	0	0	0.007	0.007
508	1820221	793868	0	0	0	1	8	9	0	0	0	0.003	0.005	0.008
502	1820221	793862	0	0	0	1	10	11	0	0	0	0.001	0.008	0.009
516	1820221	793876	0	0	0	0	10	10	0	0	0	0	0.01	0.01
500	1820219	793860	0	0	0	0	7	7	0	0	0	0	0.011	0.011
510	1820221	793870	0	0	0	0	8	8	0	0	0	0	0.012	0.012
500	1820223	793860	0	0	0	0	10	10	0	0	0	0	0.012	0.012
510	1820223	793870	0	0	0	3	5	8	0	0	0	0.008	0.004	0.012
506	1820223	793866	0	0	0	1	19	20	0	0	0	0.00001	0.012	0.012

504	1820225	793864	0	0	0	0	10	10	0	0	0	0	0.013	0.013
512	1820219	793872	0	0	0	3	25	28	0	0	0	0.007	0.006	0.013
514	1820221	793874	0	0	0	1	20	21	0	0	0	0.003	0.01	0.013
518	1820225	793878	0	0	0	1	13	14	0	0	0	0.003	0.01	0.013
508	1820229	793868	0	0	0	0	11	11	0	0	0	0	0.014	0.014
508	1820225	793868	0	0	0	1	33	34	0	0	0	0.003	0.012	0.015
512	1820225	793872	0	0	0	4	6	10	0	0	0	0.013	0.004	0.017
508	1820223	793868	0	0	0	3	17	20	0	0	0	0.01	0.008	0.018
510	1820225	793870	0	0	0	0	18	18	0	0	0	0	0.022	0.022
504	1820219	793864	0	0	0	3	1	4	0	0	0	0.021	0.001	0.022
510	1820229	793870	0	0	0	4	20	24	0	0	0	0.009	0.02	0.029
516	1820223	793876	0	0	2	4	23	29	0	0	0.065	0.016	0.013	0.094
516	1820225	793876	0	0	0	4	25	29	0	0	0	0.012	0.017	0.029
514	1820225	793874	0	0	0	5	17	22	0	0	0	0.025	0.009	0.034
506	1820229	793866	0	0	0	8	18	26	0	0	0	0.027	0.013	0.04
500	1820225	793860	1	0	0	5	20	26	0.503	0	0	0.024	0.024	0.551

APPENDIX C: RESULTS OF DYNAMIC IMAGE ANALYSIS ON SOIL SAMPLES FROM GROUP 5PS-D

Northing	Easting	Latitude	Longitude	Weight	0.5mm	Weighted 0.5mm	1.0mm	Weighted 1.0mm	2.0mm	Weighted 2.0mm	4.0mm	Weighted 4.0mm	Total Counts	Weighted Counts
504	500	1820219	793860	286.6	4	0.08	3	0.06	0	0	0	0	7	0.14
504	504	1820219	793864	310.6	9	0.18	5	0.1	0	0	0	0	14	0.28
504	506	1820219	793866	304.7	12	0.24	0	0	0	0	0	0	12	0.24
504	508	1820219	793868	252	11	0.22	1	0.02	0	0	1	0.02	13	0.26
504	510	1820219	793870	324.8	11	0.22	2	0.04	1	0.02	1	0.02	15	0.3
504	512	1820219	793872	267.2	2	0.04	2	0.04	1	0.02	0	0	5	0.1
504	514	1820219	793874	320.1	4	0.08	2	0.04	1	0.02	0	0	7	0.14
504	516	1820219	793876	314.5	11	0.22	5	0.1	2	0.04	0	0	18	0.36
506	500	1820221	793860	299.9	7	0.14	4	0.08	1	0.02	0	0	12	0.24
506	502	1820221	793862	334.6	1	0.02	3	0.06	1	0.02	0	0	5	0.1
506	506	1820221	793866	293.1	0	0	0	0	2	0.04	0	0	2	0.04
506	508	1820221	793868	294.8	2	0.04	1	0.02	1	0.02	0	0	4	0.08
506	510	1820221	793870	360	0	0	3	0.06	0	0	0	0	3	0.06
506	512	1820221	793872	359	11	0.22	7	0.14	3	0.06	0	0	21	0.42
506	514	1820221	793874	283.7	2	0.04	3	0.06	1	0.02	0	0	6	0.12
506	516	1820221	793876	291.7	3	0.06	1	0.02	0	0	1	0.02	5	0.1
506	518	1820221	793878	272.5	3	0.06	5	0.1	0	0	1	0.02	9	0.18
508	500	1820223	793860	313.6	40	0.8	10	0.2	2	0.04	1	0.02	53	1.06
508	502	1820223	793862	303	13	0.26	9	0.18	0	0	0	0	22	0.44
508	506	1820223	793866	229.2	0	0	1	0.02	0	0	0	0	1	0.02
508	508	1820223	793868	238.1	0	0	0	0	0	0	0	0	0	0
508	510	1820223	793870	249.9	1	0.02	1	0.02	0	0	0	0	2	0.04
508	512	1820223	793872	259.5	0	0	1	0.02	1	0.02	1	0.02	3	0.06
508	514	1820223	793874	240.9	6	0.12	4	0.08	1	0.02	0	0	11	0.22

