Aguateca in 3D:

Ritual Performance of Maya Kings

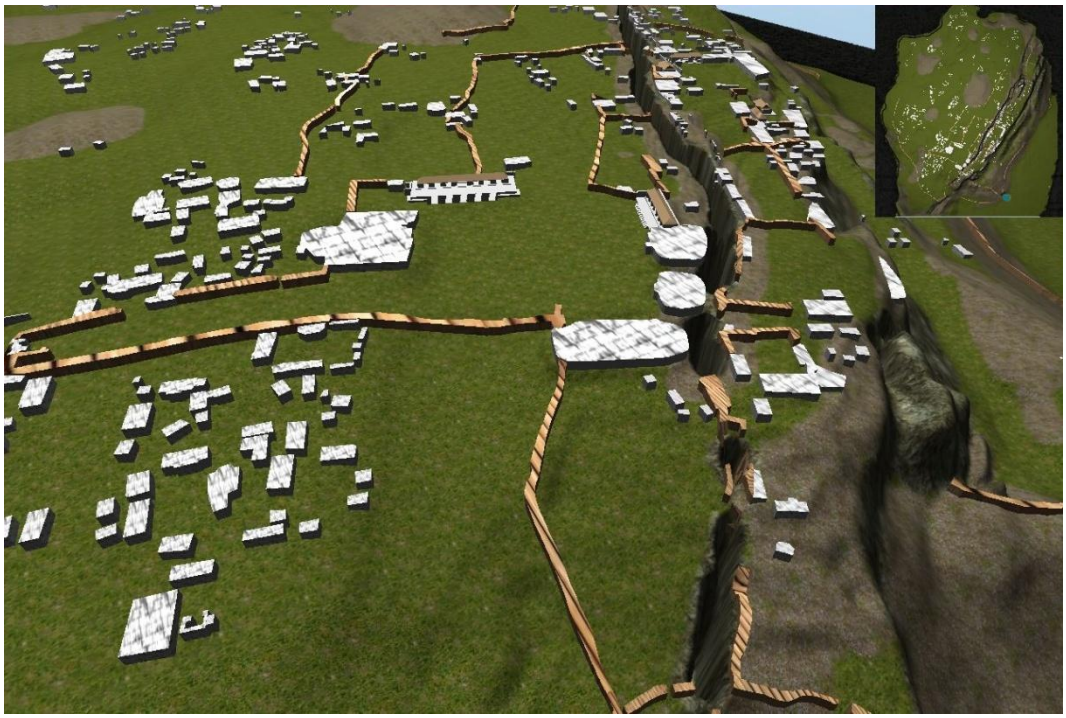

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Figure on the cover is a screenshot of the completed model in Unity3D

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Contents

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1) Introduction

Maya rulers, lords in their kingdoms, deities even. They ruled their people, waged war against other kingdoms and extracted tribute to pay for it all. The question is however: how did they maintain the loyalty of their people? Was it merely the fact that they were presented as gods in the visual culture, did they use fear and oppression or was there something else? Contemporary scholarship brought forward the idea that Maya kings performed various rituals in a theatrical way to ensure the continuing loyalty of their people (Inomata 2006). There is various archaeological evidence to support this theory, but several questions remain. Were these theatrical rituals visible for the entire city and did they truly have the effect that is attributed to them? Or is it possible that these rituals were perhaps only to be viewed by a specific subset of those people? These questions can be answered though re-enacting the ritual in a virtual world, as then the visibility of the ritual can be determined. Although it was the original plan of this thesis to go into these questions using a 3D model of the city, it was later decided to leave these questions for later and focus this thesis around the construction of the 3D model that is accurate enough to do that research. Although this model can later be used to go deeper into the theoretical debate of the kingship ritual as theatrical performance, this thesis will therefore only focus on the construction of the 3D model and explore the space in which these rituals were probably enacted.

The case study will be a city known as Aguateca, a Maya city of Classic times in Guatemala, of which roughly the entire city area will be implemented in a 3D model. Reasons for the choice of this city are the extensive research done on the city by Arthur Demarest (Demarest 2006) and Takeshi Inomata (i.e. Demarest 2006, 117; Inomata et al. 2001, Inomata et al. 2002, Inomata 2006) and their teams, combined with the fact that its history is very short (ca. AD 700 - 800), which makes it less problematic to build a 3D model as it can be assumed that all the structures found belong in the same timeframe. This makes it possible for the 3D model to give us a precise view of a ritual when re-enacted in the virtual world.

The very first step in doing research into Mayan kingship rituals is of course determining what we already know about it and therefore the next chapter will be discussing the Maya. After shortly introducing the Maya, it will then proceed to the city of Aguateca and give a thorough description of what we know of it through earlier work. The third and last part of the chapter is directed towards Maya kingship and

discusses many facets of that highest position available in a Maya city. With a proper picture of the Maya, chapter three will continue to go deeper into the ritual part of kingship ritual, including some discussion of the theatricality of Maya kingship ritual that Inomata (2006) proposed. Chapter four will then be more technical, as this chapter will discuss the 3D model that was made of Aguateca. After shortly discussing the method, it will give a report of the construction process, the limitations and possibilities of the model and the problems encountered during the construction and how these problems were dealt with. During the discussion the model will be used to explore the ritual space of Aguateca in the form of a tour through the virtual city of Aguateca. During this tour various viewpoints will be examined to give some first indications towards the answers to the questions that were posed above. Finally there will be some concluding remarks as well as recommendations for future research using the model created and what will be required to prove that the theatricality of the kingship ritual was not only possible, but also probable based on a view shed analysis next to the arguments that were already given by Inomata (2006).

2) The Maya: a background

In this chapter the required background for the Maya in general and the case study of Aguateca will be given as well as some more in depth discussion on Maya kingship and all it pertains.

In general the Maya chronology can be divided into three periods, namely the Preclassic (ca. 2000 BC - AD 250), the Classic (ca. AD 250 - 909) and the Postclassic Period (AD 909 - 1697) (Martin and Grube 2000,8). The amount of literature is big on each of those periods and for this thesis the focus will be on the Classic Period. The reason for this is that the official occupation period of Aguateca was from ca AD 200 until its abandonment during the Classic Maya Collapse (ca. 830 - 950).This collapse marked the transition from the Classic Period to the Postclassic Period (Demarest et al. 2004, 3). In terms of area the Maya lived in a large region during the various centuries that their social system prevailed in Mesoamerica. Aguateca is located in the southern lowlands of the Yucatan (see figure 1) and therefore our focus will be in that area. Other Maya polities can be referred to when strong links can be made, but the focus of the thesis will be on the southern lowlands during the Classic Period.

Politically, it is not entirely certain how the Maya area should be viewed. Generally there are three models that try to describe the situation in broad lines. The first of these, known as the city-state model, considers all kingdoms independent of each other and roughly equal in comparison to the other kingdoms. The decision on which cities could be called kingdoms a specific name called an *emblem glyph* was used. This term will be explained in chapter 2.2.1. A second model, called the super-state model, works on the same basis, except that the specific kingdoms of Tikal and Calakmul are seen as being two opposite nations of roughly equal power. All other kingdoms are seen as allies to either of those cities and partly dependent on them. Which city is a kingdom in this model is also based on the emblem glyphs. The third model is called the regional-state model and is based on the idea that any kingdom could not control anything that was further than one day of marching from the city. Given a maximum military movement of sixty kilometres in a day, the maximum area that any Maya kingdom could control was roughly eleven thousand square kilometres (Chase and Chase 1998, 14).

Fig. 1: Map of Yucatan (after people.wku.edu)

2.1) Aguateca: A History

The Maya city Aguateca is located in the southwest of the most northern province of Guatemala, Petén, as can be seen in figure 2. The first settlement of the area was during the Late Preclassic period, around 200 BC, although the official date of the founding of the city was around 700 AD after almost complete abandonment during the Early Classic Period (150 - 600 AD) (Inomata and Webster 2004, 161). Aguateca and Dos Pilas, a nearby city which can be seen on figure 1, were the capitals of the dynasty that ruled the area around it.

Fig. 2: Map of Guatemala (www.enjoyguatemala.com)

Of those two, Dos Pilas was initially the most important. It was founded in 625 by the brother of the ruler of Tikal, named B'alaj Chan K'awiil, and quickly turned into a

military outpost of that city(Salisbury and Koumanelis 2002, 1). Soon afterwards however, Calakmul, an enemy of Tikal, attacked and conquered Dos Pilas. Instead of disposing of the ruler, he was maintained on the throne in return for his allegiance, turning him against his own brother. Although much smaller in size, Dos Pilas managed to win a decisive battle against Tikal after a decade of warring, ending in the Tikal ruler being brought to Dos Pilas to be sacrificed by his own brother (Salisbury and Koumanelis 2002, 1). However, defeat in the Maya area did not automatically mean complete destruction and Tikal prospered to later defeat Calakmul in 695 AD (Ponciano and Inomata 2004, 2). From 700 AD onwards, perhaps due to the defeat of Calakmul, Dos Pilas became less important as a capital city until 761 AD, when it was abandoned by the rulers (Ponciano and Inomata 2004, 2). As Dos Pilas has a less strategic position than Aguateca, it might be that the rulers no longer felt safe in this city. In any case, they decided to move to Aguateca, which also caused that city to expand even further.

Around Aguateca, a city wall was built in the last few years of its inhabitancy with a total length of 4.8 km and the city area was roughly ⅞ km^2 [1]. The city was sacked around 800 AD, after which the remaining population quickly abandoned it (Inomata et al. 2002, 305). All elite residences that have been excavated showed signs of burning and the inhabitants either fled or were forcibly removed. The city was not looted apparently, as the possessions of those inhabitants were left behind for the archaeologists to find (Inomata et al. 2002, 305). The attackers did not remain in Aguateca as they left no material markers in the city of occupation and the city was not inhabited again after the attackers left (Inomata et al. 2002, 323).

Although there had been some observations in Aguateca, the first actual research to be done on the site was carried out in 1989 by the Petexbatún Regional Research Project under the direction of Arthur Demarest and Stephen Houston (Demarest 2006). This project was focused on the area around the lagoon Petexbatún in the southwest of Petén, Guatamala and its primary research aim was to better understand the so called Classic Maya collapse. In 1990 the research focus on Aguateca started under the direction of Takeshi Inomata, still working within the Petexbatún project (Demarest 2006, 117). Since 1996 the Aguateca Archaeological Project has performed extensive excavations on the site under the direction of Inomata, Triadan and Ponciano (McCracken 2002).

[1] Calculated using ImageJ on fig. 3

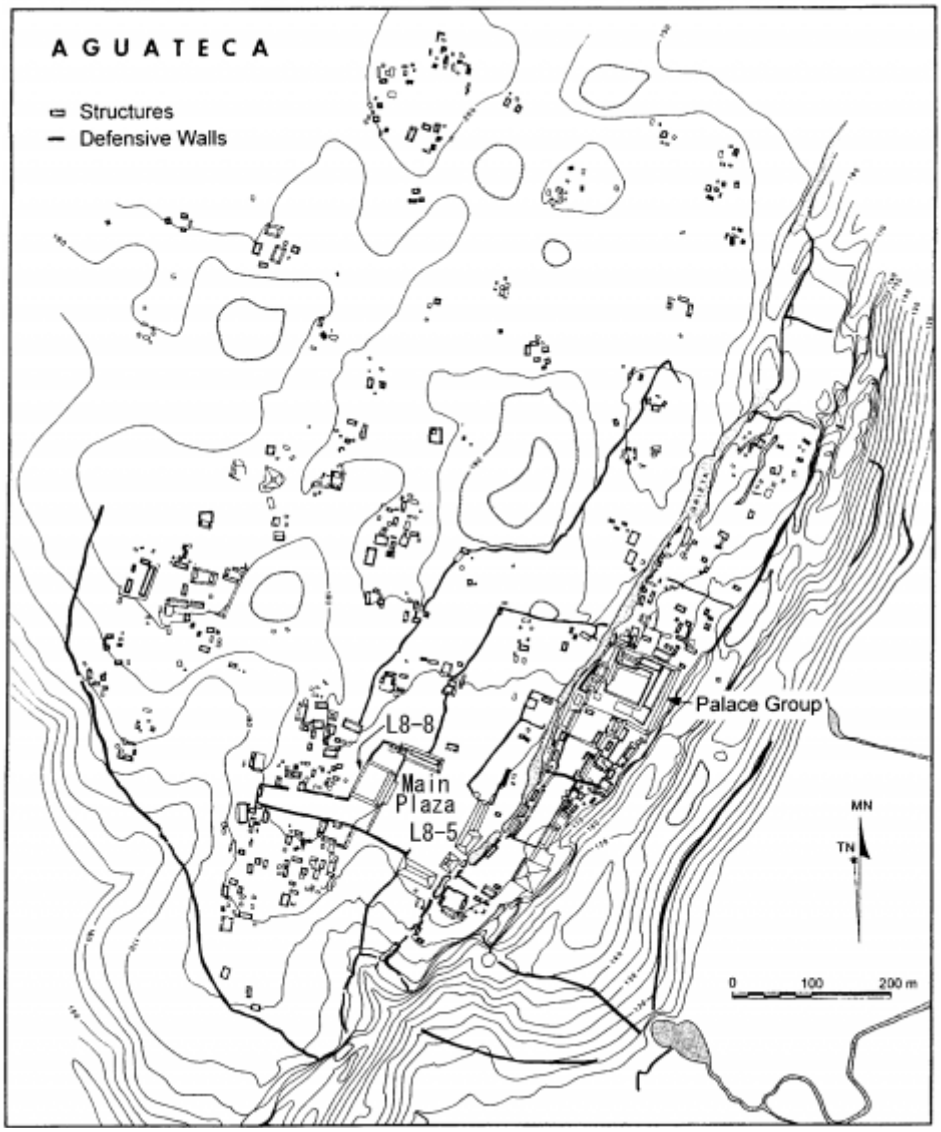

Fig. 3: Map of Aguateca (jsa.revues.org)

Figure 3 shows a plan of the city with the walls, structures and the Main Plaza and the Palace Group marked. The Main Plaza measures 11.456 m2 was built around 700 AD, when the city centre was created (Inomata 2006, 816). It has been suggested that the location of the plaza was ritual as it was built next to a large chasm that was located along the west side of the Palace Group and the causeway leading to it. Surrounding the Main Plaza there are several temples and on the plaza there are multiple stone monuments, which indicates it was a public ceremonial place in the city (Inomata et al. 2001, 289).

The structure with the largest dimensions in Aguateca is structure L8-8 and it can be found on the west side of the Main Plaza. From excavations it seems evident that

this building was being built when the city was attacked around 800 AD, leaving the building in an unfinished state. Altars were found in this structure, which leads to the interpretation that it was a temple (Ponciano and Inomata 2004, 6).

From the Main Plaza, there is a causeway, along which there are several elite residences, leading to the Palace Group. These buildings were both used as a residence for the king and for administrative purposes of government (Inomata et al. 2001, 288). The Palace Group consists of several buildings which all surround a plaza. In comparison to the Main Plaza, the Palace Plaza seems less public and it is also much smaller, measuring only 3.289 m2 (Inomata 2006, 816). Thus far, two buildings of the Palace Group have been completely excavated and investigated, designated M7-22 and M7-32. Based on the archaeological evidence they were probably used as main living quarters by the royal family, though the central rooms could also be used for audiences and political meetings (Inomata 2001, 302).

As both these structures show evidence of cleaning and a room was found to contain several possessions, it seems probable that the royal family fled the city because of the external enemies that were threatening to attack and that they wanted to return at a later time. It also makes revolt of the citizens or other internal factors unlikely as the cause of the royal family to leave to city (Inomata 2001, 303).

The elite residences on the causeway showed signs of continued habitation until the final destruction of the city (Aoyama 2007, 24). This evidence includes signs of artistic creation as well as production of various crafts. Also the unfinished temple, L8-8, is evidence that life continued until that moment and that although there were enough signs of danger for the royal family to escape, the inhabitants of the city seemed to continue their life, though they did build the walls in an effort to protect the city against the attacks.

2.2) Mayan Kingship

The social structure of the Maya civilization was clearly defined and can generally be seen as a class society (Freidel 2008, 192). Lineage was very important and though it seems possible that some switches could be made from one class to another, the importance of lineage makes these changes unlikely. At the apex of the system was the king, who will be central in this chapter, whose position is a patriarchal hereditary function supported by a nobility class (Houston and Inomata 2009, 163; Martin and Grube 2000, 14). A king can legitimize his position through a claim of being selected, in several ways, by gods or other beings from a spiritual world. However, the political body of a law in which he is formally recognized as a king is an important element of the kingship presented here, as the ritual that will be discussed in the next chapter requires the king to be a stable, and thus lawful, factor in society. That the function is patriarchal hereditary means that as a rule, a son of a king will be the heir and will gain the position of king after his father. There may be various rules in place when a situation occurs in which this ideal situation is impossible, for instance by letting one of the daughters rule or put the husband of such a daughter on the throne. The power to allegate or retract titles is used to ensure that the king can maintain his position, which is a point that will be elaborated on later in this chapter (Houston and Inomata 2009, 166).

Though a large part of the discussion on Maya religion is not important for this thesis, religion did pervade many aspects of Maya society and as such should also be explained properly. The main aspect of Maya religion that should be considered is that it was shamanic in nature (Freidel 2008, 192). What this means is that although the Maya religion knew several deities, the ordinary people did not directly communicate with them, but rather did so through a specific individual, in the Maya case the king. That does not mean that the ordinary people had no direct contact with being of the other world, as they could communicate with for instance the ancestors. There were also evil beings such as demons from the other world who sought contact with the ordinary people to hurt or frighten them (Blaffer 1972).

Directly below the king in terms of position were the elite or nobility, which included the courtiers who functioned as priests in certain other cultures. The nobility class was also responsible for the part of the administration that was not done by the king or royalty (Inomata and Triadan 2003, 156). Below this nobility class there is a huge gap after which two classes of the commoners are present: the artisans and craftsmen had a slightly higher position than the rest of the people inhabiting the

Maya cities and towns. The slaves and captives were of course of another class altogether, but they can also be considered to be outside of the system entirely (Houston and Inomata 2009, 169).

Elite can be defined as a minority of powerful people who, through their control of social institutions, bring about effects of broad significance for society at large (Inomata and Triadan 2003, 156). This definition consists of three parts. Firstly the elite is exclusive as there was only a very limited number of people that could be part of the elite. Secondly, this group has control over the social institutions that binds the society together. Thirdly, it can use that control to influence the society in such ways that it can shape the future for the other members in the society. This definition has several implications. The most important is that elites are not necessarily rich: although in general it might be assumed that wealth brings a certain amount of influence, it is not the same. A person can have a certain amount of influence to shape society and still not have a lot of wealth and likewise there could be rich people that do not have a lot of influence in the governing body. Through this definition, that first person would be part of the elite and the second would not. Furthermore, this means that the elite is not always visible in the archaeological record as the larger residences might indicate wealth of a person living there, but not his influence (Inomata and Triadan 2003, 156).

The elite, while quite important, were actually not visible for most of the Maya period. They appeared in enormous numbers in various texts in 650 AD, although the first mentioning of that class was in the 50 years before, and left with the same speed from the textual record after 800 AD. This does not mean that there was no elite class beyond this period of 150 years, but it does limit our understanding of their position and influence in Maya society (Houston and Inomata 2009, 172). While kings were visible during a much longer period, it is the intention of this chapter to focus mostly on the Classical Period kingship.

2.2.1) How were kings viewed?

In order to get a good view on the position of the king, it is important to have clear the power structure that was present in the Maya area. Influence and power was mostly based on the ancestors: kinship and lineage were even used when determining who could get certain administrative and political positions (McAnany1995, 130). The king, being the top of the social hierarchy during the Classical Period, was no exception: his position was based on his lineage as well. It is from his ancestors

therefore that he derived any right to the throne and that was also the first and foremost virtue that a king had to have (McAnany 1995, 128). These ancestors comprised of a select group of idolized deceased individuals that are considered important to a certain lineage and with whom a careful reciprocal relationship should be held. Although western thought would generally use the word ancestor to describe the entire group of people that went before, the ancient Maya thought of very specific individuals when dealing with the ancestors (Houston and Inomata 2009, 193). They had names and could be communicated with. They were, however, not randomly chosen but carefully selected and they were generally those who were considered important people in the past. They could be the heads or founders of a lineage, old kings or individuals who had done something to make a name for themselves. As lineage was an important factor in Maya society and advise could be sought from the ancestors, it was important to keep having good relationships with them, as social position could suffer from neglecting to pay proper respect to the ancestors. Although the ancestors were comprised of deceased people of the past, the ancestors were very much alive for the Maya as in their view their soul was still present in their own world (Houston and Inomata 2009, 193).

Very important to the lineage of the king was the founding dynasty of the city that the king ruled. If a king could make a rightful claim to be descendent of the city founders, then his claim was more likely to be accepted (Houston and Inomata 2009, 133). While the general term of settlement refers to any area where a number of dwellings are located, the term city is more ambiguous. In this thesis, it is defined as a political term and refers to a locally focused administrative, economic and cultural centre within a kingdom. Firstly a city is an administrative centre, meaning that it has some form of governing body present, which in the Maya case refers to the king. Secondly, it is an economic centre, which means that a relative large part of trade in and out of the area of the city is carried out by those living in the city or organized by them. Thirdly it is a cultural hotspot, which means that the city is a religious and artistic focus of the region. Lastly, the city is locally focused, which means that one can pinpoint a specific spot on a map where the city is found (Chase and Chase 1998, 15). It should be noticed that the emblem glyph, a title used to proclaim control over a certain place, is not used for defining a city. This is because it can be argued that there are settlements that fall under the category of city that do not have an emblem glyph of their own.

Unlike most other ancient civilizations the Maya acknowledged descent through both the female and male lines of the family. This means that even if an individual was related to royalty or nobility on one side, that individual could compete for the power that would come from the descent. However, there were two terms for lineage, one referring to patrilineal descent and the other to matrilineal descent, so perhaps there was still a difference between the two lineages (McAnany 1995, 128). An important point here to note is that although it would seem that there is a strong dichotomy between the elite and non-elite, there were various states in-between these two positions. Not to belittle the gap that did exist, but merely to point out that the relations based on kinship were more complex than a simple division between these two groups (McAnany 1995, 25).

Next to having such a lineage, the ancestors were also considered active actors in the Maya society. They were thought to be the experts on how the world worked and could be consulted for guidance (Tate 1992, 15). As such, the ancestors should be paid the proper respects and they could be communicated with. When rituals and offers to the ancestors are referred to, it seems that the Maya considered their ancestors to be deified and among the most important gods (McAnany 1995, 28). The worship of the ancestors seems to have been performed mainly through the form of feasting and banquets, which was not restricted to the higher classes of the society, but rather actively participated in by all classes in Maya society (McAnany 1995, 31). However, while a king had to use these feasts (in part) to give others gifts and bind them to him, similar feasts in kinship circles generally allowed those who brought in the most to leave with the most as well (McAnany 1995, 133). From this importance of the ancestors, it follows that the most important individuals would fall under the header of 'founders'. There was special interest in the lineage of the one who brought a certain ritual to Tikal and bringing that ritual ensured later that no less than 33 individuals from that line could follow in their ancestor's footsteps and be ruler of Tikal (Freidel 2004, 200).

An important part of being a king is of course the title and as the saying goes "it is not titles that honour men, but men that honour titles."[2] The meaning of this quote, in this context, is that no individual can be king, but through others who honour him as such. In Maya, the common word used for a king is *ajaw* which is generally interpreted as lord, but can supposedly also link linguistically to the verb shouting(Houston and Inomata 2009, 131). This could imply that the oratory skills of

[2] Generally attributed to Niccolo Machiavelli, though the exact source has not been determined.

a king were considered to be important. As of yet, this theory has not been proven however.

