

USING GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN  
SPATIAL ANALYSIS OF MORTUARY PRACTICES IN  
THE KELLIS 2 CEMETERY, DAKHLEH OASIS, EGYPT

by

HEBA ABD ELSALAM  
B.A. Cairo University, 2003

A thesis submitted in partial fulfillment of the requirements  
for the degree of Master of Arts  
in the Department of Anthropology  
in the College of Sciences  
at the University of Central Florida  
Orlando, Florida

Summer Term  
2011

© 2011 Heba Abd Elsalam

## **ABSTRACT**

This thesis focuses on the use of geographic information systems (GIS) to examine mortuary practices in the Romano-Byzantine period Kellis 2 cemetery located in the Dakhleh Oasis, Egypt. The first research objective examines the relationship between age, sex and grave substructures of 701 burials in Kellis 2 cemetery. The aim of this research objective was to determine if the presence and style of grave substructures were influenced by sex or age. Although not statistically significant, GIS analysis revealed that most of the graves in the Kellis 2 cemetery have no associated substructures, but of those that did have associated substructures, adult male burials were more likely to have a substructure than adult females or juveniles. Moreover, males and females aged from 22 to 50 years were more likely to have an associated substructure than younger and older individuals. In the juvenile age categories, newborns and children aged 1 to 5 years were more likely to have an associated substructure than the other juvenile age categories. This may be related to the second research objective which focused on the spatial relationship between infant and adult burials in the Kellis 2 cemetery. The second objective was to determine if infants were more likely to be buried between two adults, perhaps representing family units. GIS and statistical analysis revealed that the infants in the Kellis 2 cemetery were more likely to be buried closer to each other or to adult females than to adult males. Of those 25 infants buried between two adults most of them were either buried between two adult females, or between an adult male and female. Only three infants were found buried between two males. Interestingly, many of the adult females buried in close proximity with an

infant were of child-bearing age. GIS was a very useful tool for examining questions of mortuary practices, particularly in examining spatial relationships between variables recorded for the Kellis 2 cemetery.

To Allah

## **ACKNOWLEDGMENTS**

There are too many people and too little space. I would like to express my deepest gratitude to my mentor and academic advisor, Dr. Dupras. Not only did she help me during my research, but she also was so kind with me. I give special appreciation to all my committee members; Dr. Dupras, Dr. Williams, Dr. Wheeler and Dr. McIntyre. There are no words that can express my appreciation to them. In addition, I would like to acknowledge all the help and support from my friends and colleagues: Jacqueline Sivén, Elizabeth Okrutny, Danielle Dangerously, Victoria Ingalls, Asia, Sama and Amanda Groff for their help. I would also like to thank Dr. Paul Kucera and Dr. John Walker for helping me with GIS. I would also like to thank my great wonderful husband Ahmed for his help and support. Very special thanks to my Mom, my sisters Dina and Aya, and my brother Nader for their encouragement and prayers.

## TABLE OF CONTENTS

LIST OF FIGURES .....	x
LIST OF TABLES .....	xiii
CHAPTER ONE: INTRODUCTION.....	1
Overview .....	1
The Dakhleh Oasis .....	2
Kellis.....	2
Kellis 2 Cemetery.....	2
Research Objectives .....	3
References .....	4
CHAPTER TWO: THE RELATIONSHIP AMONG AGE, SEX AND SUBSTRUCTURES IN THE KELLIS 2 CEMETERY .....	5
Introduction .....	5
The Use of GIS in Spatial Analysis in Archaeology.....	6
Placing the Kellis 2 Cemetery in a Temporal Context: The Early Christian and Late Roman Periods in Egypt .....	9
Roman and Christian Periods in the Dakhleh Oasis .....	10
The Dakhleh Oasis and Kellis, Egypt .....	11
Methodology .....	14
Statistical Analysis .....	18

Kellis 2 Cemetery Substructures .....	18
Results .....	20
Results of the GIS and Spatial Analyses of Substructures Associated with Adult Females .	26
Results of the GIS and Spatial Analyses of Substructures Associated with Adult Males ....	35
Results of the GIS and Spatial Analyses of Substructures Associated with Juveniles .....	44
Discussion .....	54
Conclusion.....	60
References .....	62
<b>CHAPTER THREE: SPATIAL RELATIONS BETWEEN ADULT AND INFANT BURIALS</b>	<b>68</b>
Introduction .....	68
The History of Studying Mortuary Archaeology .....	69
Geographic Information Systems (GIS).....	73
GIS Data Structures.....	73
Geographic Information Systems and Archaeology.....	74
Dakhleh Oasis, Egypt.....	75
Kellis Townsite.....	76
Kellis 2 Cemetery .....	78
Mortuary Practices in the Kellis 2 Cemetery .....	79
Methodology .....	79
Frequencies.....	85
Chi-Square Test.....	86
Results for the North Half of Kellis 2 .....	86



Results for the South Half of Kellis 2 .....	88
Discussion .....	89
Conclusion.....	90
References .....	91
CHAPTER FOUR: CONCLUSIONS.....	100
Overview .....	100
The Relationship between the Substructure Styles and Burial Demographics .....	100
Spatial Relationship Between the Infants and the Adults Buried Next to Them .....	103
Final Comments .....	103

## LIST OF FIGURES

Figure 1: The location of the Dakhleh Oasis in Egypt.....	12
Figure 2: The Dakhleh Oasis showing the location of Kellis. ....	13
Figure 3: Map of the Kellis 2 Cemetery (Williams 2008).....	15
Figure 4: Example of section views of vaulted substructures at the Kellis 2 cemetery: a-b, found with and without plaster ‘caps’ covering the vaulted bricking (Wheeler 2009).....	19
Figure 5: Plan view examples of head and foot niches at the Kellis 2 cemetery. These features are found in combination with all types of super- and substructures (Wheeler 2009). ....	19
Figure 6: Cross-section illustrations of Kellis 2 substructures styles (after Wheeler 2009). Each depicts the burial cut with placement of mud bricks. ....	21
Figure 7: The distribution of age categories in the Kellis 2 cemetery. ....	22
Figure 8: The distribution of adult males, females and juveniles in the Kellis 2 cemetery.....	23
Figure 9: The distribution of substructure styles in the Kellis 2 cemetery. ....	24
Figure 10: The distribution age categories of adult females in the Kellis 2 cemetery.....	27
Figure 11: The distribution of substructure styles associated with adult females in the A1 category (16-21 years old). ....	28
Figure 12: The distribution of substructure styles associated with adult females in the A2 age category (22-35 years). ....	29
Figure 13: The distribution of substructure styles associated with adult females in the A3 age category (36-50 years). ....	30
Figure 14: The distribution of substructure styles associated with adult females in the A4 age category (51-60 years). ....	31
Figure 15: The distribution of substructure styles associated with adult females in the A5 age category (60+ years). ....	32
Figure 16: The distribution of adult male age categories. ....	36

Figure 17: The distribution of substructure styles associated with adult males in the A1 age category (16-21 years). .....	37
Figure 18: The distribution of substructure styles associated with adult males in the A2 age category (22-35 years). .....	38
Figure 19: The distribution of substructure styles associated with adult males in the A3 age category (36-50 years). .....	39
Figure 20: The distribution of substructure styles associated with adult males in the A4 age category (51-60 years). .....	40
Figure 21: The distribution of substructure styles associated with adult males in the A5 age category (60+ years). .....	41
Figure 22: The distribution of juvenile age categories in the Kellis 2 cemetery. ....	45
Figure 23: The distribution of substructure styles associated with the juvenile F age category (18-36 weeks gestation). .....	46
Figure 24: The distribution of substructures styles associated with the juvenile P age category (37-40 weeks gestation). .....	47
Figure 25: The distribution of substructure styles associated with the juvenile N age category (birth - 1 year). .....	48
Figure 26: The distribution of substructure styles associated with the juvenile C1 age category (1-4 years). .....	49
Figure 27: The distribution of substructure styles associated with the juvenile C2 age category (5-10 years). .....	51
Figure 28: The distribution of substructure styles associated with the juvenile C3 age category (10-15 years). .....	52
Figure 29: Graph showing the number of male, female and juvenile individuals associated with each substructure style. “0” represents no associated substructure. See Table 3 and Figure 6 for explanation of styles 1-16. ....	55
Figure 30: Graph showing prevalence of substructure styles (based on the whole population) for only those individuals with a substructure present. ....	55
Figure 31: Graph showing the prevalence of substructure styles (based only on those with substructures). .....	56

Figure 32: Graph showing the presence of substructures in each age category in the Kellis 2 cemetery.....	56
Figure 33: Graph showing the number of substructures per adult female age categories. ....	58
Figure 34: Graph showing the number of substructures per adult male age categories. ....	59
Figure 35: Graph showing the number of substructures per juvenile age categories. ....	61
Figure 36: The location of the Dakhleh Oasis and the site of Kellis in Egypt (adapted from Kron 2007). ....	77
Figure 37: Map showing the data divide between the north and south portions of the Kellis 2 cemetery.....	82
Figure 38: GIS map showing the location of infants buried between two adults. Squares (□) represent infants buried between two adult males, triangles (△) represent infants buried between two adult females, and circles (○) represent infants buried between an adult male and female. 83	
Figure 39: GIS map showing infants buried in close proximity to adult females. Squares (□) represent infants associated with adult females of maternity age, while circles (○) represent infants found in proximity to females who are older than maternity age. ....	84

## LIST OF TABLES

Table 1: Age categories of individuals from the Kellis 2 cemetery. ....	16
Table 2: Distribution by age category and sex of the individuals from the Kellis 2 cemetery.....	16
Table 3: Substructure style descriptions. ....	25
Table 4: Results of the cross tabulation table showing substructure by age and adult females. ..	33
Table 5: Chi-square test results examining the relationship between females and substructures.	34
Table 6: Descriptives and one-way ANOVA results to test for the relationship between substructure, age and females. ....	34
Table 7: Cross tabulation results for substructure by age for males. ....	42
Table 8: Chi square test for male age and substructures.....	43
Table 9: Descriptives and results of the One-Way ANOVA test for the relationship between substructures and male age. ....	43
Table 10: Results of cross tabulation table showing substructures by juvenile age categories....	53
Table 11: Results of the Chi-square test for the relationship between juvenile age category and substructures. ....	53
Table 12: Descriptives and one-Way ANOVA test results testing the relationship between substructure style and juvenile age categories. ....	54
Table 13: The number of infants one year and less buried between two adults. ....	85
Table 14: Results of Chi-square test. ....	86
Table 15: The results for cross-tabulation of paired graves (based on sex: Sex1 vs. Sex2) for the north part of the Kellis 2 cemetery. ....	87
Table 16: Chi-Square test result for the north half relationship between Sex1 and Sex 2. ....	87
Table 17: The results for cross-tabulation of paired graves (based on sex: Sex1 vs. Sex2) for the south part of the Kellis 2 cemetery. ....	88

Table 18: Chi-Square test result for the south half relationship between Sex1 and Sex 2. .... 89

# CHAPTER ONE: INTRODUCTION

## Overview

Geographic information systems (GIS) is a very important tool in addressing spatial associations in archaeology. GIS provides important research tools which can solve many archaeological problems. This research focuses on the use of GIS to examine spatial relationships between the graves in the Kellis 2 cemetery and the presence of substructures. GIS has become an important tool in archaeology because it can assist in locating sites, as well as helping to understand spatial relationships of sites within their environmental contexts. GIS can also help elucidate spatial patterns with archaeological sites. The main difference between GIS and other mapping and drawing systems is the spatial database. It holds a collection of spatial data which are organized in group of layers so that each group of data holds a different characteristic of study area (e.g. buildings, artifacts, etc.).

This study examines specific parameters of mortuary practices from a Romano-Byzantine Kellis 2, located in the Dakhleh Oasis, Egypt, including the spatial relationship between and among the graves in the Kellis 2 cemetery. More specifically, this research aims at identifying the relationships among grave substructures, age and sex using GIS and statistical analysis. At present, only preliminary research has been conducted on the presence and type of substructures in the Kellis 2 cemetery (Wheeler 2009). An examination of the relationship between infant and adult burials will also be conducted to look for potential familial burial patterns in the Kellis 2 cemetery.

## The Dakhleh Oasis

Dakhleh Oasis is considered to be the largest Oasis of Egypt's great Western oases. Dakhleh present between 80 km east-west and a maximum of 25 km north-south, has been occupied throughout the historical period (Bard 1999). The area is located some 600km southwest of Cairo and is centered on 25°30' N and 29°00' E. Dakhleh Oasis depended on agriculture as its primary economic source. Agriculture is considered to be the common craft for most of Dakhleh residents. The climate is hyperarid and all agricultural and domestic water needs are supplied by artesian water from subterranean aquifers through springs and wells (Bard 1999).

## Kellis

The Romano-Byzantine town site of Kellis (Ismant el-Kharab, "the Ruined") in the Dakhleh Oasis lies 2.5 km east of the modern village of Ismant (25°32' N, 29°04' E). The site of Kellis became an important administrative center of the Oasis during the 4<sup>th</sup> century, and was occupied by several thousand people (Hope 1988) Kellis is well preserved in mud-brick which attracted the DOP project to work there since 1977 ( Mills 1999). The bioarchaeological research focuses on two cemeteries connected with the ancient town of Kellis: Kellis 1 and Kellis 2 (Birrell 1999).

### Kellis 2 Cemetery

Kellis 2 cemetery is located to the northeast of Kellis. Based on archaeological evidence, the Kellis 2cemetery is thought to have been used during the later Roman and early Christian periods, circa 50-400 AD (Hope 2001; Bowen 2003). Kellis 2 is considered to be one of the best



preserved archeological sites containing a unique mortality sample. There is a suggestion that K2 contains between 3000 to 4000 burials (Molto 2001). Many of the individuals in Kellis 2 appear to be buried in clusters or groups, suggesting the cemetery may have been organized on familial lines (Molto 2001).

### Research Objectives

As of 2007, 701 burials have been excavated from the Kellis 2 cemetery. Some of the graves in the Kellis 2 cemetery have substructures of different styles. The substructures consist of mud-brick and typically cover burials. It has been suggested that substructures may be related to the age and sex of individuals (Wheeler 2009). Since the estimated ages of the burials vary between less than one-year old to 70-years old and the cemetery contains males, females and children, the first research objective is to investigate if there are any relationships among the presence of a substructure and its style, and demographic parameters such as sex and age by using GIS and statistical analysis. GIS is used to identify and analyze the location of the various substructure styles and their relationship to specific age categories for each group. In addition, this study investigates which substructure is the most common among the various demographic parameters. It is hypothesized that there is a significant relationship between the population demographics and the substructure style. The second research objective is to attempt to identify the spatial relationship among infants and fetuses and the other burials in the cemeteries by using GIS. Some of the infants and fetuses have been buried between two adults. It is hypothesized that there are specific locations in the cemetery for burying infants and fetuses and that there are spatial relationships between the location of these burials and the sex and age of adults buried close to them.

## References

- Bard, K. (Ed.). (1999). *Encyclopedia of the Archaeology of Ancient Egypt*. London: Routledge.
- Bowen, G. E. (2003). Some observations on Christian burial practices at Kellis. In G. E. Bowen & C. A. Hope (Eds.), *The Oasis Papers III: Proceedings from the Third International Conference of the Dakhleh Oasis Project* (pp. 167-182). Oxford: Oxbow Books.
- Birrell, M. (1999). Excavations in the cemeteries of Ismant el-Kharab. In C. A. Hope & A. J. Mills (Eds.), *Dakhleh Oasis Project: Preliminary Reports on the 1992-1993 and 1993-1994 Field Seasons* (pp. 29-41). Oxford: Oxbow Books.
- Hope, C. A. (1988). Three seasons of excavation at Ismant el'Gharab in Dakhleh Oasis, Egypt. *Mediterranean Archaeology*, 1, 160-78.
- Hope, C. A. (2001). Observations on the dating of the occupation at Ismant el-Kharab. In M. Marlow & A. J. Mills (Eds.), *The Oasis Papers I: The Proceedings of the First International Symposium of the Dakhleh Oasis Project* (pp. 43-59). Oxford: Oxbow Books.
- Molto, J. E. (2001). The comparative skeletal biology and paleoepidemiology of the people from Ein Tirghi and Kellis, Dakhleh Oasis, Egypt. In C. A. Marlow & A. J. Mills (Eds.), *The Oasis Papers I: The Proceedings of the First Conference of the Dakhleh Oasis Project* (pp. 81-100). Oxford: Oxbow Books.
- Mills, A. J. (1999). Introduction. In C. S. Churcher & A. J. Mills (Eds.), *Reports from the Survey of the Dakhleh Oasis 1977-198* (pp. ix-xii). Oxford: Oxbow Books.
- Wheeler, S. M. (2009). *Bioarchaeology of Infancy and Childhood at the Kellis 2 Cemetery, Dakhleh Oasis, Egypt*. Ph.D. Dissertation, Department of Anthropology University of Western Ontario, London, Canada.

## **CHAPTER TWO: THE RELATIONSHIP AMONG AGE, SEX AND SUBSTRUCTURES IN THE KELLIS 2 CEMETERY**

### Introduction

Mortuary data provides important information about societal attitudes and customs, especially in ancient Egypt (Grimal 1992). Mortuary data, especially skeletal data, provides archeologists with significant information which can assist in the understanding of the theoretical problems by emphasizing the intra-site distribution of archaeological data (Pearson 2003). The research included in this thesis aims to address the relationship among sex, age, and the presence of substructures in the Kellis 2 cemetery (K2), located in the Dakhleh Oasis, Egypt. As of 2007, there have been 701 burials excavated from the Kellis 2 cemetery. At Kellis 2 at least 8 different variations in super- and substructures have been identified (Sheldrick 1997; Wheeler 2009). This chapter aims to address any associations among age, sex and the different types of substructures found in the Kellis 2 cemetery. Geographic information systems (GIS) and statistical analysis will be used to address these research questions.

It has been hypothesized that the spatial distribution of individual graves in the Kellis 2 cemetery is related to family groups (Molto 2001; Tocheri et al. 2005). In addition to the Kellis 2 cemetery, individuals from the associated ancient village of Kellis were also buried in the Kellis 1 cemetery (an earlier Ptolemaic dated cemetery), and in the Kellis town site itself (Molto 2001, 2002), and as such only part of the population was buried at K2 cemetery ( Birrell 1999 ;

Molto 2002). Although many of the burials from the K2 cemetery are complete and undisturbed, many were disturbed by looters and sometimes parts of the remains were lost (Wheeler 2009).

Thus, the data used for analysis is only a fraction of the original population and may not be representative of the whole population. However, it has to be noted that K2 probably represents a relatively complete cross section of the later Roman early Christian population, as well as the largest collection of fetal remains.

The Kellis 2 cemetery is characterized by the presence of mud-brick superstructures (e.g., tomb structures and mastabas) and substructures. A substructure is a feature that is located below the surface of the grave cut, and may be found alone or in combination with a superstructure (Wheeler 2009). The substructures include false floors, vaulted body crypts, head crypts, and head and foot niches. Almost 29% of juveniles and 38% of adults are buried with some kind of mortuary super- or substructure (Wheeler, 2009). For this analysis, only substructures were used because they are more likely to be found with graves and most of the superstructures were eroded over time (Wheeler 2009).

### The Use of GIS in Spatial Analysis in Archaeology

Moyes (2002) pointed out that GIS is one of the greatest tools accessible for the analysis and display of archaeological records at every spatial scale. Using GIS in archaeology helps in saving the archaeologists time and effort. For instance, archaeologists spend much time mapping and drawing the archaeological site which is not an easy task due to the time involved. GIS offers very accurate and precise maps which are easy to save and access. While visualization can be used with other programs, no other system is able to create geo-referenced maps (Moyes

2002). Georeferencing ties the map with real physical coordinates of the site and allows for digitizing data sources for archaeological interpretation.

The capacity to use spatial data in different forms, and extract additional meanings is referred to as spatial analysis (Bailey 1994). To analyze and derive spatial information from archaeological sites, several methods and procedures, from disciplines such as geography and statistics, are utilized. The core of spatial analysis is based on relative and proximal locations that create spatial relationships. Three general types of spatial analysis tasks have been described by Bailey and Gatrell (1995): exploratory data analysis, visualization, and model building. Complexity in spatial analyses ranges from simple map overlay operations to statistical models. The extensive data management and display capabilities in GIS provide map overlay operations which allow for computing new values for locations based on multiple attributes or data “layers”. This also allows for identification and display of locations based on specific criteria (Tomlin 1990).

GIS was first applied in archaeology in the 1970s. The first use of GIS in archaeology was used to analyzing artifact densities, and patterns of site distribution within a region. In 1980, when the new trend in archaeology began to treat the environment as “constructed and shaped by social actions” which in turn were shaped by the environment, the true potential of GIS was realized (Wheatley and Gillings 2002:9). Once GIS became available and commercialized, and as an outcome accessible with a wider range of functions, and it became user friendly. In the 1980s GIS was commonly used by North American archaeologists and Cultural Resource Management. In the 1990s, a series of conferences stimulated the growth of interest among the European colleagues (Wheatley and Gillings 2002). Most archaeological projects regularly use GIS among their research tools.

GIS has been used to address many research questions. For instance, Maschner (1996) used it to anticipate and locate the sites of Tinglit in Alaska by analyzing the environmental parameters of known sites. Lock and Harris (1996) re-examined the areas of influence among forts at Danebury. The Ch'amak Pacha Archaeological Project used GIS to document excavations at the Jiskairumoko site in Peru (Craig et al. 2002). Selcuk University created the a GIS map of the archaeological site under the modern city of Kelenderis in Turkey for future use in conservation management, public presentation and further study (Erdi 2003). In the Maya area, the "Electronic Atlas of Ancient Maya Sites" is being created by Clifford Brown and Walter Witschey. It currently contains around 4,400 sites (<http://mayagis.smv.org>). Moyes and Awe (2000) used GIS for mapping and analysis of spatial distribution of the artifacts in Actun Tunichil Muknal cave. McKillop (2002) investigated the sea-level rise at Wild Cane Cay through analysis of artifact distribution and densities. Al-Muheisen and Al-Shorman (2004) used GIS to show its applicability in Jordan. They concluded that the visualization of sites developed from a computer-based spatial analysis was effective in interpreting the various spatial relationships among the various features at archaeological sites. In Jordan using GIS in predictive modeling and visualization of sites divorced from a computer-based spatial analysis has been applied to the interpretation of various spatial relationships among the various features at archaeological sites. The created predictive model would effectively guide the coming excavations at the sites in a cost-effective manner.

Not only does GIS help in the representation and spatial analysis of data, but it is also a tool for storage and recovery of information. Its power lies in the ability to use a diversity of customary databases, and to dynamically combine spatial and non-spatial information from different sources without significant sacrifices of storage effectiveness.

## Placing the Kellis 2 Cemetery in a Temporal Context: The Early Christian and Late Roman Periods in Egypt

After the death of Cleopatra in 30 B.C., Egypt became a Roman province, and during this time period, Egypt was essentially an agricultural region. The main crops cultivated were wheat and barley (Ferguson 2003). Therefore, Egypt was considered an important economic province, providing huge amounts of grain to the Roman Empire. Moreover, during the Greco-Roman period, animal-driven waterwheels were used causing a major growth in the quantity of land irrigated and the area of cultivable land became better than before (Bagnall 1993). In addition, the Roman Empire exploited Egypt for other products such as olives, dates, textiles, minerals such as salt and gold, precious stones, and materials for masonry such as alabaster, red granite, and imperial porphyry (Peacock 2000). Egypt was also a very important geographical connection of commercial routes from the south to the east, and important exotic products such as pearls, pepper, and silks found their way through Egypt into the Roman world (Bagnall 1993).

In contrast to earlier Ptolemaic times, the Romans did not encourage immigration to Egypt. All Roman provinces were an amalgam of Roman traditions and the local culture, so that even with Roman dominion over Egypt, the population maintained a mixture of Greek and Egyptian identity and ideology (Bagnall 1993). It is thought that Christianity was brought to Egypt by the Apostle Mark in 64 A.D. and that those who accepted his Christian message were none other than the local Egyptians (Bagnall 1993). During the first two centuries A.D., Christianity started to appear in Egypt and gained widespread acceptance in the third century A.D. Alexandria is considered to be the first Christian settlement in Egypt during this period (Koester 1995). In the second century, Christianity spread very fast in urban and rural areas (Bagnall 2009). Religious documents were written so that the local people could understand

them easily, and for that reason, it is thought that Christianity spread faster in the rural areas (Pearson 2004; Shillington 2005). Major changes in the history of Egypt and the broader Roman Empire occurred during the reigns of Diocletian (A.D. 284-305) and Constantine (A.D. 306-337). Both had transformed the current administrative structures and directly impacted the religious life of the Empire. Diocletian introduced a bipartite division of Egypt and reorganized the magistracies and councils (Rowlandson 1998). Christian persecution began in a sporadic way until the Great Persecution of Diocletian (A.D. 303-311). The imperial persecution of Christians ended during the rule of Constantine. Constantine restored property rights and status to the church, and in A.D. 313, the church received official recognition (Peacock 2000).

There is some evidence of Coptic and Christian religions found in archaeological remains in the Dakhleh Oasis. For example two churches have been discovered in Kellis and nearby areas in the Dakhleh Oasis (Bowen 1998, 2002, 2003; Gardner 2002, 2003). It is believed that Christianity had spread to and was adopted in Kellis prior to the fourth century (Bowen 2002, Williams 2008).

#### Roman and Christian Periods in the Dakhleh Oasis

Archaeological remains belonging to the Roman period have been uncovered in the Oasis, including Roman villages, and cemeteries, with major sites discovered at Smint, Amheida, and Qasr (Vivian 2000). The Dakhleh Oasis was an agricultural area in the far corner of the Roman Empire. Several crops such as wheat, barley, and cotton were cultivated by the population in the Dakhleh Oasis (Bagnall 1993). In addition, the occupants of Dakhleh used presses to make olive oil and wine. Beside agriculture, Dakhleh's population raised animals such as goats/sheep, donkeys, cows, pigs and chickens. The Dakhleh Oasis had only a few ruined



fortresses compared to the Kharga Oasis, which is known to have dozens of Roman fortresses (Rice 2003).

The population of the Dakhleh Oasis declined towards the end of the Roman period. However, Christianity spread in Dakhleh and there are several remains of Coptic churches and buildings dating back as early as the 3rd century A.D. Mills, the head of the Dakhleh Oasis Project, believes that those ruins are the most significant archaeological remains in Dakhleh (Mills 1984).

### The Dakhleh Oasis and Kellis, Egypt

The Dakhleh Oasis is located in the Western Desert of Egypt, as shown in Fig. 1. Since 1978 the Dakhleh Oasis Project has studied the Oasis to enhance the understanding of the relationship between humans and the harsh desert environment. The project is under the direction of Anthony Mills, and is an international, multidisciplinary collaboration (Mills 1999). Located about 250 km west of the Nile Valley, the Dakhleh Oasis is considered one of five major depressions in Egypt's Western Desert. The Oasis extends approximately 80 km east-west and approximately 25 km north-south and is a depression that is roughly 100 m below the surrounding desert, which is bordered by a large escarpment along the northern portion (Kleindienst et al. 1999). Moreover, the Oasis is known for seasonal extremes in temperature, with winter night temperatures reducing to freezing (Sutton 1950). However, from March through June, the Oasis has high winds and sand storms are frequent, while it remains somewhat calm in January and February (Kleindienst et al. 1999). Rain is quite rare; the annual rainfall is about 0.3 per mm/year (Sutton 1947). Generally speaking, it is thought that present environmental conditions have prevailed during the last 5,000 years (Mills 1999).



Figure 1: The location of the Dakhleh Oasis in Egypt.

The town site of Kellis (Fig. 2) was occupied by thousands of people in the fourth century AD, and during this period Kellis was a vital economic and political center in the Oasis (Hope 1988, 2001). The archaeological remains of Kellis are placed next to the ancient desert commercial route that runs into the Oasis (Hope 1988). The town center was governed by various local estate owners and Roman administrators and includes numerous households, Egyptian and Roman temples, a Roman bathhouse, two Christian churches, many Roman vaulted brick tombs and two associated cemeteries (Knudstad and Frey 1999; Hope 2001, 2002, 2003).

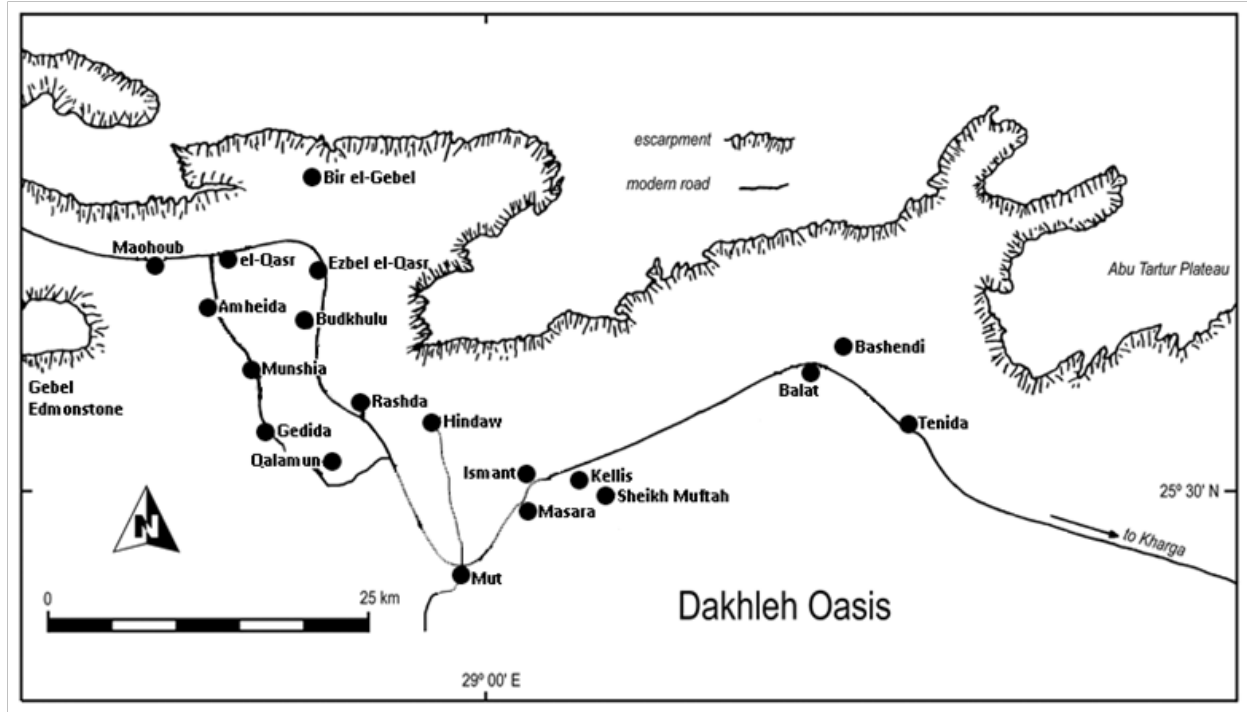


Figure 2: The Dakhleh Oasis showing the location of Kellis.

