To the Graduate Council:

I am submitting herewith a thesis written by Rachel Lynn Vykukal entitled "*Purpurae Florem* of Mitrou: Assessing the Role of Purple Dye Manufacture in the Emergence of a Political Elite." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

Aleydis Van de Moortel, Major Professor

We have read this thesis
and recommend its acceptance:

David Anderson

Benjamin Auerbach

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original Signatures are on file with official student records.)

Purpurae Florem of Mitrou: Assessing the Role of Purple Dye Manufacture in the Emergence of a Political Elite.

A Thesis Presented for
the Master of Arts
Degree
The University of Tennessee, Knoxville

Rachel Lynn Vykukal
August 2011

Acknowledgements

It is a pleasure to thank those individuals who helped me in writing this thesis. Thank you to Drs. David Anderson and Benjamin Auerbach for editing previous versions and providing many helpful suggestions, especially regarding the statistical analysis. Thank you to my advisor and committee chair, Dr. Aleydis Van de Moortel, for your invaluable insights into this research project as a whole and for helping me to become a better researcher. Thank you for editing and revising this thesis from start to finish. I would also like to thank Debbie Ruscillo for providing me with information on *Murex* analysis and methodologies. Thank you, Chris Hale and Arinn Cirulis, for sharing preliminary conclusions from your research with Mitrou materials. Thank you to Mr. Thanasis Berdekas for collecting *Murex* for the experiment I conducted. Thank you to the University of Tennessee's Classics Department for providing the travel funds to study the *Murex* remains in Tragana, Greece. I would like to say a special thank you to my beloved family and friends. I never could have completed this without your unconditional love, constant support, and guidance. Thank you for always being there to listen, encourage, and motivate.

Abstract

Evidence suggests that purple dye was produced on the islet of Mitrou, a Bronze Age and Early Iron Age site in central Greece. The goal of this study is to determine the chronological and spatial patterning of *Murex* shells in order to better understand the emergence of dye manufacture. The research hypothesis is that *Murex* dye production was related to the rise of a visible political elite and that the scale of production was large enough at Mitrou to have exceeded the needs of the household, thus providing a cash crop for this elite to obtain imports from the Eastern Mediterranean. Multi-layered statistical analyses were employed to test this two-pronged hypothesis. The first hypothesis that *Murex* dye production was related to the rise of the elite at Mitrou was confirmed by a series of chi-squared analyses. Based on site-wide estimates of original *Murex* population, the second hypothesis that dye production exceeded domestic scale cannot be rejected. Since we know the prehistoric Mycenaeans produced very ornate, multi-colored and often banded garments, it is possible that *Murex* dye was produced at Mitrou to color raw wool for the production of thread, which could then be embroidered on fabric or traded as such. If it was in fact colored thread that was being produced, the site-wide estimates suggest that dye production could have exceeded domestic levels at Mitrou and dyed thread could have been a lucrative trading commodity.

Table of Contents

List of Tables

List of Figures

Chapter 1
Introduction

> *Quapropter excusata et purpurae sit insania. sed unde conchyliis pretia, quis virus grave in fuco, color austerus in glauco et irascenti similis mari?*
> Pliny the Elder (*Naturalis Historia*, IX, 60)
>
> Therefore, let the frantic passion for purple be excused. But whence does the high value of the purple shell-fish come, what is the unpleasant potent liquid in the dye, the color morose in a grayish hue and resembling that of a raging sea?

This "frantic passion for purple" to which Roman author Pliny the Elder alludes in his magnum opus *Naturalis Historia* was precipitated by the famous royal purple dye industry of antiquity. This dye, produced by carnivorous sea snails belonging to the *Murex* and *Thais* genera, reached a value equivalent to ten to twenty times its weight in gold in Roman times and wearing *Murex* dyed textiles became the exclusive right of emperors and nobility (Born 1937; Reinhold 1970; Michel and McGovern 1990A). In the 1st century AD, Nero even closed all of the shops in Rome that sold *Murex* purple dye, and publicly stripped a matron of her clothing for wearing the forbidden color (Jenson 1963: 113). At this time, purple dye production was monopolized by the mercantile Phoenicians at dye centers in Sarepta, Tyre, and Sidon in the ancient Levant, which each produced its own hue of purple on an industrial scale. However, the purple dye industry had more modest beginnings in the Aegean some 1,700 years earlier on Crete and the Greek mainland. Very recently, evidence for purple dye production in the Late Bronze Age has been discovered at the Greek mainland site of Mitrou. At the same time, there is evidence to suggest that a political elite was emerging at Mitrou that may have been

involved in purple dye manufacture. What might have driven an emerging political elite to engage in the notoriously smelly, laborious task of creating purple dye from marine mollusks?

Mitrou is a small tidal islet in the Northern Euboean Gulf of central Greece, which has evidence for continual occupation from the Early Helladic IIB (EH IIB) through the Late Protogeometric (LPG) phases, ranging from ca. 2400-900 BC (Figure 1.1) (Van de Moortel and Zahou forthcoming: 1). As a result of the 1894 Atalante earthquake, Mitrou is no longer part of the mainland as it would have been in antiquity. Excavations were conducted at Mitrou from 2004-2008 by the 14th Ephorate of Prehistoric and Classical Antiquities at Lamia and the University of Tennessee under the co-direction of Drs. A. Van de Moortel and E. Zahou. In 2003 and 2005, geophysical surveys of the islet suggested that two large building complexes were located in the northwest and northeast quadrants of the islet. In the course of five field seasons, excavations have focused mainly on these areas as well as smaller areas in the northeast corner, extreme east, and central parts of the islet, uncovering 777 square meters in area or roughly 2.2% of the islet (Figure 1.2). An intensive surface survey has covered 25% of the islet, roughly 8,900 square meters of the estimated 3.6 hectare surface in the north and central-eastern parts. Since 2009, the project has focused on studying the finds for publication.

In the summer of 2010, I conducted a study of *Murex* remains collected during the 2004-2008 field seasons. The goal of this study was to determine the chronological and

spatial patterning of the three purple producing species: *Murex trunculus, Murex brandaris,* and *Thais haemastoma,* in order to better understand the emergence of dye production at Mitrou. The hypothesis to be tested is twofold. First, I will investigate whether *Murex* dye production was, in fact, related to the rise of a visible political elite at

Figure 1.1: Balloon photograph of Mitrou at the end of the 2008 excavation season. K. Xenikakis, Mitrou Archaeological Project

Mitrou. Secondly, I want to determine whether the scale of production was large enough to have exceeded the needs of the household, providing a cash crop that Mitrou's elite could have exchanged for imports such as copper and tin used to make bronze, which would have been vital to their legitimizing of power. To test my two-pronged hypothesis, I will employ rigorous quantification methods as well as multi-layered statistical analyses.

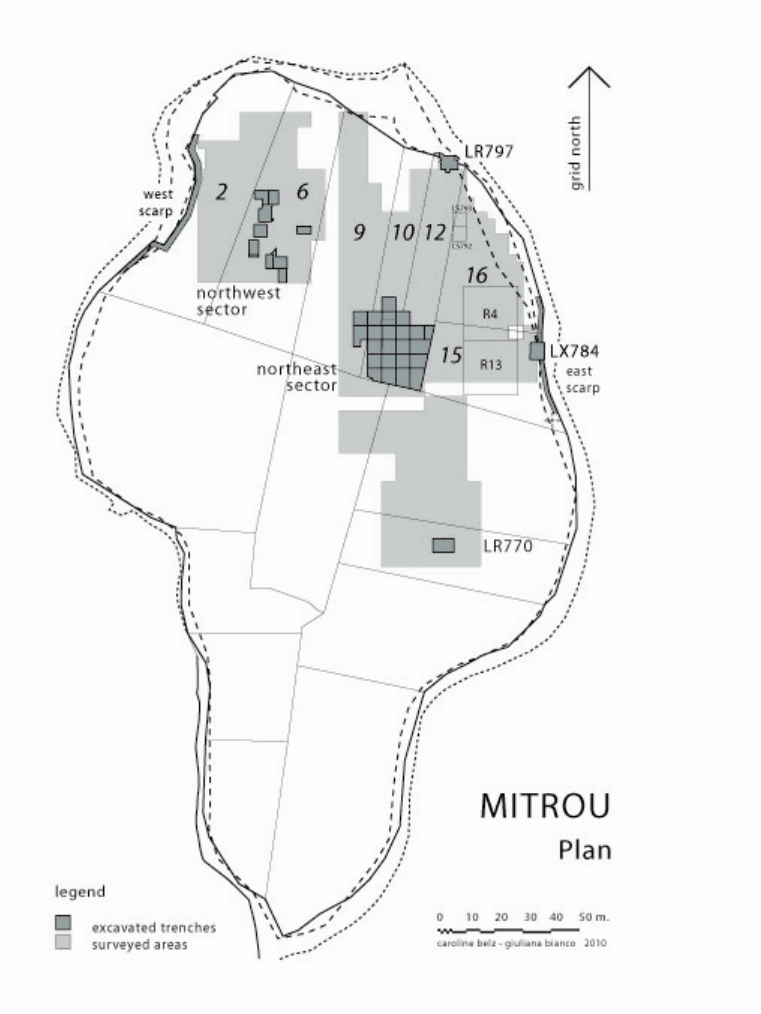


Figure 1.2: Site plan of Mitrou in 2009. G. Bianco, Mitrou Archaeological Project

Copper, tin, and purple in the Bronze Age East Mediterranean

Copper and tin were important metals in the Middle and Late Bronze Age because together they form bronze. The necessity for these materials stimulated interregional trade (Knapp 1990; Muhly 2003). The use of copper alloyed with tin was a more efficient metal than copper alone in that it was easier to cast and work (Dickinson 1994:98). As the main material used for the manufacture of weapons during the Bronze Age, bronze was essential to the elite's military power. Furthermore, the use of bronze precipitated the production of elaborate tools, weapons, and vessels, which served as outward displays of the power and wealth of the elite (Dickinson 1994:98). During the Middle Bronze Age, some copper must have come from Laurion in Attica and possibly from the Cyclades (Davis 2001; Van de Moortel 2010). However, by the Late Helladic phase, the majority of copper came from Cyprus. The source of tin, on the other hand, is more uncertain, but it must have been imported from outside the Greek mainland (Dickinson 1994: 29). In the Middle Bronze Age, some tin may have come from Anatolia, as it was produced in the Taurus Mountains during this time (Van de Moortel 2010). Tin may have been imported into Anatolia from Afghanistan by the Assyrians and from there was traded throughout the Mediterranean. Bronze made from tin was used in the Levant and Egypt as well, so the prehistoric Aegeans could have feasibly imported it from either of these areas.

Aegean prehistorians have wondered for a long time what commodities the Aegean would have been able to offer in exchange for copper and tin. A plausible suggestion was offered by Burke (1999), who proposed that *Murex* dye would be a good candidate for such a cash crop, because we know from literary evidence that it was highly

valued as a prestige item in the East. A 14th century BC Tell el-Amarna letter mentions various items trimmed with or made of "blue-purple wool" (Moran 1992: 53). This letter was written by King Tusratta of Mitanni who gave these purple colored textiles as a bride gift to his daughter and the pharaoh Akhenaten (Moran 1992; Michel and McGovern 1987). In addition, documents of the same century from Ugarit reveal that purple garments were sent as tribute by King Niqmad to King Suppiluliumas, the ruler of the Hittite Empire (Reinhold 1969). Pliny the Elder mentions an eighth century BC inscription that lists tribute goods received by the king of Assyria, Tiglath-Pileser III, from the king of Tyre. Included in the list are expensive items of clothing, made of wool dyed in Tyrian *Murex* purple (Chehab 1969). Purple had clearly attained status as an elite good by at least the mid second millennium BC.

The high value of the dye is probably linked to the nature of the pigment itself and its production methods, which will be discussed further in Chapter 3. *Murex* purple dye was the only color-fast dye in antiquity that did not fade with multiple washings (Reinhold 1969: 301). Furthermore, purple dye production was a laborious, tedious, and-- not to mention-- odorous task that took over nine days to complete and required many mollusks. Given its high value in the East, it is indeed conceivable that the elite at Mitrou would have been producing purple dye as a cash crop to obtain copper and tin for producing bronze. To test this proposition, it is important to investigate to what extent purple dye manufacture at Mitrou coincided with the rise of this elite, and gain a better understanding of the scale of production.

Brief overview of main cultural periods excavated at Mitrou

The main cultural periods at Mitrou that will be covered in this study are (Table 1.1): the Corridor House period (Early Helladic IIB pottery phase), EH III-MH III Village period (Early Helladic III-Middle Helladic III), Prepalatial period (Late Helladic I-Late Helladic IIIA:2 Early), Palatial period (Late Helladic IIIA:2 Middle-Late Helladic IIIB), Post-Palatial period (Late Helladic IIIC), LH IIIC/PG, and the Early Iron Age Village period (Early Protogeometric-Late Protogeometric).

In the Corridor House period, the main architectural finds were the fairly substantial walls of two successive buildings, the function of which is unknown, uncovered at the eastern edge of the islet in Trench LX784 (Van de Moortel and Zahou forthcoming: 2). Baked roof tiles were found in Trench LX784, as well as in trench LR797 in the Northeast corner of the islet and at the western sea scarp. These are important finds, because roof tiles are most commonly associated with large buildings known as “Corridor Houses” in other parts of the Greek mainland, which suggest a fairly complex societal organization. Preliminarily, the distribution of roof tiles seems to be widespread across the islet, but no remains of a Corridor House have been securely identified in the small areas excavated (Van de Moortel and Zahou forthcoming: 3). Occupation during this period covered at least the northern half of the islet, but the layout of the settlement has not been determined.

At the end of the EH IIB phase, the civilization of the Corridor Houses collapsed throughout central and southern Greece, and was followed by a simpler society with more or less egalitarian villages. The EH III-MH village at Mitrou was extensive throughout

the islet and likewise covered at least the northern part of the islet. Two buildings were uncovered in trench LX784: Buildings K and L (Van de Moortel and Zahou forthcoming: 4). Building L, which was constructed in EH III/MH I and went out of use early in MH I, had a hard-baked clay floor with a rectangular bin made of mudbricks. Building K was constructed in MH I over Building L and was made up of at least two rooms also with clay floors and a substantial hearth. Above this building were four later MH II levels that included refuse pits, but no identifiable structures. MH habitation levels were also excavated in trench LE792. The remains of a small wooden boat was found lying on a narrow pebble and dirt road dating to the MH II Early pottery phase (Van de Moortel and Zahou forthcoming: 4). Two more roads had been laid atop this road. In both trenches, MH habitation levels alternated with cist graves. At present, too little of the EH III-MH settlement has been exposed to fully understand its organization.

The settlement of the Prepalatial or Formative period was urban and shows strong evidence for the rise of an elite at Mitrou. The emergence of this elite is reflected in the construction of two elite buildings, complexes D and H, found in the northwest and northeast of the islet; two graves with monumental characteristics; and an accompanying major reorganization of the settlement (Van de Moortel and Zahou forthcoming: 5). As the Prepalatial period is of primary interest to the current study, this evidence will be discussed in more detail below. This urban settlement was destroyed by fire in the 14th century BC (LH IIIA:2 Early). In the succeeding Palatial period, very few architectural remains have been found (Van de Moortel and Zahou forthcoming: 10). We know that the settlement was not abandoned and remained in contact with other areas of the

Mycenaean world. This is evidenced by ceramic drain tiles thought to belong to a large building at this time as well as by significant pottery deposits dating to this period, which include imported pottery (Van de Moortel and Zahou forthcoming: 11). In addition, we know that Road 1 was maintained throughout the Palatial period, as it was repaved many times.

In the Post-Palatial period, Mitrou was rebuilt as an urban settlement. A new Building B was constructed over the foundations of the Prepalatial Building D, a practice which seems to be repeated throughout the settlement as old foundations were reused in this period. The function of Building B is unknown. Van de Moortel and Zahou suggest that the layout of the Prepalatial settlement was revived in the Post-Palatial period (Van de Moortel and Zahou forthcoming: 11).

Just before the end of the LH IIIC period, Mitrou reverted back to a rural settlement. In the Early Protogeometric phase, a large apsidal structure, Building A was built partly inside the ruins of Building B (Van de Moortel and Zahou forthcoming: 12). Two construction phases have been identified and use of the structure ceased early in the Late Protogeometric phase. Significant pottery deposits were found inside Building A, many related to drinking practices. Van de Moortel and Zahou suggest that Building A may have been the dwelling of some sort of leader due to its size and the pottery content, although it is conceivable as well that the settlement was more egalitarian (Van de Moortel and Zahou forthcoming: 12). Sometime later in the Late Protogeometric phase, Building E was constructed partially over the ruins of Building A, and the apsidal area of Building A was converted into an earthen courtyard. To the south, Building I was

Table 1.1: Cultural periods distinguished at Mitrou and their associated pottery phases and absolute dates

Cultural Periods	***Pottery Phases***	***Absolute Dates***
Corridor House	EH IIB	2400-2200/2150 BC
EH III-MH III Village	EH III-MH III	2200/2150-1700/1600 BC
Prepalatial	LH I-LH IIIA:2 Early	1700/1600 - 1390/1370 BC
Palatial	LH IIIA:2 Middle to LH IIIB:2	1350/1335-1190 BC
Post-Palatial	LH IIIC	1190-1050 BC
LH IIIC/PG	LH IIIC/PG	1190-900 BC
Early Iron Age	EPG-MPG	1050-1000 BC
	LPG	1000-900 BC

constructed, with thin walls. Finally in the 10th century BC, the settlement of Mitrou was abandoned completely, the cause for which has not been determined.

Evidence for Murex dye production at Mitrou

Murex dye production has been suggested at Mitrou on the basis of both direct *in situ* evidence of *Murex* dumps and manufacturing installations and indirect evidence of scattered refuse of shell fragments found as secondary deposits throughout the excavated areas (Veropoulidou 2007; Van de Moortel 2007; Van de Moortel and Zahou forthcoming). Direct evidence was found in the northwest excavation sector inside a Prepalatial elite complex designated Building H--specifically in Trench LE792—as well

as in the northeast excavation sector in LPG levels associated with Building E's courtyard (trench LN783). In trench LE792, two small *Murex* dumps were found in successive strata in an earthen courtyard of Building H. These dumps were identified by the project's shell specialist, R. Veropoulidou and are currently being studied by her. For this reason, they are inaccessible to me and will not be included in the present study. Each dump contained a few kilograms of crushed *Murex* shells (Van de Moortel and Zahou forthcoming: 8). The earliest of these two *Murex* dumps, excavated mostly with Stratigraphic Unit (SU) LE792-018, is dated by its associated pottery to the Late Helladic I-Late Helladic II A phases. This SU also contained fist sized cobbles, larger boulders, large pottery fragments, and animal jaw bones (Van de Moortel 2007: 19). The fist sized cobbles could have been used as pounders, while the larger boulders could have served as crushing platforms. The pottery contains the profile of a cooking pot and a krater, or mixing bowl. This dump extended as high as SU LE792-015, where more *Murex* was found with worked stone, animal jaw bones, and a spindle whorl (Van de Moortel 2007: 19). A second midden was found 0.30 meters to the east in a Late Helladic IIB levels. Excavated with SU LE792-011, this small heap measured 0.10 x 0.14 meters in area and was 0.09 meters thick (Van de Moortel 2007: 20). In close proximity to this overlying midden and possibly related to it was a layer containing *Murex* shell and a considerable amount of ash, excavated with SU LE792-014. This SU also contained two worked bones and an Aeginetan cooking pot (Van de Moortel 2007: 19).

Murex dye production has also been identified by R. Veropoulidou in a LPG level in the courtyard of Building E, located on top of the ruined apse of Building A (trench

LN783). A possible crushing platform was found abutting the wall of Building E. Three hearths were found to the north of this platform, including two placed directly on top of one other, which may have been used for the simmering of *Murex,* an essential step in purple dye manufacture. Two saddle querns also may have been used for crushing *Murex* shells. A large pithos was buried in the courtyard for storage of some kind.

Indirect evidence for *Murex* dye production was identified by Veropoulidou in an unpublished pilot study in 2007, which focused on contexts deemed significant by their pottery contents. In those contexts she found hundreds of crushed *Murex trunculus* and *Murex brandaris* shells that belong to a minimum of 746 *Murex* individuals. She did not find *in situ* activity, but rather shell reused in the sub-bases and finished surfaces of floors and in mixed refuse dumps. Veropoulidou identified a possible dump of consumption and dye production refuse in a deposit of Building H in trench LG789, dating to the Prepalatial period (1700/1600- 1390/1370 BC) (Veropoulidou 2007:11). In this same deposit, she found pottery thought to be associated with dye production in the form of three cooking pots and three kraters (Veropoulidou 2007:11-12). In the Post Palatial period, a LH IIIC Middle surface to the northwest of Building D was identified by Veropoulidou as having a large quantity of fragmented *Murex* shells. Veropoulidou suggests that the area was used for various household activities or for the disposal of waste from household activities.

