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Pompeiian Mill-Bakeries: Spatial Organization and Social Interaction

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Pompeiian Mill-Bakeries: Spatial Organization and Social Interaction

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Introduction

"Traveler, you enjoy bread at Pompeii, but at Nunceria you drink."[1]

For centuries, laypeople and classicists alike have focused on the political and macroeconomic elements of feeding the Roman Empire: the politics of the grain dole – half of the famous 'bread and circuses' that could could make or break a regime – and the economics of the vast trade networks that carried grain across the Mediterranean Sea.[2] In contrast, we know much less about those whose task it was to transform grain into a final edible product – bread. Bread was a foodstuff that remained a staple of the ancient Mediterranean diet for centuries; it continues to be a staple foodstuff across the Mediterranean today. Yet without small-scale bread making operations scattered across cities of all sizes, not only would the politics and economics of grain distribution have been meaningless but also the social order and the lives of the Empire's would have been imperiled.

Indeed, those who performed the critical task of baking bread to feed the masses are largely forgotten. Their presence is assumed, but their lives and labor have been overlooked despite the necessity of their labor. This owes largely to the fact that many, if not all, of these bakers were of servile or low status. As a result, there is little textual evidence about those who produced the bread that fed the Roman Empire. Instead, the most significant evidence is archaeological, most notably the remains of mill-bakeries from the city of Pompeii, preserved by the eruption of Mt. Vesuvius in 79 CE. This thesis aims to shed light on the importance of these anonymous bakers and provide a framework for understanding their lives by analyzing the

[1] *CIL* IV.8903.
[2] For more information on the political and macroeconomic aspects of grain in ancient Rome, see Geraci 2018.

spatial organization of bread production within several representative mill-bakeries from Pompeii. More specifically, the aim is to apply the methodology of spatial syntax – a theory of spatial relations developed by B. Hillier and J. Hanson – to determine patterns of social interaction within the mill-bakeries. By analyzing patterns of social interaction in this way, combined with artistic and literary descriptions of Roman mill-bakeries, this thesis will provide fresh insights into the lived experiences of the mill-bakers who fed the Roman Empire.

In order to bring to life these anonymous mill-bakers, we must first understand what they produced, how they produced it, and where they produced it. Chapter One examines the bread produced by these mill-bakers and how it fitted into the ancient Mediterranean diet more broadly. Chapter Two discusses the process by which bread was produced in Pompeii, while Chapter Three discusses the history of Pompeiian mill-bakeries and the methodologies employed in this study. Chapter Four describes and analyzes five unique mill-bakeries – I.12.1-2, VI.2.6, VII.1.36-7, IX.1.3/33, and IX.5.4 – in order to reconstruct the lived experiences of the workers who fed the empire.[3]

It does not seem unreasonable to argue that there would have been no Roman Empire without bread, and there would have been no bread without mill-bakers. The hope is that by analyzing the archaeological remains of mill-bakeries through the application of the methodologies of spatial syntax, we will gain a deeper appreciation for the importance of these neglected workers.

[3] The names of sites included in this study follow the nomenclature developed by archaeologists studying Pompeii. The first number, written in Roman numerals, refers to the *regio*, or neighborhood within the town. The second number refers to the *insula,* or city block, and the final number refers to the entrance(s) of the specific bakery. Thus, I.12.1-2 refers to the building located at Regio I, Insula 12, Entrances 1 and 2.

Chapter One: A Brief Overview of the Roman Diet

There was no single Roman diet in the first century CE; just as today, diet varied significantly based on region, cultural beliefs, and class. Nevertheless, copious literary sources and the unique preservation of sites have provided scholars a reasonable understanding of the 'average' Roman diet in the region of Campania.[4] The eruption of Mt. Vesuvius preserved evidence of a population with a widely varied diet. The fertility and abundance of Campania, the fertile plain in which Pompeii is located, was well-known to Roman authors, who associated the region with agricultural deities, such as Bacchus and Ceres.[5] Pliny the Elder asserts in his *Natural History* that "the land was in crop all the year round" and it "never tired of giving birth."[6] This fertile countryside provided a wide variety of cultivated foodstuffs to the residents of Pompeii. Carbonized food remains recovered from Pompeii and Herculaneum include nuts, fruits, and legumes.[7] The easily accessible coastline led to widespread consumption of fish and seafood – often in the form of the fermented fish sauce *garum* – by large portions of the population. Isotopic analysis of skeletons from Herculaneum indicate that fish and other seafood made up around 30% of the dietary protein. This was augmented by terrestrial sources of protein, most especially lamb and pork.[8] Within this wide variety of available foodstuffs, the ancient diet

[4] For a more extensive discussion of diet in the ancient world, see Garnsey 1999, Donahue 2015, and Erdkamp and Holleran 2019.
[5] De Simone 2016, 33.
[6] Plin. *NH* 18.29, trans. H. Rackham, 1961. Pliny the Elder, hereafter referred to as Pliny, wrote in the middle of the first century CE, and thus was contemporaneous with the mill-bakeries studied in this paper. Pliny famously had a home in Campania and perished in the eruption of Mt.Vesuvius in 79 CE, which preserved these mill-bakeries. According to his nephew, the *Natural Histories* was his last work, probably written in the decade before his death. Pliny the Younger, *Letters,* III.V, trans. Betty Radice, 1969.
[7] Meyer 1980, 401-37.
[8] Rowan 2019, 298-300.

was especially defined by the Mediterranean triad of grapes, olives, and cereal grains. These foodstuffs provided the majority of an individual's caloric intake, and were considered to be the foodstuffs of 'civilized' people. They involved relatively common plants undergoing complex technological processes in order to be transformed into sophisticated final products.