There is some archaeological evidence that indicates that Kellis was inhabited until the end of the fourth century AD until its abandonment (Hope 2001; Bowen 2003).

There are two burial sites that have been recognized as being connected with ancient Kellis. Kellis 2 cemetery consists largely of skeletonized bodies, while the earlier dated Kellis 1 cemetery consists of a succession of at least two dozen small tombs cut into the face of a sandstone terrace (Birrell 1999). The Kellis 2 mortuary practices represents a significant departure from the earlier use of rock-cut tombs that dominated Pharonic and Ptolemaic burial practices in Dakhleh and the rest of Egypt (Williams 2008). The radiocarbon dates from K2 indicate that the Christian burial practice may have been in use before Egypt became officially Christian circa A.D. 265 (Molto et al. 2006; Williams 2008). The burials at K2 cemetery are organized in single graves, each with an individual oriented in an east-west direction, a

characteristic of Christian burials, and with rectangular mausoleum type tombs that have several individuals (Fig. 3) (Williams 2008). It has been suggested that the tomb structures may have been the focal areas for the clustering or grouping of burials (Molto 2001; Kron 2007). Molto (2002) suggested that, depending on the grouping of graves within Kellis 2 and the open spaces in some sections of the cemetery, it appears that Kellis 2 is organized in a segmented and accretionary pattern and this may indicate a social grouping system within the cemetery. Molto (2002) has also hypothesized that the individuals in Kellis 2 were buried according to familial relationships, and that tomb structures formed the basis for grouping individuals. It is estimated that Kellis 2 has about 3000 to 4000 burials, and 701 of which are mapped and analyzed (Fig. 3). Archaeological and carbon dating evidence suggests that the Kellis 2 cemetery was used by inhabitants of the Kellis town during the later Roman period (about A.D. 100 – 400), which falls largely into the Christian period (A.D. 265 onward) (Bowen 2003).

### Methodology

As of 2009 there have been 701 individuals recovered from the Kellis 2 cemetery, and more than half are the remains of juveniles (under the age of 15 years) (Wheeler 2009). For the purposes of this research, individuals have been placed into four juvenile age categories, and five adult age categories. See Table 1 for the age categories and their breakdowns. Table 2 includes information regarding the breakdown of the Kellis 2 sample by age category and sex.

Since the purpose of this thesis is to address spatial relationships, Geographic Information System (GIS) is used to illustrate the relationship among sex and age of individuals and the presence of substructures in the graves of the Kellis 2 cemetery. GIS software has useful tools which can help to determine the relationship among these variables. In addition, GIS tools

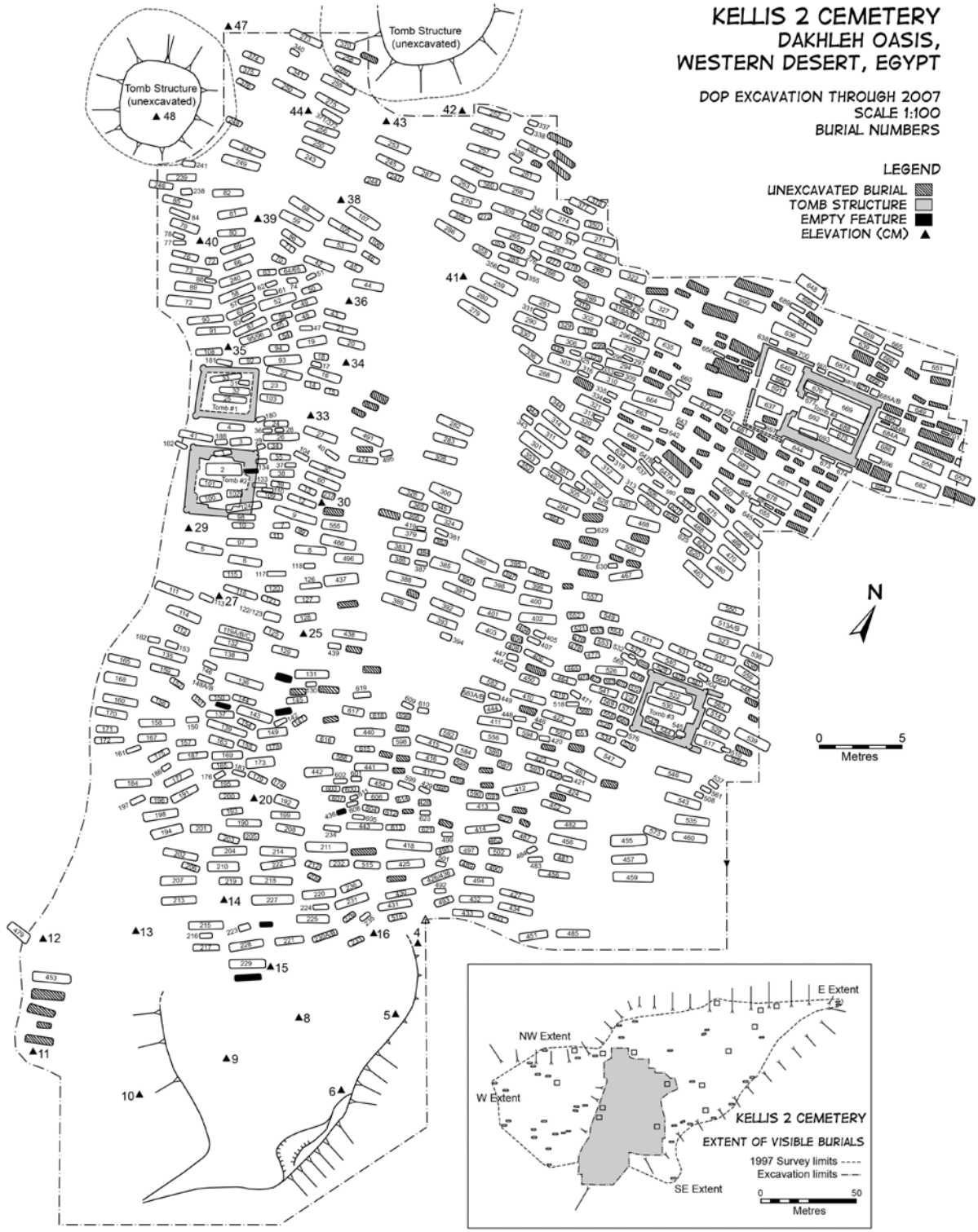


Figure 3: Map of the Kellis 2 Cemetery (Williams 2008).

Table 1: Age categories of individuals from the Kellis 2 cemetery.

Age category	Age
F	Fetuses (18-36 week gestation)
P	Perinates (37-40 weeks gestation)
N	Infant ( birth-1 years)
C1	Young children (1-4 years)
C2	Middle children (5-10 years)
C3	Older children (10-15 years)
A1	Younger adult (16-21 years)
A2	Young adult (22-35 years)
A3	Middle adult (36-50 years)
A4	Old adult (51-60 years)
A5	Older adult (60+ years)

Table 2: Distribution by age category and sex of the individuals from the Kellis 2 cemetery.

Sex	Age category	Total
F	A1	14
F	A2	56
F	A3	46
F	A4	19
F	A5	18
M	A1	10
M	A2	48
M	A3	33
M	A4	6
M	A5	8
J	F	40
J	N	178
J	P	64
J	C1	104
J	C2	48
J	C3	21
Total		701

F= female; M= male; J =juvenile

will help to determine the relationship among age, sex and substructures found with each group of individuals. For example, GIS maps will be created for males, females and juveniles to illustrate how the substructures are associated with these groups. The intent of this thesis is to design a GIS database for the storage, retrieval, editing, and analysis of data related to the Kellis 2 cemetery, and to address, what the relationship among demographics (sex and age) and the presence of grave substructure, and the location in the cemetery.

The mortuary data used in this study was obtained from Drs. Tosha Dupras, Lana Williams, and Sandra Wheeler (University of Central Florida, Department of Anthropology), all members of DOP bioarchaeology team. Global positioning satellite (GPS) data was collected by the author during the 2010/11 field season. The types of data in this research project include digitized data obtained from fieldwork, other remotely sensed and digital data, and historical data from both primary and secondary sources. These data are in digital format or have been converted into digital forms for inclusion in the GIS database. The design customizes the geodatabase object-relational model by the Economic and Social Research Institute (ESRI) to integrate these diverse data types into one GIS database. The conceptual model will identify the entities and the attributes, behaviors, and relationships that these data encompass. Subsequently the logical model will code these objects and their methods and behaviors into the geodatabase format.

GIS research on the Kellis 2 cemetery has been previously conducted by Kron (2007), who used GIS to test the hypothesis that Kellis 2 was organized according to kinship patterns based on non-metric skeletal traits. Kron (2007) used ArcGIS™ software to examine the spatial

distribution of three non-metric morphogenetic skeletal traits. The significant difference between Kron's previous work and this current research is that double positioning GPS data has been used in this project to obtain real coordinates, and the map has been georeferenced.

### Statistical Analysis

The statistical analyses in this thesis rely on demographic data to help understand the population of the Kellis 2 cemetery. SPSS software (v.18) is used for statistical analyses. Statistical tests, such as chi-square and ANOVA tests, are used to determine if there is a significant relationship among age and sex and substructure. Cross-tabulation is used to show the statistical relationship of age and sex and substructure.

The chi-square test is used to analyze cross-tabulated categorical variables. More specifically, this is used to test the independence of two variables. In addition, chi-square tests also show if the relationship between the burial and substructure is significant or not. Categorical independent variables (i.e., two or more categories) and a normally distributed interval dependent variables may be tested for differences in the means of the dependent variable using ANOVA. This breaks down the dependent variable by the levels of the independent variable.

### Kellis 2 Cemetery Substructures

The substructures recorded in the Kellis 2 cemetery consist of mud-brick constructions usually placed below the surface of the grave cut, sometimes found by itself or in combination with a superstructure (Fig. 4). Substructures can consist of a false floor and vaulted body crypts. Some of the more elaborate substructures include those with mud-brick (Fig 4). Some burials also include head or foot niches at the grave floor (Fig. 5) (Wheeler 2009).



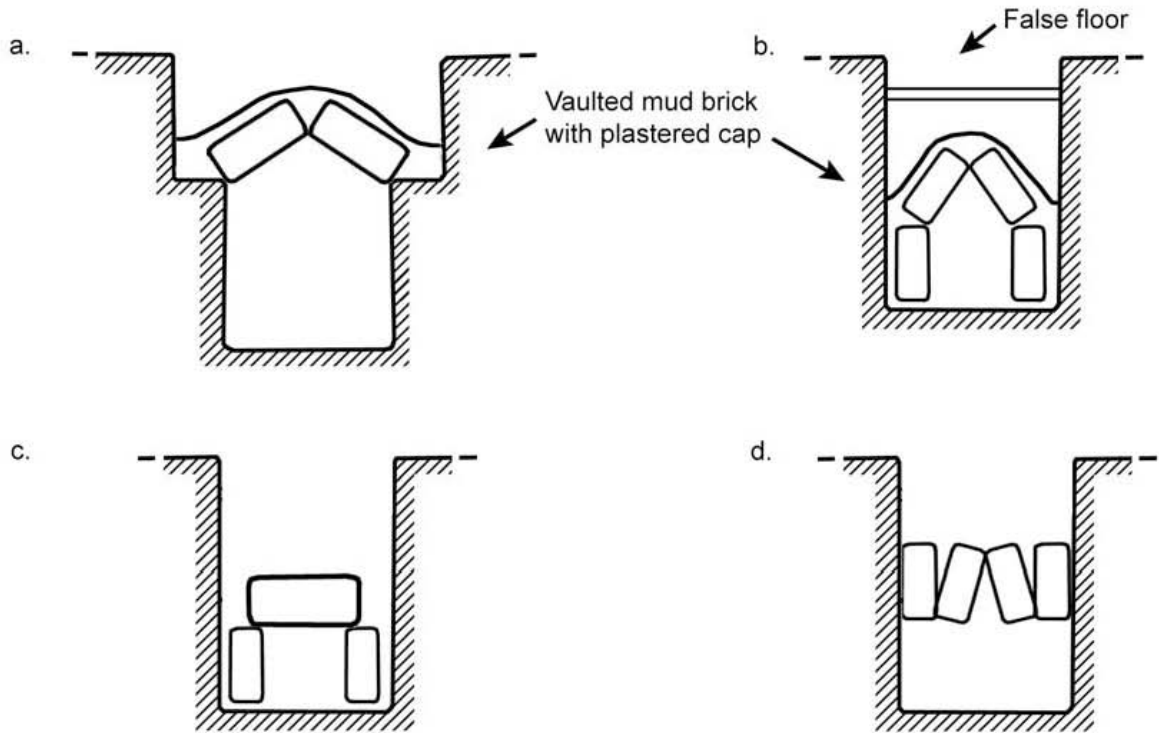


Figure 4: Example of section views of vaulted substructures at the Kellis 2 cemetery: a-b, found with and without plaster 'caps' covering the vaulted bricking (Wheeler 2009).

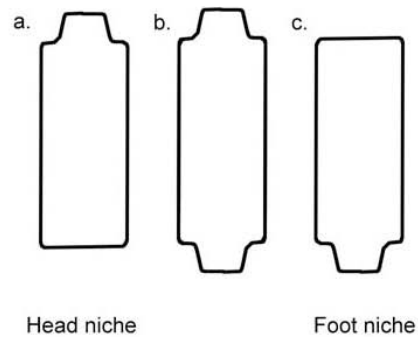


Figure 5: Plan view examples of head and foot niches at the Kellis 2 cemetery. These features are found in combination with all types of super- and substructures (Wheeler 2009).

Sixteen different types of substructures have been identified in the Kellis 2 cemetery (Fig. 6). According to Wheeler (2009), substructures are found more frequently than superstructures; however this may be due to the fact that many superstructures have been eroded over time (Wheeler 2009). The numbering system (1-16) seen in Figure 6 is used in the legends of each GIS map to designate the type of substructure. The designation “0” is used to indicate that no substructure is present. Table 2.3 provides a description of each of the substructure styles.

## Results

The following section includes all the GIS maps constructed for each of the variables considered in this chapter. Graves filled in with black represent empty graves. These graves may have been looted or not used. Figure 7 shows the distribution of all age categories in the Kellis 2 cemetery. The parameters for each age category are listed in Table 1. Figure 8 shows the distribution of adult males, females, juveniles and unknown sexed individuals. Figure 9 illustrates the distribution of the substructures 0 to 16 found in the Kellis 2 cemetery (see Table 3 and Figure 6 for descriptions). This map indicates that most of the individual burials in Kellis 2 have no associated substructures (style 0). However, all sixteen styles of substructure are present and are distributed the cemetery as shown in Figure 9.

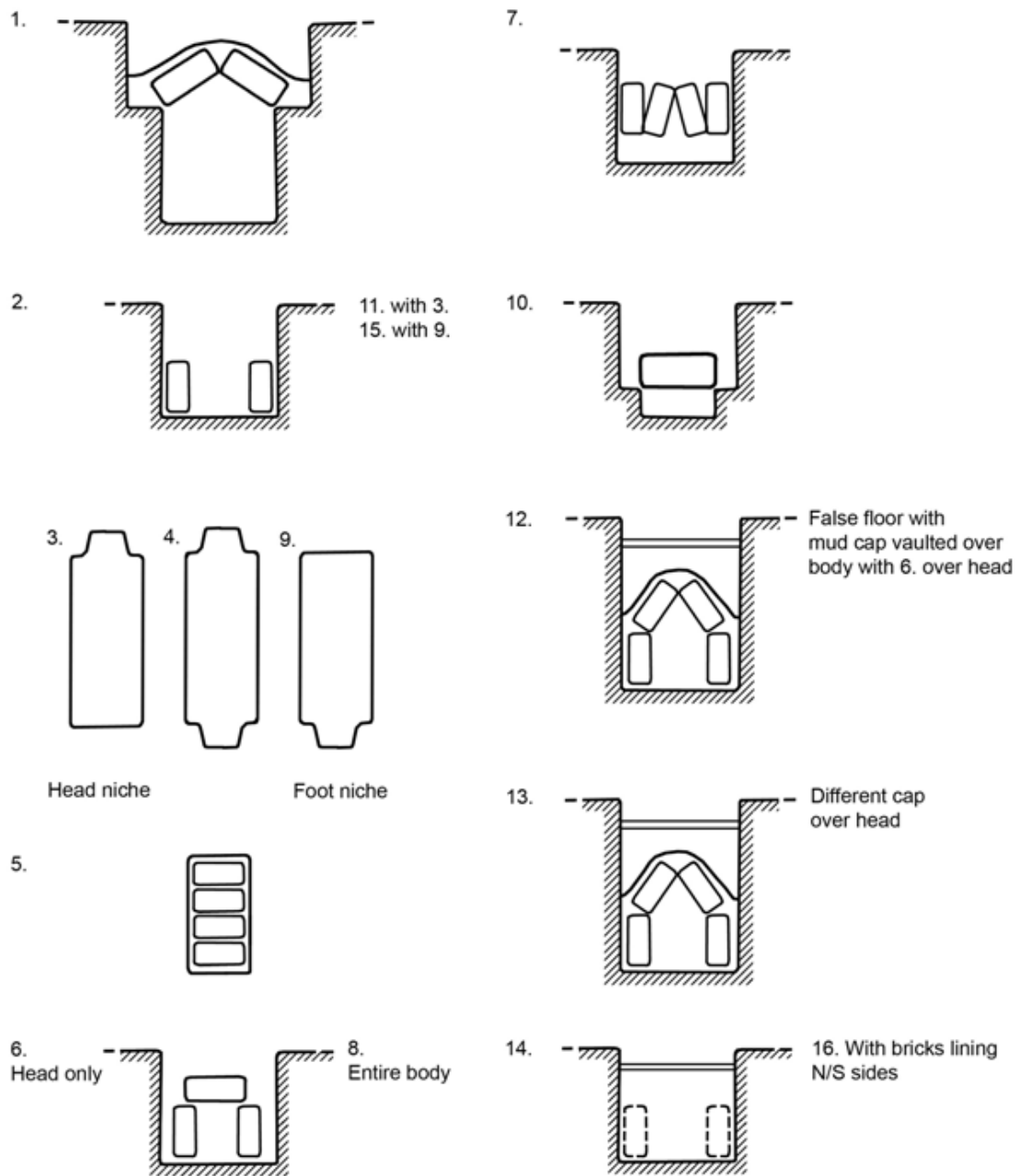


Figure 6: Cross-section illustrations of Kellis 2 substructures styles (after Wheeler 2009). Each depicts the burial cut with placement of mud bricks.

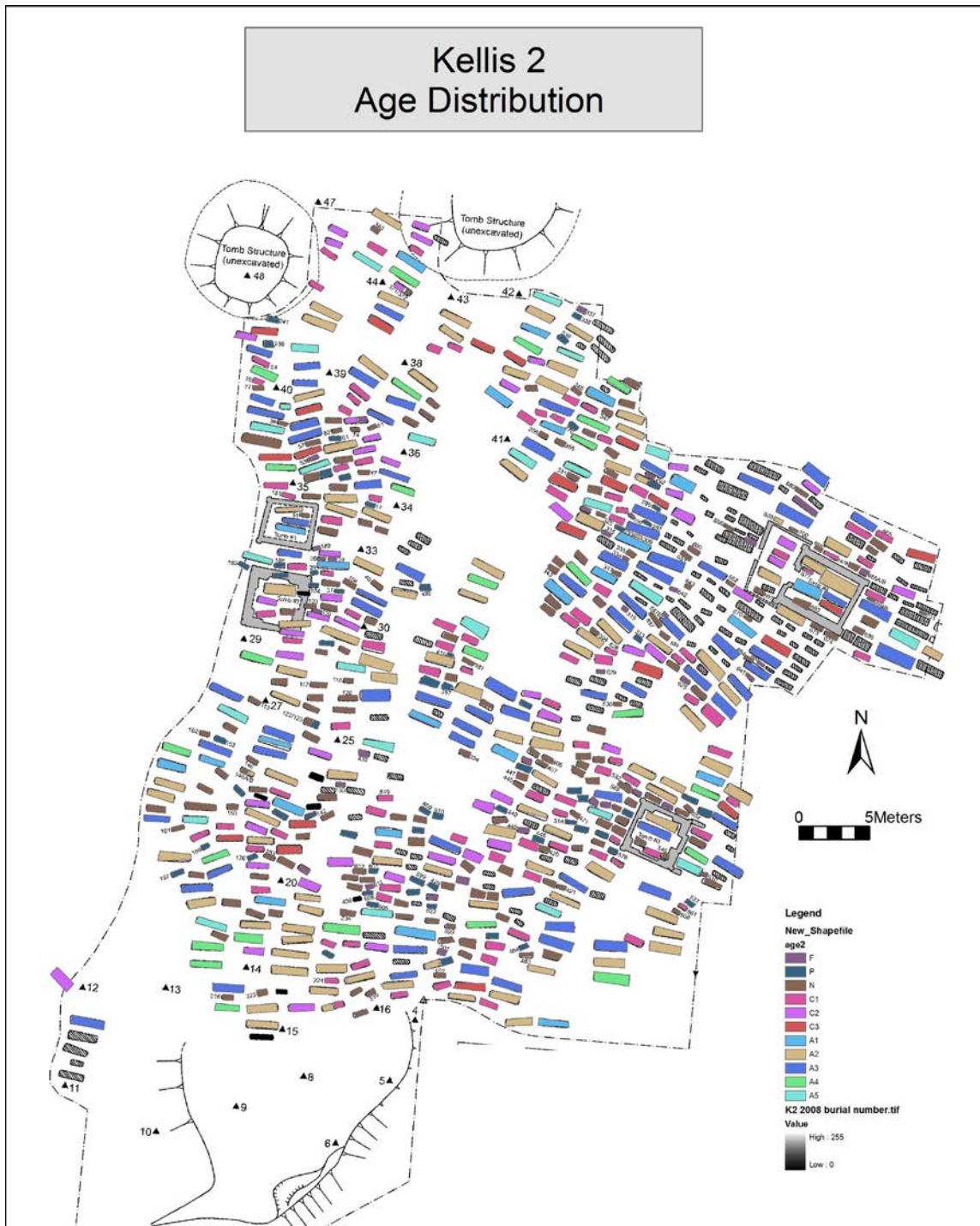


Figure 7: The distribution of age categories in the Kellis 2 cemetery.

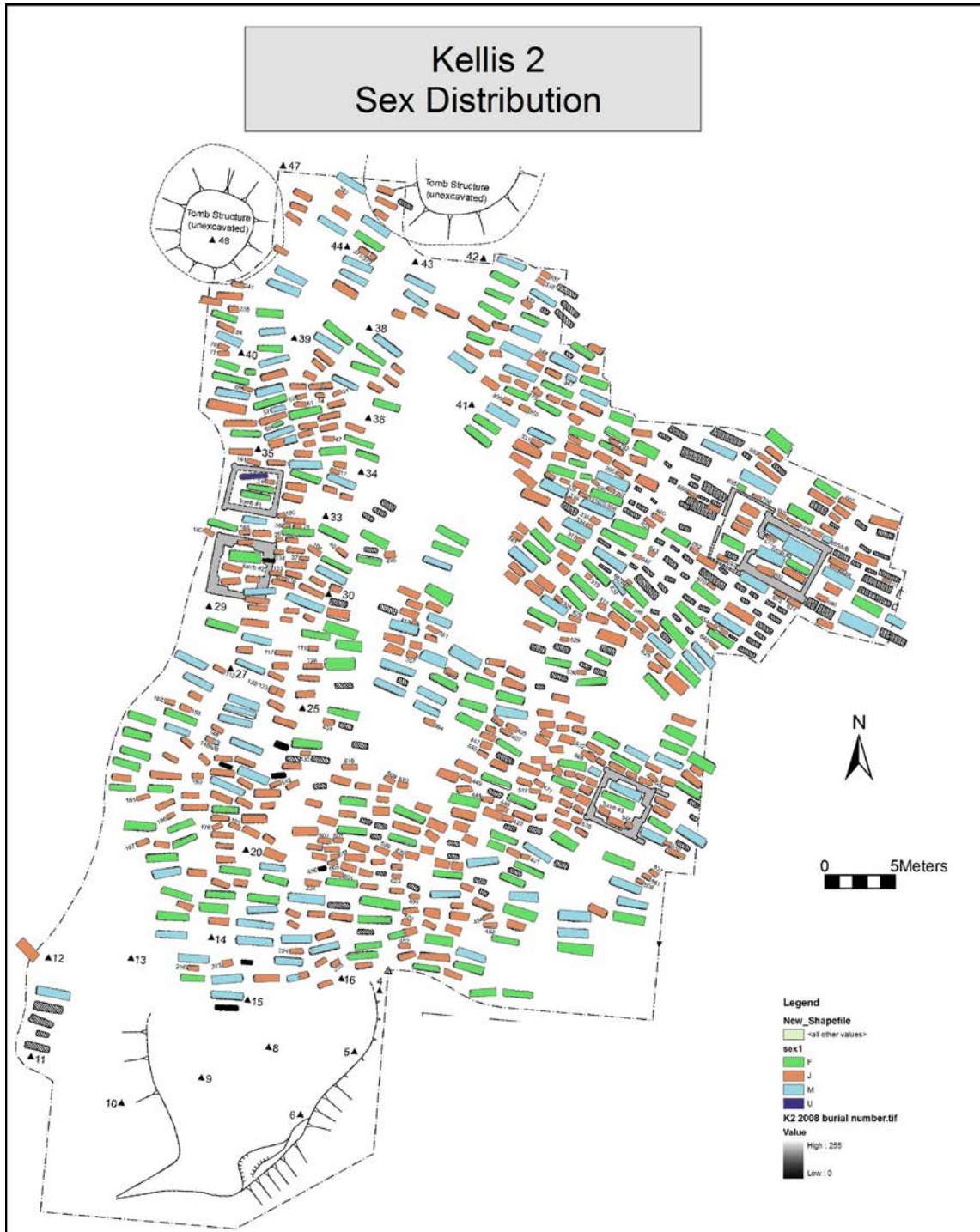


Figure 8: The distribution of adult males, females and juveniles in the Kellis 2 cemetery.



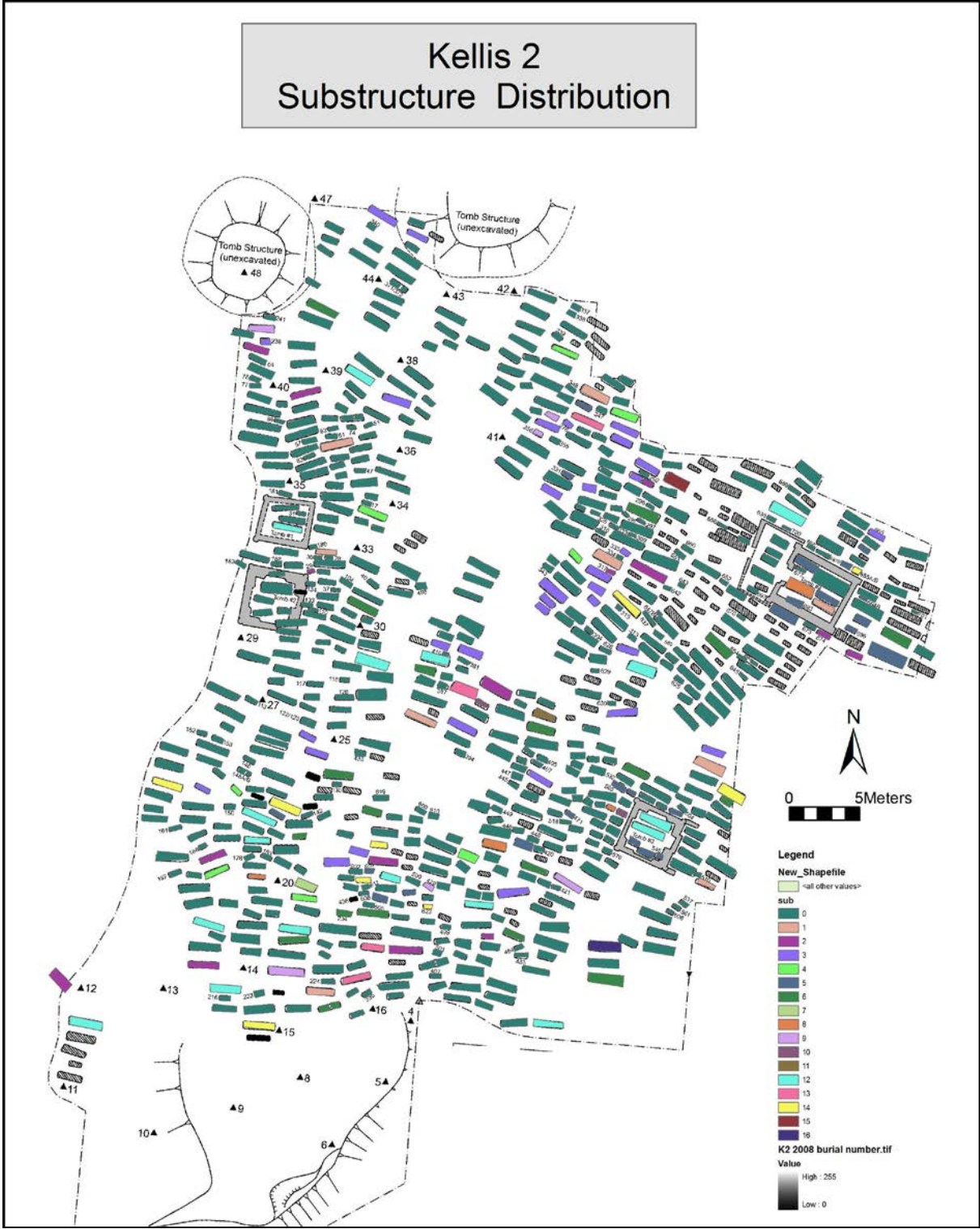


Figure 9: The distribution of substructure styles in the Kellis 2 cemetery.