Towards the end of the Classic Period, the title for rulers gained the adjective *k'uhul*, which means *divine* or *holy*, which implied that rulers were more seen as half-deities rather than completely human. However, some cities continued to make do without that adjective, which could be explained as preference, a certain status in regards to the people he ruled over or perhaps some difference in status between different rulers we do not know of (Houston and Inomata 2009, 135). Given that most kingdoms were quite autonomous, though perhaps not completely independent, it seems unlikely that kings would accept other kings to choose their titles for them. It might be that this difference was caused by those kings having either a smaller court, or a court that was more stable, causing less internal friction. This would mean in turn that these kings did not have the necessity of being divine to keep full control over their city, a measure that was almost certainly required in the larger cities. Furthermore, kings could also link their name to the place or area they had control over. Such names are called *emblem glyphs*. When this emblem came more in use to actually mean 'rule over [name of place]', the term *ajaw* on its own became more a general term to refer to royalty (Houston and Inomata 2009, 131). Kings could also name themselves after a certain god at the moment they were initiated into their position of king. Such a name is called a *theonym* and it seems clear that the kings intended to claim a strong connection to the specific god they named themselves after, even on the occasion when they did not claim to be divine themselves (Houston and Inomata 2009, 133).

The accession to the throne was a ritual that was very important and even considered to be a supernatural event and was often recorded on monuments. The transfer of authority came usually from the parents and great care was given to make sure that the true lineage was clear and that the new king was truly the son of the former king or otherwise from a royal lineage. However in some cities, of which Palenque is a good example, the parents played a much smaller role in the transfer of authority. Instead, there are nobles depicted on a sculptural panel, which shows the accession ritual and they hand a headband with a figure of the Jester God to the newly installed king (see fig. 4) (Schele and Miller 1986, 112). It might be significant when combining this with the earlier statement that some cities did not require to have themselves referred to as divine. This also points to some cities having a much

stronger nobility, requiring the king to make a firm difference in titles to ensure he continues to come out on top.

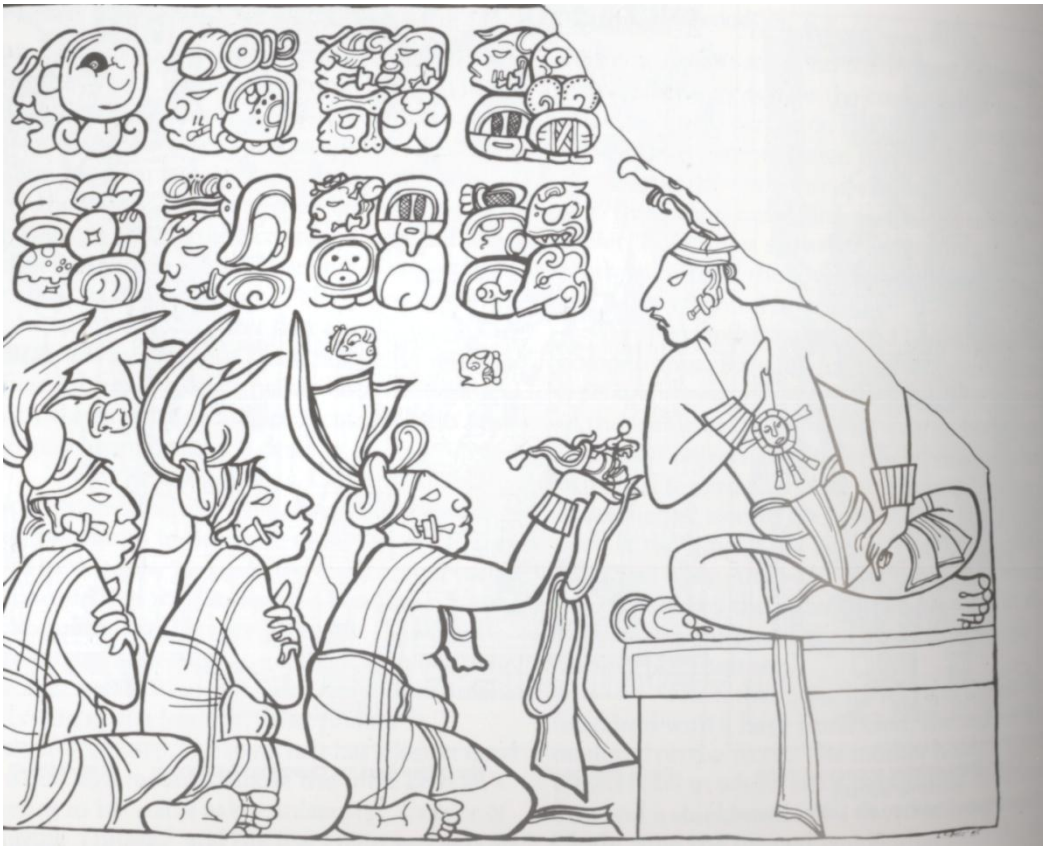

Fig. 4: Bonampak panel, an ascending king is presented a headband (Schele and Miller 1986, 116)

2.2.2) Queens in the picture

Although lineage had meaning through both male and female lines, the continuation of the royal line was preferentially done through the men. Some women did achieve that highest position and became queen, but that generally only happened when no male heir could be produced or he was killed or captured without another male being able to take his place (Martin and Grube 2000, 14). In that rare occasion that such a woman did attain that highest position, those women could then use the full emblem title tying the area or city they controlled to their name. This was generally not done by women who were more in the position of wife or consort of the ruling king. A good example of a woman who did attain this position would be the woman from Dos Pilas, who rejuvenated the royal line of Naranjo and became their queen. There is no

record of the father of her son, who would be the heir, which is a strong point of evidence that she was the ruler of the time in both name and act (Houston and Inomata 2009, 146). Like the elite mentioned above, the royal women were also active in making certain crafts, mostly textiles, which brought in additional wealth. This was probably not something she did on her own in her quarters, but it was rather done as a group activity. They also played a role in various rituals, which is based on imagery of women offering blood and in pain, although the men were still more important and had the spotlights (Houston and Inomata 2009, 148).

Next to the woman from Dos Pilas there is another woman known to have had strong political power. Her name is Lady Xoc. She was the first wife of Itzamnaaj B'alam II and she remained an important figure in the political life of Yaxchilan in the years after his death. She is depicted on three lintels from Yaxchilan in structure 23 which is identified as a temple dedicated to her (Martin and Grube 2000, 126). The first lintel in which Lady Xoc is depicted is lintel 24 (see fig. 5) and on this lintel a self sacrifice is shown. Here a kneeling Lady Xoc is shown to pull a rope with thorns through her tongue while her husband, the king, wears a shrunken head and holds a spear while standing before her. Lintel 25 shows a continuation of lintel 24 as again Lady Xoc is shown, but she is now depicted having a hallucination of a Tlaloc Warrior. That this is a hallucination is shown through the fact that this warrior is shown to come out of the Vision Serpent. That this scene should be seen as a consequence of the bloodletting ritual shown on lintel 24 is evidenced by the fact that the serpent rises out of a bowl of blood, while a similar bowl is shown underneath Lady Xoc, which was used to catch her blood. The last lintel depicting Lady Xoc shows a scene in which she hands her husband a helmet and a shield, possibly to prepare him for battle. It could also imply she ritually shows he is ready to take on the responsibility of leading the armed forces of the city, given that this bloodletting ritual is interpreted as an ascension ritual (Schele and Miller 1986, 177). Various sources suggest that many people were present during the ritual on the plaza and even had prepared it through fasting, abstinence and steam baths (Schele and Miller 1986, 178).

Fig. 5: Yaxchilan, Lintel 24 showing Lady Xoc perforating her own tongue (Tate 1992, 206)

An interesting fact is that the preferred royal matches were made with a woman from another kingdom. Not unlike many other ancient civilizations, women seemed to have been quite valuable for forging marriage alliances with the Maya as well (Houston and Inomata 2009, 150).

2.2.3) What were the functions of a king?

Because the kings were seen as divine, they did have specific functions to perform. These functions are not completely clear and there is still an ongoing discussion on both which these functions were and which were the most important. Demarest argues that his main function was to be a mediator between the gods and the people and as such the king was a link to the gods (Demarest 1992, 156). Freidel thinks that instead of just the ritual function, the king actually had a responsibility to ensure that his people had enough food and that the exchange system functioned properly (Freidel 2008, 195).

There are various important rituals identified with kingship, including a bloodletting ritual, in which the king would take his own blood by use of obsidian blades, thorns or a stingray spine (Martin and Grube 2000, 15). The importance lay in the cultural meaning of the bloodletting ritual as an expression of piety to the gods. Kings had to show their piety at various intervals through bloodletting. The tools that were used for this giving of blood became holy themselves and therefore became a symbol. There were even objects of similar design but of more precious material such as jade, that were used as symbolic objects and not as the tools on which they were based (Schele and Miller 1986, 176). This bloodletting was even so important, that the first sign we have of actions of a king that was displayed in public was that of bloodletting. It was shown by the king called *Bac-T'ul* who decided to display his act of bloodletting, rather than the accession for which the bloodletting was actually done (Schele and Miller 1986, 179). The importance of roles in a ritual can be shown through a few scenes depicted on a ceramic vessel from the Late Classic Period. While the king is shown at the moment he is about to give blood as he points a lancet at his penis, a nobleman is shown to pull a rope through his tongue (see fig. 6). This secondary role was performed by the wife of the king at Yaxchilan, who wore the same headdress as that wife, showing that it was the role that was the determining factor of wearing that particular ritual object (Schele and Miller 1986, 180).Another important rite was carried out when someone ascended the throne and this was the binding of a Jester figure to that individual his head. The Jester God was a sign of royalty and even in the Late Classic period, wearing this remained a prerogative of royalty (Martin and Grube 2000, 14).

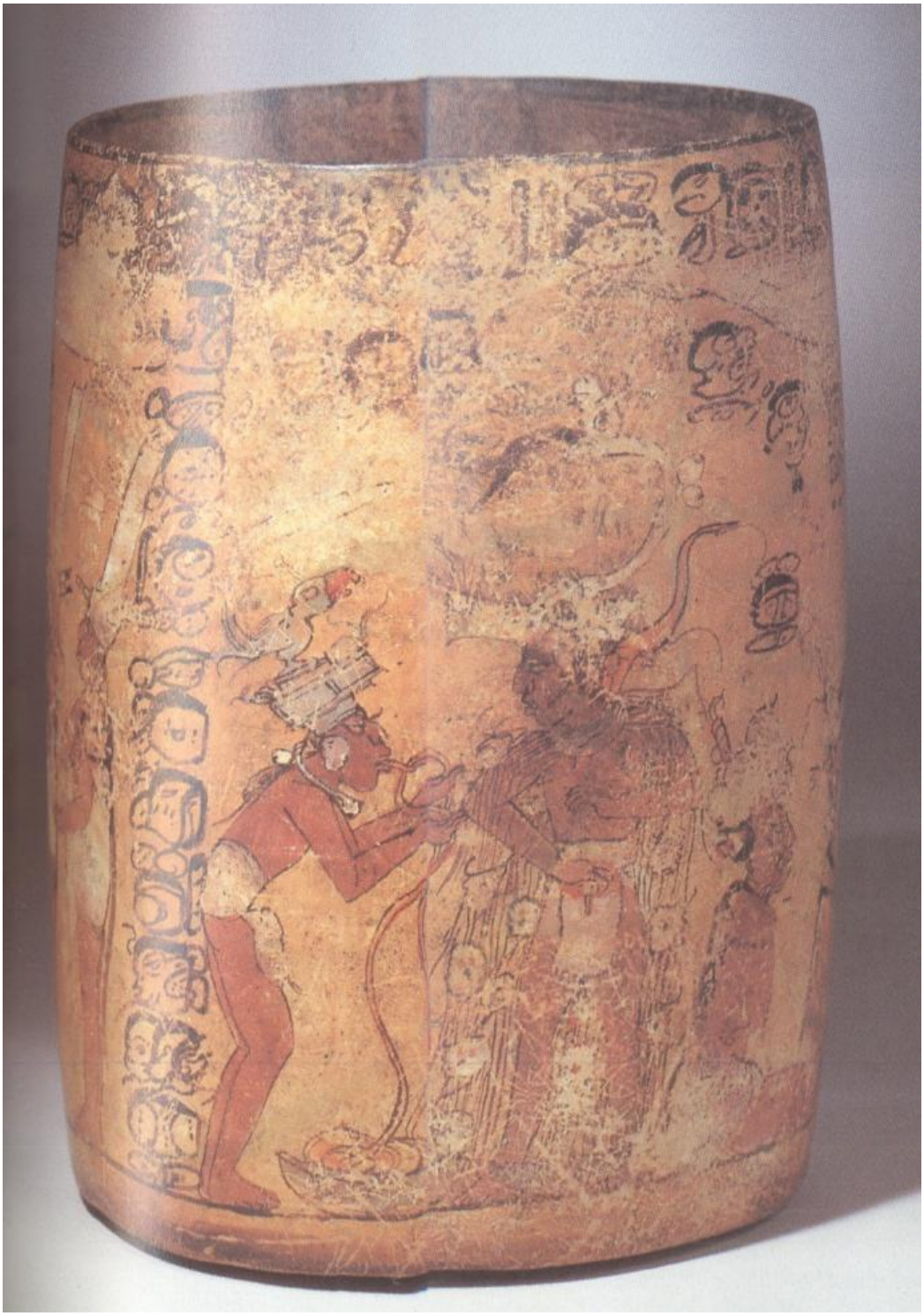

Fig. 6: Accession scene on a ceramic vessel (Schele and Miller 1986, 206)

As discussed above, kings were viewed as a link between the people on the one hand and ancestors on the other hand. Ancestors is not a name for the entire group

of all the dead of their society for all time, however. The group referred to as ancestors is a select group of dead individuals and they were generally those individuals who were considered to be the more important people, including the heads of lineages and kings (Fitzsimmons 2009, 62). As kings were always expected to become ancestors, special care was given for their graves, as the ancestors had to be taken care of. When a king died, the first ritual that was performed was the preparation of the dead body of the king, which generally took a few days. There is only one occasion known where this process took much longer (Fitzsimmons 2009, 62). Archaeological evidence of such preparation rites are scarce and it is unknown to what extent embalming and similar practices were performed (Fitzsimmons 2009, 64).

The royal grave has been subject to many discussions and even the definition of such structures have been problematic enough to not have resulted in any definitive definition of the variations that exist between them (Fitzsimmons 2009, 64). This problem is much too broad to be tackled in this thesis, so let us simply use the word grave for any structure that is used for the purpose of burial. There are some different interpretations for the meaning of the royal graves that were built. One of those interpretations is that the grave was an underworld surface (Fitzsimmons 2009, 68). This interpretation is based on a so-called 'water-entering', in which a soul would enter a body of water. These graves would in this case represent the water surfaces into which the body is brought and in that way, the soul of the deceased would be brought to the entrance of the underworld. Certain graves also had caches into where the bodies of the nobles were brought. This way, the nobles could be brought to the entrance of the underworld as well (Fitzsimmons 2009, 70). As in many pre-Columbian Mesoamerican cultures caves were viewed as entrances to the underworld, it is a logical step to surmise that the graves could be seen as being similar to caves. These manmade caves would then be used as a place to bring the dead, as natural caves had been before (Fitzsimmons 2009, 71). A last presentable theory on the general interpretation of graves is that they were considered to be houses of the dead. Fitzsimmons presents parallels for this interpretation in his work (Fitzsimmons 2009, 72). Next to his information, it seems logical to think of this interpretation as the dead are, to the Mayans, not really dead, especially when kings are discussed. As ancestors, it could be the Mayans felt they would require a house to live in, as much as the ancestors required food, which was given during certain feasts.

2.2.4) How did the Mayan kings maintain their power?

Although the title of king did come with quite some privileges to the person bearing it that allowed him to get almost everything he wanted, he still had to actually make sure he maintained that control. A loss of control could come from the population, when he was considered to not perform the function he had as king, or from the nobles in their eternal struggle for power. Some kings who failed at performing their duties might have still retained their title, even if they did not actually have the position to exert any power. In such a case others would make the decisions in his stead, while the king merely sat at the council and played a marionette (Houston and Inomata 2009, 131).

However, those that did intend to actually be in power, also had various means to ensure themselves of that position. These means are derived firstly from their economic monopoly: they had more means than any other in their kingdom to get things done in the way they want it to be done. Secondly, they had control over the law and although they were limited partly in the sense they could not change too much as that would upset the population. They could, for instance, make sure that they alone were allowed certain things or traits, in order to make sure that everyone was indoctrinated with the fact that he was better than everyone else. One example of this would be the titles that he could use. Lastly, he could use imagery and have statues made in his honour, something that was a prerogative of the king. An interesting fact regarding this is that during the Late Classic Period, this prerogative of being shown in monumental displays was somehow cancelled out and there are various individuals in the nobility that take their chance and use these same means to project themselves. This might be an indication that the influence and power of the king was reduced to a large extent, as he was seemingly powerless to stop them (Houston and Inomata 2009, 134).

As has been discussed above, leading armies into battles was one of the functions kings had. To maintain their position they were generally required to win such a battle, as ill fortune awaited those who lost. The least troublesome possibility was when the king was allowed to keep his throne. He would then generally be a vassal of the victorious king, but for the rest things would remain the same. One good example of this was the case in Dos Pilas, which has already been discussed. This was quite a rare occasion however. Losing kings would generally lose their position and could either flee the field and live in exile, or be killed on the battlefield. The worst fate a king could meet was to be taken captured. Apart from the public

humiliation that would always follow such an event the king would also be tortured and killed. His death could be brought almost painlessly in the form of a beheading, but there are also cases where the king was tied together to become a ball form and thrown off flights of stairs (Martin and Grube 2000, 16).

A much used form of kingship propaganda is through making stelae. These are stone statues, depicting the king, sometimes with inscriptions of their name, feat or anything else the king wanted to present as something that was to be linked to himself. Such stelae were used as early as 600 BC in Mesoamerica, though it was not until 100 BC that it was the prevalent art form. These stelae combined easily with other forms of sculpture, of which architectural sculpture is most notable. As architectural sculpture was the first art that was effectively used for political means, it became the most important tool for kings to make propaganda and as such it was used on an immense scale (Schele and Miller 1986, 34). The actual message was transferred through many symbols that were put next to or on the sculpture in question. The depicted figure (generally kings) wore various costumes, which were symbols and referred to certain rituals or moments in time. Next to the costumes, the depicted figure also often had various objects that could, for instance, be used in rituals and those could show the relationship the depicted king had to the world and the society (Schele and Miller 1986, 72).

Most of this architectural sculpture is found on the exterior of the structures, for which the main reason is that Maya culture was based on what went on outside. This cultural phenomenon can be seen through the importance they attributed to the plaza and also through the concept of various rituals that were theatrical in nature. With the plaza as the main place within a city where a large group could gather, it is logical to expect the plaza to be the place where the most effective use could be made of these architectural sculptures and stelae (Schele and Miller 1986, 35).

3) Perspective on ritual

In this chapter the concept of 'ritual' will be explained and discussed, following largely on the work of Rappaport (1999).As a theatrical performance is the form in which Inomata (2006), said that the ritual can be viewed this chapter will also go deeper into this concept.

3.1) On Ritual

This subchapter will be entirely devoted to the term ritual and explaining the definition that will be given in the beginning. It is a subject that is extremely viable for various interpretations and discussions and one could fill bookcases completely with theory of ritual. For the purpose of this thesis the discussion of this term will be limited to this chapter. In the next subchapter, the definition that is explained here will be applied to the Maya society specifically.

The definition for ritual that will be used in this thesis is based on one that has been suggested by Roy Rappaport and is as follows: "ritual... [is] the performance of more or less invariant sequences of formal acts and utterances not entirely encoded by the performers." (Rappaport 1999, 24). In this definition he recognizes five features, of which two are designated through the same word, 'formal'. The altered definition will be given at the end of this chapter, after discussing that fifth feature.

The first feature refers to the concept that a ritual is performed by certain individuals who were not involved in writing the script. They follow rules that have been set by others and those rules are followed without questioning. The obvious problem here is that every ritual must have a beginning somewhere. Various answers have been proposed. One option would be to claim that a certain set of actions only becomes a ritual through re-enactment of that set of actions. This implies that all rituals were not rituals to begin with, but grew to be so. Next to this, it could be argued that no ritual was ever created in a single moment as such a phenomenon would generally not be accepted by the population as a ritual. Generally rituals grew over time, building on elements taken from other rituals which are again changed and rearranged to form a new ritual. The creators of those changes would often escape responsibility of that creation, using various ways out (Rappaport 1999, 32). This does not mean that those creators would deny making the changes, but that when they made any changes, they would point to how it continued to be the same. They might also point to how the change would strengthen another part that stayed the

same, making the ritual 'better' based on what it was supposed to be doing (for instance: it was more honourable to a god after the change). The above problem is mainly focused on religious rituals, which are generally the kind of rituals that will be discussed in this thesis.

The second feature is the obvious one and also generally the feature on which the assignment of the word ritual to a certain set of actions is based. This simply means that there are certain very firm rules in regards to behaviour in ritual performance that need to be followed to the letter. However, it is not possible to simply divide behaviour in either the group of carefully regulated behaviour through the following of strict rules or completely spontaneous behaviour in which the individual is free to choose what he does and how he does it. Rappaport (1999, 34) recognizes five levels of decreasing spontaneity and increasing formality. The first level is a free form of communication with only the stylized words and gestures that might be repeated every now and then. The second level includes various expressions that are used in daily life as for instance greeting behaviour. The third level is the last level in which the formality is not instantly recognizable, as in this level are the patterned behaviours of longer duration, which might, to use a contemporary example, include a talk during coffee break between two individuals who hardly know each other. Such a conversation could include subjects like the weather, the news of the day and perhaps some common ground like study or work related topics. The flow of the conversation has some formality in its form and subjects, but is otherwise still quite free in prescribed rules. The fourth level however does have more specific rules and this level includes events of formality like job interviews, weddings and similar events. In this level there will be various actions that are set by very specific rules and there might be specific statements that need to be made. However, next to these specific sets of actions, there are still possibilities for differences. This could be the contents of speeches that are held of which the contents differ from one event to the other. In the last level there is no longer any room for spontaneous action. Every part of the event is rigorously controlled by rules and an individual who would break those rules would be frowned upon at the very least. Most events on this level are religious in nature (Rappaport 1999, 35)

From the strict adherence to form, it seems a logical step to assume that a ritual is, through that adherence, completely invariable. This invariability is the third feature embedded in the definition. What is important to note is that this invariability does not make it unchangeable, at least, not completely. While the invention of a completely

new ritual or change of an entire already existing ritual is almost impossible, the change, invention or removal of specific elements can be done and generally happens overtime. One reason for this, is that rituals are never stated so specifically that no change is possible. There is also a factor of variation between multiple performers, based on perhaps different interpretations of certain elements, which can also cause change in the long term. The important point to be understood from this feature is that while ritual is built to resist change, change is nevertheless possible. It is invariant, not unchangeable (Rappaport 1999, 36).

Performance, the fourth feature, is the very heart of ritual. When the 'doing of certain actions' is not present, than it follows that one cannot speak of ritual. However, not all formal performances are automatically ritual. Rappaport puts the term ritual against various other terms which seem quite alike according to his definition, but he then goes on to describe how these other terms differ from ritual. The important aspects to highlight in regards to ritual will follow here. Firstly while myth and ritual imply each other, they are not the same: a written word and a spoken word are not equivalent. A good example can be found in Catholicism where there is the ritual of the profession of faith in which the performer gives a speech of a standard format, which is considered a rite of passage. While the words of paper have the same meaning as the words that are spoken, it is the act of speaking them that is considered the rite of passage, this is not found in the meaning of the words themselves. Rappaport also brings forward the comparison with theatrical performances such as plays. The difference between these and rituals lies in the activity of the attendants. In the case of theatrical performances, there are performers on stage who give the performance while the other attendants form an audience that is passively taking in that performance. In the case of ritual however, the attendants are all expected to be active at some point during the ritual, for instance by singing or dancing. Some may be expected to be more active than others, but everyone present has a certain role. Although it is technically possible to be present at a ritual and still not participate, those would not be considered part of the ritual by those who are participating (Rappaport 1999, 40). Another clear difference between such theatrical performances and rituals is the intention behind the action of the performers. In theatrical performances the actors play a part and as such are only faking action, whereas those performing in ritual are really taking an action (Rappaport 1999, 42).