The Mediterranean Triad: Grapes and Wine

The first element of the Mediterranean triad – the grape – was consumed mainly in the form of wine.[9] Although the Romans consumed other beverages, wine was considered the beverage par excellence in the ancient Mediterranean world. Unlike other processed beverages consumed by Romans, including milk and beer, wine could be shipped over considerable distances.[10] Thus, while local tastes in beverages persisted throughout the empire, wine was an iconic beverage associated with belonging to the civilized Greco-Roman world across the Mediterranean. Grapes were grown and processed into wine all across the Roman Empire, with wines from Italy being considered to be of a particularly high quality. Pliny calls Italy the 'special parent' – *peculiaris parens* – of viniculture; elites from across the empire imported high quality Italian wines to serve at their banquets.[11] Meanwhile, the lower classes consumed lower-quality sweet wine mostly from Italy and Southern Gaul.[12] In Pompeii, local wines were popular with Romans of all classes; the most common wine was called *Vesuvinum,* made from one of the four varieties of wine grapes cultivated on the slopes of Mt. Vesuvius.[13] Graffiti from one Pompeiian bar shows cheap wine was available for a price of one *as,* a nominal amount,

[9] For more information on ancient viniculture, see McGovern 2019.
[10] Broekaert 2019, 141-2.
[11] Plin. *NH.* 14.1, trans. H. Rackham.
[12] Broekaert 2019, 145-7.
[13] De Simone 2016, 33.

while better wines were available for two and four asses each.[14] It is difficult to determine exactly how much wine the Romans consumed as there is little information about the consumption patterns of the lower classes. Written sources focus almost exclusively on the elite who consumed considerable quantities of high-quality wines with every meal.[15]

Wine was produced by a process of treading and pressing grapes in order to extract the fresh grape juice – *mustum* or must – that was then fermented. Since grapes are soft, no special equipment was used to break the skin and begin the process of separating the must from the pulp. Workers used their bare feet to squish the grapes in a special treading vat. The grape pulp and skins were then pressed multiple times to extract the rest of the juices. The juice was filtered into the fermentation vats – *dolia* – where it was left to ferment naturally.[16]

The Mediterranean Triad: Olives and Olive Oil

The vast majority of the fat consumed by the Romans came from a single source: olives. The edible fruit of the *olea europaea* tree, olives were consumed both as table olives – made by either pickling or drying the fruit – and as olive oil.[17] It is estimated that Romans in olive-producing regions consumed an average of 20 liters of olive oil per year – roughly one-fifth to one-sixth of an individual's caloric intake.[18] Olive oil was also a source of micronutrients such as vitamins E and K.[19] Olives are successfully cultivated only in regions with mild winters and dry hot summers – regions with a true Mediterranean climate.[20] Thus, for those who lived away from the coasts and river valleys where olives could be cultivated, olive oil

[14] CIL IV.1679.
[15] Broekaert 2019, 140.
[16] Thurmond 2006, 121-132.
[17] Rowan 2019, 132.
[18] Rowan 2019, 135-8.
[19] Rowan 2019, 136.
[20] Garnsey 1999, 14.

was an imported good.[21] However, for the residents of Rome and Pompeii olive oil was a significant part of their diet. The region of Campania is well-suited to the cultivation of olives; according to Pliny, the best olive oil came from Venafrum in Campania.[22]

The process of extracting oil from the olive fruit was very similar to the process of making wine from grapes. First, the olive was crushed into a paste by a rotary mill known as a *trapetum* or *mola olearia*.[23] The olive pulp was then pressed multiple times until all of the liquid had been extracted from the pulp.[24] The same presses were often used for both wine and olive oil production at different times of the year.[25] Finally, the extracted liquid – consisting of oil, water, and solids from the olive pulp – is left to settle in large vats (*dolia*) until the oil separates from the rest of the mixture. The oil is skimmed off the top and placed in sealed vessels to be sold.[26]

Olive oil served a variety of purposes, not all of them culinary. It was also used for both personal hygiene and as lamp fuel.[27] As part of the Roman diet, olive oil was served as a "marinade for meat and fish, a cooking medium, a dressing for cooked food and green vegetables, and as a conserving agent."[28] It was a critical source of flavor and fat in a diet that relied heavily on cereal grains.