Table 3: Substructure style descriptions.

Substructure Style Number	Description
0	No substructures
1	Burial cut with vaulted bricks over top.
2	Mud bricks lining north and south aspect of grave.
3	No structure of mud brick, but a built-in head niche.
4	No structure of mud brick, but a built-in head and foot niche.
5	Mud bricks lining north and south aspect of grave, and a layer of mud bricks on top.
6	Head crypt built of mud bricks.
7	Mud bricks lining both north and south sides of tomb, and mud bricks placed in vault shape placed on top.
8	Mud bricks lining north and south sides of grave, with mud bricks placed flat on top.
9	No structures of mud brick, but a built-in foot niche.
10	Burial cut is stepped-in near the bottom and mud bricks are placed flat on top of cut.
11	Mud bricks placed on the north and south side of grave, with a built-in head niche (a combination of types #2 and #3).
12	Mud brick head crypt (#6), with false floor and vaulted mud bricks.
13	Vaulted mud brick head niche with false floor.
14	False floor.
15	Mud bricks on north and south side of tomb, with built-in head niche (combination of styles #2 and #9).
16	Mud bricks on the north and south side, with a false floor.

Note : these numbers correspond to numbers designating types of substructures in Fig. 2.6. table adapted from (Wheeler 2009: 238)

## Results of the GIS and Spatial Analyses of Substructures Associated with Adult Females

The following set of maps show the distribution of substructure styles associated with adult females. Following these maps are the results of the statistical analyses. Figure 10 shows the distribution of adult female age categories in the Kellis 2 cemetery. Figure 11 shows the distribution of the substructure types associated with adult females in the A1 age category (16-21 years old). The map reveals that nine females in this age category have no substructure, two females are buried with substructure style #3, while one female has style #12, and one has style #15. The map in Figure 12 shows the distribution of grave substructures associated with adult females in the A2 age category (ages 22 to 35 years). There are 56 females in the A2 age category, and of these 39 have no substructures. Two adult female burials are associated with substructure style #1, and one female is associated with style # 2. Substructures style #3 found in with three females, and style #4 appears in one female burial. Styles #6 and #12 each appear four times and style #14 appears in two female burials. Figure 13 shows the distribution of substructures associated with adult females in the A3 age category (ages 36 to 55 years). There are 45 females in the A3 category, and three of these are associated with substructure style #2, and two females have substructure style #3. Substructures styles #4, #5, #6, #12 and #14 are only each associated with one female. Figure 14 shows the distribution of substructures of adult females in the A4 age category (51 to 60 years of age). There are 19 females categorized as A4 in Kellis 2, and 15 of these do not have any substructures. Only four individuals in this age category have substructures, styles #2, #3, #6 and #13 each appear once. Figure 15 shows the distribution of substructure styles of females classified in the A5 age category (greater than 60 years of age). There are 18 females classified in this age category, and 14 of these have no



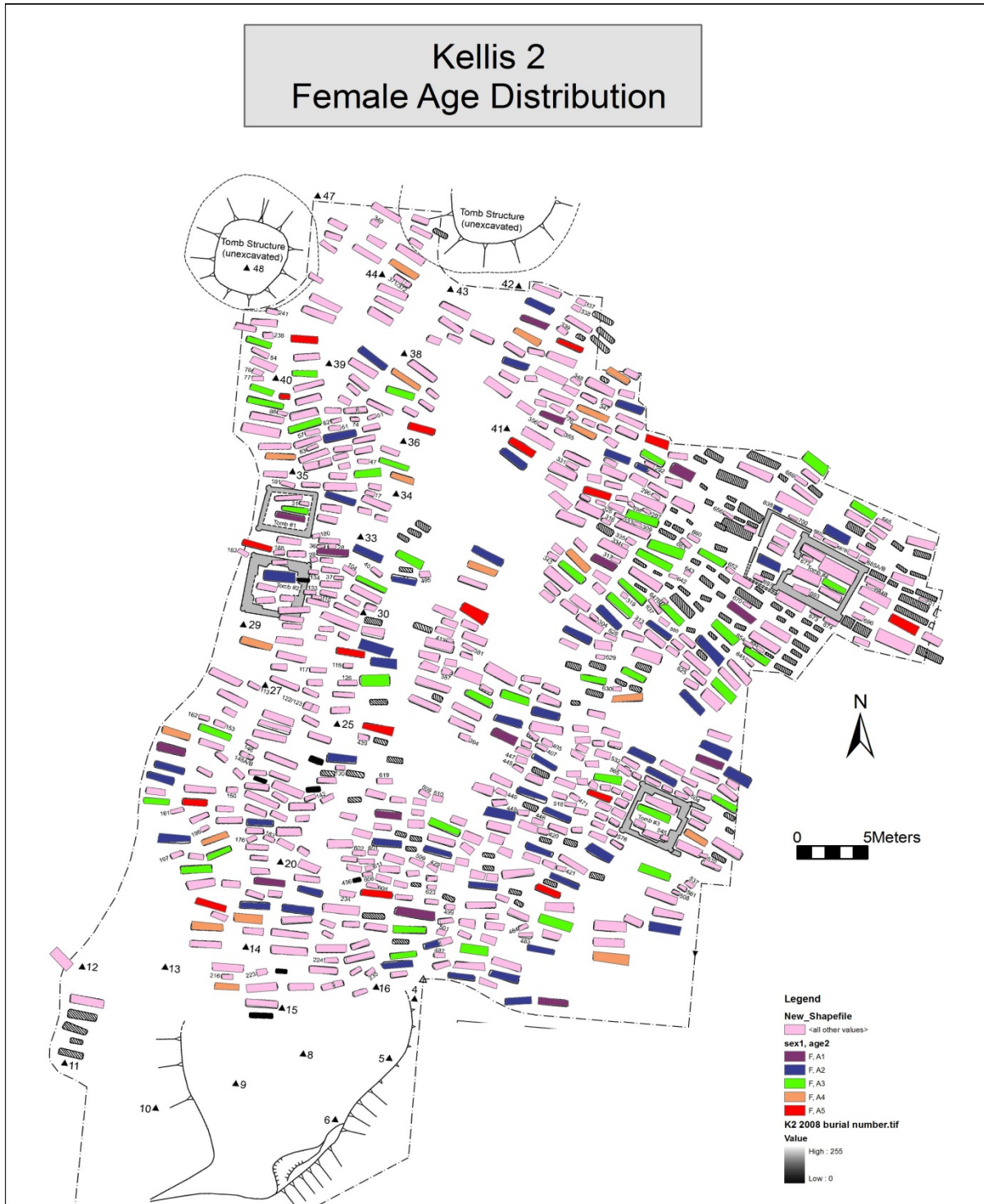


Figure 10: The distribution age categories of adult females in the Kellis 2 cemetery.

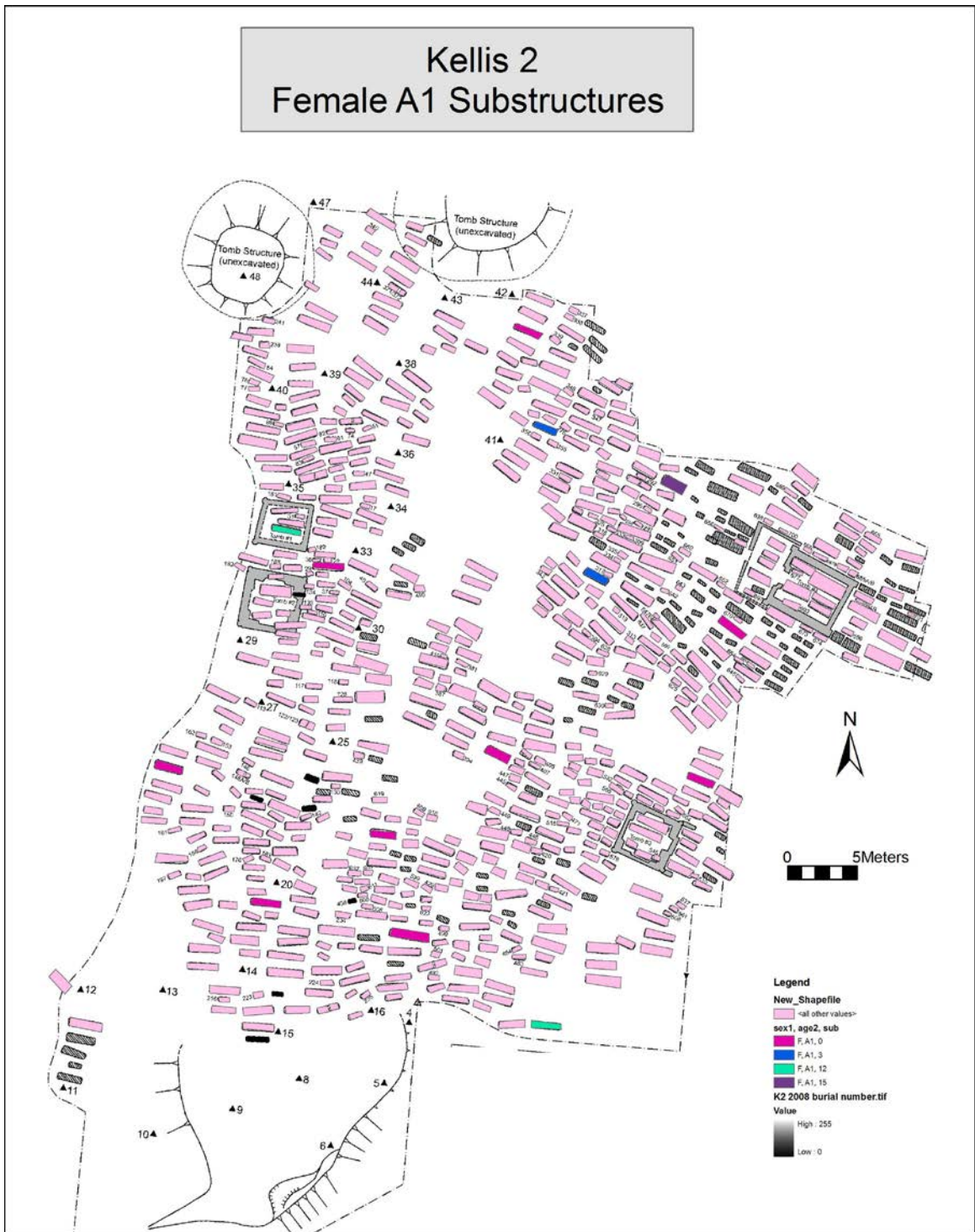


Figure 11: The distribution of substructure styles associated with adult females in the A1 category (16-21 years old).

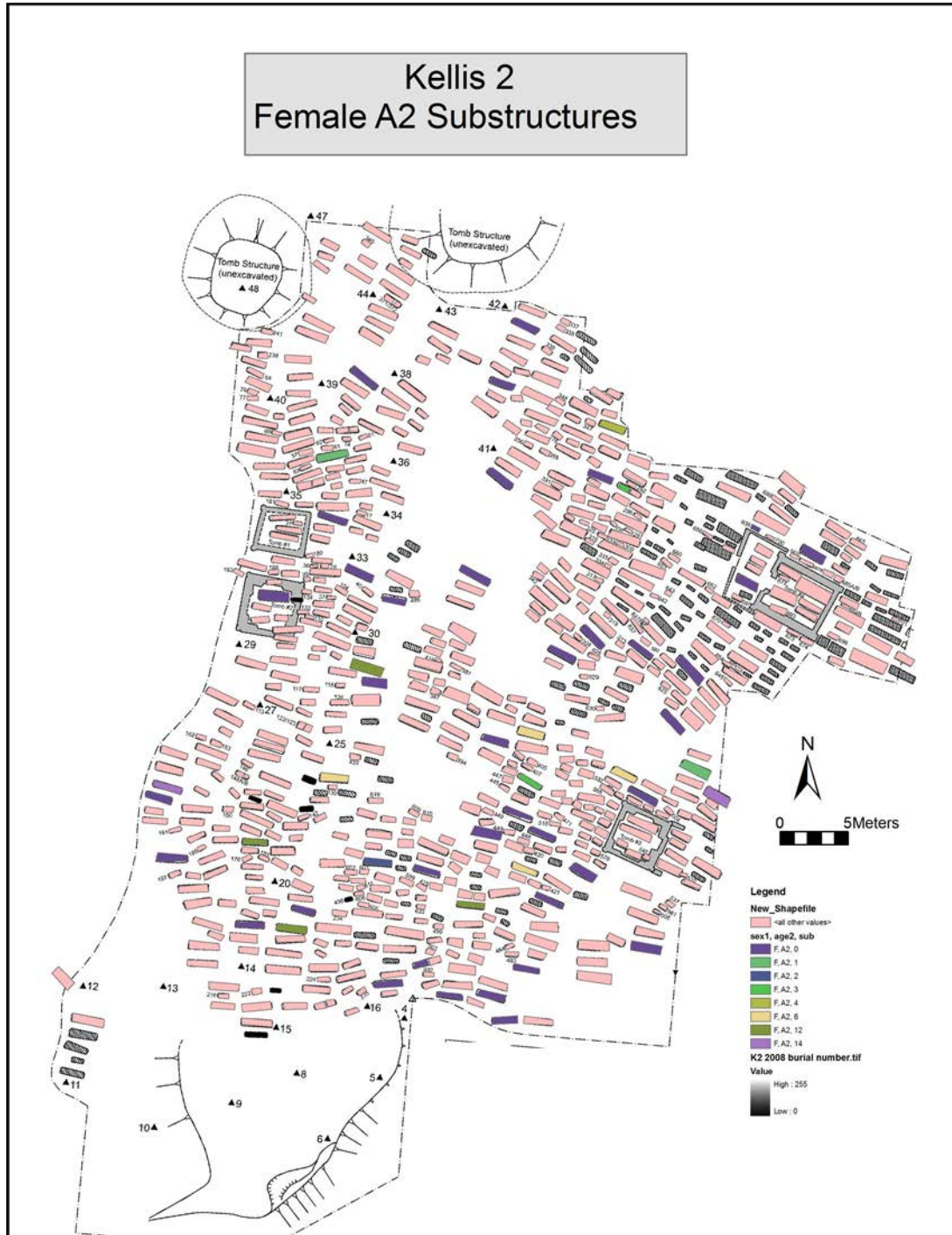


Figure 12: The distribution of substructure styles associated with adult females in the A2 age category (22-35 years).



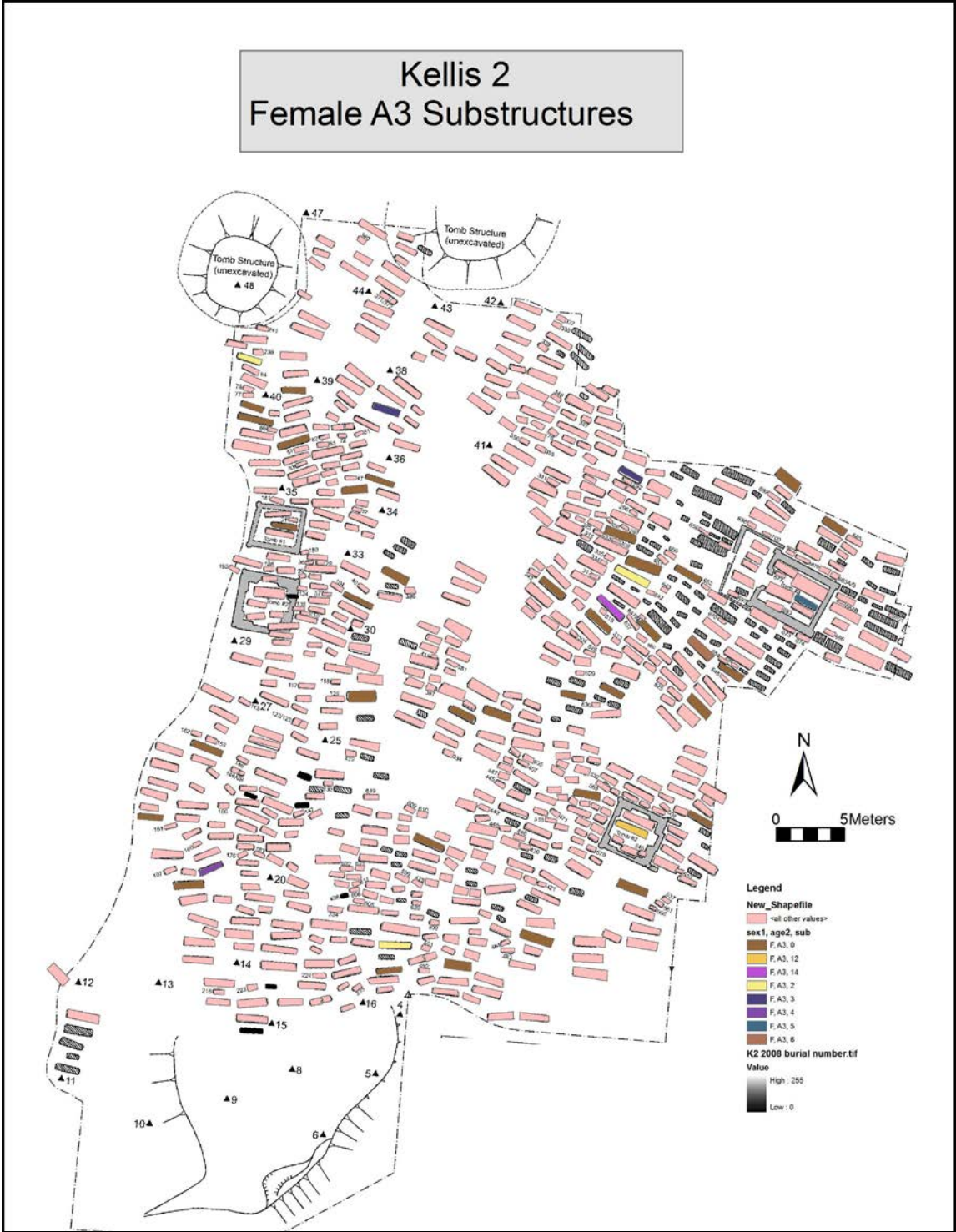


Figure 13: The distribution of substructure styles associated with adult females in the A3 age category (36-50 years).

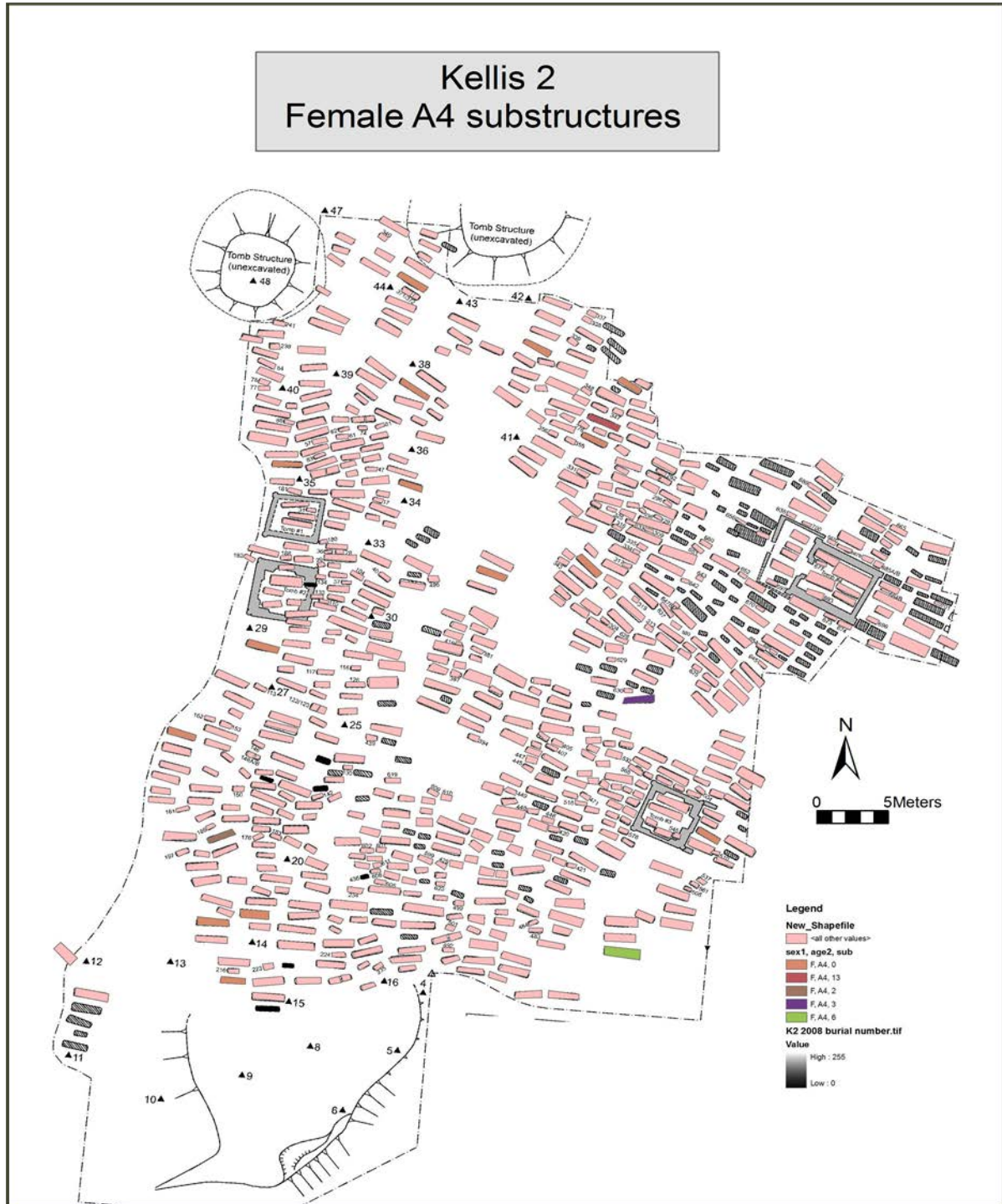


Figure 14: The distribution of substructure styles associated with adult females in the A4 age category (51-60 years).

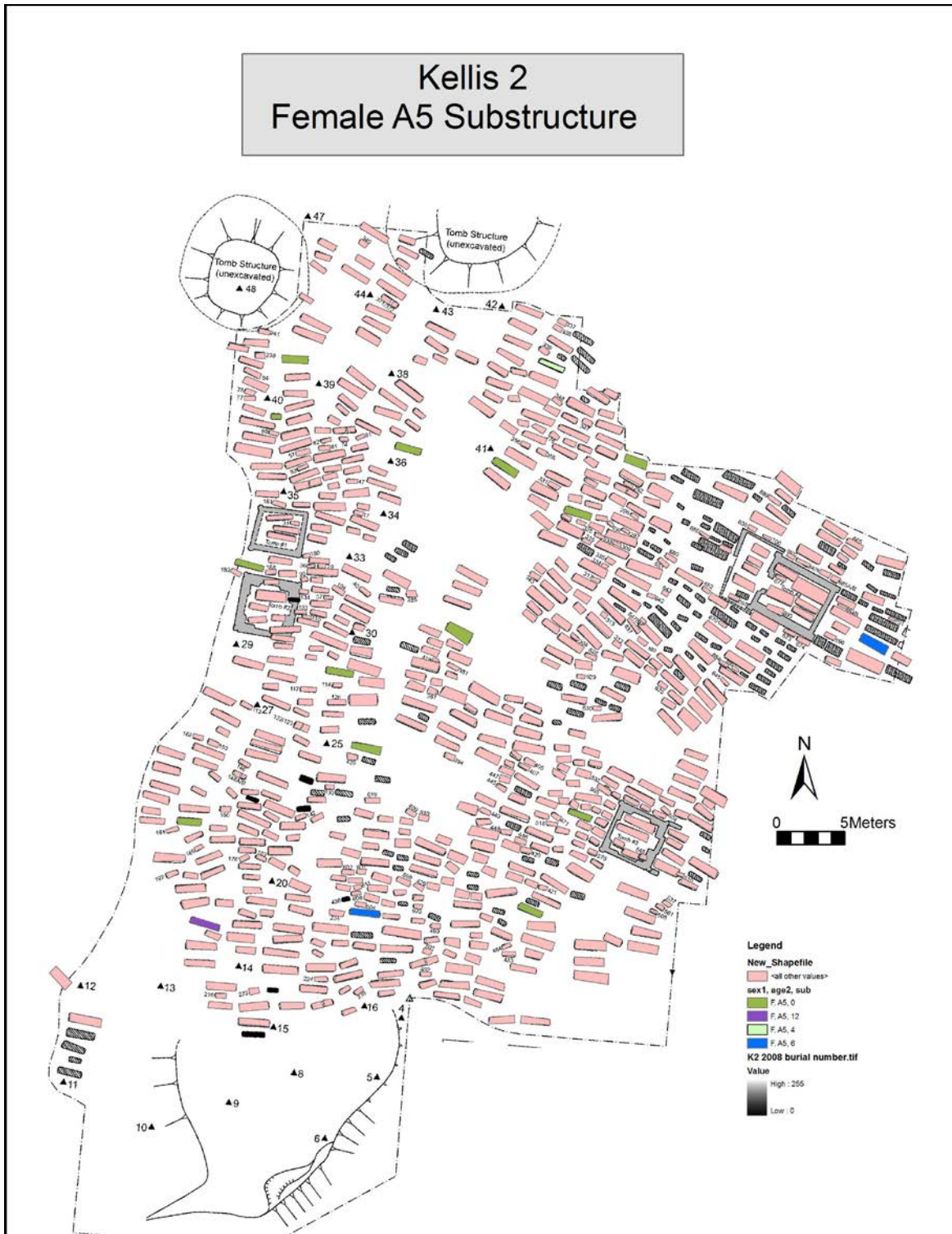


Figure 15: The distribution of substructure styles associated with adult females in the A5 age category (60+ years).

substructures. Substructure styles #4 and #12 are only found once in this age category, while style #6 appears two times.

Table 4 shows the cross tabulation table of substructure by age category for adult females. The results show that there are 152 adult females in Kellis 2 sample, and that 112 (73%) of them have no substructures. Substructure styles #7, #8, #9, #10, #11, and #16 are not found to be associated with any adult females. Styles #3, #6, and #12 were the most common style to be associated with adult females, each appearing eight times, while styles #1, #5, #13 and 15 appears only once. Styles #4 and #14 appear three times.

Table 4: Results of the cross tabulation table showing substructure by age and adult females.

Substructure	Age Cat.					Total	Percent
	A1	A2	A3	A4	A5		
0	9	39	35	15	14	112	73.4
1	0	2	0	0	0	2	1.3
2	0	1	3	1	0	5	3.2
3	2	3	2	1	0	8	5.1
4	0	1	1	0	1	3	1.9
5	0	0	1	0	0	1	0.6
6	0	4	1	1	2	8	5.1
12	2	4	1	0	1	8	5.1
13	0	0	0	1	0	1	0.6
14	0	2	1	0	0	3	2.5
15	1	0	0	0	0	1	0.6
Total	14	56	45	19	18	152	100.0



The chi-square test results (Table 5) indicate that there is statistically significant relationship between females and the presence of substructures ( $p = 0.5$ ). Table 6 shows the results of the one-Way ANOVA test for the relationship between substructure, age and females. The results show that  $F=1.487$  and the P value = 0.225, indicating that there are no statistically significant relationships between substructures, age and females.

Table 5: Chi-square test results examining the relationship between females and substructures.

	Value	Degrees of freedom	Asymp. Sig. (2-sided)
Pearson Chi-	157.000 <sup>a</sup>	10	0.5
Likelihood Ratio	180.315	10	0.5
Linear-by-Linear	97.271	1	0.5
N of Valid Cases	157		

Table 6: Descriptives and one-way ANOVA results to test for the relationship between substructure, age and females.

Age (years)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
.00	115	39.44	15.877	1.481	36.51	42.38	0	72
1.00	40	35.87	16.178	2.558	30.70	41.05	0	70
Total	155	38.52	15.980	1.284	35.99	41.06	0	72

#### ANOVA

Age (years)

	Sum of Squares	Degrees of freedom	Mean Square	F	Sig.
Between Groups	378.510	1	378.510	1.487	.225
Within Groups	38945.698	153	254.547		
Total	39324.208	154			



## Results of the GIS and Spatial Analyses of Substructures Associated with Adult Males

The following section presents the results of the GIS maps examining the distribution of substructure styles associated with adult male age categories. Following the GIS maps, the results of the statistical analyses are presented. Figure 16 shows the distribution of adult male age categories. Figure 17 shows the distribution of substructure style associated with adult males from the A1 age category (16 to 21 years of age). Of the ten males in this age category, six of them have no substructures. Four males in this age category have substructures, and each has a different style, styles #1, #3, #8 and #14. The map in Figure 18 shows the substructure styles associated with males assigned to the A2 age category (ages 22 to 35). There are 47 males in the A2 age category, and of these 29 have no substructures. Styles #1, #2, #9, and #14 each appear once, while styles #3, #4, # 5 and #13 each appear twice. Styles #6 and #12 each appear three times. Figure 19 shows the distribution of substructure styles associated with adult males assigned to the A3 age category (between the ages of 36 to 55 years). There are 33 males assigned to this age category, and of these 20 of them have no substructures. Substructure styles #1, #2, #5, #9 and #16 each appear once, while substructure style #6 appears twice, and style #12 appears four times. The map in Figure 20 shows the distribution of substructure styles associated with adult males classified in the A4 age category (51-60 years old). There are six males categorized as A4. Four of these males have no associated substructures, while two of them have associated substructures styles # 2 and #3. Figure 21 shows the distribution of substructure styles associated with males designated to the A5 age category (over 60 years of age). Although there are eight males assigned to this age category, none of them have associated substructures.

