Spatial distribution of artifacts and site formation at the Lower Town of Mycenae

By

Ryan Patrick Shears

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By

Ryan Patrick Shears

Approved:

____________________________________
Evan Peacock
(Major Professor)

____________________________________
James W. Hardin
(Committee Member)

____________________________________
Michael L. Galaty
(Committee Member)

____________________________________
David M. Hoffman
(Graduate Coordinator)

____________________________________
Rick Travis
Dean
College of Arts & Sciences
The “Lower Town” archaeological site in Mycenae, Argolis, Greece has been excavated since 2007 and multiple periods of occupation and abandonment are represented in the stratigraphy uncovered. Sedimentary deposits were grouped into two general categories during excavation and these categories shaped fieldwork decisions: yellow-orange sediment with denser artifact concentrations representing potential occupation and red sediment with sparser artifacts representing abandonment. The distributions of point locations of artifacts within these bodies of sediment are analyzed statistically for spatial homogeneity using Ripley’s K in a GIS environment to test these site formation assumptions. Statistically significant spatial clustering in artifacts is assumed for autochthonous occupation deposits. These analyses were designed to be used to explicitly test otherwise implicit assumptions during fieldwork in future fieldwork. Results are mixed, with several factors complicating the interpretation of results without the hindsight of post-fieldwork artifactual and geoarchaeological analyses.
DEDICATION

This thesis is dedicated to my parents, who have always encouraged me to explore the past.
ACKNOWLEDGEMENTS

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CHAPTER I
BACKGROUND

The Dickinson College Excavation Project and Archaeological Survey of the Lower Town of Mycenae (DEPAS MYCLT) has conducted systematic geophysical survey since 2003 and since 2007 excavated a site titled the “Lower Town”, recording distinct periods of occupation over several centuries with heavy sediment inflow between occupations in a dense archaeological landscape near the Citadel of Mycenae site in Argolis, Greece (Dierckx and Maggidis 2012; Maggidis and Stamos 2006; Stamos 2011). Due to this sequence of interleaved occupation and abandonment strata, a thorough understanding of site formation processes, both cultural and geological, is necessary before interpreting the artifacts from any stratigraphic context as evidence of past behavior at that specific location. Spatial statistics, approached from a GIS perspective, offers a method of characterizing meaningful distinctions in the spatial arrangements of artifacts, distinctions that reflect differing agents of artifact deposition. In this case, the distinction is between contexts comprised of a red sediment associated during excavation with few artifacts, and thus presumably periods of abandonment, and a paler yellow-orange sediment with denser artifact concentrations. The method modeled in this study can be conducted on data already recorded during excavation to test such distinctions in the midst of fieldwork and can thus be a tool to make explicit sampling decisions.
Site Background

The Lower Town site is part of a larger archaeological landscape called Mycenae, located in the modern country of Greece in the Argolis Prefecture on the Peloponnese Peninsula. It is comprised of multiple buildings built on a three hectare bedrock outcrop, known as the Citadel of Mycenae, and the remains in the valleys that surround it among multiple mountain peaks (Figures A.1 and A.2). The Citadel exhibits surface and subsurface remains demonstrating human occupation since the Neolithic period (Wace 1949). Among the most conspicuous and most published-upon are monumental fortifications and buildings with assumed functions of workshops, storage facilities, military barracks, religious complexes, and palatial buildings on the Citadel dating to the “Late Helladic” (LH) period (1550-1050BC) (French 2002; Iakovides and French 2003; Mylonas 1983). The Late Helladic is the mainland Greek expression of the Mediterranean Late Bronze Age, characterized by organization into agricultural states ruled by an authority based at least in part in citadels with “Palaces” that engaged in the production and exchange of goods throughout the Mediterranean; Mycenaean ceramics are found in Egypt and the Levant and Egyptian goods found in contemporary Greek contexts. These states collapsed and political organization decentralized within a context of a larger western Mediterranean “Bronze Age Collapse” that resulted in the abandonment of the Citadel (Dickinson 1994; Shelmerdine 1997, 2008).

Since the late 19th century, architectural survey and excavation have been almost continuous at Mycenae (Dierckx and Maggidis 2012; Iakovides 2006; Mylonas 1966; Schliemann and Gladstone 1880; Tsountas and Manatt 1897; Wace and French 1980). Today, Mycenae is a protected cultural heritage site administered by the Greek Ministry
of Culture and Sports, and fieldwork there is being conducted by multiple institutions. DEPAS MYCLT’s geophysical survey, begun in 2003, and excavation, begun in 2007, uncovered strata representing periods of occupation and abandonment in a valley to the south of the Citadel (Dierckx and Maggidis 2012).

### Geophysical Landscape

The Citadel of Mycenae, as a topographic landscape feature, is a limestone outcrop of more than three hectares in the saddle between two limestone mountain peaks, Profitas Elias and Mt. Zara. The surrounding gorges and valleys are underlain by conglomerates and marls (Karkanas In Press). The area is subject to extensive seismic activity, and so the landscape is in part defined by fault scarps (Iakovides and French 2003).

The Citadel is defined to the north by the now-dry, broad, shallow channel of the Kouvetsi River and to the west and southwest by the narrow and deeply incised intermittent channel of the Chavos River. The Citadel extends west from an extension of Mt. Zara and then to the south, becoming the north-south linear hill known as the Panagia Ridge. The Citadel, Panagia Ridge, and mountain peaks separate low-lying areas into valleys to the south and north of the Citadel and a gorge between the Citadel and Mt. Zara (Figures A.1 and A.2). The study site for the DEPAS MYCLT excavation is the valley to the south.

### Architectural Remains

Architectural remains are extensive throughout the Argolid Plain, and Mycenae is a particularly dense area. The Citadel, as an architectural complex, is rimmed by a 900 m
monumental circuit wall, in areas 2 m thick. It has a height in sections of at least three meters in its current deteriorated state (Mylonas 1983). The Citadel has buildings across its surface from various periods, with facilities proposed to have been barracks, workshops for goods such as gold and ivory, dedicated religious facilities, residences, and storage. The peak of the hill features the palace, a large complex of rooms and courtyards featuring a “megaron,” a tripartite rectangular building plan that includes a throne room with a hearth (French 2002; Mylonas 1966, 1983). This notion of a palace with accompanying fortifications, production and storage facilities, and civic spaces is a recurring feature in Greece at the time. Earlier literature assumed a highly centralized monarchy or feudal system that collected from agricultural production in the surrounding area via taxation and that monopolized workshops and trade, but this has been challenged in recent times with evidence of emerging market activity and extra-palatial production and exchange of manufactured goods (Parkinson et al. 2013; Nakassis et al. 2011; Pullen 2013; Shelmerdine 2013).

Though the larger area around Mycenae has not been intensively surveyed with subsurface testing, pedestrian survey and more than a century of targeted investigations have recorded many structures. Large residential complexes, regularly characterized as residences and workshops for bureaucrats, merchants, or nobles and having uniquely high numbers of manufactured goods such as lead items, wine, oil, and ceramics have been excavated in the area outside the walls of the Citadel, generally on the slopes of the Citadel’s hill and the Panagia Ridge (Mylonas-Shear 1987). Tholoi (beehive-shaped tombs built into hillslopes), Grave Circles (cemeteries of graves dug on flat land surrounded by a retaining wall) and chamber tombs (cave-like hollows dug into hillsides)
comprise the monumental funerary architecture in the landscape (Wace 1932; Mylonas 1983; Iakovides and French 2003). Walls, roads, bridge/dam structures, and earthworks are found throughout the slopes and valleys of Mycenae (Iakovides and French 2003).