The fifth and final feature that is used to designate an action to ritual is that the ritual is not necessarily designed to be as effective as possible to reach a certain

objective. This is not to say that any ritual act or utterance is ineffective for a given purpose, but that the ritual is not meant to have a measureable effect. It is based on the belief that those who perform it have on its workings regardless of any provable effectiveness towards the purpose that the ritual is expected to have. This feature can be explained by observing how a ritual is supposed to work. Unlike a concept that Rappaport calls 'technique' (Rappaport 1999, 47), ritual acts do not attempt to achieve a certain goal through applying the laws of science through measurable actions into calculable results, but through an appeal on specific agents or forces to achieve a certain result for those who perform the ritual. For instance, a person could pray to a god to obtain something instead of obtaining it himself through whatever means would be required for accomplishing that. This feature therefore also implies that performers of ritual put the responsibility of the achievements or failures into the hands of the agents or forces they appeal to. Rappaport ascribes this feature to the term 'formal' as well (Rappaport 1999, 46). However, in order to make use of a complete definition, it does not suffice to have multiple features ascribed to single terms. Else we could make do without so carefully phrased definitions and ascribe all the features we need to a single term. As such, the definition of Rappaport will be altered to include the phrase "*and not necessarily effective for the acclaimed purpose*" that will refer to this fifth feature. The definition of ritual as used in this thesis will therefore be as follows:

"Ritual is the performance of more or less invariant sequences of formal acts and utterances not entirely encoded by the performers and not necessarily effective for the acclaimed purpose."

3.2) Maya ritual

So how can this, still quite broad, definition of ritual be linked to the case of the Maya? In the following paragraphs, examples and explanation of the above features will be given in relation to the Maya.

The first feature above stresses that the performers are not in control of the script: this was designed by others. In the case of Maya kingship rituals, these rituals were based on Maya worldview and as such written by society at large over a larger period. Kings were, like all other Maya people, born into the society and therefore had to adhere to the cultural rules, which included the rituals in the case of the king. In the few cases of actual change, there is no knowledge of whom initiated the

change. The example from Xunantunich that will be given later on shows only that a certain change is visible, but if the king of that time made the decision to change, it was not made visible to the outside world.

As was already explained in the general theory on performance, it is only a small step from the encoding being done by others than the performers to a formal attitude following very strict rules, especially when the set of actions is based on a religious background. In the case of the Maya it is equally logical that when a ritual is based on the worldview of a society, that those rituals follow strict rules to fall in line with that worldview. This means that change is not permitted easily, as the effect of the change cannot be allowed to have the ritual fall out of line with the worldview of the society. Some of those specific rules can be seen in the archaeological record. One example would be the various stelae depicting rulers in a ritual outfit. During certain rituals, such an outfit was required of the king and regardless of any personal wish, he had to wear the outfit. Another example would be the need for human sacrifice on several occasions. It was rigidly specified when ritual human sacrifice was to take place and these rules had to be followed strictly.

The invariance aspect meant that while the ritual is following strict rules, some change is still possible, though it can only slightly be changed to avoid any resistance from the population that is to follow such altered ritual. In the above paragraph the adherence to rules and unchanging aspect of ritual was discussed, so now an example of change in ritual will follow, showing a case in which a major part of the ritual was changed through a major shift in the political system.

The case in question is the Maya pyramid in the city of Xunantunich in Belize that was excavated by Richard Leventhal (2009), who also gave a presentation on the discoveries that were made at the site. When excavating the pyramid, they found the main stair to be discontinuing in the middle, which meant that a person that wanted to go up to the top, could not do so using the main staircase only. Instead, that individual had to take a secret staircase, one that was hidden from view, at the side of the pyramid. The excavations also showed that in earlier building stages, this hidden stair was not present and instead the main stairs continued to the top. From this the situation can be reconstructed that the ritual to climb the stairs was first performed in plain sight of whoever was watching, but in later times, the ritual was changed and instead the ritual was, in part, performed out of sight of those with a spectating role. The transformation that was considered to happen during that climb was changed from public to private. Leventhal notes that this change occurred in the

same period that the political system was changing, proving that ritual can change even rigorously when the society that uses the ritual changes (Leventhal 2009).

Ritual is performance. Before anything can be described as a ritual, it must be proven to be an act, someone is doing something and depending on some other variables, that act is either a ritual or not. But the act must be done before even considering all other factors. Inomata (2006) has written precisely on this subject, in which he uses the space of various sites in the Maya area to explore the theatrical aspect of ritual. He goes further than this basic theory and views ritual as theatrical performance, in which he defines performance as "creative, realized, achieved acts which are interpretable, reportable, and repeatable within a domain of cultural intelligibility" and the theatrical aspect refers to "the emotional - including both positive and negative - responses that the performance produces in participants and its symbolic reality, with a semiotic system distinct from that of unconscious, routine acts." (Inomata 2006, 806). Such a ritual is an act that can be performed many times and elicits an emotional response from those that are involved in the ritual based on the symbolic meaning of the performed act. A last aspect he brings in that is specifically attributable to large-scale public performances, is that it was used by the Maya as a binding factor of the community living in the city.

The fifth feature considers the effectiveness of ritual. For the Maya an important ritual act was sacrifice, which is most easily seen in the bloodletting rituals. These rituals were intended to be acts that were required to have the gods continuing to favourably look at their society (Schele and Miller 1986, 176). From a technical point of view, the actual giving of blood gives no special advantage for the future of their society. As the fifth feature explains, it is based on an appeal to the gods to ensure that the event for which the bloodletting is done will have a positive outcome. It gives the responsibility of that good future to the gods and the bloodletting gives no calculable result.

3.3) Theatrical Performance

So far the subject of ritual as theatrical performance has only been touched upon as being a theory by contemporary scholarship. In this chapter, this theatrical performance will be outlined using the work of Inomata (2006).

It is the view of Inomata that ritual performances, a view that is further looked into through this thesis, are theatrical in nature. The theatrical performances that he discussed are those which are shared by a larger part of a community which is a larger group than anyone's social circle. In other words, those present do not communicate on a regular basis with every other person participating in the ritual. He argues that these public events were a requirement for the development of the large centralized polities. Because of this, it seems that these theatrical performances are an extremely important factor in deciding where the political power really lies. The entire community participates in the ritual and therefore the ritual is also an important factor in shaping that community. That the plazas in the various Maya cities were used for these large-scale theatrical performances in the colonial period is a well-documented phenomenon in historical sources, but this has not been proven for the Classic period. Although the erected stelae can be seen as monuments of such rituals, as they show kings in ceremonial attire, they are not proof that such rituals were actually performed there.

A strong point in favour of these theatrical performances being conducted at the plazas is the mere sizes of them. When giving $1m^2$ per person, the main plaza at Aguateca could already hold over 140% of the estimated population at the time. Although the cities of Tikal and Copan were much larger and the plazas by comparison smaller, those plazas could still hold a larger part of the population, especially when giving $0.46m^2$ per person, which meant that the Great Plaza in Copan could hold over 27000 people which is 126% of the estimated population of the city in that period. This, combined with the easy access that these plazas had, implies that great care was taken in the city planning to include a plaza large enough to hold the entire population of the city. Inomata concluded that these numbers, combined with the social information that is available on the Maya, it seemed likely that the theatrical performance of the rulers was greatly pronounced by the community.

4) Making 3D

In this chapter the actual building of the 3D model of Aguateca is explained. It is the ritual performance of the king that this thesis is attempting to research further. The first step to do this is to examine his position in his architectural context. The recent discussion on the view on the king, his function, his ability to keep control and the influence of those around him has been outlined in chapter 2 in order to approach the social dimension as well. Without a full picture on this position, it is hard to fully understand any kind of ritual movement concerned with Mayan kingship. With this background discussed above, the actual 3D reconstruction of Aguateca will be elaborated on.

The main advantage of a 3D model over a physical scale model is that a 3D model allows the user to walk through the model and see the visibility within the scene from various points within the model. For instance, one can look from the Main Plaza towards the Palace Group. To achieve this with a physical scale model, the model would have to be life size, and even then it might not be possible to view the scene from any desired point. The best example of such an invisible point in a life-size physical model would be any point in the air, which can be seen through a flying camera in a virtual world, but requires flight equipment in the real world. A further disadvantage of a physical model is that it would be time-consuming to build and requires many resources to build the structures making such models far too expensive to be practical.

While the advantages of having a 3D model are clear for presentation or education purposes, the scientific values are harder to prove. The only direct scientific goal of a 3D model, the only type of question that can be directly researched using the 3D model itself, is a question involving a view shed analysis. This is an analysis based on the visibility between two or more points. Space syntax, for example, does not really require a 3D model, only accurate plans. Next to this direct scientific goal, there is also an indirect scientific goal that is of importance when deciding the usefulness of 3D modelling in archaeology. Archaeology is, in short, the science that uses materials of the past to learn, understand and reconstruct the past, where reconstructing means to learn things from the past based on the research in the broadest sense. When building a 3D model, it is not merely a visualization of that reconstruction. It is also a tool that can later be used to ask questions on what is really known and understood about the past that archaeology intends to uncover.

Examining such a model, new insights can be developed into what is or is not known. Then, with that new insight, archaeologists can ask themselves new research questions that might not have been thought of without that 3D model. For example: if a house was found in the archaeological record and though the foundation is known, the roof is not. If that house is visualized using a drawing, the archaeologist can just add a tree or two in front of the house to cover the parts where the roof is, to avoid having to ask himself what the roof looked like. Another would see the picture and perhaps not even think of the roofs because they are invisible. If that house was made in 3D, the viewer could just move around the trees and find a hole where the roofs should be and wonder: what did the roofs look like?

This chapter is mainly based on the usage of the software listed below using a trial-and-error approach, meaning there are almost no external sources for this chapter. First, the method used for making the 3D model will explained, followed by a description of the various software used during the construction. After that, the rest of the chapter is ordered by the various parts the model consists of, starting with how the terrain was made. This is followed by a subchapter in which the excavated structures will be discussed. At the end the walls and the low-resolution structures will be discussed. Each of those areas will be a description of the process from start to finish. The data that was used to make this 3D model were provided by prof. Takeshi Inomata, which consists of the AutoCAD file with the height lines and the basic ground plans and positioning of the buildings. This was complemented by the ground plans of the high-resolution buildings which were drawn from various publications (for exact sources, see the figures in appendix A).

4.1) Required tools

In order to understand the following methods, first a list and brief description of the software that was used is here provided.

AutoCAD

The first program used in making the reconstruction is AutoCAD. This is a drawing program which was published by Autodesk in 1982 after buying it from Michael Riddle, who created the program. It was designed for technical drawings which requires mostly extremely high accuracy. It is often used in the fields of building architectural works, though the high accuracy has also drawn the attention of archaeologists, electro technicians and various other professions that require the

high accuracy that AutoCAD can provide. Although not its primary function, the latest versions of the program can also make 3D models. These models also have the high accuracy of the 2D drawings, but as AutoCAD is a technical drawing program, its functions allow for limited graphical options. The scale of the buildings will be used to ensure the objects are given the exact measurements, so they will fit perfectly in the scene made in Unity3D.

A very important function, that will also be used often for the production of the 3D model for this thesis is the extrude function, which requires a 2D closed shape. A closed shape is a certain number of points, which are all connected to no more and no less than two other dots. This also means that all dots are connected. The extrude function then simply gives this form a value for a third dimension (in the z-axis), converting the 2D form into a 3D object, doubling the amount of points of the object in the process. Another function that is very important when making a 3D model is called 'object snap' which is either active or not. When active, it will automatically mark any points already put in and when the pointer is close enough to such a point, it will automatically move it to such a point. This function is very useful to create closed forms, because the high accuracy of the program causes, when this function is not active, the possibility to input a last point several nanometres from the point of origin (see fig. 7). This function should not be active continuously, as it might otherwise snap the pointer when you want to create points close to other points (see fig. 8).

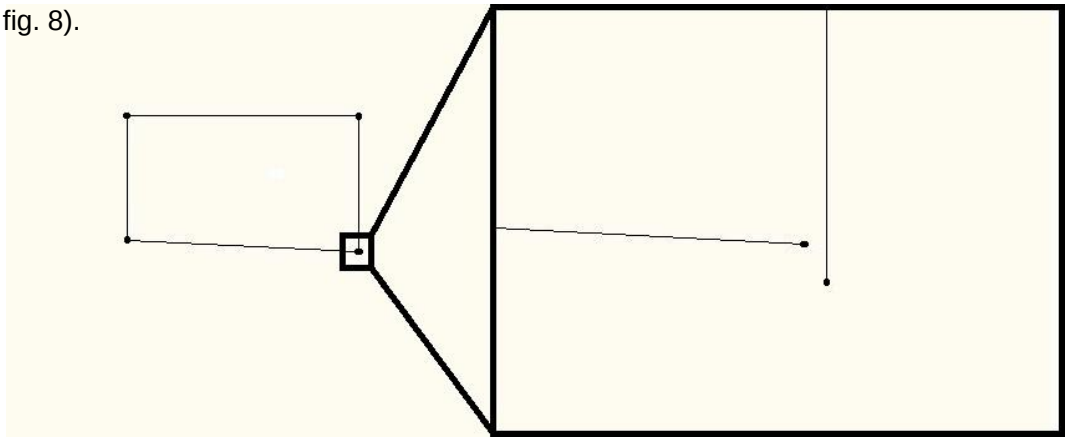

Fig. 7: On the left is drawn a shape representing a structure without the use of Snapping points. On the right zoomed in to the corner of the first and last point that should be same, but are not. (drawn by author)

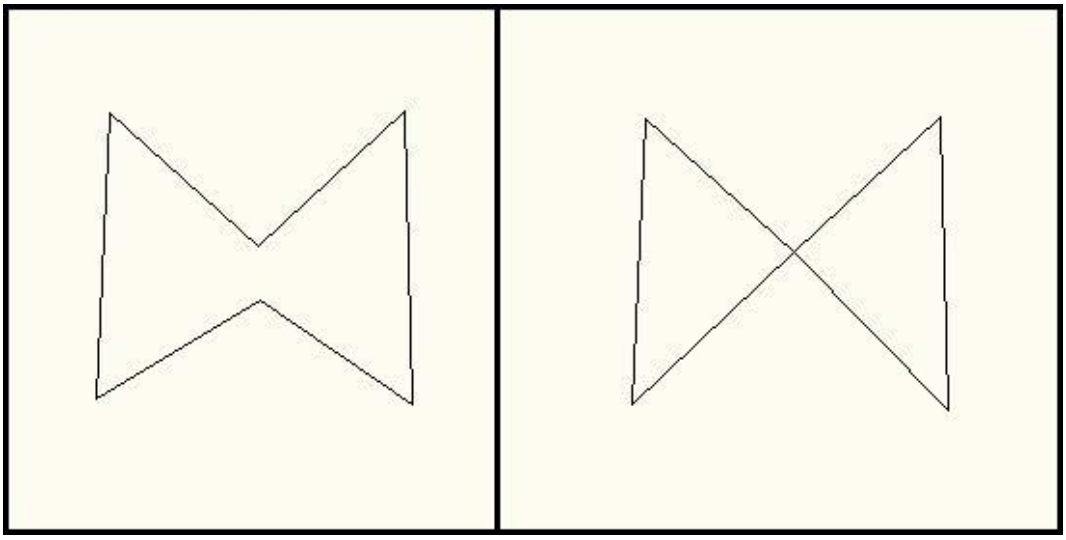

Fig. 8: On the left the actual ground plan of the structure to be drawn. On the right a result of leaving the Snap function on, causing the middle points to Snap together when attempting to draw the lower point in the middle. (drawn by author)

Illustrator

Adobe Illustrator is a vector-based graphics design program and from the very beginning until the present it is a companion program of Adobe Photoshop. Illustrator was first intended for Apple Macintosh computers and is mainly used for typesetting and work on logo's and similar graphics purposes. The main advantage of Illustrator in graphics is that it is vector-based and especially in web design it is an often-used program for any vector-based graphics that is required. For the model made for this thesis it is mainly used as a bridge between AutoCAD, which is entirely vector-based and Photoshop, which is entirely raster-based. The difference between vector and raster will be explained later when a more detailed description is given on how the model was produced.

Photoshop

Adobe Photoshop is a 2D graphics editing program and the counterpart of Adobe Illustrator. Both Adobe Photoshop and Illustrator were first published at the end of the 1990's. Unlike Illustrator and AutoCAD, Photoshop is raster-based and is ideal for 2D image editing. Although it can save into the regular image extensions like .jpg or .bmp, the default extension for images produced by Photoshop are .psd which saves much more information including layers, which is also an often used function in both AutoCAD and Illustrator. For this thesis the main function of Photoshop is to import

the terrain data from Illustrator in raster format and then export to the .raw format that is required by the terrain engine in Unity3D. For future versions of the model, Photoshop can also play a larger role as it is ideal to create or change textures used for the 3D models, which have been used unaltered for this thesis.

3ds Max

3ds max is a 3D computer graphics program and it is the second modelling program used for this thesis and this program is also produced by Autodesk. Unlike AutoCAD it is primarily used for making 3D graphics, including animation. It is, for that reason, used primarily for game development and by TV and film industries. For the reconstructions made for this thesis this program will be primarily used to fine-tune the buildings made in AutoCAD. AutoCAD is quite crude in the creation of 3D models and though very effective for erecting walls, not so practical for smaller objects. Also the graphic options are more limited in AutoCAD, so that will also be done in 3ds Max.

Not much editing will be done in 3ds Max. Applying textures is easier and better in 3ds Max than in AutoCAD, so that will be done there. Depending on the data available, smaller objects will be added to the buildings to give a more realistic impression. The most useful function of 3ds Max next to the texturing will be the wide possibilities for importing and exporting objects, which will allow the DWG files from AutoCAD to be effectively imported as 3ds files into Unity. This will result in the least amount of distortion created through file conversion. A good alternative to 3ds Max would be Maya, also published by Autodesk, but 3ds Max was chosen due to personal preference.

Unity3D

"Unity3D is a game development ecosystem: a powerful rendering engine fully integrated with a complete set intuitive tools and rapid workflows to create interactive 3D content." (Unity3D 2013, Unity). The development of the program began in 2001 and has since skyrocketed to become an international company. Since 2009 they a free version has been published next to a paid professional version. This free version allows most basic functions, such as creating a landscape, importing objects, creating light sources and manipulating those through scripts. The functions that are not supported in the free version include an audio filter, video playback and

streaming functions and real-time shadow effects. For the construction of the model for this thesis, the free version is more than sufficient. The version used is 4.1.2.

Because this program was made with the complete production of a game in mind, there are several features that make it useful when the intent is to create archaeological environments. Unlike 3ds Max or AutoCAD, Unity3D can not only create objects, but also landscapes. To make detailed objects in Unity3D is, however, quite complicated (not unlike AutoCAD) and therefore the programs mentioned above will be used to make the objects which will then be imported into Unity3D. Before the reconstructions made in the other programs are imported, the landscape will be constructed based on a contour map of the city. The scale of the map will be used to pinpoint the positions of the buildings on the landscape, so the imported objects can be placed on the right spots. When the objects are in place, the ritual will be designed by means of scripts that will allow control over the animation. Through the use of the camera function, the ritual can be observed from several positions in the city. The height of those cameras can be efficiently controlled, making it possible to measure, for instance, the minimum length of a person for visibility of certain ritual acts from pre-determined positions in the spectating crowd.

4.2) Methods: step by step

Rebuilding an ancient city in 3D is not easy. In order to visualize the theory above, the reconstruction must encompass the area in which the theatrical events took place, which in the case of Aguateca is the Main Plaza, the causeway and the Palace Group. The main source for these reconstructions will be the ground plans of the buildings that have been excavated and the first step will be to make a basic wireframe model in the AutoCAD software. An example of such a model is seen in figure 9.

When the AutoCAD models are finished, they will be imported into the 3ds Max modelling program where they will be made into realistic looking models. This will include adding textures and adding objects that are relevant. These finished models will then be imported into Unity3D, in which the basic scene has been set up. A scene in Unity3D consists primarily of a landscape area, which is a special feature in Unity3D that is easy to manipulate and to texture realistically. On this terrain, objects, such as the models of the architecture made in 3ds Max, can be placed so that all the buildings that were reconstructed will fit into their place on the plan of Aguateca in the 3D scene. This complete scene can be used for the interpretation by walking

through the model and placing the camera on the Main Plaza, the Causeway and the Palace Plaza at various points to check how the visibility was across those locations and in between. This visibility is very important, because the theory described in the above chapter states clearly that the ritual performed by the king was theatrical in nature. If the king was hardly visible during the ritual, then the theory cannot uphold. Furthermore, the king is said to have disappeared at certain moments in the ritual and reappear at another moment. This can also be seen from the model and verification of this idea might give clues on how to view the magical component of kingship that was shown through the magical act of disappearing and reappearing.

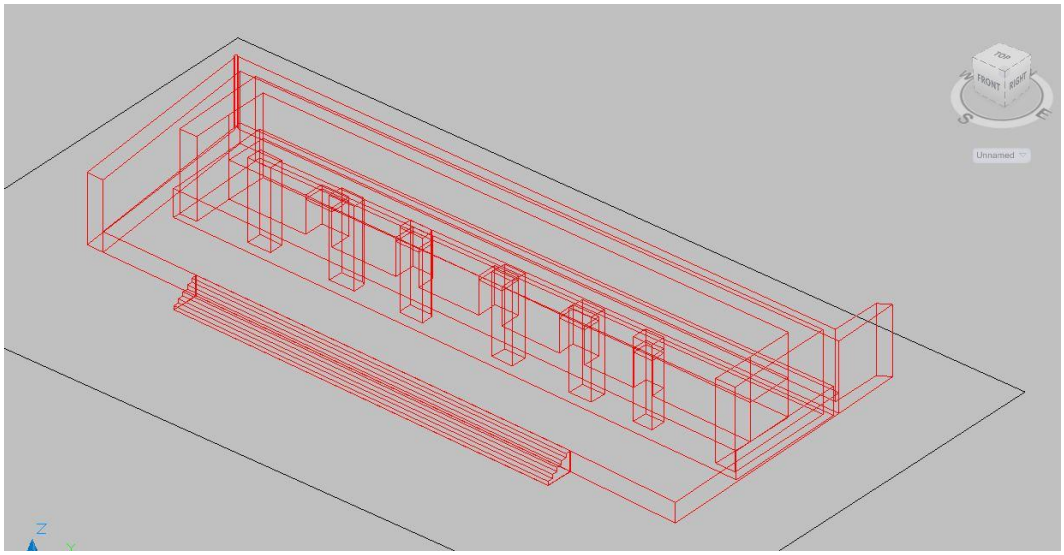

Fig. 9: Wireframe model of structure L8-4 in Aguateca (screenshot taken by author)

4.2.1) Terrain

One of the main problems to tackle before actually starting to work with the terrain was to decide how the data had to be converted into the correct files required for the 3D model. The reason for this is that the data gave one line for each height line, while the required format was to have the height data from those lines put into a single object. For this there are two main courses to follow that have the same beginning but differ in a later part. The first was by making use of a so-called 'Displacement Map'. This is a feature of 3ds Max and similar programs that can read greyscale information from a file as height information. By doing this, a 3D model of the terrain was made in 3ds Max and could then, like any other model, be imported into Unity. The second course is to import a .raw greyscale image as heightmap into Unity. This would import it into the terrain feature that Unity has. As there is a script

available online that can convert an object into a terrain, this does not seem to be complicated, but there are exceptions. A terrain that is converted from an object is much larger. Not only in file size, but also in the scene itself as the imported object is much larger than a single terrain object. As such, the terrain of Aguateca was divided into many smaller objects when imported as Unity could not handle the entire imported object from 3ds Max as a single object. This course does, however, allow much more accuracy. The problem of inaccurate terrain which will be discussed later in this chapter on page 45 and might be solved fully by building the terrain through 3ds Max. It will require some calculations into the maximum size of a single object in Unity and the import settings and might require the terrain data to be divided into multiple smaller areas when importing. For this project, the second course was used, so that the terrain was a single object in Unity and remained workable.