Based on these deposits, Veropoulidou concluded that purple dye production began in the late Middle Helladic period and that *Murex* was used intensively for dye manufacture starting in Late Helladic I (Veropoulidou 2007: 8). Her pilot study targeted

81 SUs excavated in 2004-2006 in the areas of Buildings A, B, C, D, E, and F. However, her analysis was conducted before a proper comprehensive stratigraphic study had been carried out. More comprehensive study is needed now that such stratigraphic analyses have been done and more areas have been excavated in 2007-2008, including in particular three trenches that were excavated in areas far removed from the two elite complexes. The aim of my study is to test Veropoulidou's conclusions and estimate the scale of production in the different periods by conducting a diachronic and spatial distribution study of shells. I will study shell from SUs with mixed pottery content, including surfaces without pottery deposits, fills of pits, and mixed fills found between those surfaces. A discussion of the sample chosen and the underlying rationale will be provided in Chapter 3.

Evidence for a Prepalatial elite at Mitrou

The location of LH I-IIA and LH IIB dumps found in Building H arguably links them to the rise of a visible political elite at Mitrou. According to Van de Moortel and Zahou (forthcoming: 4-5), there is a clear indication of a rising elite at Mitrou beginning as early as the LH I phase. They cite three indications of this elite: 1) the construction of two large complexes, Buildings D and H; 2) a change in settlement structure and burial practices from the Middle Helladic period to the early Late Helladic period; and 3) the construction of two graves with monumental qualities (Van de Moortel and Zahou forthcoming: 4-5). All three changes occurred simultaneously in the LH I pottery phase. Unlike other sites in mainland Greece, such as Mycenae and Tiryns, where the

emergence of the elite is indicated primarily by the appearance of more elaborate graves, such as shaft graves, and the increase of luxury items in burials, at Mitrou, we have evidence for the first time from a well-preserved settlement for the rise of an elite, and we see it emerging though significant changes in this settlement.

The first indication is the construction of two large complexes, Buildings D and H, thought to belong to the elite (Figures 1.3 and 1.4, respectively). Both were constructed during the LH I phase (Van de Moortel and Zahou forthcoming: 7). One reason for their identification as elite complexes is their sheer size. Magnetometry mapping carried out in Mitrou in 2005 shows Building H extending for roughly 750 square meters; excavations in this area have confirmed that the complex is at least 600 square meters. Even though part of Building D is not apparent in the electrical resistance survey carried out in 2003, subsequent excavation has confirmed that it is at least 230 square meters in area. Buildings D and H are substantial complexes that exceed the size of any other structure at Mitrou visible in the geophysical surveys; what is more, Building H is much larger than any other complex of LH I-IIA date discovered on the Greek mainland thus far.

The two complexes seem to have served different functions within the settlement. Some walls of Building D are substantially built. Already in its first architectural phase, dated to LH I, wall 104 of Building D is 0.75 meters in width and built with very large, roughly cut rectangular stones. In its second and third architectural phases, dated to LH I and LH IIB, respectively, the northwest part of Building D is taken up by a monumental

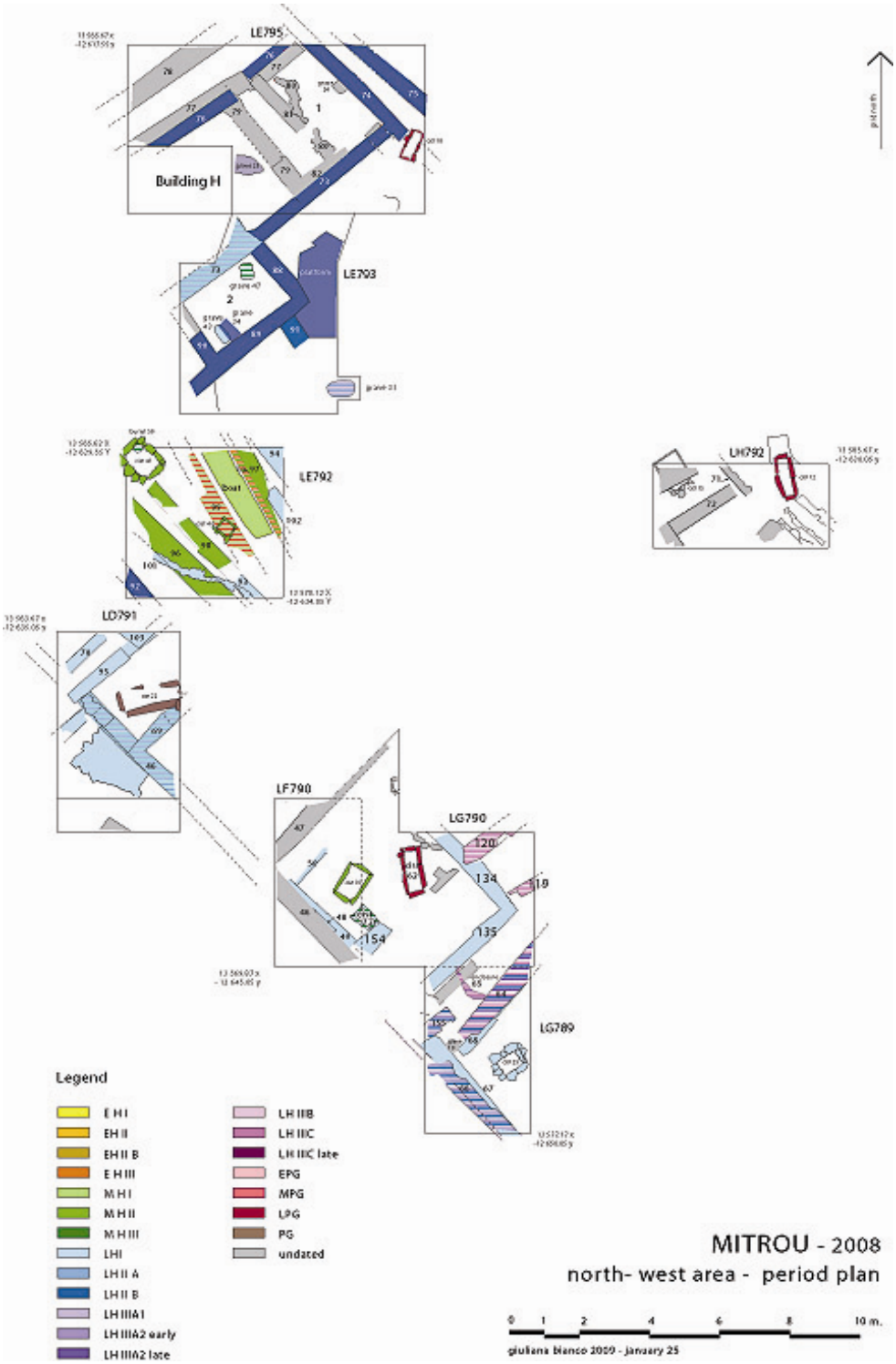


Figure 1.3: Building H in the northwest excavation area, 2008. G. Bianco, Mitrou Archaeological Project

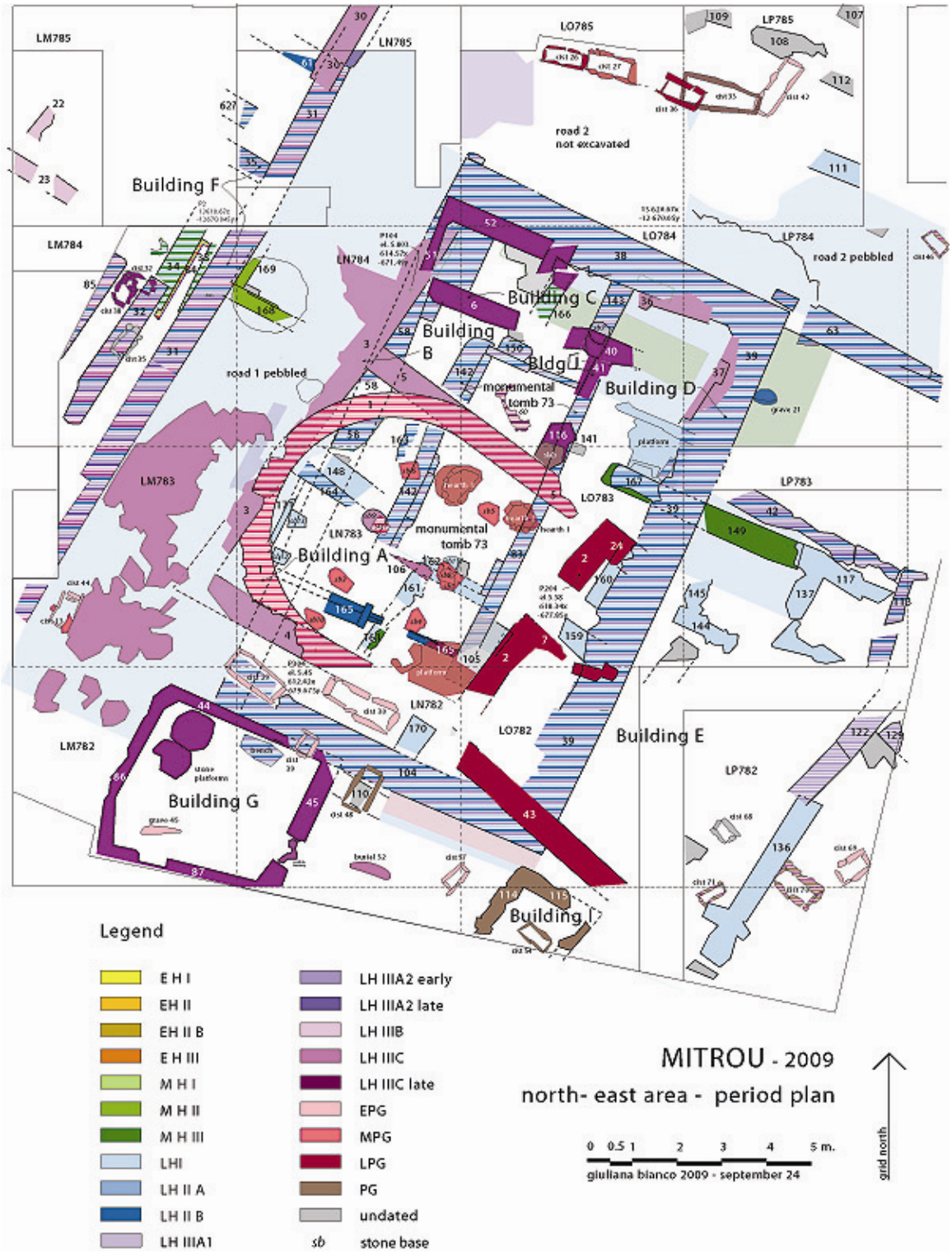


Figure 1.4: Building D in the northeast excavation area, 2009. G. Bianco, Mitrou Archaeological Project

tomb and a rectangular funerary enclosure (13.5 x 8.25 m). The enclosure's walls are widened to 1-1.2 meters in the LH IIB phase. These walls likewise have been built with the largest stones of any structure at Mitrou. Moreover, the LH IIB walls of the funerary enclosure are the thickest walls found in existence in all of mainland Greece during the Prepalatial period; their monumentality seems to represent the purposeful and outward display of a central authority (Van de Moortel and Zahou forthcoming: 7). Earthen and lime plaster floors were found in Building D, but very little of the complex outside the funerary enclosure has been excavated and few artifacts have been found within. Thus the function of this elite complex is still unknown.

Building H is different from Building D in its architecture and the activities thought to have been carried out within, but it, too, reflects elite behavior. This complex was partially excavated in 8 trenches, most of which were spaced some distance apart. The walls of Building H were not built on a monumental scale like those of Building D; they are more in line with walls of an ordinary domestic structure (Van de Moortel and Zahou forthcoming: 7). The rooms reflect a range of activities: chipped stone tool production, processing and storing of food and drink, pottery mending, and high quality dining. An earthen interior courtyard contained evidence for the butchering and processing of animals, as well as the two small *Murex* heaps. The fact that none of these activities are repeated throughout the eight trenches suggests that they all belong to one complex rather than to individual smaller structures occupied by different households. This configuration is not unlike the elite complexes found on Crete, such as Quartier Mu at Malia (Poursat 1992). The fine dining pottery in Building H included Southern Aegean

pottery imports, some of which are pottery associated with elite drinking and dining (Van de Moortel and Zahou forthcoming: 8). In addition, a cheek piece of a horse bridle made of deer antler was found in Building H. Such bridle equipment, found exclusively in elite contexts, originated from the Balkans and is extremely rare in mainland Greece. These imports reflect Mitrou's involvement in an elite exchange network (David 2007; Van de Moortel and Zahou forthcoming)

The second indication of the rise of a visible political elite at Mitrou in the LH I phase is a major reorganization of the settlement layout and mortuary practices, particularly the building of wide orthogonal roads and the possible abandonment of the habitation area north of Building D and its conversion to a cemetery (Van de Moortel and Zahou forthcoming: 4-5). These substantial changes suggest more intensive societal organization than existed in the preceding EH III-MH Village period and thus point to a stronger central authority. Stretches of four separate roads have been excavated running either NNE-SSW or WNW-ESE; they correspond to linear alignments seen in the geophysical map running throughout the site (Van de Moortel and Zahou forthcoming: 5). Three of the four excavated roads border Buildings H and D. Roads 1 and 2, which border Building D to the west and north, respectively, are 3 meters wide and have been carefully laid with pebbles. These roads are very straight. Road 1 has evidence for 13 repavings, ranging in date from LH I to LH IIIC. Part of an MH building was excavated below Road 1, indicating that Road 1 had been built with no discretion for MH structures below it. Van de Moortel and Zahou argue that this reflects a central authority that had the power to disregard pervious property boundaries (Van de Moortel and Zahou

forthcoming 5). Moreover, all excavated MH road surfaces and open areas have been found littered with trash, whereas the LH roads were kept very clean, indicating again the ascent of a stronger authority in the LH I phase.

Another important aspect of the reorganization of Mitrou in the LH I phase was the abandonment of the northeast area of the site and its conversion to a cemetery. The northeast area referred to here is the area east of Road 1 and north of Road 2 and Building D. This abandonment and conversion can be seen in trench LX784 excavated on the extreme eastern sea scarp of the island, as well as in trench LR797 excavated in the northeastern corner of the island. Throughout the MH period trench LX784, comprising an area of about 6 x 5 meters, was a habitation area alternating with funerary use. This alternation continued into LH I, but some time during this pottery phase, structures of any sort ceased to be built here and the area became exclusively used for burials. Two LH I cist graves and one possible pithos burial were found here (Van de Moortel and Zahou forthcoming 6). Likewise in trench LR797, a grave plot of cist tombs, dating roughly to the LH I phase, was set over earlier walls and never covered by later structures (Figure 1.5). Excavation of the area revealed a total of seven cist graves, the smaller ones configured around one larger grave. One of the smaller graves, cist grave 50, was dated to LH I because it contained a biochrome amphoriskos. The other 6 graves are believed to be contemporary because pottery fragments from the settlement below the cist graves suggest a *terminus post quem* of MH III/LHI and because they are closely associated in terms of spatial organization and orientation.

There are several indications that not only trenches LX784 and LR797 but the entire northeast area of the islet north of Road 2 and east of Road 1, was abandoned by the settlement in the LH I phase and turned into a large grave plot. An electrical resistance tomography survey that extended 25 meters west and north and 15 meters south of Trench LX784 detected no architectural features in the first 75 centimeter level below the modern surface, which presumably is LH I in date because of its proximity to the LH I levels in trench LX784 (Van de Moortel and Zahou forthcoming: 6). In contrast, excavations west of Road 1 in trenches LN786 and LN787 revealed LH IIIA structures at a depth of only 15-20 centimeters below the modern ground surface. Lastly, the intensive surface survey carried out as part of the Mitrou Archaeological Project revealed

Figure 1.5: Grave plot in Trench LR797, 2008. K. Xenikakis, Mitrou Archaeological Project

unusually little LH pottery in the area east of Road 1 and north of Road 2. The majority of pottery found in this area dates to the EH and MH periods, which is in sharp contrast to what is found in the other areas surveyed where LH pottery is always most abundant. All these findings are indicative of the abandonment of the area east of Road 1 and north of Road 2. The creation of permanent burial plots marks a considerable change from the burial practices of previous cultural periods, where people were interred within the settlement, between existing buildings and in the ruins of older buildings. Adding to this, no cist burials of non-elite individuals are found in the settlement again from this advanced stage of LH I until the end of LH IIIC. This change to permanent plots suggests that in LH I for the first time a distinction is created between areas meant for the living and areas meant for the dead. Van de Moortel and Zahou argue that this again reflects a stronger central authority that can establish and enforce a different layout within the settlement (Van de Moortel and Zahou forthcoming: 7).

The third indication of an elite emerging at Mitrou in the LH I pottery phase is the construction of two tombs with monumental characteristics. One was excavated in the grave plot of trench LR797 at the northeast corner of the islet, and the other was discovered inside Building D itself (Van de Moortel and Zahou forthcoming: 9). In LR797, an unusually large cist grave (Grave 51) was found, measuring 1.8 by 1.5 meters with a depth of 0.90 meters (Figure 1.5). It had been robbed in later times and very little remains were found within, including very little human bone. However, because of its proximity to the other graves, it is thought to date roughly to the LH I pottery phase. Interestingly, Road 1 leads directly from the west side of Building D and ends at this

mortuary plot, located near the highest point of the islet, also the area most visible from the sea. The second monumental tomb is a Built Chamber Tomb (tomb 73) constructed in the northwest part of Building D and surrounded by the monumental funerary enclosure mentioned above (Figure 1.6). This tomb was significantly larger than cist grave 51, its chamber during its first architectural phase (LH I) measuring 5 by 2 meters in area and 1.2 meters in depth. It was also much more impressive in terms of its architecture. The interior of the tomb chamber was lined with mudbrick walls, which were covered in turn by sandstone orthostates that had been cut to a 1.2 x 1 x 0.15 m size and had been finely finished. The interior of the tomb was reached via a 2 meter wide corridor (*dromos*) extending at right angles from the southern part of the chamber to Road 1. Tomb 73 was enclosed by the large rectangular funerary enclosure, 13.5 x 8.25 meters in area, with walls 75 cm thick built with large roughly hewn rectangular stones. This enclosure had been separated from the rest of Building D by the deliberate cutting of adjacent walls and the laying of a thick layer of white plaster on the enclosure's exterior facades (Van de Moortel and Zahou forthcoming: 10). In LH IIB, the walls of the funerary enclosure were widened to 1.2 meters. Finds from the tomb include gold jewelry, a piece of gold foil, a bronze ring, a rock crystal lentoid disc, and pieces of boar's tusk helmets which signify that elite individuals had been buried within.

Figure 1.6: Aerial photograph of Tomb 73 and its funerary enclosure in 2008. K. Xenikakis, Mitrou Archaeological Project

Outline of the present study

This discussion has demonstrated that not only is there good evidence for purple dye production at Mitrou, but clear indications of the rise of a visible elite within the settlement, which underlies the hypotheses that will be tested in this study. This study will begin with a review of the scholarly literature on purple dye production in the Aegean, focusing on three geographic areas: the southern Aegean, north and central Greece, and the eastern Aegean. The next chapter will describe the methodology utilized in this study, including the biological aspects of the purple producing mollusks and the dye manufacturing process as understood by ancient authors and modern science. A statistical analysis of the data will follow in Chapter 4, the goal of which is to discern

significant differences in the chronological and spatial distribution of *Murex*. This will be followed by a discussion of the results and recommendations for future research in Chapter 5 and a conclusion in Chapter 6. As Pliny the Elder beseeched his readers in *Naturalis Historia*, let this frantic passion for purple be excused in this study as we delve deeply into the beloved color of the ancients.

Chapter 2
Literature Review

A Royal Color is Born: An Aegean Beginning to the Purple Dye Industry

For much of the twentieth century, scholars attributed the origin of the purple dye industry to the Phoenicians, citing Roman authors, especially Pliny the Elder, as primary sources. Excavations at dye centers at Tyre, Sidon, and Sarepta in Lebanon as well as more minor operations at Tel Dor and Tel Keisan provided archaeological evidence in support of Pliny's account (Bikai 1990; Karmon and Spanier 1987; Pritchard 1978; Stewart 2003; Stern and Sharon 1987). Even though evidence for *Murex* dye production in the Aegean began to emerge in the form of shell heaps at sites such as Palaikastro and Kouphonisi on Crete in the early twentieth century, it was not until the late 20th century that scholars began to reevaluate the origin of purple dye production. David Reese's seminal article in 1987 provided compelling evidence for an Aegean origin in the form of a multitude of sites in the region where *Murex* shell accumulations and in some cases, dye installations had been found. Later finds from sites such as Kommos on Crete, and Thessaloniki Toumba in Northern Greece supported Reese's conclusion and it is now generally believed that it was the Minoans or mainland Greeks who first engaged in the production of purple dye at least as early as the 18th century BC (Table 2.1)

Very recently, evidence for *Murex* dye manufacture has also been excavated at Mitrou. It is this evidence that is the focus of the present study. It is important first to review the archaeological literature concerning *Murex* dye production in the prehistoric

Table 2.1: Prehistoric purple dye sites in the Aegean, arranged in chronological order: NISP=number of individual *Murex* specimens (fragments and whole shells) and MNI =estimated minimum number of *Murex* individuals represented

Site	***Location***	***Relative Date***	***Absolute Date****	***NISP***	***MNI***
Kommos	Southern Aegean (Crete)	MM IB/IIB Early MM IIB	2000/1950-1790/1750 BC 1790/1750 – 1750/1700 BC	17,717	
Thessaloniki Toumba	North and Central Greece	MBA- LBA	2000-1700/1600 BC-- 1700/1600-1180 BC	29,482	7,722
Ayios Mamas	North and Central Greece	MBA	2000-1700/1600 BC	104	23?
Kouphonisi	Southern Aegean (Crete)	MM LM II B	2000-1675/1600 BC 1600/1500-1500/1450 BC		
Palaikastro	Southern Aegean (Crete)	MM II MM III/LM IA	1900/1850-1750/1700 BC 1750-1675/1550 BC	81+	53+
Eleusis	North and Central Greece	MH II late- LH II	1800-1405 BC	2,230	
Pefka Workshop	Southern Aegean (Crete)	MM IIB	1790/1750-1750/1700 BC		
Troy	East Aegean	MBA-LBA	1750-1180 BC		
Kythera	Southern Aegean	MM III	1750/1700-1675/1600 BC		
Akrotiri	Southern Aegean	LM IA	1645-1525 BC	1,096	

* Variations in the absolute dates of the MM and LM I phases relate to the unresolved controversy regarding the absolute date of the Theran eruption; many dates have been proposed for this eruption ranging from the mid-17th to the late 16th century BC.