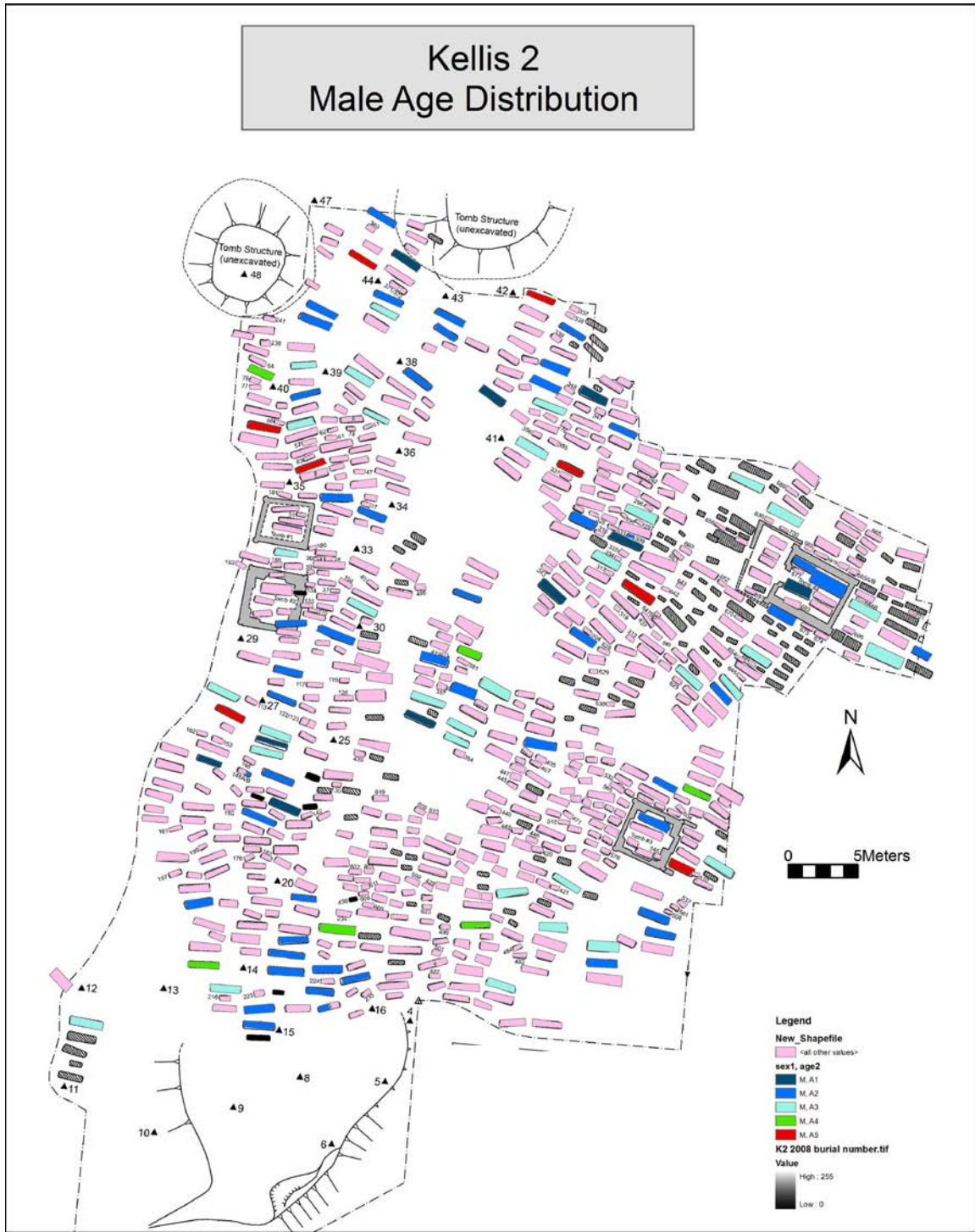


Figure 16: The distribution of adult male age categories.

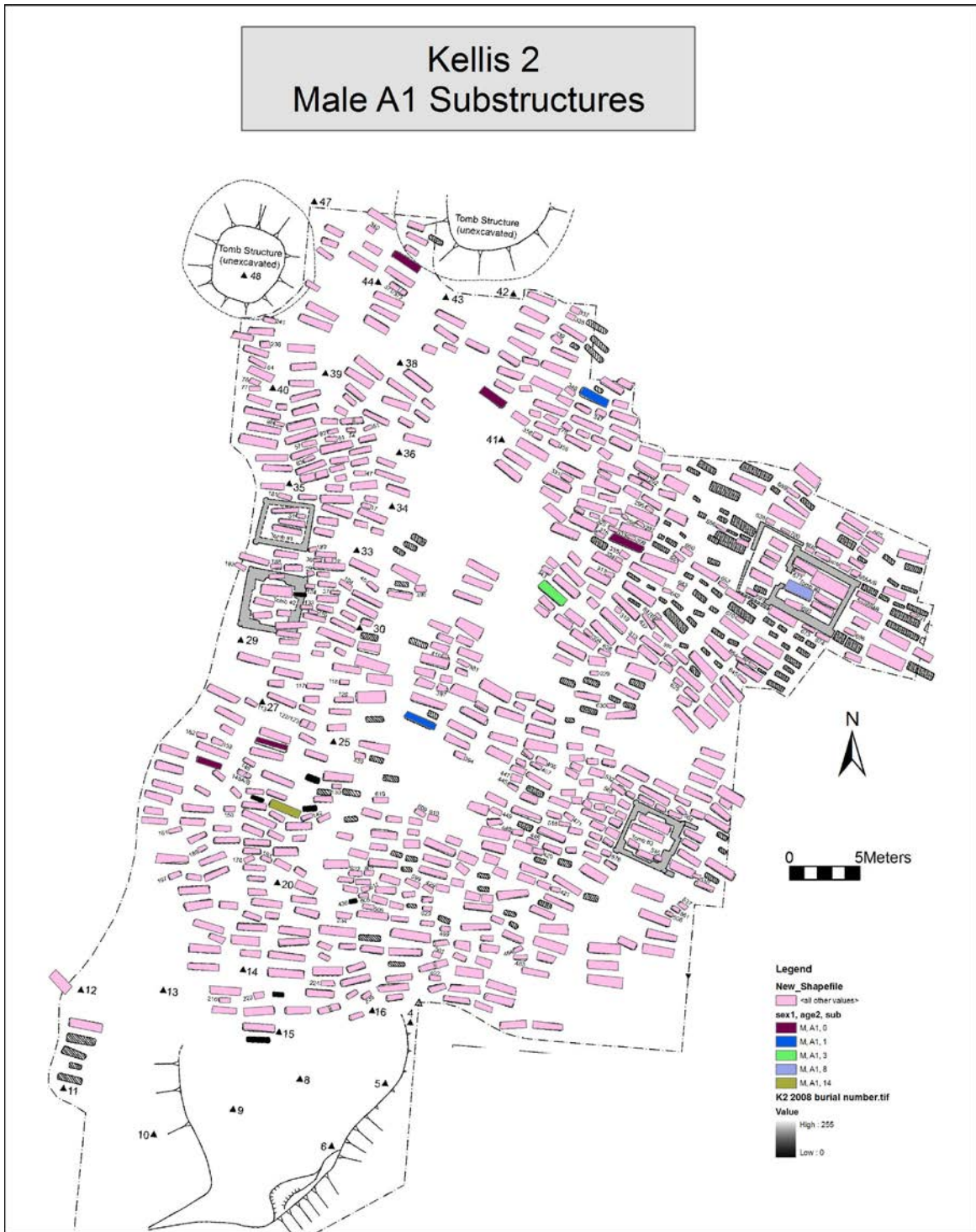


Figure 17: The distribution of substructure styles associated with adult males in the A1 age category (16-21 years).

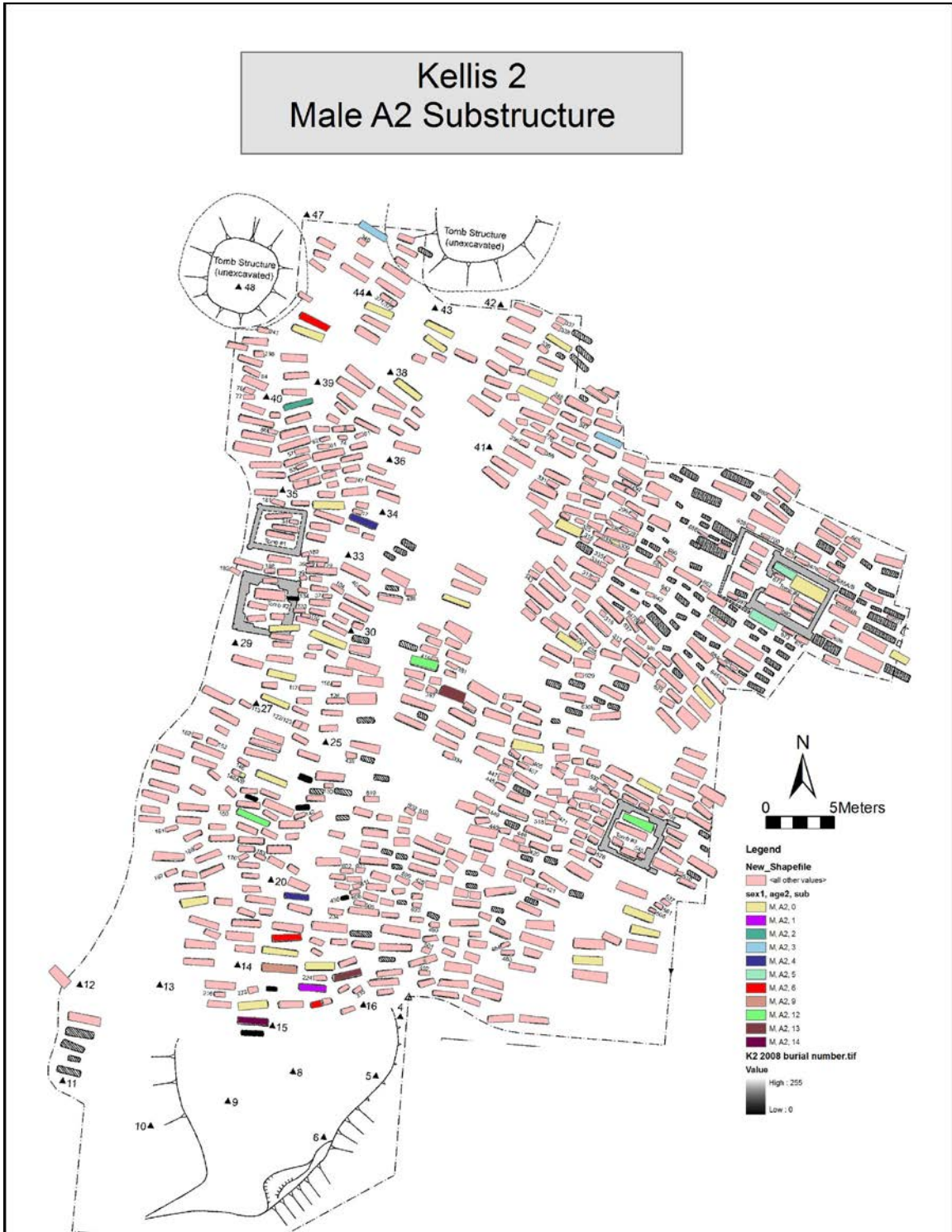


Figure 18: The distribution of substructure styles associated with adult males in the A2 age category (22-35 years).



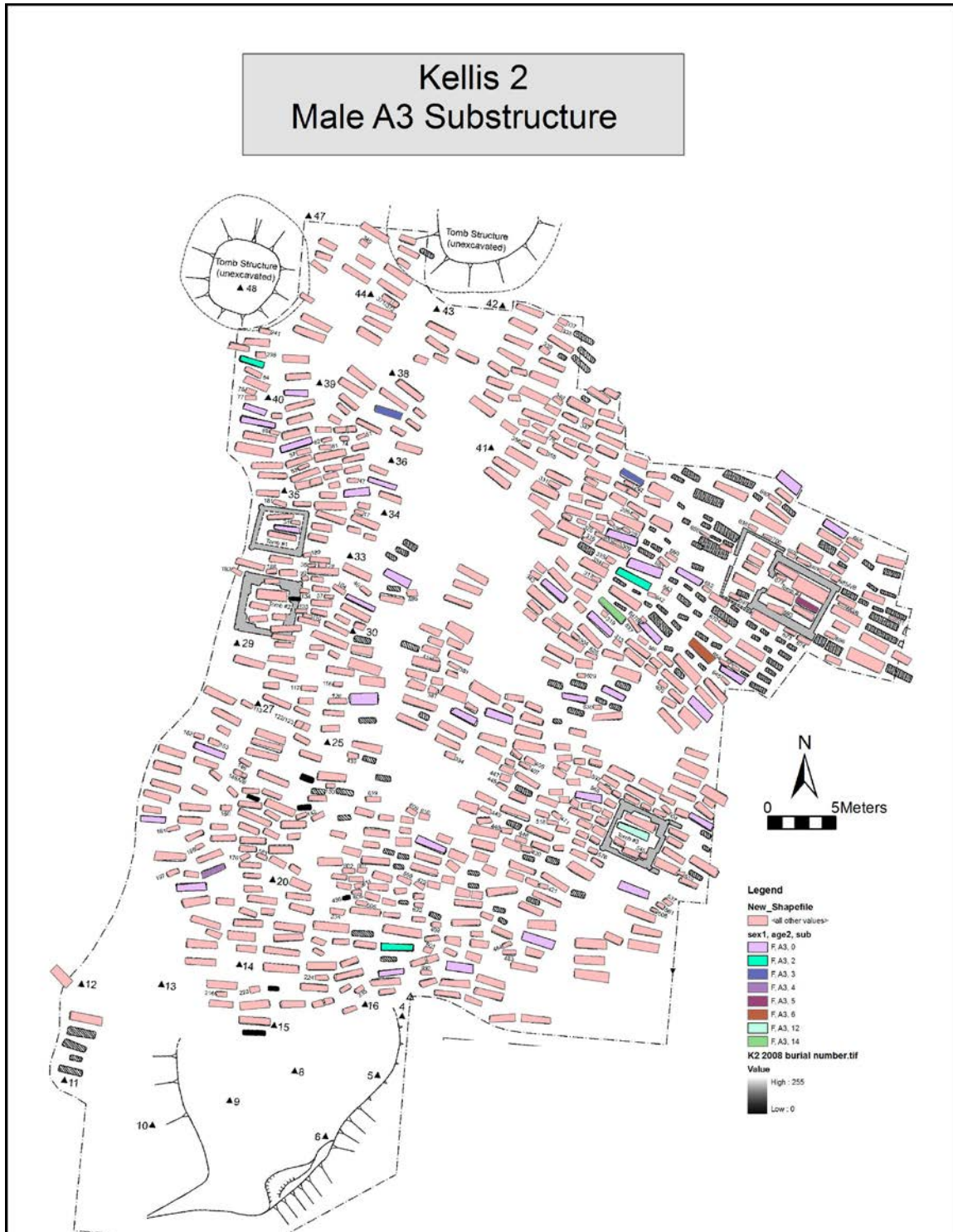


Figure 19: The distribution of substructure styles associated with adult males in the A3 age category (36-50 years).

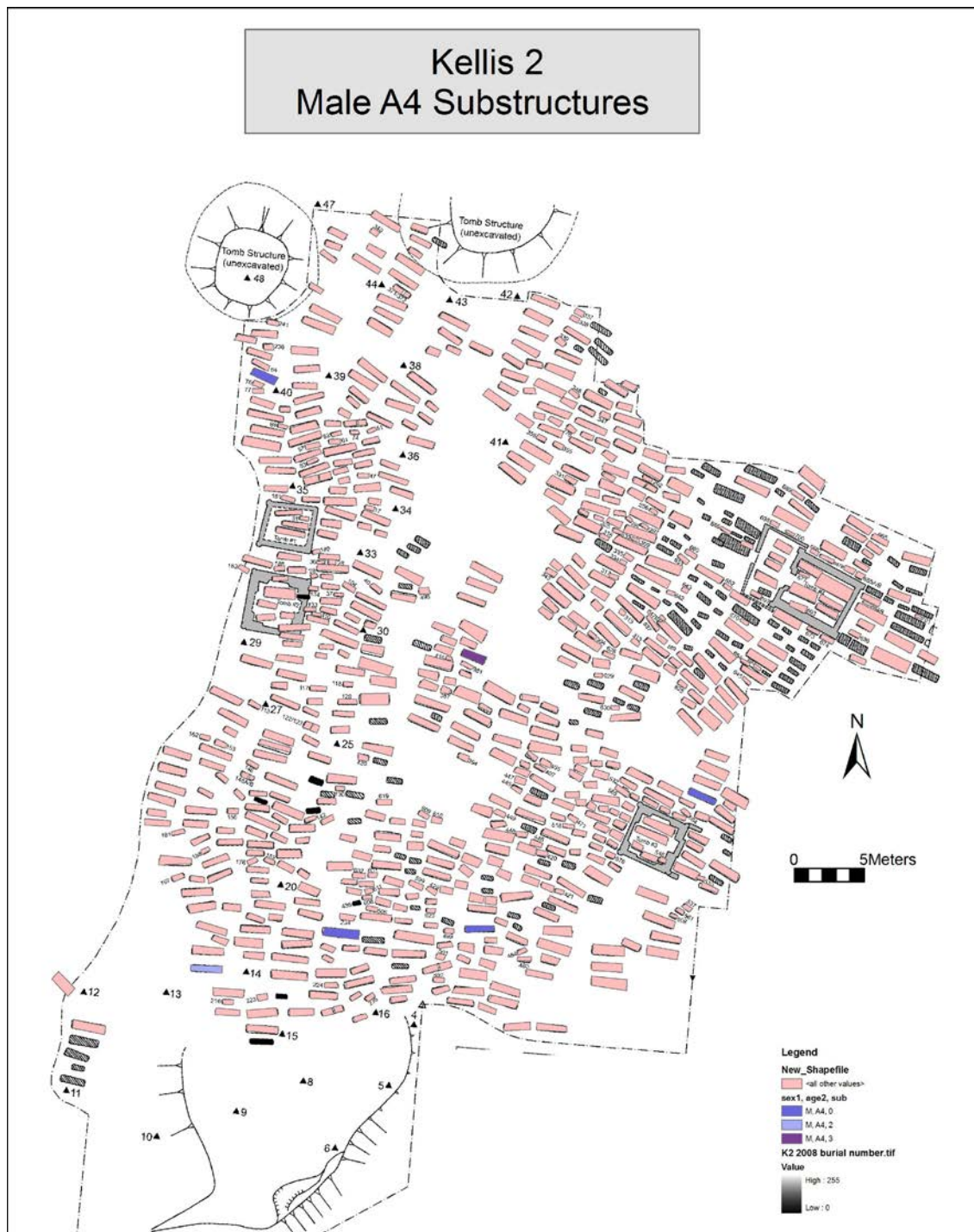


Figure 20: The distribution of substructure styles associated with adult males in the A4 age category (51-60 years).

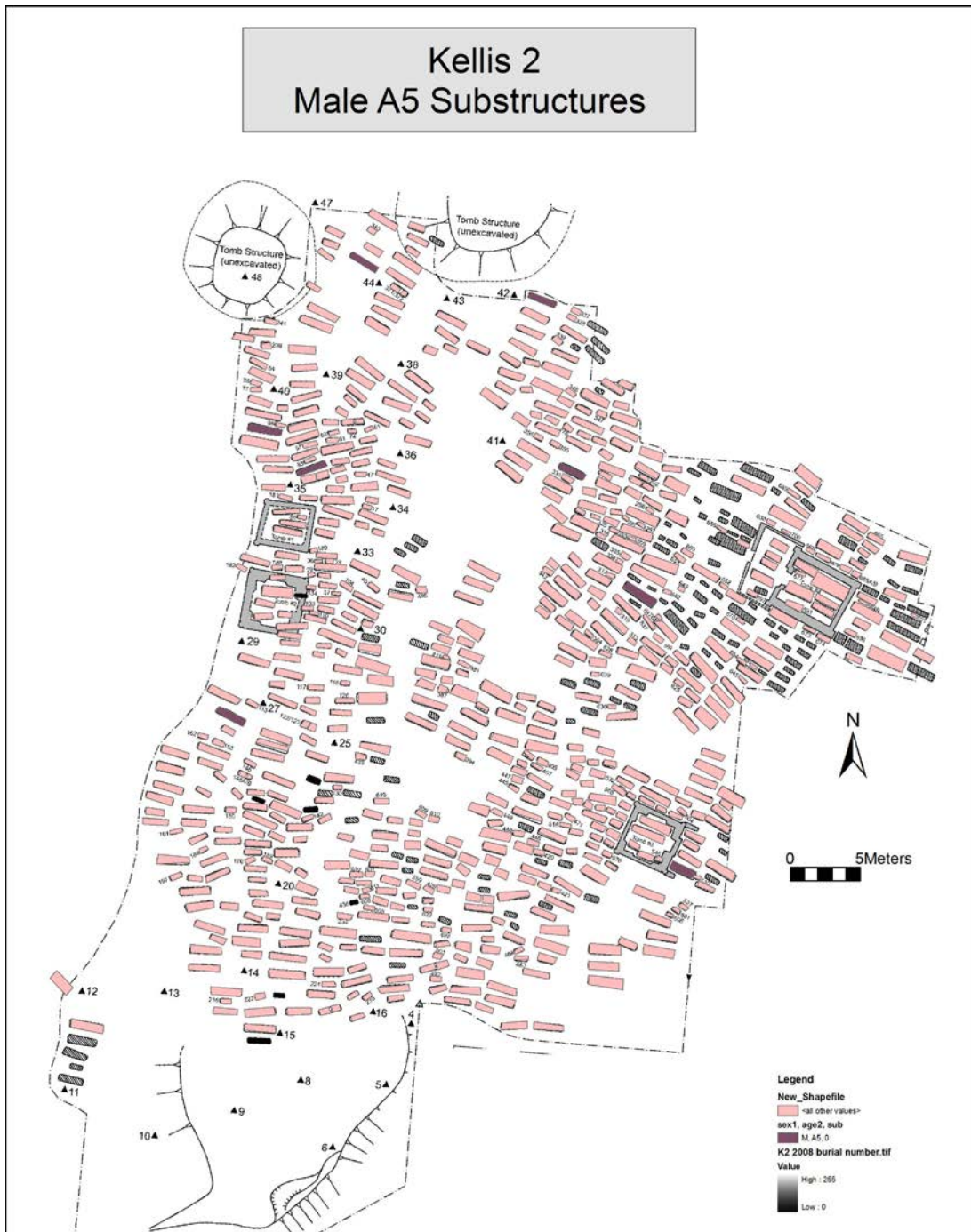


Figure 21: The distribution of substructure styles associated with adult males in the A5 age category (60+ years).

Table 7 shows the cross tabulation table results of substructure by age category for adult males. The results show that there are 104 adult males in the Kellis 2 sample and of these 66 have no substructures, and 38 males have different associated substructure styles. Substructure styles #10, #11, and #15 were not found to be associated with adult males. Styles #8 and #16 were only recorded once each, styles #4,# 9, #13, and# 14 appear two times each, styles #2 and #5 appear three times each, and style #1 appears four times. Substructure styles # 3 (found six times), #6 (found five times) and #12 (found seven times) were the most common styles found with adult males.

Table 7: Cross tabulation results for substructure by age for males.

Substructure	Age Cat.					Total	Percent
	A1	A2	A3	A4	A5		
0	5	29	20	4	8	66	64.0
1	2	1	1	0	0	4	3.6
2	0	1	1	1	0	3	2.7
3	1	2	2	1	0	6	5.4
4	0	2	0	0	0	2	1.8
5	0	2	1	0	0	3	2.7
6	0	3	2	0	0	5	4.5
8	1	0	0	0	0	1	.9
9	0	1	1	0	0	2	1.8
12	0	3	4	0	0	7	6.3
13	0	2	0	0	0	2	1.8
14	1	1	0	0	0	2	2.7
16	0	0	1	0	0	1	.9
Total	10	47	33	6	8	104	100



Table 8 shows the results of the chi-square test, testing if there is any relationship between male age categories and substructure style. The results,  $p = 0.5$ , indicates that there is not a statistically significant relationship between the adult male age categories and substructure.

Table 9 shows the results of the One-Way ANOVA to test for the relationship between substructure and male age category. The results,  $F = 1.189$  and  $P = .278$ , indicate that there is not a statistically significant relationship between the substructures and males age.

Table 8: Chi square test for male age and substructures.

	Value	Degrees of freedom	Asymp. Sig. (2-sided)
Pearson Chi-Square	110.000 <sup>a</sup>	12	0.5
Likelihood Ratio	143.047	12	0.5
Linear-by-Linear Association	65.416	1	0.5
N of Valid Cases	110		

Table 9: Descriptives and results of the One-Way ANOVA test for the relationship between substructures and male age.

Age (years)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for		Minimum	Maximum
					Lower Bound	Upper Bound		
.00	71	35.83	16.072	1.907	32.03	39.64	0	70
1.00	38	32.63	11.431	1.854	28.87	36.38	0	55
Total	109	34.72	14.647	1.403	31.94	37.50	0	70

#### ANOVA

Age (years)

	Sum of Squares	Degrees of freedom	Mean Square	F	Sig.
Between Groups	254.576	1	254.576	1.189	.278
Within Groups	22915.539	107	214.164		
Total	23170.115	108			

## Results of the GIS and Spatial Analyses of Substructures Associated with Juveniles

The following series of maps shows the distributions of substructure styles associated with individuals classified in the juvenile age categories. Statistical results of the chi-square and ANOVA tests to test for the relationship between substructure style and are presented after the maps. Figure 22 shows the juvenile age category distribution in the Kellis 2 cemetery. Figure 23 shows the distribution of fetal individuals associated substructure styles. Of the 42 individuals in this age category (18 to 36 weeks gestation), only four individuals are associated with substructures. Substructure styles #5 and #14 have been recorded twice each. Figure 24 shows the distribution of substructure styles associated with individuals categorized in the “P” (perinate) category (aged 37 to 40 weeks gestation). Of the 65 burials classified as perinates, 35 of them have no substructures. Substructure styles #1, #4, #9, #10 and #14 have been recorded once each; styles #2 and #3 were associated two times each, while style #5 appears three times. Figure 25 shows the distribution of substructure styles associated with individuals classified in the juvenile “N” (infant) category (birth to 1 year of age). There are 186 individuals classified in the N category, and of these 150 of them have no substructures. Substructure styles #1, #2, #3, #5, #6, #8, #9, #10 and #14, have been found to be associated with juveniles in the N age category. Substructure styles #1, #4, #9, and #10 appear once each, while #2, #8 and #14 appear two times each. Substructure style #6 found three times, and style #3 is found eight times. Figure 26 shows the distribution of substructure styles associated with juveniles classified in the C1 age category. There are 104 individuals classified in the C1 age category (1 to 4 years old), and 87 of them have no substructures. Substructure styles #2 and #14 appear two times each, while style #5 appears four times, and styles #3 and #6 appears five times each.

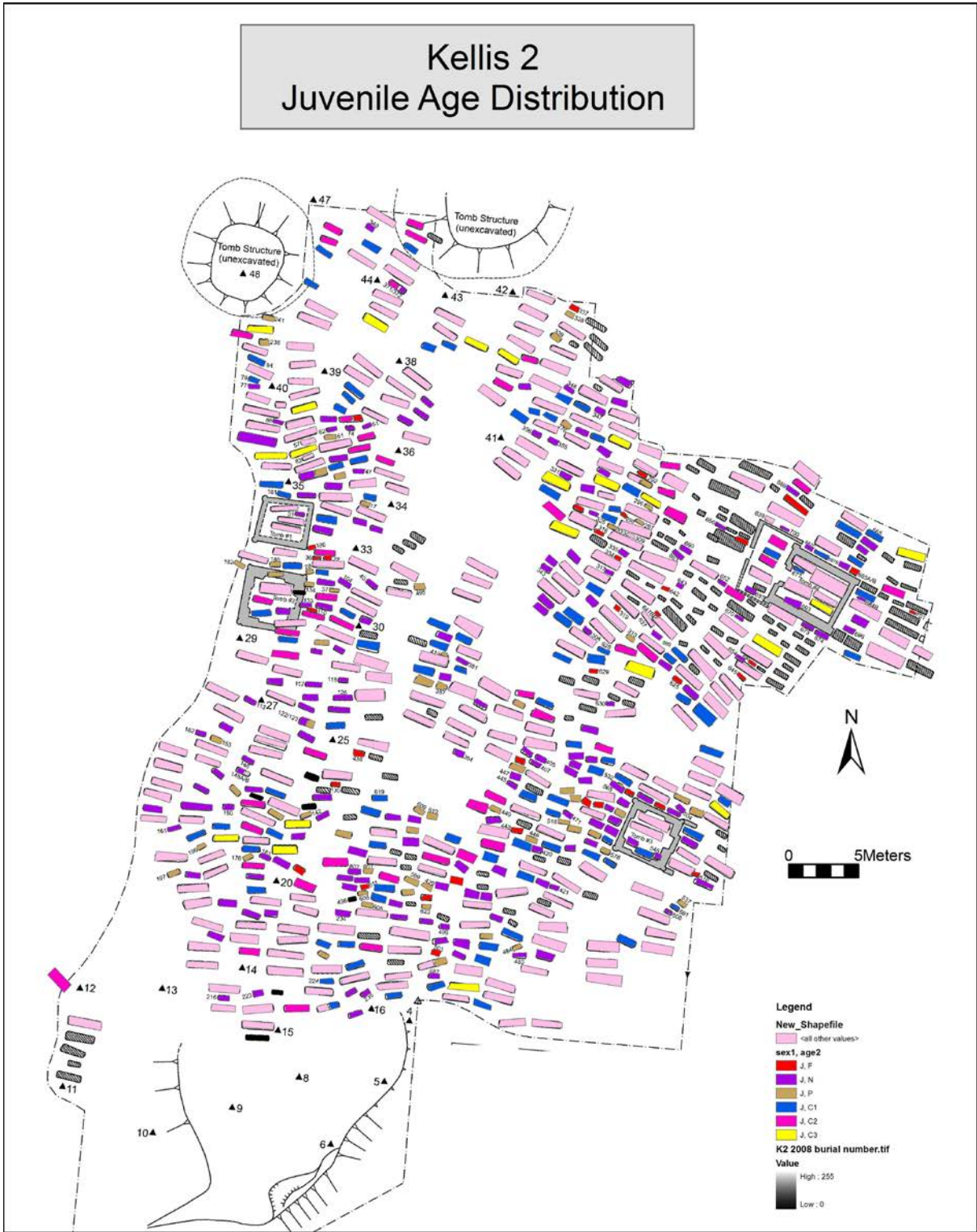


Figure 22: The distribution of juvenile age categories in the Kellis 2 cemetery.