The terrain was the first part of the model that was made and also the part that took most of the time. It is based on an AutoCAD file given by prof. Inomata, which contained the height lines for the entire area. These height lines were all contained in a single layer in AutoCAD, making it easy to work with. However, the lines were not continuous in the sense that they had a maximum of 499 points each. Any height line of more than that amount was broken up into multiple polylines. As it is necessary for the making of the terrain to work with areas, the first step was to join these lines. As many polylines were not closed, but ran from one side to another, additional polylines were drawn along the outline (a polyline which simply connected all the outer points). This new polyline could then be joined with the polyline that ran from one side to another so that the result was a closed polyline. To illustrate this, see figure 10 for a schematic drawing of this process.

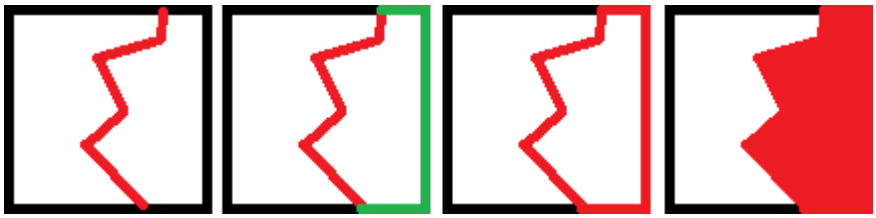

Fig. 10: making polylines into areas in four steps (left to right)
Step 1: a polyline (red) going from one side of the drawing to another
Step 2: drawing a new polyline (green) along the outline (black) between the endpoints of the first
Step 3: joining both polylines to get one polyline surrounding an area
Step 4: the area enclosed that will later have the height that this height line refers to
(drawn by author)

When all the polylines were closed, height information had to be given to the lines and as the above described method requires, the lines were given a greyscale colour based on the height they were representing. Colours on a computer are generally discussed using their so called RGB value. This consists of three numbers, each of which represents the amount of ‘red’, ‘green’ and ‘blue’ there is in a colour. This number ranges from 0 to 255 where 0 means ‘not present’ and 255 means ‘fully present’ Therefore, an RGB value of [0,0,0] means black (all colours are not present) and [255,255,255] means white (all colours fully present). If the values are all the same, it will return a greyscale, where the darkness will depend on how high or low the number is.

[0, 0, 0] was given to the outline and after some calculations, the actual height lines from the AutoCAD file had to be given a darkest colour of [39, 39, 39] and a lightest colour of [252, 252, 252]. These correspond to 99.5m and 206m. With the height lines coloured the next phase was to fill the space between the lines, so that the lines become the differences between the areas of a certain height. In AutoCAD there is no good function for this, so the file was imported into Adobe Illustrator where a closed polyline can be filled (which also shows the necessity of making all polylines closed in AutoCAD). All the used colours in the drawing are shown in a list in Illustrator and they are named 'AutoCAD color ?' where the question mark is numbering the amount of colours used. As the value shows when selecting it, the colours can be renamed so they can be sorted, making it easier to find them in the list later. With this done, the lines can be selected and filled by selecting the colour in the 'fill' option. There is, however, one problem to overcome after this stage which is caused by a concept called the 'Stack Order'. This refers to the order in which the different polylines are shown in the drawing. It can be visualized as a list where all objects in a drawing are listed from top to bottom and when there is any kind of overlap between the objects, the object on top is shown over the one that is lower on the list. If the outline is on top of that list, then none of the other objects in this drawing would be shown, as the filled outline covers the entire drawing. So the polylines had to be selected based on their height/colour and then placed on the list in such a way that the smallest areas were on top of those areas that covered a larger area.

Until this point, the file was a vector-based drawing. This means that it consisted of individual points in a coordinate system. This is opposed to a raster-based image which consists of pixels: squares or rectangles that each have a certain colour (but

no more than one colour). The main difference is noticed when zoomed in on the image: a vector-based drawing will keep the lines the same width and the image will stay sharp. A raster-based image will on a higher zoom start to show the pixels and become more vague (see fig. 11).

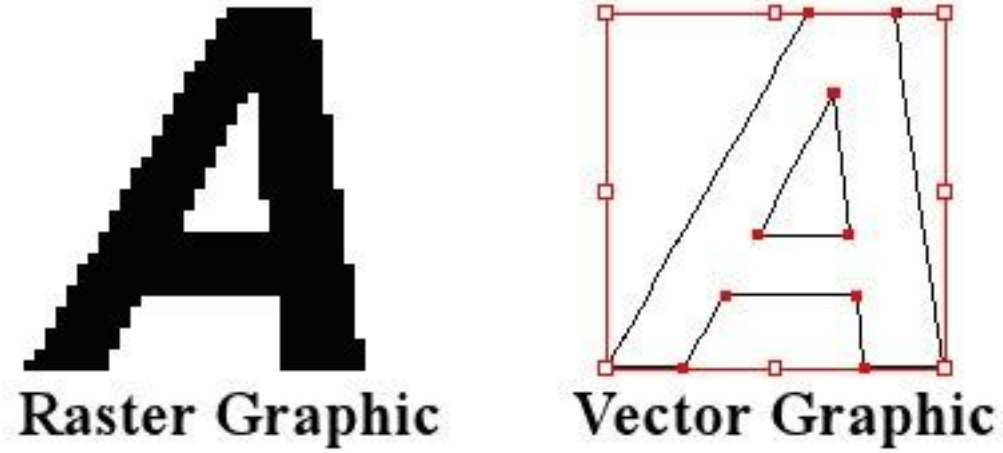

Fig. 11: The difference between a raster image and a vector image (blog.pixellogo.com)

To turn the image to a terrain later, a raster-based greyscale image is required. The greyscale is already fixed, but the vector-based drawing has to be converted to a raster-based image. For this project, Photoshop was used to further work on the raster-based image, so it had to be imported into that program. After many attempts, the .TGA extension was the one that produced the best result in Photoshop as a raster-based image (see fig. 12). Some of the others caused a lot of distortion in the colours given to the pixels, causing a very rough terrain in Unity, which was much harder to work with. With the file in Photoshop, the next step was to look at the actual requirements for importing the file into Unity. Those are that the imported file has to be in .RAW format. As Photoshop can export to that extension, that is not a problem. Secondly, the imported file has to have a square format with a size of powers of 2. To make the image square, it does not suffice to change the image size to any square format, because that would stretch the image. Instead, the image was copied into a new image that had the correct size. For this model, the image size was reduced to 1024 x 1024, as that came closest to the actual area of the terrain. Before turning it into a .RAW, the background was made black, so that the area which is technically outside the drawing would be read as a lowest height, which would not be as problematic as it would be, if the area was raised above the highest part of the terrain. Lastly, the image had to be flipped horizontally to be projected correctly in Unity. The reason behind this is at present unknown to the author of this thesis, but

the flipping of the image easily resolves the problem of the terrain not showing correctly.

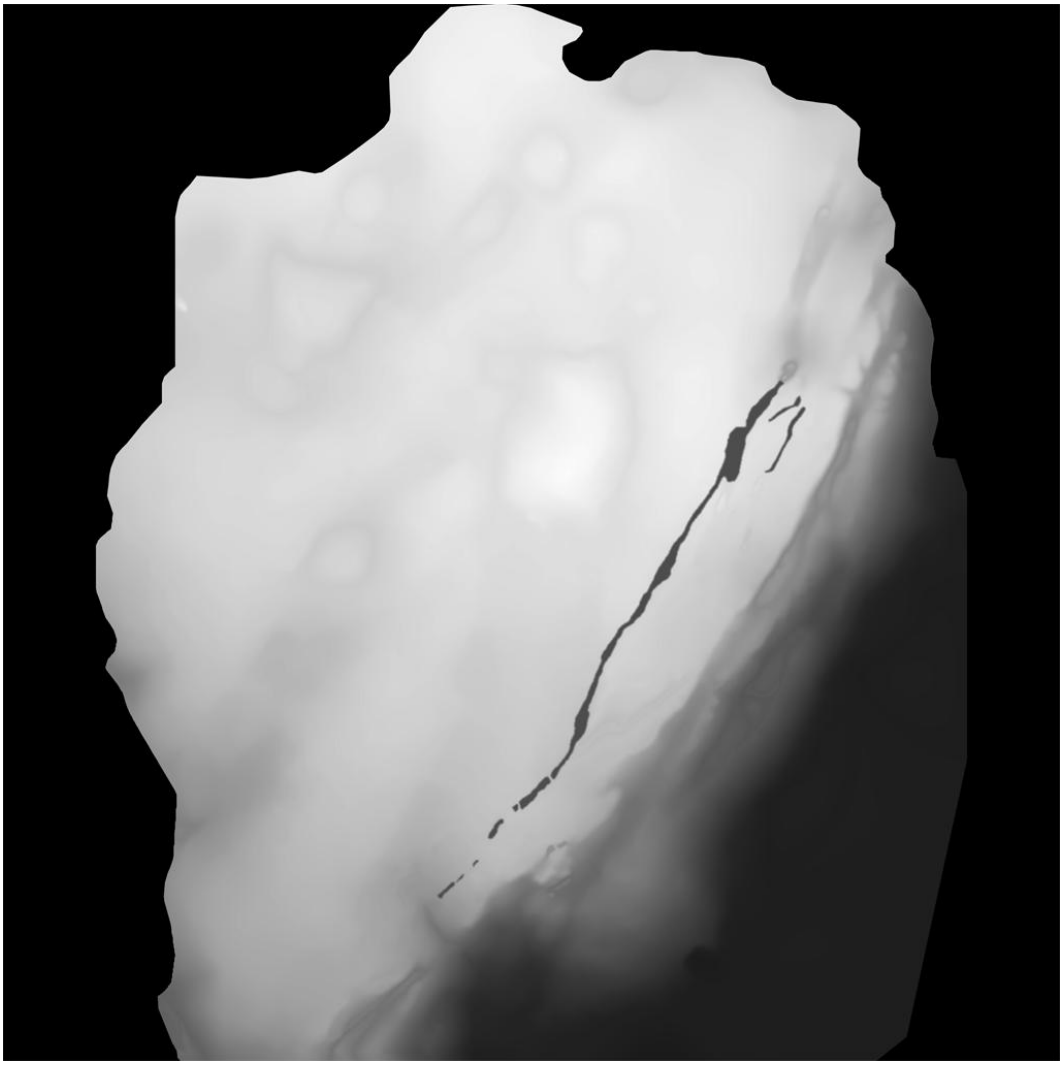

Fig. 12: the raster image that is used to make the terrain (made by author)

With the .RAW greyscale image that has the correct size and is flipped correctly, it can now be imported into Unity3D. For this, a new terrain is made in Unity after which the resolution for this terrain is set. Important at this point is that the heightmap resolution is set to the length/width + 1. So if the image is 1024 x 1024 than this value should be at 1025. The first three values for the terrain refer to the length, width and maximum height of the terrain. These four values should be set correctly, so that the image is applied correctly to the terrain. After the terrain is imported with these

settings, it does not automatically mean that the terrain has a correct height. When calculating in Unity, it seemed that the algorithm used to build a terrain from the .RAW file is not linearly based on the colour. Using test cubes in Unity, the exact height of various points could be measured and after testing, the best result was found when the terrain height was set to 100. When measuring the heights of various points, the most important part was the difference between the heights, rather than whether the height of a certain point was correct. The reason for this is that visibility can be different if the differences between certain height lines is larger or smaller in the model than in reality. Therefore the measurements were compared to each other to see what the difference was between the expected height of the points (which was based on the line colour) and the actual height in Unity. If two measured points had the colours [0,0,0] and [10,10,10] then it would have an expected height difference of 5 meters as every shade was a difference of 0.5m.If in Unity those points would be 8 meters apart, then the area between those two points would have a height difference of 3 meters. Using this system, the height setting that was searched was the one where the area that is the most important for the goals of this thesis (roughly the area between 180 meters and 196 meters, which includes the main plaza, the causeway and the palace group) was as accurate as possible, so that any distortion in the terrain could only be found in the other areas. At the height setting of 100, this was the case and the result was that in the lowest regions of the model there is a difference of roughly 8 meters between the units in Unity and the difference in meters based on the given colours. However, in the region between 180m and 196m of real heights this difference is zero and therefore accurate. Shifting this height resolution will mean other areas of the model become accurate at the dispense of this one.

The difference between the various heights is of course a bit rough as specific lines were used as borders between two areas with 0.5m difference in height. Therefore the first tool used after importing terrain is the 'smooth terrain' tool, which simply softens the edges of those lines so that the difference in height becomes more fluid across the entire terrain. When doing this, the only really important thing to pay attention to is to not smooth any area so much that it actually changes the required height. On smaller hills this could happen causing the hill to be flattened slowly, while the ridge across the town really should be avoided with this tool, as the smooth tool uses averages between heights of points to smoothen the terrain. For both the ridge and the cliffs, this average is so different from the minimum and the maximum that a lot of ground is shifted, which is not the intention when using the smoothing tool. After

the terrain is smoothed and as a more natural appearance, it should also be given a more natural colour and therefore the next stage is pasting textures on to the terrain. This stage is completely arbitrary in this project as it is mainly based on the elevation of the terrain. Four different textures were used: grass for the flat or nearly flat terrain, hills for the slopes, cliffs for the cliffs (which is the elevation that cannot be walked up) and sand around the lake at the bottom of the cliffs.

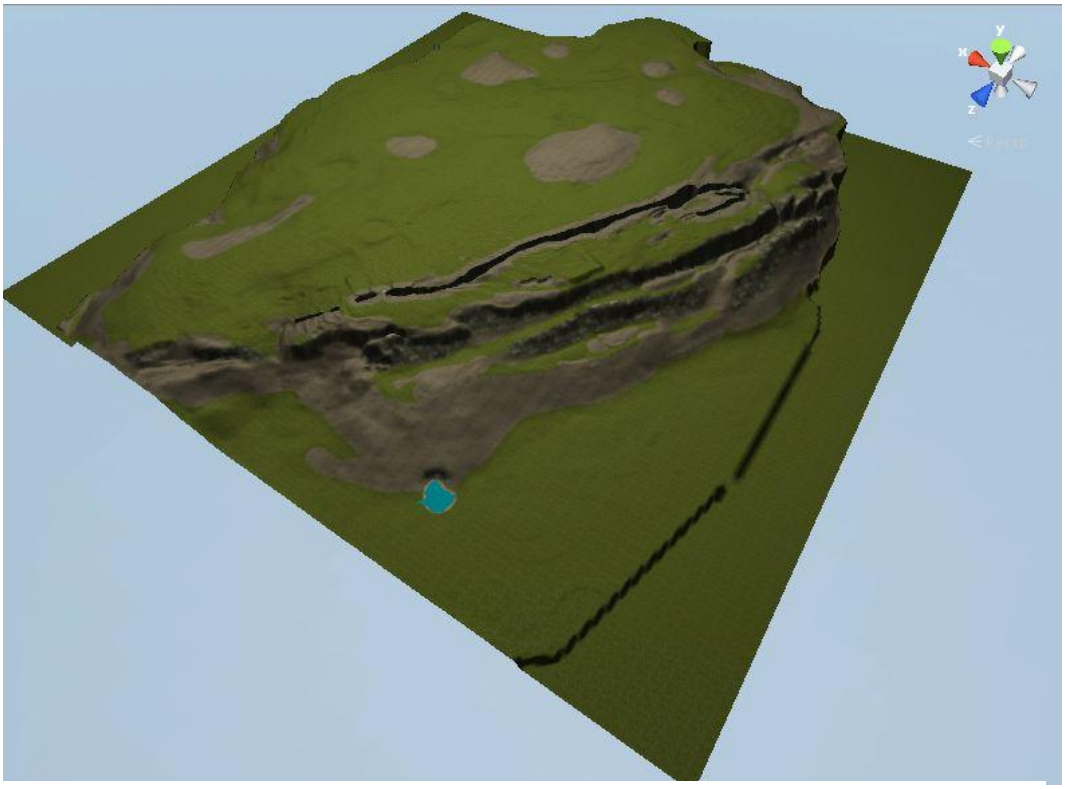

Fig. 13: The final terrain in Unity3D (screenshot taken by author)

4.2.2) High-resolution structures

The second part of building the 3D is the modelling of the high-resolution structures. The high-resolution structures are based on the ground plans that were the product of excavations done by prof. Inomata. These ground plans and the specific sources can be found in Appendix A. The first step here was to make sure the model was set with the correct measurements. This does not only refer to the general settings of the unit designation, but also to the scale bar on the ground plan that should be aligned to that metric system in AutoCAD. So assuming the general settings are taken care of, the ground plan can be inserted as a raster image (clicking "attach" in the image tab will allow the selection of an image). Before the image is inserted some settings

can be changed, but the most important of these at this moment, the rotation at zero and the file location at full path, should have these value on default. When the image is inserted, it has to be scaled according to the scale bar in the image. AutoCAD has a special function to do this, which can be used after clicking the "scale" button in the home tab to start the rescaling of the image. When the image is selected after clicking the "scale" button, the user is prompted to select a base point. After selecting that point, instead of selecting a second to use as modifier, right click and select "reference" from the menu. This function will allow the user to set two base points and then insert a number, telling AutoCAD how many units there should be between the two points. To improve accuracy here, make sure the two points are on either side of the scale bar on the image and on the same horizontal axis. A higher deviation on the vertical axis between the two points will result in a higher distance in the program between the two points then actually is in the drawing. As the various ground plans used in this thesis have difference scales, the accuracy also differed as higher resolution plans will also result in less loss of accuracy with the same deviation on the vertical axis in this process.

With the image of the ground plan in place, the next stage was to start modelling the building. For this, change the layer, so that the drawn structure is in a different layer than the image. This is important later, when the structure is imported into 3DS Max. This is the phase where archaeological inference already starts to become a part of the process, as the user has to define the various plateau's in the image by drawing a polyline around it. The walls, for instance, are of the same height and are in this case one plateau. Each room had one or more polylines depending on the amount of heights that were present in the room (the niches are also drawn with a single polyline) and each step of the stairs are a polyline as well. The stack order becomes a tiny issue now, as any new object will be placed at the top of that list. Some polylines however, have another polyline overlapping them at every point. If that overlapped polyline is drawn first and the rest later, it cannot be selected normally, as the overlaying polyline will be selected. The easiest way around it is to select both polylines and then deselect the upper one, but as this is only a problem in a few cases, a bit of planning is better to prevent this from happening.

The same is true for the next phase, which is extruding the polylines to give them a height and effectively turn them into 3D objects. Notice here that extruding will give the same effect as being placed on top of the stack order when in top view, so the problem discussed above should be considered in this phase as well when deciding

which object to extrude first. This phase has the most interpretation in the building of the model, as for each height, the user has to decide what height to give each area. Whether the walls are 2 or 6 meters high will of course have significant effect on any analysis based on how the object was seen. For this model the decision was to make the walls 3 meters high, which is based on a drawing by prof. Inomata (see fig. 14). When the extrusion is finished, the modelling part of AutoCAD is finished and it is ready to be imported into 3DS Max (see fig. 15 for a final model in AutoCAD).

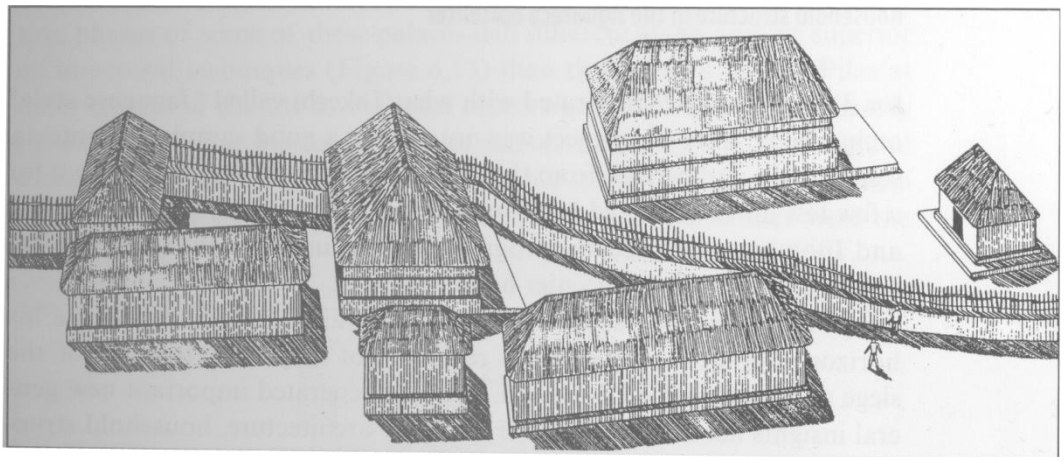

Fig. 14: Reconstruction drawing by Inomata (Demarest 2006, 119)

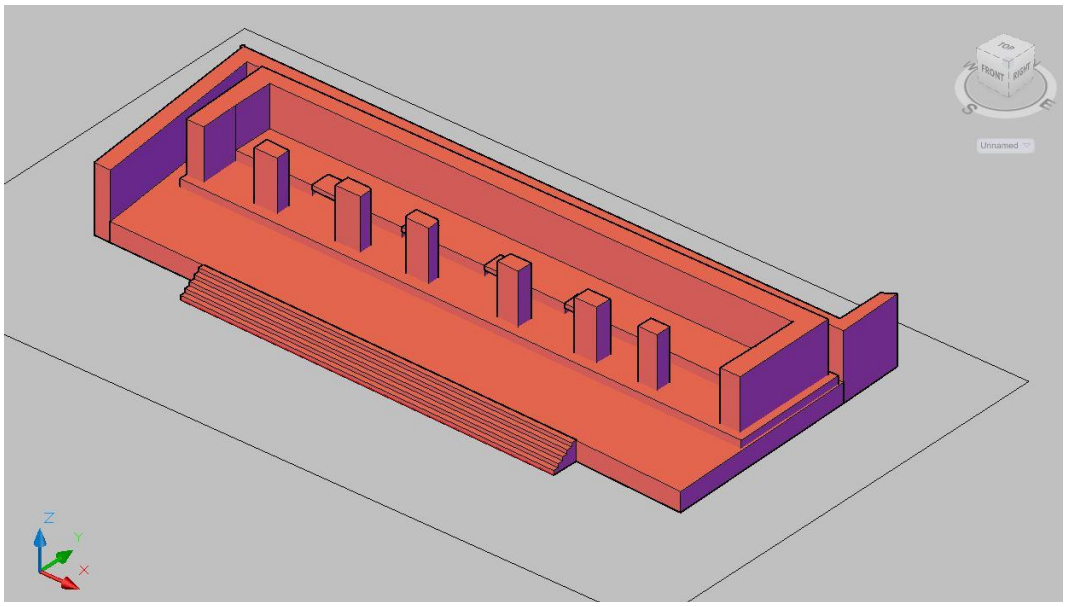

Fig. 15: The final model in AutoCAD of structure L8-4 in Aguateca (screenshot taken by author)

In 3DS Max, the model needs to be imported as a whole, instead of every plateau being an object on its own, so the import setting should be set on 'based on layer'

instead of 'based on entities'. We will only need the layer in which the polylines were drawn and not the image of the ground plan. Also, it is important to make sure that the metric system is used for the incoming units and in the settings of the file. For the high-resolution structures roofs could be modelled and this was started by drawing a rectangle over the structure with the four corners exactly places on the outer corners of the wall. The height of this rectangle was set on 2 meters, again an educated guess based on the drawings shown in figure12. The four points around the upper face were then brought together on the short sides, resulting in the equivalent of a triangle placed on one side of the structure and then extruded along the length of the structure. Then both points were move inwards by 1 meter, so that the triangle was no longer completely vertical, but more of a slope, as can be seen on figure 16. Although it was not done for this 3D model of Aguateca, any further structure modelling should be done at this point. The reason for this is that it is harder to do any good modelling in Unity, because Unity is not made for that purpose.