The Mediterranean Triad: Cereal Grains

Since the first tentative experimentations with agriculture about 10,000 years ago, cereal grains have been the most important staples for the vast majority of civilizations. The Romans

[21] Rowan 2019, 133-4.
[22] Plin. *NH*. 15.3.
[23] Thurmond 2006, 92. The Roman polymath and prolific author Varro used the terms *trapetum* and *mola olearia* interchangeably; however, Columella, an agricultural writer of the first century CE, argues they refer to two separate types of rotary mill.
[24] Thurmond 2006, 100.
[25] Thurmond 2006, 124-5.
[26] Thurmond 2006, 105-9.
[27] Rowan 2019, 133.
[28] Donahue 2015, 87.

were no different; it is estimated that about 60% of their caloric intake came from cereals.[29] While the exact percentage varied significantly depending on social class and region, it is certain that cereals were a key staple across the Roman Empire.[30] The Romans produced a wide variety of cereal crops; however, wheat – generally defined as any (sub)species of the genus *triticum* – was the most important, largely due to it being considered the most suitable for making bread.[31]

Pliny's *Natural History*, the best ancient textual source on the varieties of cereal, comments on the wheat produced in the Roman Empire, stating that "varieties of wheat are not the same everywhere, and where they are the same they do not always bear the same name."[32] This illustrates one of the central issues with determining exactly what subspecies of wheat were produced by the Romans: the imprecise terminology used in both ancient and scholarly sources.[33] Furthermore, multiple varieties of wheat were often produced in a single context in order to reduce risks associated with crop failure. Multiple wheat (sub)species are present in almost any archaeobotanical context, alongside barley and other minor cereal crops.[34]

The varieties of wheat available to the Romans can be divided into two broad categories: husked wheat — wheats in which the husk is fused with the kernel and cannot be removed without roasting and pounding[35] — and naked wheat —wheats which could be freed from their husks by threshing instead of roasting.[36] The naked wheats most commonly used by the Romans include *triticum durum,* a hard wheat that is used today to make pasta and is grown widely in

[29] Garnsey 1999, 12.
[30] Heinrich 2019, 107.
[31] Heinrich 2019, 102.
[32] Plin. *NH.* 18.14.
[33] Heinrich 2019, 102.
[34] Heinrich 2019, 103.
[35] Thurmond 2006, 18.
[36] Moritz 1958, xxii-xxiii.

modern Sicily.[37] Although *triticum durum* was used to make bread in antiquity, the preferred wheat for breadmaking was *triticum vulgare*.[38] Also known as the subspecies *aestivum* of the species *triticum aestivum,* today it accounts for 95% of all wheat cultivated.[39] The Latin term for this wheat is *siligo*; discussions of cereal varieties in Roman literature assert that the best bread was made from *siligo*. Pliny states:

" Common wheat [*siligo*] I may properly designate the choicest variety, whether in whiteness or goodness or weight… Common wheat [*siligo*] flour makes bread of the highest quality and the most famous pastry."[40]

Alongside his discussion of the variety of cereal crops available to the Romans of the mid-first century CE, Pliny states that until the third century BCE, there were no bakers or bakeries in Rome.[41] Instead, cereals were prepared into finished consumable products at home by women. Even after the emergence of professional mill-bakers, cereals continued to be processed in domestic contexts on a modest scale, especially in rural areas. According to Pliny, the early Romans did not eat bread; instead they ate porridge – *puls* – made from emmer wheat – *far*.[42] Emmer wheat is husked and requires roasting; it is thus better suited for making porridge than making bread.[43] Pliny cites the Roman custom of offering porridge instead of bread at certain rituals as evidence for the historic significance of porridge.[44] As the Romans shifted from the cultivation of emmer wheat to the cultivation of naked wheats, likewise they shifted from relying

[37] *Triticum durum* is either a synonym for or a subspecies of *triticum turgidum*; it is also known as 'hard wheat,' 'macaroni wheat,' or 'semolina wheat.' Moritz 1958, xxiii; Thurmond 2006, 20; Heinrich 2019, 103.
[38] Moritz 1958, xxiv.
[39] Heinrich 2019, 102-3.
[40] Plin. *NH.* 18.20.
[41] Plin. *NH.* 18.28.
[42] The scientific name for emmer wheat is *triticum turgidum* subspecies *dicoccon*. See Heinrich 2019, 103.
[43] Moritz 1958, xxii.
[44] Plin. *NH.* 18.19.

on porridges as a dietary staple to relying on bread. Even so, the Romans did not entirely abandon porridge; it retained its role in certain rituals, and likely continued to be part of the diets of the lower classes.[45] However, by the middle of the second century BCE it was bread which defined the Roman diet.

The definition of bread – *panis* – seems obvious to most people, yet there are countless varieties of bread, many of which bear little resemblance to each other. For the sake of clarity, I adopt Frits Heinrich's definition of bread as "all solid foodstuffs made out of any grade of fragmented cereal and/or other starchy staple that was mixed with a liquid to create a batter or dough and that has been solidified through baking or frying."[46]

To elaborate briefly on his definition, there are two main types of bread: unleavened and leavened bread. Unleavened bread is made by immediately baking or frying the dough, without any fermentation taking place. Leavened bread is bread made from dough fermented by microorganisms – either lactic acid bacteria (as in sourdough) or yeasts (as in most modern commercial breads). These microorganisms can either be naturally present in the environment or purposefully added. In the latter case, fermentation agents could either be immediately added to the entirety of the dough and kneaded or mixed with flour and water into a paste and allowed to ripen before being added to the rest of the dough.[47] Examples of fermentation agents used by the Romans include "grape must cakes (yeast occurs naturally on grape skins) or (fermented) cereal bran, crushed millets or pulse pastilles."[48] The Romans were familiar with many fermentation agents; however, it is generally agreed that Pliny is accurate when he asserts that bakers usually