Aegean in order to better understand what the evidence is for purple dye production at other sites, how it was interpreted, and how Mitrou fits into the picture. This overview has been divided into three geographic areas: the Southern Aegean; East Aegean; and Northern and Central Greece. Table 2.1 gives a summary of the data for each site.

Southern Aegean

One of the earliest dye installations found to date is at Kommos, a Minoan harbor town on the Libyan Sea in south-central Crete. In excavations conducted by the University of Toronto between 1990 and 1997, Ruscillo located a *Murex* dye installation and several concentrations of *Murex* shells in the Southern Area of the site. This area contains a succession of large civic buildings, of which the earliest identified is MM IIB Building AA (Ruscillo 2006: 784). The earliest evidence for *Murex* dye production was found in the massive building fills of this structure, associated with more than 27,000 pottery fragments that overwhelmingly date to the MM IB, MM IIA, and MM IIB Early phases (ca. 2000/1950 to 1790/1750 BC) (Ruscillo 2006: 824; Van de Moortel 2006: 317-319). This represents our earliest secure date for purple dye manufacture in the Aegean (Table 2.1). Concentrations of shell were also located among patchy sections of pebble pavement in the southeast corner and along the North Stoa of the Central Court of Building AA. Ruscillo argues that this *Murex* is in secondary context, as the shells were originally fragmented for dye production and secondarily used in the pavement. Another *Murex* concentration, this one burnt, was found to the east of Building AA. Ruscillo suggests that it, too, is secondary refuse from the paving of Building AA's Central Court

that must have been displaced during the construction of later structures, predominantly Buildings T and P, which overlay Building AA. Therefore, the consistent date of MM IB/IIA is suggested by Ruscillo which, in the light of Van de Moortel's dating of the construction of Building AA, should be revised to MM IB/IIB Early. Moreover, crushed *Murex* weighing 4.4 kilogram was found as part of a floor makeup in Room 38 of the Late Archaic Building Q, located over the north end of the Central Court of Building AA. These shells are very similar in their state of preservation to the earlier ones used in the paving of the Central Court. Their discovery has led David Reese to suggest that these shells originated from the MM IB/IIB Early dye production as well and were reused in the Late Archaic period, just as they were in the MM IIB phase for the paving of Building AA's Central Court (Reese 2000: 645). Ruscillo analyzed the *Murex* assemblage, which consisted of 684 whole shells, 2,033 large fragments, and over 15,000 tiny pea-sized fragments, weighing 12 kilograms in all.

Excavations at Kommos also produced the remains of a dye installation located in the area of Gallery P5 of the LM IIIA:2-B Building P, which is below the Central Court of Building AA. The installation consisted of a flat stone slab floor and a 12 centimeter wide channel, both which were found filled with crushed *Murex* (Ruscillo 2006:808). Ruscillo suggests that the slab was used for crushing the shells for gland extraction (see Chapter 3), as the stone would have been easy to clean off each time after a *Murex* batch had been processed. Its stratigraphic position is ambiguous, and it is not clear whether the installation was put in place prior to the construction of Building AA or in an early phase of this building (Ruscillo 2006: 808). At any rate, the pottery evidence indicates that it

was still in use during the lifetime of Building AA, as late as the MM IIB Late phase (Ruscillo 2006: 824). Thus it is safe to conclude that purple-dye manufacture at Kommos was controlled by the ruling elite. Even if the construction of the installation predated Building AA, it would have been located not far from Building AA's predecessor, and thus it is still likely to have been elite-controlled (Shaw 2006: 11, 846-847; Van de Moortel 2006: 321-323).

Another Middle Bronze Age purple dye operation has been discovered on the island of Kouphonisi, located off the southeastern coast of Crete in the Libyan Sea. This island is situated about 130 kilometers southeast of Kommos. The ancient Greek name of this island was Leuke, the "White Island" and one of its present names is Chryssi, the "Golden Island". According to Guarducci, an Italian epigrapher, a Cretan inscription from the 2nd century BC explicitly states that the island of Leuke was a center of Tyrian purple dye manufacture (Guarducci 1940 in Stieglitz 1994:51).

This site was first documented by British archaeologist R.C. Bosanquet in 1903 (Bosanquet 1904: 321). He discovered a *Murex* midden "a foot deep and over 8 feet in diameter" on the northwest end of the island, on a hill overlooking the north shore (1940: 72). The presence, quantity, and fragmentary nature of the *Murex* shells led Bosanquet to interpret it as a site of purple dye manufacture, although this interpretation was met with considerable skepticism at the time (Stieglitz 1994: 49). Based on its association with Middle Minoan vase fragments and a steatite bowl fragment, Bosanquet dated the midden to the Middle Minoan period (Bosanquet 1904: 321; 1940:72). Surveying the same site in 1981, Robert Stieglitz, a Near Eastern and Mediterranean archaeologist, located the

Murex heap that Bosanquet first discovered (Stieglitz 1994:50). Stieglitz discovered more pottery fragments, obsidian chips, and the foundations of a large stone structure. Near the shore, he also found what he interpreted as a dye factory that consisted of stone and clay vats, a well, and basins and channels for handling liquids. It is likely that these structures were used for purple dye manufacture since as we learn from Pliny, many gallons of water, both salt and fresh, were needed to produce the dye (Stieglitz 1994: 51). However, Stieglitz dates the dye factory to the Hellenistic period, which means that the Middle Minoan *Murex* heap on the hill represents a different activity. Stieglitz dates the early *Murex* dye industry to 2000-1600 BC (Stieglitz 1994: 49).

In 2008, a small settlement was excavated on Kouphonisi by Vili Apostolakou, Philip Betancourt, and Thomas Brogan (2010: 150). According to their preliminary report, the settlement was located near large deposits of *Murex* shells. It is not clear in this report what the proximity of this settlement is to the purple manufacturing site that Bosanquet and Stieglitz located. The remains of 12-20 houses were present on the surface. The authors excavated four of these houses and determined that they were all built and abandoned in LM IB (1600/1500-1500/1450 BC). Although neither the size of the *Murex* deposits nor shell counts were reported, the authors argue that the site was used extensively for purple dye production in the Protopalatial and Neopalatial periods. Considering that the authors suggest a LM IB date for the settlement, which is near the end of the Neopalatial pottery phase, it is unclear what evidence supports a Protopalatial date for *Murex* dyeing. Their evidence makes it clear that a purple dye industry existed on the island in the LM IB phase as well.

Betancourt, Apostolakou, and Brogan also excavated a dye installation known as the Pefka workshop at Pacheia Ammos in East Crete. The installation consists of a row of basins and two man-made depressions, all of which were carved directly into the bedrock, as well as the scant remains of small buildings (Betancourt et al 2010:1-2). Seven of the rock-cut basins are rectangular in shape, a little over 1meter long by less than 1 meter wide (Betancourt et al 2010: 3). It is thought that these would have been the wool dyeing vats. All have a shallow trough at one end that would have allowed the wool to be pulled out of the dye, but the excess dye to drain back into the vat. The authors suggest that these held different colored dyes, one of which they believe was *Murex* purple. They do not quantify the amount of *Murex* found at the workshop, but simply state that *Murex* shells were crushed in large enough quantities to suggest dye production. Basins 1 and 2 are believed to have been used for the washing of the raw wool because of their large size and width. Basin 1 was circular in shape, with a diameter of 2 meters, while Basin 2 was a rectangular basin 4 meters long and located at the top of an 8.5 meter deep well/cistern. Basin 4 connects to Basin 2 and thus the well/cistern via a drainage channel. The authors suggest that it, too, was used for washing and the channel would have allowed excess water to drain back into the well/cistern to be reused. The two depressions in the bedrock are thought to be mortars for crushing *Murex*. In addition, artifacts associated with dyeing were found, such as pounders and large numbers of pottery fragments from pithoi, basins, and cooking pots (Betancourt et al 2010: 4). Chemical residue analysis will determine the original contents, but the authors suggest that they would have held dye ingredients and finished products (Betancourt et al 2010:

3). There are very few loom weights found and therefore, the finished product was likely not cloth, but wool dyed in various colors (Betancourt et al 2010: 4).

The site of Pefka is not associated with any town or village, but it is suggested that the dye operation was under palatial control because of the size and number of the rock cut receptacles. Furthermore, the permanent rock cut vats and structures, even though their exact function is not known, suggest continuous use. The authors suggest that it would have required a staff of at least fifteen people (Betancourt et al 2010:5). They conclude that the site was probably a remote workshop belonging to one of the Minoan palaces nearby, either Gournia, which is just a few km away to the west, or Malia, which is ca. 40 km away. The site is dated to MM IIB (1790/1750-1750/1700 BC) on account of its numerous MM IIB ceramics, especially carinated cups with horizontal grooves (Betancourt et al 2010:2).

Another site that has produced early evidence of *Murex* dye production is Palaikastro, on the east coast of Crete. The production site is located on the southern slope of the Kastri Hill, close to the sea (Stieglitz 1994: 50). It was also first discovered by Bosanquet (1904: 321; Reese 1987: 204). He noted two large deposits of fragmented *Murex* shells on the hill associated with pottery from the MM II phase, which in the early twentieth century he understood as dating to 1800-1625 BC, but is now dated to 1900/1850-1750/1700 BC. Stieglitz later confirmed the deposit that Bosanquet found and in addition, he discovered the remains of a large stone structure with numerous *Murex* fragments surrounding it (Stieglitz 1994: 50). He does not quantify the amount of shells in the *Murex* deposit. However, a photograph of the shells shows that they have been

crushed in the manner indicative of dye production (unnamed photo, Stieglitz 1994: 50). This structure is close to the sea and likely represents a dye installation.

Possible evidence for later purple dye manufacture at Palaikastro was identified by David Reese on the basis of a sample of *Murex trunculus* saved from Popham and Sackett's 1963 excavation at Rousolakkos located a few hundred meters south of the earlier dye production site. This sample included 64 stem fragments, 17 upper shell fragments, and body fragments from at least 53 individuals (Reese 1987:204). Reese dates the sample to no later than MM III/LM IA, in the early Neopalatial period, although it is not clear on what evidence he bases this interpretation. Neither Bosanquet, Reese, nor Stieglitz provide estimates of the scale of *Murex* dye production at Palaikastro.

In addition to the Cretan sites, the Minoan colony on the island of Kythera, located off the southern tip of the Peloponnese, provides evidence of purple dye industry. *Murex* shell deposits were found in the Minoan levels of the Kastri site at the base of the Palaikastro Mountain. *Murex* was also recovered from the "Neck" area between the Kastri fort and the Kastraki fort, an area thought to represent the outskirts of the Minoan town (Coldstream and Huxley 1972: 36-37). Most of the fragments were identified as *Murex brandaris* species, while a few belong to *Murex trunculus* and *Thais haemastoma*. Pottery sherds decorated with purple paint were found in association with the *Murex* in Middle Minoan III levels (1750/1700-1675/1600 BC) (Coldstream and Huxley 1972:37). Coldstream and Huxley suggest that the purple pigment on the pottery came from the local *Murex* dye industry on the island, although the identification of the purple pigment has never been confirmed by chemical analysis. Other than the crushed *Murex*, no

structures such as clay vats or channels have been found. In support of their interpretation of a local dye industry, the authors cite an interesting observation by Aristotle that Kythera was called Porphyroussa, which translates to "Purple Island" (Coldstream and Huxley 1972: 36). It is important to note that they do not quantify the amount of *Murex* shells, but the accumulation of *Murex* shells suggest to them that a purple dye industry existed on Kythera in the Neopalatial period and that the industry remained active until at least the time of Aristotle in the 4th century BC (Coldstream and Huxley 1972: 36-37).

Another Middle Bronze Age site with claimed evidence for dye production is Middle Helladic Asine located in the Argolid, although this evidence is not convincing. This site is included here with the Southern Aegean because even though it is located in the northeast Peloponnese, it was part of the exchange network of Crete. This will also be true for Aegina discussed below. Reese suggests possible evidence for dye production in the form of 224 worn *Murex trunculus* fragments, representing at least 42 individuals (1987: 204). They were found in a Middle Helladic III (1700-1575 BC) fill of Tomb B. Furthermore, in a cist tomb dating to the same period, 29 worn fragments from at least 12 individuals were found. As Veropoulidou et al. (2005) point out, many scholars find this claim questionable because the remains are so scarce and the context is unusual. The 224 fragments would correspond to production at an extremely small scale. Furthermore, worn fragments would seem to indicate that the individuals were collected dead, and since dye can only be produced from live *Murex*, production seems unlikely.

Further archaeological evidence for the existence of a Bronze Age purple dye industry in the Southern Aegean comes from Akrotiri on Thera, a small island about 100

kilometers north of Crete. In the 1969 excavation, a purple colored powder was discovered by archaeologists while digging a posthole for the installation of a modern roof covering the site (Aloupi et al. 1989: 488). This powder was found in an LM IA level. Because of the high bromine content, identified by XREF analysis, and its saturated purple color, this powder was confirmed as having derived from *Murex* sea snails. The authors argue that the substance is the dye in powder form. It may have been intended for cosmetic use or as a pigment in Theran wall paintings. The latter interpretation seems less likely, since no true *Murex* purple has been found on any Theran wall paintings. In addition to the purple powder, many fragmented *Murex* shells have been found scattered all over the excavated LM IA area at Akrotiri (Aloupi et al. 1989: 489: Becker 2001: 127). Some 1,220 *Murex* shells have been found, mostly fragmented, of which 1,196 belong to *M. Trunculus* (Karali-Yannacopoulou 1989: 41l). For this reason, it has been suggested that Akrotiri, too, was a site of purple dye production and that the purple powder had been locally produced (Karali-Yannacopoulou 1988 in Aloupi et al. 1989: 489). The authors give no indication of the proposed scale of dye operations at Akrotiri.

Another purple manufacturing site has been tentatively identified at the House of the Dyers on Aegina by Reese (1987) and Becker (2001), but the evidence is inadequate and the date is questionable. Reese (1987: 205) does not indicate the amount of shells found, but Becker reports that a few dozen “purple shells” were recovered (Becker 2001: 127). Neither author indicates whether the shells were crushed. Their dating of the evidence does not agree. Reese dates the sample of *M. trunculus* shells to 1650-1600 BC, which would be the MH III pottery phase. This date would seem to fit with the dates we

have for purple dye manufacture at Eleusis, a site located nearby on the Greek mainland. However, Becker reports that the *Murex* evidence belongs to the Early Bronze Age settlement of Kolonna and dates to 2400-2300 BC (Becker 2001:127). Since the evidence is scant, this site should be discounted as a purple dye site until further analysis of the remains is conducted.

In addition to archaeological evidence for the manufacture of purple dye in the form of crushed *Murex* shells or the physical infrastructure, the wearing of purple garments in the Southern Aegean is indicative of purple production. Stieglitz cites the Priestess fresco at Akrotiri, dating to the LM IA phase (mid 17th to late 16th century BC) which depicts a priestess with a red and purple striped dress (1994:25). This fresco dates to the mid-17th to mid 16th century BC, depending on the absolute date of the Theran eruption (Stieglitz 1994: 53). Stieglitz does not argue that it was painted with *Murex* purple, but instead depicts a *Murex* dyed garment. Another such example is provided by the Hagia Triada sarcophagus, which dates to the LM IIIA:2 Late phase, around 1450 BC. This sarcophagus depicts beautifully dressed male and female mourners, whose garments are decorated with various shades of purple stripes (Stieglitz 1994: 53). In both frescoes, it is possible that the artists were depicting people wearing garments that had been dyed with *Murex* dye.

Northern and Central Greece:

Archaeological evidence from Northern and Central Greece is not as prevalent as that from the southern Aegean, but it covers the same chronological range. Three sites are

discussed in the literature as possible dye production sites: Toumba at Thessaloniki, Ayios Mamas on the Chalkidiki peninsula, and Eleusis in Attica. Veropoulidou et al. (2005) analyzed *Murex* remains from Thessaloniki Toumba. In contrast to researchers' interpretations of dye sites in the Southern Aegean, Veropoulidou et al. do *not* claim that dye at Toumba was produced on a large scale. Rather, they argue for production on a smaller, domestic scale (Veropoulidou et al. 2005:14). Here as much as 65% of the shell remains, which equals 29,482 fragments representing a minimum of 7,722 individuals, belonged to the *Murex* species (Veropoulidou et al. 2005:8). Most of these were adult *Murex trunculus* gathered alive. They were highly fragmented as documented at other sites in the southern Aegean, with most of the breaks occurring above the last body whorl.

Murex has been found not only at the edge of the settlement at Toumba but also in habitation areas. Hundreds of *Murex* fragments were found in several rooms belonging to building complex A. This complex, for which no specific function was given in the report, is located on top of the mound and dates to the Late Bronze Age (Veropoulidou et al. 2005: 12). In one small room, hundreds of shells were found with no other architectural finds or artifacts. The authors suggest that this was a dump for the byproducts of dye production. Also, *Murex* was found in nearby rooms of the complex in association with domestic structures and artifacts: benches, hearths, and cupboards. Furthermore, specialized workspaces with *Murex* remains were found in the eastern wing of the complex. This is a very unusual find because this seems to represent a dye

production site within close quarters of residential buildings, which would mean that the notorious smell of production would have been ever-present.

In addition, several areas at the edge of the Toumba settlement have been identified as possible dye sites. In an open space at the edge of the mound, a concentration of small hearths and a kiln associated with cooking vessels and ceramic vats was interpreted as such by Veropoulidou et al. (2005:10). *Murex* was found in a density of 475 fragments per 1 m^3. There was also evidence for burning. This area dates to the Middle Bronze Age. An open space in the same area, but dating later (1700 BC) is thought also to be related to dye production. It dates to 1700 BC and represents a relatively short depositional phase in which 1,246 specimens were deposited (Veropoulidou et al. 2005: 11). In this area, three pits with plaster lining, a ditch for the removal of overflow water, a kiln, ceramic vats, pounders, and weaving supplies were found. Interestingly in light of what we have discovered at Mitrou, *Murex* quantities at Toumba decline in the 13th and 12th centuries BC and increase again at the beginning of the 1st millennium BC. Veropoulidou et al. suggest that this may be due to sampling bias, since the top of the mound has not been as thoroughly excavated, or it could be that purple dye production was moved elsewhere, away from habitation zones (Veropoulidou et al. 2005:12).

Veropoulidou et al. argue that purple dye production at Toumba was small in scale and meant to meet the needs of the household and community (Veropoulidou et al. 2005:14). This is remarkable because the roughly 29,500 fragments at Toumba well exceed the 17,000+ fragments found at Kommos, where purple dye manufacture was

found in spatial association with elite Building AA and was obviously controlled by the ruling elite. Furthermore, only two-thirds of the shell that was collected at Toumba has been analyzed; therefore, the count may actually be higher once the analysis is complete (Veropoulidou et al. 2005:7). Clearly, in view of the evidence from Kommos, the interpretation that purple-dye production at Toumba was conducted on a domestic scale must be viewed with caution.

Additional evidence for purple dye manufacture comes from the site of Ayios Mamas, which is located on the coast of the Chalkidiki Peninsula less than 60 kilometers southeast of Thessaloniki Toumba. Ayios Mamas is a tell situated 3 kilometers away from the shore and is roughly contemporary with Toumba (Becker 2001:124; Veropoulidou et al. 2005: 14). Excavations by the Free University of Berlin were conducted between 1994-1996 and focused on the Middle Bronze Age layers (2000-1700 BC) (Becker 2001:123). In all, 104 mollusk fragments from the *Murex trunculus* and *brandaris*, and *Thais haemastoma* were recovered from these levels, representing 19% of the total marine mollusks collected from the site. They were recorded by anatomical parts: 7 whole shells, 24 apical fragments, 35 body fragments, 18 distal end fragments, and 23 columnella fragments. Three-fourths of this quantity is *Murex trunculus*. As many as 72% of the marine mollusk remains found in MBA contexts are preserved largely intact, which indicates that they were boiled and eaten. This seems to be the common method of eating sea food in Ayios Mamas and other places in the Aegean. The *Murex* shells at this site are the only shells that are fragmented. In spite of the small amounts recovered, the highly fragmentary nature of the shells and the proximity of the site to the

shore, suggest to Becker that a small scale domestic dye industry existed at Ayios Mamas (Becker 2001:129). No architectural dye installations have been found. However, if dye was being produced on a small scale, permanent dye installations would not be mandatory.