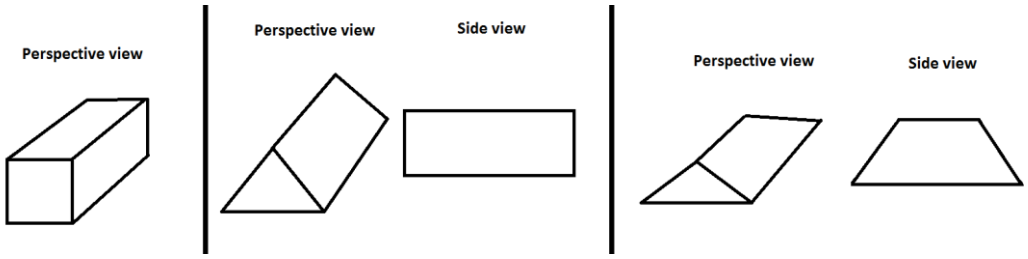

Fig. 16: Building the roof in 3 steps:
- Step 1: make a cube with a height of 2m and a length of width to fit the structure (snapping the points before extruding the rectangle)
- Step 2: snap the top points together, halfway the width. From the front and back it will now look like a triangle, but from the side it is a rectangle.
- Step 3: drag the top points 1m towards each other, causing a slope in the roof to exist on all four sides of the roof
(drawn by author)

With the structures built, they can be exported to Unity. In this project, the extension .FBX was used for this. With the export, the most important setting is that of the units, which should be the metric system. In Unity, .FBX files are imported with a scale setting of 0.01, which should be rectified after importing it. That it is imported with this scale is an automatic result of certain settings that cannot be changed, but luckily this is remedied easily enough. An imported object can be dragged into the scene directly, or by dragging it into the hierarchy. The positioning was dependent on the low-resolution structures, on which the next subchapter will elaborate. As each of

the high-resolution structures is also present in the group of the low-resolution structures, they could be dragged towards the same position and aligned to those low-resolution structures. This means that also the rotation can be based on those low-resolution structures, which also puts the high-resolution structures at the correct relative position on the scene. The final version of the structure can be seen in figure 17. Lastly, the coordinates given to the whole object and to the sub-objects is for an unknown reason not very logical as the pivot point, in most objects the central point and the place from which an object can be moved, is sometimes even 100 units off. This can be rectified by reducing the values in the x, y and z axis of both sub-objects by equal amounts. This is more for practical reasons in manipulation of the object then any performance reason.

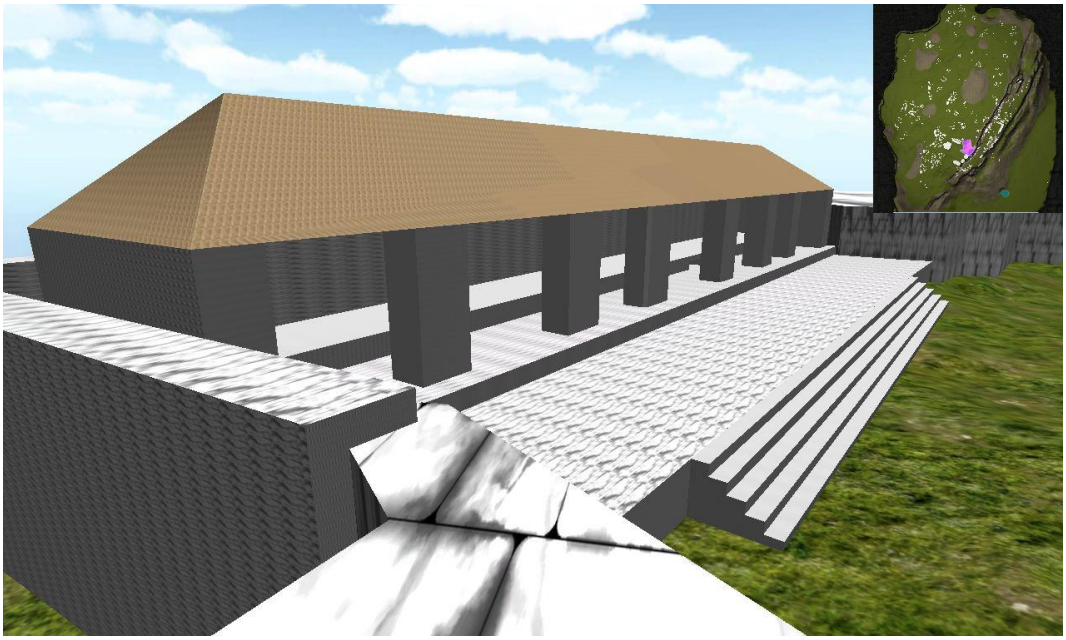

Fig. 17: Final version in Unity of structure L8-4 in Aguateca (screenshot taken by author)

4.2.3) Low-resolution structures and walls

The low-resolution structures and walls fall in the third and last part of the model to be discussed. Although they are different from an archaeological point of view, they were both drawn directly from the AutoCAD drawing and as such were imported together into Unity. But before Unity, they had to be made into objects. In the AutoCAD file they were simple polylines and many were not closed. Unlike the process with the height lines of the terrain, the completion of the areas in this part was not as straightforward and required some archaeological inference as to where the walls could be assumed to continue and where there was an actual break

between several wall sections. In quite a few cases there were structures between wall sections where presumably those walls were built against the structures, giving those structures a defensive value as they were also functioning as a part of the wall. In each of those cases the wall-objects themselves were not extended, so that the wall piece could be fit next to the structure instead of seemingly running through it. When all the polylines were closed, they were all extruded to a height of 3m. As this was also the height chosen for the walls in the high-resolution structures. A drawing made by Inomata also suggests this height for the walls, which are not only slightly less than twice the human height, but also reach exactly to the point where the wall and the roof of the drawn building intersect (see fig. 14). Before exporting the low-resolution structures and the walls, it was necessary to include a way to carefully position them on the terrain later. For this, the outline, which was drawn along all points at the outer edges of the height lines, was extended to cover a small area and then extruded by 0.1m to make it a 3D object. Finally, the layers should have distinct different colours before exporting: one for the walls, one for the structures and one for the outline (see fig. 18).

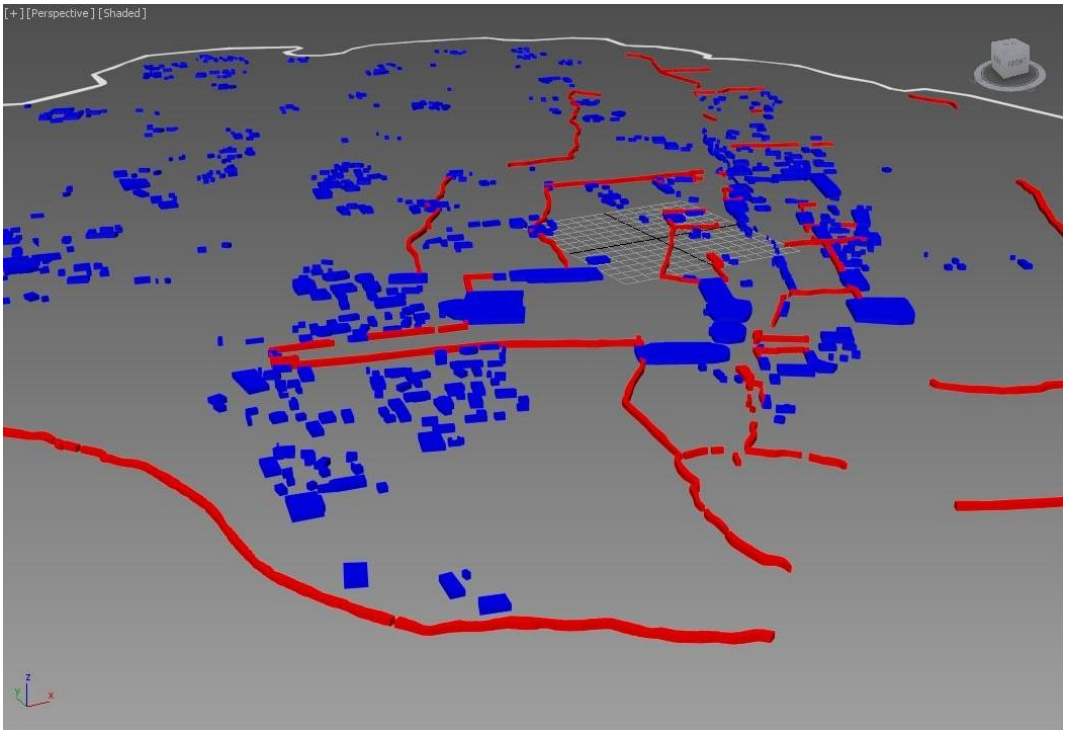

Fig. 18: Colours of the layers just after being imported into 3DS Max (screenshot taken by author)

The next stop is 3DS Max where the model is made ready for the import to Unity. First and foremost, it should be noted that the import setting for the model should be based on entities and not on layer. Otherwise, the program will consider the entire layer as one single object. Also, the layer information should be imported, but that is true in the standard settings, so no changes should be made for that. As the layers were given different colours, it is easy to rename the objects as a part of the group. In the 'scene explorer' (found under the 'tools' menu button) you can sort all objects in the scene based on colour and then, using the shift key and selecting the first and last of a specific colour, rename all objects appropriately after which they will be numbered. So all the walls will be named 'wall, wall1, wall 2' and so on and the same is true for the structures. The outline will not be numbered as that is only one object. Just like the high-resolution structures export to .fbx, again it's important to ensure that the export settings measure in the metric system.

In Unity the imported file will result in a prefab again and the parent-object should be used to place all the structures and the walls on the right x-axis and y-axis. As we have continually imported the various structures and walls in a single file, their relative positioning is still correct. However, they also have to be aligned to the terrain which came through a different route to the Unity project. For this, the outline could be used. After resetting the import size again to 1 instead of 0.01, the low-resolution prefab is dragged to a height above the terrain, so they can be positioned correctly on the x and y axis in regards to the terrain. After some experimenting, the scale on which the prefab was set was 0.71 on both the length and width. During the tests, the outline object was checked against the outline of the terrain to make the most fitting match. As the outlines matched, the objects in the rest of the prefab (which were each scaled along with the prefab) were in the correct position, though floating above the ground. Therefore, they were then dragged to the terrain thereby making sure that the entire model was on the ground, which sometimes caused part of the model to be under the ground. The alternative was to have less of those objects below the terrain, but that would also cause part of the buildings to float over the terrain and a decision was made against that (see fig. 19 for a schematic of the alternatives).

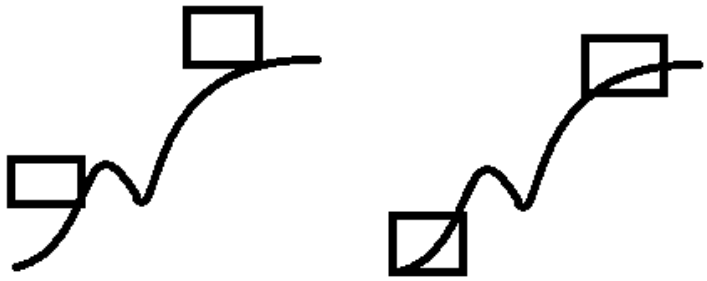

Fig. 19: On the left floating structures on the terrain and on the right structures partly under the ground to prevent floating (drawn by author)

The outline object itself was scaled down after this to 0.99 on width and length so it would be on the outer rim of the terrain, but just before the 'cliff to the edge of the world'. It was also scaled up in the height to cover the entire model from base to top. The 'Mesh Renderer' component, which is automatically added to any added object, was ticked off, which resulted in the object becoming invisible. Lastly, a 'Mesh Collider' was added, which stops the First Person Controller to walk through the object. This effectively made the outline an invisible wall around the scene.

The final action left is to position the walls correctly in height. Unlike the structures, they could not just be dragged downwards. Most of the walls would hardly be visible or floating as height difference they cover is much larger than in the case of the structures. To fix this problem a script was written to have the walls follow the terrain more accurately (see Appendix B for this script as well as the other scripts used). As terracing is preferable to use for the structures in a more advanced model and structures require all walls to be straight up from the ground, this script was not used for the structures.

The project was exported to executable files for Windows, Mac and Linux platforms. These will be provided in a zip file along with this text. The project data of the model will remain on my personal computer. This means that it will be impossible for others to make changes in this model, but anyone can walk through it. See the contact details on the backside of the cover if either you want a copy of the model, or access to the project data itself. To use the program simply double-click the executable of your platform, all keys that can be used are shown in the program legend. Also, you can resize the window to whatever size you like while using it. In the next chapter the usage of the program will be shown and all commands will be explained as well.

5) Discussion

In this chapter the focus will be on the possibilities the made 3D model gives. Firstly, a short tour of the 3D model will be given, showing how the interpretation of the model can be done and what should be given attention to when doing so. For this a video was made in which one can see the path taken (for link: see Appendix C). Also, several screenshots of the route were made and these are shown in Appendix C, they will be referred to in the text, so it is clear at which points screenshots are used to clarify the points made.

When the model is started by double-clicking the Aguateca.exe, the starting position is at the base of the highest hill on the map and in the middle of the map, so that from the map, so that from this position any other part of the map is easily accessible. Also, when looking at how the walls are positioned around this point, it might be seen as an entry point to the city (fig. 26). In the lower left corner of the screen a legend is shown (not shown in appendix C) which state all the controls that can be used in the program. The letters W, A, S and D can be used to walk in a certain direction, just like the arrow keys. The numbers 1, 2 and 3 will toggle the walls, low resolution structures and high resolution structures respectively, allowing the user to remove them from sight and walk through space previously occupied by them or return them again to the scene. The T key will enable the user to walk at ten times the normal speed. Pressing it again will return the user to normal speed again. Pressing the R will return the user back to the starting point, which is specifically useful if fallen into the chasm, as one cannot walk out of that again. That chasm can be jumped if the turbo function is active, as the ‘gravity’ that is present in the scene is not affected by the increase in speed.

From the starting point, when walking south along the walls and in between two structures, you quickly reach the backside of structure L8-11. With the walls up, it is quite a detour to actually reach the Main Plaza but in this program you can jump over at the right side of L8-11 to reach it quickly. Here, bothL8-11 and structure L8-4 are easily seen as more accurate models in contrast to the other buildings around the Plaza. At the end of the Plaza a wall can be seen that was built later which runs along the entire south side of Plaza and is built against the southernmost structure at the Plaza (fig. 27).Though there is some difference in elevation across the Plaza, this does not become very large until past the wall at the south side, meaning that the entire Plaza more or less has the same sight across it. The visibility of anything that

can happen in the buildings seems slightly problematic. L8-11 is located on the highest part of the Plaza and while the building itself is very clearly visible, part of the building is blocked off by the front platform of the structure (fig. 29 and fig. 30). If an individual is standing on that front platform, that person would be visible, but not if that individual was sitting on the bench in that structure. This is different for L8-4, which is clearly visible from various spots across the Plaza (fig. 31 and fig. 32). This might be because the front platform is much smaller or because it is located slightly lower than L8-11. This could have served a function in the Kingship ritual, as the King might at some point want to temporarily be invisible like with the ritual described at Xunantunich. Sitting at the bench of L8-11 would give a similar effect with very little effort at hiding.

When turning that perspective around and putting the viewpoint at either of those two buildings, the entire Main Plaza is clearly visible as well as the other structures (fig. 27 and fig. 33). A hidden individual on the bench of L8-11 might be visible from the front platform of L8-4. Also, it seems that when putting the viewpoint on the Plaza or on the front platforms of either L8-11 or L8-4, it is only the Plaza itself that is visible, as at the edge of the Plaza at all sides there are structures or walls to block the view outwards. With the walls turned off (in other words: the situation before the crisis in the final period of the town) there is much more visibility outwards, but especially towards the northeast of the Plaza. In the south the terrain goes downhill, so the visibility there is only significant when you get closer towards the south end and you can see the hill moving down (fig 27 and fig. 28). The structures towards the southwest of the Plaza block the view in that direction if the walls are off. The same goes for the structures towards the west and northwest of the Plaza. Towards the northeast of the Plaza however, turning off the walls makes a part of the Palace Group and the Causeway visible which seems to be a more significant effect on the visibility with the Main Plaza as view point (fig. 34 and fig. 35).

Next to visibility, another aspect of theatrical performance is the audibility at the Plaza. This model cannot give any conclusive evidence towards this aspect as Unity3D requires the pro version to make use of audio filters and as such realistically work with the audio sources to recreate the actual effect to audibility of the structures and walls. However, when the viewpoint is placed on the front platforms of L8-11 or L8-4, the placing of the structures seem to suggest a certain reflection of any sounds made towards the Plaza. This can be linked to the argument made earlier which stated that the outside is blocked from view from the Plaza and vice versa. If this is

indeed the case, it would be a strong argument in favour of the theatricality of the performances acted out on the Plaza, as it would define the Main Plaza more as a ritual space.

From the Main Plaza the next views to consider are towards and from the causeway leading to the Palace Group. The walls actually block any entrance to the Causeway, so to access it, the walls were turned off. When walking to the Causeway, it is clear that it is not an easy part of the town to access. It is across the large chasm when approached from the Main Plaza and therefore a pass had to be found to cross. The first pass, located just southeast next to the Plaza is blocked by a structure built over it, so to access the Causeway, you would have to walk around the structure south of the Plaza to get to an access point which has more structures all around (fig. 37). When looking towards the Causeway during this trip, the entire panorama is blocked with structures on the Plaza side of the chasm, meaning that most of the Causeway is continuously blocked from view (fig. 36). On the Causeway, the view is also quite limited: structures and terrain on both east and west sides force anyone walking across it to either look at those structures and small hills or ahead towards the Palace Group, though the Palace Group itself is blocked from view by the structures next to it (fig. 38). Also, along the entire Causeway, the Main Plaza is largely blocked from view (fig. 39, fig. 40 and fig. 41). About halfway the Causeway the structure density allows more view towards the part of town across the chasm, but the terrain continues the view blocking instead. By walking up the terrain and behind the structures, there is much more visible of course, but at this point you are beyond the Main Plaza. The walls, however, effectively removed this view from the Causeway towards the rest of the town. On the eastern side the structures are less frequent view blockers and instead, the terrain does a larger part of this work. However, as on this side it is mostly a cliff that would be seen, it seems more significant if any specific effort was made to decrease any view here and the few structures that block any view do not seem to have been specifically placed to include that function.

Finally, the tour through Aguateca reaches the Palace Group. As can be expected by the ground plans alone, it is quite secluded and hardly anything of the Palace Group is really visible from the outside (fig. 42), as the Palace Plaza is completely surrounded by structures. However, when looking from the southern part of the Palace Plaza towards the Causeway, the terrain allows the viewer to see the entire Causeway quite clearly and this seems significant (fig. 43). Because of the elevation

this is only possible from the south western part of the Plaza however. The Causeway is in the model also visible from the somewhat heightened platform at the south eastern part of M7-22 although it is not clear whether this effect is intentional. The Palace Plaza is similar to the Main Plaza in the sense that it too is focused inward and while the view from the outside is blocked, any part of Plaza is clearly visible from another part of the Plaza (fig. 44 and fig. 45). As the terrain is not completely accurate in the much higher or lower parts of the map, the visibility in the model of or from those areas is unfortunately only of very limited use and therefore not considered here.

So how can the above be linked to the rituals of kings that was explained in earlier chapters? Before going into this question, first the requirements for such rituals should be discussed. What are the actual requirements for rituals that are theatrical performances on a scale of being played out in front of an entire city or community? The auditory and visual requirements have already been elaborated on, which are important for any ritual that has to reach a lot of people. If a larger part of the populace that was supposedly on the Plaza had no way of knowing, through sight and through hearing, what was happening on the stage, then the ritual could not really connect to those people and the theatricality could not have had any real function. As Inomata has stated in his article on theatrical performances, the king used these rituals to indoctrinate the populace with their own worldview, history and similar facets of their cultural views (Inomata 2006, 808). This means that these performances had to include ways in which these views are actually conveyed to the people that are participating or at the very least public to these performances. As stories and ideologies could very well have been told or shown with sounds or phrases to make them understood, the auditory function of the Plaza should be taken into account. The visual aspect is most certainly very important. Various stelae, which have often been subject of research in Maya archaeology show rulers in ceremonial attire and they were probably used to strengthen the message of the theatrical performances (Inomata 2006, 810). Here the visual aspect is of course paramount as it is the only aspect that actually contains a message (which may or may not contain a written message).

6) Conclusions and recommendations

In this thesis the main goal was to build a 3D model of Aguateca to explore the ritual space of Aguateca which could lead later to a better understanding of kingship ritual in the Classic Period of the Maya. The importance of lineage to the position of the king was discussed and this was something they had to present in some way to the people. The king had to prove he had the right to be in that exclusive position. This also means that the king had others around him, who had to help him to maintain that status, which in return gave those people powers of their own. The ritual that the king performed, supposedly in front of the entire community in the Plaza was one such way in which he attempted to retain that status. The model created for this thesis was explored and it is clear that the first impression was that the architectural choices made by the Maya could be interpreted as being made with this ritual in mind. Nevertheless, this model cannot yet conclusively prove that these rituals could be performed in such a way in front of the entire populace of the city. For such proof, the model would have to include the ritual being played out, the Plaza filled with people after which the camera can be installed on various individuals across the Plaza to see how the ritual was seen from those various points. If all could see and hear clearly what was happening, that could be considered enough proof to make the theory presented by Inomata considered as true or at least very probable.

The 3D model is in that sense not complete and at the moment only useable for the exploration of space rather than any definite proof and any further work on it might want to go this step further. However, the accuracy problem presented is also still present and this makes the model only useable for the region between 180 meters and 196 meters. In the future it could be helpful to remake the model through the displacement map in 3DS max as was explained to make the entire terrain accurate. While a first attempt at realism was also made in this model, the used textures are not perfect and especially close up the 'feeling' of the scene being real is not there yet. In a future project, this can also be worth looking into, especially when the model is used for presentation purposes. Of course for this thesis it was not as important, so therefore less effort was put into this part of the model.

Abstract

In this thesis the Classic Maya city of Aguateca is reconstructed using Unity3D. This city, which had a very short lifespan, was nevertheless the home to a royal family which came from the nearby city of Dos Pilas when the situation for them appeared to have become more hostile. The walls that were later built in Aguateca and are also shown in the 3D model are evidence of the hostility in the area. The main features in the 3D model are the Main Plaza, the Palace Group and the Causeway that connects the two. The Main Plaza is separated from the Causeway and Palace Group by a deep chasm. This model was created to serve as a scene in which kingship ritual was probably performed to bind the populace of the city to the reigning king. This thesis follows the article on ritual performance by Inomata (2006) in regards to this theory. While the ritual itself is not given form in the scene, various preliminary conclusions based on the visibility in the scene indicate a high probability for such rituals to have taken place.

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Salisbury, D. F. and M. Koumanelis, 2002. *Newly revealed hieroglyphs tell story of superpower conflict in the Maya world.* www.vanderbilt.edu/exploration/news/features/dos_pilas/news_dospilas_overview.htm (visited 11-12-2013)

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Inomata, T., D. Triadan, E. Ponciano, E. Pinto, R. E. Terry and M. Eberl, 2002. Domestic and Political Lives of Classic Maya Elites: The Excavation of Rapidly Abandoned Structures at Aguateca, Guatemala. *Latin American Antiquity* 13 (3), 305-330.

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(www.famsi.org/reports/03101/31ponciano_inomata/31ponciano_inomata.pdf, consulted 2013).