508	516	1820223	793876	229.7	1	0.02	3	0.06	0	0	0	0	4	0.08
510	500	1820225	793860	260.6	5	0.1	13	0.26	1	0.02	0	0	19	0.38
510	502	1820225	793862	229.7	11	0.22	5	0.1	1	0.02	0	0	17	0.34
510	504	1820225	793864	214.1	1	0.02	5	0.1	4	0.08	0	0	10	0.2
510	506	1820225	793866	199.2	8	0.16	2	0.04	1	0.02	2	0.04	13	0.26
510	508	1820225	793868	215.6	1	0.02	1	0.02	0	0	0	0	2	0.04
510	510	1820225	793870	195.1	1	0.02	0	0	1	0.02	0	0	2	0.04
510	512	1820225	793872	197.3	0	0	0	0	0	0	0	0	0	0
510	514	1820225	793874	203.9	0	0	0	0	1	0.02	0	0	1	0.02
510	516	1820225	793876	242.7	0	0	1	0.02	0	0	0	0	1	0.02
510	518	1820225	793878	208.6	0	0	0	0	1	0.02	0	0	1	0.02
512	500	1820227	793860	242.2	1	0.02	3	0.06	1	0.02	0	0	5	0.1
512	502	1820227	793862	243.6	7	0.14	1	0.02	2	0.04	0	0	10	0.2
512	504	1820227	793864	224	2	0.04	0	0	3	0.06	0	0	5	0.1
512	508	1820227	793868	213.6	0	0	1	0.02	1	0.02	0	0	2	0.04
512	510	1820227	793870	218.7	3	0.06	0	0	0	0	0	0	3	0.06
512	512	1820227	793872	205.8	0	0	0	0	2	0.04	0	0	2	0.04
512	514	1820227	793874	193.8	0	0	2	0.04	1	0.02	0	0	3	0.06
512	516	1820227	793876	271.2	6	0.12	3	0.06	0	0	1	0.02	10	0.2
514	500	1820229	793860	220.7	0	0	1	0.02	0	0	0	0	1	0.02
514	502	1820229	793862	164.9	3	0.06	1	0.02	0	0	0	0	4	0.08
514	504	1820229	793864	256.4	6	0.12	5	0.1	3	0.06	0	0	14	0.28
514	506	1820229	793866	259.8	12	0.24	3	0.06	0	0	0	0	15	0.3
514	508	1820229	793868	174.6	0	0	1	0.02	1	0.02	1	0.02	3	0.06
514	510	1820229	793870	192	0	0	0	0	1	0.02	0	0	1	0.02
514	516	1820229	793876	301.9	18	0.36	3	0.06	3	0.06	0	0	24	0.48