Cosmopoulos et al. have suggested in a 2003 preliminary report that purple dye was also being produced at the site of Eleusis, located in western Attica. Like many other dye sites, thousands of *Murex trunculus* fragments were found along with 81 fragments and 2 intact shells of *Murex brandaris* (Cosmopoulos et al. 2003: 150). These remains were excavated on the southwest slope of the hill at the site. The authors note that this hill is away from the Classical cult area, although they do not state the exact distance; therefore, the authors do not think that the *Murex* is related to cult activity (Cosmopoulos et al. 2003: 145). *Murex* shells appear in significant numbers in the late MH II (1800-1700 BC) contexts, increase in LH I-II (1675/50 – 1435/1405 BC), and then disappear completely in LH III (Cosmopoulos et al. 2003:151). The researchers also note a proportionate increase in crushed *Cerithium muscarum* shells in the same contexts as the *Murex*. They suggest that these shells may have been used in purple dye production, even though they admit that the role of the species in the dye process is unknown. Even though I agree that a positive trend exists, it seems unlikely to me that *Cerithium* was used in dye production. The quantity is small--15 fragments in late MH, 24 fragments in LH I, and 45 in LH I-II--and it is possibly negligible in relation to the quantity of *M. trunculus* shells. Furthermore, as *Cerithium muscarum* is often the prey of *Murex* and has been used as bait to catch *Murex*, they could have been collected accidentally. Lacking from this report

is any indication of exactly how these shells are fragmented. This was published as a preliminary report and hopefully more information will be made available in the future.

East Aegean:

It has often been mentioned that Troy engaged in purple dye production (Reese 1987: 205; Stieglitz 1994: 53; Becker 2001: 128). Carl Blegen, who excavated the site in the early twentieth century, located multiple layers of crushed *Murex* in an open space at Troy VI (Blegen 1937: 582). This open space was a passage between the citadel wall of the Sixth City and the large houses E, F, and G on the citadel and was believed to be a dump for dye production refuse. Six pits were found nearby behind the Sixth City wall that might be related to purple dye manufacture. Pounders, stone grinders, and worn millstones likely used for crushing the *Murex* were found in the same area as the dump. *Murex* shell numbered in the thousands, although no exact count was reported. Blegen argues that the *Murex* layers were all deposited within a short period of time, probably in LB II or LB III (Blegen 1937: 583). The fact that these remains were located on the citadel indicates elite control over purple dye manufacture at Troy.

In a recent abstract by Ralf Becks and Canan Çakirlar in a 2010 conference in Copenhagen entitled "KOSMOS: Jewelry, Adornment, and Textiles in the Aegean Bronze Age," the authors reevaluate the evidence for *Murex* dye production at Troy. They suggest that production began in Troy VI during the Middle Bronze Age, around 1750 BC and lasted through Troy VII until the end of the Late Bronze Age, around 1180

BC. They argue for a major industry at Troy that was inextricably linked to the booming textile industry during the corresponding time periods.

Conclusion

This review, in my opinion, underscores how nascent the scholarly literature still is on the subject of purple production in the Aegean, as many reports are lacking in evidence or provide incomplete quantification. However, it helps us understand the chronological distribution of possible dye sites. The earliest sites that have the most compelling evidence are Kommos and Thessaloniki Toumba from the early part of the Middle Bronze Age. The earliest evidence at Kommos dates to the early 18th century BC, and may even go back as early as the 20th century BC. Both Kommos and Thessaloniki Toumba have considerable amounts of *Murex* shells and possible dye installations, and these sites seem to be on par with one another in terms of scale. Kouphonisi and Palaikastro are roughly contemporary with Kommos and Toumba, but scale cannot be determined since shell amounts have not been quantified. Ayios Mamas too is roughly contemporary, but there seems to be too little evidence in support of production at this time. Purple dye production at Eleusis begins not earlier than the 18th century BC, while the Pefka workshop is in use in the 18th century as well. Purple dye production at Kythera and Troy both begin in the mid 18th century, although the industry in Troy extends nearly to the end of the Bronze Age in 1180 BC. The latest site with evidence for purple dye production is Akrotiri, which is also the most remote geographically.

In light of the archaeological evidence, general observations can be made about purple dye production in the Aegean. The wide spatial distribution of sites throughout the Aegean and the absence of contacts between several sites suggests the existence of at least two separate and independent dye traditions: a Minoan tradition and a Northern/Central Greek tradition. There seems to be a parallel development of purple dye production at Kommos and Toumba. The knowledge of dye production expands in different directions from these sites. The northern tradition starting with Toumba expands south and east with Ayios Mamas, Eleusis, and Troy. The Minoan tradition spreads northeastward generally with Kouphonisi Palaikastro, and Pefka. As the Minoans expanded their trade networks, possible dye sites at Kythera and Akrotiri appeared at slightly later dates.

In conclusion, this overview has shown that although the Romans and even modern scholars until recently, credited the Phoenicians with discovering how to manufacture purple dye from *Murex* mollusks, archaeological evidence from sites such as Kommos, Kouphonisi, Pefka, and Toumba has shown that it was a Middle Bronze Age Aegean invention, beginning in the early 18th century BC, if not earlier. The evidence for *Murex* dye manufacture found at Mitrou fits into this chronological framework. In the following chapters, the evidence from Mitrou will be analyzed in order to investigate the scale of purple dye production as well as its relationship to the rise of a visible ruling elite.

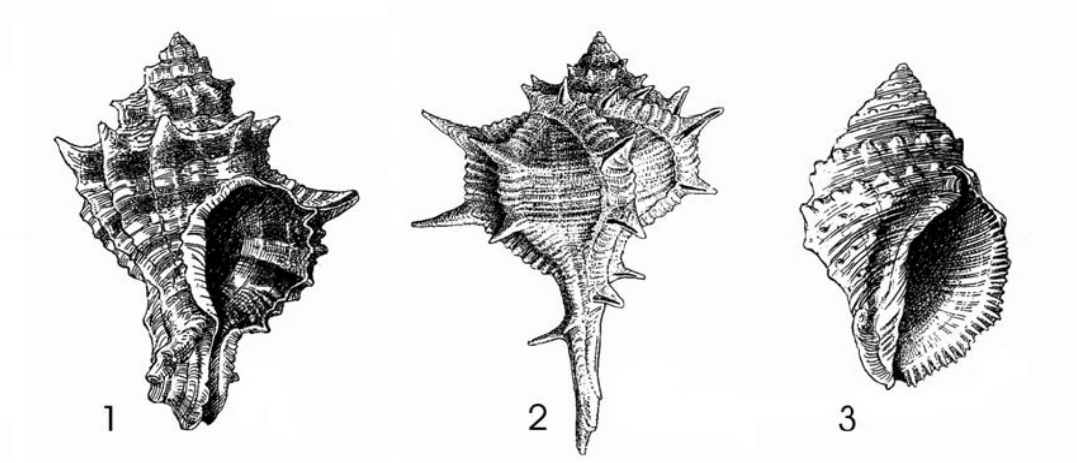
Chapter 3
Methodology

In an attempt to gain a more thorough understanding of purple dye production at Mitrou, a sample of the *Murex* assemblage was analyzed during the 2010 study season. The expectation was that with these data, it would be possible to detect meaningful patterns in the chronological and spatial distribution of *Murex*. In the present chapter I will develop criteria for identifying archaeological *Murex* remains used in purple-dye production as opposed to *Murex* employed for other uses, and I will establish a methodology for quantifying the minimum number of individuals (MNI) from *Murex* fragments. The sampling strategy employed in this study will also be presented here. Statistical analyses will be discussed in chapter 4.

In order to identify *Murex* used for the extraction of purple dye, one must understand the biological properties and seasonal behaviors of these marine mollusks. This discussion will include a description of the process of purple dye manufacture as it was understood by later Greek and Roman authors and as it is known by contemporary chemists and dye specialists. Previous scholars already established a number of criteria for identifying purple dye production. Through ethnographic research in the Mitrou area in 2010, I am now able to propose additional criteria that make this identification more secure. These aspects, of the creatures themselves and of the process of producing dye, underlie the methodological approach utilized in this study.

Current scientific understanding of purple-producing shellfish

The three mollusk species most often employed for purple dye production belong to the *Muricidae* and *Thaisidae* families (Figure 3.1). In the Mediterranean, the two most commonly used species in the past were *Murex trunculus* and *Murex brandaris* (Reese 1987: 203; Ziderman 1990: 99). A third species known as *Thais haemastoma*, sometimes also referred to as *Purpura haemastoma,* was used to produce dye as well, however, never without one of the *Murex* species (Ziderman 1990: 99). Each species occupies slightly different maritime zones, although there is some overlap. *Murex trunculus* lives in shallow waters at depths anywhere between 1.5 and 12 meters and prefers hard, rocky ground, while *Murex brandaris* lives at considerably greater depths of 10 to 150 meters and is found in sandier, muddier habitats. *Thais haemastoma* lives on rocks in waters less than 1.5 meters deep. Based on habitation alone, one would expect to find more *Murex*



Σχ. 1. 1. Murex trunculus, 2. Murex brandaris, 3. Thais haemostoma.

Figure 3.1: Three purple-producing *Murex* and *Thais* species (Besnier: 770, Figure 5887)

trunculus because this species can be collected closer to the shore and therefore, would be less labor intensive to collect. The choice of *Murex* species may also have depended on a preference for the different hue of purple they produce. *Murex trunculus* produces a more bluish hue whereas *Murex brandaris* yields a reddish purple.

Karmon and Spanier point out that *Murex* accumulate in shallow waters to begin the cycle of reproduction in early spring, although they do not specify which species of *Murex* (Karmon and Spanier 1987). This would have been the optimal season for catching and harvesting the animals for dye production. According to Bruin, the amount of dye precursors in the hypobranchial gland is relatively greater before reproduction (Bruin 1970: 83). It is reportedly best to gather the female mollusks before they have laid their eggs, since it is thought that some of the dye precursors are passed on to the offspring during reproduction (Jensen 1963: 108).

The uses of the various *Murex* species are not limited to dye production alone. *Murex* is edible and can be consumed like other shellfish. When used this way, the shells are not likely to be crushed. They are often cooked whole, which allows the meat to be easily removed without breaking the shell (Ziderman 1990:100). In my conversations with a local Greek fisherman in the area of Mitrou, Mr. Thanasis Berdekas, I learned that this is still in practice today. He explained that he boils the *Murex* in the shell whole and the meat easily slips out. Becker argues that smashing *Murex* for eating would have been unnecessary and counterproductive (Becker 2001:124). Tiny shards of shell would have to be removed before consumption and could impale the meat. Mr. Berdekas also informed me that *Murex* are used intact as fish bait—a use that up to now has been

ignored in archaeological studies. Thus, one would expect that *Murex* that had been eaten or used as fish bait would be found in the archaeological record as intact shells, and could also be found in middens mixed with kitchen refuse or bone.

Other possible uses of *Murex* would be as ornaments, such as in jewelry, or as burial offerings, in which case the shells would probably be intact as well (Reese 1980:81). Moreover, *Murex* can be crushed further and utilized in the makeup of floors, as pottery temper or in lime production, as documented by Reese at Sidi Krebish in Berenice, Libya (Reese 1980: 92). However, in those cases, one would expect there to be no predilection among the crushed shell towards *Murex*, as any shell could be crushed and used for these purposes.

The present study is concerned with the use of *Murex* in purple dye production. The purple dye does not exist as such in the mollusk, but instead is derived from colorless precursors, sometimes called chromogens, found in the hypobranchial gland of the mollusk (McGovern and Michel 1990B: 97; Cooksey 2001: 736). The function of this gland is unclear, although David Reese suggests that it may function to ward off predators in the wild (Reese 1980: 79). The mollusk may secrete its colorless substance for the same reason as an octopus secretes ink. The colorless substance contains a pigment known as dibromoindigotin, which includes two atoms of bromine. Mollusks from the *Muricidae* and *Thaisidae* families are unique in that they have the ability to bind bromine, which is naturally occurring in seawater, with indigo that they produce to form the pigment (Greenspan 2003: 96). The pigment acquires its purple color through contact with light and oxygen. Once this reaction occurs, the pigment is very stable and has an

unusually low solubility in organic solvents, which renders it colorfast on textiles (Cooksey 2001:761; Greenspan 2003: 96). Garments dyed in *Murex* purple could be washed many times in water and would not lose their color. This is a great advantage over plant-based dyes of antiquity, which faded quickly with washing (McGovern and Michel 1990 A).

Modern experimentation has shown that the three species of purple producing mollusks produce slightly different colors of dye. *Murex brandaris* was the species used exclusively in the famed Tyrian dye, which produced a more reddish purple (Reese 1980: 81). This species, along with *Thais haemastoma* contains only the dibromoindigotin pigment (McGovern and Michel 1985: 1516A). *Murex trunculus* was used at other dye sites, such as Sarepta and Sidon to produce a more blue-purple or hyacinth colored dye (Reese 1980:81). This species is different from the other two in that it contains the dibromoindigotin pigment as well as an additional molecule of indigotin, which gives the pigment a bluer tint (McGovern and Michel 1985: 1516A). Combining *Murex* and *Thais* species in different proportions would have produced a slightly more bluish or reddish dye. The exact role of *Thais haemastoma* in purple dye production is still unclear. It has been suggested that it is only used in conjunction with one of the other *Murex* species to produce different variations of purple dye (Veropoulidou et al 2005: 3). This is confirmed so far by the archaeological record. *Thais haemastoma* has never been found in significant proportions at any proposed dye site and is always found with significantly larger numbers of one of the other *Murex* species. The later Roman author Pliny mentions a third purple-producing mollusk species, the *buccinum*, of which the juice was

considered very inferior if employed by itself. However, when used in conjunction with that of *Murex*, it blends with it very well, and lightens its color while giving it a bright luster, so that it acquires the shining crimson hue that is particularly valued (*Naturalis Historia* IX,62). It is well possible that the Latin word *buccinum* refers to *Thais haemastoma*.

Ancient sources on Murex dye production

Testimonials of ancient authors from poets to historians confirm and complement modern insights into the purple-producing shellfish and the manufacturing of purple dye. Most of the ancient comments are very brief and do not reveal any details to us about the dye process. However, four authors, namely Aristotle, Vitruvius, Pliny the Elder, and Plutarch contribute significant information. Purple dye is mentioned in Aristotle's *Historia Animalium,* written in the 4th century BC and in a minor work written in the Aristotelian tradition entitled *On Colors*. In *HA* V, Chapter 15, Aristotle writes that *Murex* is caught in the spring when males and females are beginning to cluster in a "honeycomb" formation for reproduction. If *Murex* are not caught at this time, around the time of the Dog-Star, the pigment is not useable for dye. Aristotle refers to the purple pigment as the "bloom", which he reports lies in a white looking membrane between the liver and the neck of the creature. The bloom or vein appears as a dark streak. People crush the small shells to remove the vein because it is too difficult to extract when the shell is whole; however, they carefully extract it from the large shells without breaking the shell. If this was the case in the Bronze Age Aegean as well, then modern authors

quantifying *Murex* used in dye production who exclude large intact shells with man-made holes systematically underestimate the minimum number of individuals. The pigment must be extracted when the mollusk is still alive, which Aristotle explains is why fishermen kept *Murex* in pools until enough have been collected. The minor work *On Colors*, which was written sometime between 322 and 269 BC by an unknown author working within the Aristotelian tradition, reveals more details about the purple dye manufacturing process (Hett 1936: vii-viii). According to this work, the *Murex* shell is broken and the coloring matter from the vein of the fish is poured into an earthenware vessel and boiled (On Colors V). With sufficient boiling, the color changes from brown to black and hazy to a vivid, bright purple.

The works of Vitruvius and Plutarch offer minor details related to dyeing. Vitruvius in his *Book on Architecture* VIII (c.xiii) writes that the shade of purple from shellfish varies by the amount of sun it receives. It receives more or less light according to the geographic location in which the *Murex* was found. In Gaul and Pontus, the shade is black because these countries are northernmost; to the west, the pigment has a bluish shade, then a violet shade; and in the south, it has a red shade. He mentions that the shells are crushed with iron tools, which forces out "the purple fluid like a flood of tears" (VIII, xiii). The remains are then covered in honey, so that they do not dry up. A hundred years later, Plutarch mentions purple dye in his bibliographic work on Alexander the Great (75 AD). He mentioned that Alexander found 5,000 talents' worth of purple, presumably cloth, at the Persian court of Susa that had been dyed 190 years earlier at Hermione and still retained its vibrant color (Plutarch *Lives*, 36.1). He attributes the extended brilliancy

of the purple color to the use of honey, because it remains pure and lustrous over time (Plutarch *Lives* 36.2).

Although these authors reveal various details, the fundamental source of information from antiquity about the ancient dyeing process is Pliny the Elder's account in the first century AD, roughly two millennia after the purple dye industry began (Pliny, *Naturalis Historia* IX, 60-65). Pliny reiterates a number of Aristotle's observations. The 'purples', as he calls the mollusks, conceal themselves until they reproduce around the rising of the Dog-Star. The juice used for dyeing is contained in a white vein in the throat of the animal as a tiny drop referred to as "purpurae florem" (*NH* IX, 60). *Murex* must be caught alive, because when the mollusk dies, it discharges its juice. The shell is pierced to extract the gland from the large mollusks. The shell of the smaller mollusks must be crushed. After the glands of the mollusks are removed, the purple veins are extracted.

In addition, Pliny adds a number of informative details not mentioned by Aristotle. Salt is added to the flesh at a rate of a sextarius (a Roman pint) per every 100 pounds of mollusk flesh (*NH* IX, 62 para 1). This mixture is allowed to steep for three days and is then diluted with eight gallons of water per 50 pounds of dye. Then it is boiled in a tin or lead cauldron for nine days. There is no consensus on whether the cauldron was made of tin or lead, because the Latin word *plumbo* can mean either, according to which adjective is supplied (McGovern and Michel 1987:139). The temperature is regulated and kept uniform throughout the nine days by a pipe connected to a remote furnace. The simmering causes the flesh of the mollusks to detach from the

hypobranchial glands and float to the top of the vat, to be strained periodically. The liquid is tested until the precise color of purple is attained, at which point a woolen fleece is dipped into the mixture. It is allowed to steep in the liquid for five hours, then is carded, and dipped again in the purple mixture until it has fully soaked up the color. According to Pliny, the highest quality of dye has "the color of congealed blood and is of a blackish hue at sight, but of a shining appearance when held up to the light" (*NH* IX, 62 para 1). Surprisingly, this is probably not the color that comes to *our* mind when thinking of the color purple. It is obvious that our modern concept of purple has evolved somewhat since Pliny's time. In terms of the quantities of purple needed to dye wool to a deep purple color, Pliny specifies that for fifty pounds of wool, two hundred pounds of juice are needed of the buccinum (possibly *Thais haemastoma*) and one hundred and eleven of juice of the pelagiæ (*Murex* sp.). Scholars have deduced from this account that purple dye manufacture was extremely labor intensive and required large numbers of mollusks.

Even though Pliny the Elder's account is the most complete account of purple dye production we have, it is highly unlikely that Pliny actually observed this process. We know from his nephew, the Roman author Pliny the Younger, that Pliny was more of an armchair naturalist, who did not experiment or analyze himself, but instead based his writings on information from earlier authors (Murphy 2004:5). Murphy argues that *Naturalis Historia* "owes more to literary tradition than empirical observation" (Murphy 2004: 5). For instance, it is clear that Pliny was referencing Aristotle's work when he wrote his account of purple dye manufacture. Some of the details repeat almost word for word Aristotle's account, such as the passages on biological properties of *Murex* and the

collection procedures. It is thus likely that Pliny referenced also some other writers' account of the dye process, whose works have not survived. Considering that Pliny probably never observed the process of dye production himself, I argue it is possible that he did not get all the details correct and thus, we should use his account with caution.

Modern experiments with ancient dyeing procedures

Even though Pliny's description is the most detailed account we have from antiquity, it is hardly complete. For hundreds of years, scholars lacked concrete scientific evidence to explain and replicate purple dye production. Modern scientists have conducted experiments to validate Pliny's account and fill in the missing information. In 1833, Bartolomeo Bizio was the first person to describe the origin and chemical properties of Tyrian purple dye. His paper marked a renewed interest in the ancient dye process. Since then, many others have followed in attempts to elucidate the exact methods behind the dyeing process and correlate it to the steps that Pliny the Elder described. Most of the research has focused on the chemical aspects of the dye process. In addition, archaeologists have tried to develop methods of identifying *Murex* purple dye on artifacts and the remains of purple dye production in the archaeological record (McGovern and Michel 1990A).