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List of Figures

APPENDIX A: Ground Plans

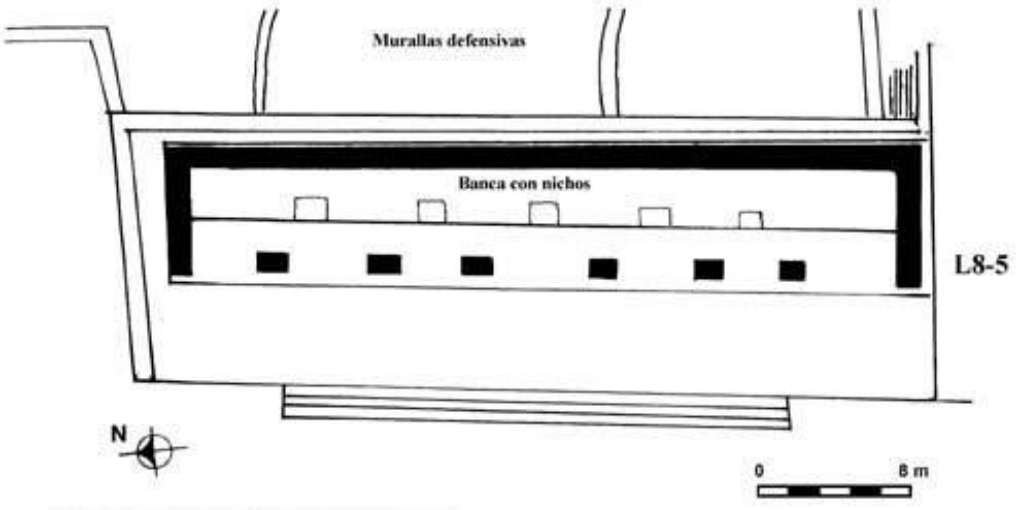

Fig. 20: Structure L8-4 (Ponciano and Inomata 2004, 9)

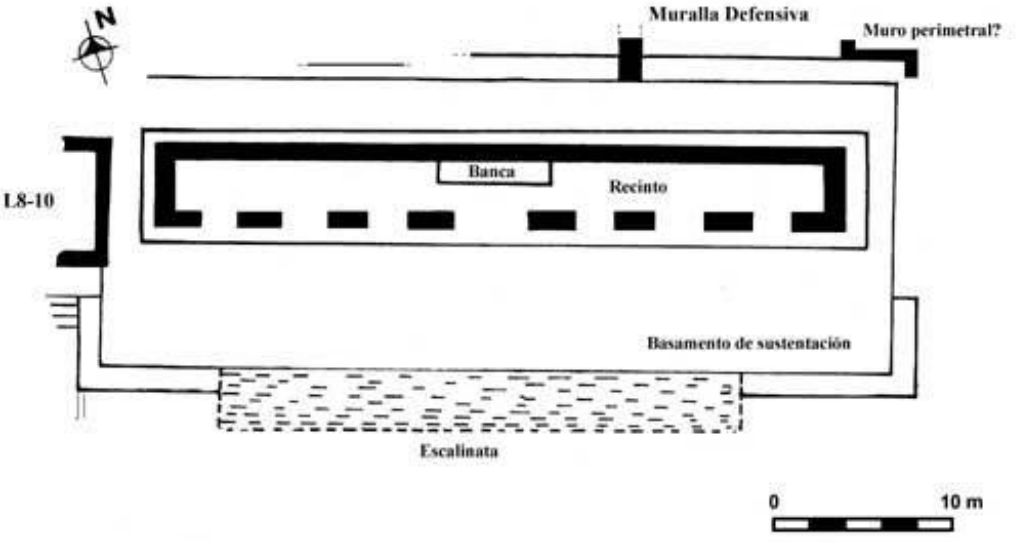

Fig. 21: Structure L8-11 (Ponciano and Inomata 2004, 8)

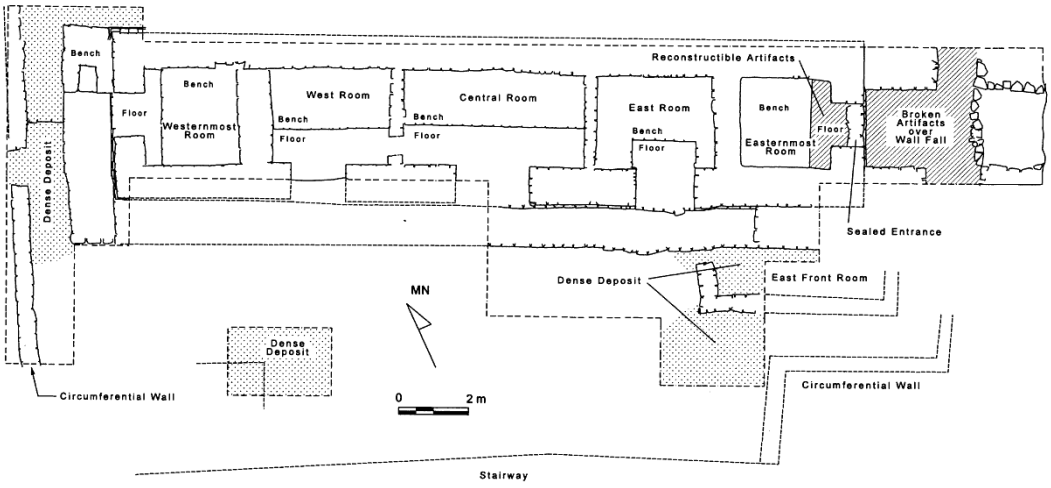

Fig. 22: Structure M7-22 (Inomata et al. 2001, 291)

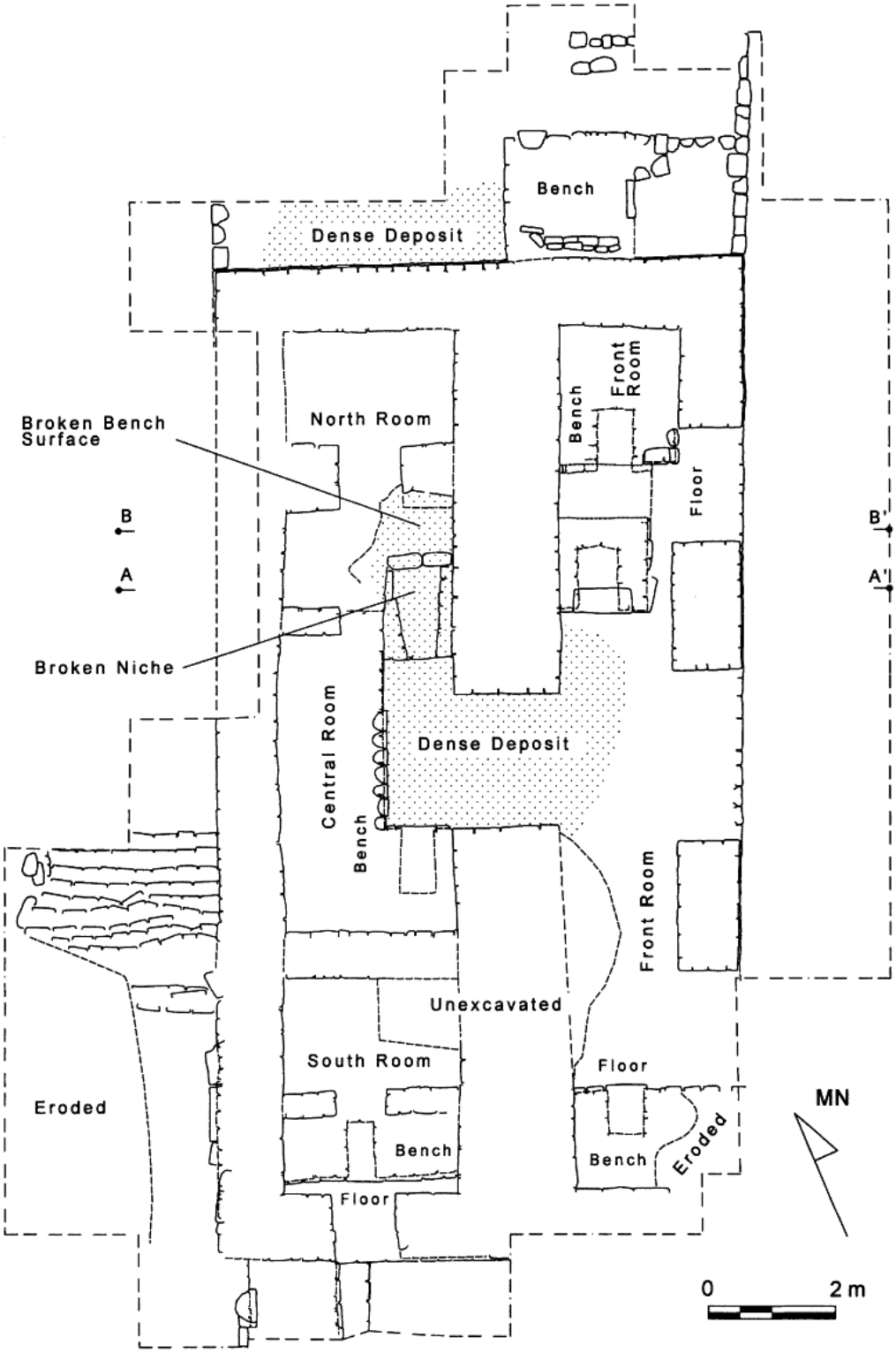

Fig. 23: Structure M7-32 (Inomata et al. 2001, 295)

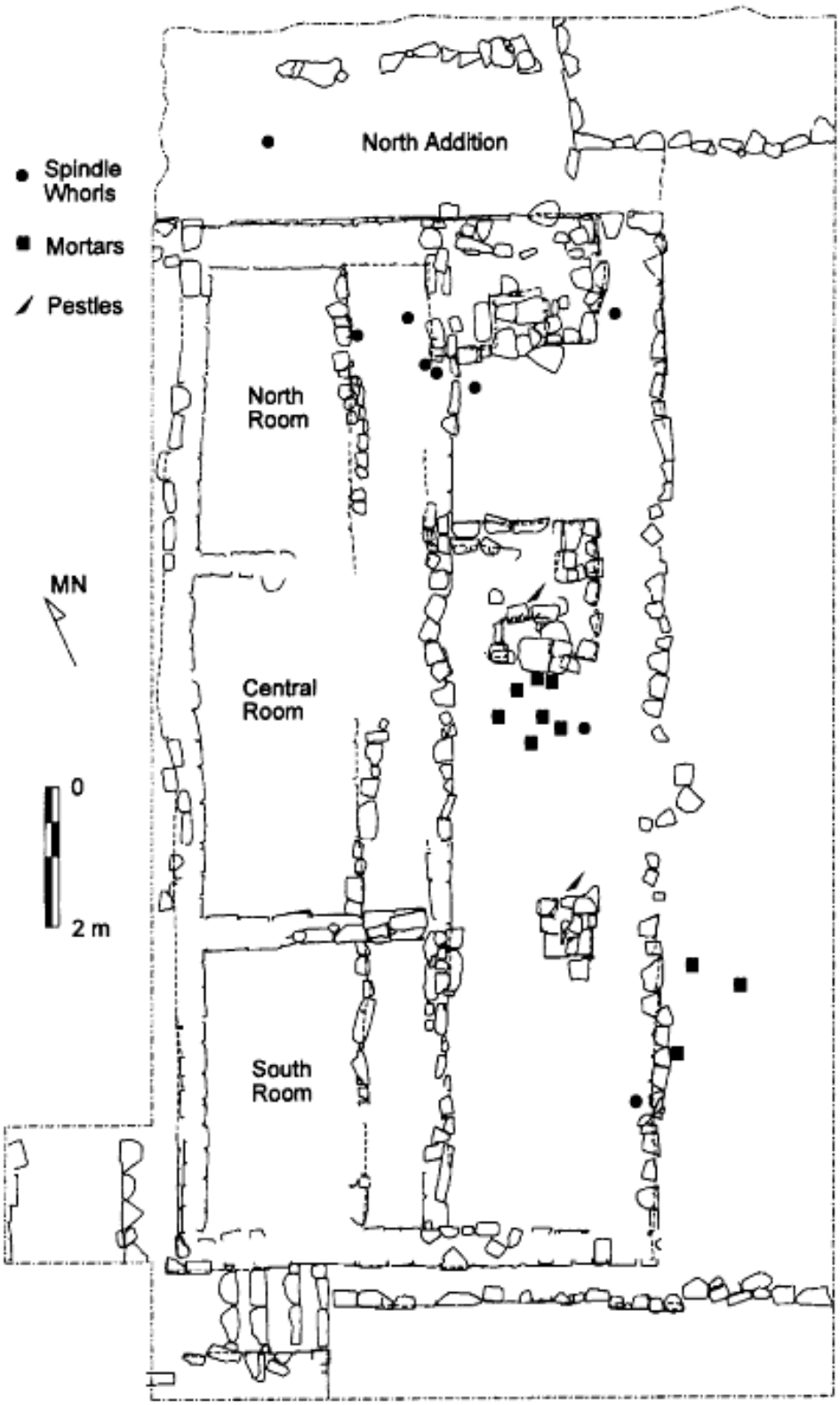

Fig. 24: Structure M8-4 (Inomata et al. 2002, 313)

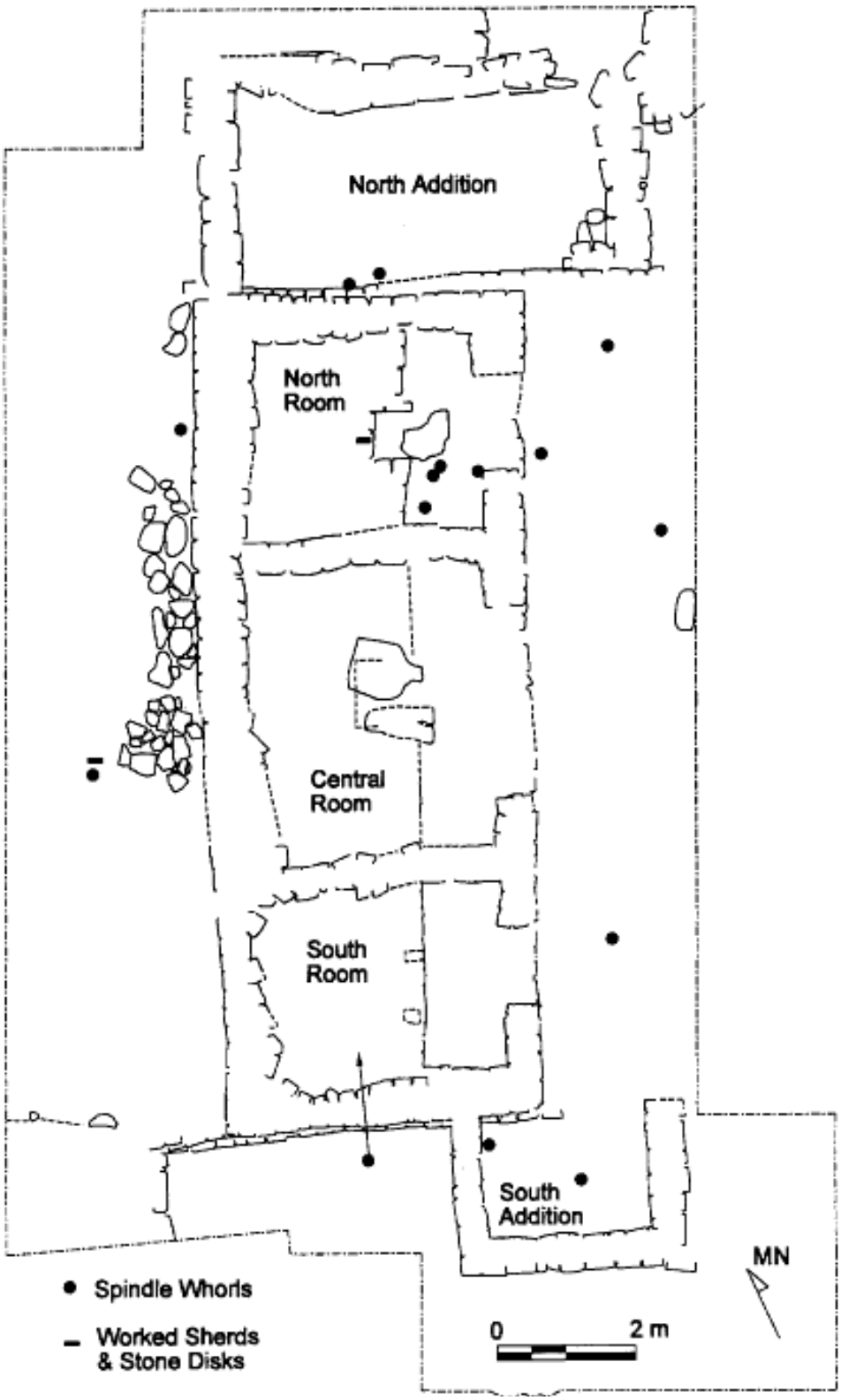

Fig. 25: Structure M8-8 (Inomata et al. 2002, 320)

APPENDIX B: Scripts

The following scripts were used next to standard inbuilt scripts. As those inbuilt scripts come along with any free download of the Unity program, they were not included in this section.

Script to put the walls on the terrain (explained intext)

```
function LandMesh(obj: Transform, offsetY: float)
{
varbaseY = Terrain.activeTerrain.GetPosition().y + offsetY;
varpos = obj.position;
pos.y = Terrain.activeTerrain.SampleHeight(pos)+baseY;
obj.position = pos; // define new object's position
var mesh = obj.GetComponent(MeshFilter).mesh;
varverts = mesh.vertices;
  for (var i = 0; i <verts.length; i++)
  {
var w = obj.TransformPoint(verts[i]); // get vertex in world space
var h = Terrain.activeTerrain.SampleHeight(w) + baseY;
w.y = w.y - pos.y + h; // find the new height
verts[i] = obj.InverseTransformPoint(w);
  }
mesh.vertices = verts; // update the vertices...
mesh.RecalculateBounds(); // bounds...
mesh.RecalculateNormals(); // and normals
  // update the mesh collider too
obj.GetComponent(MeshCollider).sharedMesh = mesh;
}

function Start()
{
LandMesh(transform, 1.5f);
}
```

Script to toggle the item the script is attached to

```
function Update()
{
   if (Input.GetKeyDown("2"))
{
renderer.enabled = !renderer.enabled;
collider.enabled = !collider.enabled;
   }
}
```

this script is actually used in various forms, in which the GetKeyDown changes depending on the key that was intended to use as toggle key. Also, for the map toggle, instead of the renderer and collider it was the camera that was enabled or disabled with the keypress, while the legend toggle only required the renderer to be toggled. In the above example, pressing the key "2" would make the object to which the script was attached either appear or disappear depending on its current status.

Turbo and Reset Script

```
function Update () {
        if (Input.GetKeyDown("t")){
        Turbo();
        }
        if (Input.GetKeyDown("r")){
        Reset();
        }
}

function Reset () {
varcharTransform = gameObject.GetComponent(Transform);
charTransform.position = Vector3(500,100,500);
}

function Turbo () {
varcharMotor = gameObject.GetComponent(CharacterMotor);
        charMotor.movement.turbo = !charMotor.movement.turbo;

        if (charMotor.movement.turbo)
                {
        charMotor.movement.maxForwardSpeed = 60.0;
                charMotor.movement.maxSidewaysSpeed = 60.0;
                charMotor.movement.maxBackwardsSpeed = 60.0;
                }
                else
                {
        charMotor.movement.maxForwardSpeed = 6.0;
                charMotor.movement.maxSidewaysSpeed = 6.0;
                charMotor.movement.maxBackwardsSpeed = 6.0;
                }
}
```

This script both sets the possibility of walking 10 times as fast ("t" key) and the reset function, which sets the user back to the starting position when the "r" key is pressed.

APPENDIX C: Tour through Aguateca

Video of the tour:

http://www.youtube.com/watch?v=p0V-y0AU8_o&feature=youtu.be

All figures in this appendix are screenshots taken by the author

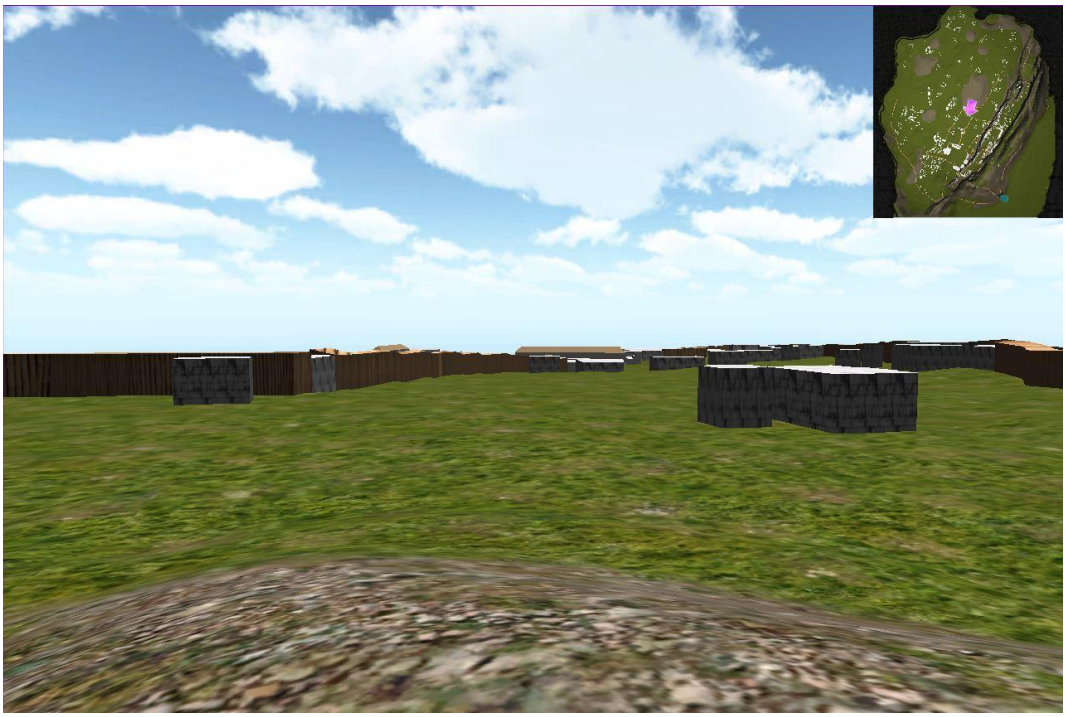

Fig. 26: Looking south from the starting point

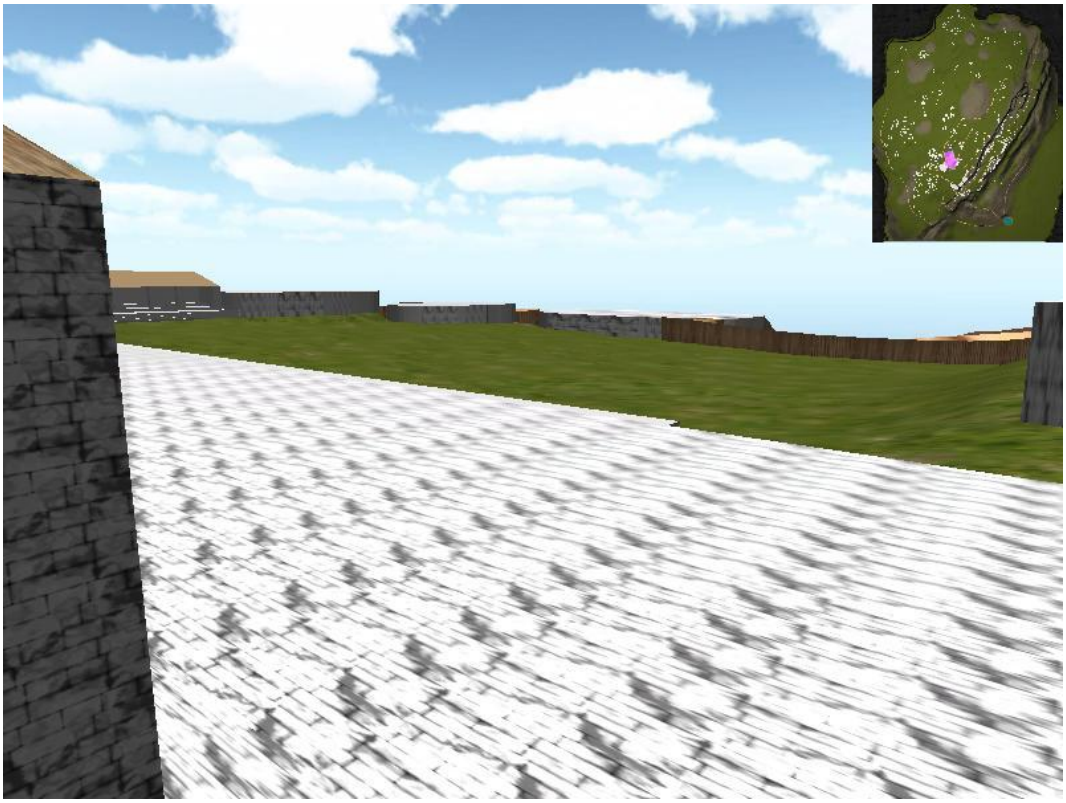

Fig. 27: Looking at the Main Plaza from the western side of structure L8-11

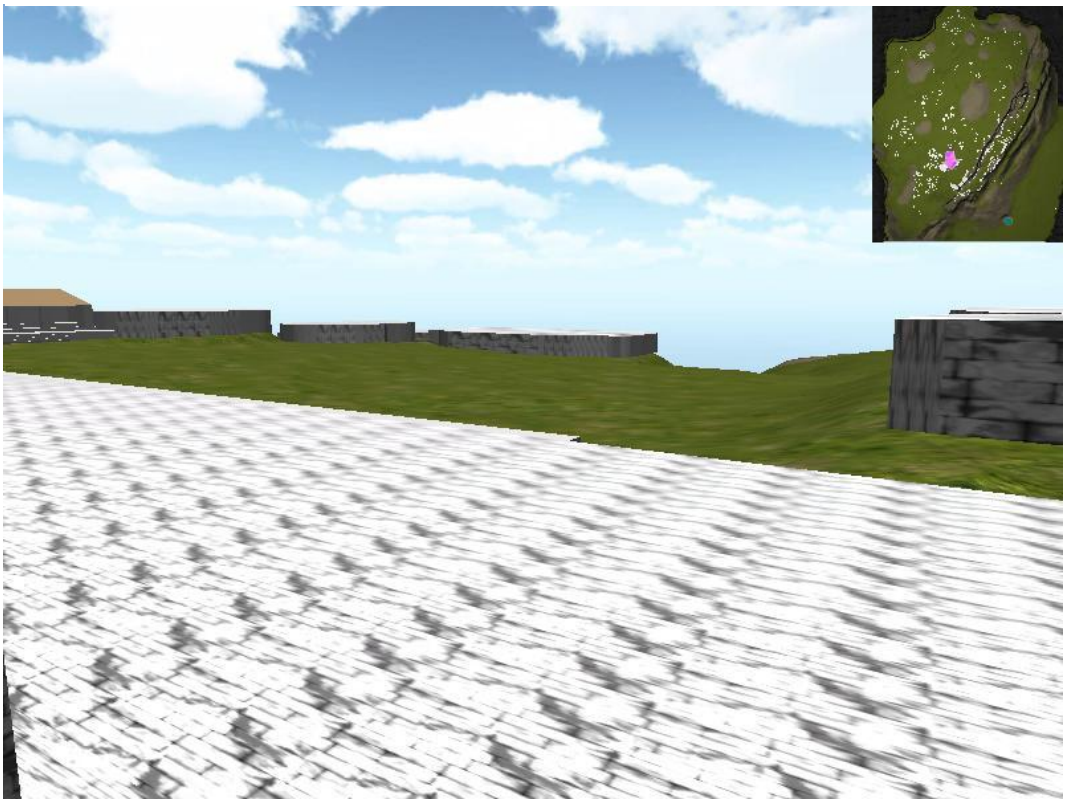

Fig. 28: Looking at the Main Plaza from the western side of structure L8-11 with the walls removed

