In the Maw of the Earth Monster

Mesoamerican Ritual Cave Use

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CHAPTER 11

Cluster Concentrations, Boundary Markers, and Ritual Pathways: A GIS Analysis of Artifact Cluster Patterns at Actun Tunichil Muknal, Belize

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This chapter analyzes the spatial patterning of artifact deposition in the Main Chamber of Actun Tunichil Muknal, an ancient Maya ritual cave located in western Belize. The aim of my research is to demonstrate that by taking a cognitive-processual approach, an intensive study of a single site can increase our knowledge of cave ritual and aid in our understanding of ancient Maya spatial cognition within caves. This new approach (Renfrew and Bahn 1991:431–434; Renfrew and Zubrow 1994:xiii) draws on cognitive, mathematical, and computer sciences in an attempt to develop techniques that can be used with archaeological data. Underlying the method is the premise that the archaeological record was produced by the human mind and was therefore patterned by mental processes.

The artifact record clearly demonstrates that caves have been intensely utilized throughout Mesoamerica from the Preclassic Period to the ethnographic present. All available archaeological, ethnographic, and ethnohistorical evidence suggests that in the Maya Lowlands, caves were used exclusively for ritual purposes (Brady 1989). Cross-culturally, dark zones of caves are useless even for temporary habitation except in extreme circumstances (Farrand 1985:23) and are used almost exclusively as ritual spaces (Faulkner 1988; Hole and Heizer 1965:47). According to Chard (1975:171), most "caves" used for refuge were actually rockshelters. Particularly in tropical areas, caves are dank and often infested with bats and insects, which carry a number of deadly diseases, including histoplasmosis, rabies, and Chagas. In his survey of caves in the Maya Lowlands, Brady (1989:5–6) concludes that "habitation within the dark zone is practically inconceivable."

The ritual context is advantageous to the archaeologist, since it provides an interpretive paradigm to be used in cave studies. Another advantage is that the formal and repetitive characteristics of ritual behavior facilitate its study in the

artifact record. As Rappaport (1979:176) observes, ritual is repetitive and must be performed in prescribed ways. Although Turner (1982:81) argues for an organic and improvisational aspect of ritual behavior, he proposes that the looser elements operate only within the framework of the formal structure. Vogt (1965) provides ethnographic evidence for the existence of such a framework in the Maya area. He describes a phenomenon in the Tzotzil Maya village of Zinacantan that he terms "replication": patterned aspects of ritual behavior observed in a variety of contexts, settings, and scales. Therefore, we may expect that artifact deposition in ritual contexts will not be haphazard and that some spatial patterns will reflect repetitive behaviors.

In his article on the structure of archaeological data, Aldenderfer (1987:95) describes archaeological "signatures" and defines them as "unambiguous indicators of a behavioral process." Ball (1993:180) adds that signatures are behavioral units created by humans whose patterns correlate with group activities that are represented archaeologically as patterned associations between artifacts and their contexts. Ritual behavior is likely to leave signatures due to these formal and repetitive characteristics and should produce identifiable spatial patterns. As Marcus and Flannery (1994:56) have observed, "artefacts used in ritual should exhibit a pattern of use and discard which is non-random and yields insights into the nature of the ritual itself."

Stone (1997; Chapter 10 here) has suggested that cave ritual may be studied by examining the spatial patterning of artifacts within caves and comparing them with spatial models reported by ethnographers and ethnohistorians. Analogical arguments that link the ethnographic present to the archaeological past may be established using the Direct Historical Approach (Marcus and Flannery 1994; Wedel 1938). Despite objections to this method from Kubler (1973), in Mesoamerica cultural continuity allows for particularly strong analogical arguments. In this case, the success of the argument is largely dependent on (1) the degree to which it relates to a specific question; (2) the pervasiveness of the ethnographic analog over time and space; and (3) the rate of the analog's known occurrence. A commonly occurring referential analog is more likely to be correct partially because of probability. Additionally, if distinct recognizable patterns or specific elements of the referential analog can be sufficiently isolated, a strong inference may be made when those patterns or traits are identified in the archaeological record.

This study employs a Geographical information system (GIS) to help identify spatial patterns of artifact deposition in the Main Chamber of Actun Tunichil Muknal. Patterns are interpreted using strong ethnographic and ethnohistorical analogies that are pervasive over time and space. The research demonstrates that applying technology to intrasite analyses can enhance our understanding of ritual practice in caves.

The Setting

The Western Belize Regional Cave Project (WBRCP), under the direction of Dr. Jaime Awe, has conducted field research at the cave of Actun Tunichil Muknal since 1996. The Main Chamber of the site was the area chosen for analysis because of its secluded location, which left it undisturbed by looters, and because it was the area most intensively and extensively utilized by the ancient Maya (Moyes and Awe 1998, 1999a, 1999b).

A GIS was created for the chamber to facilitate the evaluation of artifact depositional patterning on a global scale. The advantage of a GIS is that it provides an easily manipulated database, a means of visual display, and a tool for the analysis of spatially referenced data. The display capabilities allowed the entire Main Chamber to be viewed on a single map, facilitating global assessments of artifact placement and distribution.

Actun Tunichil Muknal (ATM) is located in the Cayo district of Belize on a tributary of the Roaring Creek River (Figure 11.1). It was discovered in 1986 by geomorphologist Thomas Miller (Awe et al. 1997; Miller 1989, 1990), who produced a map of the cave system (Figure 11.2). The system is composed of a five-kilometer tunnel along which the ancient Maya used several loci. The Main Chamber, located in a high-level passage that splits off from the main tunnel system five hundred meters from the cave entrance, is the most remote area of utilization in the system (Moyes and Awe 1998, 1999a, 1999b). The east-facing entrance to the tunnel system is through a keyhole-shaped archway approximately eight meters high that towers over a blue green pool (Figure 11.3).

The chamber measures approximately 183 meters in length, 35 meters at its widest point, and 5 meters at its narrowest. The area encompasses 4,450 square meters. It is oriented on an east/west axis that is entered through a squeeze in the easternmost section of the chamber. The ceramics from the Main Chamber were classified using the type-variety system and cross-dated with James Gifford's (1976) Barton Ramie collection. They date to AD 830–950, the Terminal Classic Spanish Lookout phase (Jaime Awe, personal communication, 1997; Moyes 2001).

The chamber is composed of a number of rooms and passageways partitioned by large areas of breakdown, stalagmitic columns, and large, isolated boulders. Based on these configurations, the Main Chamber was divided into the following smaller areas: (1) the Creek; (2) Boot Hill; (3) the Passage; (4) the Burial Chamber; (5) the Ransom Chamber; (6) the Cathedral; (7) the Angel's Room; (8) the West Wall; and(9) the Crystal Sepulcher (Figure 11.4). Some of these areas were named by previous cavers, and none of the names are intended to reflect Maya thought or traditions.

Much of the floor of the Main Chamber consists of a series of rimstone (or

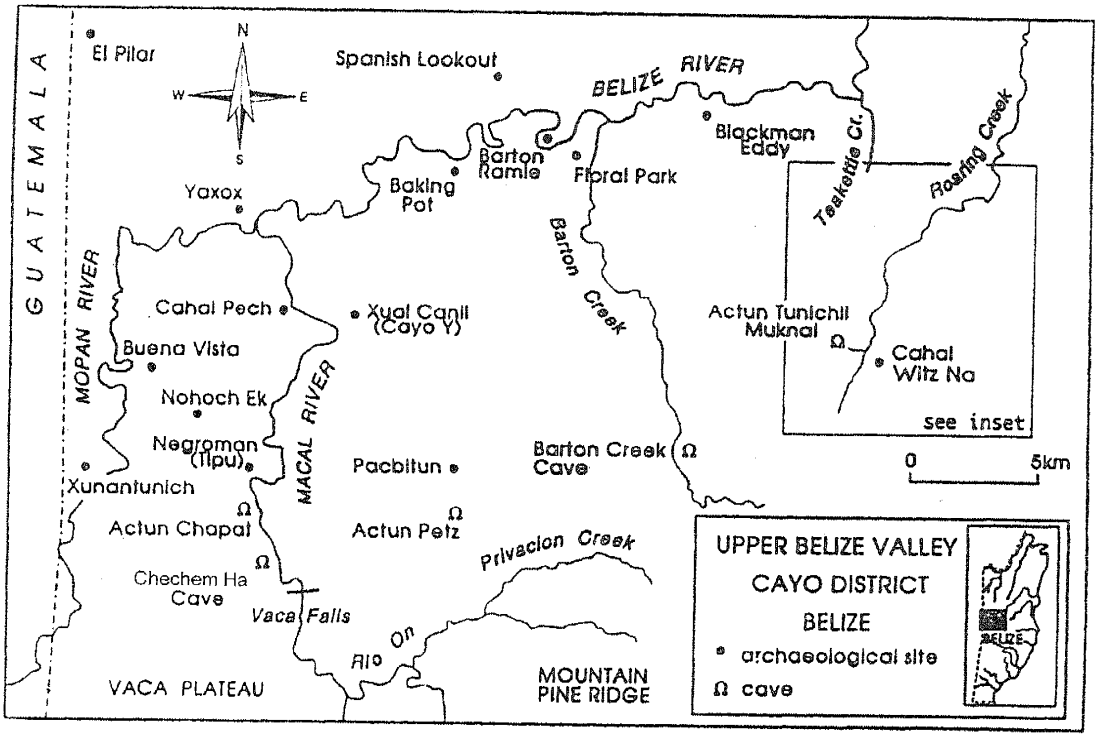
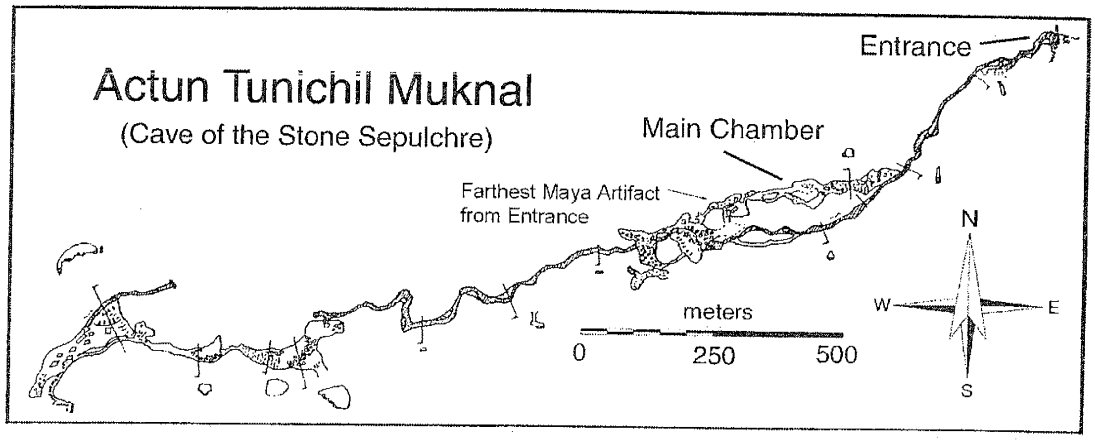


Figure 11.1. Actun Tunichil Muknal, located in the El Cayo district of Belize on a tributary of the Roaring Creek River. Map courtesy WBRCP.