Today the process is regarded as a vat dyeing procedure, where a reduced form of the dye is kept in a vat or bucket, into which fabric is dipped to impregnate it with the pigment (McGovern and Michel 1987: 139). The pigment is reduced to its yellowish leuco compound, which is a soluble form of the pigment (McGovern and Michel 1990B:

98). The solution is subsequently reoxidized, returning the dye to its water insoluble form, thereby making it colorfast. Experiments have established that two important factors influencing the hue of the purple are contact with air and sunlight, which is partly in step with Vitruvius' assessment that sunlight is a factor, although his reasoning of geographical location is flawed (Cooksey 2001). In response to air or sunlight, the color of the dye progresses from a light yellow/green all the way to deep purple. It has been observed that in the strong Mediterranean sun, this process can take place in less than ten minutes time (Verhecken 1994:33). Initially many experiments were concerned with identifying the reducing agent. Furthermore, owing to the ambiguity of Pliny's Latin term for the cauldron material, researchers have had varied success in actually reducing the dye solution in tin or lead cauldrons.

A breakthrough was made in 2000, when an engineer turned dye specialist John Edmonds produced purple dye with the fermentation vat process, similar to the procedure used in indigo dyeing (Edmonds 2000: McGovern and Michel 1990A: 156). Indigo is chemically similar to the dibromoindigotin pigment found in *Murex*. The reducing agent in a fermentation vat consists of the flesh of the decaying mollusks themselves. Edmonds was able to produce dye in a glass jar using the fermentation vat process, with a solution of water, salt, hypobranchial glands, and preserved cockle flesh set in a bath of alkaline potash. With this mixture, he successfully dyed multiple pieces of unspun wool. Israeli chemist Zvi Koren also successfully created purple dye from this process and reported, "The complexity of this puzzle, which waited nearly a millennium and a half to be completely deciphered, lay in its simplicity!" (2005: 142). Every ingredient needed for

dye production save potash, which could be culled from the fire pit, is contained within the *Murex* themselves. The gland provides the pigment and the rotting flesh serves as the reducing agent. These experiments proved that the nature of the cauldron, whether it was lead or tin, had no effect on reducing the solution. Moreover, it is unlikely that only lead or tin cauldrons were used in Antiquity, since only ceramic or stone vats have ever been verified archaeologically in any dye installation.

Experimentation also has shed light on the amount of *Murex* needed to produce dye. According to Friedländer's 1909 experiment, 12,000 *M. brandaris* were required to produce 1.4 grams of dye (cited in Reese 1987; Edmonds 2000:13). This estimate is often reported in the scholarly literature. However, in the last decade, researchers have cast doubt upon its validity. John Edmonds argued that if it were correct, the amount of *Murex brandaris* needed to dye 3 square meters of wool would fill a 5,670 liter (1,080 gallon) vat completely (Edmonds 2000: 26). That is merely accounting for the fleshy matter itself, not the large amount of required water. Vats of this size have never been verified archaeologically, not even at the large commercial dye centers of the Phoenicians. At an 18th century BC dye installation in Qatar, located on the Persian Gulf, vats associated with purple dye could hold only about 600 liters (Edmonds 2000: 25). Thus, Edmonds argues that Friedländer's estimate is impractical and not supported by archaeological evidence.

Edmonds (2000) and Zvi Koren (2005) successfully produced dye from much smaller quantities of *Murex*. Edmonds was able to produce a purple dye solution from "less than a gram of the *Murex* dye" in a solution with six preserved cockles, which was

enough to dye a piece of unspun wool (Edmonds 2000: 28). It seems that what Edmonds means by "*Murex* dye" is actually dry extracted *Murex* pigment, as he states earlier in the article (Edmonds 2000: 27). However, it is difficult to accurately quantify his results, as he does not specify how large the piece of wool was nor the amount of dye solution that less than a gram of pigment produces. Koren is more explicitly quantitative in his report (2005). He found that 1 gram of unspun wool can be dyed to a level of "good purple coloration" with only three mollusks (Koren 2005: 142). However, seven medium snails were required for the dyeing of 1 gram of wool to a deep, uniform purple and he concludes that to dye a full robe to the deep shade so exalted by Pliny, 5,000-10,000 mollusks would have been needed (Koren 2005: 146). Koren does not explain how he arrived at those numbers. However, if we follow Edmonds' lead and assume that a robe required at least 1.36 kilograms of wool, 9,525 mollusks would have been required to dye it to a deep purple and 4,082 mollusks for a less uniform purple color according to Koren's results. These results invalidate Friedländer's estimate, according to which the same amount can produce only 1.4 grams of dye, probably only enough solution to dye a small piece of wool.

Criteria for identifying Murex dye production

The biological properties of *Murex* and the process of dye production previously outlined serve as the foundation upon which the methodology for this study is constructed. Since *Murex* could have been employed for many uses, its mere presence in the archaeological record is not enough to determine that it was used for dye production.

Using criteria employed by previous archaeological studies of *Murex* finds as well as my own observations, I have established the following criteria for determining whether *Murex* found at an archaeological site had been used in the manufacture of purple dye:

Murex must be found in a fragmented state or have a man-made hole in the main body whorl of the shell. These characteristics are in keeping with Aristotle's and Pliny's accounts and have been demonstrated in dye experiments (Ruscillo 2006). According to these ancient authors, smaller shells would have been crushed and larger ones pierced in order to extract the hypobranchial glands. A man-made hole can easily be distinguished from an animal-made hole, since man-made holes are irregularly shaped whereas animal-made holes are uniformly drilled on all sides and the hole often has beveled edges (Ruscillo personal communication) (Figures 3.2 and 3.3). Generally, the small to medium sized shells should be fragmented, while the larger shells should be either fragmented or pierced individually. The tiny *Murex* likely would not have been crushed at all, because

Figure 3.2: Man-made hole in *Murex brandaris* shell from Mitrou. R. Vykukal, Mitrou Archaeological Project

Figure 3.3: Animal-made hole in *Murex trunculus* shell from Mitrou. R. Vykukal, Mitrou Archaeological Project

they do not yield enough dye to warrant the labor of collecting them (Ruscillo 2006:812).

As Aristotle, Pliny and Vitruvius all stated, *Murex* must be alive prior to gland extraction. Whether a shell was caught dead or alive can be determined in the archaeological record by analyzing the taphonomic processes that affected the shell. It is certain that shells that are highly abraded and water worn were collected dead. As I observed myself, hermit crabs sometimes inhabit these shells after the *Murex* has died. A hermit crab could easily have been collected accidently by hand collection as well as accidently been caught in the baited baskets. Ruscillo explains that the death of the *Murex* creature stops the calcium renewal process and makes the shell susceptible to wear caused by surf action (Ruscillo 2006: 813). The discontinuation of calcium renewal would have made the shell susceptible to pitting as well. Therefore, a high level of pitting

would indicate that the *Murex* had been collected dead. An animal-made hole in a *Murex* shell also indicates that the *Murex* had died prior to being extracted from the shell, likely eaten by a member of the same species while being stored for food or dye production.

Another criterion used in modern literature as evidence that the mollusk was collected dead is parasitic encrustation, especially by *Vermetus* worms. It is thought that the parasites could opportunistically invade only when the shells have been weakened (Ruscillo 2006: 813). Thus, parasitic encrustation would indicate that the *Murex* had not been used for purple dye production. I became skeptical of this criterion when I noticed that a large majority of the shells I analyzed at Mitrou showed signs of parasitic encrustation, yet these shells were found together with shells that did not have such encrustation and had been broken in the same manner indicative of gland extraction. I decided to conduct an experiment to test the hypothesis that only dead *Murex* attracted parasites. With the help of Dr. A. Van de Moortel, I contacted a local Greek fisherman, Mr. Thanasis Berdekas. He informed us that he catches *Murex* daily for use as bait and promised to catch some quantity for us. I requested 100 *Murex* shells, which he told us would take a day or two to collect. To our delight, Berdekas caught 226 live *Murex* of both the *trunculus* and *brandaris* species. I examined them and described them as having slight, heavy, or no encrustation. In all, I found that 46% of live *Murex* had some form of parasitic encrustation. This proportion was actually greater than the proportion in the archaeological *Murex* data from Mitrou (Figure 3.4). Thus, it is clear that parasitic encrustation alone cannot be used to determine if the *Murex* was alive or dead when caught in Antiquity.

Figure 3.4: Live *Murex* with *Vermetus* worm encrustation at the top of the shell. R. Vykukal, Mitrou Archaeological Project

Recovery Method and Sampling Strategy:

Following these criteria, a representative sample of the stratigraphic units (SUs) from Mitrou was analyzed for presence of *Murex* exploited for dye production. Chronologically, this sample covered the entire range excavated at the site, from the EH IIB to LPG pottery phase (ca. 2400-900 BC). Rena Veropoulidou, the project's shell specialist, conducted a pilot study examining shells of 81 SUs from contexts excavated in 2004-2006 deemed significant on the basis of their pottery contents, and wrote an unpublished report on this study (Veropoulidou 2007:1). She identified 1,451 individual specimens (NISP) as *M. trunculus*, 75 as *M. brandaris*, and 2 as *T. haemastoma,* corresponding to an estimated 705, 39, and 2 minimum number of individuals (MNI),

respectively (Table 1: Veropoulidou 2007: 2-3). The results of her analysis have been presented in Chapter 1, and will be integrated with my own results in Chapter 5.

Of the roughly 5,000 stratigraphic units (SU) excavated at Mitrou in 2004-2008, some 2,700 SUs contained shell. Time did not allow for complete analysis of all 2,700 SUs. Instead, a representative sample of 327 SUs with shell remains was analyzed, of which 229 SUs contained *Murex*. The studied SUs came from trenches LE792, LM783, LM784, LN783, LN784, and LX784, which collectively included possible dye production areas as well as non-production areas and encompassed all cultural periods. Trench LE792 was selected as a representative of Building H and examined in its entirety, because it contained the two *Murex* dumps, thought to represent refuse of nearby dye production (Chapter 1). Its 20.25 square meter area takes up an estimated 3.4% of the total excavated area of Building H (600 m^2), and 2.7% of the estimated area of that complex (750 m^2). Moreover, it is the only trench in Building H that was excavated deep enough below the LH I-II complex, uncovering many levels of MH date and one EH level. Thus it was expected to provide a good diachronic perspective into the emergence of *Murex* dye production at that location. In all, 97 SUs were excavated in this trench and *Murex* shell was found in a total of 51 of these SUs. At the extreme eastern edge of the island, trench LX784 was chosen to serve as a control, since of all the trenches that contain LH I-II occupational levels, this trench is spatially the furthest from Building H. Also, it is the only trench of which the excavated strata include the same temporal range as trench LE792. In fact, it was excavated even deeper down than trench LE792, into several EH IIB levels, thus providing an even greater diachronic perspective. Its inclusion

provides a context against which to assess the significance of the spatial association of *Murex* with Building H in trench LE792. In trench LX784, 157 SUs were excavated and *Murex* shell was found in a total of 56 SUs. Trenches LE792 and LX784 are comparable because they are the deepest trenches excavated at the site and both have a stratigraphic sequence spanning most or all pottery phases.

A few additional locations were targeted to serve as the main study groups for the later Palatial, Post Palatial, and Protogeometric periods. In trench LN783, 91 Protogeometric SUs were sampled that were associated with the courtyard of Building E, overlying the apsidal area of Building A, of which 72 SUs contained *Murex* shell. These were selected because this courtyard has been identified as a site of possible LPG *Murex* dye production (Chapter 1). Since purple dye production in the rural economies of Early Iron Age Greece can reasonably be assumed to have taken place on a domestic scale, it was expected that its analysis would provide a useful comparison for evaluating whether the scale of the earlier LH I-II manufacture exceeded that of domestic production. In addition, 50 SUs from LH Road 1 in trench LM783 were analyzed, of which 33 had *Murex* shell. This road was chosen because its 13 repavings produced the only closed contexts from the Palatial period (LH IIIA:2 Middle-LH IIIB) and even though very small, these contexts represent a complete and well-dated Palatial sequence. Finally, a total of 18 SUs from trenches LM784 and LN784, located in and below Building F, were analyzed in order to serve as another contextual comparison for the Late Helladic I-II levels in Building H, some 40 meters to the northwest. All but 1 SU from the 18 selected from trenches LM784 and LN784 contained *Murex* shell.

Thus, a representative sample was selected from the northwest sector with 67 shell-bearing SUs from trench LE792, from the northeast sector with 159 shell-bearing SUs from trenches LM783, LM784, LN783, and LN784, as well as from the eastern edge of the islet with 101 shell-bearing SUs from trench LX784. Other trenches were excluded on the basis of their context or lack of chronological depth. The northeast corner of the islet excavated with trench LR797 was excluded from this study because it was predominantly a mortuary plot in the Prepalatial period. It was excavated down to EH III levels, but very few MH and EH remains were exposed, and these were unlikely to provide much additional diachronic information. Even though Building D was an elite complex like Building H, the SUs associated with this complex were excluded from this study. Since most of the excavated area of Building D was taken up by the funerary enclosure of Built Chamber Tomb 73 and very little remains were found outside or underneath this enclosure, it was not expected to reveal much information about everyday activities. Lastly, the southernmost trench excavated at Mitrou, trench LR770, was excluded because the strata excavated thus far are chronologically shallow.

My study focused on *Murex* from mixed contexts in the selected trenches because this is the only way in which I could investigate broad trends over time. Too few primary contexts (floor deposits, primary dumps) have been excavated at Mitrou to provide a representative sample of *Murex* use for each period. By looking at all other types of contexts, including mixed fills and random accumulations, I managed to work with a sample that was large enough to be representative of most periods and allow diachronic comparisons. Secondary contexts at Mitrou were carefully excavated, recorded, and

studied. Even though the date of their contents is mixed, the latest date of each context represents the *terminus post quem* for its closing and the stratigraphic position of the context provides an additional indication for its chronological relationship to other contexts. Thus, when carefully excavated, even mixed deposits can reveal the appearance over time of new elements in the archaeological record. Even though their data are not pure and homogenous, they can reveal broad patterns of change.

The 2004-2008 excavations at Mitrou were carried out with respect to natural stratigraphy, and each stratigraphic unit was assigned a SU number. The location of each SU was measured with a Total Station, drawn into the trench notebook, and photographed. Trench supervisors described for each SU the characteristics of the soil matrix, stones and other debris, and recorded all archaeological finds. The volume of sediments contained by each SU was calculated on the basis of the number of buckets of sediments removed as well as by measurements on the ground. These data make it possible to calculate the overall density of artifacts and ecofacts of each SU. A specific percentage of each SU, depending on its perceived importance, was dry-sieved with a 0.5 centimeter mesh screen, and a percentage, up to 100%, of the sediments from each potentially primary context was water-sieved through various screens, the smallest having a mesh size of 330 microns.

Shells were systematically collected from all SUs. After the shells had been washed and dried, the *Murex* remains were sorted by the author into their appropriate species: *M. trunculus, M. brandaris* and *T. haemastoma*. The number of individual specimens (NISP) and weight (g) were recorded for each species. NISP represents a raw

count of every individual fragment or intact shell. The shells from each *Murex* species were further separated into categories according to the anatomical part of the shell remaining (Figures 3.5 and 3.6): 1) intact shell, 2) apex, 3) siphonal canal and columnella, 4) siphonal canal and apex, 5) columnella, 6) aperture, 7) apex and aperture and 8) body fragment. I separated the fragments into these categories because these anatomical parts would be the basis for determining the minimum number of individual *Murex* shells (MNI) represented by the raw count.

Intact shells were measured from their apex, or top of the shell spire, to their siphonal canal at the edge of the shell, because the relative age can be determined from this dimension. Finally, the specimens within each shell category were analyzed with respect to their condition. I established eleven conditions (Table 3.1) that incorporate the three types of taphonomic processes that act on shells in single or combined states: abrasion or erosion as a result of wind and water action; encrustation by parasites; and perforation or pitting as a result of a breakdown in the structure of the shell (Claasen 1998). Analyzing the condition of the shell is important for determining whether the shell was collected dead or alive in antiquity, and whether or not it could have been used for purple dye manufacture.

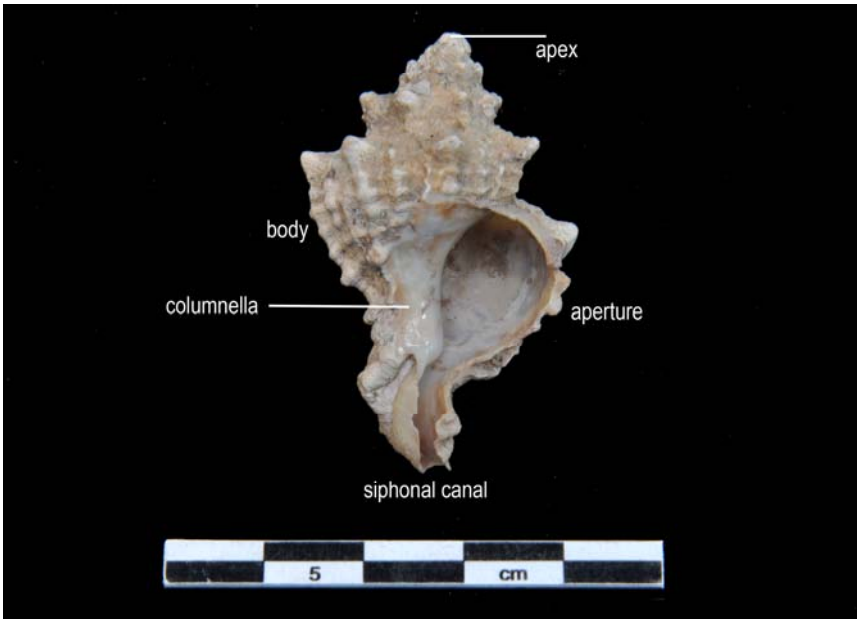


Figure 3.5: Intact *M. trunculus* from Mitrou with anatomical parts labeled. R. Vykukal, Mitrou Archaeological Project

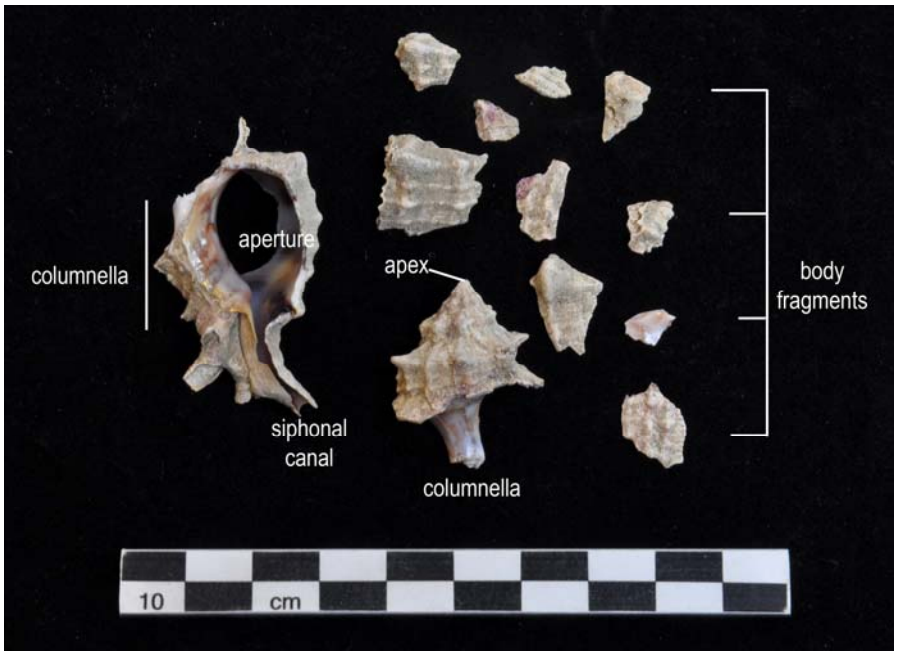


Figure 3.6: Fragmented *M. trunculus* from Mitrou with anatomical parts labeled. R. Vykukal, Mitrou Archaeological Project

Methodology for quantifying Murex

In order to estimate the quantities of *Murex* deposited in each period, we cannot rely on the NISP, since multiple fragments, or specimens, may belong to the same *Murex* individual. The measure often employed for this purpose in faunal studies is the minimum number of individuals (MNI) represented in the remains. Unfortunately, there is little consistency in how this number is determined with respect to *Murex* species. Generally, the apex or columnella can be used to estimate the MNI represented by the fragmented debris (Ruscillo, personal communication). The apex is often used because it is a non-repetitive part of the *Murex* shell and thus there is a one to one correlation of apex to individual. However, I decided not to use apex counts at Mitrou because very small shell fragments were not recovered during excavation and flotation residues were not analyzed in this study. Thus, I feared that sampling bias would skew the results if apices were used to determine the MNI. The columnella is sometimes used because it is the strongest part of the *Murex* shell (Ruscillo, personal communication). However, even though the columnella is a sturdy part of the shell, it can fragment under enough pressure and therefore, two columnellae could have belonged to the same individual. Consequently, determining MNI solely by columnellae could inflate the original number of individuals. A third method would be to divide the total weight of *Murex* shell by average shell weight (Ruscillo 2006: 785). However, I weighed only 13 complete shells individually in this study, because they happened to occur in an SU with no other fragmented *Murex* shell. This sample is too small to determine average shell weight and the results would not yield an accurate estimate of the MNI.