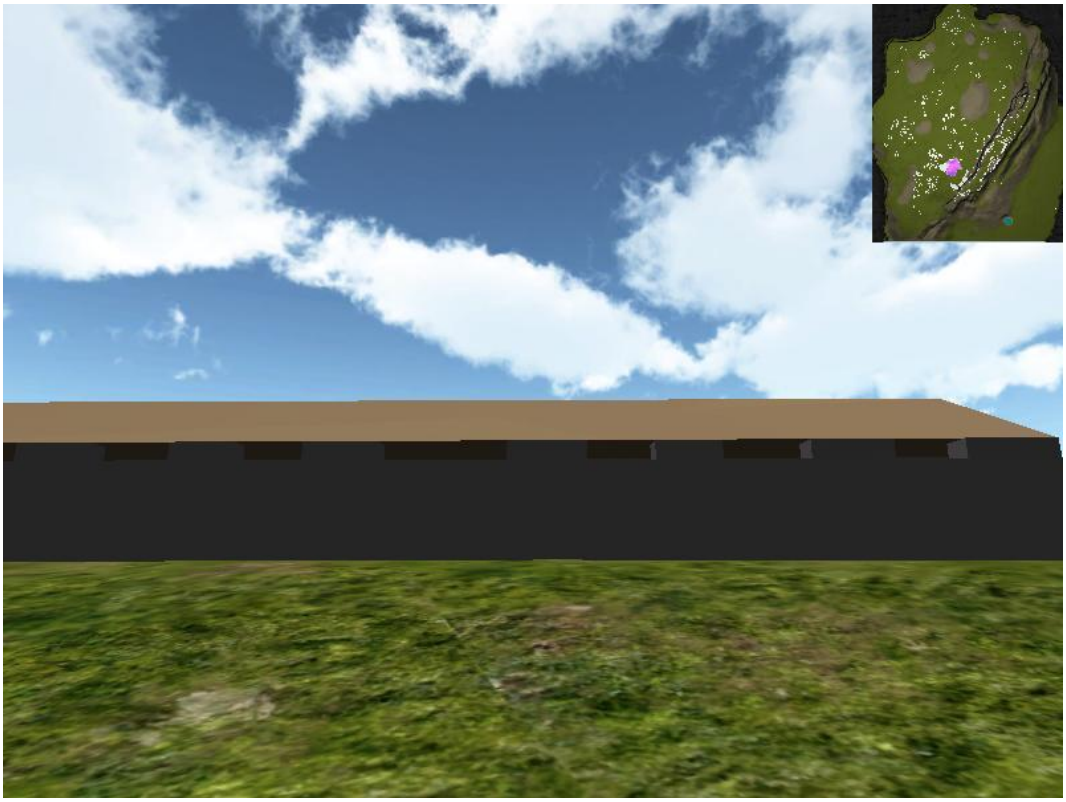

Fig. 29: Looking at structure L8-11 from a viewpoint on the Main Plaza close to it

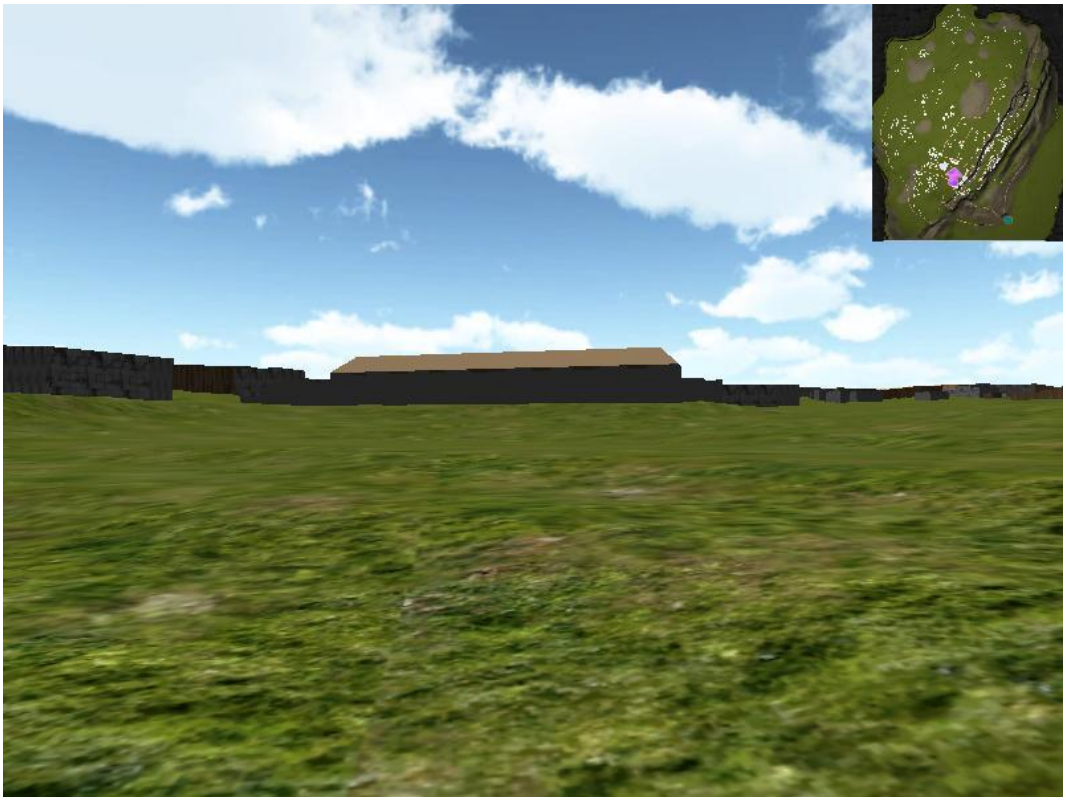

Fig. 30: Looking at structure L8-11 from further away

Fig. 31: Looking at structure L8-4 from a viewpoint on the Main Plaza close to it