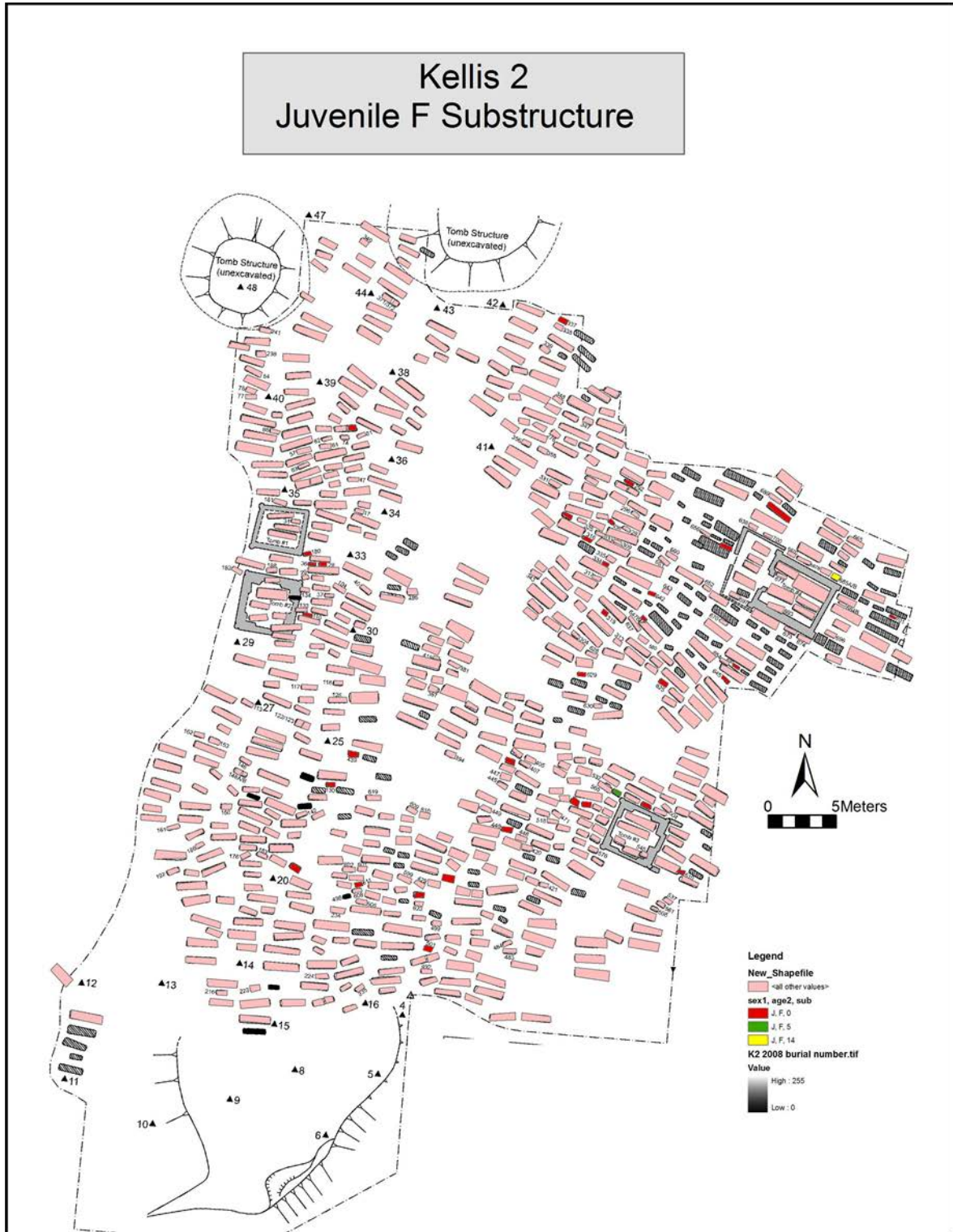


Figure 23: The distribution of substructure styles associated with the juvenile F age category (18-36 weeks gestation).



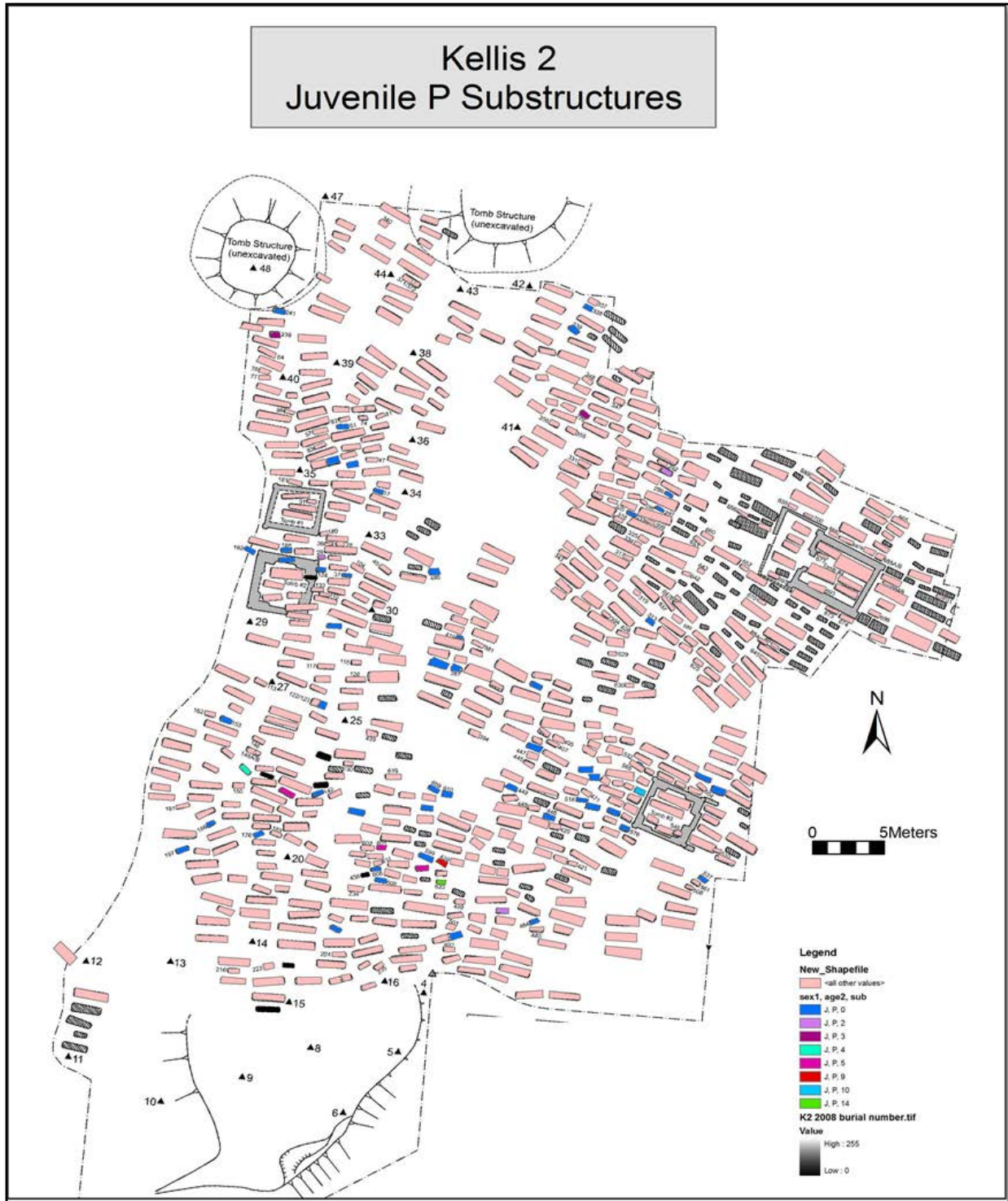


Figure 24: The distribution of substructures styles associated with the juvenile P age category (37-40 weeks gestation).

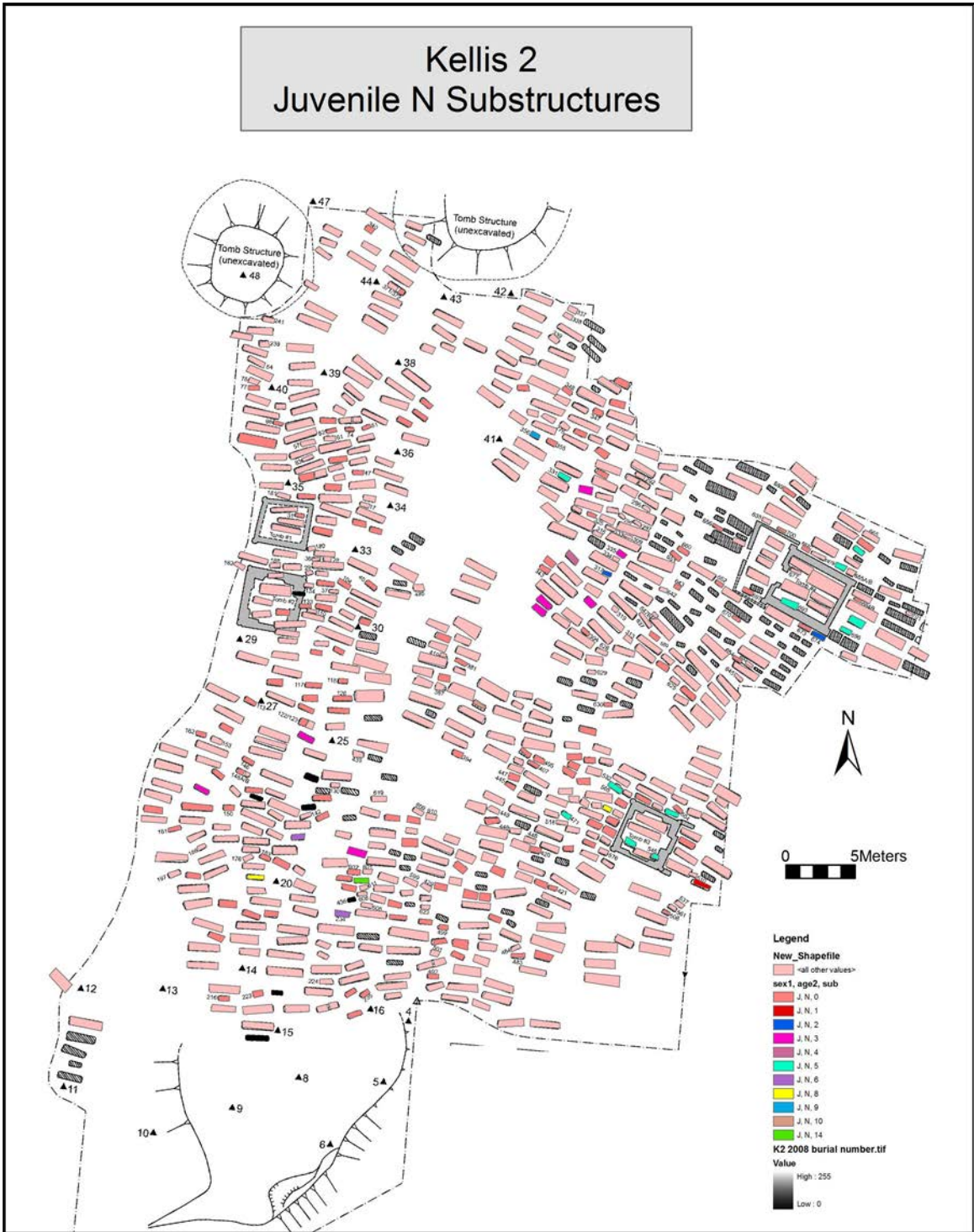


Figure 25: The distribution of substructure styles associated with the juvenile N age category (birth - 1 year).

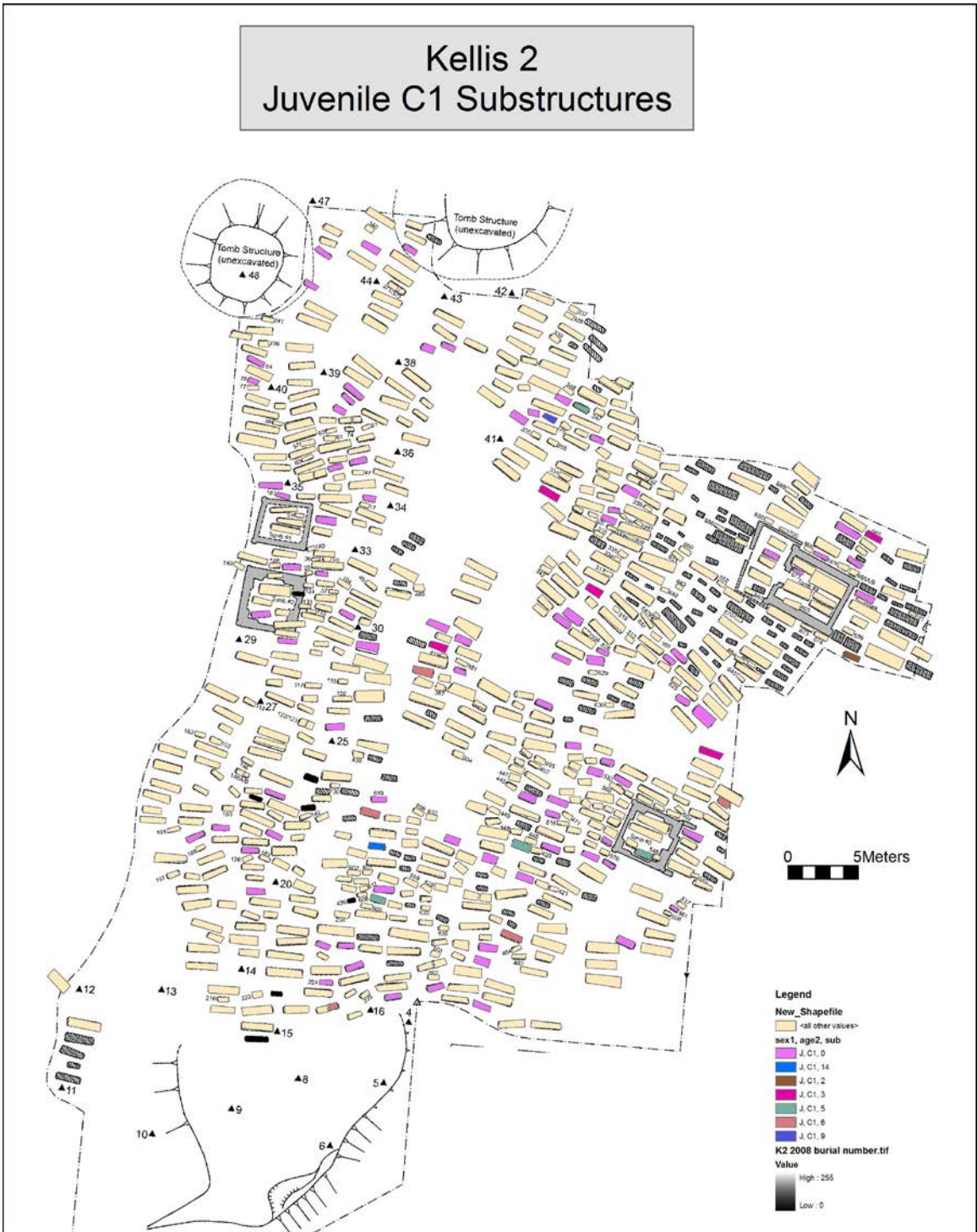


Figure 26: The distribution of substructure styles associated with the juvenile C1 age category (1-4 years).



Figure 27 shows the distribution of substructure styles associated with individuals in the C2 age category (5 to 10 years old). There are 48 burials classified in the C2 age category, and of these 35 have no associated substructures. Style #3 appears four times, and styles #1, #2, #4, #7, #8, #11, #12, and #13 appear one time each. Figure 28 shows the distribution of substructure styles associated with individuals classified in the C3 age category. There are 21 individuals classified in the C3 age category (10 to 15 years of age). Of these 21 individuals, 17 do not have substructures. Substructure styles #1, #3, #9 and #12 have been recorded one time each.

Table 10 shows the results of the cross-tabulation table examining substructure by age categories for juveniles. The table shows that substructures styles from a total of 462 juveniles in Kellis 2 cemetery were examined in this study. Of the 462 individuals, 381 (82%) have no associated substructure. Styles #15 and #16 were not associated with any juveniles, and styles #7, #11 and #13 are found in only one instance each. Substructure styles #10 and #12 are found twice each, while styles #4 and #8 are found 3 times each. Style #1 is found 4 times, style #9 is found 5 times, style #2 is found 6 times, and style #6 is found 8 times. By far the most popular styles are #5 with 19 occurrences, and #3 with 20 occurrences. Table 11 shows the results for the Chi-square test examining the relationship between the juvenile age categories and substructure. These results indicate that there is statistically significant relationship between juvenile's age and substructure. Table 12 shows the results of the One-Way ANOVA test to determine the relationship between substructure style and juvenile age categories. The results,  $F=3.080$  and  $P=0.80$ , indicate that there is no statistically significant relationship between the substructure and juveniles age.



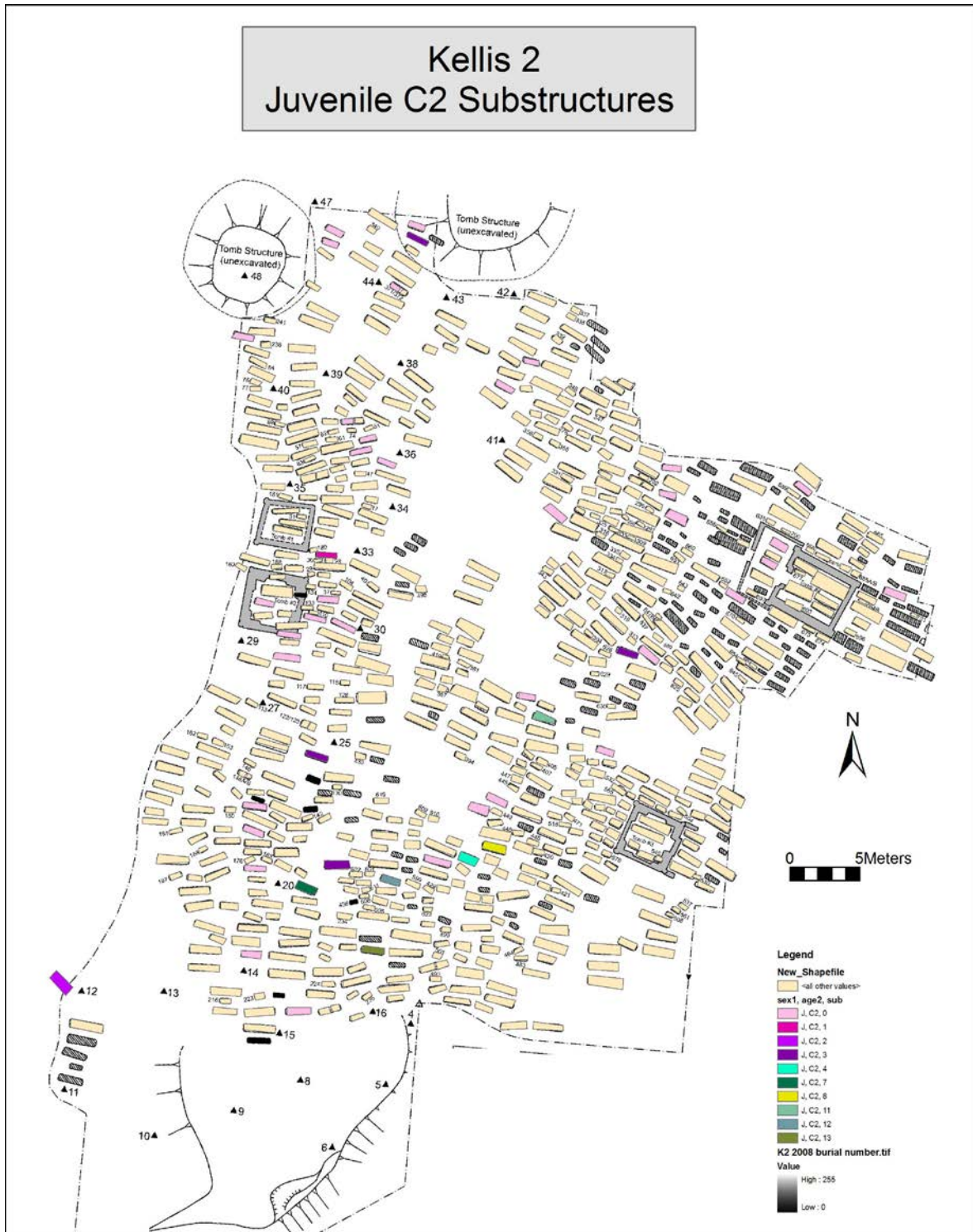


Figure 27: The distribution of substructure styles associated with the juvenile C2 age category (5-10 years).

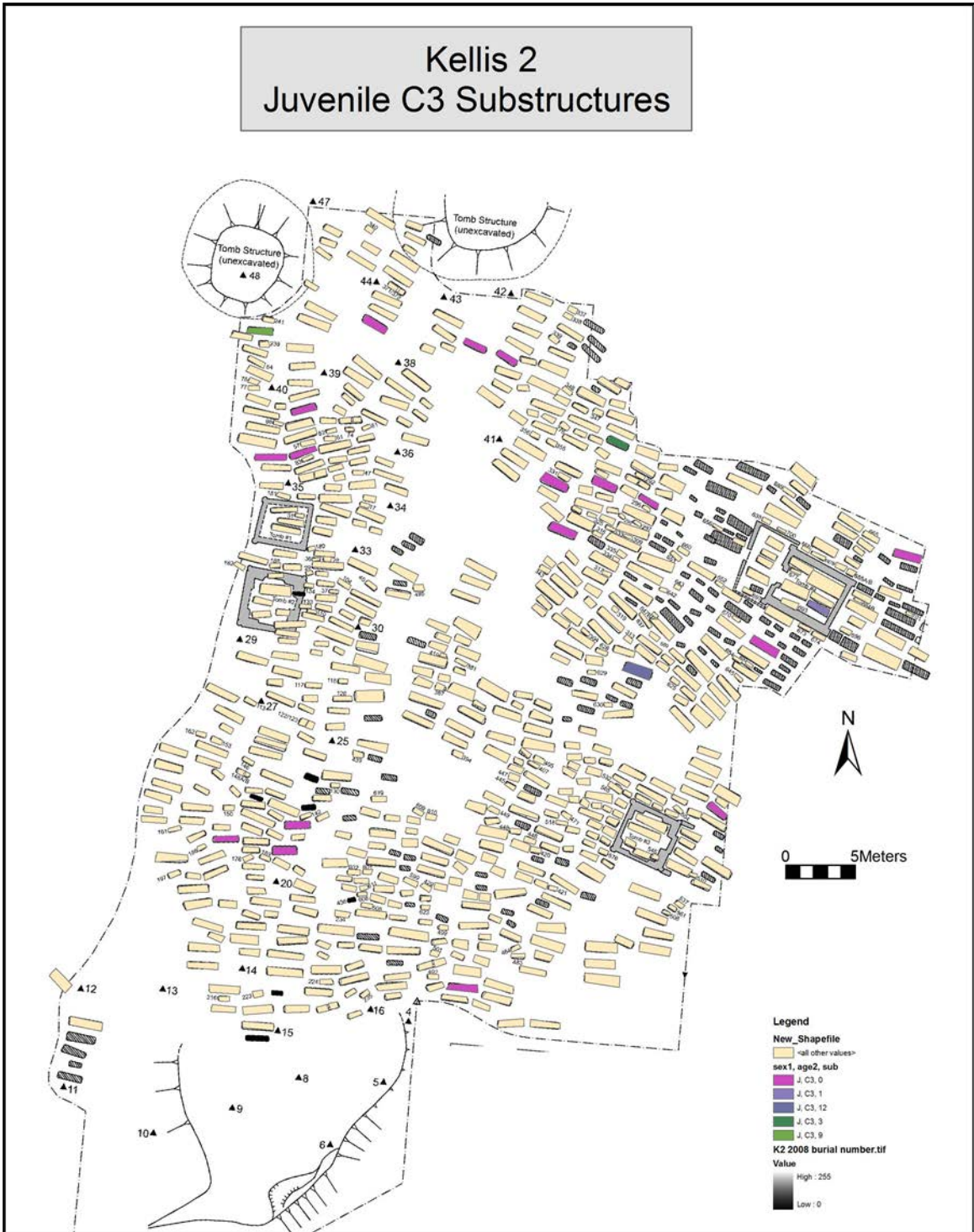


Figure 28: The distribution of substructure styles associated with the juvenile C3 age category (10-15 years).

Table 10: Results of cross tabulation table showing substructures by juvenile age categories.

Substructure	Age Cat.							Percent
	C1	C2	C3	F	N	P	Total	
0	87	35	17	39	150	53	381	82.3
1	0	1	1	0	1	1	4	.9
2	1	1	0	0	2	2	6	1.3
3	5	4	1	0	8	2	20	4.4
4	0	1	0	0	1	1	3	.7
5	4	0	0	1	11	3	19	4.2
6	5	0	0	0	3	0	8	1.8
7	0	1	0	0	0	0	1	.2
8	0	1	0	0	2	0	3	.7
9	2	0	1	0	1	1	5	1.3
10	0	0	0	0	1	1	2	.4
11	0	1	0	0	0	0	1	.2
12	0	1	1	0	0	0	2	.4
13	0	1	0	0	0	0	1	.2
14	1	0	0	2	2	1	6	.9
Total	104	48	21	42	182	65	462	100.0

Table 11: Results of the Chi-square test for the relationship between juvenile age category and substructures.

	Value	Degrees of freedom	Asymp. Sig. (2-sided)
Pearson Chi-Square	453.000 <sup>a</sup>	14	.000
Likelihood Ratio	422.377	14	.000
Linear-by-Linear Association	312.664	1	.000
N of Valid Cases	453		

Table 12: Descriptives and one-Way ANOVA test results testing the relationship between substructure style and juvenile age categories.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower	Upper		
.00	365	1.91	3.118	.163	1.59	2.23	0	15
1.00	79	2.62	3.842	.432	1.76	3.48	0	15
Total	444	2.04	3.265	.155	1.73	2.34	0	15

#### ANOVA

Age (years)	Sum of Squares	Degree of freedom	Mean Square	F	Sig.
Between Groups	32.677	1	32.677	3.080	.080
Within Groups	4689.924	442	10.611		
Total	4722.601	443			

#### Discussion

In this chapter, the relationships between age, sex and substructure were tested using ARCGIS 5 maps and statistical tests. The analysis has been conducted for three categories (females, males and juveniles) to show the relationship between sex, age and substructure.

Figure 29 indicates that most of the burials in the K2 cemetery have no associated substructure, while Figure 30 shows the prevalence (based on the total population) of substructures styles with those that have associated substructures. Figure 31 shows the prevalence of substructure styles based only on those that have substructures. Figure 32 illustrates the prevalence of substructures by age category for those individuals that do have associated substructures.

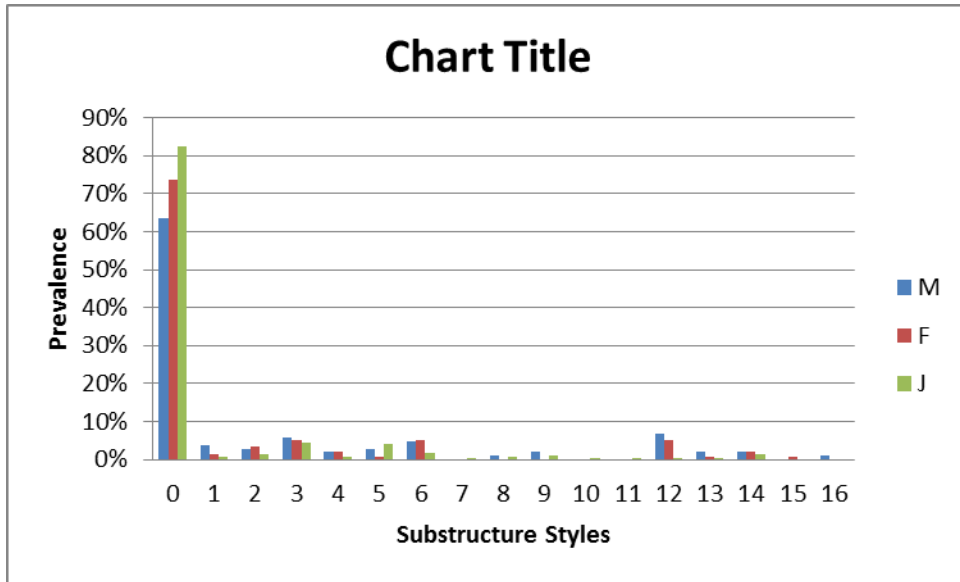


Figure 29: Graph showing the number of male, female and juvenile individuals associated with each substructure style. “0” represents no associated substructure. See Table 3 and Figure 6 for explanation of styles 1-16.