The possibility of an urban area connected to Mycenae has been long debated. Older models of settlement around LH citadels assumed it would be comprised of many hamlets consisting of few or even single households in the larger area, with the citadel itself a relatively isolated complex (Wace 1949). However multiple Mycenaean citadels have had adjacent residential complexes discovered adjacent to them, and walled cities around fortified citadels are common at contemporary sites in other regions like Anatolia. Tiryns, roughly 15 km south of Mycenae and visible from it, is similarly comprised of a fortified citadel and excavations have uncovered a surrounding area of at least 15ha, “Der Unterstadt” (German for “Lower City” or “Lower Town”), with smaller-scale residences (Dickinson 1994). A “Lower Town” has also been identified at Pylos, a palatial site at the opposite side of the Peloponnese in the region of Messenia, currently being investigated by the University of Cincinnati (Davis and Stocker 2016). Following the identification of extensive subsurface architecture via systematic geophysical survey, the DEPAS of MYCLT project initiated the excavation whose data are studied here (Maggidis and Stamos 2006).
CHAPTER II
PREVIOUS FIELDWORK

Survey

The Dickinson Excavation Project and Archaeological Survey of the Mycenae Lower Town conducted geophysical survey from 2003 to 2009 in the southern valley to investigate the scope and manner of the settlement near the Citadel. Today, the valley is broken into several terraces delineated by modern built terrace walls running east-west and the Chavos channel cutting NE-SW (Figures A.2). Twelve terraces were surveyed with a fluxgate magnetic gradiometer, and five of the terraces closer to the Citadel were also surveyed using Ground Penetrating Radar. The first and currently only excavation area, Southwest Bank IIB, was chosen based on the results of this survey (Dierckx and Maggidis 2012; Stamos 2011).

Excavation

Excavation began in 2007 and has uncovered multiple occupation layers, buildings, 4,799 individually cataloged artifacts and 5,074 aggregate bags of artifacts (Figures A.3 and A.4). Remains range in date from the Late Bronze Age through the modern period, with the majority of structures and occupation layers proposed to date from either the Late Helladic period or the Geometric (10th and 8th centuries BC) and possibly Archaic (8th to 5th centuries) periods (Dierckx and Maggidis 2012).
There are several apparent building and structure foundations. Among the LH structures are a complex of small, enclosed square and circular spaces (Buildings V-VII) abutting a possible perimeter wall made of field stones, comprised of segments named Walls B (Beta) and Γ (Gamma) at the west side of the site. These walls are particularly tall; sections of Wall B more than 2 meters. To the northeast of this is a presumed well or cistern, Building IV. Another long wall, Wall A, is lower but made of dressed stone on its west face, possibly because it is a retaining wall. Walls B and A delineate a large part of the site into three sections east to west; they are roughly parallel to one another, running approximately North-South, and are each more than 15m long (Dierckx and Maggidis 2012).

A second set of structures has been dated to the Geometric or possibly Archaic period. The structure called Building VIII is an expansion of the preexisting Walls B and Γ with several repairs, additional courses and extensions. There is a megaron in the far southeast, Building I, and to the north of this is a set of orthogonal walls forming multiple rooms across one or more buildings, named during excavation Buildings III, IV, and IX (Dierckx and Maggidis 2012).

All excavation was conducted stratigraphically, divided by natural levels but also subdividing these levels into artificial spits of 10 cm, with the goal of recording any apparent changes in soil color, nature or number of artifact inclusions as separate stratigraphic contexts. Per the Wheeler method, a grid of 4 m excavation squares separated by 1 m balks was used. Contexts in each of these excavation squares were numbered and recorded separately from other squares for the purposes of recording. As excavated, there are 546 separate stratigraphic contexts.
It is almost certain that a number of these separately recorded contexts are contemporary in their formation, and would even have been considered the same context if they were within the same excavation unit. Burial depth would be a useful proxy for correlating contexts if the layers were continuous across site; Steno’s Principal of Original Horizontality dictates that continuous layers of sediment will deposit level or in conformal layers. However, beyond any more specific exceptions, Walls A and B complicate the use of this proxy. Wall A and B have been dated by diagnostic pottery in construction layers and architectural style as dating the Late Helladic, predating most of the excavated strata (Dierckx and Maggidis 2012). Much of Wall A is at least 1 m tall, and Wall B is more than 2 m in sections, and they are roughly parallel. Because of this, they divided much of the site’s layers into three discontinuous sections from east to west and therefore acted as de facto retaining walls, maintaining different contemporary surface elevations and rates of deposition to either side of each wall.

An overall site formation history has been developed that synthesizes excavation observations and laboratory geoarchaeological and artefactual analysis. Subsequent to any yet-excavated architecture, the valley floor was blanketed in fluvial sediment from seasonal flooding of the Chavos River. Late Helladic architectural features were built on and cut into this fluvial sediment. No further construction occurred, and at some point during the Protogeometric Period (the timespan between the Late Helladic and Geometric), a massive influx of red sediment was deposited onto the site from the northeast and east. This cause of this influx is theorized to be that after the abandonment of the Citadel, dams upriver from the site deteriorated due to lack of maintenance and caused the Chavos River to go into disequilibrium and resume flooding temporarily,
depositing large amounts of stored sediment. Wall B acted to block the influx of red sediment against its eastern face, and there is no red sediment to the west of it.

Any subsequent construction in the Geometric Period was built on and cutting into this red sediment. No red sediment was deposited after the Geometric construction, presumably because the Chavos River returned to equilibrium in its incised channel and no longer flooded its banks. Rather, any further sediment influx was a more reduced soil that appears orange, yellow, or even grey, with a much higher density of artifacts and characteristic of lower-energy deposition. At least some of the sediment deposits may be autochthonous occupation layers, but at least some of the rest is slopewash from the northwest and north from the Panagia Ridge and Citadel, and the artifacts present in them are eroded from occupation deposits upslope (Dierckx and Maggidis 2012; Karkanas In Press).

During excavation these two colors of sediment, red and yellow-orange, were used as broad categorizations considered in fieldwork planning and in sampling strategies as representing abandonment (red) and representing potential occupation (yellow-orange).
CHAPTER III

PROBLEM DESCRIPTION

Theoretical Considerations

The notion of assigning an archaeological deposit into a binary “cultural” or “natural” system is not without problems. Taphonomic processes modify artifact locations, distributions, and the artifacts themselves, through mechanical and chemical effects of soil chemistry, water movement, plant growth, and non-human animals (Rick et al. 2006:200; Wood and Johnson 1978). This would be true even in the ideal embodied in the “Pompeii Premise” fallacy that Schiffer (1972, 1983, 1985) defines as the notion that items are abandoned in the exact horizontal location of their use. Conversely, “natural” phenomena can rarely be divorced from influence by human cultural behavior, whether from intentional or unintentional modification of soil chemistry, drainage, erosion, and other factors. And an assemblage of artifacts relocated by physical phenomena like gravity can retain spatial relationships as it moves, including those developed by cultural deposition processes (Rick 1976), though he still found overall randomness in artifacts redistributed downslope and Bertran et al. (2015) found significant diffusion of simulated artifact clusters even over the course of five years. In that it treats certain contexts with cultural material as non-cultural, this distinction could appear to be an example of Binford’s (1981) different definition of a “Pompeii Premise” fallacy, that an archaeologist would treat a deposit as either worth studying or not based on how closely
it is perceived to reflect past behavior, but in this case the distinction is being drawn as an explicit choice for a specific goal rather than for overall study.