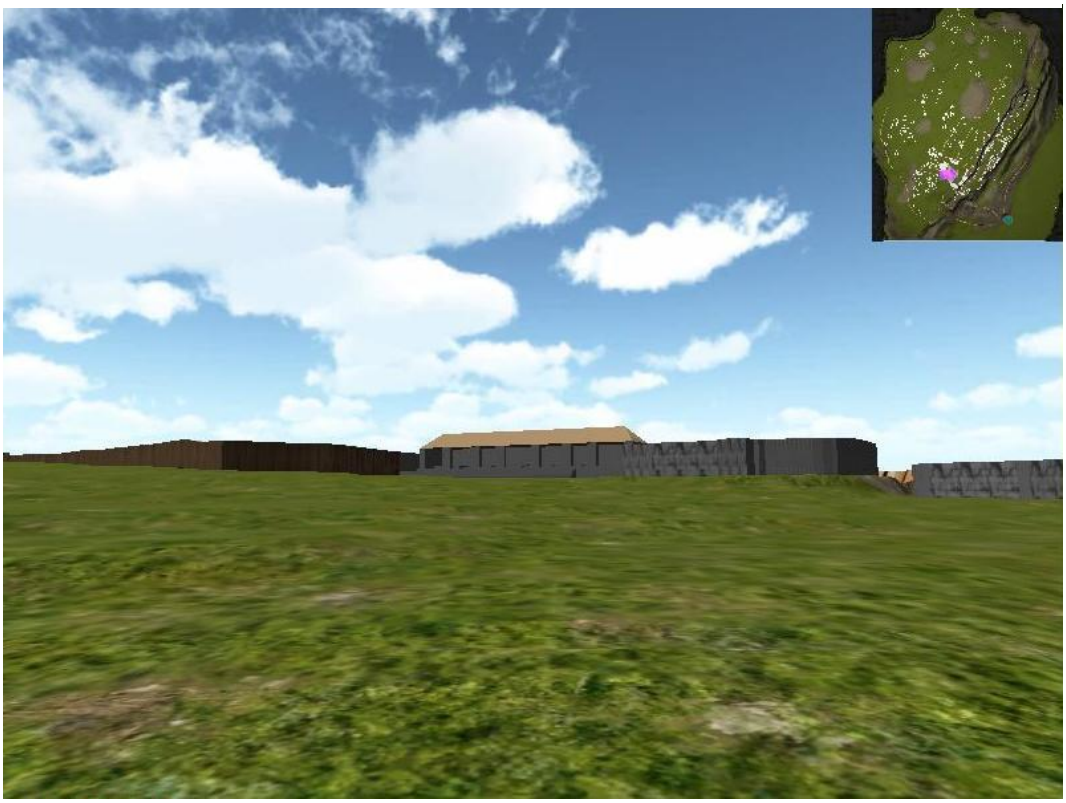

Fig. 32: Looking at structure L8-4 from further away

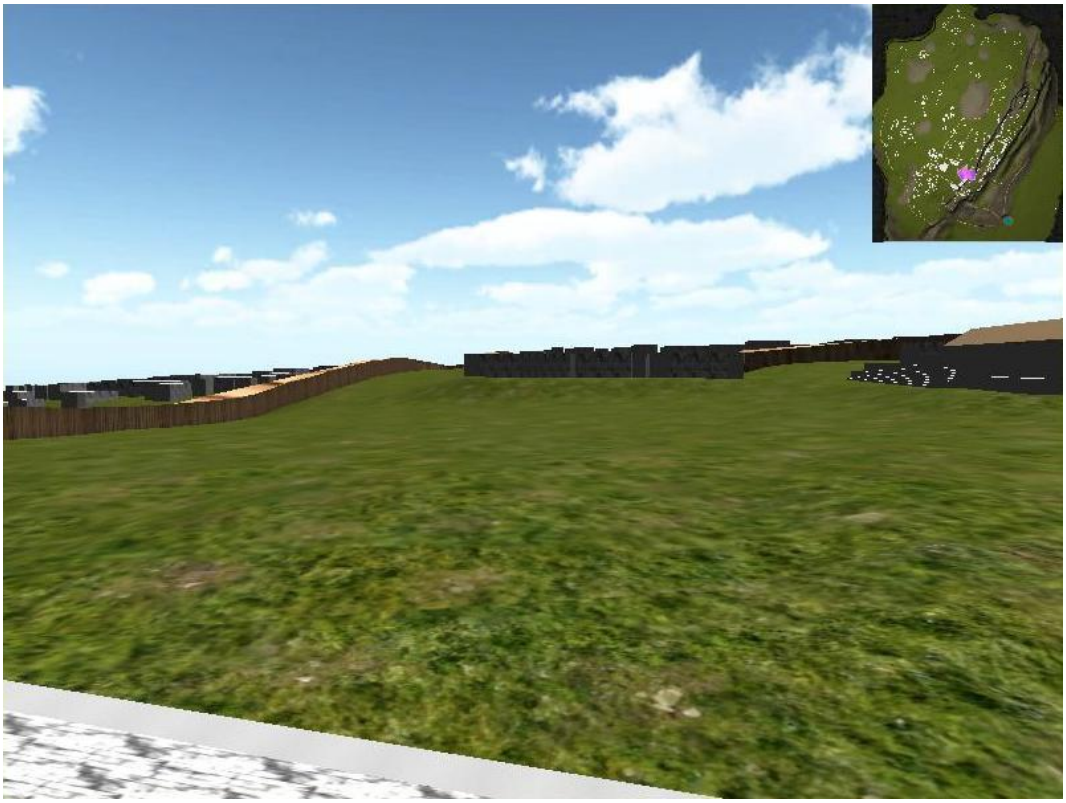

Fig. 33: Viewing the Plaza from the platform in front of structure L8-4

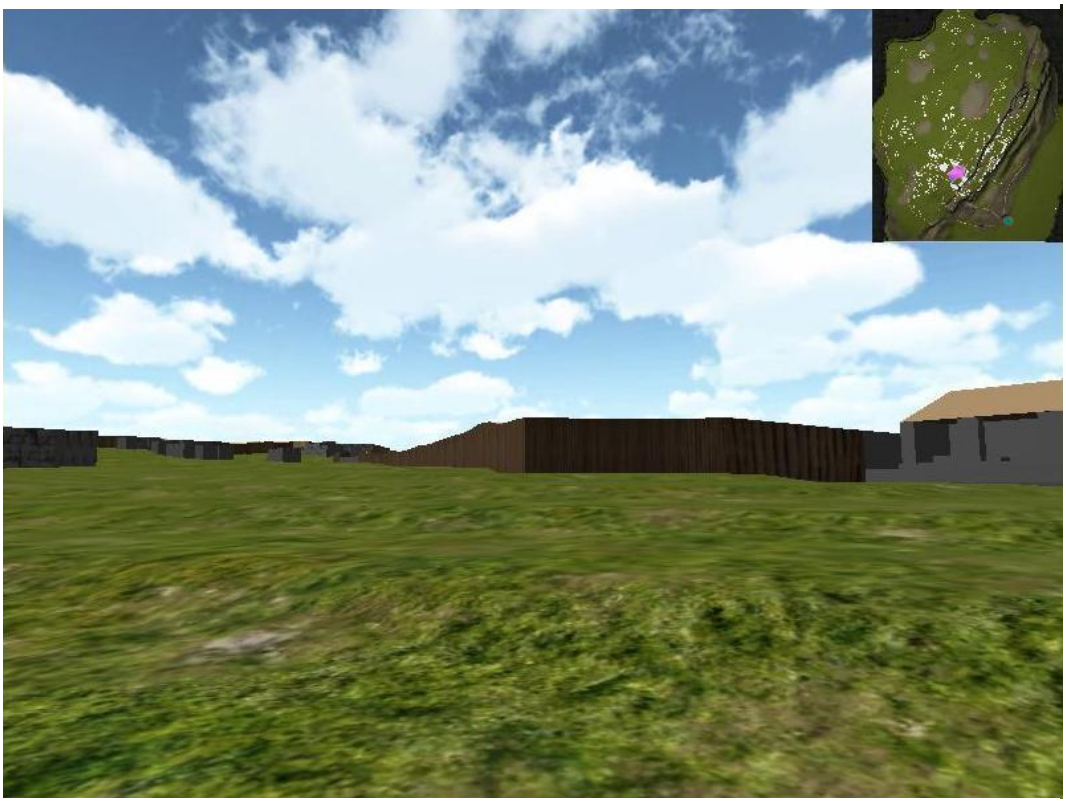

Fig. 34: Looking towards the northeast from the Main Plaza

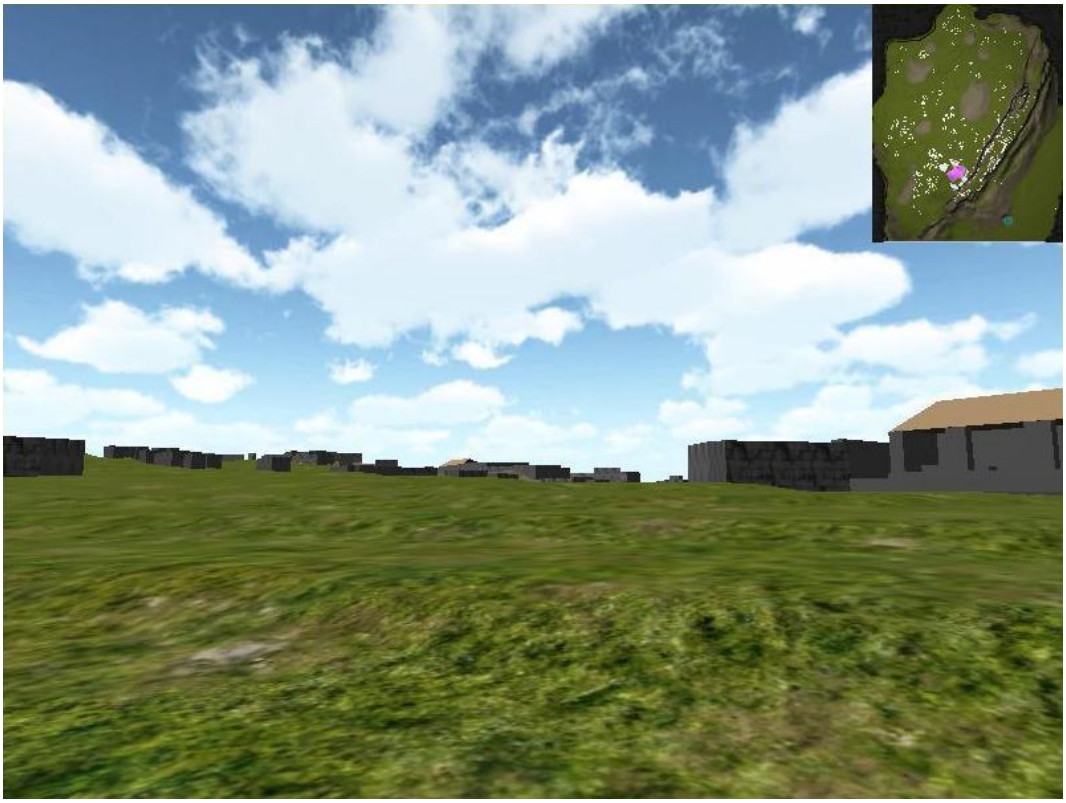

Fig. 35: Looking at the northeast from the Main Plaza without the walls

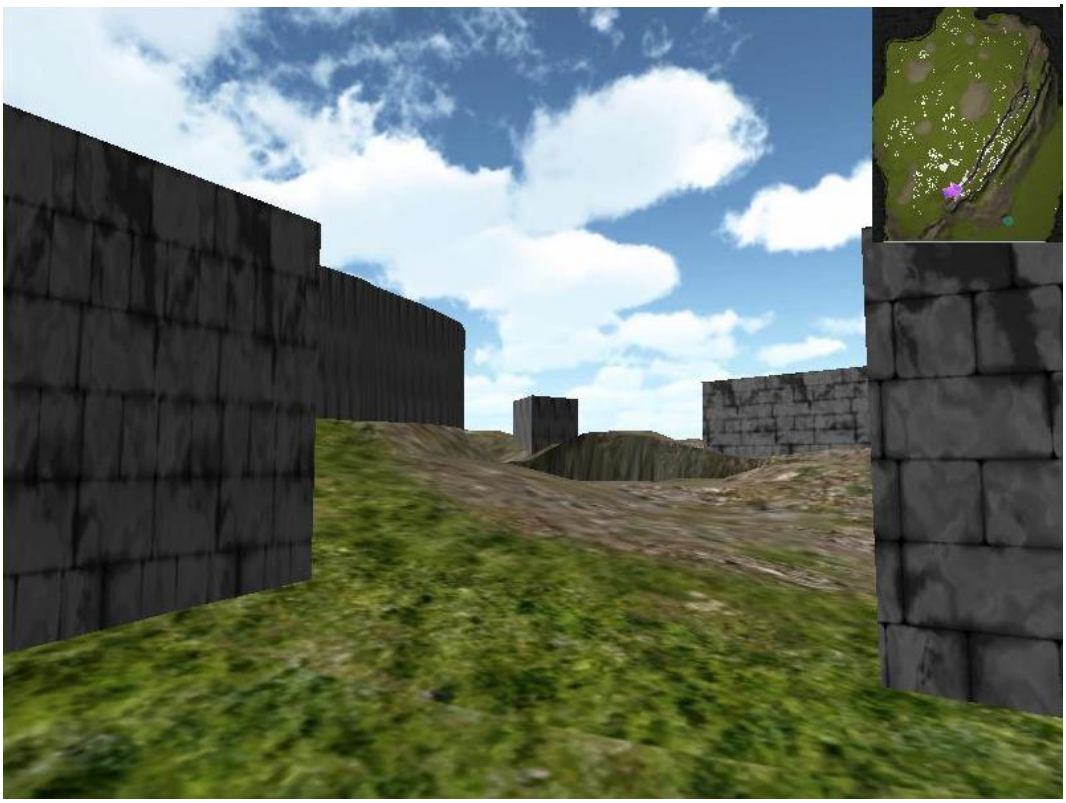

Fig. 36: Looking at the Causeway from a viewpoint south of the Main Plaza

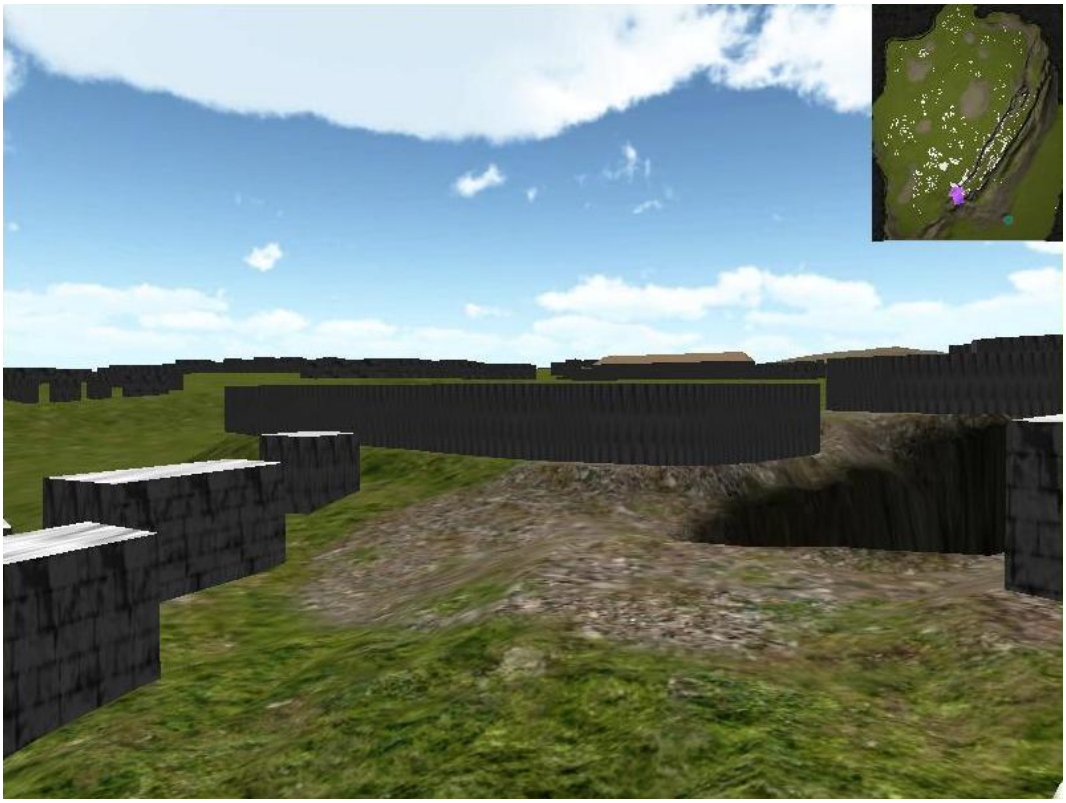

Fig. 37: Showing the access point to the Causeway from the Plaza

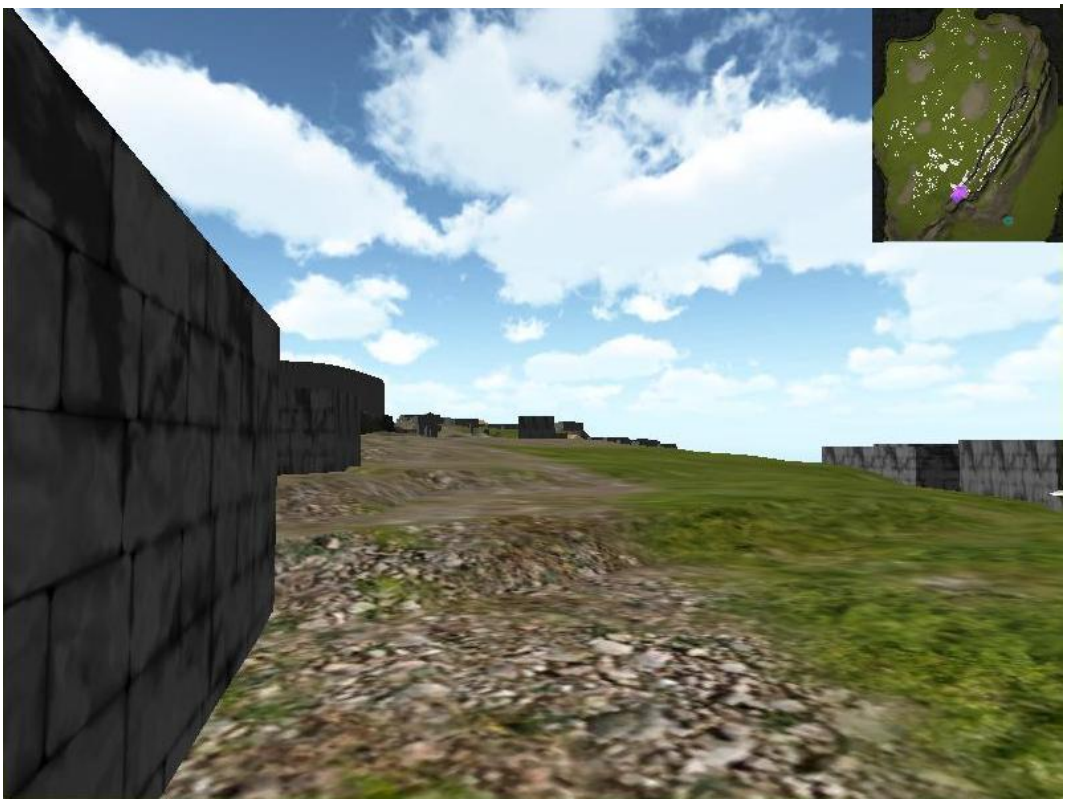

Fig. 38: Looking towards the Palace Group from the access point of the Causeway

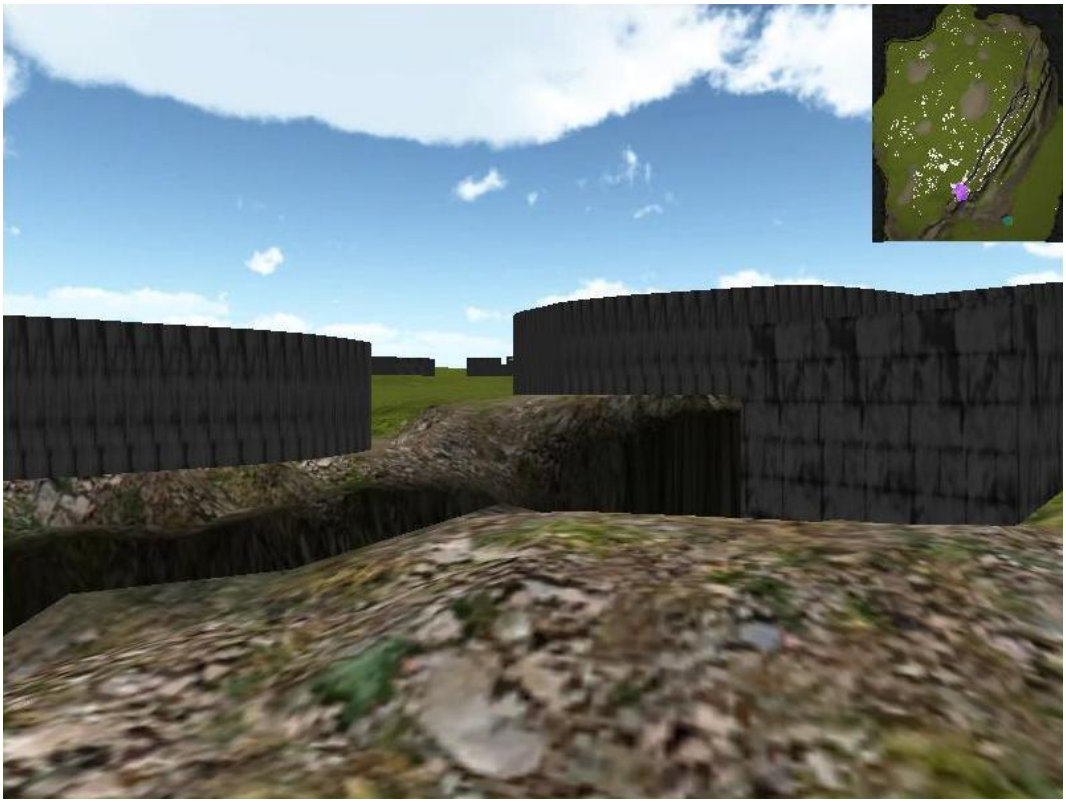

Fig. 39: Looking northwestwards at the Main Plaza from the Causeway

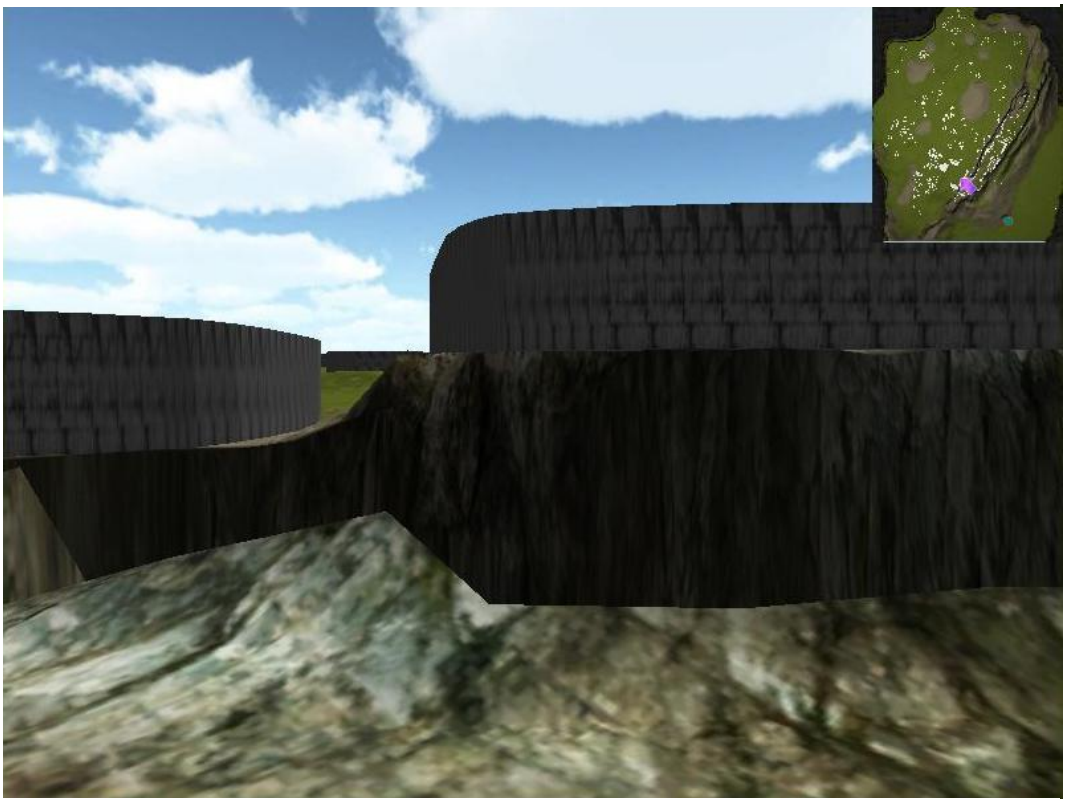

Fig. 40: Looking westwards at the Main Plaza from the Causeway

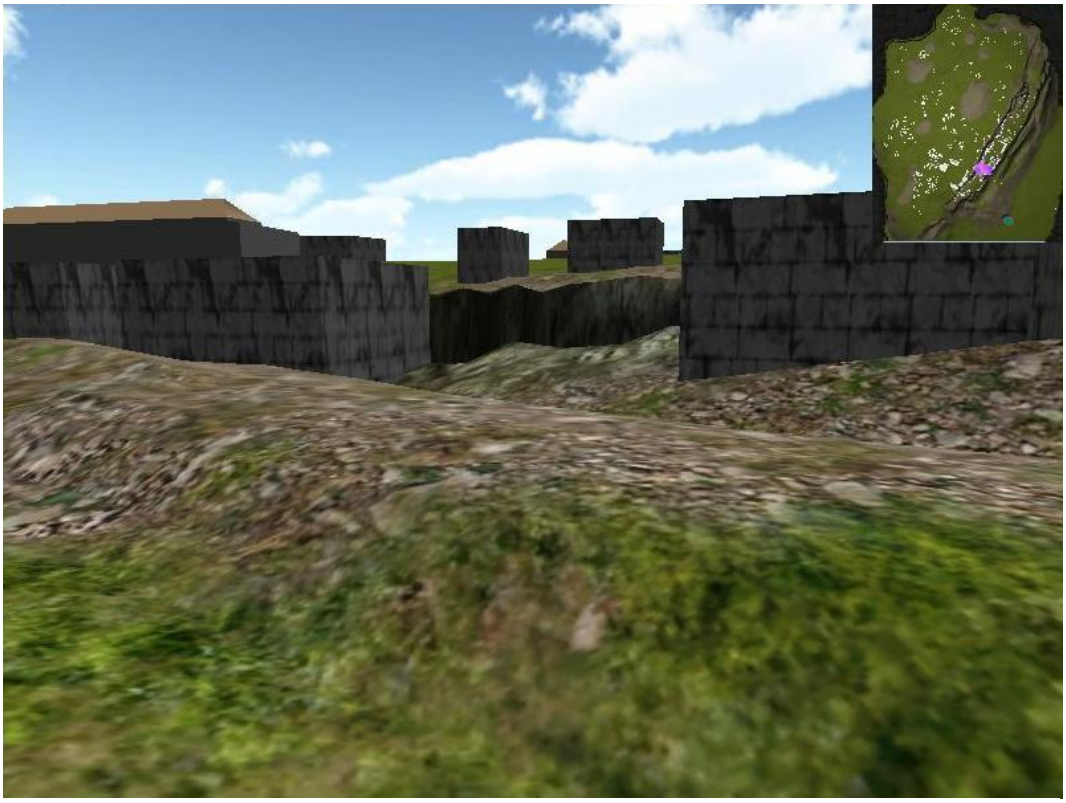

Fig. 41: Looking southwestwards at the Main Plaza from the Causeway

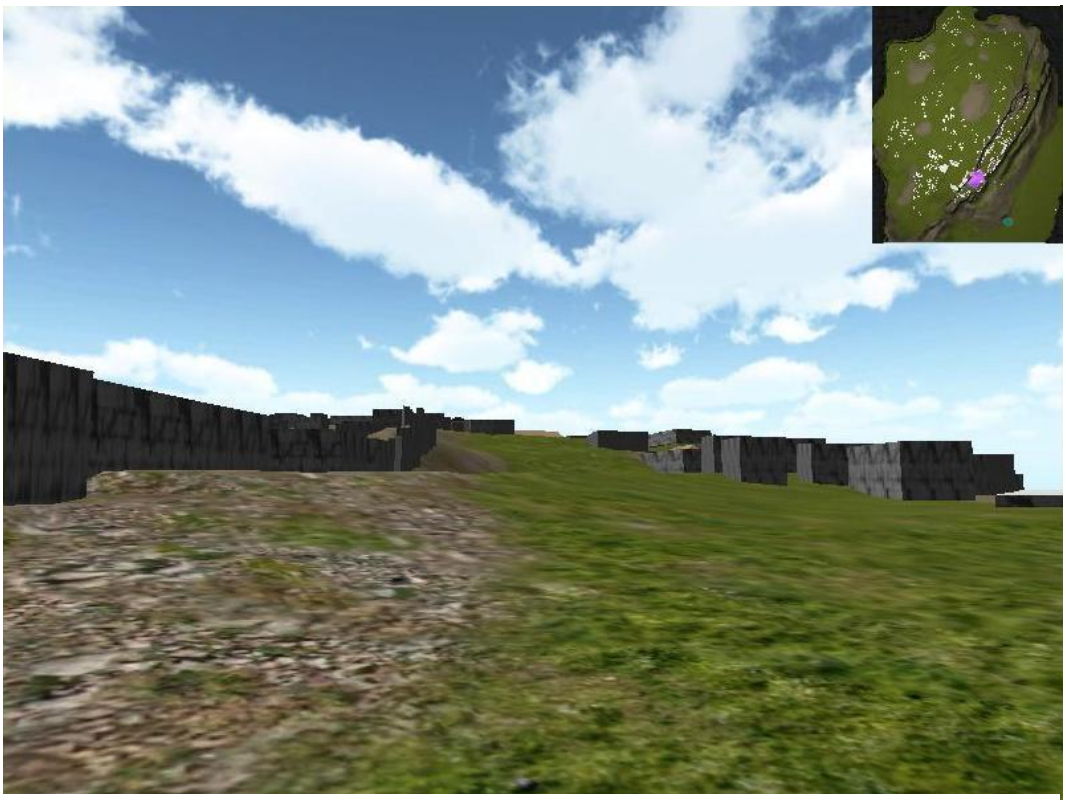

Fig. 42: Looking towards the Palace Group when halfway the Causeway

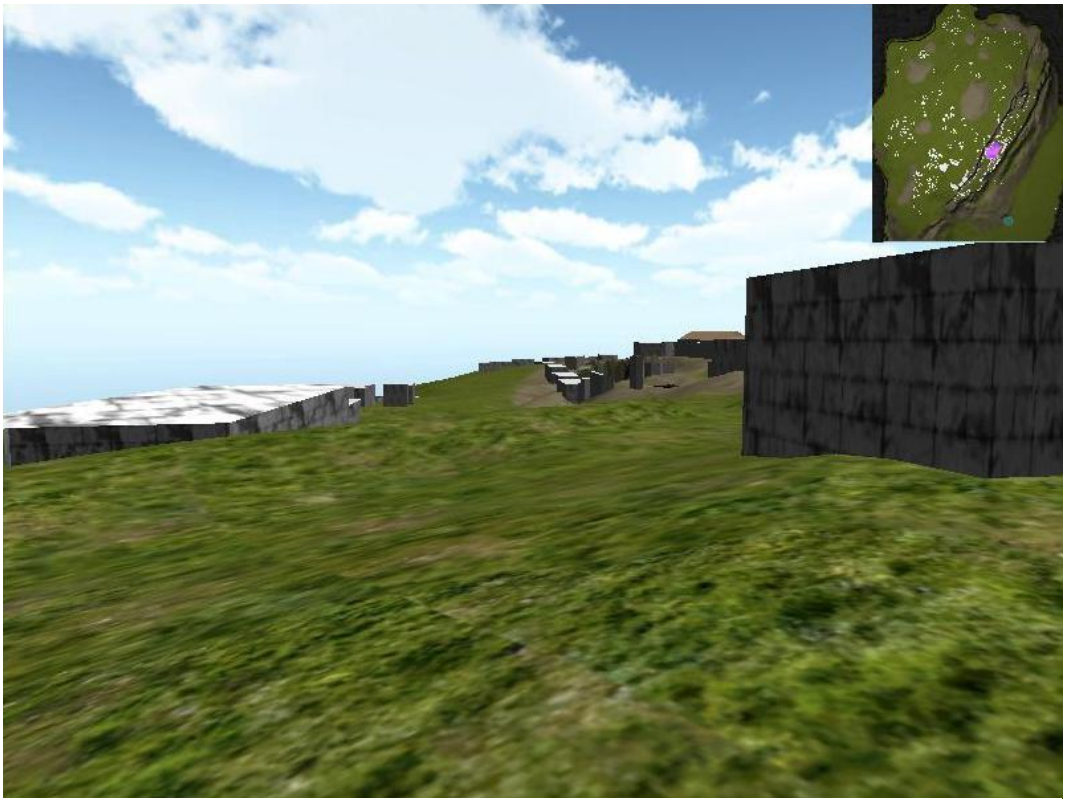

Fig. 43: View of the Causeway from the southern part of the Palace Plaza

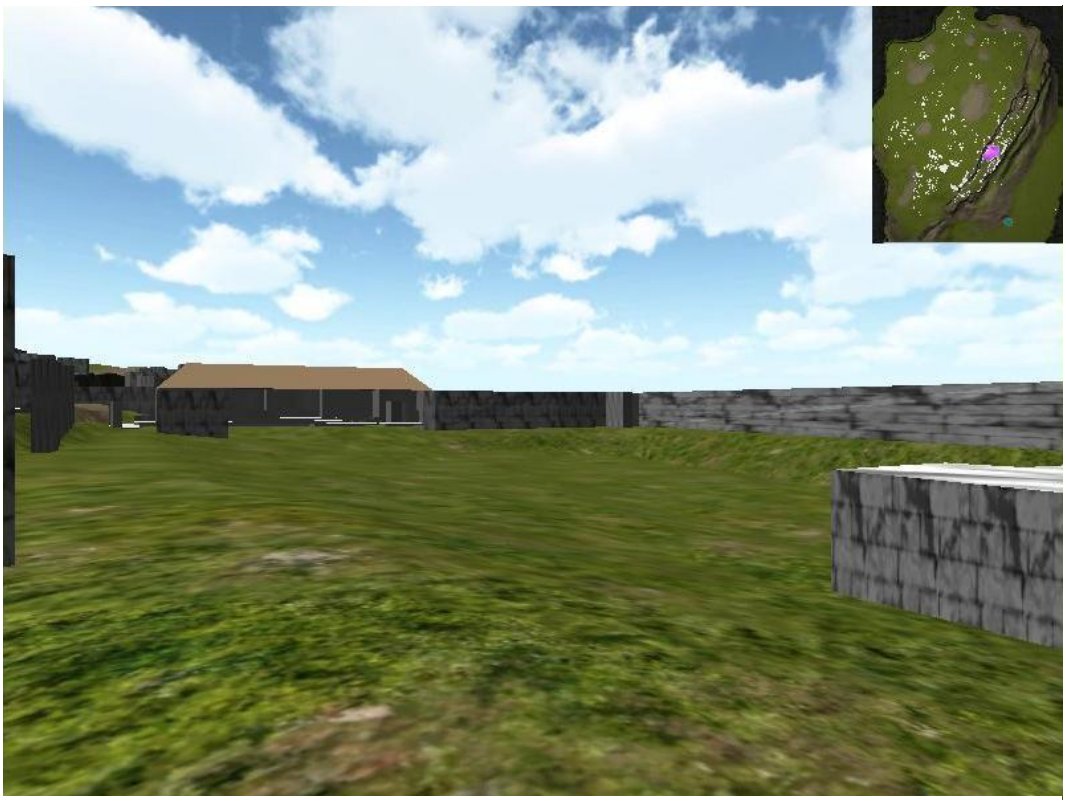

Fig. 44: View of the Palace Plaza from the entrance

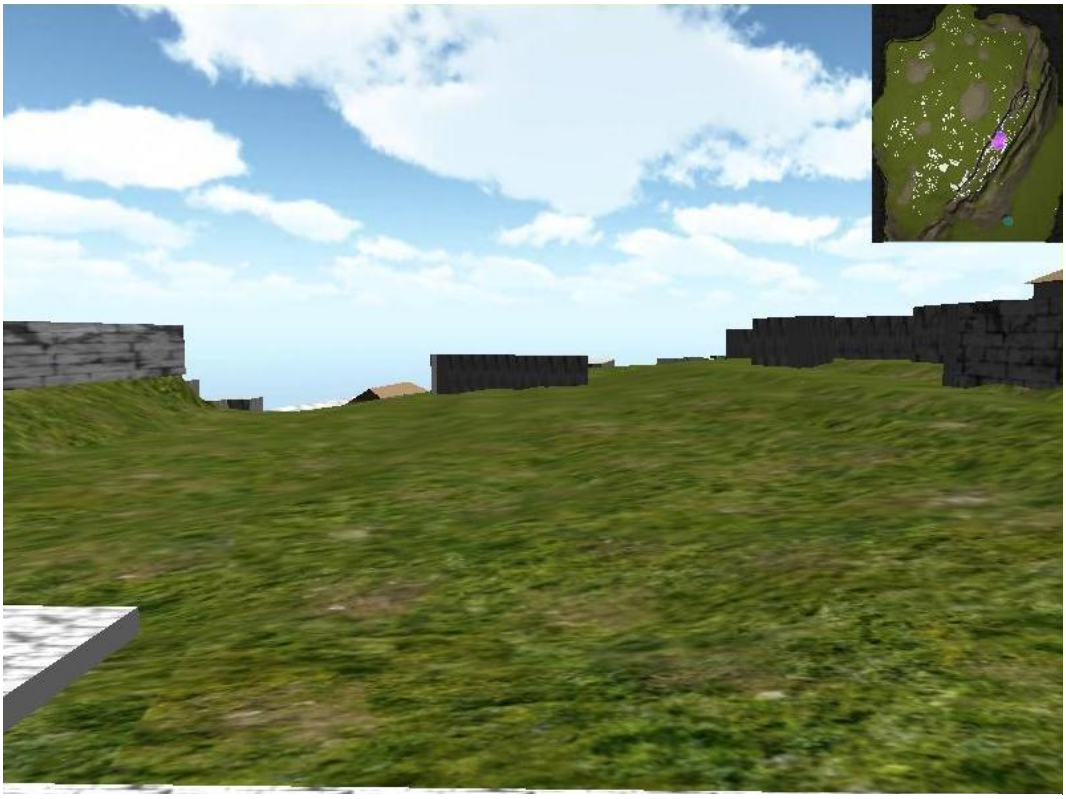

Fig. 45: View of the Palace Plaza from structure M7-22