Table 3.1: Taphonomic condition of *Murex* shells

Condition	***Description***
I	Abrasion
II	Heavy encrustation
III	Slight encrustation
IV	Slight encrustation and abrasion
V	Heavy encrustation and abrasion
VI	Perforation
VII	Perforation and abrasion
VIII	Perforation and slight encrustation
IX	Perforation and heavy encrustation
X	Perforation, slight encrustation, and abrasion
XI	Perforation, heavy encrustation, and abrasion

Given the difficulties involved with all existing methods of estimation, I propose a different diagnostic feature to estimate MNI: the joined siphonal canal and columnella (Figure 3.7). This part is the juncture between the columnella and the end tip of the shell, a feature that occurs only once in each individual. I found that my count of the joined siphonal canal and columnella fragments was much larger than my count of apices and significantly smaller than my count of columnellae alone, thus confirming my suspicions of the usefulness of the other two anatomical parts as bases for quantification (Table 3.2).

Thus, I argue that the use of the joined siphonal canal and columnella fragments leads to the most reliable MNI counts.

In conclusion, the methods employed in this study for identifying and quantifying *Murex* used for purple dye manufacture draw on the inherent biological characteristics of *Murex* and *Thais* species of marine mollusk as well as on the process of dye manufacture as they are described by ancient authors and understood from modern scientific insights and experimentation. The sampling strategy employed allowed me to finish the study within the available time frame while producing a sufficient sample size for detecting broad trends in the data and studying them with relation to the rise and fall of the elite at Mitrou in the LH period. Trends in the data were analyzed by means of statistical techniques. These techniques and their results will be discussed in the following chapter.

Figure 3.7: Diagnostic anatomical part for calculating the MNI: siphonal canal and columnella. R. Vykukal, Mitrou Archaeological Project

Table 3.2: MNI of *Murex* in the present study sample, as determined by various anatomical shell parts

Anatomical part	***MNI***
Apices	306
Columnella and siphonal canal	743
Columnella	828

Chapter 4
Statistical Analysis of *Murex* Remains

Preliminary Remarks:

The present study aims to detect meaningful patterns that may exist in the chronological and spatial distribution of *Murex*. The hypothesis of this study is that the emergence of *Murex* dye production is related to the rise of a visible political elite at Mitrou in the Prepalatial period (LH I-LH IIIA:2 Early) and furthermore, that the scale of production was large enough not only to have served the needs of the household, but also to have provided a cash crop that could have been exchanged for copper and tin in the eastern Mediterranean, as proposed by Burke (1999), or other luxury items from the Mediterranean Basin. The first part of this hypothesis is assessed by determining if the frequencies of *Murex* are significantly higher in the area of elite complex H (trench LE792) during the period of the elite's rise (LH I-II phases) than in other periods or excavated areas of the site. Elite complex H was targeted over elite complex D because it contained evidence of *Murex* dye manufacture, whereas most of the excavated area of complex D was taken up by a large tomb complex, and did not provide readily identifiable evidence for *Murex* dye production. The examination of *Murex* on a broad scale—across the sampled areas of the site for all time periods—will demonstrate if there is a general spatial and temporal trend to support the initial portion of the hypothesis. This part of the study will be followed by narrower scale analyses, where spatial differences will be investigated within each cultural period and chronological differences within each excavation area. In the following chapter, the results will be placed in their

archaeological context, in order to gain a better understanding of the relation of *Murex* dye production with Mitrou's emerging elite.

In order to analyze the material chronologically, SUs were grouped into meaningful cultural periods based on developments that occurred at Mitrou and elsewhere on the Greek mainland (Chapter 1). Individual SU dates were provided by A. Van de Moortel (stratigraphic study); and C. Hale, B. Lis, S. Rückl, J.B. Rutter, S. Vitale, and E. Zahou (Early, Middle, and Late Helladic and Protogeometric pottery studies). There is still considerable scholarly debate over the absolute dates of the mainland Helladic pottery phases, primarily because of the disagreement over the absolute date of the Theran volcanic eruption (Rutter 1993: 756). The present study uses mostly the high absolute dates proposed by J.B. Rutter (2005), since these are widely accepted in the scholarly literature, but also takes into account the possible low absolute dates of the Theran eruption. This study uses the following seven cultural periods: Corridor House period, Early Helladic III to Middle Helladic III Village period, Prepalatial, Palatial, and Post-Palatial periods, Late Helladic IIIC/ Protogeometric period, and Early Iron Age Village period (Table 1.1). At Mitrou, the Prepalatial, Palatial, and Post-Palatial periods are urban. The reversion from the urban to rural settlement happened at the site before the end of the LH IIIC period, and is not entirely understood. Therefore, a LH IIIC/PG period is analyzed separately in this study, grouping together the pottery of the LH IIIC and PG periods because it is often impossible to distinguish between the two.

An initial assessment of the distribution of *Murex* suggests that there are spatial and chronological trends that are worth further exploration (Table 4.1). The largest MNI

of *Murex* occurs in the area of building H (LE792), constituting 78.68% of the total MNI in the examined areas. The next most abundant sample of MNI occurs in trench LN783, representing PG levels in Building A and the overlying courtyard of Building E. This accounts for 9.16% of the total sample. Chronologically, the largest percentage (59.6%) of *Murex* is found in the Prepalatial period (LH I-LH III A:2 Early) , and the second-highest percentages in the LH IIIC/PG (16.24%) and Early Iron Age Village periods (9.77%) combined, totaling 26% of *Murex*. However, because the amount of excavated soil varies among the periods, an analysis of MNI alone could be misleading. Instead, the MNI was scaled for volume in each period and trench and the resulting densities were subjected to statistical analyses.

Chi-square tests of the densities of *Murex* (MNI per cubic meter of excavated soil) within each of these trenches and time periods are used to determine if these distributions are statistically significant. Volumes of excavated areas and densities are provided in table 4.2. Given the apparent concentration of *Murex* in the area of Building H and in the period of Building H's use (LH I-II), it is important to test whether these trends are significant and support the research hypothesis that *Murex* dye manufacture was related to Mitrou's Prepalatial elite. Likewise, the significance of the concentration of *Murex* in Building E's courtyard in the Late Protogeometric should be assessed. Unless otherwise noted, statistical significance throughout this chapter was assessed at a 0.05 level.

Table 4.1: Distribution of *Murex* in the analyzed portion of the site. Numbers indicate MNI (% of site total MNI)

	Cultural Period						
Trench	***EH III-MH III Village***	***Prepalatial***	***Palatial***	***Post-Palatial***	***LH IIIC/PG***	***Early Iron Age Village***	***Total***
LE792	54	387			108		549 (78.68%)
LM783		14	5				19 (2.72%)
LM784/LN784		6		12	1	2	21 (3.15%)
LN783				3		61	64 (9.16%)
LX784	25	8			4	5	42 (6.29%)
Total	80 (11.5%)	415 (59.63%)	5 (0.72%)	15 (2.16%)	113 (16.24%)	68 (9.77%)	696 (100%)

Table 4.2: Volumes of excavated soil (m3) and associated densities (MNI/m3) across the analyzed portion of the site.

Trench	*Cultural Period*													
	EH III-MH III Village		***Prepalatial***		***Palatial***		***Post-Palatial***		***LH IIIC/PG***		***Early Iron Age Village***		***Total***	
	volume **(m^3)**	***density*** ***(MNI/*m^3*)***	***volume***	***density***	***volume***	***density***	***volume***	***density***	***volume***	***density***	***volume***	***density***	***volume***	***density***
LE792	15.23	**3.55**	10.13	**38.22**			2.63	*	15.19	**7.11**			43.17	**12.72**
LM783			3.01	**4.65**	2.46	**2.03**							5.47	**3.47**
LM784/LN784			0.82	**7.28**			3.60	**3.34**	0.22	**4.55**	0.30	**6.67**	4.94	**4.25**
LN783							0.10	**0.03**	0.20	*	4.91	**12.41**	5.21	**12.28**
LX784	42.1	**0.59**	12.10	**0.66**					3.81	**1.05**	0.79	**6.31**	77.35	**0.57**
Total	57.19	**1.40**	26.06	**15.93**	2.46	**2.03**	6.32	**2.37**	19.42	**5.82**	6.01	**11.31**		

* MNI=0. Therefore, density could not be calculated.

M. trunculus and *M. brandaris* were found in very different frequencies across the site. A total of 2,849 *M. trunculus* fragments were found, representing 92.9% of the *Murex* assemblage sampled, while only 219 fragments of *M. brandaris* were found, representing 7.1%. Only 1 fragment belonged to the third species often exploited for dye production, *Thais haemastoma*. The disparity between the species is even greater when MNI is taken into account; the MNI for *M. trunculus* was 679, representing 97.1 % of the total, while the MNI for *M. brandaris* was 20, or 2.9%. The single fragment of *Thais haema*stoma was undiagnostic in terms of MNI. Since 97.1 % of total MNI belonged to *M. trunculus* it is abundantly clear that the inhabitants of Mitrou chose this species almost exclusively. For this reason, the species have been pooled in this analysis.

Site Wide Analyses

Initial statistical analyses aimed to test the significance of the observed differences in chronological and spatial distribution of *Murex* broadly across all examined areas of the site (Table 4.2). Although 31 NISP were found in levels dating to the EH IIB Corridor House period, none were diagnostic for determining the MNI. As a result, this period could not be compared chronologically with the other periods. Since EH IIB contexts were not recovered from any trenches besides LX784, no spatial comparisons could be made either.

The null hypothesis of the first chi-square analysis was that *Murex* shells are distributed equally among cultural periods across the site. This is not supported by the results (Expected frequency=6.477; $\chi^2_{(5,\, N=38.859)} = 27.089$; $p < 0.05$). Thus, the chronological distribution shown in Table 4.2 and the great deviation from expected

frequencies with far higher densities of *Murex* in the Prepalatial period than expected is statistically significant. A significant difference in the distribution of *Murex* exists among cultural periods.

In order to assess the spatial distribution of *Murex*, analyzed trenches were grouped into three areas: the area of Building H (trench LE792), the habitation and burial area on the eastern sea scarp (trench LX784), and the Northeast area, covering parts of Buildings A, D, E and F (represented by trenches LM784, LN784, and LN783). A chi-square analysis of these three areas is valid because the SUs analyzed from these three trenches in the Northeast area encompass the same cultural periods as are found in trenches LE792 and LX784 with the exception of the Corridor House period and the EH III-MH III Village Period, which were excluded here. Furthermore, these three trenches of the Northeast area all are associated with structures other than those excavated in trenches LE792 and LX784. Trench LM783, with its Palatial period SUs in Road 1, was not included in this test, because no Palatial levels were identified in Trenches LE792 and LX784, and thus, they could not be compared spatially for that period. The chi-square analysis of a site-wide spatial distribution of *Murex* shows that the observed differences of *Murex* among these three areas is significant (Expected frequency=8.877; $\chi^2_{(2, N=26.631)}=16.666$; $p < 0.05$) (Table 4.2). It is clear that *Murex* specimens were concentrated primarily in trench LE792.

Thus, the initial set of analyses has demonstrated that *Murex* is not evenly distributed spatially or chronologically at Mitrou for all periods and all areas combined. The higher frequencies of *Murex* in the area of Building H during the Prepalatial period

are not due to chance, and must have another explanation. Follow-up analyses will examine the spatial and chronological distribution in greater detail.

Distribution Analyses among Cultural Periods and Trenches

The following analyses examine the specific spatial patterns in which the shells are distributed in each cultural period. This will elucidate whether the concentrations of *Murex* are significantly associated with Building H in all periods or whether there are spatial shifts over time. Subsequent analyzes of chronological differences within selected areas will determine if there are significant increases or decreases in *Murex* shells in each of these areas through time. Once again the Corridor House period was not analyzed in this set of analyses, as only trench LX784 contained SUs dating to EH IIB. The Palatial period was also excluded from this set of analyses because *Murex* dating to this period was recovered in only one area (trench LM783).

EH III-MH III Village period contexts were found only in trenches LE792 and LX784 of all the examined trenches (Table 4.2). According to the chi-square analysis, there is no significant difference in the distribution of *Murex* shells between trenches LE792 and LX784 in this period (Expected frequency=2.07; $\chi^2_{(1,\, N=4.14)}=2.104$; $p=0.15$). Even though the shell density in LE792 is six times greater than in LX784, the difference is not statistically significant.

A similar analysis of the distribution of *Murex* in the Prepalatial period included trenches LE792, LM783, LM784/LN784, and LX784 (Table 4.2). Trenches LM784 and LN784 were combined in this and further chi-square analyses, because they are both

associated with Building F. Unlike in the EH III-MH III Village period, it is clear from the results of the chi-square analysis that *Murex* are not distributed equally among these areas in the Prepalatial period. The higher density of *Murex* in the area of Building H is statistically significant (Expected frequency=12.704; $\chi^2_{(3, N=50.816)}=70.092$; $p < 0.05$). The density of *Murex* tapers off towards the east of the islet. These findings support the research hypothesis that *Murex* dye production was associated with Building H during the documented period of its use (LH I-II pottery phases).

Similar chi-square analyses were conducted for the LH IIIC/PG and the Early Iron Age periods. LH IIIC/PG contexts with *Murex* have been found in trenches LE792, LM784/LN784, and LX784. The chi-square analysis (Table 4.2) does not indicate a significant difference in the spatial distribution of *Murex* among these three areas in the LH IIIC/PG period (Expected frequency=4.235; $\chi^2_{(2, N=12.706)}=4.371$; $p=0.11$). It must be noted that the overall ambiguity of the dating of LH IIIC/PG SUs makes the picture less certain than desired. The analysis of purely Early Iron Age SUs, found in LM784/LN784, LN783, and LX784, shows the same trend. *Murex* shell is distributed equally among the trenches in this period (Expected frequency=8.464; $\chi^2_{(2, N=25.393)}=2.717$; $p=0.25$). No *Murex* was found in trench LE792 that could be dated to this period. Thus, the greater density of *Murex* in the courtyard of Building E in trench LN783 is not significant, even though a possible dye production installation was found in this area.

Finally, chronological changes in *Murex* frequency within specific excavation areas were examined. Only trenches LE792 and LX784 were considered because these were the trenches for which all SUs containing shells have been studied, thus providing a

complete diachronic overview (Tables 4.1 and 4.2). Chi-square analysis shows that there are significant diachronic differences in the density of *Murex* in trench LE792, with the Prepalatial period being very prominent (Expected frequency=16.293; $\chi^2_{(2, N=48.879)}=44.663$; $p < 0.05$). The density of *Murex* in this trench is lowest in the EH III-MH III Village period (3.55 MNI/ m^3), but spikes dramatically in the Prepalatial period (38.22 MNI/m^3), and then decreases again in the LH IIIC/PG period (7.11 MNI/m^3). It is worth mentioning that although *Murex* fragments were found in LE792 that could be dated within the Post-Palatial (LH IIIC) period (NISP=13), the minimum number of individuals could not be determined. There are no architectural features dating to this period and comparatively little sediments have been recovered (2.63 m^3), which could explain the lack of MNI.

The range of densities of *Murex* in trench LX784 is not as large overall as in trench LE792, with densities never exceeding 6.31 MNI/m^3. However, the differences between the cultural periods are statistically significant, with the Protogeometric period having the highest density (Expected frequency=2.155; $\chi^2_{(3, N=8.618)}=10.758$; $p < 0.05$). It is necessary to point out that the volume of Early Iron Age sediments excavated in trench LX784 is exceedingly small (0.79 m^3), and is possibly associated with a cist grave. It is conceivable that the high density of *Murex* here is not related to purple-dye manufacture, but to burial practice.

A subsequent chi square analysis further investigates the time period in which the frequency of *Murex* peaks in the area of Building H. The increase of *Murex* is substantial in trench LE792 in the Prepalatial period. However, this period may be as long as 330

years. It may be possible to discern significant increases in *Murex* with greater precision, by comparing the frequency of *Murex* in various subphases of this period. A series of Prepalatial surface deposits in trench LE792 allows the division of the period into four stratigraphic phases: 1) fill below the lowest LH I surface, 2) floor deposit on top of the lowest LH I surface and fill between the first and second LH I surfaces, 3) the floor deposit on top of the second LH I surface and fill between the second LH I surface and the LH II surface, and 4) material accumulated on top of the LH II surface. The LH I and II surfaces appear to belong to an earthen courtyard within the complex of Building H. The chi-square analysis demonstrates that the distribution of *Murex* is statistically different among these shorter stratigraphic phases of the Prepalatial period (Expected frequency=38.29; $\chi^2_{(3,\, N=153.17)}=47.05$; $p < 0.05$) (Table 4.3). The highest concentrations are those on or above the second LH I surface and the LH II surface, thus suggesting a peak of activity in the advanced stage of the Prepalatial period.

In addition to the trend in the Prepalatial period, Table 4.3 also shows a seemingly important increase in density in the MH IIC/MH III phase—the final stage of the EH III-MH III Village period in trench LE792. It was worthwhile to investigate if this increase is statistically significant. A chi-square analysis was conducted for the sub-phases of the EH III-MH III Village period in trench LE792. This period was divided into the smallest cultural phases that could be securely dated by our current understanding of pottery chronology at Mitrou: EH III/MH I, MH II A/B, and MH IIC-MH III. According to the chi-square analysis, there is no significant difference in the frequency of *Murex* in these phases ($\chi^2_{(2,\, N=16.63)}=5.544$; $p=0.08$).

Table 4.3: Distribution of *Murex* in subdivisions of the Prepalatial period and the EH-MH Village Period in trench LE792

		MNI	***Volume*** m^3	***Density*** MNI/m^3
Prepalatial Period	Fill on top of LH II surface	**209**	**3.55**	**58.87**
	Floor deposit and fill between second LH I surface and LH II surface	**81**	**1.36**	**59.56**
	Floor deposit and fill between first and second LH I surfaces	**68**	**3.04**	**22.39**
	Fill below the lowest LH I surface	**25**	**2.03**	**12.35**
Village Period	MH IIC-MH III	**44**	**4.46**	**9.87**
	MH II A/B	**9**	**3.08**	**2.92**
	EH III/MH I	**1**	**0.26**	**3.85**

As the entire stratigraphic sequence of both trenches LE792 and LX784 was analyzed, it is possible to compare the number of SUs with *Murex* to those without *Murex* to further investigate how widespread these shells were. Table 4.4 shows the proportion of SUs examined in this study with and without *Murex.* SUs already studied by Veropoulidou as well as most SUs associated with graves were not analyzed in this study and therefore, are excluded from this analysis. In total, 23 SUs were excluded from trench LX784 and 31 SUs from trench LE792 for this reason. The chi-square analysis demonstrated that the proportion of SUs with *Murex* versus SUs without *Murex* is indeed different between the two trenches ($\chi^2_{(1, N=200)}=22.377$; $p < 0.05$). The much lower proportion of SUs without *Murex* (22.7%) in trench LE792 is statistically significant, and

Table 4.4: Chi-square analysis of the degree of dispersal of *Murex* in the area of Building H (trench LE792) and at the eastern edge of the island (trench LX784). Bold numbers are the observed frequencies; numbers in parentheses are expected frequencies.

	LE792	**LX784**
SUs with *Murex* present	**51** (35.31)	**56** (71.69)
SUs with *Murex* absent	**15** (30.69)	**78** (62.31)

indicates that *Murex* was more widely distributed in this trench. It should be noted that SUs vary in size and may be defined arbitrarily or on the basis of soil changes. Thus this analysis provides only a rough assessment of the different mode of deposition of *Murex* in these two areas of the site. At the same time, the relatively low degree of dispersal of *Murex* in trench LX784, with more than half the SUs lacking these mollusks, can be added to the fact that this trench also has the lowest density of *Murex* of all areas examined in this study. For this reason, and because this trench is located some 60 to 100 meters away from any identified site of dye manufacture at Mitrou, the data from LX784 are used as representative of the minimum frequency of *Murex* all over the site. In other words, they provide the site-wide standard noise level of *Murex* at Mitrou.

The results of the chi-square analyses provide an interesting picture of what is happening with *Murex* chronologically and spatially throughout the site. In general, it has been determined that *Murex* is, in fact, distributed unequally throughout the cultural periods and the three examined excavation areas, with the highest concentrations in trench LE792 in the Prepalatial period. More detailed analyses resulted in the same conclusion. There are no significant concentrations in the EH III-MH III Village period in

the excavated trenches. However, there is a statistically significant concentration of *Murex* in the Prepalatial period in trench LE792. In the following period, LH IIIC/PG, no significant differences in the distribution of *Murex* were detected nor were there any significant differences in the Early Iron Age. When *Murex* density for the cultural periods was analyzed in LE792 alone, the periods had statistically different distributions of *Murex*, with the Prepalatial again having the greatest amount. Furthermore, trench LE792 had a greater proportion of SUs with *Murex* than LX784. By examining the data from the multitude of angles employed in this statistical analysis, it is clear that trench LE792 in the Prepalatial period has significant concentrations of *Murex* shell.

Since the fracture patterns of the shells are similar in all examined areas, one may conclude that purple dye production indeed is associated to a significant extent with the area of Building H in the Prepalatial period and its relative prominence peaks in the advanced stage of the Prepalatial period. It is puzzling why there is still a relatively large amount of *Murex* in the LH IIIC/PG period in trench LE792, since no architectural remains or occupational surfaces of this period have been identified in this area. Possible reasons will be discussed in the next chapter. The implications of these statistical results will be analyzed in greater detail and placed in their archaeological contexts in the next chapter as well.