This distinction can still be a useful one to draw and is so at MYCLT; given that there are areas with denser populations previous to and contemporary with MYCLT’s inhabitations in all upslope directions, it is entirely possible there are bodies of sediment with artifacts that were relocated from a location other than SWBII. That is to say, that some artifacts could have been found on this site because they eroded downslope or transported by flooding. To explicitly operationalize this distinction, the portable artifacts in a “natural” deposit were those that left human contact in a horizontal location outside of the excavated extent of the stratigraphic context. Conversely, “cultural” deposits would consist of portable artifacts that left human contact within the excavated stratigraphic context’s extent.

These categories do not map onto Schiffer’s (1972) primary and secondary contexts, those deposited in their location of their primary function, however defined, and those deposited elsewhere, for example at a dedicated disposal site. Rather, my “cultural” deposits include both primary and secondary deposits that have not been horizontally relocated after initial deposition, whereas “natural” deposits contain artifacts from any number of primary and secondary contexts whose horizontal location and spatial interrelationships are more representative of sedimentary processes than cultural processes at my scale of analysis.

My hypotheses are built around the assumption that the cultural deposits would be more clustered than the natural deposits, because the mass transport at much larger spatial scales than the excavation units used sufficiently dispersed the artifacts such that the
distribution of their point locations are statistically indistinguishable from a random
distribution of the same number of points in the same extent.

Problem Background

A substantial amount of sediment has accumulated on the modern terrace on
which SWBII is located, overlaying all structures such that the only architectural features
visible on site prior to fieldwork were low modern retaining walls, less than half a meter
tall. The aforementioned Late Helladic Wall B is over 2 m tall in spots along its length
and was entirely buried even after vegetation and topsoil removal (Dierckx and Maggidis
2012).

Aside from unique isolated contexts such as graves, foundation trenches, and
accumulated floors, bodies of sediment were characterized as two types by excavators:
yellow-brown (10 YR 4/4-5) and a darker red-brown (7.5 YR 3-4/4-5). The former bore
markedly more artifacts, and several contexts of the latter had no apparent portable finds.
Due to the difference in artifact density, on-site interpretations linked the difference to the
presence or absence of human activity. Chemical analyses agree with these
interpretations, identifying the two sediments as sharing same parent. That sediment
shares the same deep red color as the culturally sterile contexts. The paler color of the
presumed anthropogenic soil comes from human occupation reducing the oxidized parent
sediment and also incorporating ash, and therefore the difference in color is one of land-
use at some point prior to burial (Karkanas In Press).

Thus, a rough site formation interpretation was used on the site during fieldwork:
red sediment eroded out of its upslope source and was transported to the location where it
was found during excavation. If there was relatively little or no human occupation during
the period in which the sediment was at the surface, it retained its red color. Conversely, human occupation contributed to reduction during soil formation, giving it the paler color observed during excavation. Artifact density, as recorded in the field, generally agrees with this supposition; the red contexts exhibit very few artifacts, ranging from few fragmentary artifacts to culturally sterile sediment. Bodies of red sediment seem to indicate periods of cessation of human occupation.

The inverse inference is borne out: bodies of sediment that pedogenically exhibit signs of human inhabitation have more artifacts. However, there is an issue of equifinality that needs to be addressed: it is possible that this anthropogenic reduction and incorporation of artifacts did not occur on SWBII, but rather at some upslope location. Additionally, if artifacts from this prior location were moved along with the sediment, this body of sediment would be a “false positive” as representing human activity on this location during the time of deposition. Other complementary analyses could directly address this, for example analysis of edge wear for evidence of tumbling, but this data is not yet available.

There are several approaches that could distinguish between these categories of deposit formation. Finer-scale geomorphologic analysis of micro-morphological thin sections and soil chemistry analysis can be employed (Karkanas et al. 2012; Rick et al. 2006), and were conducted by geoarchaeologists associated with DEPAS MYCLT subsequent to the end of excavation (Karkanas In Press; Fallu 2015) that identify deposition rates, compaction, and other factors. Stylistic and functional analysis of artifacts can attempt to discern “working floors”, “households”, “refuse”, and other hypothesized uses of space, and ceramic analysis of materials from the Lower Town are
ongoing (Peterson 2017). Clear examples of specific functional assemblages in certain contexts would be a powerful argument for an anthropogenic genesis (Ault and Nevett 1999; Foster et al. 1996; Gnivecki 1987).

The above analyses required specific laboratory processing of materials and present logistical concerns including time and manpower for artifact processing, funding, curation of artifacts in Greece rather than at home institutions of researchers, and the shared use of facilities. These strictures mean that these types of analyses were largely not conducted until excavation had been paused for several years for this project.

However in DEPAS MYCLT’s record-keeping system, numerous recordings, notably grid-based or point-based recordings of object spatial location, are made in the field and provide a body of information that can be data-mined without further physical access to materials and once prepared and pre-scripted, can be updated in a matter of minutes. These analyses will not have the same fine scale and nuanced consideration of variation as those augmented with laboratory data, but they can provide a framework for explicitly testing assumptions made implicitly by excavators about the spatial scale at which bodies of artifacts, and their intra-unit spatial relationships, reflect past human behavior. Moreover, in addition to testing these assumptions in concert with the more detailed analysis results already made, in future work these analyses can continue to test these assumptions on a regular basis while excavation is ongoing, assumptions that heavily inform sampling and recording decisions.
CHAPTER IV
METHODS

Methods Background

GIS (variously Geographic Information Science, Studies, or Systems) is an umbrella term for many closely allied fields that are used to record, manipulate, and analyze data in reference to geographic space, borrowing from traditional analog mapmaking and surveying techniques, mathematic disciplines including statistics and geometry, and computer science theories of relational databases (Conolly and Lake 2006).

GIS seeks to model data in such a way that geographic proximity, distribution, coincidence, and interconnection can be analyzed and displayed in conjunction with other data. Travel time, climatological recordings, and population data have long been illustrated in printed and drawn maps. However, as developed in modern computer systems, the field allows one to keep data stored in relation to geographic space to facilitate any number of associations, analyses, and visualizations (Conolly and Lake 2006).

An important concept in GIS is the geodatabase: a body of computer data with relationships to geographic space included. A special case of the relational database, the geodatabase models data in a series of tables. Each table represents a category of entity; each column models an attribute of that entity and each row is a specific instance of the entity.
entity. These entities need not represent tangible, discrete objects; they must simply be independent from one another in a consistent conceptual scheme. A database will consist of multiple tables; relationships between tables are defined by identifying columns that contain equivalent information (Figure A.5). Once the data are so stored, they can be queried and analyzed in any number of ways, whether to produce maps, renderings, graphs, statistical figures, or other results (Conolly and Lake 2006).

The geographic component in GIS datasets is modeled in one of two ways. Vector data describe shapes mathematically using coordinate pairs representing individual points, the path of linear features, and the vertices of polygons. Vector data are usually used to model discrete phenomena; e.g., points for trees, car accidents, and geological boreholes; lines for roads, trails, and the courses of streams; polygons for watersheds, geographic boundaries, and building footprints (Conolly and Lake 2006).