Figure 11.2. Tunnel system of Actun Tunichil Muknal. After Miller (1989, 1990); map courtesy WBRCP.



travertine) dams. The dams create a honeycomb of gour pools that cover the central portion of the floor area and descend gradually toward the eastern entrance (Moyes 2001; Moyes and Awe 1998, 1999a, 1999b). Initial speculation was that the chamber had been dry for quite some time. However, in July of 1997, torrential rain caused the chamber to fill with water. Natural drainage began almost immediately, but some standing pools persisted for three weeks. It is likely that the chamber has been wet on and off since ancient times, which would account for the thick calcite buildup.

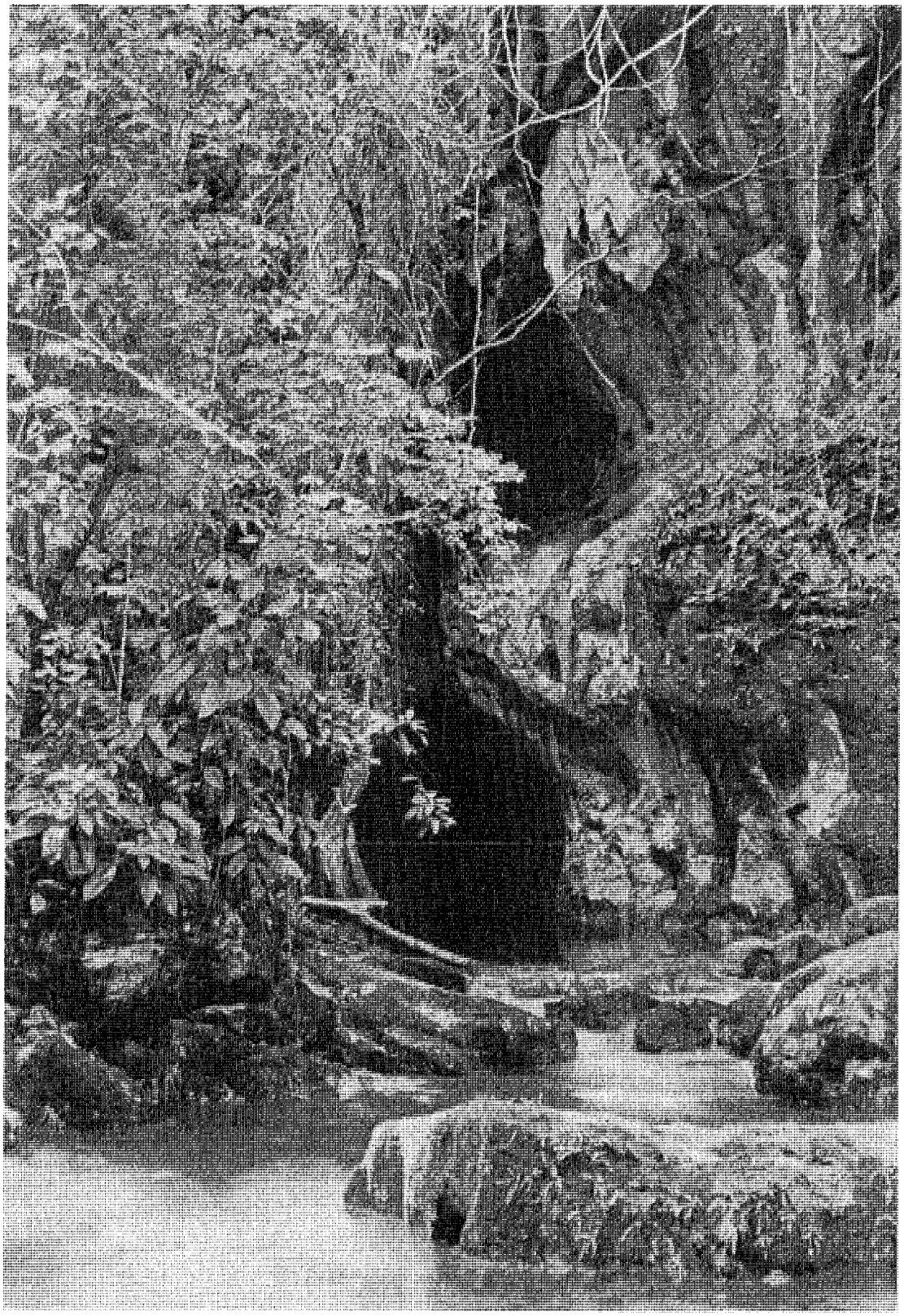


Figure 11.3. Keyhole-shaped entrance of Actun Tunichil Muknal. Photo by the author.

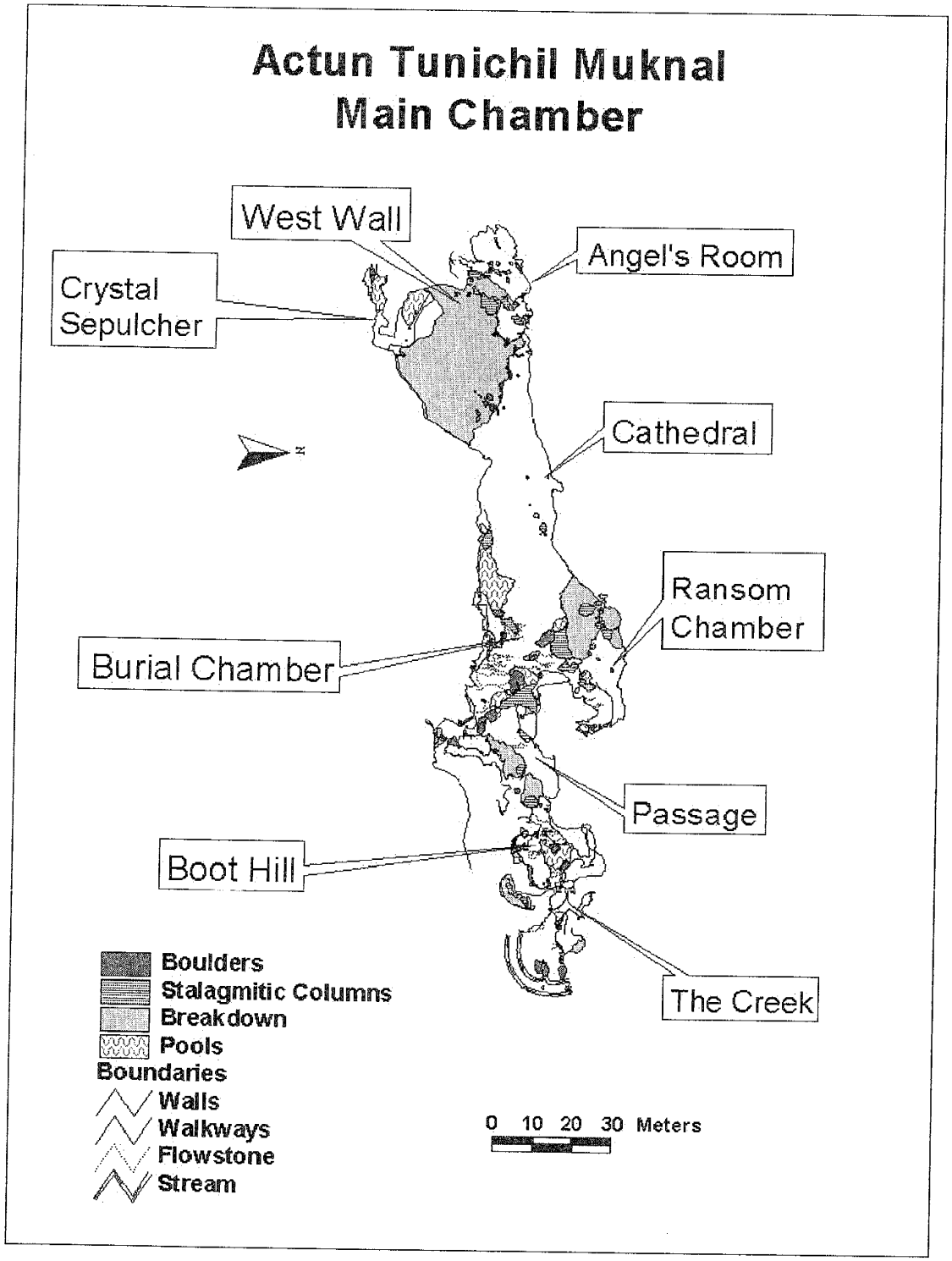


Figure 11.4. GIS map of the Main Chamber of Actun Tunichil Muknal illustrating area divisions within the chamber.

A major concern in the analysis was that artifacts could have been displaced by water turbation. The expectation was that, if water movement had occurred, objects would have collected upslope of large features such as boulders or stalagmitic columns that were capable of impeding water flow. In viewing the distribution of artifacts located around these features an even artifact distribution

was observed on the upslope and downslope sides, which would preclude water movement of artifacts.

Although over 99 percent of the artifacts in the chamber were broken, this could not be attributed to water movement. In ritual contexts, ceramic vessels were commonly smashed during ceremonies, and water turbation could not account for their condition. Additionally, ceramic sherds did not exhibit evidence of water erosion, such as smoothed edges.

In some areas, artifacts located on top of rimstone dams were situated in an upright position and had been lightly cemented to the floor by calcite. This indicates that, from the time of deposition, water rarely flowed over the dams and, even when this occurred, it was insufficient to cause artifact displacement, much less, breakage. The combined evidence indicates that water movement was not a major factor in artifact deposition within the chamber.