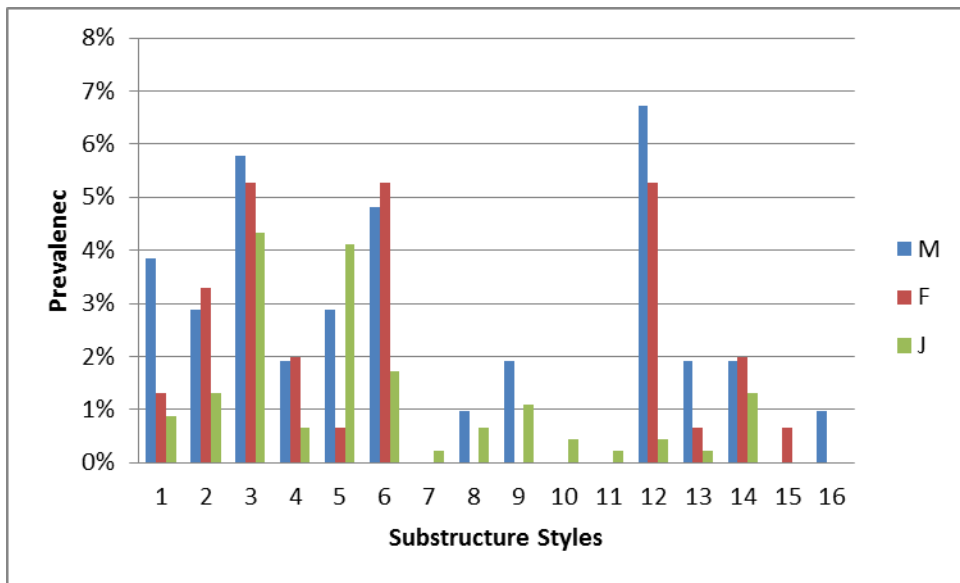


Figure 30: Graph showing prevalence of substructure styles (based on the whole population) for only those individuals with a substructure present.

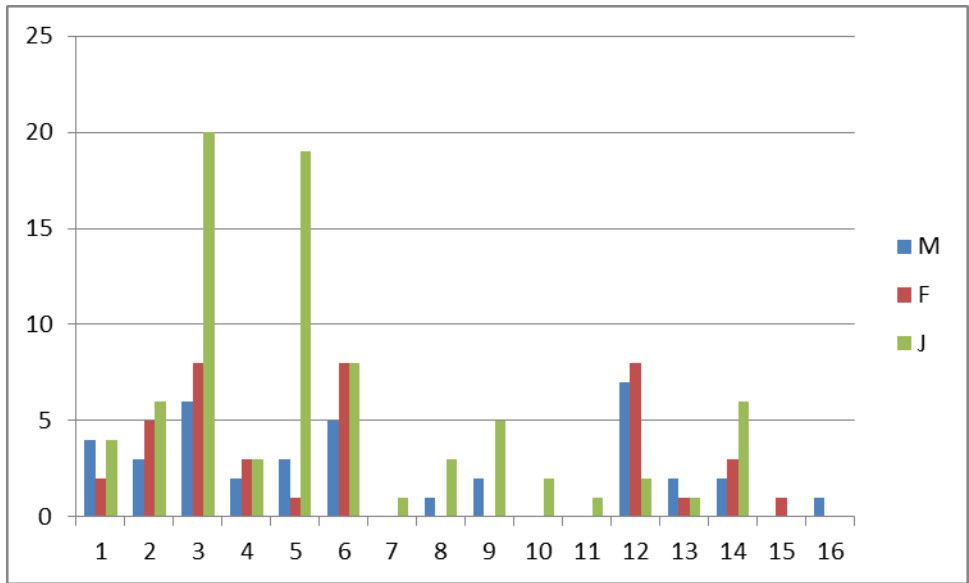


Figure 31: Graph showing the prevalence of substructure styles (based only on those with substructures).

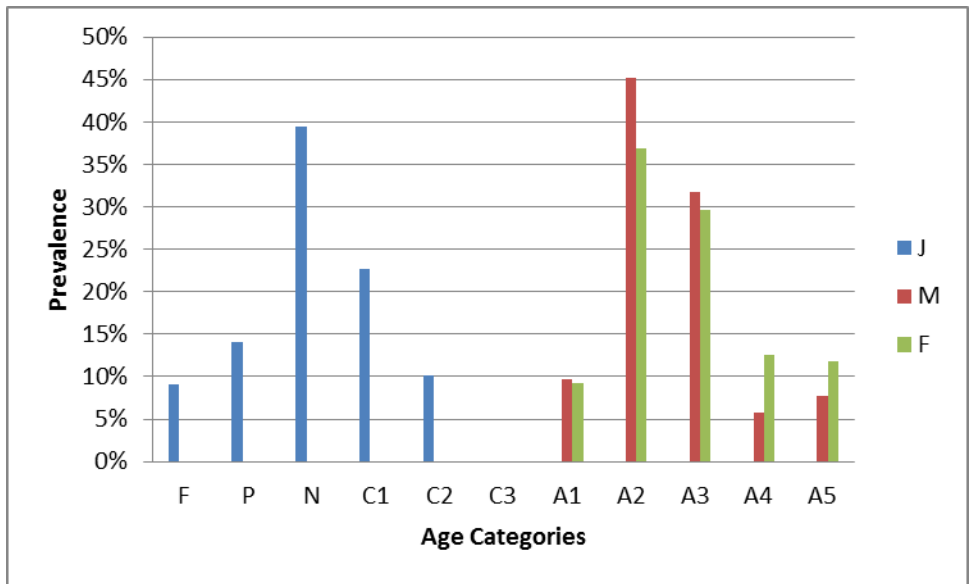


Figure 32: Graph showing the presence of substructures in each age category in the Kellis 2 cemetery.

The GIS maps and cross-tabulation tables for adult females show that substructures were rarely found for females aged in A1 and A5 categories. Figure 33 shows the number of substructures associated with each age category for adult females. Many substructure styles were found to be associated with individuals who were classified in the A2, A3 and A4 age categories (Figures 12, 13 and 14). Styles #3, #6, and #12 were the most common substructure styles for females. These styles include only a built-in head niche (#3), a head niche built from mud bricks (#6), and a head niche built with vaulted mud brick and an associated false floor (#12). Of these styles, only style #12 would require extra labor and materials, and perhaps may have been associated with an individual of higher status. False floors may be considered to have been a grave feature built to protect the items buried with the individual (perhaps jewelry or other valuable items). Unfortunately many of the individuals with these types of substructures have been looted, so it is unknown if false floors are associated with higher status burial items (Wheeler 2009).

Although there some interesting patterns were noted, statistical analysis showed that there are no statistically significant relationships between age, sex and substructures for adult females. Although it is difficult to suggest why there are differential patterns in those age categories of adult females that are associated with substructures, and which substructures, it may be suggested that more labor intensive substructure styles may have been built in burials associated with higher status females. In addition, female aged between 30-55 played an important role for the family during the Roman period, and this may be an explanation for why females in those age categories have associated substructures.

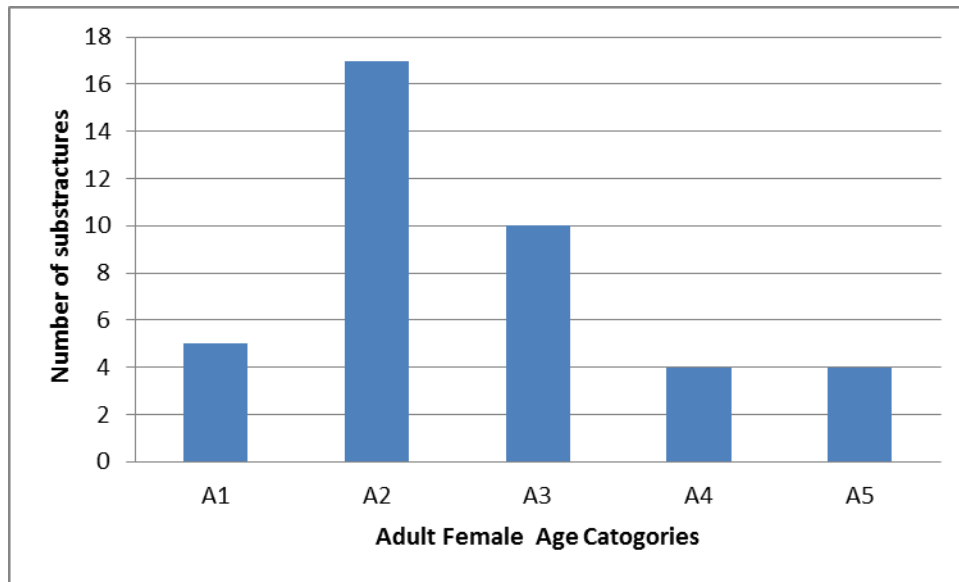


Figure 33: Graph showing the number of substructures per adult female age categories.

The GIS maps for males show that the number of males who have substructures present is limited compared to those with no substructure (Figure 29). Although the statistical analysis showed that there were no statistically significant relationships between age, sex and substructure for adult males, some interesting patterns were noted. Similar to adult females, adult males in the A2 and A3 age categories were more likely to be associated with substructures (Figure 34). As such, it could be inferred that in this population, there was an interest in building various substructures for adults in that particular age group. It could be hypothesized that these particular age groups (A2 and A3) are associated with substructure since this is the common age for males and females to have well established households and accumulated wealth (Bagnall 1993). Moreover, individuals aged from 30 to 50 are more likely to have worked in agricultural jobs or they were part of the military which could indicate that their status may have been higher than those in other age groups. On the other hand, older individuals may not have performed



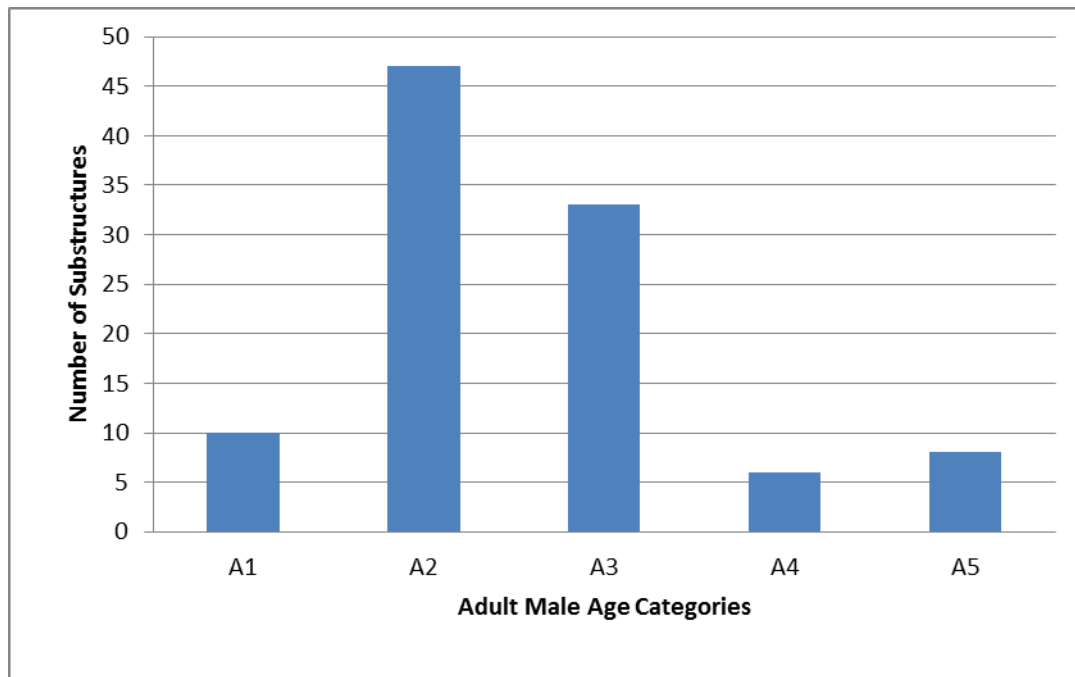


Figure 34: Graph showing the number of substructures per adult male age categories.

physical labor, or contributed to household wealth, and may not have been able to afford any kind of substructure. Also similar to females, substructure styles #3, #6 and #12 were the most common for males' burials. These styles include only a built-in head niche (#3), a head niche built from mud bricks (#6), and a head niche built with vaulted mud brick and an associated false floor (#12). Much like the commentary for adult females, perhaps the males associated with substructure style #12 were individuals of higher status. Like the adult females, many of these burials were looted, and therefore it is difficult to determine if these burials did hold higher status burial items. The results show that males had the largest number of substructures compared to females, which could indicate gender inequality during the Roman period (Hergenhahn 2008).

The GIS maps for juveniles show that 14 styles of substructures were found to be associated with the various juvenile age categories (Figure 31). Although the statistical analysis showed that there were no statistically significant relationships among age and substructure for juveniles, there are discernable patterns. In comparison to adult males and females, juveniles have the least number of substructures styles represented. The substructures are most commonly associated with infants, while individuals in the P, C1 and C2 categories are also associated with substructures (Figure 35). This indicates that individuals living in the Dakhleh Oasis at Kellis (most likely the children's parents) were only interested in building substructures for these specific age groups, and did not invest much time or resources into the burials of fetuses. The presence of all ages of juveniles in the cemetery indicates an adoption of Christian burial practices (Bowen 2003). The practice of including burial substructures with very young children may be due to Christian practices where children have the same burial practices as adults (Bowen 2003). Similar to both adult males and females, style #3 was the most commonly used style for juvenile substructures. This style only incorporated a built-in head niche, and may have been created simply as a solution to compensate for a grave that was initially dug too small. Style #5 (mud bricks placed in a north-south orientation lining the top of the grave) was also very prevalent, followed by style #6 (head niche built from mud brick). Both of these styles indicate that time and resources had to be available, and perhaps these children had parents of some status in the community.

### Conclusion

Most of the individuals buried in the Kellis 2 cemetery are not associated with the presence of a substructure. Although not found to be statistically significant, a variety of

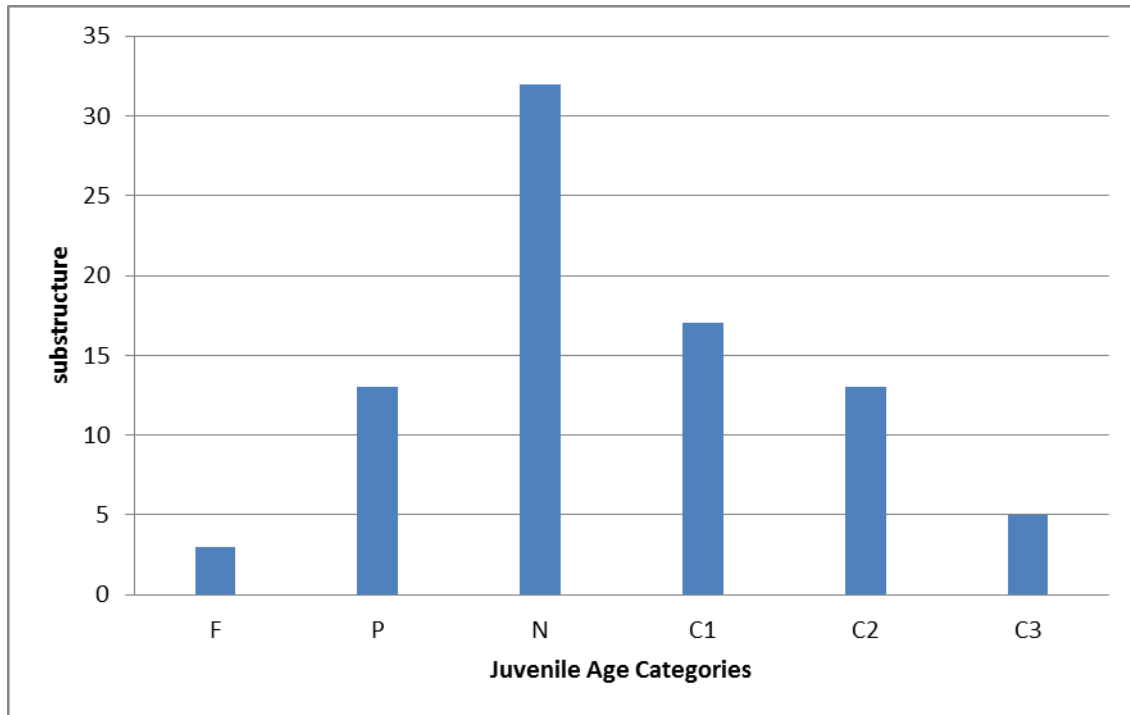


Figure 35: Graph showing the number of substructures per juvenile age categories.

substructure styles were found to be associated with specific groups of age and sex. The substructures appear most frequently in specific age groups for adult males and females, age categories A2 and A3. Individuals in these age categories played an important role in household economics. Style #3 was most commonly used in the all sex groups, including juveniles. This style incorporated a head niche dug into the grave, and it is speculated that this feature was a simple solution to a grave that was initially dug too small for its intended occupant. Style #16 was found only one time (for a male). Statistical analysis showed there is no statistically significant relationship among age, sex and substructure for males, females and juveniles. This result is not surprising given that the number burials with substructures are limited in each sex category. This may suggest that burials with a substructure, particularly those that were time and

resource intensive were reserved for only a small number of individuals. It might be speculated that these individuals were associated with the higher status groups in Kellis.

Since the number of burials with substructures is limited, it may lead to the assumption that these burials may be related to the same time period. Future research would be needed to tie existing radiocarbon dates and further testing for these burials into the GIS maps to examine the placement of substructure styles with appropriate dates.

### References

- Al-Muheisen, Z., & Al-Shorman, A. (2004). The archaeological site of Bediyeh: The constructed landscape. *Syria*, 81, 177-189.
- Bagnall, R. S. (1993). *Egypt in Late Antiquity*. Princeton, NJ: Princeton University Press.
- Bagnall, R. S. (2009). *Early Christian books in Egypt*. Princeton, NJ: Princeton University Press.
- Bailey, T. C. (1994). A review of statistical spatial analysis in geographical information systems. In S. Fotheringham & P. Rogerson (Eds.), *Spatial analysis and GIS* (pp.13–44). London, U.K: Taylor and Francis.
- Bailey, T. C., and Gatrell. C. (1995). *Interactive spatial data analysis*. Essex, U.K.: Longman Scientific and Technical.
- Birrell, M. (1999). Excavations in the cemeteries of Ismant el-Kharab. In C. A. Hope & A. J. Mills (Eds.), *Dakhleh oasis project: Preliminary reports on the 1992-1993 and 1993-1994 field seasons* (pp. 29–41). Oxford, U.K: Oxbow Books.
- Bowen, G. E. (1998). *The spread of Christianity into Egypt in light of recent discoveries from ancient Kellis*. (Unpublished PhD dissertation), Monash University, Melbourne: Australia.

- Bowen, G. E. (2002). The fourth-century churches at Ismant el-Kharab. In C.A. Hope & G.E. Bowen (Eds.), *Dakhleh Oasis Project: Preliminary Reports on the 1994-1995 to 1998-1999 Field Seasons* (pp. 65–85). Oxford: Oxbow Books.
- Bowen, G. E. (2003). Some observations on Christian burial practices at Kellis. In G.E. Bowen & C.A. Hope (Eds.), *The Oasis Papers III: Proceedings from the Third International Conference of the Dakhleh Oasis Project* (pp. 167–182). Oxford: Oxbow Books.
- Craig, W. J., Harris, T. M., & Weiner, D. (2002). *Community participation and geographic information systems*. London: Taylor and Francis.
- Erdi, A. (2003) Applications of Mapping and GIS at the Kelenderis Excavation Site.  
<<http://www.esri.com/news/arcnews/spring03/articles/applications-ofmapping.html>>.
- Ferguson, E. (2003). *Backgrounds of early Christianity*. Grand Rapids, MI: Eerdmans Publishing Co.
- Gardner, I. (2002). The Coptic texts from Ismant el-Kharab: report on work in progress. In C. A. Hope & G. E. Bowen (Eds.), *Dakhleh Oasis Project: Preliminary Reports on the 1994-1995 to 1998-1999 Field Seasons* (pp. 151–152). Oxford: Oxbow Books.
- Gardner, I. (2003). Report on the editing of both the Coptic and the Manichaean texts from Ismant el-Kharab. In G.E. Bowen & C.A. Hope (Eds.), *The Oasis Papers 3: The Proceedings of the Third International Conference of the Dakhleh Oasis Project* (pp. 201–205). Oxford: Oxbow Books.
- Grimal, N. (1992). *A history of ancient Egypt*, trans. I. Shaw. Oxford: Blackwell (1993) Travaux De l'Institut Français d'Archéologie Orientale En, 1993, pp.425–519.
- Hergenhahn, B. R. (2008). *An Introduction to the History of Psychology* (6th ed.). Florence, KY: Wadsworth.

- Hope, C. A. (1988). Three seasons of excavation at Ismant el'Gharab in Dakhleh Oasis, Egypt. *Mediterranean Archaeology*, 1, 160–178.
- Hope, C. A. (2001). Observations on the dating of the occupation at Ismant el-Kharab. In M. Marlow & A.J. Mills (Eds.), *The Oasis Papers 1: The Proceedings of the First International Symposium of the Dakhleh Oasis Project* (pp. 43–59). Oxford: Oxbow Books.
- Hope, C. A. (2002). Excavations in the settlement of Ismant el-Kharab in 1995-1999. In C.A. Hope & G.E. Bowen (Eds.), *Dakhleh Oasis Project: Preliminary Reports on the 1994-1995 to 1998-1999 Field Seasons* (pp. 167–208). Oxford: Oxbow Books.
- Hope, C. A. (2003). The excavations at Ismant el-Kharab from 2000-2002. In G.E. Bowen & C.A. Hope (Eds.), *The Oasis Papers 3: The Proceedings of the Third International Conference of the Dakhleh Oasis Project* (pp. 207–289) Oxford: Oxbow Books.
- Kleindienst, M. R., Churcher, C. S., MacDonald, M. M. A. & Schwarcz, H. P. (1999). Geography, geology, geochronology and geoarchaeology of the Dakhleh Oasis region: an interim report. In C. S. Churcher & A. J. Mills (Eds.), *Dakhleh Oasis Project: Reports from the Survey of Dakhleh Oasis, Western Desert of Egypt, 1977-1987* (pp. 1–54). Oxford: Oxbow Books.
- Knudstad, J. E., Frey, R. A. (1999). Kellis: the architectural survey of the Romano Byzantine town of Ismant el-Kharab. In C. S. Churcher & A. J. Mills (Eds.), *Dakhleh Oasis Project: Reports from the Survey of Dakhleh Oasis, Western Desert of Egypt, 1977-1987* (pp. 189–214). Oxford: Oxbow Books.
- Koester, H. (1995). *Introduction to the New Testament: History, culture, and religion of the hellenistic age*. New York: Walter De Gruyter Inc.

- Kron, H. (2007). *The Efficacy of GIS for Spatial Analysis of Mortuary Data based on Morphogenetic Traits in the Kellis 2 Cemetery, Dakhleh Oasis, Egypt*. M.A. Thesis, Department of Anthropology, The University of Western Ontario. Ontario, Canada.
- Lock, G. R., & Harris T. M. (1996). Danebury Revisited: An English Iron Age Hillfort in a Digital Landscape. In M. Aldenderfer & H. Maschner (Eds.), *Anthropology, Space, and Geographic Information Systems* (pp. 214-240). New York: Oxford University.
- Maschner, H. D. G. (1996). Geographic information systems in archaeology. In H.D.G. Maschner (Ed.), *New Methods, Old Problems: Geographic Information Systems in Modern Archaeological Research* (pp. 1-24). Carbondale: Southern Illinois University.
- McKillop, H. I. (2002) *Salt, White Gold of the Ancient Maya*. Gainesville, FL: University Press of Florida.
- Mills, A. J. (1984). Research in the Dakhleh Oasis. In L. Kryzaniak & M. Kobusiewicz (Eds.), *Origin and Early Development of Food Processing Cultures in North-Eastern Africa* (pp. 205-210). Poznan: Polish Academy of Sciences.
- Mills, A. J. (1999). Introduction. In C.S. Churcher and A.J. Mills (Eds.), *Reports from the Survey of the Dakhleh Oasis 1977-1987* (pp. ix-xii.). Oxford: Oxbow Books.
- Molto, J. E. (2001). The comparative skeletal biology and paleoepidemiology of the people from Ein Tirghi and Kellis, Dakhleh Oasis, Egypt. In C.A. Marlow & A.J. Mills (Eds.), *The Oasis Papers I: The Proceedings of the First Conference of the Dakhleh Oasis Project* (pp. 81-100). Oxford: Oxbow Books.
- Molto, J. (2002). Bio-archaeological research at Kellis 2: an overview. In C.A. Hope & G.E. Bowen (Eds.), *Dakhleh Oasis Project: Preliminary Reports on the 1994-1995 to 1998-1999 Field Seasons* (pp. 239-255). Oxford: Oxbow Books.



- Molto, J. E., Stewart, J. D., Reimer, P. J. & Williams, L. (2006). The Dating of the Kellis Cemetery: An Ongoing Conundrum. Paper presented at the Fifth International Conference of the Dakhleh Oasis Project, Cairo.
- Moyes, H., & Awe, J. J. (2000). *Spatial Analysis of an Ancient Cave Site*.  
<<http://www.esri.com/news/arcuser/1000/cave.html>>.
- Moyes, H. (2002). The use of GIS in the spatial analysis of an archaeological cave site. *Journal of Cave and Karst Studies*, 64(1), 9-16.
- Peacock, D. (2000). The Roman Period (30 BC–AD 395). In I. Shaw (Ed.), *The Oxford History of Ancient Egypt* (pp. 422-445). Oxford: Oxford University Press.
- Pearson, M. (2003). *The Archaeology of Death and Burial*. Gloucestershire, UK: Sutton Publishing.
- Pearson, B. A. (2004). *Gnosticism and Christianity in roman and Coptic Egypt*. Edinburgh: T. & T. Clark Publishers.
- Rice, M. (2003). *Egypt's making: The origins of ancient Egypt, 5000-2000 BC*. London: Routledge.
- Rowlandson, J., Ed. (1998). *Woman and Society in Greek and Roman Egypt*. Cambridge: Cambridge University Press.
- Sheldrick, P. (1997). The archaeology of the Kellis 2 cemetery. Second Conference of the Dakhleh Oasis Project. Royal Ontario Museum, Toronto.
- Shillington, K. (2005). *Encyclopedia of African History*. Boca Raton: CRC Press.
- Sutton, L. J. (1947). *Rainfall in Egypt: Statistics, Storms, Run-off*. Cairo: Government Press.
- Sutton, L. J. (1950). The climate of Egypt. *Weather*, 5, 59–62.

- Tocheri, M. W., Dupras, T. L., Sheldrick, P., & Molto, J. E. (2005). Roman period fetal skeletons from the East Cemetery (Kellis 2) of Kellis, Egypt. *International Journal of Osteoarchaeology*, 15, 326-341.
- Tomlin W. R. (1990). *Geographic Information Systems and Cartographic Modeling*. Englewood Cliffs, NJ: Prentice-Hall.
- Vivian, C. (2000). *The western desert of Egypt: An explorer's handbook*. Cairo: American University in Cairo Press.
- Wheatley, D., & Gillings, M. (2002). *Spatial technology and archaeology: The archaeological applications of GIS*. London: Taylor and Francis.
- Wheeler, S. M. (2009). Bioarchaeology of Infancy and Childhood at the Kellis 2 Cemetery, Dakhleh Oasis, Egypt, Ph.D. Dissertation, The University of Western Ontario, Ontario, Canada.
- Williams, L. J. (2008). Investigating Seasonality of Death at Kellis 2 Cemetery using Solar Alignment and Isotopic Analysis of Mummified Tissues. Ph.D. Dissertation. The University of Western Ontario, Ontario, Canada.

## **CHAPTER THREE: SPATIAL RELATIONS BETWEEN ADULT AND INFANT BURIALS**

### Introduction

The study of mortuary practices provides useful information about burials and assists in the interpretation of the socio-political systems of past communities (Metcalf and Huntington 1991). Studying mortuary practices can help archaeologists to understand the rituals and ideology surrounding how a population chose to bury their dead. In addition, mortuary research provides useful information about social organization (Braun 1979; Brown 1971). In bioarchaeology incorporating skeletal biological information with archaeological data has allowed for an increase in the holistic approach to the understanding of past populations (e.g., Blakely 1971; Buikstra 1977). In addition, social dimensions like age and sex can play an important role in mortuary practices (Carr 1995).

This study focuses on the spatial analysis of burials from the Romano-Christian period Kellis 2 cemetery in the Dakhleh Oasis, Egypt. More specifically, this research will investigate the spatial relationship between infant (aged from birth to one year, n = 124) and adult burials in the Kellis 2 cemetery using Geographic information system (GIS). GIS is one of the best tools to solve spatial problems, however, the number of researchers who apply GIS to bioarchaeological questions is limited (Kron 2007).

GIS is a tool used to produce and analyze spatial data. This tool has its origin in geography where it was used for resource administration (Burrough 1987). Since GIS presents

an easy way to answer many kinds of spatial questions, it has become one of the most important tools now used in a variety of disciplines (Marble 1990). Presently, many archaeological studies involve the analysis of huge amounts of spatial and other kinds of data. With such increased complexity, the analysis can no longer be undertaken manually (Yermakhanova 2005). One type of such analysis is View shed analysis which is conducted with a GIS in order to determine the visible regions on a specific landscape from a specified location (O'Sullivan and Unwin 2003). This type of analysis involves operations conducted locally on grid cell centroids in a digital elevation model (DEM) in order to determine the indivisibility to all other points on the DEM (O'Sullivan and Unwin 2003). Since the purpose of this chapter is to study the burial spatial relationships, a brief history about mortuary archeology and geographic information systems will be presented in this chapter.