[45] Thurmond 2006, 18.
[46] Heinrich 2019, 105.
[47] Thurmond 2006, 61.
[48] Heinrich 2019, 106.

use a starter made from " the dough kept over from the day before" as a fermentation agent.[49] Fermentation produces bread that is lighter and airier than its unleavened counterparts, and thus generally considered more pleasant to eat. Both literary sources and the archaeology of Pompeiian mill-bakeries demonstrate that the typical bread of the first century CE was a leavened loaf.[50]

Just as modern consumers can choose from a wide variety of breads, each suited to particular tastes and occasions, so too did the Romans. Pliny asserts that there are so many varieties of bread that "it appears superfluous to give an account of its various kinds."[51] However, both direct and indirect evidence of the bread produced in Pompeii points to a common form of a round loaf scored into sections.

Fig. 1. Carbonized loaf of *panes quadrati* from Pompeii, part of the *Museo Archeologico Nazionale di Napoli's* collection. Image provided by the Erich Lessing Culture and Fine Arts Archives.[52]

[49] Plin. *NH.* 18.26; Thurmond 2006, 64.
[50] Thurmond 2006, 65.
[51] Plin. *NH*. 18.27.
[52] *Cake or Flat Loaf of Bread*, 79 CE, Museo archeologico nazionale di Napoli.

The direct evidence for the type of bread produced by Pompeiian mill-bakeries includes eighty-one loaves of carbonized bread recovered from the oven of the mill-bakery located at VII.1.36-7. These remarkably preserved loaves are round with diameters of roughly eight inches. They are scored into eight sections (*panes quadrati*). Some examples of carbonized bread loaves from Pompeii and Herculaneum are stamped with the name of the bakery, although this does not seem to have been a common practice.[53] The prevalence of *panes quadrati* is further attested by indirect evidence, including numerous still life frescoes from Pompeii.[54] Other bread products such as rolls and cakes are attested in wall-paintings; some bronze pans used to shape cakes and other pastries were recovered from bakeries in both Pompeii and Herculaneum.[55]

Generally, the Romans demonstrated a preference for white bread – bread made from the finest flour with as much of the dark bran removed as possible. Whole grain bread, as well as bread made from lesser grades of flour, was considered to be food for the poor.[56] The varying qualities of bread produced by a baker were a result of using varying grades of flour produced from the same variety of *triticum vulgare*. The subject of the next chapter is the process by which wheat was turned into varying grades of flour – milling – and how that flour was turned into bread – baking.

[53] Mayeske 1972, 46.
[54] Mayeske 1972, 49-51.
[55] Mayeske 1972, 47-53.
[56] Mayeske 1972, 34.

Chapter Two: The Mill-Baking Process

In order to understand the social interactions of mill-bakers, we must not only understand the product of their labor – bread – but also the means by which it was produced, since so much of the baker's labor was tied to this process. This chapter focuses on the production of bread within commercial settings like the mill-bakeries included in this study. Bread-production in the first century CE was primarily a commercial process. Although the milling of bread grains certainly occurred within domestic contexts as well, domestic milling and baking was far more common in the countryside than in the cities. In cities like Pompeii, domestic milling likely only occurred on an *ad hoc* basis using small hand-mills.[57]

Prior to the widespread use of water-powered mills in the fourth century CE, the processes of milling and baking occurred in a single commercial establishment, which often also sold the final product.[58] The owner and operator of this establishment, hereafter referred to as a mill-baker, was known as a *pistor;*[59] and his mill-bakery was called a *pistrinum*. Both the term for the mill-baker and the term for the mill-bakery derive from the verb *pinso, pinsere* meaning "to beat, pound, bray, crush." According to the tradition imparted to us by Pliny, there were no bakers or bakeries in Rome until the third century BCE. However, more reliable evidence dates the arrival of professional mill-bakers in Rome to about 170 BCE.[60] By the time of Vesuvius' eruption, there were more than thirty bakeries in Pompeii supplying a population of around

[57] Thurmond 2006, 37.
[58] Thurmond 2006, 48.
[59] *Pistor*, *-oris*, m. a miller, bread-maker, baker. Elem. Lewis
[60] Thurmond 2006, 37.

10,000 people with their daily bread.[61] Despite differences in size and organization, these mill-bakeries each produced a similar amount of bread. There was little variation in the number of mills present in a mill-bakery; most mill-bakeries featured three or four mills. The highest output mill-bakery in Pompeii featured only five mills, a vast difference from the largest mill-bakery at Ostia which featured at least ten mills.[62] This indicates that despite the processes and tools remaining the same, commercial bread production became increasingly industrialized between the first and fourth century CE.[63]

The process of bread-making in 79 CE was very similar to the process today; indeed, the steps involved in making bread have remained largely the same since bread was first invented in the early Neolithic period. The steps are as follows: first, the baker acquires grain; next, the grain is milled into flour; then, the flour is mixed with water – if making leavened bread, a fermentation agent is also added – and kneaded; finally, the dough is baked in an oven.[64] This basic process has remained the same across numerous cultures and time periods; however, the tools used in the production of bread vary considerably from the very basic mortar and pestle to the industrial machines of today.