Methodology

Paper maps were produced using tape and compass and were drawn on a scale of 1:60 using a two-dimensional top-plan view. A total of 1,408 artifact fragments were piece-plotted on one-meter grid squares, which were then entered onto the base map. The GIS was created from the base map using ESRI software. Maps were digitized using ArcInfo and imported into ArcView 3.1 for analysis and display.

Artifact breakage presented a problem in the quantification of the data because from one to thirty fragments could represent a single artifact. While in the field, "in situ" refitting was undertaken by searching the immediate area for like fragments. Only ceramic sherds ten centimeters or greater in length were counted. With few exceptions, these fragments were located within one to two meters of each other. Based on in situ reconstruction, the 1,408 fragments could be reduced to a minimum number of 718 discrete objects. The majority of the assemblage consisted of ceramic sherds and speleothems. Speleothems are defined as "any secondary mineral deposit that is formed by water" (Gary et al. 1972:679); however, in this case, the artifact category is limited to stalactites and stalagmites.

Using the minimum number, ceramics accounted for the majority of the assemblage (77 percent); followed by speleothems (16 percent); animal remains (4 percent); groundstone objects such as *manos, metates,* and celts (2 percent); chipped stone such as obsidian and crystal (1 percent); slate (0.7 percent); and a stelalike monument. Nine percent of the assemblage was so encrusted in calcite that these artifacts were impossible to identify positively.

Although this method aided in the quantification of artifacts, artifact points did not provide adequate information for evaluating spatial distributions. First

of all, it is unclear whether the ancient Maya considered a fragment of an object to be an offering. This information would greatly influence the way spatial data from sacred contexts could be handled. Since researchers have not addressed this issue, a different way of looking at the data was developed. The alternative method does not rely on specific data points as a unit of analysis, but on the spatial distributions of clusters of points.

Creating a Cluster Coverage Using GIS

An examination of the artifact distribution revealed that, in many cases, artifacts were deposited in small groups that could provide a unit of measurement independent of the number of artifact fragments in the cluster. Because like fragments from discrete artifacts tended to be in close spatial proximity to one another, they could be encompassed within a single cluster. However, identification of clusters posed some problems. Although some artifact clusters, such as those placed in niches (Figure 11.5), were well bounded and easy to identify, others were not. Difficulties arose when evaluating artifact scatters in open spaces, where clustering was more difficult to define. To address this issue, a k-means cluster analysis was conducted to aid in the identification of optimal cluster configurations.

The program is a pure locational analysis developed by Kintigh and Ammerman (1982). It was applied in this context to determine whether specific artifact classes could be placed into a set of groups based on their pure spatial location. These groups, should they exhibit robust patterning, could then be related to specific morphological features in the cave. In this research context, this approach is superior to point-pattern methods such as nearest-neighbor analysis. Point-pattern methods are generally concerned with the evaluation of the degree to which the individual members of a single artifact class have a tendency to be distributed randomly across a space, homogeneously, or clumped together with reference only to members of that class (Bailey and Gatrell 1995:75). While these methods are powerful, they assume that the spatial relationship of the members of that single class of artifacts vis-à-vis one another is intrinsically more important than the degree of spatial proximity of those artifacts to members of a different artifact class.

In contrast, pure locational clustering is not specifically concerned with a single artifact class, but instead with the degree to which members of different artifact classes are found in close spatial proximity. The content of these clusters can then be evaluated to gain insight into past behaviors. This approach has the advantage of not weighting a priori any specific artifact class. Instead, the method seeks to define "natural" groupings of objects across a space. While it is

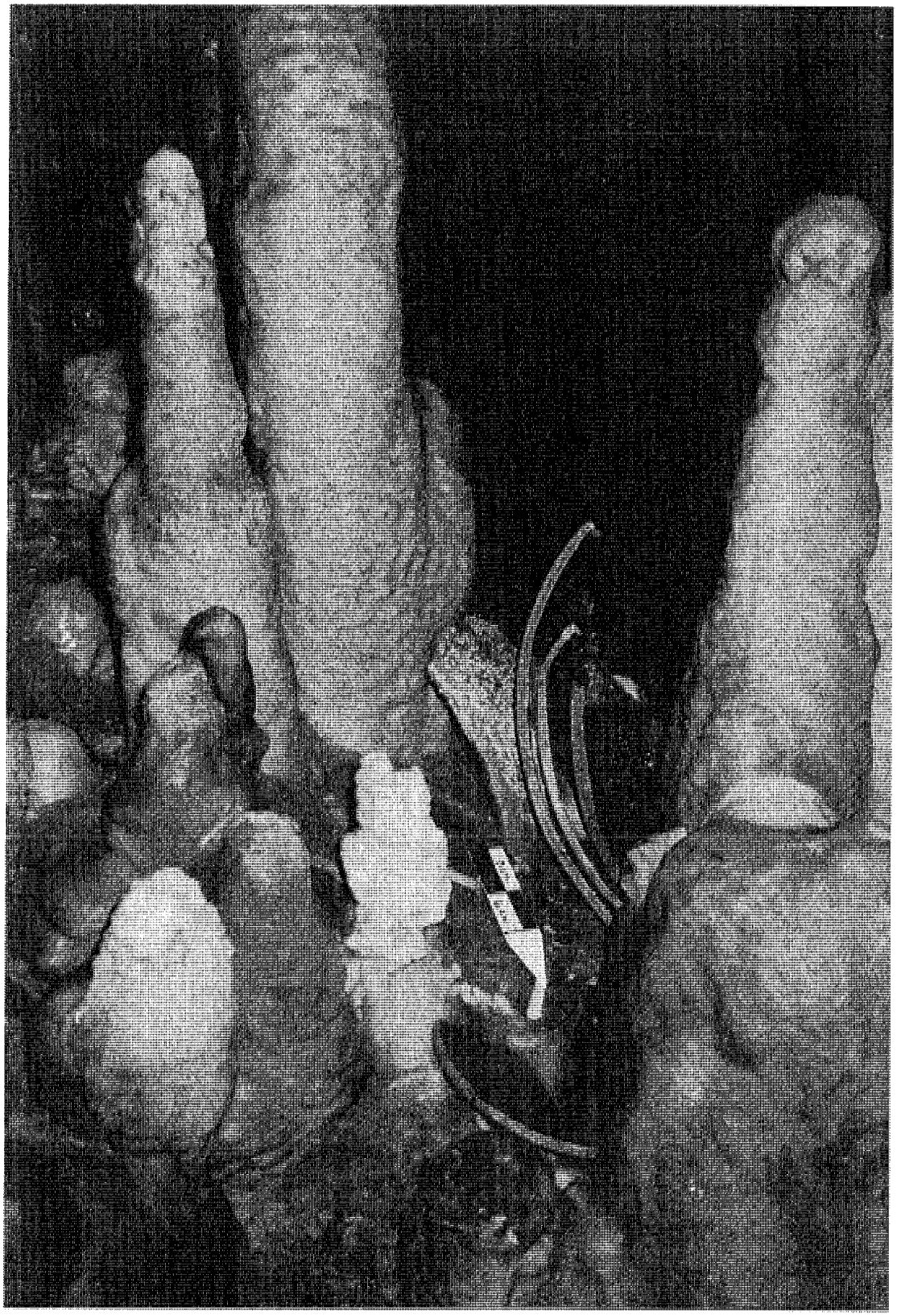


Figure 11.5. Ceramic sherds stacked and cached in a group of stalagmites. Photo by the author.

necessary to acknowledge that these methods often impose a structure on a data set, experimental studies have shown that k-means clustering generally provides excellent recovery of known data structure, especially when patterning is strong within the data (Aldenderfer and Blashfield 1984:48–49).

The number of clusters to be generated by the k-means program is determined by the user. The k-means algorithm allocates each point to one of a specified number of clusters and attempts to minimize the global goodness-of-fit measures by using the SSE (sum squared error), which is the distance from each point to the centroid of the cluster. Some programs allow the operator to view plot files of the SSE data in order to determine the number of clusters that produced the best goodness-of-fit configuration, but these programs can handle only small data sets. In order to handle the large Actun Tunichil Muknal data set, it was necessary to run the program in SPSS. Unfortunately, SPSS does not generate SSE plots, and although SSEs were numerically generated, they were produced by using a linear function, which was ill suited for the ATM spatial data.

A new method using GIS functions was developed in order to determine the ideal number of clusters to be requested for the k-means analysis. Although one option was to estimate the number based on perusal of the data, this was rejected for two reasons: first, it would have introduced bias into the data and defeated the purpose of numerical clustering; second, not all of the points were well clustered, and decisions on the number of clusters present in these areas would have been difficult, if not arbitrary. Instead, the aid of another computer program, LDEN (local density analysis) was enlisted.

Local density analysis, proposed by Johnson (1976, 1977), is a global measure designed to compute densities of artifact classes within a fixed radius of each point. Using the *x,y* spatial coordinates from the 1,408 artifact fragments generated by the GIS program, an LDEN was conducted on the data. The LDEN was iterated in 0.25-meter increments beginning at zero and increasing to 3 meters. The program was directed to produce a plot file of the results. The plot file demonstrated that the highest local density coefficients of the spatial data occurred at the 0.25-meter radii.

Using ArcView, a 0.25-meter buffer was produced surrounding each of the 1,408 artifact points, and overlapping buffers were dissolved by the program, which resulted in 252 polygons. The k-means analysis was then initiated using the spatial data (*x,y* coordinates) from the 1,408 artifact fragments and directed to generate 252 clusters.

Before importing the data into ArcView for further analysis, this number was tested for goodness of fit. To do this, the cluster number designation of 252 was tested against higher- and lower-numbered configurations by examining the coefficient of variation (CV) of *x,y* point coordinates within randomly selected

clusters from each set. The CV is defined as the ratio of the standard deviation to the mean:

$$CV = \frac{s}{\bar{X}}$$

It is used to compare variables with unequal means by comparing the relative variability of a frequency distribution. Relatively less dispersed variables have lower coefficients of variation.

To test the CV, k-means cluster configurations were generated for eight variables, including the 252-cluster configuration. The numbers chosen were 240, 250, 251, 252, 253, 254, 255, and 264. Seven numbered clusters from each configuration generated by the k-means were chosen at random for analysis. They were cluster numbers: 9, 23, 44, 78, 158, 175, and 176. The CVs for the *x,y* point coordinates for each cluster configuration were added and compared. The results of this test showed that cluster configuration 252 had the lowest combined CV (.026554), demonstrating less dispersal in the variables and producing the best goodness of fit.