Raster data, instead, define a rectangular grid of squares; each square bears a value. The rectangle’s extent is then defined as overlaying a particular area in geographic space. It is implicit in this data modeling that any given point in the rectangular area has a value, and this shapes the use of raster data for modeling. The normal use case is for data that are continuous across a landscape, like elevation and temperature; aerial photographs are a special case in which the reflectance of visible light is the value. Rasters can also be used to represent discrete data that would normally be modeled by vector data; many mathematic transformations and analyses are much more computationally simple than analogous vector methods, and so in older studies most or all processing was done with rasters (Hietala and Larson 1984).
Archaeology and GIS

GIS, developed in large part for civic planning and environmental analysis, saw early application to archaeology and is currently used extensively in the field (Conolly and Lake 2006). Due to its extensive applications in fields like hydrology, forestry, and mining, GIS software packages usually have built-in tools for analyzing landscape and topography that have ready applications to archaeology on a broader spatial scale. Cost-path analysis and predictive site location analysis help to identify likely transport routes and inhabitation sites respectively using elevation, ground cover, bodies of water, and other spatial data (Siart et al. 2008). Exploratory analysis of aerial photography can detect denuded landforms and crop marks that are not apparent at ground level (Štular et al. 2012; Verhoeven et al. 2012). Topographic data are used to conduct viewshed analysis and inter-visibility studies to support arguments regarding the placement of monumental architecture (Ogburn 2006).

However, finer-scale analyses also have seen application in archaeology. With both the increased focus on identification of past human activities using spatial patterning by function and focus on quantitative results in the Processual Movement, techniques like cluster analysis of artifact and site locations and unguided classification of aerial imagery promised to give researchers a tool to “objectively” identify behaviors like production, use, recycling, disposal, etc. (Hietala and Larson 1984; Rick 1976). But with the evolution of computer technology came the ability to include cluster solutions and descriptive statistics of distributions using vector data (Arroyo 2009; Bollong 1994; Enloe 2006; Kelly et al. 2006; Spikins et al. 2002). Some of these analyses use data recorded to an extremely high level of detail, including orientation of each object in three
dimensions, to attempt to identify the effects of factors like high-energy fluvial deposition and trampling on assemblages (Andrews 2006; McPherron 2005; Dibble et al. 1997). There are also numerous theoretical concerns related to these studies, in that the effects of human/animal trampling and overburden and sediment consolidation are difficult to determine without an intimate understanding of the sedimentological environment, and even then it may not be possible (McPherron 2005). In any case, an intensive study of soils and depositional environment is necessary to interpret spatial results (Andrews 2006).

One vector analysis that is used in archaeology is “Ripley’s K”, a statistical measure and associated multi-scale implementation that describes the density of points at several different scales in comparison with the overall density of points, usually with the goal of comparing the dataset’s homogeneity and degree of clustering against a theoretical random distribution in the same area (Ripley 1977). For practical purposes the measure is calculated approximately. But, if calculated exactly, the process would be to count the number of neighboring points within a set distance of each point, and to derive a value based on how this number of neighbors varies within the dataset. This set distance is the spatial scale of this K value.

A perfectly regular grid of dots would have the lowest possible values, since all points will have the exact same number of neighbors at any given scale. Strongly clustered data with several tightly packed piles of dots, separated with few dots between, would have the very high values, as the points in the middle of clusters would have many more neighbors than those not in clusters. A statistically random distribution would have a value in the middle, with the number of neighbors at a given distance varying but at not
at extremes. Figure A.7 shows examples of each of these distributions. The individual K values are difficult to interpret; the numerical values are relative to the range of possible values for the area of analysis at the given scale. To aid in interpretation, most software implementations of the measure calculates K across a range of scales, and a teach scale run multiple permutations of random data for the same sample size and area as a Monte Carlo analysis to derive an average and upper and lower significance values. The result is a line graph, with the x-axis representing the size of the radius and therefore the spatial scale and the y-axis is the Ripley’s K value. There are four lines traced: one is the actual value for the distribution across scales, one is the average value for the random distribution across scales in the same extent, and two enclose a range within which the actual data is not significantly different from the random permutations at a 95% significance level. As such, one can trace as the spatial scale expands whether the data is significantly different from a Poisson, or true random, distribution (Dixon 2002; Ripley 1977). When applied to a set of points representing the find locations of archaeological artifacts, it would allow one to determine if, at any scale, that set does or does not adhere to a Poisson distribution (Dixon 2002; Ripley 1977).

**Materials**

As GIS assistant and Geodesist for DEPAS of MYCLT, I have been maintaining and organizing GIS data into ArcGIS geodatabases since 2009, following up on efforts by previous GIS data managers on the project (Shears In Press). There are several geodatabases with data at different scales and used for different purposes, including one with excavation-scale spatial data such as artifact locations and extents of delineated contexts, and one with survey-scale data such as aerial photography, terrace and terrace
wall locations, surface remains, and geophysical survey results. Others store regional topographic data and a collection of scanned maps published by previous surveys.

The find locations of portable artifacts are recorded in two different ways: specific coordinate points for individual artifacts and grid references for aggregate units of objects. The choice of artifacts to piece-provenience is linked to the collection methods of the excavation. As a general rule, two types of artifacts are recorded individually: artifacts of a category, whether defined by material, function, or style, that are relatively rare on the site, or individual objects thought to have particular interpretive value. For example animal bones, pottery sherds, debitage, and animal shell are not as a rule recorded individually; all the materials from one stratigraphic unit are collected and recorded as one mass bag. However, an identifiable vessel of a distinctive form or with a distinctive painting style, an intact stone tool, or piece of jewelry made from shell would be individually recorded if found as long as it was found before being moved by the excavator. Metal objects, figurines, and obsidian debitage are all relatively scarce, and so would also be recorded individually, even without any immediate interpretive goal, because it can still be done expediently. Aggregate artifact bags also consist of those sherds, debitage, and other artifacts collected during sifting and thus have no location data more detailed than the extent being excavated.

MYCLT recorded point locations for such select artifacts in 3-dimensional coordinates using total stations with sub-centimeter accuracy. The devices output coordinates to an arbitrary number of decimals as an artifact of trigonometric calculation; preexisting project goals dictate recordings in centimeters, so the values were rounded to two decimals. The total station was referenced to control points daily, generally taking
the form of nails sunk into bedrock outcrops with a clear sightline to the excavation site, to ensure that day-to-day recordings are consistently referenced to the Hellenic Geodetic Reference System 1987 (ΕΓΣΑ'87) with sub-centimeter accuracy.

The aforementioned aggregate units of artifacts are referenced to a site-wide 1 m grid system, consisting of numbered 5 m squares and 1 m sub-squares 1-5, and a-e by row and column, respectively. Excavators generally noted these locations informally and thus with inconsistent formatting— for example, a bag of pottery having come from “Grid Square 2, 1a-c and 2a.” As part of database entry I converted this to a more explicit text description – “GS2 1a, GS2 1b, GS3 1c, GS2 2a.” I then wrote a Python script that parsed these text descriptions and merged them with a master file of excavation square extents to derive an extent polygon for each aggregate unit. This process was also repeated for each stratigraphic unit.

There is one possible problem with this technique: lack of specificity in excavator recordings. Frequently, the provenience of a “Pail Unit” is not given as exactly as it might have been, because it was implicitly clear to the excavator. For example, a bag ofdebitage may have come from the entire extent of Grid Square 10 currently being excavated, in which case it was simply listed as “GS10”. At face value then, one would defer to the most general definition of GS10 – that is to say, to assume that the debitage came from all 25 sqm that comprise GS10 – to avoid Type I errors with regard to clustering. However, certain pieces of information are known that can narrow the definition of GS10 – for example, because grid squares at MYCLT are standardly excavated with the easternmost column and southernmost row of 1 m squares left unexcavated for stratigraphic control. So, even though a bag is labeled simply GS10, and
thus implicitly “all” of GS10, we may know that column 1 and row e were never originally excavated in GS10, and therefore the extent is narrowed to 16 sqm. Square 1a was later opened to further investigate an opening in a wall prior to this bag being sampled, and thus “all of GS10” can only logically mean 1a and 2-5a-d, 17 square meters.