Not only are the steps of the bread-making process similar to modern methods, but the tools used to produce bread in the first century CE are also well-preserved. Many of them are made of permanent materials such as stone and brick, which tend to survive in the archaeological

[61] Monteix (2016, 154) identifies thirty-nine bakeries in Pompeii. However, some of these bakeries were pastry shops which did not mill their own flour. Furthermore, not all of these bakeries were operational in 79 CE. The recent excavation of a mill-bakery at IX.10.1 brings the total number of known bakeries to forty (Iovino 2023). Bakker (1999, 13-14) calculates that the average mill-bakery supplied between 270 to 360 people with their daily bread, assuming the scholarly consensus of a population of approximately 10,000 residents is accurate. The actual number is probably lower, as Bakker does not include several recently excavated mill-bakeries in his calculations.
[62] Bakker 1999, 11, 110-111.
[63] Bakker 1999, 110-113. The excavated mill-bakeries in Ostia were mostly constructed during the later second century CE and the early third century CE; most ceased operation in the fourth century CE.
[64] Monteix 2016, 155-156.

record. Along with the unique preservation of sites like Pompeii, this means that there is significant archaeological evidence of each step of the bread-making process preserved in its original context. By combining our knowledge of the bread-making process and the archaeological evidence with both written and artistic descriptions from the first century CE, the operational sequence of bread-making in Pompeii can be reconstructed in great detail.

The Acquisition and Tempering of Grain

The work of a Pompeiian mill-baker began with the acquisition of grain. Unlike the city of Rome, where grain had to be imported, stored, and distributed in a complex series of steps, ancient Pompeii enjoyed steady access to grain owing to the fertility of the plain of Campania in which the town was located. In Rome, the government "intervened in a systematic way in the regular procurement of" grain because political stability in the city relied on a consistent supply of cheap grain to feed the hungry populace.[65] The government had provided a subsidized grain ration in the city since the Gracchan program of the late second century BCE, but this program did not extend beyond the city itself.[66] Most importantly for the purposes of our study, there is no evidence of government intervention of this type concerning the grain supply of Pompeii. Rather, the fertility of the region allowed the mill-bakers of the city to operate within a normal system of supply and demand.[67] In these circumstances, once the bakery purchased the threshed and winnowing grain from the agricultural estates surrounding the city, it was delivered by cart to the mill-bakery.[68]

[65] Garnsey 1999, 31.
[66] Mayeske 1972, 59.
[67] Mayeske 1972, 81.
[68] Monteix 2016, 156-7. Recent excavations in Pompeiian mill-bakeries have not yielded any evidence of chaff, indicating that the processes of winnowing and threshing occurred before the grain arrived at the workshop.

Once the clean grain had arrived in the mill-bakery, it was prepared for milling by tempering, a process that involved soaking the grain in water to make it easier for the bran to separate from the kernel. This step produced a whiter flour than untempered grain.[69] According to Pliny, grain should be tempered in salt water, although there is no evidence either that salt water was more effective or that it was used to temper grain in Pompeii.[70] The archaeological evidence indicates that many Pompeiian mill-bakeries seem to have lacked tempering facilities; indeed, of the mill-bakeries included in this study, only one has the necessary facilities for tempering – VII.1.36-37.[71] This demonstrates that the Romans did not consider tempering to be necessary; instead it was considered an optional step used in the production of high quality flours.

Milling

Until 1958, when L.A. Moritz published his seminal work on milling in the ancient world – *Grain-Mills and Flour in Classical Antiquity* – scholars generally assumed there was little change in milling technology from the first mention of mills in the Homer's works until the introduction of water mills during the height of Roman Empire. Scholars of the 19th and early 20th century – those who excavated much of Pompeii – assumed that at some point in prehistory the "most primitive grinding appliances" – the mortar and pestle – were replaced by rotary mills. They assumed these rotary mills changed very little over the next millennia until they were replaced by water-powered mills. Moritz proved this assumption to be categorically false; not

[69] Monteix 2016, 156.
[70] Plin. *NH.* 18.87, trans. H. Rackham.
[71] Monteix 2016, 157.

only did the tools used for milling change significantly over this period but also the most primitive styles of mills continued to be used alongside more advanced styles of mills.[72]

Although grain-mills underwent significant evolution during the classical period, all styles of mills, known as *mola* in Latin and μύλη in Greek,[73] operated under the same basic principle: "the grain was crushed between two stones, of which the upper was the mobile, the lower immobile."[74] The earliest mill-type to operate under this common principle was the saddle-quern. This simple device consisted of a large stone slab, usually sloped and sometimes grooved, and an upper, traveling millstone. The upper millstone is alternatively pushed and pulled across the lower stone, grinding the grain between them. Using a saddle-quern to grind grain is laborious; still, many traditional cultures today still use saddle-querns on a small scale.[75]