Using the 252 k-means cluster configuration, a cluster-attribute table was produced in ArcView. Each of the 1,408 artifacts was assigned a cluster number between 1 and 252. Numbers were highlighted and graphic polygons were created using artifact points as nodes. Clusters contained between 1 and 30 components.

The graphic was converted to a shapefile and imported into ArcInfo. Topology for the new cluster coverage was built and reintroduced into ArcView. The advantage of building the coverage from artifacts generated by the k-means as opposed to clusters generated by the GIS program was that the k-means polygons were smaller and possessed their own unique irregular shapes, which increased the accuracy of spatially driven analyses.

Cluster Concentrations, Linear Scatters, and Boundary Markers

In viewing the artifact clusters there were three identifiable patterns of artifact deposition: (1) concentrated clusters; (2) linear distributions; and (3) isolated clusters located in peripheral areas (Figure 11.6). Cluster concentrations occurred in the eastern and middle sections of the Main Chamber in the areas of the Burial Chamber and Boot Hill. Closely spaced clusters suggested intense usage in these areas. The Burial Chamber was the area of highest concentration as evidenced not only by the number of clusters but also by the most variation in artifact classes (Moyes 2001; Moyes and Awe 1998).

Linear distributions were defined as multiple clusters of artifacts that fol-

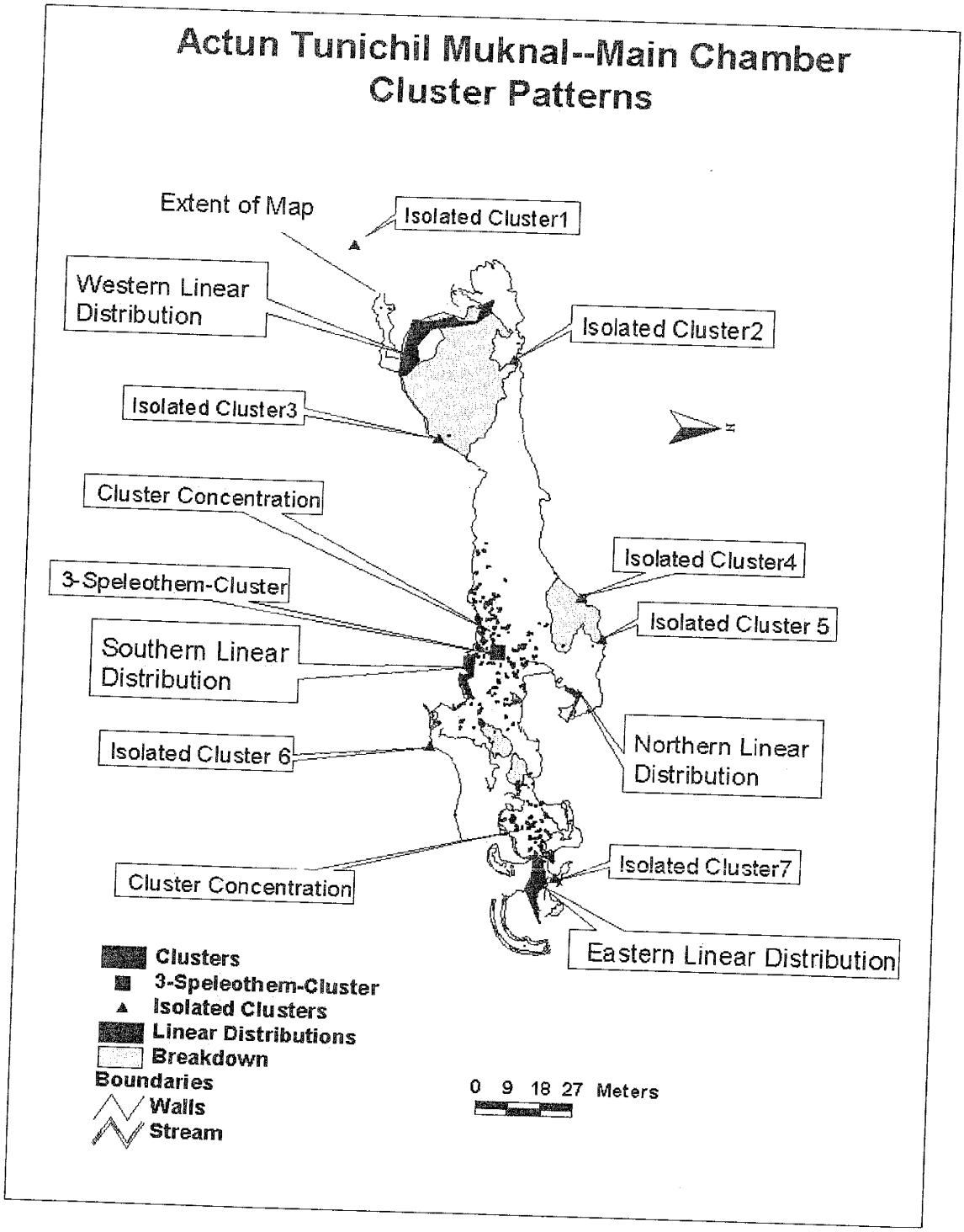


Figure 11.6. Cluster concentrations, linear distributions, and isolated clusters located in peripheral areas of the Main Chamber of Actun Tunichil Muknal. The 3-speleothem-cluster is located in the chamber's center.

lowed the outline of walls or walkways (Moyes and Awe 1999a, 1999b). Four linear distributions are located in the Main Chamber, each associated with one of the cardinal directions (see Figure 11.6). The first is the eastern pathway. It commences just above the tunnel stream and follows the only negotiable path leading to the entrance of the Boot Hill area. Artifacts located along this route consist of jar sherds, dish sherds, *metate* fragments, speleothems, and an obsidian blade found inside a smashed jar. Charcoal was found on the floor of the route and inside jar sherds.

The next two linear distributions are located in the middle section of the Main Chamber. The northern pathway commences just inside the entrance to the Ransom Chamber and runs along the south wall of the northernmost area of the Main Chamber. The artifact scatter consists of jar sherds and speleothems, and at the terminus of the scatter is a human skeleton.

The southern distribution runs along the southernmost wall of the Burial Chamber. The route runs between a group of large boulders that creates a partition between the Burial Chamber and the Passage. It leads to the remains of three individuals as well as a dense artifact distribution in the center of the chamber. Charcoal is found scattered along the wall, and the artifact assemblage consists of a speleothem, an animal bone, and, primarily, jar sherds.

The final and most explicit example is the western linear distribution. The artifact distribution runs along the westernmost wall of the cave over a large area of breakdown. Located at both termini are human remains; an additional skeleton was found in the area of breakdown near the route's center. Carbon scatters and ash lenses are most abundant approaching the area of the Crystal Sepulcher. Artifacts found along the route consist of jar sherds and broken speleothems as well as special finds, including a smashed shoe-shaped vessel, a carved speleothem bead, a large bowl, and a dish. The artifact distribution across the breakdown delineates the easiest and, indeed, the only passage across the conglomeration of roof fall that separates the Angel's Room from the West Wall areas (Moyes 2001; Moyes and Awe 1999a, 1999b).

Isolated clusters—the third category of patterning—are located in peripheral areas such as along the outermost walls of the Main Chamber or at the termini of crawl spaces or alcoves. Seven clusters of this type were identified (Figure 11.7). Each cluster consists of a single artifact. Of these, three are smashed and four are almost intact.

The group of artifacts located farthest from the cave entrance provides the most dramatic example of an isolated cluster (see Figure 11.2). A small subsidiary tunnel accessed through the Crystal Sepulcher originates at the west end of the Main Chamber and eventually rejoins the river. This tunnel is almost devoid of artifacts, except for a small cluster of speleothems and the sherds of three jars. Isolated cluster 1 (I1 on Figure 11.7), located at the terminus where the passage

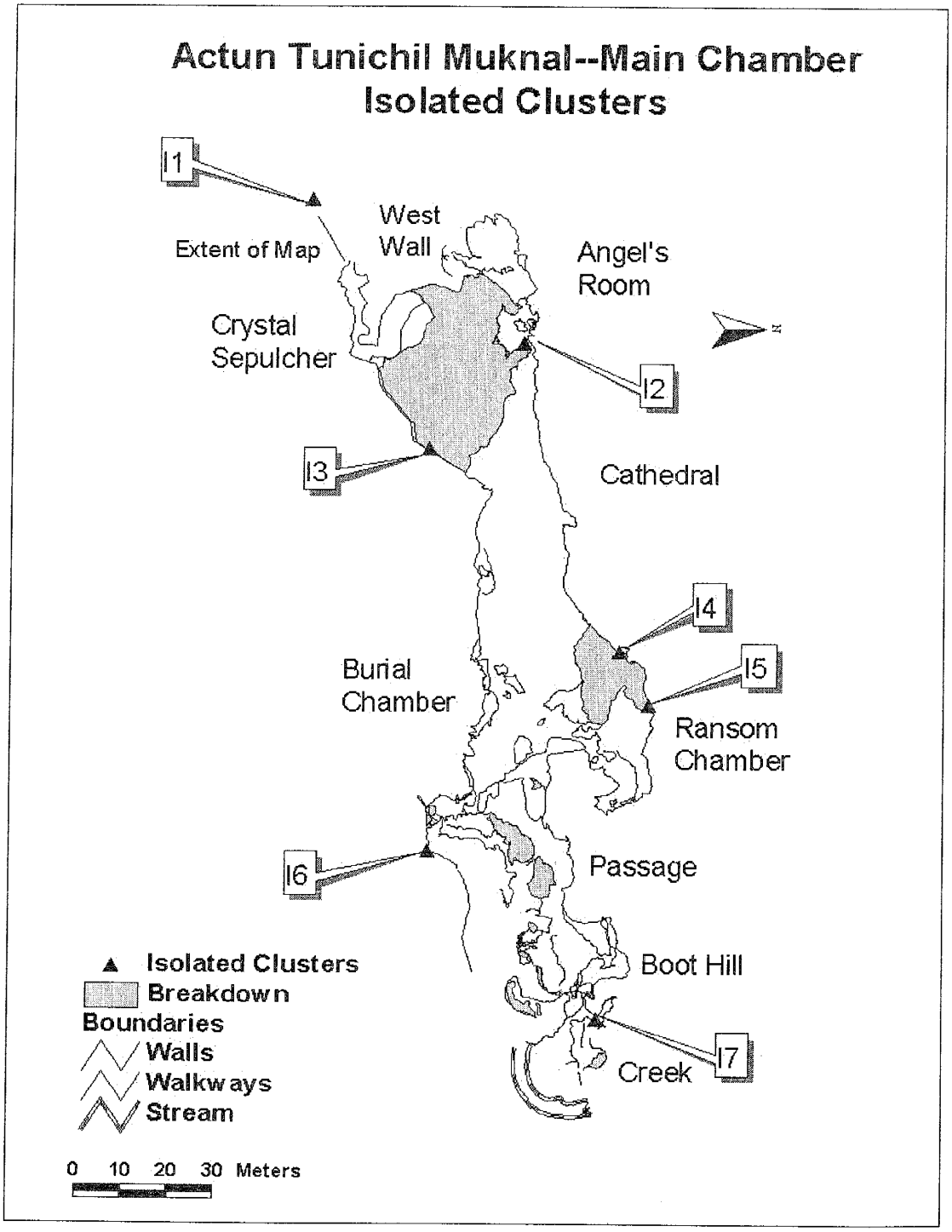


Figure 11.7. Isolated clusters in the Main Chamber of Actun Tunichil Muknal.

rejoins the main tunnel system, is a single jar sherd containing a charcoal placed on a clay mound (Michael Mirro, 1998, personal communication).