To avoid having to encode manually all of these exceptions into scripts, I instead used a polygon file of the maximum extent of ground opened by the end of each year (these recordings were taken for creating finished full-site plans for each year). By temporarily splitting the file of square meters from pail units by year, the script uses the polygon file for the given year in the ArcGIS “Clip” tool, essentially applying a “cookie cutter” and trimming away any areas known to have never have been excavated in that year. A more accurate system would be to have the maximum extent of excavation by the end of each day, or even more strictly the areas actively excavated on a given day, and clipping the files based on their date, but establishing these daily extent files would require substantial reconstruction from drawings, photographs, and excavation reports, whereas the year-end extents were already explicitly recorded.

Several products can be derived from this file, i.e. the clipped copies of square meters with a pail unit associated to each, especially when combined with additional analysis data including artifact counts. For spatial analyses that require gridded data, the counts for each unit can be divided among the squares and those squares used as input for these analyses. For analyses that require point data, all squares comprising each “Pail Unit” can be combined by using the ArcGIS merge tool, and a number of random points
corresponding to the count of sherds, pieces of debitage, etc. can be generated within the outline of the resultant polygon (Figure A.6). Ripley’s K requires such data.

**Methods**

Using the data products described above, I use the recorded extents of aggregate units of artifacts to generate random points. I then combine them with the recorded point locations to form a body of point data representing collected artifacts. These data remain associated with both the contexts from which they came and artefactual attributes. I also, using excavation records, classify contexts based on several criteria, including their sediment type, whether they are enclosed horizontally by architecture, and whether they are stratigraphically in the topmost surface layers that overlay all architecture. I then excise subsets of points, using database joining and filtering to combine multiple excavation contexts, based on the characteristics of those contexts as appropriate to each hypothesis and derive a Ripley’s K graph for each. I also re-analyze gross classes of artifacts separately for each hypothesis; for example, distinguishing between clay, stone, and metal, to determine if any specific subset of artifact may specifically exhibit unique distribution because of physical properties or cultural behavior. Rick (1976) found that, with downslope movement, denser artifacts like stone traveled further downslope than less dense artifacts like bone, but this was distribution across a hillside. The results for the analysis of each subset of points are interpreted based on whether their clustering lies within or without the expectation for a random distribution, with the assumption that artifacts whose locations are owed primarily to geologic processes would be random and those due to cultural processes would not necessarily be so.
CHAPTER V
PROBLEM STATEMENT AND HYPOTHESES

Problem Question

Do assumptions of site formation, namely whether the proximal cause for the placement of artifacts in their find locations was the result of human behavior or of sediment flow based on sediment color, correlate with statistical measures based on the assumption that sediment flow produces a random spatial distribution?

Hypotheses

Among samples consisting of sets of merged strata, the point distribution of artifacts of each will follow one of the following paradigms with the following expected result:

1. The topmost surface layers were deposited by downslope movement, and any artifacts they bear were also relocated from upslope locations by downslope movement. Therefore, these are natural deposits and the Ripley’s K measures of their combined points are statistically indistinguishable from a random distribution.

2. The artifacts in buried contexts enclosed by architecture were constrained from large-scale horizontal transport. Therefore, these contexts are cultural deposits and the Ripley’s K measures of the points from within each building are statistically distinct from a random distribution.
3. The artifacts in contexts with red sediment have been transported from outside the excavation area by sediment flow. Therefore, these contexts are natural deposits and the Ripley’s K measures of the artifacts, with those from each of the three sections of the site as divided by Walls A and B combined, are indistinguishable from random distributions.

4. The artifacts assemblages in contexts with yellow-orange sediment are autochthonous. Therefore, these contexts are cultural deposits and the Ripley’s K measures of the artifacts are distinguishable from random distributions.
CHAPTER VI
RESULTS

Format of Results

Artifact location data from archaeological contexts were gathered and interpolated as described above, and the contexts were subsetted into samples. I calculated Ripley’s K for each sample twice; once for only the piece-provenienced artifacts and once also including interpolated points from aggregate units. Each instance of calculation has one figure, and each figure has two components.

The first component is the Ripley’s K plot. The plot’s two axes represent a range of spatial scales (x-axis) and Ripley’s K values (y-axis). The spatial scales, labeled as “r” in the scales, are radius sizes as described above, in the same units as the coordinate data, in this case meters. The maximum value and subdivisions, in this study, are default values chosen by the implementation in R. Documentation recommends against changing these defaults.

A solid line represents actual K values for the sample, a dotted line represents average K-values of a random distribution in the same spatial extent, and a gray area encompasses the range of values within which values are not significantly different than a random distribution within the same spatial extent at a 95% level. Values above the upper boundary of the gray area are significantly more clustered than a random distribution at
that spatial scale, and values below are significantly more homogenous than a random distribution.

The second element of each figure is a schematic map. The black linework outlines the sampling area input to the Ripley’s K analysis, created by combining the recorded spatial extent of all contexts comprising the sample. Red lines approximately outline stone walls; these are included only for reference, and the maximum excavated extent is shown, not necessarily the extent at the time of excavation of the sample. In the figure representing only piece-provenienced artifacts, each artifact is shown as an open black circle. In the figure also including interpolated aggregate units, each interpolated artifact is an open black circle and each piece-provenienced artifact is an open orange circle.

Samples

Layer 1

Layer 1 is a uniquely recorded stratigraphic unit; the uppermost layer of sediment below topsoil (with any artifacts found in and among vegetation and topsoil as a stratigraphic context named “Surface”) is universal across the site, and artifacts coming from this body of sediment in any given trench were recorded as coming from this “Layer 1” rather than a uniquely named unit for the trench. It contains artifacts from at least the Late Helladic through the Late Middle Ages, and is almost certainly wash from upslope (Karkanas In Press). Piece-provenienced artifacts from Layer 1 are shown in Figure A.8. Artifacts are significantly more clustered than a random distribution at smaller spatial scales, and are not significantly clustered at larger spatial scales. Combined piece-provenienced and interpolated artifacts from aggregate layers are shown in Figure A.9.
There are only a small number of artifacts from aggregate units, less than 10. The distribution is similar; artifacts are significantly more clustered than a random distribution at smaller scales and not significantly clustered at larger scales.

**Red Sediment**

Piece-provenienced artifacts from the oxidized “red” sediment layers are shown in Figure A.10. These are specifically the body of red sediments deposited during the Protogeometric period, between the Late Helladic and Geometric periods of occupations (Karkanas In Press). Artifacts are significantly more clustered than a random distribution at all spatial scales, with the most extreme K values at intermediate spatial scales. Combined piece-provenienced and interpolated artifacts from red layers are found in Figure A.11. The overall distribution is similar, with values showing significant clustering at most spatial scales with the largest relative difference at intermediate scales, but the values are not significantly clustered at the largest spatial scales.

**Behind the Corner of Walls B and Γ**

Piece-provenienced artifacts from the contexts comprising the body of reduced, presumed anthropogenic sediment behind the point at which Walls B and Γ meet are shown in Figure A.12. These strata form a body of sediment filling the area behind the two walls and underlay and thus predate the post-LH red sediment fill. Artifacts are not significantly clustered at any spatial scale. Combined piece-provenienced and interpolated artifacts from aggregate units from these contexts are shown in Figure A.13. Artifacts are significantly more clustered than a random distribution at all spatial scales.
**Building III**

Piece-provenienced artifacts from the pale reduced sediments from within Building III, a complex of rooms above the red sediment dated to the Geometric Period (Dierckx and Maggidis 2012), are shown in Figure A.14. Artifacts are only significantly clustered at the smallest spatial scales, and are not significantly different from a random distribution at other scales. Combined piece-provenienced and interpolated artifacts from aggregate units from these contexts are shown in Figure A.15. Artifacts are significantly more clustered than a random distribution at all spatial scales.