The saddle-quern was succeeded in classical antiquity by the Olnythus mill. The Olynthus mill, also known as the 'hopper-rubber,' consisted of two grooved rectangular stones. The upper stone featured a rectangular slit through which grain was poured into the mill. A large wooden rod was attached to the sockets on the sides of the upper stone, which was fixed near one end of the wooden rod. The wooden rod functioned as a lever; the long end was a handle and the short end was attached to a pivot. Some reconstructions propose that a metal post was used as the pivot, while some archaeological finds suggest that the wooden rod was inserted into a niche in the wall and pivoted. Workers would push the lever back and forth, grinding the grain between the two grooved stones.[76] This mill-type developed in the eastern Mediterranean and diffused

[72] Moritz 1958, 1-52.
[73] Moritz 1958, 2.
[74] Blümner 1912, 1:22, quoted in Moritz 1958, 9.
[75] Thurmond 2006, 38.
[76] Moritz 1958, 42-46.

towards the west; examples of the Olynthus mill in mainland Greece date to the fifth-century BCE. Notably, no examples of the Olynthus mill have been found in Campania or Latium.[77]

These early mill-types utilize back-and-forth motion to grind the grain, in contrast to the rotary motion usually associated with milling. In fact, Mortiz argues that there is little evidence of the widespread use of rotary mills prior to the Roman period.[78] The only type of rotary mill that is well attested before the Roman period is the *trapetum*, used to crush olives. The *trapetum* consists of two stone hemispheres placed on their edges in a large stone basin and revolved around a central axle. Although the use of this mill-type is well attested in the production of olive oil, there is no evidence it was ever used to grind grain.[79]

The main advantage of using a rotary mill to grind grain is that rotary mills can be turned by animal or water power, while mills that utilize back-and-forth motion must be operated by humans. The *trapetum* was ill-suited for animal power, as the ground product collected in the bottom of the basin and thus needed to be emptied frequently. Some rotary mills used to grind grain were not powered by animals, such as the small rotary hand quern, known in Latin as the *mola manuraria*. These hand mills consisted of two cylindrical mill-stones with the same diameter stacked atop one another, connected by a central spindle. The upper stone, the *catillus*, had a socket in which a hand crank was inserted.[80] This small mill was used by Roman legionaries to grind their grain ration, as well as by smaller households.[81] However, the development of the rotary hand mill did not precede the development of the larger donkey-powered mill. The first evidence of the rotary hand mill comes from Numantia in Spain

[77] Frankel 2003, 1-8.
[78] Moritz 1958, 53-57.
[79] Moritz 1958, 57-58.
[80] Thurmond 2006, 40-41.
[81] Mayeske 1972, 9-10; Moritz 1958, 116-117.

and is dated to around 150 BCE.[82] This coincides with the first evidence of the larger donkey-powered mill in literature, indicating that the two likely developed in tandem. Moritz argues that since the main advantage of the rotary grain-mill is the ability to employ animals to turn the mill, it is more likely that the rotary hand-mill was derived from the larger donkey-powered mill and not *vice versa*.[83] This hypothesis is supported by finds of smaller mills similar in form to the Pompeiian donkey-powered mill from Sicily, dating to the third century BCE.[84] However, these Silician mills did not employ donkeys, and it is unknown if the Sicilian style of milling had any influence on Roman milling habits.

Pompeiian Mills

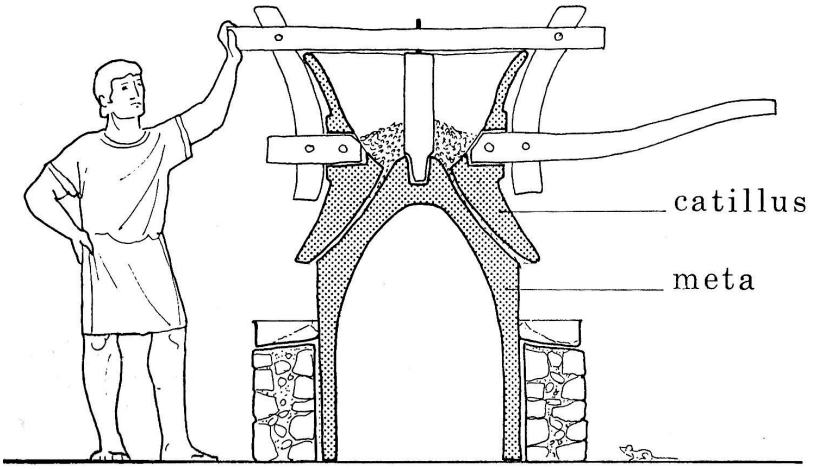

Fig. 2. Schematic cross-section of a Pompeiian mill. From Bakker.[85]

Certainly, the grain-mill par excellence in the Roman world, and perhaps the ancient Mediterranean more broadly, was the Pompeiian donkey mill, known in Latin as the *mola*

[82] Moritz 1958, 57-58.
[83] Moritz 1958, 105.
[84] Mayeske 1972, 8.
[85] Bakker 1999, 5.

asinaria, and hereafter referred to as the Pompeiian mill.[86] This mill type was known in Rome certainly by 160 BCE and possibly earlier, although its exact provenance is unknown.[87] The widespread use of the Pompeiian mill roughly coincides with the emergence of commercial mill-bakeries in Roman Italy.[88]