Chapter 5
Discussion

The statistical analyses presented in the previous chapter have revealed significant trends in the chronological and spatial distribution of *Murex* at Mitrou. Clearly, the highest concentration of *Murex* shells crushed for dye production occurs in the area of Building H during the Prepalatial period. Statistical analysis has further demonstrated that the height of *Murex* deposition in the Prepalatial period was in the advanced LH I and LH II pottery phases and *Murex* concentrations are highest again in this area in ambiguously dated LH IIIC/PG levels. What do these results reveal about the role of purple dye production at Mitrou during the Prepalatial period? Is this activity associated with the rising elite, and was it carried out at a sufficiently large scale to have produced valuable items that could have been exchanged for copper and tin in the East?

The drastic rise in the frequency and density of *Murex* indicates that purple dye manufacture reached its greatest height in the Prepalatial period, and was associated with Building H. Not counting the LH I and LH II *Murex* dumps of Building H, which were not examined in this study, one sees that within the Prepalatial period the greatest amount of *Murex* debris within Building H dates to the late LH I and LH II pottery phases and is found in sediments lying on successive surfaces of the earthen courtyard. The two small dumps were associated with the upper LH I surface and the LH II surface. Since purple dye was manufactured in the vicinity of these surfaces during both the LH I and LH II pottery phases, this can be interpreted as a significant increase of *Murex* dye manufacture during the later Prepalatial period. This was a time of increased display of wealth on the part of Mitrou's elite, as indicated by the enlargement of Built Chamber Tomb 73, and

the greater monumentalization of its funerary enclosure wall. It also was a time of increased adoption of Mycenaean elite customs, and thus of emulation of the powerful and wealthy elites of the northeast Peloponnese (Vitale 2008; Van de Moortel and Zahou forthcoming). The contemporary increase in the frequency of *Murex* suggests that this increased wealth was the result of a rise in purple-dye production, and conversely, that the desire of Mitrou's elite to display this wealth and emulate Greece's leading elite may have fueled a further increase in *Murex* dye manufacture.

In addition to that trend, a large amount of *Murex* (MNI =108) was found in the LH IIIC/PG period in the area of Building H. This is not what we would expect if *Murex* dye production were related to the elite in that period, because elite complex H was no longer in use and the only elite structures excavated for this period were Building B in the Northeast excavation sector, set on top of the ruins of Building D, and Buildings A and E built on top of it. Before the end of the LH IIIC period, the settlement reverted to a rural state, and during the PG period, or Early Iron Age, it may have been largely egalitarian or weakly ranked under a leadership located first in Building A (EPG-LPG Early) and then in Building E (LPG). I would argue, however, that the high counts of *Murex* in the area of Building H during the LH IIIC/PG period are more related to the stratigraphic positioning of LH IIIC/PG levels than they are a reflection of the location of purple dye production at that time. Since no Palatial contexts have been encountered in trench LE792, LH IIIC/PG levels actually sit directly atop the Prepalatial strata. The larger number than expected could be the result of the kickup of earlier Prepalatial debris by random bioturbation or human activities. The pottery data support this interpretation, as the majority of the

sherds in the LH IIIC/PG SUs in trench LE792 dates to the LH I and LH II phases of the Prepalatial period.

As discussed in Chapter 1, Van de Moortel and Zahou (forthcoming) presented convincing arguments for the rise of a ruling elite at Mitrou in the LH I phase. The rise of a stronger central power is indicated by changes in burial practices and the creation of an urban settlement layout as well as the construction of two elite complexes and two elite tombs. The results of this research show that these major changes happened simultaneously with a significant increase in the deposition of crushed *Murex* shells at Mitrou, possibly reflecting a marked increase in *Murex* dye production. Moreover, in terms of spatial distribution, statistically higher concentrations of *Murex* are found in elite complex H during the LH I and LH II pottery phases, which correspond to most of the Prepalatial period. The final pottery phase of the Prepalatial period—LH IIIA:2 Early—was not identified as a separate occupation level in trenches LE792 or LX784. Thus, the chronological and spatial distribution patterns of crushed *Murex* shells at Mitrou support the first part of my research hypothesis that purple dye production is related to the rise of a political elite during the Prepalatial period.

My second research hypothesis is related to the scale of *Murex* dye production at Mitrou. Brendan Burke (1999) has proposed that *Murex* dye was used in the Aegean to dye textiles that could be exchanged for copper and tin in the East. These metals were of vital importance for the maintenance of the Aegean elites' military power. In order for Mitrou's elite to have acquired tin and copper—as well as other foreign commodities—

by trading purple textiles, it is necessary that the scale of its purple-dye production exceeded that of the household level.

An estimate of the scale of purple-dye production at Mitrou can be made using counts not only from the SUs examined in the present study, but also those reported in Veropoulidou's unpublished 2007 shell study. It must be noted that there is no overlap between Veropoulidou's counts and the ones presented here, as Veropoulidou analyzed only primary contexts deemed significant on the basis of their pottery contents, while I analyzed mixed contexts. Combining the two will allow us to make a more accurate estimate. Table 5.1 shows that the combined MNI of *Murex* used for dye production reported by Veropoulidou and myself is 1,445. This amount does not include the two *Murex* dumps from the area of Building H, as they are currently being analyzed by Veropoulidou and their data were not accessible to me. An estimated 5 kilograms of shell was recovered from these two dumps, but not all were *Murex* (Van de Moortel 2007:1). In order to include these dumps in the estimate of the scale of production for this study, we can assume that at least 3 of the 5 kilograms of shell were *Murex* shell fragments (Van de Moortel, personal communication). Based on the average MNI per kilogram of weight in my data, I tentatively estimate that 1 kilogram of *Murex* shell fragments represents an MNI of 90. Thus, the estimated 3 kilograms of *Murex* fragments in the two dumps in Building H may represent an additional 270 *Murex*, increasing the total MNI to 1,715.

Table 5.1: *Murex* data from 2007 and 2010 shell analyses

	Total SUs	***MNI***
2007 *Murex* analysis by Veropoulidou	81	746
2010 *Murex* analysis by the author	327	699
Hypothetical amount of *Murex* in LH I-II dumps	3	270
Total	**411**	**1,715**

In order to evaluate the scale of dye manufacture at Mitrou, it is necessary to recall how many *Murex* were needed to dye a specific amounts of cloth. As discussed in Chapter 3, somewhere between 4,000 and 10,000 mollusks are needed to dye a full woolen robe with a weight of 1.36 kilogram to a purple hue, according to Edmonds' and Koren's experimental data. Therefore, the total minimum of 1,715 individuals recovered from SUs analyzed thus far by Veropoulidou and myself would dye at least 254 grams of unspun wool to a deep uniform purple or 571.7 grams of wool to a "good level of purple coloration." In terms of a complete robe, it would dye only about 18% of a 1.36 kilogram robe deep purple or about 42% of this robe a "good" purple. Thus, all *Murex* from all periods at Mitrou included in Veropoulidou's and my studies and the estimated amounts from the *Murex* dumps would not be enough to dye even a single robe. If we assume that full garments were dyed a deep or a "good" royal purple, our evidence would seem to reject the hypothesis that the scale of *Murex* dye production at Mitrou was sufficiently large to produce purple cloth to be exchanged for copper and tin.

However, several considerations should be kept in mind for a proper evaluation of the data. First of all, this sample must represent only a small fraction of the total amount of *Murex* that the site contains. Maximum and minimum site-wide estimates of the total population of *Murex* at the surface area of the site can be made based on the amount of *Murex* found within our sample. Only 2.2 % of the surface area of the site has been excavated with a total of 3,584 individual SUs (excluding surface SUs). Of these, 2,705 SUs contained bulk shell. The current study has only examined 327 of these shell-bearing SUs and Veropoulidou examined another 81 SUs, making for a total of 408 SUs examined. These 408 SUs represent 15% of the total of 2,705 shell-bearing SUs excavated at the site. If we assume that the relative amounts of *Murex* in the examined SUs are representative of the entire excavated area and that dispersal patterns are similar across the rest of the excavated area, the amount of *Murex* from excavated trenches would be as much as 9,633 MNI. If we add this to the 270 MNI from the two dumps, we obtain a total of 9,903 MNI for the excavated areas.

To extrapolate these results over the rest of the site, we assume that similar occupational levels covered the entire islet. This assumption is supported by the results of Mitrou's fine-grained surface survey, which covered 25% of the islet in an intensive fashion (Van de Moortel and Zahou forthcoming: 1), and 100% in an extensive fashion (Kramer-Hajos and O'Neill 2008: 177, fig 10). These surveys suggest that EH, MH, and LH occupational levels are distributed pretty much across the islet. Considering that only 2.2% of the site has been excavated, and assuming again that the amounts found in the examined SUs are representative of the spatial distribution of *Murex* site-wide, we

calculate that the site could contain as many as 450,136 MNI of *Murex*, enough to dye 45 robes a deep purple and 112 to a "good" purple. This estimate includes all periods examined. Since Prepalatial levels included 60% of all MNI found in my study sample (Table 4.1), I estimate that site-wide Prepalatial levels contain ca. 270,000 *Murex*—enough to dye 27 robes a deep purple and 67 robes a "good" purple. These should be considered maximum estimates, however, because they are based on the assumption that similar conditions in the examined areas existed over the entire site.

A minimum estimate of MNI can be obtained by using only *Murex* counts from Trench LX784. This trench can be considered representative of the standard "noise" level of *Murex* fragments present in non-production areas at the site because it is farthest away from the *Murex* dye activity in trench LE792 and there is no indication that dye was produced there (Chapter 4). Since the surface survey confirmed that LH occupational levels are distributed across the entire islet, it is possible to project the amount of *Murex* found in the Prepalatial period in LX784 onto the whole island. In Trench LX784, Prepalatial levels had a surface area of 24 square meters and a minimum of 8 individuals (Table 4.1). Therefore, the entire surface area of the entire islet (3.6 ha) may have contained an original population of 12,000 *Murex* collected for dye production in the Prepalatial period. This estimate would have been enough to dye only one robe a deep purple or three robes a "good" purple. This is most likely an underestimate, however, because the amount of *Murex* in Building H and the northeast excavation sector was greater than in trench LX784. Moreover, this estimate does not take into account any reuse of *Murex* refuse in the material used for floors. The scale of Prepalatial production

is likely somewhere between the minimum MNI of 12,000 individuals and the maximum of 270,000. Even so, if we assume that only full robes were dyed purple, the maximum estimate of 27 to 67 robes does not represent a large number, considering that the LH I and LH II phases had a time span of about 170 to 300 years. This would still indicate a domestic scale of production, especially considering the labor intensive nature of collecting and processing *Murex* and of the manufacture of dye. It must be pointed out that there are limitations to these estimates because they assume that our sample is representative and that the rest of the site has similar dispersal patterns of *Murex*, which may turn out to be false. Moreover, part of the site has now been eroded by the sea. In spite of these limitations, these estimates are useful to discuss issues of scale.

The possibility should be considered, however, that purple in the Bronze Age Aegean was used not only for full robes but also to dye thread which would have been woven into or embroidered onto garments of different color. The scholarly literature on early *Murex* dyeing rarely, if ever, discusses the extent to which Bronze Age Aegean textiles were colored purple. Koren states that a robe of deep purple required around 10,000 mollusks, but was deep purple the most desired color in the Late Bronze Age? Furthermore, did people of the Aegean dye full garments in purple or did they dye only parts of those garments? Barber's excellent discussion of Bronze Age textiles from the Aegean and neighboring regions sheds some light on this topic.

As cloth does not preserve well in the temperate Aegean, we have scant remains of the textiles themselves, primarily burial wrappings of metal objects impregnated by metal corrosion, and impressions of fabric on pottery (Barber 1991: 145, 174). Since

these were probably not high-quality textiles, they do not tell us much about Aegean elite garments. There is one possible textile fragment dyed or painted in red and blue from the tholos tomb at Routsi, near Pylos in the southeast Peloponnese, which was excavated by Marinatos (1957: 540). Marinatos suggests that it may have been part of mat or blanket on which the man was buried, but Barber argues that it could have been a garment.

Since so few actual textiles have been found in the Aegean proper, Barber suggests examining Aegean textiles within a broader regional textile tradition, incorporating evidence from the Caucasus mountain region between Georgia and Russia. Two finds from that area show the use of multiple colors on single garments or pieces of cloth. Partially preserved garments of a tribal chief from a burial at Tsarskaja, in the Caucasus, dating to the mid to late 3rd millennium BC, included a linen-like undergarment "decorated with a purple color" and covered with red tassels as well as another garment with black on bright-yellow plaid stripes (Barber 1991: 169). There is ambiguity in Barber's account as to what the excavator meant by 'decorated with purple'. Another indication of textiles in this region is an intricate tapestry impression found beside a burial pit at the Tri Bata cemetery located in the same region and likewise dating to the 3rd millennium BC (Barber 1991: 170). The impression shows a complex and elaborate design with various patterns. Thus, Barber argues that weaving and "exuberantly elaborate patterning" are well attested in the broader regional tradition to which the Aegean belongs (Barber 1991:313).

Whereas textile fragments are very scarce, representational and epigraphic evidence from the Bronze Age Aegean reveals much more information about the

garments that were worn. Minoan and Mycenaean frescoes and figurines show figures wearing multicolored garments. We do not have representational evidence for garment colors in the Middle Bronze Age or Prepalatial period on the Greek mainland, but we do have evidence from Crete and the Cyclades. A clay figurine of a woman from Petsofá, Crete, dating to the Middle Minoan II phase, includes a dress with a series of thick contrasting stripes. Middle Minoan III to Late Minoan IB figurative wall paintings from Crete and the Cyclades display very ornate women's clothing whereas men's clothing is on the plain side (Barber 1991: 315-316). Fancy edgings and intricate patterns are commonplace for the dress of men and women. One of the most complicated examples is the dress of a seated female figure from a relief fresco at Pseira, an islet located off the north coast of East Crete (Barber 1991: 318). Each sleeve has a unique and detailed pattern, both of which are different from the pattern of the skirt (Figure 5.1). The highly intricate patterning of this dress is indicative of Barber's Classical Minoan style.

In the ensuing Late Minoan II-IIIA phase, during which Mycenaean elite culture permeated Crete and the Aegean islands, there is a continuity of preference for intricate edgings on garments and complicated patterns, only now the most beautiful and ornate patterns are found on men's loincloths. Women's clothing is still patterned, but overall plainer than in the Classical Minoan style (Figure 5.2). The Procession Fresco at Knossos

Figure 5.1: Drawing of seated female relief from Pseira, Crete (Seager 1910, Plate V)

Figure 5.2:"Mycenaean Lady" from Cult Center, Mycenae (photograph by author)

is a perfect example of this period. The patterned kilts of the male cupbearers are each unique, with elaborate tassels hanging down. The Mycenaean style of the Palatial period on the Greek mainland (LH IIIA-B) is quite different from Minoan dress (Barber 1991: 315). Overall, fabrics are plainer and decoration more conservative. Typical are the plain dresses edged with bands. The edgings are not ornate, but merely provide a contrasting color and fabric.

Although literary evidence is far scarcer, Linear B texts dating to the LM IIIA-B and LH IIIA-B periods provide additional insight into Aegean textiles. Barber notes that Linear B contains four different words for textile edgings--*onukh, odak, termi*, and *ampuk*--although the difference between these bands or edgings has not been determined (Barber 1991: 312). Texts even mention band-loom specialists, making it clear that edgings or bands were very important in Mycenaean textiles. Cloth came in a variety of colors, including white, red, and purple. Barber, like many other scholars, points out that 'purple' can actually encompass a variety of shades from reddish purple to blue, both in light or dark hues. Even more compelling evidence in support of the nature of Aegean textiles is the Linear B word *poikilos*, which means "multicolored, with variegated design" and is often used to describe textiles (Barber 1991: 313). When the epigraphic evidence is combined with the artistic depictions of clothing in the Aegean and archaeological evidence from the Caucasus region, a clearer picture of the range of possible uses of purple in Prepalatial textiles on the Greek mainland arises.

Even though Mycenaean textiles were plainer than Minoan textiles and their decoration more conservative, their garments always included different-colored edgings, and as the Linear B word *poikilos* implies, sometimes even multicolored patterns. Therefore, we should not automatically assume that purple dye was used at Mitrou to color complete robes or large pieces of textiles. Instead, we should envision the possibility that it was used also to dye edgings or threads used in multi-colored weavings or embroiderings. Mainland Greek styles in the Prepalatial period may have been ornate enough and colorful enough to have incorporated *Murex* purple into the array of colored threads used.

The hypothesis that purple dye was used in Building H at Mitrou to color thread rather than complete textiles is supported by two lines of evidence. Firstly, the LH I and LH II *Murex* heaps found in Building H were small, each containing a MNI of ca. 135. One can reasonably assume that these are the remnants of two individual production episodes. Each of these episodes would not have produced enough purple to dye a full robe, but would have dyed 19 to 45 grams of unspun wool, which could have been spun to 190 to 450 meters of fine purple thread with a spindle whorl of 8 grams (Cirulis, personal communication).

Secondly, important evidence is provided by the fact that at Mitrou forty-eight intact or fragmentary clay spools have been found that would have been suitable for holding thread. Twenty-six of those come from LH I-II levels within Building H (trenches LE792, LE793, and LE795). In addition, those trenches yielded 17 spindle whorls for spinning thread. Arinn Cirulis, who is analyzing the weaving equipment from

the site, points out that dyeing unspun wool before making it into thread yields the most durable color (Cirulis, personal communication). In contrast to the evidence for spinning, there is little evidence from Building H to support the proposition that cloth was being woven. This lack of evidence for weaving in Building H would accord well with the absence of dyeing installations, since large vats would have been needed to dye large swatches of woven textiles or garments, whereas unspun wool could have been dyed in smaller quantities in smaller receptacles, as Edmonds and Koren have clearly demonstrated. This hypothesis must remain tentative, however, because most of Building H remains to be excavated, and dye and weaving installations could lie in this unexcavated area.

If we assume that *Murex* purple was used at Mitrou to dye unspun wool for thread or even small pieces of textiles rather than complete robes, we may now reassess the issue of the scale of purple dye production in the Prepalatial period. The projected amount of *Murex* according to the earlier minimum estimate reveals an MNI of 12,000 *Murex* in the Prepalatial period over the entire site. Even though this would only dye somewhere between 1 and 3 robes to light or deep purple, the same amount would have dyed between 1,714 and 4,000 grams of unspun wool, depending on the desired hue. If we assume that in the Bronze Age Aegean about 10,000 meters of fine thread could be spun from 1 kilogram of wool with a small spindle whorl of 8 grams, it is obvious that many garments could have been embroidered with this purple thread or woven with this and other colored threads.

Another consideration is that our estimate of the scale of production would increase considerably if large dumps of *Murex* were to be found elsewhere at the site, or if we could determine in the future that *Murex* had been reused in the manufacture of lime and mixed plasters used in many places at the site. Veropoulidou (2007) already found that *Murex* was reused in the makeup of some floors, but this has not been systematically studied. It is also possible that much of the *Murex* refuse had been dumped in the sea and can no longer be recovered archaeologically. Keeping this in mind as well as the possibility that Mitrou's elite was producing purple thread instead of monochrome purple garments, one can argue that the scale of production in Prepalatial Mitrou indeed exceeded domestic level and could have provided dyed goods to be exchanged for copper and tin in the East. As a final argument in support of this interpretation, one can point out that the amounts and densities of *Murex* associated with Building H in the Prepalatial period have been shown in this study to be statistically significant, whereas the quantities and densities associated with the purple-dye installation uncovered in the courtyard of LPG Building E are not statistically significant. Since Mitrou's Early Iron Age village was at most weakly ranked, purple-dye production in Building E's courtyard must have happened on a domestic scale. Thus this difference in the significance of the spatial distribution of *Murex* again suggests that the scale of production in Building H during the Prepalatial period exceeded that of the household level.

Admittedly, extremely little bronze has been found in the Prepalatial period at Mitrou elite complexes H and D. Only one large bronze finger ring, likely made for a male, and a bronze arrowhead were recovered from monumental Built Chamber Tomb 73

inside Building D. This is not much, but metals, and especially bronze, are notoriously rare at most archaeological sites in the Aegean because they easily corrode and are often reused by later people. Given the elite's warlike disposition at Mitrou, as demonstrated by the boar's tusk helmets with which they were buried and the import of horse bridle equipment (presumably with chariot equipment) from the Balkans and as indicated by the warlike nature of Mycenaean elite culture in general, it is inconceivable that they would have not needed to import copper and tin to make bronze weapons for themselves and their warriors in support of their power.