**Northeast of Grid Square 21**

Piece-provenienced artifacts from the reduced presumed anthropogenic sediments in Grid Square 21 are found in Figure A.16. These strata overlay and thus post-date the post-LH red sediment deposition. Artifacts are significantly more clustered than a random distribution at all but the smallest spatial scales. Combined piece-provenienced and interpolated artifacts from aggregate units from these contexts are shown in Figure A.17. Artifacts are significantly more clustered than a random distribution at all spatial scales.
CHAPTER VII
DISCUSSION

Results are mixed; among the samples, only Building III and the Northeast of Grid Square 21 completely adhered to hypotheses. However, because this implementation of Ripley’s K analysis data returns values across a range of spatial scales, samples can be clustered at some ranges and not at others, and several samples show expected results at some scales. Overall, results were weighted toward significant clustering unless sample sizes are low. Their much greater sample sizes, or factors in data recording described below, may underlie a pattern in which samples that include the interpolated artifacts from aggregate units are more clustered at all scales than the piece-provenienced.

Spatial scale needs to be handled in different ways by different applications with this statistic. Ripley’s K is frequently used in archaeology as a tool to identify specific scales at which clustering is present. An example given by Connelly and Lake (2006) would be, if sites are believed to cluster based on political association, to find scales at which point locations of those sites have particular high Ripley’s K values and connect that radius size to a presumed size of political entities. However, in this case, the comparison is instead a binary significant/insignificant comparison of clustering similar to nearest-neighbor analysis, but without the need to identify a single most relevant spatial scale (Conolly and Lake 2006). However, the logic that underlies the model of down-slope transport is that it operated on a much larger spatial scale than the sample
area. It would make sense, then, to focus on the larger spatial scales. Per the
documentation and code of the R implementation of Ripley’s K analysis, the default
maximum value of r is determined by a multi-step algorithm but at largest is one quarter
of the shorter of the length or width (Dixon 2002). These largest sizes, that are still only a
fraction of the sample area then would seem to be most appropriate when attempting to
identify a spatially random distribution much larger than the sampled area.

Samples

Layer 1

The expectation for Layer 1, per Hypothesis 1, would have been for the artifacts
to never be significantly different from a random distribution. This hypothesis was not
supported, because at all but the largest scales significant clustering occurred. I analyzed
this sample intending it to be a relatively certain example of sediment-deposited artifacts.
As described previously artifacts are broadly mixed, soil appearance and formation is
continuous across site and does not indicate agricultural use, and there are no
architectural features to indicate inhabitation. This fact, and the fact that horizonation is
intact and Late Bronze Age deposits are more than a meter below Layer 1, seems to rule
out site wide bioturbation bringing artifacts to the surface. Presumably, then, artifacts
would have been deposited from their current location from upslope.

However, though this specific region of the valley has no evidence of inhabitation
or development, the larger area around the Citadel has and the area is not isolated and
there is agricultural land-use in the rest of the nearby area, including shepherds and
goatherds and olive groves in other parts of the same valley.
A related consideration unique to this site is the Citadel’s history of more than a century of both archaeological research and tourism. The land is privately owned, but from personal experience hikers come through the valley on an almost daily basis, and those working, informally exploring, or simply passing through the area could have been redistributing artifacts, whether intentionally (for example by collection) or unintentionally (for example in developing trails and paths), in a way that exhibits clustering at a greater level than that which would have been exhibited purely by sediment transport. That the artifacts exhibit less clustering, to the point of insignificance, at larger spatial scales might indicate that there is small scale redistribution of artifacts but broad-scale patterning indicative of sediment transport. Also, there are historic references to spoil piles from previous Citadel excavations from the last century, at times in which ceramic fragments would have been discarded, at the northernmost parts of this terrace, tens of meters north of this excavation area, which could have acted as a proximal concentrated source of artifacts.

Red

The expectation for the red sediment, per Hypothesis 3, would have been for the artifacts to never be significantly different from a random distribution. This expectation was not supported; the piece-provenienced artifacts are always significantly more clustered than a random distribution, and when combined with the interpolated artifacts are not significantly different from a random distribution only at the largest scales. Because the red soil suggests little anthropic impact on soil formation and therefore periods of abandonment, the relatively few artifacts would have been from off-site. Based
on visual inspection of the maps, there are several clusters of artifacts that could be causing the higher K values.

Grid Square 63 has a distinct artifact cluster, to the west of Wall A. A notable feature in that same area, found underlyng the red soil, is large-scale rock debris. For more than 8 meters starting in Grid Square 63 and continuing south, Wall A is missing courses of stones, and adjacent to the wall are several large stones; without being fully excavated, there are at least 10 stones more than half a meter in least one dimension in an area approximate 3x4 m. Presumably these large stones comprised the missing courses, and were toppled at some point prior to burial. The presence of the large stones, not present further north along the wall, could have significantly influenced distribution. Several large impediments to sediment flow would reduce its velocity and deposit artifacts in a different pattern than in areas with a flatter terrain.

Several clusters of artifacts, including piece-provenienced artifacts around Grave 1 and aggregate artifacts at the intersection of Wall A and the northwestern corner of Building I and rooms 4 and 5 of Building I, are even denser. Like the rubble in Grid Square 63, the enclosed areas in and around Building I may have acted to collect artifacts, by some combination of reduced velocity and true physical constraint. This stage of the burial process of walls, in which sediment must build up against and then pass over and fill in behind, would create a depositional environment very distinct from any open areas upslope. The area around the grave may be of this type, if sediment flow was predominantly from the northeast into the northwest-southeast orientation of Wall B, or may be due to disturbance in the construction of Grave 1. Grave 1 is a pit lined with flat stones dated via grave goods to the Geometric period, subsequent to the deposition of
the red sediment and more than 500 years after the latest Bronze Age anthropogenic surface (Dierckx and Maggidis 2012). The back-filling of the pit may have incorporated artifacts, or that collection of artifacts was more rigorous and exhaustive near the grave than it was in other areas.

In all of these clusters of red soil cases, the assumptions that underlie the hypothesis are violated. In the case of the rubble, the assumption was that sediment would be transported across a continuous surface, with relatively little variation. The tumbled stones and enclosed rooms presented a radically different depositional environment than open ground. If the area excavated in the construction of Grave 1 included the areas in which the artifacts around it were found, then it represents a different depositional event that should be combined with other red soil in analysis.

**Behind the Corner of Walls B and Γ**

Per Hypothesis 2, the expectation for the artifacts in the reduced contexts behind the angle between the corner of Walls B and Γ would be significant clustering. As the soil properties indicate inhabitation, a very high number of artifacts were found, and the location immediately behind these walls would have blocked sediment flow from multiple directions, NW though SE, so it seems a likely location for anthropogenic artifact deposition. The piece-provenienced and combined samples disagree radically in this; piece-provenienced artifacts are not significantly clustered, but the combined sample is extremely so.

Based on visual inspection, recorded artifact bearing extents are extremely dense or empty – there are 6389 objects in an L-shaped area of less than 18 square meters, and more than 11 square meters are recorded as having no artifacts. This seems very extreme;
even in a situation with highly dense artifact concentration, for example a single point of 
frequent disposal with a surrounding unused area, two square meters bearing more than 
600 artifacts and the two adjacent, with otherwise continuous sediment, having 0 seems 
unlikely. This is the case in the southernmost section along Wall B. The section touching 
Wall Γ is much less extreme in its gradient – there is one central square that is most dense 
and the ones surrounding still bear artifacts. There is the possibility that the gridded 
 extents of these aggregate unit extents were not accurately recorded.