The Pompeiian mills are made of highly porous, dark gray, volcanic stones of two different origins. The majority are leucitite, likely sourced from one of the main production centers for such millstones near modern Orvieto in Umbria.[89] The minority are made of leucitite-augite-tephrite materials and were likely produced locally.[90]

The classic Pompeiian mill consists of two large millstones: the lower stone – the *meta* – and the upper stone – the *catillus*.[91] In Pompeii, the *meta* was usually placed within a rubble masonry foundation with a diameter of about 4.5 ft (1.38 m) and a height of about 1.5 ft (0.46 m).[92] This foundation served as a catchment area for the milled grain as well as a platform that allowed the mill worker to reach the top of the *catillus.*[93] A lead sheet placed at the joint between the *meta* and the foundation facilitated flour recovery.[94] The foundation is surrounded by a hard basalt pavement, which prevented the floor from being damaged "by the repeated circular movement of the working animals."[95] Pompeiian *metae* are bell-shaped, but not grooved like the

[86] Thurmond 2006, 42.
[87] Moritz 1958, 74.
[88] Mayeske 1972, 10; Moritz 1958, 151; Thurmond 2006, 37.
[89] Antonelli, Nappi, and Lazzarini 2001, 183.
[90]Peacock 1989, 206. Of the mill-bakeries included in this study, there are only 5 examples of leucitite-augite-tephrite millstones: all of the *catilli* from VII.1.36-37, and one *catillus* from IX.5.4.
[91] For a detailed typology of millstones of the Pompeiian type, see Peacock 1989.
[92] Thurmond 2006, 44.
[93] Mayeske 1972, 11. Rubble masonry foundations are usually present in Pompeii but completely absent in Ostia.
[94] Monteix 2016, 159.
[95] Monteix 2016, 158. The basalt pavement is not always present; for example, the fourth mill in mill-bakery I.12.1-2 lacks this pavement.

lower stones of the saddle quern or the Olynthus mill type.[96] The typical *meta* has a diameter of about 2.5 ft (0.75 m) at the base and a height of about 2 ft (0.60 m).[97]

The upper stone – the *catillus* – is hollow and hourglass shaped with a typical height of 2.33 ft (0.70 m) and a diameter of 2.33 ft (0.70 m) at the widest point.[98] The lower half of the hourglass fit over the *meta*, while grain was poured into the upper half. At the narrowest point on the exterior of the *catillus,* there are two square sockets with additional holes for pins.[99] Representations of bread production in funerary art such as the Tomb of Eurysaces and the sarcophagus of P. Nonius Zethus show horizontal wooden beams inserted into these sockets.[100] Since the beams could not connect through the *catillus* without disrupting the movement of grain, they are attached to vertical beams which are connected by a further horizontal crossbeam overtop of the *catillus*.[101] The donkey was then attached to the horizontal wooden beams by a yoke or harnessed to the wooden crossbeam with chains.[102] Pictorial representations of the milling process show the animals harnessed extremely close to the mills; this is reflected in the archaeological remains of Pompeiian mill-bakeries. Moritz observes that the average distance between two mills is 3.5 ft (1.05 m).[103]

The process of using these millstones is as follows; first, grain was poured into the top of the *catillus*. Then, the yoked donkey, urged on by a whip, walked in a circular path around the

[96] Moritz 1958, 79. According to Mortiz, the steep slope and porous material of Pompeiian *metae* negated the purpose of the grooves – ie. to allow grain to flow better and be cut rather than crushed.
[97] Moritz 1958, 75; Bakker 1999, 5.
[98] Moritz 1958, 75; Bakker 1999, 5.
[99] Moritz 1958, 77.
[100] Wilson and Schörle 2009, 110; Moritz 1958, 79. See fig. 17 and fig. 18
[101] Bakker 1999, 5.
[102] Moritz 1958, 80.
[103] Moritz 1958, 94. Moritz also observes that the minimum distance between a millstone and the wall is 18 inches (0.46 m). However, both Mayeske (1972, 93) and the author of this paper attest that the mill-bakery located at VI.2.6 features a mill-stone a mere 16 inches from the wall.

mill, turning the *catillus*, which grinded the kernels of grain between the two stones. Finally, the flour was collected. It is unclear whether these three tasks - pouring grain into the mill, urging the donkey with a whip, and collecting the milled grain - were performed by the same individual or separate individuals. Pictorial representations of milling in Roman art either show only a donkey yoked to the mill or one individual associated with each mill.[104] For example, the Tomb of Eurysaces frieze includes two mills with associated individuals – one of these figures is whipping the donkey, while the other is collecting the milled grain.[105] The spatial constraints also point to a single individual alternating between tasks. However, it would have been quite difficult for a single individual to perform all of these tasks since an individual could not hold all the necessary implements at once. Furthermore, it would have been unsafe for a worker to maneuver behind a donkey to collect the milled flour without someone restraining the beast. At the same time, the space between the mills in many mill-bakery was not wide enough for two donkeys to pass.[106] Thus, the movement of donkeys around each mill had to be carefully timed and guided. Furthermore, the timing of the grain being poured into the *catillus* had to be carefully managed. Although it cannot be confirmed, it is reasonable to suppose that it would have been far safer and more efficient to have two people operating each mill: one managing the donkey and one managing the grain. This would have allowed for near continuous operation of the mill with less risk of injury.