The few other imports that were excavated from Mitrou that survived later looting could also have been obtained by trading purple-dyed thread or purple embroidery. The few gold ornaments found in Built Chamber Tomb 73 in Building D must have been imported because there are no sources of gold in this part of the Greek mainland. Known sources of gold existed in Thrace (north Aegean), in Anatolia and in Egypt in the Prepalatial period (Ogden 2000: 161). Another remarkable import is the rare horse bridle piece uncovered in a LH I destruction level within Building H (Van de Moortel and Zahou forthcoming: 8). The bridle piece is made of deer antler and decorated with a *Wellenband* decoration, which is a Balkan design. It was likely imported along with chariot equipment from the Balkans in the context of an elite exchange network. There very well could have been more luxury imports at Mitrou, but as most tombs at Mitrou had been plundered and very few destruction deposits were found in the inhabited areas, many precious goods must have disappeared from the archaeological record. Such prestigious goods and equipment may well have been obtained in exchange for *Murex*

dyed thread or embroidered textile pieces. It cannot be denied that other commodities may have been exchanged for copper and tin, such as organics like olive oil or wine. However, no evidence has been found of production installations and no botanical analysis has yet been done to support the possibility that these or any other viable commodity were being produced at Mitrou in sufficient quantities to have been used in foreign exchange.

Before concluding this discussion, it is worthwhile to comment on relative species counts of purple-producing snails and the colors possibly produced. There is a significantly larger number of *M. trunculus* than of the other two dye producing species. This could suggest that the inhabitants of Mitrou were preferentially selecting *M. trunculus* over *M. brandaris,* because they desired a dye that was more blue than red, as is the case with some of the later Phoenician dye centers that specialized exclusively in the extraction of glands from one species over the other (Ziderman 1990: 99). However, it could also have been less an act of human agency and more an effect of the environment that these species inhabit. *M. trunculus* are generally located closer to shore in the shallow waters between 1.5 and 12 meters; *M. brandaris* live at considerably greater depths of 10 to 150 meters (Ziderman 1990:99). Thus, harvesting location cannot be ruled out as a factor influencing which species was collected. Throughout the course of dye production at Mitrou, a few *M. brandaris* might have been used, since they too have been fragmented in the typical way for gland extraction. Either because of purposeful or logistical reasons, *M. trunculus* were preferentially chosen for gland extraction and it can be assumed that a more blue-purple dye was produced.

In conclusion, the second research hypothesis that *Murex* dye was used as a cash crop for trade of copper and tin cannot be rejected, as even with our minimum site-wide estimate of *Murex* remains purple dye could have been produced on a sufficient scale for dying thread for weaving or embroidering multi-colored textiles. Our maximum estimates would even allow for the dyeing of robes. These purple colored threads or embroidered designs could have been traded for copper and tin, as well as for other high-quality imports found at Mitrou, such as gold jewelry, or the horse bridle and chariot equipment.

Further research is needed to understand other aspects of the dye industry at Mitrou. It would be worthwhile to examine the faunal record for evidence of wool production. A large percentage of the animal bones recovered belonged to sheep and goat, and there should be a generally higher occurrence of sheep that were kept for wool than for meat or milk production at the site if they were being slaughtered on the islet. However, absence of significant amounts of wool-producing sheep bone on the site would not mean that the inhabitants of Mitrou were not producing wool. These sheep could have been kept in a nearby, but accessible location and they could have been slaughtered and their bones discarded off-site. A study of the faunal record could reveal information about the source of the wool being dyed. Furthermore, chemical residue analysis could determine if the clay spools actually held *Murex*-dyed thread. The presence of the dibromoindigotin pigment could confirm *Murex* purple. One clay spool has been sampled unwashed and is awaiting chemical residue analysis. The other clay spools have been washed with water, which probably has made them unusable for residue analysis. Expanding the spatial coverage of the present study would be desirable as well

in order to test whether the trends presented in this study hold true. It would be especially important to include LE795, a trench in the elite complex H where many of the clay spools were found and where also a lot of fragmented *Murex* was noted. It is expected that the data from this trench would be helpful in developing a more secure understanding of purple thread production in Building H.

Chapter 6
Conclusion

The goal of this research has been to better understand the emergence of purple dye production at Mitrou through a spatial and chronological distribution study of *Murex* shells. My hypothesis was that the emergence of *Murex* dye production is related to the rise of an elite in the Prepalatial period (LH I-LH IIIA:2 Early) and furthermore, that the scale of dye production was large enough not only to have served the needs of the household, but also to have provided a cash crop that could have been exchanged for copper and tin in the eastern Mediterranean and other luxury goods from various Aegean locations. Copper and tin were used to produce bronze for weapons, tools, and vessels and thus were essential to the military survival and status preservation of the elite. This two-pronged hypothesis was tested by multi-layered statistical analyses that sought to confirm or deny that higher concentrations of *Murex* shell are associated with elite complex H in the Prepalatial period.

A series of chi-square analyses of scaled densities confirmed the first part of my hypothesis. The emergence of dye production at Mitrou is, in fact, strongly related to the rise of the elite. By far, the largest concentrations of crushed *Murex* are located in the area Building H (Trench LE792) during the periods of its use (LHI- LHII) in the Prepalatial period. My research supports the conclusions of Veropoulidou's 2007 pilot study that purple dye production at Mitrou began in the late Middle Helladic period and intensified in the LH I phase.

The hypothesis that *Murex* dye was produced on a large enough scale to be a viable trading item in exchange for copper and tin in the East is not as straightforward to

sustain, but cannot be rejected outright either. Site-wide estimates of *Murex* refuse based on the sample examined indicate that the original population of *Murex* collected for dye production in the Prepalatial period was between 12,000 and 270,000 specimens. Modern experiments suggest that the minimum estimate would have been enough to dye only one full garment a deep color purple, or three garments a "good" purple. At first sight, this would mean that the scale of Prepalatial purple production did not exceed that of household needs. However, since we know that Mycenaeans produced very ornate, multi-colored and often banded garments, it is proposed here that *Murex* dye was produced to color raw wool for thread production. Even the minimum estimate of 12,000 *Murex* would have been sufficient, then, to produce large amounts of purple-colored threads which could have been used to make many ornate embroidered or woven textiles for export. This hypothesis is supported by the presence of spindle whorls and clay spools that could have held colored thread and the absence of weaving equipment in the elite complex of Building H. Finally, a comparison of the spatial distribution of *Murex* associated with Building H in the Prepalatial period and Building E during the Early Iron Age likewise indicates that purple-dye production in Prepalatial Building H exceeded the household level.

What might have driven the emerging political elite at Mitrou to undertake the laborious and putrid task of producing dye from the carnivorous sea-snails of the Mediterranean? We can never know *for certain* the motivations of past peoples, but our study suggests that the *purpurae insania* at Prepalatial Mitrou may have been driven by its elite's passion for wealth and power.

List of References

Aloupi, E., Y. Maniatis, T. Paradellis, and L. Karali-Yannacopoulou. 1989. Analysis of Purple Material found at Akrotiri. In C. Doumas, J.A. Sakellarakis, and D.A. Hardy (eds), *Thera and the Aegean World III, Vol. 1: Archaeology, Proceedings of the Third International Congress*, September 1989. London: 488-490.

Aristotle 1936. On Colors. In *Minor Works I.* trans. by W.S. Hett. Cambridge, MA: Cambridge University Press.

Aristotle 1910. *The Works of Aristotle: Historia Animalium Volume IV.* Trans. by D.W. Thompson. Oxford.

Apostolakou, V., P. Betancourt, and T. M. Brogan. 2010. Recent Excavations at Pacheia Ammos and Chrissi Island: A Preliminary Report. In M. Andrianakis and I. Tzachili (eds), *Archaeological Work in Crete 1: Proceedings of the 1st Meeting. Rethymnon, 28-30 November 2008*. University of Crete: Faculty of Letter Publications, 143-154.

Barber E.J.W. 1991. *Prehistoric Textiles: The Development of Cloth in the Neolithic and Bronze Ages.* Princeton, NJ: Princeton University Press.

Becker, C. 2001. Did the People in Ayios Mamas produce purple dye during the Middle Bronze Age? In H. Buitenhuis and W. Prummel (eds) *Animals and man in the past: essays in honour of Dr. A.T. Clason, emeritus professor of archaeozoology,* Rijksuniversiteit Groningen, The Netherlands: ARC Publications 122-134.

Becks, R. and C. Çakirlar 2010. Purple Dye Production at Troia [abstract]. 13th International Aegean Conference: KOSMOS: Jewelry, Adornment, and Textiles in the Aegean Bronze Age, 19-23 April 2010, University of Copenhagen.

Besnier, M. 1877-1919. *Dictionairre des Antiquites Grecques et Romaines: Tome IV. C.* Daremberg and E. Saglio (eds), Paris: Hachette, 770.

Betancourt, P., T.M. Brogan, and S. Apostolakou. 2010. The MM IIB Murex Dye Workshop at Pefka near Pacheia Ammos, East Crete. Paper read at the 13th International Aegean Conference: KOSMOS: Jewelry, Adornment, and Textiles in the Aegean Bronze Age, 19-23 April 2010, University of Copenhagen.

Bikai, P. 1990. The Phoenicians: Rich and Glorious Traders of the Levant. *Archaeology* 43: 22-30.

Bizio, B. 1833. Scoperta del principio purpureo nei due Murex brandaris e trunculus Lina, e studio delle sue proprietà. *Annali delle Scienze del regno Lombardo-Veneto* 3:346-364.

Blegen, C.W. 1937. Excavations at Troy, 1937. *American Journal of Archaeology* 41: 553-597.

Born, W. 1937. Purple. *Ciba Review* 1: 106-111.

Bosanquet, R.C. 1904. Some Late Minoan Vases Found in Greece. *The Journal of Hellenic Studies* 24: 317-329.

1939/1940. Dicte and the Temples of Dictaean Zeus. *The Annual of the British School at Athens* 40: 60-77

Bruin, F. 1970. Royal Purple and the Dye Industries of the Mycenaeans and Phoenicians. In M. Mollat (ed) *Societes et compaignes de commerce en Orient et dans l'Ocean Indien; actes du huitieme Colloque international d'histoire maritime* (Beyrouth, 5-10 septembre1966). Bblioteque Generale de l'Ecole Practique des Hautes Etudes, 73-90.

Burke, B. 1999. Purple and Aegean Textile Trade in the Early Second Millennium BC. In P.P. Betancourt et al. (eds) *Meletamata: Studies in Aegean Archaeology Presented to Malcolm H. Wiener as He Enters His 65th Year*. *Aegaeum 20*. Leige, Belgium: Universite de Liege, 76-82.

Chehab, E. M. 1969. *Tyre: Through the Ages.* Beirut: Dar el-Mashreq Publishers.

Claasen, C. 1998. *Shells*. Cambridge, UK: Cambridge University Press.

Coldstream, J.N. and G. Huxley. 1972. *Kythera: excavations and studies conducted by the University of Pennsylvania Museum and the British School at Athens.* London: Faber.

Cooksey, C.J. 2001. Tyrian Purple: 6,6'-Dibromoindigo and Related Compounds. *Molecules* 6: 736-769.

Cosmopoulos, M.B., H. J. Greenfield, and D. Ruscillo. 2003. Animal and Marine Remains from the New Excavations at Eleusis: An Interim Report. In E. Kotjabopoulou et al. (eds) *Zooarchaeology in Greece, Recent Advances.* Great Britain: British School at Athens, 145-152.

David, W. 2007. Gold and Bone Artefacts as Evidence of Mutual Contact Between the Aegean, the Carpathian Basin, and Southern Germany in the Second Millennium BC. In I. Galanaki, et al (eds.) *Between the Aegean and Baltic Seas: Prehistory Across Borders.* Liège and Austin: Aegaeum 27, 411-420.

Davis, J.L. 2001. Review of Aegean Prehistory I: The Islands of the Aegean. In T. Cullen (ed.) *Aegean Prehistory: A Review.* Boston: Archaeological Institute of America, 19-76.

Dickinson, O. 1994. *The Aegean Bronze Age.* Cambridge, UK: Cambridge University Press.

Edmonds, J. 2000. *The Mystery of Imperial Purple Dye.* Historic Dye series no. 7, Little Chalfont: published by the author.

Greenspan, A. 2003. Bromine. *Chemical and Engineering News* 81(36): 96.

Guarducci, M. 1940. Contributi alla Topografia della Creta Orientale. *Rivista di Filologia* 18: 99-107.

Jensen, L.B. 1963. Royal Purple of Tyre. *Journal of Near Eastern Studies* 22(2): 104-118.

Karali-Yannacopoulou, L. 1989. Sea-Shells, Land Snails, and Other Marine Remains from Akrotiri. In C. Doumas (ed), *Thera and the Aegean World III, Vol. 2: Earth Sciences: Proceedings of the Third International Congress*, September 1989. London: 410-415.

Karmon, N. and E. Spanier. 1987. Archaeological Evidence of the Purple Dye Industry from Israel. In I. Herzog (Ed.), *The Royal Purple and Biblical Blue*. Jerusalem: Keter, 147-158.

Knapp, A.B. 1990. Ethnicity, Entrepreneurship, and Exchange: Mediterranean Inter-Island Relations in the Late Bronze Age. *BSA* 85:115-153.

Koren Z.C. 2005. The First Optimal All-*Murex* All-Natural Purple Dyeing in the Eastern Mediterranean in a Millennium and a Half. In J. Kirby (ed). *Dyes in History and Archaeology* 20*.* London: Archetype Publications, 136-149.

Kramer-Hajos, M. and K. O'Neill. 2008. The Bronze Age Site of Mitrou in East Lokris: Finds from the 1988–1989 Surface Survey. *Hesperia* 77(2): 163-270

Marinatos, S. 1957. A Magnificent Find of Homeric Gold and Gems from an Unplundered Tomb at Nestor's Pylos. *The Illustrated London News* 230 (April 6): 540-543.

McGovern, P.E. and R.H. Michel. 1985. Royal Purple Dye: Tracing Chemical Origins of the Industry. *Analytical Chemistry* 57(14): 1514 A-1522B.

1987. The Chemical Processing of Royal purple Dye: Ancient Descriptions as Elucidated by Modern Science. *Archeomaterials* 1(2): 135-143.

1990 A. Royal Purple Dye: The Chemical Reconstruction of the Ancient Mediterranean Industry. *Acc. Chem. Res*. 23: 152-158.

1990 B. The Chemical Processing of Royal purple Dye: Ancient Descriptions as Elucidated by Modern Science, Part II. *Archeomaterials* 4(1): 97-104.

Moran, W. L. 1992. *The Amarna Letters.* Baltimore: John Hopkins University Press.

Muhly, J.D. 2003. Trade in Metals in the Late Bronze and Iron Ages. In N.C. Stampolides and V. Karageorghis, (eds) *PLOES: Sea Routes and Interconnections in the Mediterranean 16th-6th c. BC.* Athens: University of Crete, 141-150.

Murphy, T. 2004. *Pliny the Elder's* Natural History: *The Empire in the Encyclopedia.* Oxford: Oxford University Press.

Ogden, J. 2000. Metals. In P.T. Nickolson and I. Shaw (eds), *Ancient Egyptian Materials and Technology.* Cambridge, UK: Cambridge University Press, 148-176.

Pliny the Elder. 1967 *Naturalis Historia* Volume II: Libri VII-XV. L. Ian and C. Mayoff (eds.). Stutgardiae, Germany: Teubner.

Plutarch.1919. *Lives, VII, Demosthenes and Cicero, Alexander and Caesar*. Trans by. B. Perrin. Loeb Classical Library.

Poursat, J-C. 1992. *Guide de Malia au temps des premier palais: Le Quartier Mu.* Athenes: Ecole Francaise D'Athenes.

Pritchard, J.B. 1978. *Recovering Sarepta, A Phoenician City.* Princeton, NJ: Princeton University Press.

Reese, D.S. 1980. Industrial Exploitation of *Murex* Shells: Purple-dye and Lime Production at Sidi Krhrebish, Benghazi (Bernice). *Libyan Studies: Annual Report of the Society of Libyan Studies* 11: 79-93.

1987. Palaikastro Shells and Bronze Age Purple Dye Production in the Mediterranean Basin. *The Annual of the British School at Athens* 82: 201-206.

2000. Appendix 6.1: Iron Age Shell Purple-Dye Production in the Aegean. In J.W. Shaw and M.C. Shaw (eds.). *Kommos IV: The Greek Sanctuary*. Princeton, NJ: Princeton University Press, 643-646.

Reinhold, M. 1969. On Status Symbols in the Ancient World. *The Classical Journal* 64(7): 300-304.

1970. History of Purple as a Status Symbol in Antiquity. *Collection Latomus* 116: 1-73.

Ruscillo, D. 2006. Faunal Remains and *Murex* Dye Production. In J.W. Shaw and M.C. Shaw (eds). *Kommos V: The Monumental Minoan Buildings*. Princeton, NJ: Princeton University Press, 776-840.

Rutter, J. 1993. Review of Aegean Prehistory II: The Prepalatial Bronze Age of the Southern and Central Greek Mainland. *American Journal of Archaeology* 97(4): 745-797.

2005. *The Prehistoric Archaeology of the Aegean* (online textbook). Hanover, NH: Dartmouth College. Retrieved January 2011 from http://projectsx.dartmouth.edu/history/bronze_age/index.html

Seager, R.B. 1910. *Excavations on the Island of Pseira.* Philadelphia: University of Pennsylvania Museum Publications.

Shaw, J.W. 2006. The History and Functions of the Monumental Minoan Buildings at Kommos. In J.W. Shaw and M.C. Shaw (eds). *Kommos V: The Monumental Minoan Buildings*. Princeton, NJ: Princeton University Press, 846-854.

Stieglitz, R.R. 1994. The Minoan Origin of Tyrian Purple. *Biblical Archaeologist* 57(1): 46-54.

Stern, E. and I. Sharon. 1987. Tel Dor:1986 Preliminary Report. *Israel Exploration Journal* 37: 201-211.

Stewart, A. 2003. *The History of Tel Dor.* Berkley, CA: University of California, Berkley. Retrieved April 20, 2011 from http://arf.berkeley.edu/projects/teldor/history/index.htm

Van de Moortel, A. 2006. Middle Minoan IA and Protopalatial Pottery. In J.W. Shaw and M.C. Shaw (eds). *Kommos V: The Monumental Minoan Buildings*. Princeton, NJ: Princeton University Press, 264-377.

2007. *Mitrou Director's Report.* Unpublished internal report, Mitrou Archaeological Project.

2010. Interconnections between the Western Mesara and the Aegean in the Middle Bronze Age. In A. Philippa-Touchais et al. (eds). *Mesohelladika: The Greek Mainland in the Middle Bronze Age.* Athens: École française d'Athènes, 875-884.

Van de Moortel, A and E. Zahou Forthcoming. Five Years of Archaeological Excavation at the Bronze Age and Early Iron Age Site of Mitrou, East Lokris (2004-2008): Preliminary Results. In A. Mazarakis Ainian and A.Doulgeri-Intzesioglou (eds.), *3rd Archaeological Meeting of Thessaly and Central Greece 2006-2008 From Prehistory to the Contemporary Period,* Volos.

Verhecken, A.1994. Experiments with dyes from European purple-producing shell-fish. *Dyes in History and Archaeology* 12: 32-35.

Veropoulidou, R. 2007. *Shell Report.* Unpublished internal report, Mitrou Archaeological Project.

Veropoulidou, R., S. Andreou, and K. Kotsakis. 2005. Small-scale purple-dye production in the Bronze Age of Northern Greece: the Evidence from the Thessaloniki Toumba. In Afrano, C. and Karali, L. eds. Vestidios, Textiles Y Tintes. Estudios sobre la produccion de bienes de consume en la Antiguedad. Actas del II Symposium Intarnacional sobre Textiles y Tintes del Mediterraneo en el mundo antiguo (Atenas, 24 al 26 de noviembre, 2005). Purpureae Vestes II (Textiles and Dyes in Antiquity). Universitat de Valencia, 1-19.

Vitale, S. 2008. Ritual Eating and Drinking at LH IIIA2 Early Mitrou, East Lokris, Evidence for Mycenaean Feasting Activities? In L.A. Hitchcock, R. Laffineur, and J. Crowley (eds) *DAIS: The Aegean Feast, Proceedings of the 12th International Aegean Conference 25-29 March 2008. Aegaeum 20*. Leige, Belgium: Universite de Liege, 229-237.

Vitruvius. 1914. *The Ten Books on Architecture.* Trans. by M.H. Morgan. Cambridge, MA: Cambridge University Press.

Ziderman, I.I. 1990. Seashells and Ancient Purple Dyeing. *Biblical Archaeologist* 53(2): 98-101.

Vita

Rachel Vykukal was born in Hitchcock, Texas. At the age of five, she and her family relocated to Spartanburg, SC, where Rachel attended primary and secondary school. She graduated Salutatorian of Boiling Springs High School in May 2001 and later that year enrolled in the College of Charleston to pursue majors in Studio Art and Anthropology. She graduated *summa cum laude* from the College of Charleston in May 2005 with a BA in Studio Art and a BS in Anthropology, along with a minor in Arts Management. Rachel spent the next few years working as an archaeologist at various sites in the southeastern United States, as well as in France and Greece. Her most rewarding position was working as a Staff Archaeologist for Charles Towne Landing State Park in Charleston, SC in 2006-2007. She returned to College of Charleston in the fall of 2008 to complete the requirements for a classically focused AB degree in Anthropology, which was conferred in May 2009. Rachel enrolled in the University of Tennessee the following fall to pursue an MA degree in Anthropology with a concentration in Mediterranean Archaeology. She is expected to graduate from the MA program in the summer 2011 and begin the PhD program the following fall. Her research interests include Bronze Age craft industries, archeological chemistry, and chemical residue analysis.