Barring this possibility, though the assumed primary source of sediment is from 
the north, the Chavos Ridge forms slopes to the west of the entire terrace, including here. 
Wall Γ continues to run west and abuts the overlapping buildings V, VI, and VII, 
blocking sediment from moving into this area from north, at least until the opposite side 
was entirely filled in. However, if sediment moved into this area from the west to east, 
considering that the top of the ridge was inhabited, it is possible that this is an example of 
artifact bearing anthropogenic soil transported to this location by downslope movement. 
This could explain the lack of clustering in piece-provenienced artifacts, if they are more 
reliable data as currently recorded.

The area analyzed here is narrow – 2 meters wide – and the sediment further to 
the west is an unexcavated balk. The amount of material and area tested may not be 
robust enough to understand the nature of the deposition without greater context. Similar 
density of piece-provenienced artifacts further west may suggest this sediment being 
slope-wash, or clusters, architectural features, and diagnostic artifacts may indicate 
functional use of space in which the densities consequently can be interpreted with regard 
to cultural meaning.
Building III

The artifacts within Building III are at most scales significantly more clustered than a random distribution, as predicted by Hypothesis 2. Building III, bounded on 3 sides by rectilinear courses of stones enclosing a space approximate 3x3 m with a cobbled surface, seems likely to be an interior room. Whether the cobbled surface represents an entire interior space is ambiguous; its northern boundary is not a wall constructed in the same way as the other three sides and Buildings III, II, and IX follow a similar orientation and may comprise a larger complex or a palimpsest of separate buildings. Whether the artifacts were deposited at the location of use or via disposal, the clustering suggests they were deposited anthropogenically rather than via wholesale sediment transport. The lack of significant clustering at some scales might indicate that either some of the contexts included in the sample are sediment transport infill with a similar color or that the ceramic artifacts in this dataset are neither anthropogenic in the sense imagined in this study nor from sediment transport, but rather temper from mudbrick debris that filled the space but was denser in some areas than others. It may also be that at least in this case, the deposit is all anthropogenic but the degree of clustering is not relevant at all scales measured analyzed or that there is clustering, but not sufficient to be significant at that scale.

Northeast of Grid Square 21

This area in the northeast corner of Grid Square 21 is comprised of reduced presumed anthropogenic sediment in a gap between two stone structures, Wall Γ and Building IV. It is a unique deposit with regard to the distinction between in situ and downslope artifact deposition, because it is one of the only locations comprised of the
anthropogenic sediment but north of any stone walls and was therefore the likeliest spot to find reduced sediment deposited by downslope motion. As predicted by Hypothesis 4, as a body of the reduced sediment, it is significantly clustered in most scales of piece-provenienced artifacts and at all scales in aggregate artifacts. There are two likely options; one is that it is legitimately an anthropogenic deposit; the other is that the proximity of the walls parallel to the direction of flow was enough to change the rate of deposition and invalidate the assumption of unconstrained flow. It seems likely that this was a well-trafficked area; Structure IV is a well and the space between it and Wall Γ is approximately 3 m. Other than being an exterior space, the lack of understanding of the nature of Walls B and Γ makes any estimation of activities in the area difficult.
CHAPTER VIII
CONCLUSIONS

Ripley’s K results showed differences in the presence of significant spatial clustering between subsets of artifacts from stratigraphic contexts believed to have been autochthonous and those believed to have been deposited by down-slope soil transport. However, Ripley’s K is measured across multiple spatial scales for each sample and the results were not absolute. Among piece-provenienced artifacts there was significant clustering in all samples at least some scales, and even in contexts like the immediate subsurface Layer 1 that are almost certainly composed of artifacts transported from down-slope from off-site, clustering was observed. It seems that mitigating factors, violating the expectations of the model of sediment-transported artifacts, occur throughout the site and means that the method cannot be applied to samples without interpretation.

The presence of stone architecture seems to have had a major effect on the horizontal transport of artifacts. There are several sets of rectilinear building ruins found during excavation, especially in the area to the east of Wall A. Though these buildings were predominantly constructed of mudbrick, their foundations were made of one or a few courses of stones. Upon abandonment, this mudbrick, due to a lack of maintenance of the walls themselves and the roof structure protecting the mud from rain, degrades and flows under gravity to form a sediment deposit. With sufficient rain, and if the mud used
was from the surrounding area (a common occurrence) and only organic tempering material was used, with sufficient exposure time the brick complete disintegrates and can be difficult or impossible to distinguish macroscopically (Friesem et al. 2014). The result in this case is a complex of low orthogonal stone walls and seems the likeliest scenario here (Karkanas In Press).

At this site such remains, in addition to the presumed retaining Wall A, walls of unknown function like B, Γ, Δ, and E and large-scale pieces of rubble could have violated implicit assumptions underlying the model of downslope transport of sediment. The expectation of random distribution in artifacts is rooted in the notion that the depositional forces are consistent across a much larger spatial scale than anthropogenic deposition would be. The stone walls can radically alter flow velocity of sediment at a small scale, both because width is constrained, selectively increasing flow, and because larger clasts like sediments can be blocked or trapped by obstructions. Few open outdoor spaces are represented in the trenches that have been excavated; the results may have been more straightforward if they were.

The use of aggregate units requires further exploration of the effects of recording errors and imprecision. Given that recording occurs at a 1 sqm resolution, that (barring unique cases like the site-wide Layer 1) stratigraphic units are excavated and recorded as fractions of 16 sqm excavation trenches, and that aggregate units are not always from the entire spatial extent, aggregate units may only span a few units of resolution. Additions or omissions of 1 sqm across each of multiple aggregate units that comprise a sample may have radical effects on the Ripley’s K results for a sample.
Layer 1 and Red were the only samples that were not significantly clustered at all scales. This was expected, but these samples were significantly larger in spatial extent than any of the other samples and even then at most scales Layer 1 and Red were clustered. It would be useful to simulate data in a wide combination of artifact counts, overall spatial extents, and constituent aggregate unit sizes and observe when growing and shrinking aggregate units does not affect the significance of results.

The use of simulated artifact locations from aggregate units still offers many advantages. Unlike piece-provenienced artifacts, aggregate artifact units are intended to be exhaustive. Sampling preferences that bias piece-provenienced artifacts towards objects either recognized as diagnostic or rare for the project are not relevant to an analysis like this one that regards them as clasts in sediment. Even if the reduced piece-provenienced sample was still spatially representative of the larger sample of artifacts of the general type, sample size is greatly reduced in ways that can make certain statistical methods inappropriate or unusable. Spatially recording all artifacts from an excavation individually is not unprecedented, especially in cave sites (Dibble et al. 1997; McPherron 2005; Fisher et al. 2015). However, it would have a significant impact on the workflow of recording and would not be an option on a study like this one that seeks to use data as it is already recorded in the midst of ongoing excavation. Understanding the limitations of the technique, including being able to recognize samples that are not excessively sensitive to variation in recording technique, expands the number of situations in which this method can be applied.

All of these complicating factors do not invalidate using Ripley’s K, in general or specifically trying to draw this in-situ vs. sediment transport artifact distribution
distinction. However, it does call into question the ability to use this method as a tool on a day-to-day basis to make sampling decisions. Knowledge of the overall distribution of stone architecture and the depositional history of the area, developed subsequent to several seasons of fieldwork, was incorporated into both selection of samples and into interpretation of results.