Isolated cluster 2 (I2) is located in the northwest part of the Main Chamber in a small room adjacent to the Angel's Room. It is a *metate* that is largely intact and placed within a group of stalagmites (Figure 11.8). The third isolated

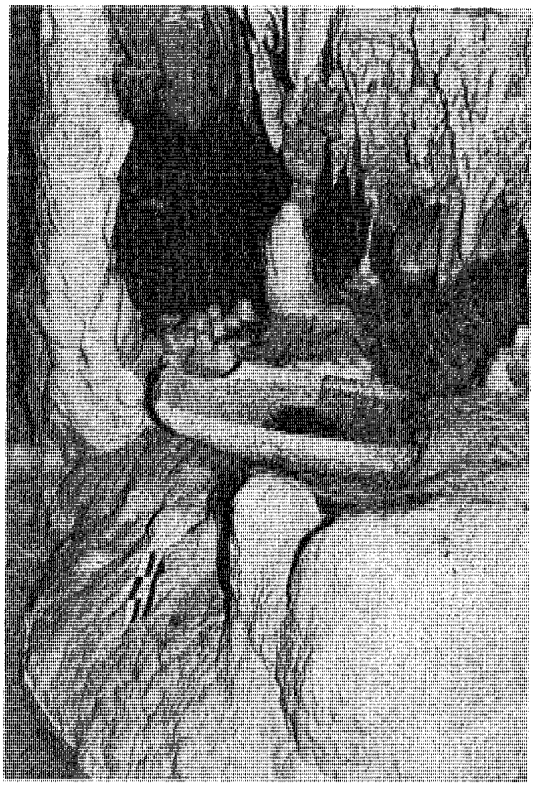


Figure 11.8. Isolated cluster I2, a *metate* placed within a group of stalagmites. Photo by the author.

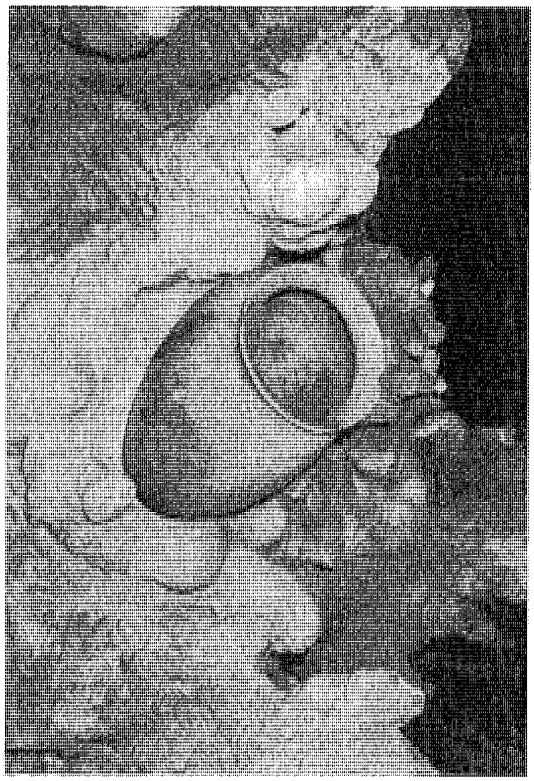


Figure 11.9. Isolated cluster I4, an intact shoe-shaped vessel placed within a group of stalagmites. Photo by the author.

cluster (I3) is found in the area of breakdown that separates the Cathedral area from the West Wall. It is located high above the floor of the Main Chamber and consists of approximately three-quarters of an unslipped jar smashed into three fragments. The sherds contain a scatter of charcoal and ash.

In an area of breakdown east of the Cathedral, located approximately six meters above the Main Chamber floor, is isolated cluster 4 (I4). The artifact is a single, intact shoe-shaped vessel placed within a group of stalagmites (Figure 11.9). Isolated cluster 5 (I5), a hollow bone tube, is located in a flat sandy area 13.5 meters east of I4, near the northernmost wall of the cave. The tube was fashioned from an animal long bone and is 8.1 centimeters long and 1.5 centimeters in diameter. One end is smoothed and the other is fractured.

Isolated cluster 6 (I6) is located in the Boot Hill area along the southernmost wall of the cave. The artifact is a red-slipped bowl situated on a shelf high above the floor of the chamber near the cave ceiling. The last example is I7, located in the area of the Creek. Placed against the cave wall at the entrance to a small alcove is half of a wide-necked, unslipped jar.

Although some isolated clusters were located in areas of high elevation, others were not. This pattern of deposition seems to indicate that the remote position

of these artifacts near the outermost areas of the cave is the key factor in their placement. The placement of artifacts at a high elevation is coincidental with the cave walls' upward curve along the periphery. The pattern of these peripherally placed artifacts does not suggest that intense activity occurred in these areas.

Models of Ritual Space and Artifact Patterning

The Quincuncial Model

Years ago, Eliade recognized that, cross-culturally, the world is perceived as having a center or navel from which extend four horizons projected in the four cardinal directions. He referred to this square constructed from a central point as an "imago mundi" (Eliade 1959:42–45). According to Eliade (1959:45), this paradigmatic cosmological model becomes "the archetype of every creative human gesture, whatever its plane of reference may be." Encountering this spatial model over time and space throughout Mesoamerica should not be surprising. Evidence for its presence among the Pre-Columbian Maya can be found in the Codex Madrid, in the layout of tombs at Río Azul (Adams and Robichaux 1992:412), and in site construction typified by the twin pyramid complexes at Tikal (Ashmore 1991:201).

Ethnographers report that the earth is thought of as a four-sided, horizontal flat plane that sits beneath the overarching dome of the sky (Gossen 1974:34; Holland 1963; Redfield and Villa Rojas 1962:114; Sosa 1985:417–423; Vogt 1976:13). In one of the most well recognized models, Gossen (1974:34) illustrates that the sun was thought to move in a vertical circular pattern around the flat earth plane. The sun's rising and setting on summer and winter solstices delineated the four corners of the plane, and its zenith and nadir marked the center of the square-earth model.

Much of our ethnographic knowledge of Maya spatial cognition also comes from the work of Hanks (1984, 1990) and Sosa (1985), who both worked among the Maya in Yucatán. They recognized that the directional principle was the cognitive spatial model at the heart of ceremonies performed by shamans and note that among the contemporary Maya, the quincuncial model is the basic spatial model used in ritual.

Hanks (1990:299–302) dichotomizes the sacred and the profane use of directionality by differentiating between cardinal "directions" and cardinal "places." Cardinal directions constitute "an abstract coordinate system, presumably fixed by features of the natural environment (terrestrial and celestial), relative to which any actor can orient himself or any other object"; cardinal places serve to define

a schematic totality of spatial zones. Cardinal places used in ritual discourse may be thought of as representing "miniuniverses." They are conceptualized as a central point surrounded by a four-sided polygonal structure whose sides are created by joining the four intercardinal points.

This concept, described as a "frame" by Douglas (1966:63–64), divides reality, both temporally and spatially, between that which is within the frame and that which is outside it. In Hanks's model, the frame represents a totalized space conforming to any scale, from a household altar to a milpa to a community to the entire cosmos. Although the earth itself is described in terms of the frame, in practical usage, a frame can also represent a "minicosmos" at a smaller scale. Therefore, the frame may be nested within progressively larger social spaces in the way that a Chinese box may open into another and another.

Hanks's work is instrumental in providing an understanding of the purpose of the frame. Through shamanic discourse that invokes the cardinal directions, spirits are brought down from their celestial realm in a procedure referred to as "binding the altar" (Hanks 1990:336–337). At the culmination of a ceremony, they are sent back to their spiritual abode, and the altar is said to be "untied." Sosa (1985:470–471) notes that the "tying," or binding, of ritual space is modeled after the Maya understanding of the cosmological order and references the sun delimiting the boundaries of the cosmos in its daily circuit around the earth.

Hanks points out that binding of the altar is best thought of as creating a secure place. He explains that the "altar is secured in the sense that spirits are bound to absolute locations around it, at once protecting the shaman from attack by any marauding spirits in the area and also preventing the lowered spirits themselves from wandering around" (1990:337). Even fully beneficent spirits can cause damage when loosed, and the protective procedure creates a zone of spiritual safety so that powerful beings may be manipulated. Hanks (1990:349) summarily states: "Without its perimeter, a place has no unity and is potentially dangerous. The frame may have the same protective quality when operating on a larger spatial scale at the community level. Barbara Tedlock (1992:82) reports that at Los Cipréses in Highland Guatemala the priest-shaman makes a four-part pilgrimage to the mountains surrounding the town. This ritual circuit is referred to as either the "sewing and the planting" or the "stabilization" of the community. The latter is a metaphor for the firm placing of a table on its four legs so that it will not wobble or tip over in times of natural or other disasters.

At the village of Chan Kom in Yucatán, during the *loh* (meaning "redeem" or "free"), a curing ceremony, the participants traverse a ritual circuit to each of the four entrances of the village and at each point bury crosses, obsidian, and salt in the road in order to prevent evil winds. Afterward, they proceed to the cenote to throw in thirteen wooden crosses so that "the winds [will] not come out of it again" (Redfield and Villa Rojas 1962:176). Sosa (1985:343, 344, 451,

452) describes the similar *loh kàah* ritual in the town of Yalcoba, but adds that it is a nighttime ceremony to propitiate the cave-dwelling deity Yum Baláam, who protects the populace from evil winds that cause disease. This guardian possesses four aspects that correspond to the corners of a quadrilateral structure. During curing ceremonies, one *h'men* (priest-shaman) walks a ritual circuit encompassing the community and leaves offerings at the corners while another remains at the centrally located church.