### The History of Studying Mortuary Archaeology

The aim of this study is to examine spatial relationships in the Kellis 2 cemetery by using GIS as a research tool. This background section will address debates about mortuary archaeology that are present in archaeology. Cemeteries are given inherent value by people, evoking different ways of thinking and feeling. A cemetery, “can be appraised for its utilitarian, religious, and aesthetic qualities” (Tuan 1979:94). Additionally, people often have emotional attachments to a place because of its historical context. As a result, defining a place or a cemetery depends completely on the archaeologist's views and beliefs. For example, space and place as perspectives are important for cemeteries. The space or location of a cemetery exists whether humans interpret it or not. Place is individualistic which makes it open to various interpretations.

Individuals give meaning to cemeteries, and conversely, meaning gives importance to the rich trove of information within the cemetery to then be interpreted.

The study of mortuary archaeology first began in North America in 1912. In 1927 both Webster and Kroeber present explanations of indigenous mortuary practices (Kroeber 1927). Webster published a catalogue of southwestern mortuary practices, and Kroeber's research focused on Indian burial customs in California. Kroeber attempted to identify the stability within burial practices by examining the original death customs and exploring how the Native Americans cremated their dead. Kroeber's work was extensively cited and influenced several generations, leading to other anthropologists' interest in the field of funerary behavior (e.g., Bendann 1930; Gluckman 1937; Rakita 2005).

In 1960, archaeologists coined terms such as "flexed" to describe the position of the body in mortuary contexts without trying to deal with the actual burial itself. A significant shift occurred in mortuary studies in 1966 when the annual meeting of the American Anthropological Association held a session called The Social Dimensions of Mortuary Practices which centered on components and interpretation of social behavior as represented by burial. Ucko (1969) again reached the same conclusion when examining the effects of ethnographic material on funerary practices and the interpretation of archaeological remains.

The Society of American Archaeology published "Approaches to the Social Dimensions of Mortuary Practices" in 1971 which contained a majority of the papers presented in the AAA 1966 symposium. One such individual published in this volume was Binford (1971). According to Binford (1971), there is an isomorphism between subsistence patterns and the level of societal complexity. The social persona obtained by a person in life is interred with the corpse upon

death. Binford analyzed two prehistoric mortuary sites dated to the archaic and Mississippian periods. Binford used a cross-tabulation for subsistence categories with the number of social distinction made within a society. Based on Binford's (1971) analysis of two prehistoric mortuary sites, the form and complexity of the organizational characteristics of society are conditioned by mortuary practices.

Mortuary data took an important place in archaeology from 1970 to 1980. Several studies investigated the spatial characteristics of cemeteries and assumed the types of social groups represented. Cultural ethnography was used to generalize mortuary practices. Archaeologists hypothesized that mortuary practices directly reflect social organization (Binford 1971; Peebles and Kus 1977; Rothschild 1979; Goldstein 1980; Brown 1981). Most archaeologists argue that the analysis of mortuary practices must consider the historical context and ideological framework. Some scholars focus on individual cemeteries while others maintain that mortuary practices must be examined from a regional perspective (Beck 1995). Ariès (1974, 1981) explored recent European history for the human social response to the biological fact of death and its cyclical nature.

Work by Rothschild (1979) focused on the relationship between mortuary practices and social behavior since this relationship presented a modification in defining the character of unrestricted and hierarchically structured societies. Tainter (1975, 1980) focused on examining the amount of energy expended for burial in Middle and Late period Illinois cultures. He demonstrated that cluster analyses of energy expenditure can be applied to geographic places. He concluded that alteration in mortuary customs reflects social changes occurring from one phase to the next. Goldstein (1980) concluded that the special organization of the mortuary site could help in understanding the relationships between disposal sites. Moreover, the special component

of mortuary region may help to understand the organization principles of a complex community. Morris (1991) attempted to build upon Goldstein's contributions (1980) and worked on refining the eighth hypothesis. He was able to provide a theoretical foundation for this hypothesis by focusing upon the original anthropological distinction between funerary rites and ancestor cults.

Also in the 19th century important writings focused on how mortuary practices relate to universal religious beliefs. Tylor's (1866, 1871, 1878) discussion of animism, or the belief in individual souls and spirits, became a focus of debate in the early twentieth century. Tylor's (1878) ethnographic comparison presented the afterlife associated with the dichotomy of body and soul. Tylor's ideas have been thoroughly interpreted by Frazer in 1958. He viewed mortuary custom as an attempt on the part of the living to place the ghosts of the dead, and that the fear of the deceased ghost-soul motivated all mortuary customs. Mortuary customs were classified to three types: separation, transition, and incorporation (Van Gennep et al. 1960).

The French structurally correlated mortuary practices with other aspects of the complete social system, like economic actions and kinship obligations. French sociologists' idea of mortuary practices had been accepted by the British anthropologists. Radcliffe Brown (1922) underlined the function of mortuary behavior. Malinowski (1944) emphasized the individual reaction to death which connected death practices to essential organic human needs. Binford (1971) and Bartel (1982) present synopses of these philosophical perspectives and approaches of past investigation into the study of mortuary practices. Saxe (1971) and Binford (1971) focused on the social dimensions of mortuary practices suggesting that social organization of society was reflected in the mortuary record.



## Geographic Information Systems (GIS)

Many researchers have attempted to define Geographic Information Systems (Maguire 1991, Clarke 1997). For example, Burrough defined it as “A powerful set of tools for storing and retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes” (Gourad 1999:2). Star and Estes define it as “An Information System that is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for spatially-referenced data, as well as a set of operations for working with the data” (Star and Estes 1990:63). These definitions are in agreement that GIS combines different layers of digital spatial data and creates new outcomes, meaning that GIS is a tool that can be used to construct new information (Gourad 1999).

### GIS Data Structures

Geographic Information Systems integrates databases with graphic maps. The GIS database consists of tables of records that are connected to each other. The most popular type of these databases is the relational database. Data is usually displayed in one of two formats; vector or raster. Vector data consist of structures of points, lines, and polygons that are represented by explicitly storing the coordinates of every point and the directions of lines and connections. A raster format displays the map by storing pixel information. A point is represented by a cell, a line is represented by a group of connected cells, and a polygon is represented by grouping cells (Clarke 1997; Gourad 1999).

## Geographic Information Systems and Archaeology

The archaeological field has been using GIS since the early 1980s (Katsianis & Tsipidis 2005). Over the past two decades various techniques of applying GIS have contributed to archaeology (Gilman 1999; Capobianco 2005). The new technique of using ARCGIS proved to be a more useful tool for archaeologists to solve their spatial problems. Although the analysis could be done without the aid of GIS software, GIS enables the processing of huge amounts of data more efficiently (Kwan and Lee 2004; Conolly and Lake 2006). GIS has several different ways address spatial questions. First, GIS has tools which work as a database management system for archaeological records, which helps to create instant maps. Second, archaeologists can use GIS to determine specific locations by using previously identified site locations. Third, it is used to simulate diachronic changes in past landscapes, and has been used as a tool in intra-site analysis (Wheatley and Gillings 2002). Distribution maps are no longer the sole piece of data upon which interpretations are based. The use of GIS technology within archaeology has enabled distribution maps to become the foundation upon which further analyses are based (Wheatley and Gillings 2002:7). The use of GIS allows the distribution of finds and burial types to be formed and analyzed far more quickly and precisely. Harris (1986) focused his research on how GIS can be a useful tool for archaeologists and he outlined the fundamental benefits GIS can bring to the discipline. Harris (1986) addressed two important themes which enhance GIS applications in archaeology. First, archaeology has a strong connection with the discipline of geography since archaeological sites and the remains that make up a site are all placed in different geographical spaces. Second, the traditional teaching of archaeology is changing from using hard copy to soft copy digital data storage. Harris (1986) found that using a digital format will help to keep data arch logical updated, edited, manipulated and shared. Moreover, storing

archaeological data in a GIS database provides four benefits to archeologists, including linking, integrating, retrieving and accessing data easily based on different types of attributes (Harris & Lock 1996).

Wansleben (1988) acknowledged the benefit of using GIS in archaeology including site location analysis, site pattern predictions and site pattern reconstruction. In the 1990s, with the improvement of computer storage capacity and processor speeds, archaeologists could easily combine a number of archaeological and geographical variables to study entire regions. Hunt (1992) used GIS to analyze site catchment to understand settlement patterns. He noted that GIS enables the researcher to overlay several layers, allowing multiple variables to be used simultaneously. Guillot and Leroy (1995) have not only used GIS for analysis, but also to store and share archaeological data. By using GIS software they were able to compile data from 180,000 archaeological sites throughout France.

#### Dakhleh Oasis, Egypt

The Dakhleh Oasis is one of five major oases of Egypt, and it is considered to be one of the largest oases in Egypt's western desert (Williams 2008). Dakhleh Oasis is located in the Egyptian Western Desert, halfway between the Nile Valley and the Libyan border, at roughly the latitude of Luxor (Figure 36). The Oasis extends approximately 80 kilometers east-west and 25 kilometers north-south and occupies a lowland area at the foot of the Libyan Plateau, roughly 100 meters below the surrounding desert. High winds and sand storms, called the khamasins, are most frequent from March through June, but January and February remain mostly calm (Kleindienst et al., 1999). Since 1977, a multidisciplinary endeavor by the Dakhleh Oasis Project has been underway to understand the past life ways of the humans who inhabited the Oasis.

There are suggestions that the Dakhleh Oasis has been inhabited since at least the Old Stone Age and has seen continuous occupation for the past 2,000 years (Kleindienst et al. 1999). The past environment in the Dakhleh Oasis makes it possible to have habitation because of the existence of numerous natural and artificial wells. Water in the Dakhleh Oasis comes from the Nubian Sandstone Series (Dabous and Osmond 2001). A new agricultural technique was instituted in the Dakhleh Oasis by Roman administrators to attract migrant farmers to settle in the Dakhleh Oasis (Mills 1984). During that time period temples, villages, farmhouses, wells and irrigation systems were built throughout the Oasis (Kaper 1997). Due to new techniques of irrigation such as “assaqiya,” or animal-driven waterwheel, and agricultural practices, substantial quantities of food was grown in the Dakhleh Oasis (Bagnall 1993). The Dakhleh Oasis produced food crops such as dates and olives that were sought after in the Nile Valley (Bagnall 1997). These policies increased the Oasis’ population to its highest levels ever (Shaaban 1988). The Roman period population grew and may have exceeded the present day population, estimated at 35,000 (Shaaban 1988; Fairgrieve and Molto 2000).

#### Kellis Townsite

Kellis is an ancient village site located in the Dakhleh Oasis (Fig. 36). The result of excavations have revealed several residential, household and manufacturing structures such as Egyptian and Roman temples, a Roman bathhouse, two churches, and many Roman vaulted brick tombs (Hope 1988, 2001, 2002). Archaeological evidence demonstrates that Kellis played an important economic and political role in the Oasis when it was founded in the mid-first century until its neglect and abandonment at the end of the fourth century A.D. (Hope 2001). In its zenith, Kellis was governed by many local estate owners and Roman administrators and was

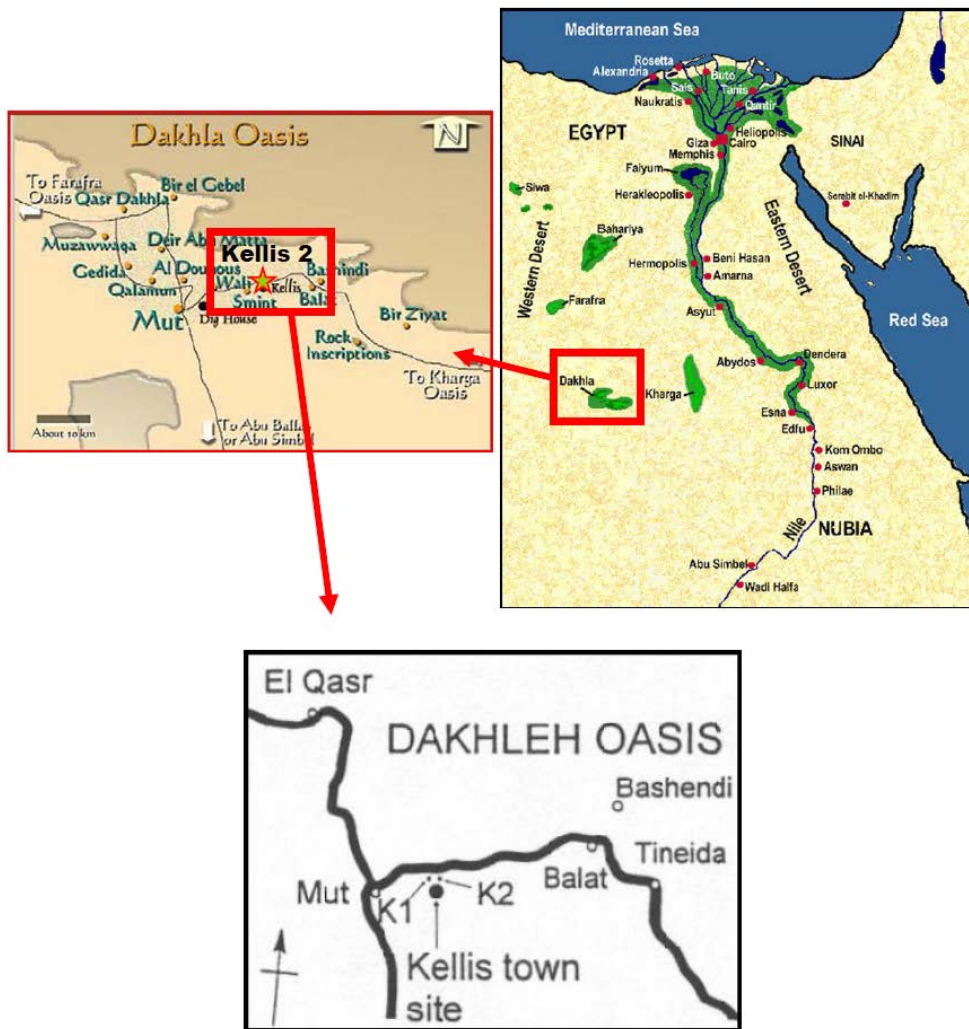


Figure 36: The location of the Dakhleh Oasis and the site of Kellis in Egypt (adapted from Kron 2007).

inhabited by several thousand people. Archaeological evidence such as the presence of churches that indicate that Kellis' inhabitants followed Christianity. There is some evidence from dated texts attesting to Christians having been present in the Dakhleh Oasis by A.D. 280, or earlier

(Bowen 2003). The existence of churches at Kellis proposes shifting religious practices from customary polytheism to Christianity (Hope 2001; Bowen 2002).

### Kellis 2 Cemetery

Two major cemeteries are associated with the village. An earlier cemetery, referred to as Kellis 1 or the West Cemetery, dates to the Late Ptolemaic-Early Roman period (ca. 60 B.C.-A.D. 100), is located to the northwest of the village and consists of a series of rock-cut tombs (Birrell 1999). The second cemetery, referred to as Kellis 2 or the East Cemetery, dates to the Roman period (ca. A.D. 50-450), is located to the northeast of the village and consists of pit graves dug into the bedrock on an east-west axis (Birrell 1999; Bowen 2003). Radiocarbon dates from human bone collagen from the Kellis 2 cemetery suggest a slightly a little earlier date than the date suggested by documentary evidence and dating of the churches (Stewart et al. 2003). According to Wheeler (2009) the radiocarbon dates may suggest that individuals began being buried in a 'Christian' manner before the building of the churches in Kellis. The inclusion of fetuses, infants, and young children in burial grounds is believed to reflect the Christian ideology of resurrection for all and, in Roman Britain, this has been suggested as a reliable criterion for the identification of Christian cemeteries (Watts 1998). As there is no prohibition on Christians being buried in the same cemetery with their pagan counterparts, the identification of Christian tombs in Kellis 2, which were often interspersed among pagan tombs, is problematic unless explicit iconography, such as a cross, is present (Johnson, 1999).

The Kellis 2 burials consist mainly of single extended burials placed in mud crypts in an east-west orientation. There are also rectangular tombs containing a number of individuals (Molto 2002). These large structures may have been the central areas for the clustering of burials

which may indicate a social grouping system within the cemetery, particularly in familial relationships (Molto 2001, 2002). It is estimated that the Kellis 2 cemetery may have 3000 to 4000 burials of which 701 have been excavated, mapped and analyzed (Wheeler, 2009). Of the 701 individuals, more than half of the burials are remains of juveniles (under the age of 15 years) (Wheeler 2009).

### Mortuary Practices in the Kellis 2 Cemetery

In Egypt, few cemeteries have been discovered with graves aligned along an east-west axis. The demographic composition of the individuals buried in these cemeteries (including the presence of fetuses, infants or children) is generally not reported (e.g., Lythgoe 1908; Martin 1974; Mills 1979). The Kellis 2 cemetery is unique in that Christian burial practices are present, and the long term excavation project has recorded all the mortuary and skeletal data.

Tomb structures in the Kellis 2 cemetery usually hold one to three adults along with a number of juveniles, buried underneath the floor of the structure. Adults and juveniles received the same type of mortuary treatment, and individuals of all ages appear to be buried in the cemetery. Individual graves are usually found with single interments, but a few exceptions include some adult females buried with infants. Some infants and fetuses were also buried in close proximity to adult graves, and others under the side walls of the mud-brick superstructures covering the adult remains (Wheeler 2009).

### Methodology

The bioarcheological data for this study came from Drs. Tosha Dupras, Dr. Sandra Wheeler and Dr. Williams (University of Central Florida), all members of the Dakhleh Oasis



Project in Egypt. During excavation and mapping it was noted that infants appeared to be buried in specific locations, particularly “sandwiched” between adult burials. Many questions arose from this observation. Were infants buried between an adult male and an adult female, perhaps representing a family unit? Are infants buried between two adult females, or two adult males? Or were infants simply being buried where there was room? This study focuses on the spatial relationship between burials of adults and infants (birth to one year old). To examine this spatial relationship, GIS for archaeological intra-site analysis, and various tools available in ArcGIS 9.3 were used to analyze the spatial relationship of infants (n=124) and adults (n=250) in the Kellis 2 cemetery.

Prior to analysis in ArcGIS the spatial data from 701 graves was transformed to be compatible with the program. For these data, the location of each excavated grave within the cemetery was mapped in ArcMap. This was done by creating a raster layer with the map of Kellis 2, and then creating a vector layer containing a point shape file on top of it. The graves were then identified as points on the map based on the center of the grave. Due to the small size of the graves compared to the whole cemetery, a slight shift may result from approximating their centers rather than exact calculation. However, this does not make a significant difference for the analysis. Extreme care was taken to verify the points.

Shape files were created to determine the location of all graves included in the analysis for the particular trait to be plotted. The data in the shape files was edited in a table. Next, three columns were added. In the first column, each grave was identified with the appropriate burial number (to do this properly, it was necessary to keep track of the order in which points were placed when initially mapping the graves). In the second column, the sex of the individual was added. The third column contained age data.

A final test of the GIS software was conducted by copying the shape files of each individual trait and the distribution by sex and reversing the numeric representation of attributes – in other words, for this test the presence of the trait is represented as 0 and the absence as 1. For example, males are represented as 1 and females as 0. All analyses with the exception of the Average Nearest Neighbor Analysis were performed on these test samples and compared in order to determine if the same results were produced. If the GIS software produced accurate results, the same pattern should be found regardless of the numeric representation of attributes (with the exception of getting cold spots instead of hot spots when the numbers are reversed).

Location coordinates were created to address the distance between each grave, and then statistical tests were run in SPSS 18 to determine if there was significant statistic relationship between the burials. To handle the large number of data points, these data were divided into two groups representing the north section of the Kellis 2 cemetery, and the south section (the dividing line is shown in Figure 37).

Coordinate analysis was used to determine the spatial relationship between infants and adults. First the data was cross tabulated to determine the number of infants buried between two adults. Chi-square analysis was then used to determine if there was a statistically significant relationship exists between the burial placement of infants and adults.

The following section includes the GIS maps and results of the spatial relationship between infant and adult burials. The map in Figure 38 shows the distribution and relationship of adult males, females and infants, focusing on the infants who were buried between two adults. Three shapes have been created to identify the sex of the individuals that have infants buried between them. The circles (○; n= 13) indicate a situation where an infant is buried between an

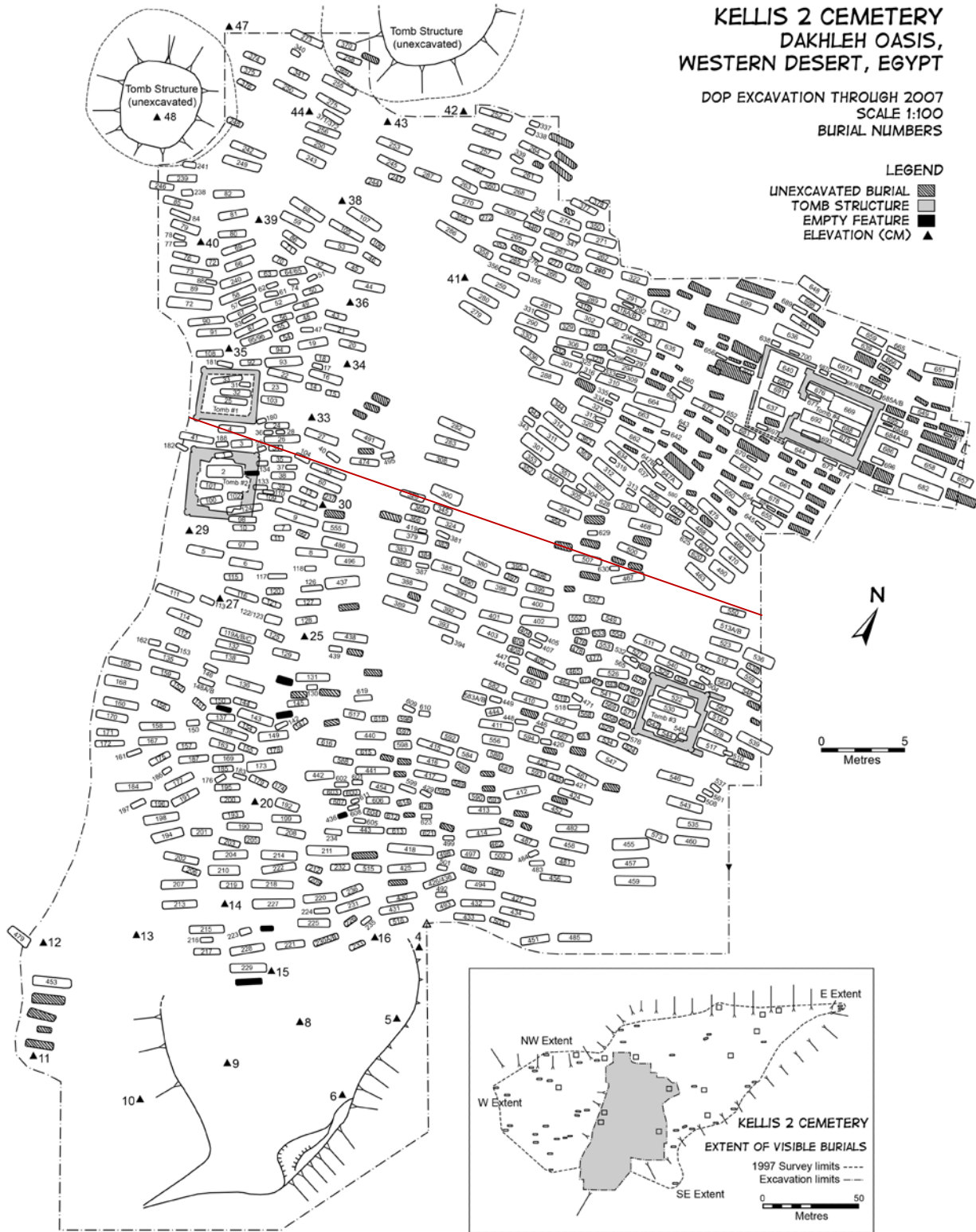


Figure 37: Map showing the data divide between the north and south portions of the Kellis 2 cemetery.

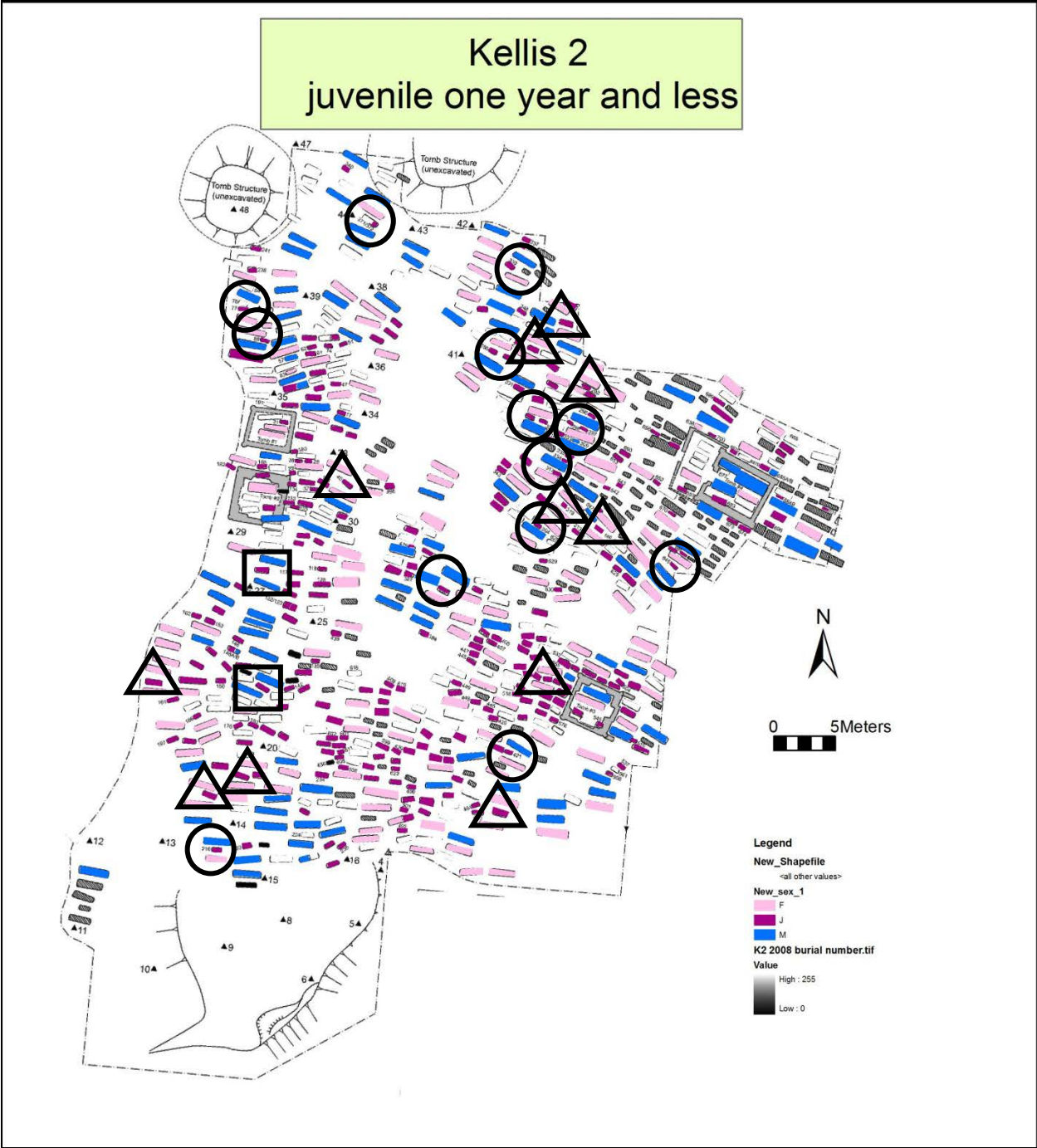


Figure 38: GIS map showing the location of infants buried between two adults. Squares (□) represent infants buried between two adult males, triangles (△) represent infants buried between two adult females, and circles (○) represent infants buried between an adult male and female.