APPENDIX D: RESULTS OF DYNAMIC IMAGE ANALYSIS FOR SOIL SAMPLES FROM STRUCTURE 5PS-12 ANNEX

Oper/Unit	#	Size Grade	Latitude	Longitude	0.5mm	Weighted 0.5mm	1.0mm	Weighted 1.0mm	Total Counts	Sample Weight	Weighted Counts
TM 37 C-3	1/8	0.5-1.0	1820235.24	793875.69	0	0	0	0	0	9	0
TM 37 C-3	2/8	1.0-2.0	1820235.24	793875.69	2	0.042553191	1	0.021276596	3	47	0.063829787
TM 37 C-3	2/8	0.5-1.0	1820235.24	793875.69	0	0	0	0	0	20	0
TM 37 C-3	3/8	0.5-1.0	1820235.24	793875.69	1	0.05	0	0	1	20	0.05
TM 37 C-3	3/8	1.0-2.0	1820235.24	793875.69	0	0	11	0.323529412	11	34	0.323529412
TM 37 C-3	4/8	0.5-1.0	1829236.437	793875.769	2	0.071428571	1	0.035714286	3	28	0.107142857
TM 37 C-3	5/8	0.5-1.0	1829236.437	793875.769	0	0	0	0	0	15	0
TM 37 C-3	6/8	0.5-1.0	1829236.437	793875.769	0	0	0	0	0	21	0
TM 37 C-3	6/8	1.0-2.0	1829236.437	793875.769	1	0.032258065	1	0.032258065	2	31	0.064516129
TM 37 C-3	8/8	1.0-2.0	1820234.63	793875.54	1	0.023809524	2	0.047619048	3	42	0.071428571
TM 37 F	M3	0.5-1.0	1829235.448	793871.934	10	0.909090909	1	0.090909091	11	11	1
TM 37 F	M3	1.0-2.0	1829235.448	793871.934	1	0.047619048	0	0	1	21	0.047619048
TM 37 F	M4	0.5-1.0	1829235.448	793871.934	2	0.222222222	0	0	2	9	0.222222222
TM 37 F	M4	1.0-2.0	1829235.448	793871.934	1	0.052631579	0	0	1	19	0.052631579
TM 37 F-2	M5	0.5-1.0	1820235	793873	2	0.285714286	0	0	2	7	0.285714286

APPENDIX E: PROVENIENCE INFORMATION FOR SOIL SAMPLES FROM 5PS-12 (TAKEN BY MARKUS EBERL)

ID	Sample Type	Sample Number	Op	Subop	Unit	Level	Depth	Amount	Date Sample Taken	Context	Comment	Season
148	S	70	37	C	3		0	0.25	5/31/2011	East Profile Back of Structure 5PS-12 behind back wall	1 of 8	2011
149	S	71	37	C	3		-0.5	0.25	5/31/2011	East Profile Back of Structure 5PS-12 behind back wall (original surface)	2 of 8	2011
150	S	72	37	C	3		-0.7	0.25	5/31/2011	East Profile Back of Structure 5PS-12 behind back wall (above bedrock)	3 of 8	2011
151	S	73	37	C	3		0	0.25	5/31/2011	East Profile Back of Structure 5PS-12 center (120 cm N of back wall)	4 of 8	2011
152	S	74	37	C	3		-0.5	0.25	5/31/2011	East Profile Back of Structure 5PS-12 center (120 cm N of back wall, original surface)	5 of 8	2011
153	S	75	37	C	3		-0.7	0.25	5/31/2011	East Profile Back of Structure 5PS-12 center (120 cm N of back wall, above bedrock)	6 of 8	2011
154	S	76	37	C	3		0	0.25	5/31/2011	East Profile Back of Structure 5PS-12 back wall	7 of 8	2011
155	S	77	37	C	3		-0.5	0.25	5/31/2011	East Profile Back of Structure 5PS-12 back wall (original surface)	8 of 8	2011
493	M	1	37	E	3		-0.5	1	5/30/2014	Structure 5PS-12: Presumed obsidian workshop	Sample from the possible workshop's original surface in the southwest corner (behind structure back wall)	2014
494	M	2	37	E	3		-0.3	1	5/30/2014	Structure 5PS-12: Presumed obsidian workshop	Sample from the possible workshop's original surface in the northern center	2014
495	M	3	37	E	1	3	-0.2	0.5	5/30/2014	Structure 5PS-12: Presumed obsidian workshop	Sample from the exterior gravel floor of the presumed obsidian workshop	2014
496	M	4	37	E	1	4	-0.3	0.5	5/30/2014	Structure 5PS-12: Presumed obsidian workshop	Sample from the fill below the exterior floor of the presumed obsidian workshop (an obsidian core fragment was found nearby)	2014
497	M	5	37	E	2		-0.2	0.5	5/30/2014	Structure 5PS-12: Presumed obsidian workshop	Sample from the northern exterior of the presumed obsidian workshop; unlike 37F-1, the excavation found no clear floor	2014