Hanks (1990:345) reports that in the "fixed earth" ceremony, a household rite designed to drive away a malignant spirit, the yard is spatially bound, or "locked in," by traversing its perimeter and "putting in" guardian spirits by showing them their "boundary stones." A similar pattern of perimeter definition occurs in ceremonies for the laying out of a milpa. The perimeter is always cut first, prayers for protection from snakes proffered, and, finally, offerings left at the four cardinal points and the center (Hanks 1990:362–364).

Awe and I (Moyes and Awe 1999a, 1999b) have suggested that the four linear scatters established inside of the Main Chamber are analogous to ritual pathways described by ethnographers. Viewed collectively, the pathways correspond quite literally to the four cardinal directions (see Figure 11.6). However, for this to correlate with the Maya frame representing the layout of the cosmos, a central feature is required. Using GIS to view the chamber, the centrally located artifacts were examined. In the center of the Burial Chamber was a stack of three modified speleothems. I have argued elsewhere (Moyes 2000, 2001) that the 3-speleothem-cluster completes the fifth central element of the quincuncial frame by representing the 3-Stone-Hearth or axis mundi (see Figure 11.6).

Freidel et al. (1993:68–93) suggest that hearths often represent the central feature in Maya cosmograms, particularly the 3-Stone-Hearth associated with the 4 Ahau 8 Kumk'u creation event of 3114 BC. Taube (1998:427–432) draws an analogy between Maya household architecture, in which the hearth is the central feature, and the architectural configuration of temple structures as "god houses." As with Maya houses, four posts support the roof of temples, and the center is the 3-Stone-Hearth, which represents both a place of creation and axis mundi connecting the sky, the earth, and the Underworld.

This analogy may be extended to caves, since they are thought of as houses of deities, particularly rain gods (Guiteras-Holmes 1961:153, 281; Holland 1963:93; Nash 1970:141; Reina 1966:181–182; Thompson 1970:267–268; Toor 1947:473), and ancestral spirits (La Farge 1947:127–128; Nash 1970:19, 45; Thompson 1970:314, 316; Vogt 1970:6). Stone (1995:35–36) argues, using linguistic evidence, that caves are thought to be houselike structures. This agrees well with Las Casas, who noted centuries ago that the Maya word for "temple" was also used for "cave" (cited in Thompson 1959:122).

The 3-speleothem-cluster located in the Main Chamber is notable because

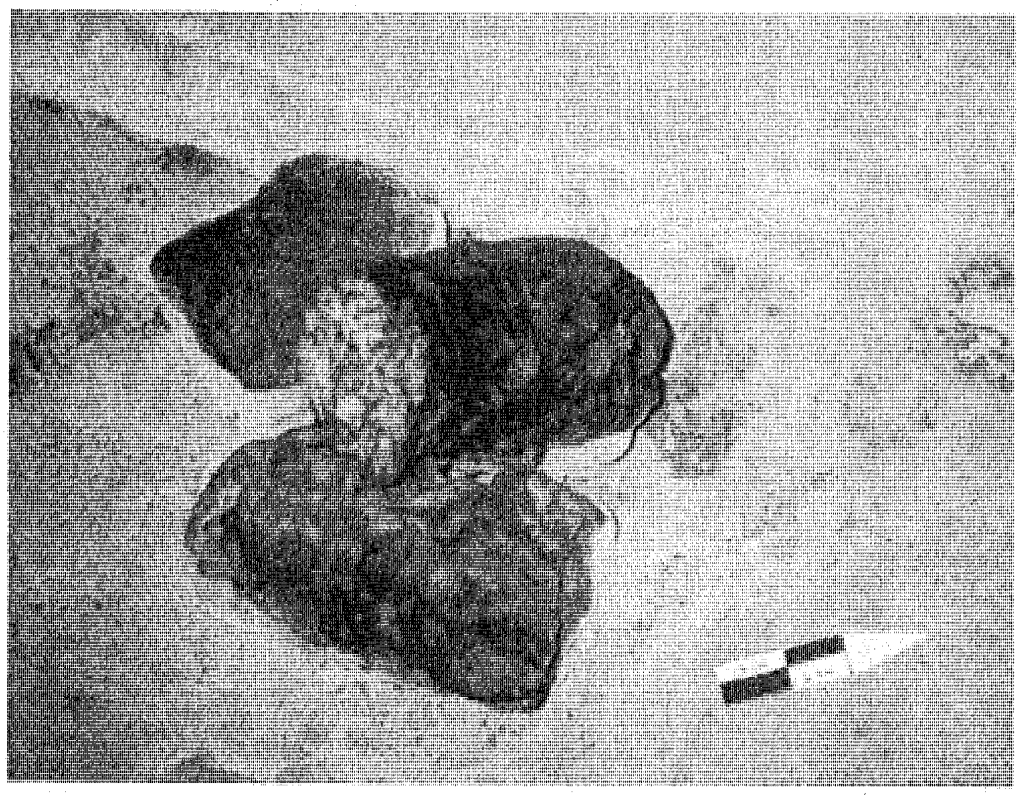
of its odd configuration of deposition. There is a high degree of confidence that the stones are in their original context because they have been firmly cemented to the floor with calcite. The three speleothems are stacked together with two on the bottom of the stack and the third on top. Taube (1998:433) notes this specific arrangement in epigraphic representations of the 3-Stone-Hearth (Figure 11.10). Of the 116 speleothems deposited in the Main Chamber, this is the only instance of this particular configuration. Additionally, the clustered speleothems were modified from their natural cone shapes to a more rounded appearance, closely resembling hearthstones.

Taube (1998:431–440) has identified iconographic elements that accompany 3-Stone-Hearth imagery: centrality, jaguars, fire, and water. Each of these elements is present in association with the 3-speleothem-cluster. First, the cluster is absolutely central not only to the Burial Chamber, where it is located, but, on a larger spatial scale, to the Main Chamber itself. Besides this element of centrality, the element of jaguars is also present. A small-scale detail map of the immediate area illustrates the provenience of two jaguar bones—a pelvis and a metatarsal—found in a cache located within five meters of the three-speleothem cluster (Figure 11.11).

Evidence of burning in the 3-Stone-Hearth symbolism would be expected as well. Although large areas of charcoal scatters are present along the walls of the Burial Chamber, any carbonized material located among the rimstone dams at the center would have floated away or been covered by flowstone. There is, however, some evidence of previous burning, since the speleothem on the top of the stack exhibits charring (see Figure 11.10).

The element of water is represented by the wet nature of the chamber itself, as evidenced by the intermittent pools formed by the rimstone dams covering the floor. Additionally, the three "hearthstones" were constructed from speleothems. Lexical evidence suggests that the Maya were cognizant, at least empirically, of the process of speleothem formation in which water was converted into stone. The Yucatec word for speleothem is *xix ha tunich,* or "drip-water stone" (Barrera Vásquez 1980:946).

In his summary of Maya cave use, Thompson (1959:124–127, in Mercer 1975:xv–xxii) suggests that, among the Maya, jars found in caves were meant for the collection of *zuhuy ha,* or "virgin water," to be used in rituals. In a personal communication (2000), Barbara Tedlock suggests that the correct spelling is *suhuy,* which translates as "pure," as opposed to "virgin." Barrera Vásquez (1980:741) defines *suhuy haa'* in Yucatec as water springing from a hole. According to Tedlock, in practice, this becomes water that is caught, such as rainwater or dew, or that comes from a spring. Water from the center of the source is particularly desirable for ritual purposes, since water from the banks or edges of the source is considered to be polluted. One of her informants, while collecting



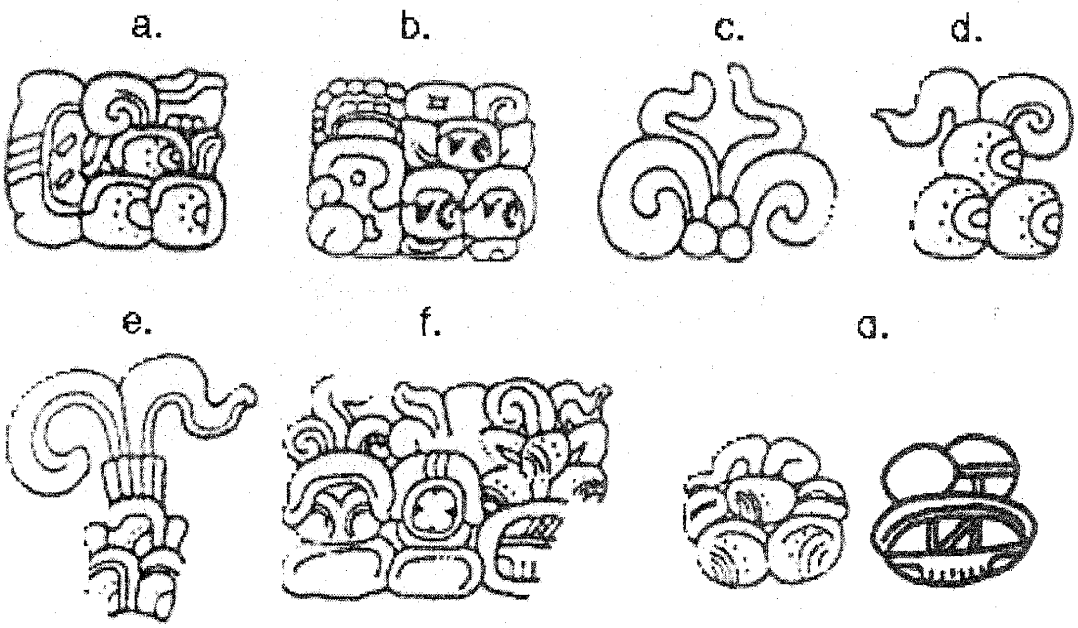


Figure 11.10. *Top:* The 3-speleothem-cluster located in the Burial Chamber of the Main Chamber of Actun Tunichil Muknal. *Bottom:* Epigraphic depictions of the 3-Stone-Hearth assembled by Taube (1998:433): (a) the green hearthstone place, Quirigua Stela; (b) the Seibal emblem glyph, Tablet 4 of Hieroglyphic Stairway, Seibal; (c) three smoking hearthstones, Monument 74, Tonina; (d) one of a series of smoking hearthstones on headdress of ruler, detail of recently excavated stela, Tonina; (e) three stones with burning wood, Naranjo Stela 30; (f) smoking sky hearthstones with glyphs for Tikal Paddlers, Stela 16, Copan; (g) smoking hearthstones with sky *ahau* glyph, Stela 1, Salinas de los Nueve Cerros. After Taube (1998:433).