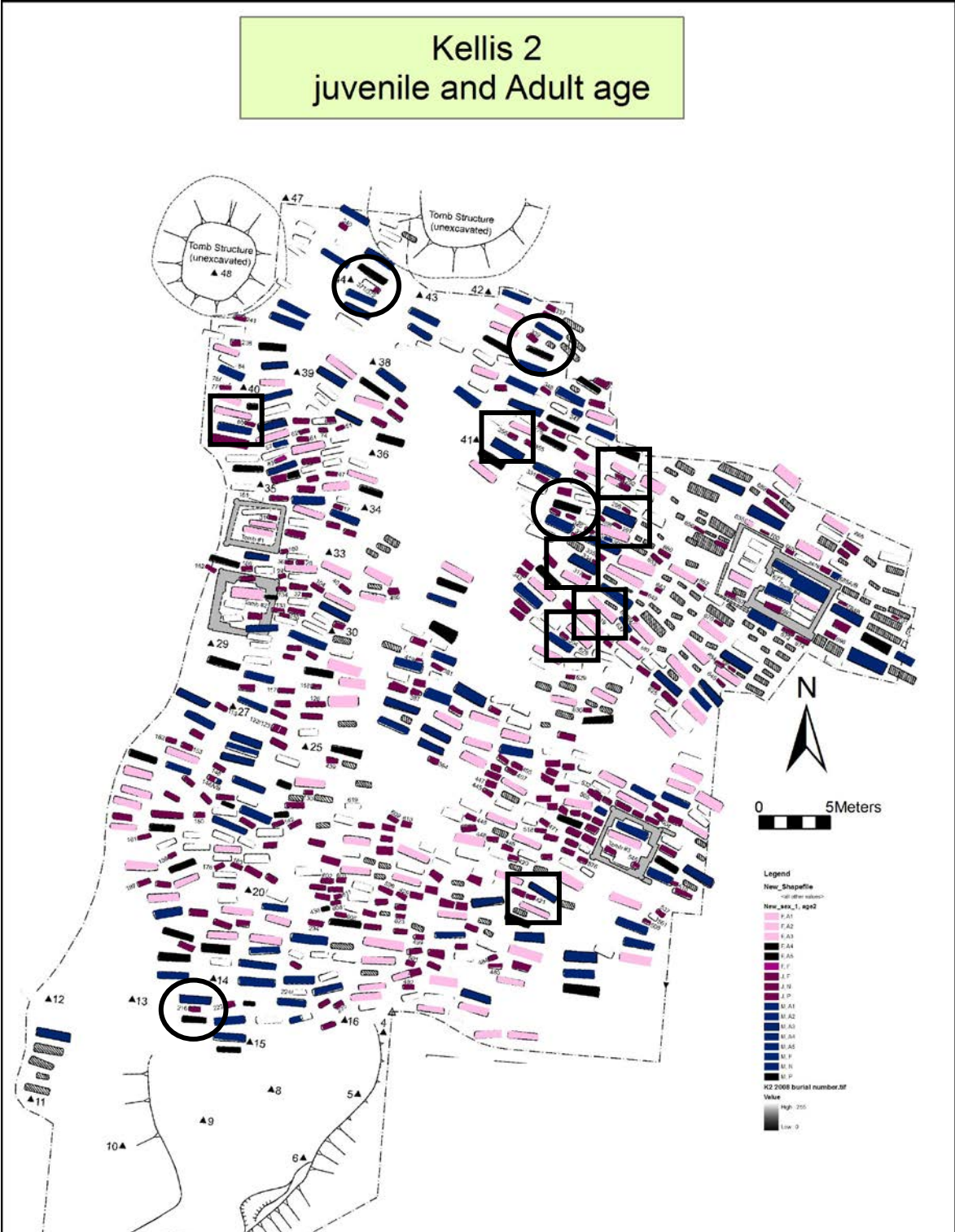


Figure 39: GIS map showing infants buried in close proximity to adult females. Squares (□) represent infants associated with adult females of maternity age, while circles (○) represent infants found in proximity to females who are older than maternity age.



adult male and female. The triangles ( $\triangle$ ; n=11) indicate where an infant is buried between two adult females, and the squares ( $\square$ ; n=2) indicate where an infant is buried between 2 adult males.

Figure 39 shows only infants buried in close proximity to adult females. The square outlines infants buried close to adult females who were classified into the maternal age range (N=8). The circles indicate infants buried in close proximity to females who are considered to be older than maternity age (N=4).

### Frequencies

The purpose of Table 13 is to show how many infants are buried between two adults. “A” represents an infant buried between an adult male and female, “B” refers to an infant buried between two females, and “C” refers to an infant buried between two adult males. Table 13 demonstrates that infants are buried between a male and female, and between two females almost the same number of times. The observed and expected for infants being buried between an adult male and female is the same, while the expected and observed for infants buried between two males, and two females is very different, indicating that this is not a significant practice.

Table 13: The number of infants one year and less buried between two adults.

	Observed N	Expected N	Residual
A	12	12	3.7
B	11	98.3	1.7
C	2	48.3	-5.3
Total	25		

## Chi-Square Test

Results from the Chi-square test (Table 14) show that there is no statistic relationship between children who buried between two adults. Since the  $p = 0.486$ , the null hypotheses cannot be rejected. To investigate the statistic relationship between the infant and adult burials in the Kellis 2 cemetery, the data have been divided by location into two halves, the north the south

Table 14: Results of Chi-square test.

Infants Between Adults			
	Observed N	Expected N	Residual
1.00	12	12.0	.0
2.00	11	9.0	2.0
3.00	2	4.0	-2.0
Total	25		

Infant Between Adults	
Chi-square	1.444 <sup>a</sup>
Df	2
Asymp. Sig.	.486

### Results for the North Half of Kellis 2

Table 15 shows that the number of females buried close to another female is more than expected. On the other hand, the number of females who were buried next to juveniles is less than expected. The number of females who were buried next to a male is close to the expected number by chance. For the juveniles, the statistical analysis showed that the number of juveniles



who were buried next to juveniles is more than expected, but the juveniles who were buried next to males is less than expected. For males, the number of males buried close to males is more than expected and fewer than expected for females and juveniles. According to the cross-tabulation result, the dead in Kellis appear to be buried by sex but not by families.

Table 15: The results for cross-tabulation of paired graves (based on sex: Sex1 vs. Sex2) for the north part of the Kellis 2 cemetery.

Sex1		Sex2			Total
		F	J	M	
F	Count	13	16	10	39
	Expected Count	11.3	18.2	9.5	39.0
J	Count	12	23	4	39
	Expected Count	11.3	18.2	9.5	39.0
M	Count	6	11	12	29
	Expected Count	8.4	13.6	7.0	29.0
Total	Count	31	50	26	107
	Expected Count	31.0	50.0	26.0	107.0

Table 16: Chi-Square test result for the north half relationship between Sex1 and Sex 2.

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-	9.665 <sup>a</sup>	4	.046
Likelihood Ratio	9.953	4	.041
N of Valid Cases	107		

The chi square test results (Table 16) shows that the data is not significant since the p-value is .041 and thus the null hypothesis could not be rejected. Therefore, there is no statistically significant relationship between the variables sex1 and sex2.

Results for the South Half of Kellis 2

Table 17 shows the results of the cross-tabulation examining the statistical relationship of burial space. The results show that the number of females buried close to another female is more than expected. On the other hand, the number of females who were buried next to juveniles is less than expected. The number of females who were buried next to a male is close to the expected number by chance. For the juveniles, the statistics showed that the number of juveniles who were buried next to juveniles is more than expected, but the juveniles who were buried next to males or females is less than expected. For males, the number of males buried close to males is more than expected and close to the expected for females. Like the north section of the cemetery, the cross-tabulation results indicate that the dead in Kellis were buried by sex but not by family units.

Table 17: The results for cross-tabulation of paired graves (based on sex: Sex1 vs. Sex2) for the south part of the Kellis 2 cemetery.

Sex1		Sex2			
		F	J	M	Total
F	Count	20	45	12	77
	Expected Count	16.7	49.6	10.0	77.0
J	Count	32	114	14	162
	Expected Count	35.1	104.3	21.0	162.0
M	Count	10	27	13	51
	Expected Count	11.1	32.8	6.6	51.0
Total	Count	67	199	40	309
	Expected Count	67.0	199.0	40.0	309.0

Table 18 shows the Chi-square test results for the examination of the relationship between burial distances. The results show that the data is not significant since the p value is .091 and thus the null hypothesis should be rejected. Therefore, there is no relationship between the variables sex1 and sex 2.

Table 18: Chi-Square test result for the south half relationship between Sex1 and Sex 2.

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-	14.991 <sup>a</sup>	9	.091
Likelihood Ratio	14.968	9	.092
N of Valid Cases	309		

### Discussion

The results of this study suggest that infants in the Kellis 2 cemetery were more likely to be buried close to each other, than to adult males or females according to the cross-tabulation and the GIS maps. However, a few infants were buried between two adults. In twelve cases infants were buried between adult males and females. This result may suggest that perhaps some infants were buried next to their mothers, and perhaps their fathers. However, without DNA analysis, this remains to be speculation. The chi-square test shows that there is no significant statistical relationship between the location of infant burials and adult burials. An interesting observation is that the GIS map in Figure 39 shows that most of the adult females who were buried close to infants and an adult male were of childbearing ages. This may support the hypothesis that in those spatial relationships with infants and adult males and females that the adult female may be the mother of the infant, or perhaps infants were being placed beside adult females as symbolic representation of the mother-child relationship in afterlife. The Chi-square

test for the spatial relationship between infants and adult burials indicate that there are no statistically significant relationships between infants and adult burial placement. It was initially assumed that people in the K2 cemetery were buried in family groups because some of the spatial relationships showed infants buried near to adult males and females, however there is no evidence to prove this assumption. Inhabitants of Kellis may have used the empty space in between two individuals to bury infants. The way to test this would be to perform DNA analyses.

The cross- tabulation test was important, because it showed that most of the individuals in the Kellis 2 cemetery were buried by sex. In other words, males were more likely to be buried together, females together, and juveniles together. The Chi-square test for all other children one year and less and other burials shows that the spatial relationships between infants and adults are not statistically significant. These results may have been affected by the number of juveniles, which is relatively large compared to the other age categories.

There are some limitations with this research. Without DNA analysis, it is impossible to know if the infants buried between adults are somehow related to these adults. In addition, the entire cemetery is not excavated, and only a part of the cemetery is being considered. Thus, the data analyzed in this thesis only represents a small portion of this population, and this could affect the accuracy of the results.

### Conclusion

The GIS maps and statistical analyses examine the spatial relationships of infants and adult burials. It was found that 25 infants were buried in close proximity to two adults. Twelve of these groups were found to have an infant buried between an adult male and female. It could be hypothesized that perhaps these represent family groupings. In addition, 8 of the adult

females were found to be of child bearing age when they died, and perhaps they were buried beside their infants. DNA analysis could be useful in answering this question. Overall, however, statistical results showed that infants were more likely to be buried closer to other juveniles, and males with males, and females with females. Further research is warranted to look at the spatial relationships between other age categories of juveniles.

### References

- Ariès, P. (1974). *Western Attitudes Towards Death: From the Middle Ages to the Present*. Baltimore: John Hopkins University Press.
- Ariès, P. (1981). *The Hour of Our Death*. New York: Knopf.
- Bagnall, R. S. (1993). *Egypt in Late Antiquity*. Princeton: Princeton University Press.
- Bagnall, R. S. (1997). *The Kellis Agricultural Account Book (P. Kell. IV. Gr. 96)*. Dakhleh Oasis Project Monograph 7. Oxford: Oxbow Books.
- Bartel, B. (1982). A historical overview of ethnological and archaeological analyses of mortuary practice. *Journal of Anthropological Archaeology* 1, 32–58.
- Beck, L. A. (1995). Regional cults and ethnic boundaries in “Southern Hopewell”. *Regional Approaches to Mortuary Analysis*, 2(1-2), 167–187.
- Bendann, E. (1930). *Death Customs: An Analytical Study of Burial Rites*. New York: Kessinger Publishing, LLC.
- Binford, L. R. (1971). Mortuary Practices: Their Study and Their Potential. In J. A. Brown (Ed.), *Approaches to the Social Dimensions of Mortuary Practices* (pp. 3-17). Washington, DC: Society for American Archaeology.

- Birrell, M. (1999). Excavations in the cemeteries of Ismant el-Kharab. In C. A. Hope & A. J. Mills (Eds.), *Dakhleh Oasis Project: Preliminary Reports on the 1992-1993 and 1993-1994 Field Seasons* (pp. 29–41). Oxford: Oxbow Books.
- Blakely, R. L. (1971). Comparison of the mortuary profiles of Archaic, Middle Woodland and Middle Mississippian skeletal populations. *American Journal of Physical Anthropology* 34, 43-54.
- Bowen, G. E. (2002). The fourth-century churches at Ismant el-Kharab. In C.A. Hope & G. E. Bowen (Eds.), *Dakhleh Oasis Project: Preliminary Reports on the 1994-1995 to 1998-1999 Field Seasons* (pp. 65–85). Oxford: Oxbow Books.
- Bowen, G. E. (2003). Some observations on Christian burial practices at Kellis. In G. E. Bowen & C.A. Hope (Eds.), *The Oasis Papers III: Proceedings from the Third International Conference of the Dakhleh Oasis Project* (pp. 187-192). Oxford: Oxbow Books.
- Braun, D. P. (1979). Illinois Hopewell burial practices and social organization: A reexamination of the Klunk-Gibson mound group. In D. S. Brose & N. Greber (Eds.), *Hopewell Archaeology: The Chillicothe Conference* (pp. 67-79). Kent, OH: Kent State University Press.
- Brown, J A. (1971). Approaches to the social dimensions of mortuary practices. *American Antiquity* 36 No. 3 Pt.2/Memoirs of the Society for American Archaeology 25, Washington DC.
- Brown, J. A. (1981). The search for rank in prehistoric burials. In R. Chapman, I. Kinnes, & K. Randsborg (Eds.), *The Archaeology of Death* (pp. 25-37). Cambridge: Cambridge University Press.

- Brown, R. (1922). *The Andaman Islanders: A Study in Social Anthropology*. Cambridge: Cambridge University Press.
- Buikstra, J. E. (1977). Hopewell in the lower Illinois River valley: Regional Study of Human Biological Variability and Pre-historic Mortuary Activity. Northwestern Archeological Program Scientific Papers, Vol. 2. Evanston: Northwestern University Press.
- Burrough, P. A. (1987). *Principles of Geographical Information Systems for Land Resources Assessment*. Oxford: Oxford University Press.
- Capobianco, K. M. (2005). Christopher Columbus to Quickbird: Utility of High Spatial Resolution Satellite Imagery in the First New World Historical Archaeology. Manuscript in preparation: University of Florida.
- Carr, C. (1995). Mortuary practices: Their social, philosophical-religious, circumstantial, and physical determinants. *Journal of Archaeological Method and Theory*, 2(2), 105-200.
- Clarke, K. C. (1997). *Getting Started with Geographic Information Systems*. Prentice Hall Series in Geographic Information Science. New Jersey: Simon & Shuster.
- Conolly, J. & Lake, M. (2006). *Geographical Information Systems in Archaeology*. Cambridge: Cambridge University Press.
- Dabous, A. A. & Osmond, J. K. (2001). Uranium isotopic study of artesian and pluvial contributions to the Nubian Aquifer, Western Desert, Egypt. *Journal of Hydrology* 243, 242-253.
- Fairgrieve, S. I., & Molto, J. (2000). Cribra orbitalia in two temporally disjunct population samples from the Dakhleh Oasis, Egypt. *American Journal of Physical Anthropology*, 111(3), 319-331.
- Frazer, J. G. (1958). *The Golden Bough*. New York: Macmillan.

- Gourad, K. (1999). *GIS in Archaeology: a Survey*. M.A. Thesis, Hunter College, CUNY, New York, NY.
- Gilman, P. (1999). "Securing a Future for Essex's Past." ArcUser, Last date accessed: April 2005. Available online at: <http://www.esri.com/news/arcuser/1099/essex.html>.
- Gluckman, M. (1937). Mortuary customs and the belief in survival after death among the south-eastern Bantu. *Bantu Studies*, 11(2), 117-136.
- Goldstein, L. G. (1980). *Mississippian Mortuary Practices: a Case Study of Two Cemeteries in the Lower Illinois Valley*. Northwestern University Archaeological Program Scientific Papers No 4. Evanston, IL: Northwestern University Press.
- Guillot, D., & Leroy, G. (1995). The use of GIS for archaeological resource management in France: The SCALA project, with a case study in Picardie. In G.R. Lock & G. Stancic (Eds.), *Archaeology and Geographical Information Systems: A European Perspective* (pp. 15-26). Boca Raton: CRC Press.
- Harris, T. (1986). Geographic Information System Design for Archaeological Site Information Retrieval. In, *Computer Applications and Quantitative Methods in Archaeology 1986* (pp. 148-161). Birmingham Center for Computing and Computer Science. Birmingham: University of Birmingham.
- Harris, T. M. & Lock G. R. (1996). Toward an Evaluation of GIS in European Archaeology: the Past, Present and Future of Theory and Application. In Aldenderfer, M. & H. D. G. Maschner (Eds.), *Anthropology, Space and Geographical Information Systems* (pp. 350-365). New York: Oxford University Press.
- Hope, C.A. (1988). Three seasons of excavation at Ismant el'Gharab in Dakhleh Oasis, Egypt. *Mediterranean Archaeology*, 1, 160-78.



- Hope, C. A. (2001). Observations on the dating of the occupation at Ismant el-Kharab. In M. Marlow & A. J. Mills (Eds.), *The Oasis Papers 1: The Proceedings of the First International Symposium of the Dakhleh Oasis Project* (pp. 43–59), Oxford: Oxbow Books.
- Hope, C. A. (2002). Excavations in the settlement of Ismant el-Kharab in 1995-1999. In C. A. Hope & G. E. Bowen (Eds.), *Dakhleh Oasis Project: Preliminary Reports on the 1994-1995 to 1998-1999 Field Seasons* (pp. 167–208). Oxford: Oxbow Books.
- Hunt, E. D. (1992). Upgrading site-catchment analyses with the use of GIS: Investigating the settlement patterns of horticulturalists. *World Archaeology*, 24(2), 283-309.
- Johnson, M. J. (1999). Pagan-Christian burial practices of the fourth century: shared tombs? In E. Ferguson (Ed.), *Christianity and Society: The Social World of Early Christianity* (pp. 385-408). London: Routledge.
- Kaper, O. E. (1997). Temples and gods in Roman Dakhleh: studies in indigenous cults of an Egyptian oasis. D. Phil. Thesis. Proefschrift, Rijksuniversiteit Groningen.
- Katsianis, M., & Tsipidis, S. (2005). Trends and problems in archaeological GIS applications. In, D. Triantis & F. Valliantos (Eds.), *Proceedings of the 2005 WSEAS International Conference on Engineering Education*, CDROM. Vouliagmeni, Athens, Greece.
- Kleindienst, M. R., Churcher, C. S., MacDonald, M. M. A. & Schwarcz, H. P. (1999). Geography, geology, geochronology and geoarchaeology of the Dakhleh Oasis region: an interim report. In C. S. Churcher & A. J. Mills (Eds.), *Dakhleh Oasis Project: Reports from the Survey of Dakhleh Oasis, Western Desert of Egypt 1977-1987* (pp. 1–54). Oxford: Oxbow Books.
- Kroeber, A. L. (1927). Disposal of the dead. *American Anthropologist*, 29(3), 308-315.

- Kron, H. (2007). The Efficacy of GIS for Spatial Analysis of Mortuary Data based on Morphogenetic Traits in the Kellis 2 Cemetery, Dakhleh Oasis, Egypt, M.A. Thesis, The University of Western Ontario, Ontario, Canada.
- Kwan, M. & Lee, J. (2004). Geovisualization of Human Activity Patterns Using 3D GIS: A Time Geographic Approach. In M. F. Goodchild & D. G. Janelle (Eds.), *In Spatially Integrated Social Science* (pp. 3-21). Oxford: Oxford University Press.
- Lythgoe, A. M. (1908). The Oasis of Kharga. *Bulletin of the Metropolitan Museum of Art*, 3, 203-208.
- Maguire, D. J. (1991). An Overview and Definition of GIS. In D. J. Maguire, M. F. Goodchild & D. W. Rhind (Eds.), *Geographical Information Systems: Principles and Applications* (pp. 9-20 ). London: Longman Scientific & Technical.
- Malinowski, B. (1944). *A Scientific Theory of Culture and Other Essays*. Chapel Hill: University of North Carolina Press.
- Marble, D. F. (1990). The potential methodological impact of geographic information systems on the social sciences In Allen, K., Green, S. & Zubrow, E. (Eds.), *Interpreting Space: GIS and Archaeology* (pp. 9-21). London: Taylor & Francis.
- Martin, G.T. (1974). Excavations in the Sacred Animal Necropolis at north Saqqâra, 1972-3: preliminary report. *The Journal of Egyptian Archaeology* 60, 15-29.
- Metcalf, P., & Huntington, R. (1991). *Celebrations of Death: The Anthropology of Mortuary Ritual*. Cambridge: Cambridge University Press.
- Mills, A.J. (1979). Dakhleh Oasis Project Reports on the first season of survey October-December 1978. *Journal of the Society for the Study of Egyptian Antiquities IX*, 163-185.

- Mills, A. J. (1984). Research in the Dakhleh Oasis. In L. Kryzaniak & M. Kobusiewicz (Eds.), *Origin and Early Development of Food Processing Cultures in North-Eastern Africa* (pp. 205-210). Poznan: Polish Academy of Sciences.
- Molto, J. E. (2001). The comparative skeletal biology and paleoepidemiology of the people from Ein Tirghi and Kellis, Dakhleh Oasis, Egypt. In C. A. Marlow & A. J. Mills (Eds.), *The Oasis Papers I: The Proceedings of the First Conference of the Dakhleh Oasis Project* (pp. 81-100). Oxford: Oxbow Books.
- Molto, J. (2002). Bio-archaeological research at Kellis 2: an overview. In C. A. Hope & G. E. Bowen (Eds.), *Dakhleh Oasis Project: Preliminary Reports on the 1994-1995 to 1998-1999 Field Seasons* ( pp. 239-255). Oxford: Oxbow Books.
- Morris, I. (1991). The archaeology of ancestors: The Saxe/Goldstein hypothesis revisited. *Cambridge Archaeological Journal*, 1(2), 147-169.
- O'Sullivan, D., & Unwin, D. J. (2003). *Geographic Information Analysis*. Hoboken, NJ: John Wiley & Sons Inc.
- Peebles, C. S & Kus, S. M. (1977). Some archaeological correlates of ranked societies. *American Antiquity*, 42(3), 421-448.
- Rakita, G. F. M. (2005). *Interacting with the Dead: Perspectives on Mortuary Archaeology for the New Millennium*. Gainesville: University Press of Florida.
- Rothschild, N. A. (1979). Mortuary Behavior and Social Organization at Indian Knoll and Dickinson Mounds. *American Antiquity*, 44, 658-75.
- Saxe, A. A. (1971). Social dimensions of mortuary practices in a Mesolithic population from Wadi Halfa, Sudan. *Memoirs of the Society for American Archaeology*, 25, 39-57.

- Shaaban, M. M. (1988). Palaeodemography of a Pre-Roman Populations from El-Dakhleh, Egypt: Evidence from the Skeletal Remains at Site 31/435-D5-2. Ph.D. Dissertation. Toronto, University of Toronto.
- Star, J. L., & Estes, J. E. (1990). *Geographic Information Systems: An Introduction*. Englewood Cliff, NJ.
- Stewart, J. D., Molto, J. E., & Reimer, P. J. (2003). The chronology of Kellis 2: the interpretative significance of radiocarbon dating of human remains. In G. E. Bowen & C. A. Hope (Eds.), *The Oasis Papers III: Proceedings from the Third International Conference of the Dakhleh Oasis Project* (pp. 373-382). Oxford: Oxbow Books.
- Tainter, J. A. (1975). Social inference and mortuary practices: An experiment in numerical classification. *World Archaeology*, 7(1), 1-15.
- Tainter, J. A. (1980). Behavior and status in a middle woodland mortuary population from the Illinois valley. *American Antiquity*, 45(2), 308-313.
- Tylor, E. B. (1866). The Religion of Savages. *Fortnightly Review*, 6, 71-86.
- Tylor, E. B. (1871). *Primitive Culture*. London: John Murray.
- Tylor, E. B. (1878). *Researches into the early history of mankind and the development of civilization*. New York: Henry Holt.
- Tuan, Y. F. (1979). *Landscapes of Fear*. New York: Pantheon Books.
- Ucko, P. J. (1969). Ethnography and archaeological interpretation of funerary remains. *World Archaeology*, 1(2), 262-280.
- Van Gennep, A., Vizedom, M. B., & Caffee, G. L. (1960). *The rites of passage*. Chicago: The University of Chicago Press.

- Wansleben, M. (1988). Applications of geographical information systems in archaeological research. *Computer and Quantitative Methods in Archaeology*, 2, 435-451.
- Watts, D. (1998). *Religion in Late Roman Britain: Forces of Change*. New York: Routledge.
- Wheatley, D., & Gillings, M. (2002). *Spatial technology and archaeology: The archaeological applications of GIS*. New York: Taylor and Francis.
- Wheeler, S. M. (2009). *Bioarchaeology of Infancy and Childhood at the Kellis 2 Cemetery, Dakhleh Oasis, Egypt*, Ph.D. Dissertation, University of Western Ontario, Ontario, Canada.
- Williams, L. J. (2008). *Investigating Seasonality of Death at Kellis 2 Cemetery using Solar Alignment and Isotopic Analysis of Mummified Tissues*. Ph.D. Dissertation. The University of Western Ontario, Ontario, Canada.
- Yermakhanova, O. A. (2005). *Kingship, Structures and Access Patterns on the Royal Plaza at the Ancient Maya City of Altun Ha, Belize: The Construction of a Maya GIS*. M.A. Thesis, Louisiana State University, Louisiana.

## CHAPTER FOUR: CONCLUSIONS

### Overview

As mentioned in the previous chapters, the main objective of this research study was to address two objectives related to mortuary data from the Kellis 2 cemetery in the Dakhleh Oasis, Egypt. The first objective was aimed at investigating the relationships among sex, age and burial substructure style, and the second objective aimed at analyzing the spatial relationships between infants/fetuses and adult burials. This research used Geographic Information Systems and statistical analyses to address these two problems. For the first problem, fifteen maps have been developed to show the relationships between the substructure styles and the demographics (sex and age) of burials. Two other maps were created to investigate the relationship between infants/fetuses less than one year old and other burials in the cemeteries.

### The Relationship between the Substructure Styles and Burial Demographics

There are sixteen styles of substructures that have been documented in the Kellis 2 cemetery. The analysis shows that 73% of female burials have no substructures while 37% have substructures. Only 10 styles of substructures have been found with female burials. Some styles of substructures were not found with female burial (e.g. styles #7, #8, #9, #10, and #11). Some styles were common with females (e.g., styles #3, #6, and #12). On the other hand, there are some styles rarely found with females such as #5, #13 and #15 (each one only found one time). The majority of substructures documented for adult females have been found to be associated

with specific age groups. Style #15 was found with one female aged as A1 while style #5 was found with a female aged A3. Style #13 appears with one female aged as A4. Males and females aged in the A2 and A3 categories are more likely to be associated with substructures more than other age categories. Also, infants are associated with substructures more than any other age group of juveniles.

Also in the Kellis 2 cemetery, 64% of the male burials have no substructures. Some styles of substructures were not found with male burials such as #10, #11, and #15. Substructure style #12 was the most common style that has been found with the male burials in the Kellis 2 cemetery. Substructure styles #16 and #9 have been only found one time each with male burials. Substructures are most commonly found with male burials aged as A2 and A3.

The results also show that 82.3% of juveniles have no substructures. Fourteen styles of substructures have been found with the juvenile burials. Style #3 was the most common style found with the juveniles, while styles #7, #11, and #13 were only found one time each. The juveniles aged in the C3 category and fetuses did not commonly have associated substructures.

There are 16 different styles of substructures recorded in the Kellis 2 cemetery, and juveniles have the most variety of substructures, while adult males have 13 and females have 10 different styles. Style #6 was most commonly found to be associated with adult males and females, and juveniles. Style #16 has been found only with males, while style #15 was only found with females. Styles #10 and #11 only appears with juvenile graves. The male group had the largest percentage of burials with substructures (36% of the total number of male burials), while only 27% of females have substructures and the 18% of juveniles have substructures. The substructures were common within a specific age group in each sex group. For example, the

substructures were more common for females who were aged as A2, A3 and A4 compared to those who were aged as A1 or A5. Males who were aged as A2 and A3 had the most number of substructures. Interestingly this finding was the same for both adult males and females. Age groups A1 and A5 have limited number of substructures. For juveniles, substructures were common for the newborn age category.

Although it cannot be conclusively resolved as to why certain individuals had associated substructures, speculation can be made. Because there are so few individuals overall who are buried with substructures, one speculation could be that the individuals with substructures were perhaps from a higher socioeconomic status. This may have also been a tradition brought from another location, or a tradition related to the age of the individual. For example, adult females and males who have substructures are most likely to be in the A2 or A3 age category, and may have been those individuals who contributed to the household wealth, were workers, or perhaps military. Another example of associated age would be the difference between substructures associated with infants and fetuses. While it is rare for fetuses to have associated substructures, it is quite common in the infant age category. This practice may reflect belief in the viability of the individual.

In addition there are some styles of substructure that appear more frequently with males, females and juveniles, especially style #3. This particular substructure consisted of a head niche dug into the side of the grave. It could be suggested that this style was common for a few reasons. It may have been the result of simply not having a burial dug to the correct specifications of the individual (pre-digging the hole before the intended individual arrives for burial, and then they are too long to fit). This would have been a simple solution to make the



grave larger. This may have also been an inexpensive way to protect the head of the individual (this is also reflected in style #6, also a common substructure style).

### Spatial Relationship Between the Infants and the Adults Buried Next to Them

Most infants were buried next to each other, with the exception of 25 infants who were buried between two adults. There are thirteen infants buried between an adult male and female, ten buried between two females, and three buried between two males. Since the number of infants who buried between an adult male and female was the highest number, it might be suggested that those groups may represent a family group. This is especially interesting as most of the adults in these combinations were of marriage/childbearing age. However, DNA analyses must be used to prove this suggestion. On the other hand, there are some infants buried between two males, and perhaps this was just because there was available burial space between the males. Also, ten children have been buried between two females, and while this may suggest a familial relationship to at least one of the females, it may have also been because there was available burial space in these locations. The results suggest that it was more common for juveniles to be buried closer to other juveniles, males closer to males, and females closer to females, suggesting that familial grouping in burial was most likely not the common practice.

### Final Comments

Throughout this research, GIS was an effective tool. GIS effectively helped to analyze the distribution of graves with substructures throughout the Kellis 2 cemetery. In addition, GIS helped to elucidate the relationships among age, sex, and substructures. GIS also helped to clarify the spatial relationship between the infants who were buried between two individuals and

the gender of these individuals. The Kellis 2 cemetery was a great archeological site for this research since it contains a well preserved environment with a good data set. Future research would be warranted to generate GIS maps to associate existing radiocarbon dates for these burials relative to substructure styles. Moreover, more analysis should be focused on the spatial distribution of other juveniles' age categories in the Kellis 2 cemetery.