Sites with fewer walls, smaller-scale interior spaces relative to excavation trench size, and denser artifact distributions may still present opportunities to use this method on a smaller and more frequent scale. A site at the base of a slope, having neighboring sites upslope, but from a cultural context that does not use resilient structures made of materials like stone would be ideal to test the ideas behind the method.

More detailed categorical data attached to individual artifacts that is not yet available, for example chronology and function, would allow more nuanced analyses of site formation. An issue unaddressed by the methods in this study is that even in “true” occupation deposits, older artifacts eroded out of sites upslope may have been littering the surface, as they do now. Separately calculated K values for pottery from different periods may reveal patterns in which clustering is found in artifacts from one period, presumably the contemporary one, and artifacts from other period are not clustered and represent the artifacts derived from slopewash. These older artifacts may currently be overwhelming any patterns apparent in those contemporary to the occupation’s era. Similarly, and usefully for artifacts without chronologically diagnostic styles, artifacts from one function or related group of functions might exhibit clustering and any other function does not. For example, clustered food storage and processing vessel sherds and
random serving vessel sherds may hint at a food processing space in that location and some location of food consumption or a pantry somewhere upslope.

This last element, though only at a very gross spatial scale, is a tool that could be useful to investigate archaeology in the larger landscape. If all deposits of artifacts from a certain chronological period on this site are random, and there is no other evidence of occupation at upslope locations from this period, it could indicate that this lack of evidence upslope is the result of erosion rather than abandonment and contributes to the larger chronology of the area.

Whether for hypothesis testing in the midst of field work or post-fieldwork site-scale analysis like this study, Ripley’s K’s multiscalar analysis of spatial distribution offers a unique approach to analyze archaeological site formation, but requires further understanding and refinement.
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APPENDIX A

FIGURES
Figure A.1  Geologic map of the larger area around Mycenae

The mountain peaks and the hill of the Citadel are limestone formations, and the Panagia ridge and bedrock underlying the valleys surrounding are comprised of conglomerates or talus and scree formations.
Figure A.2   Topographic map of the Citadel and Lower Town

The slopes of the Panagia Ridge are visible to the left of the figure, and the slopes of Mt. Zara to the right.
Figure A.3  MYCLT grid system.

Excavation has so far been constrained to SWBII, divided into 5 m squares subdivided into 1 m squares.
Figure A.4  Plan drawing of extent of Lower Town Excavation

Large Roman numerals indicate named buildings, Greek letters indicate named walls (delineated with thick linework), Arabic numerals indicate “rooms”, labels prefixed with “G-” indicate graves, and small “x”s with numbers are spot elevations.
Figure A.5  Diagram of an example relational database

This shows several tables of an imagined database for an archaeological field project, showing tables of artifacts, contexts, photographs, and staff members and ways in which they can interrelate.
In this imagined data, five 1sqm units were indicated as the extent of collection of an aggregate pottery unit. These five grid units are merged, and any area that was not part of the maximum drafted extent of the stratigraphic context from which pottery comes is removed to generate the interpolated extent. Then, given that 20 sherds came from this aggregate unit, 20 random points are generated within the extent. Multiple of these artifact units would comprise a sample.
Figure A.7  Simulated extreme examples of spatial distributions with different degrees of clustering.

Plots show simulated data of extremely clustered (high $K$ values), random (middling $K$ values), and ordered (low $K$ values) spatial distributions.
Figure A.8  Piece-provenienced artifacts from Layer 1

Graph shows Ripley’s K values (y-axis) at a given spatial radius (x-axis). Values shown are actual K values (black solid line), K values for a theoretical random Poisson distribution (red dashed line), and range of K values in which clustering is not significantly different from a random Poisson distribution (grey shading). The map shows extent of sampling (black outline), artifact locations (black circles), and architecture (red outline)
Figure A.9  Piece-provenienced and interpolated aggregated artifacts from Layer 1

Graph shows Ripley’s K values (y-axis) at a given spatial radius (x-axis). Values shown are actual K values (black solid line), K values for a random Poisson distribution (red dashed line), and the range of K values in which clustering is not significantly different from a random Poisson distribution (grey shading). The map shows extent of sampling (black outline), actual artifact locations (orange circles), interpolated artifact locations (black circles) and architecture (red outline).
Figure A.10  Piece-provenienced artifacts from Red soil

Graph shows Ripley’s K values (y-axis) at a given spatial radius (x-axis). Values shown are actual K values (black solid line), K values for a random Poisson distribution (red dashed line), and the range of K values in which clustering is not significantly different from a random Poisson distribution (grey shading). The map shows extent of sampling (black outline), artifact locations (black circles), and architecture (red outline).
Figure A.11  Piece-provenienced and interpolated aggregated artifacts from Red soil

Graph shows Ripley’s K values (y-axis) at a given spatial radius (x-axis). Values shown are actual K values (black solid line), K values for a random Poisson distribution (red dashed line), and the range of K values in which clustering is not significantly different from a random Poisson distribution (grey shading). The map shows extent of sampling (black outline), actual artifact locations (orange circles), interpolated artifact locations (black circles) and architecture (red outline).
Figure A.12  Piece-provenienced artifacts from the area behind the corner of Walls B and Γ.

Graph shows Ripley’s K values (y-axis) at a given spatial radius (x-axis). Values shown are actual K values (black solid line), K values for a random Poisson distribution (red dashed line), and the range of K values in which clustering is not significantly different from a random Poisson distribution (grey shading). The map shows extent of sampling (black outline), artifact locations (black circles), and architecture (red outline).
Figure A.13  Piece-provenienced and interpolated aggregated artifacts from the area behind the corner of Walls B and Γ

Graph shows Ripley’s K values (y-axis) at a given spatial radius (x-axis). Values shown are actual K values (black solid line), K values for a random Poisson distribution (red dashed line), and the range of K values in which clustering is not significantly different from a random Poisson distribution (grey shading). The map shows extent of sampling (black outline), actual artifact locations (orange circles), interpolated artifact locations (black circles) and architecture (red outline).
Graph shows Ripley’s K values (y-axis) at a given spatial radius (x-axis). Values shown are actual K values (black solid line), K values for a random Poisson distribution (red dashed line), and the range of K values in which clustering is not significantly different from a random Poisson distribution (grey shading). The map shows extent of sampling (black outline), artifact locations (black circles), and architecture (red outline).
Figure A.15  Piece-provenienced and interpolated aggregated artifacts from Building III

Graph shows Ripley’s K values (y-axis) at a given spatial radius (x-axis). Values shown are actual K values (black solid line), K values for a random Poisson distribution (red dashed line), and the range of K values in which clustering is not significantly different from a random Poisson distribution (grey shading). The map shows extent of sampling (black outline), actual artifact locations (orange circles), interpolated artifact locations (black circles) and architecture (red outline).
Figure A.16  Piece-provenienced artifacts from Grid Square 21

Graph shows Ripley’s K values (y-axis) at a given spatial radius (x-axis). Values shown are actual K values (black solid line), K values for a random Poisson distribution (red dashed line), and the range of K values in which clustering is not significantly different from a random Poisson distribution (grey shading). The map shows extent of sampling (black outline), artifact locations (black circles), and architecture (red outline).
Figure A.17  Piece-provenienced and interpolated aggregated artifacts from Grid Square 21

Graph shows Ripley’s K values (y-axis) at a given spatial radius (x-axis). Values shown are actual K values (black solid line), K values for a random Poisson distribution (red dashed line), and the range of K values in which clustering is not significantly different from a random Poisson distribution (grey shading). The map shows extent of sampling (black outline), actual artifact locations (orange circles), interpolated artifact locations (black circles) and architecture (red outline).