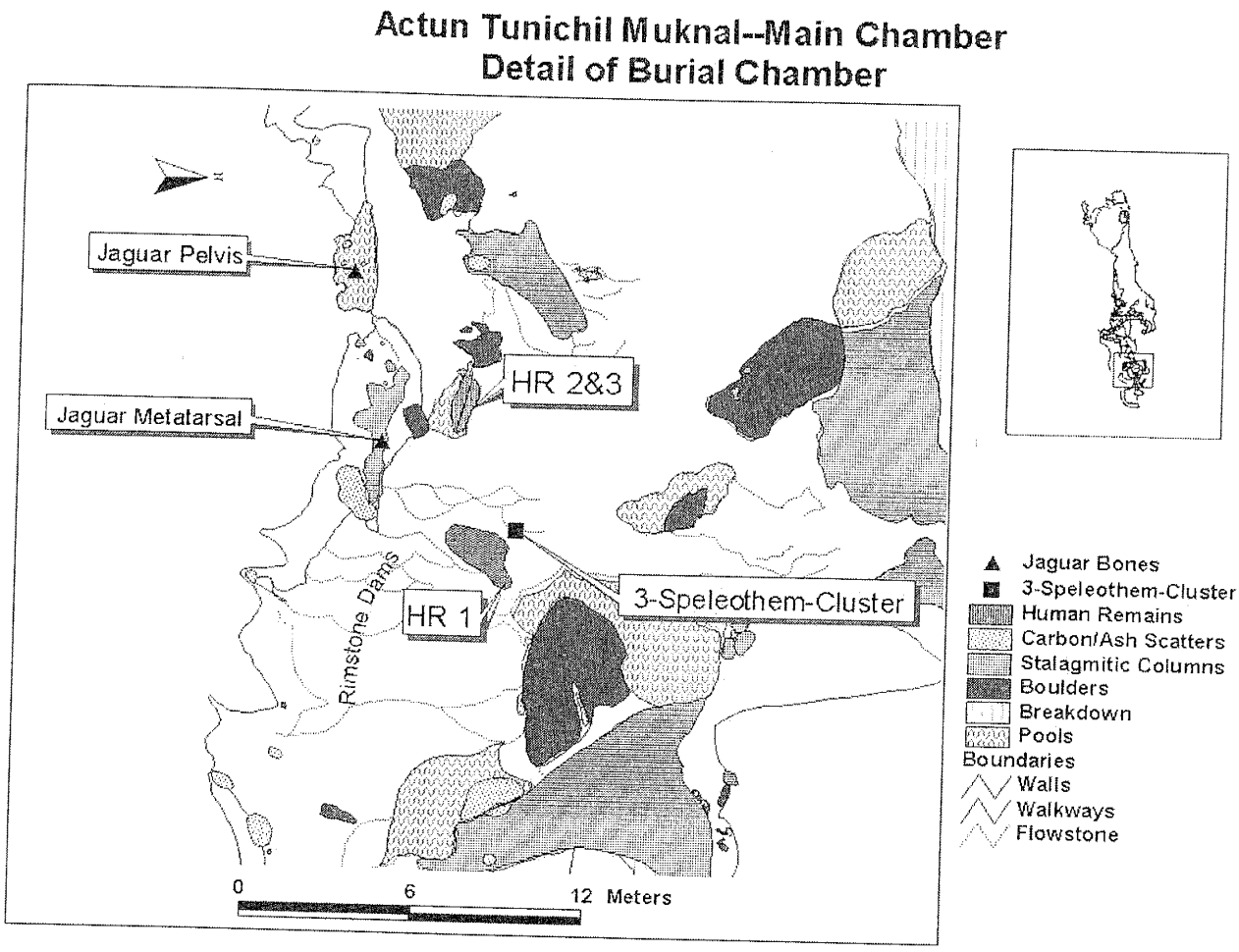


Figure 11.11. Detail of the Burial Chamber of Actun Tunichil Muknal illustrating the most central area of the cave. Note the two jaguar bones located within five meters of the 3-speleothem-cluster. After Moyes (2000).

water for rituals, stood on a stone so that she could reach into the middle of the pool and avoid drawing water from the edge of the spring for this reason. The concept is also present in Central Mexico. Aramoni (1990; also see Chapter 2 here) notes that in Tzinacapan, water coming from caves in the area is believed to be pure because it originated in the Underworld.

The creation of stone from dripping virgin water would likely imbue speleothems with special meaning, as Brady et al. (1997:725) have suggested. This implies that the 3-speleothem-cluster in the Main Chamber represents special hearthstones fashioned from pure water. The 3-Stone-Hearth element completes the quincuncial frame and, when juxtaposed with Hanks's model, the similarity to the Maya ideal is apparent (Figure 11.12).

Alternative Spatial Models

Although the quincuncial frame is an important model in Mesoamerican cognitive structure, other models exist. Taube (1988a:163–168), for example, presents

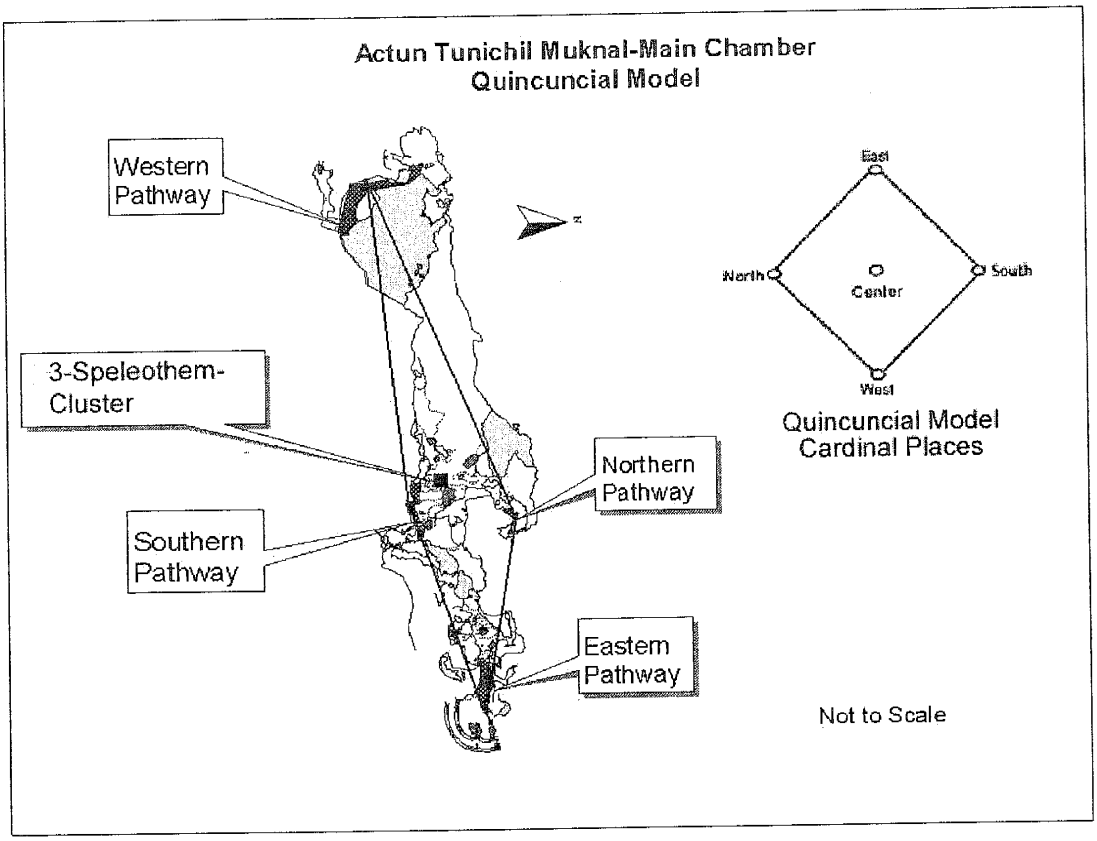


Figure 11.12. The quincuncial spatial frame in the Main Chamber of Actun Tunichil juxtaposed with Hanks's model of cardinal "places." After Hanks (1990:301, Fig. 7.2); Moyes and Awe (1999a, 1999b).

evidence from ethnohistorical texts for a circular world model. Early colonial dictionaries, the Chilam Balam of Chumayel, and the Chilam Balam of Kaua all make reference to, or show maps of, a circular earth model. Taube also points out that in Pre-Hispanic Central Mexico, the circular earth could be characterized by a round, flat mirror or a round calendar stone. A round, globular turtle could also represent the circular earth, as evidenced by the Late Postclassic stone tortoise altar figures discovered at Mayapán or in Classic Period depictions of the Maize God rising from a cleft in a turtle carapace found in Maya iconography. Taube (1988b) has suggested that turtles also represent time/space models signifying the twenty-year *katun* cycles in Postclassic Yucatán.

In both contemporary and colonial representations of the circular world, a cross or axis divides the circle into quadrants (Taube 1988a:168). Evidence suggests that this was an ancient cosmological construct as well. An Esperanza phase bowl depicting turtles with crosses on their backs was found in Tomb A-VI at Kaminaljuyu (Kidder et al. 1946:185). Additionally, pecked designs illustrating two concentric circles divided into quadrants by crossed lines were found at both Teotihuacan (Aveni 2000; Aveni et al. 1978) and Uaxactun (Smith 1950:21–22, Fig. 15a). It has been suggested that these are time/space models

that correlate calendrical cycles with astronomical events (Aveni 2000; Broda 2000).

More than one spatial model may operate simultaneously, however. For instance, both the circular and the quadrilateral worlds were referenced in rituals that established community boundaries. In his study of ethnohistorical documents, García-Zambrano (1994) points out that, to establish communities, the Zapotec, the Maya, the Mixtec, the Tarascans, and the Otomí conducted foundation rituals to establish or reestablish territorial boundaries. According to García-Zambrano (1994:220), the outward meaning of the ceremonies was to erect a "mini-cosmos" through ritual. The minicosmos was represented as an abstract time/space model of the universe in the form of a square within a circle. The circle represented time and the square, space.

This complex of rituals began with the identification of five mountains. Four were considered the periphery of the community, and the fifth, along with its water hole, became the center. From the central mountain, a group carrying ropes constructed of boughs and grasses that enclosed the space beat the boundaries of the new community, establishing borders along community perimeters. Although the visual referents for the demarcation of the boundaries formed a square with the four cardinal mountains, the procession followed a circular pattern. This pattern of movement agrees well with Gossen's (1974:34) model of the cosmos in which ritual circuits are depicted as moving in an oval pattern.

Following the beating of the boundaries, the group moved to the top of the central mountain, where two additional ceremonies occurred. A smaller circle of boughs, mirroring the larger circle used to mark the peripheries, was constructed (Alva Ixtlilxóchitl 1975:220). This was set on fire to sacralize the center and to promote the transit of the sun through the sky. Following this event, arrows were shot to the four cardinal directions. The arrows marked the territorial boundaries and divided the land into quadrants. This ritual enactment incorporated both quincuncial and circular patterns. The resulting spatial pattern was modeled by García-Zambrano (1994:220, Fig. 3) as a set of squares encompassed by a circle (Figure 11.13).

García-Zambrano's model agrees well with Hanks's (1990:350) observation that, among the Yucatec Maya, there is interplay between round and quadrilateral space in cosmological models. Hanks's informant provided a drawing of a cross section of his conceptual universe, which illustrated the earth as a quadrilateral flat plane inside a sphere (1990:305, Fig. 7.3). Similarly, Holland (1963:14–15), working in San Andrés Larrainzar, describes a model in which the sky is thought of as a cup over the flat earth. Viewed from above in two dimensions, these circular sky–flat earth models would look like a square earth contained within a circle, strongly resembling the model of foundation rituals reported by García-Zambrano.

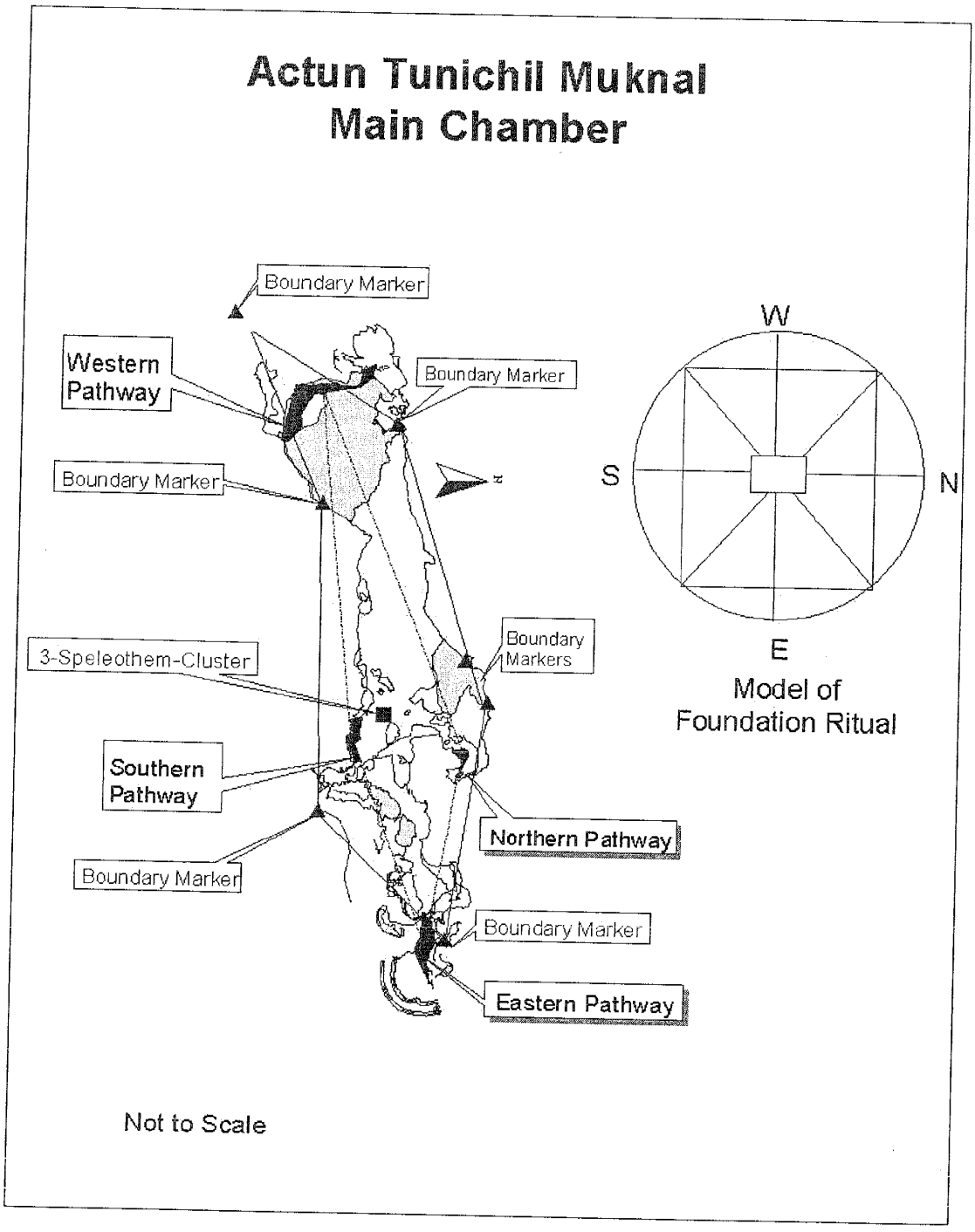


Figure 11.13. Ritual pathways, three-speleothem-cluster, and boundary markers in the Main Chamber of Actun Tunichil juxtaposed with García-Zambrano's illustration of the spatial model of foundation rituals. After García-Zambrano (1994:220, Fig. 3).

For archaeologists, the most important thing about cognitive spatial models is the way conceptualization affected behavior. In the study of material culture, it is the manifestation of that behavior in the artifact record that is of interest. Although Hanks's model of cardinal places emphasizes the intercardinal points as the corners of the spatial frame, García-Zambrano emphasizes the cardinal

points. However, in terms of behavior, they are in agreement, since, in foundation rituals, the "arrowing," or ritual marking, of the cardinal directions is directed to the intercardinal points, just as the Maya priest-shaman uses them to establish cardinal places.

As a part of foundation rituals, stone markers and/or stelae were set along borders to provide permanent boundary designations. These provided an enduring visual representation of the community boundaries to warn trespassers that they would not be tolerated (García-Zambrano 1994:219). Hanks (1990:356) reports a similar type of boundary marking in the modern community of Oxkutzcab. Several major boundaries separate the community from its neighbors and are marked with stone mounds. The markers are thought to have been placed in the woods by foreigners, wealthy men, or the town and may also delineate the property lines of wealthy ranch owners. They define the permanent limits beyond which one cannot go when choosing land for milpas. Anyone who crosses these markers is denounced.

Hanks (1990:388–389) also points out that, among the Maya, every space has a *yùumil,* or "lord owner." This concept includes all space from the expanse of the cosmos to the ownership of land. Not only do spaces have owners, but owners have spaces both in the corporal and the spiritual realms. This plays a central role in shamanic practice, particularly in the effort of the priest-shaman to keep spirits from wandering.

Marking of boundaries is also present in Zinacantecan K'in Krus rites or water-hole ceremonies reported by Vogt (1969:690–695; 1976:111–115). These renewal rites encircle the culturally utilized parts of the local environment associated with particular lineage groups in order to compensate the Earth Lord for the use of natural resources (Vogt 1976:114). Features of the natural landscape, such as caves, water holes, and rocks, as well as local officials' house-cross shrines, determine ritual stations. Offerings are given to the Earth Lord at stations constrained by geographical landmarks. As Vogt (1969:391) suggests, the definition of territorial geographic space is an important feature of Maya spatial cognition.

The placement of the seven isolated clusters in the Main Chamber (see Figure 11.7) does not correspond to the quincuncial model that is so often used in Maya ritual. Their position along the outside walls of the chamber (I2–I6) and in areas where further access is terminated (I1, I7) suggests that these artifacts are boundary markers. Their location along the natural perimeters of the Main Chamber appears to enclose the frame created by linear scatters and creates a configuration similar to that reported for foundation rituals. A comparison between illustrations of the cluster patterns found in the Main Chamber and García-Zambrano's spatial model illustrates the similarities between the uses of space in both instances (see Figure 11.13). I suggest that the placement of arti-

facts along peripheral boundaries within the cave interior represents the delineation of social space and is analogous to the beating of boundaries in foundation rites or K'in Krus renewal rituals. Although stone markers were used to reify boundaries in foundation rituals, artifact deposits appear to have been substituted to mark cave perimeters permanently.

Conclusions

Geographic information systems have most frequently been employed in archaeological studies for large-scale regional analyses and predictive modeling of settlement patterns and land use, but the potential of GIS as a tool for the organization and analysis of spatial data within a single site has hardly been explored. The use of a GIS in Actun Tunichil Muknal demonstrates that it is a powerful tool for the mapping and display of cave interiors. The GIS was vital in detecting global artifact patterns and made it possible to compare artifact patterns located within the cave to ethnographic spatial models.

Strong analogies can be drawn from numerous ethnographic and ethnohistorical studies of Maya ritual behavior patterns and can be used to explore the archaeological record. They demonstrate the pervasive use of the quincuncial template that references the creation of the cosmos. Although models of the cosmos made by the Maya themselves are commonly based on a quincuncial structure, they may be elaborated in more complex spatial models that utilize time/space/sky configurations in which the four-sided model is encircled.

In this chapter I have examined depositional patterns of artifacts from the Main Chamber of the cave. The analysis demonstrates that artifact patterning corresponds to García-Zambrano's spatial model of foundation rites. As an expression of the basic quincuncial model, linear scatters of artifacts represent ritual pathways that correspond to the four cardinal directions. The central feature of the model is marked by the 3-speleothem-cluster at the center of the chamber, which I argue represents the 3-Stone-Hearth at the center of the cosmos in Maya belief. Artifact deposits located in isolated areas function as boundary markers that express the encircling configuration. These data suggest that establishing boundaries was an important means of ritually defining a safe social space within the cave.

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