[104] Wilson and Schörle 2009, 103-116. The Romolo relief from Rome shows a single individual pouring grain into the *catillus*, while the sarcophagus of P. Nonius Zethus from Ostia shows only the donkey yoked to the mill.
[105] Wilson and Schörle 2009, 110. See fig. 17.
[106] Moritz 1958, 94.

Sifting

Once the milled grain was collected, it was sifted to separate flour from the undesired bran and germ. In order to create the fine grades of white flour that the Roman preferred, the process of milling and sifting was repeated several times. According to Pliny, *siligo* (*triticum vulgare)* underwent multiple successive siftings corresponding to different qualities of flour. The finest grade with the least residual bran was called *siligo,*[107] the intermediate grades were *flos* and *cibarium,* and the bran was called *furfur*.[108] Sieves – *criba* – of various sizes were used to produce the various grades of flour. Although there is little archaeological evidence of the smaller hand sieves, which were made of organic materials such as linen, the remains of larger sieving structures are present in numerous Pompeiian mill-bakeries.[109] These consist of low L-shaped walls located in the mill room; they were likely covered with a wooden frame and sieve.[110] After sifting, the 'milling' process of turning grain into flour, was complete and the 'baking' process of turning flour into bread, began.

[107] *Siligo* can refer to either a variety of wheat or the finest grade of flour. Lewis and Short.
[108] Plin. *NH.* 18.20; Moritz 1958, 170-4; Thurmond 2006, 55.
[109] Thurmond 2006, 55; Moritz 1958, 166. Artistic representations of these hand sieves can be seen on the right side of the sarcophagus of P. Nonius Zethus (fig. 18).
[110] Monteix 2016, 159.

Kneading and Shaping

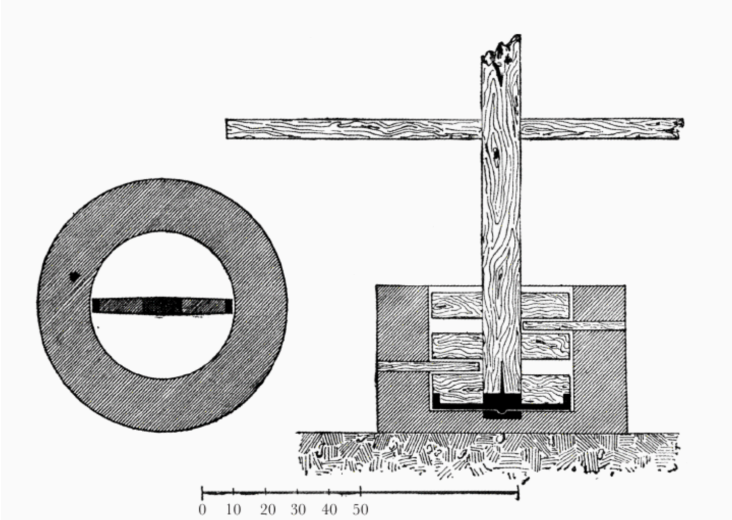

Fig. 3. Plan and cross-section of a Roman kneading machine from Pompeii. From Thurmond, after Mau.[111]

After the grain has been ground into flour, water, salt, and a fermentation agent were added to make a sticky paste. This paste was turned into a light, airy dough by kneading, which allows gluten to be produced, expanding the dough and creating pockets of air.[112] Traditionally, kneading was done by hand on a wooden chest; the remains of kneading chests are found in several Pompeiian mill-bakeries.[113] A representation of a kneading chest on the 'Romolo' relief from Rome shows three figures positioned with the arms inside a kneading chest.[114] However, in the Late Republican period, the kneading machine became more popular; about 20 mill-bakeries

[111] Thurmond 2006, 67.
[112] Thurmond 2006, 64.
[113] Monteix 2014.
[114] Wilson and Schörle 2009, 105. The Romolo relief is a travertine funerary relief from Rome depicting scenes of bread-making. It was produced between the mid-first century BCE and the end of the first century CE; it is currently located in a restaurant in Rome. For more information, see Wilson and Schörle. For this portion of the relief, see fig. 19.

in Pompeii feature kneading machines.[115] Kneading machines consist of a low, round, stone basin, with a vertical wooden post attached to an iron pivot inserted into the basin.[116] An iron blade and wooden paddles were attached to the vertical post, as well as a horizontal crossbeam. Pushing against the crossbeam rotated the vertical post; the dough was kneaded by the blades and paddles passing through it.[117] The kneading machine was operated by a single worker. Some hypothesize that these kneading machines were operated by donkeys, as depicted on the frieze of the Tomb of Eurysaces. However, the lack of pavement and the location of these kneading machines – many of them are in small rooms with narrow doorways – makes it more likely they were operated by human, rather than animal power.[118] It is possible that the dough underwent a first rising after being kneaded but before being shaped. Monteix theorizes that in mill-bakeries with kneading machines, dough rose first in wide terracotta basins. These basins, which are either embedded in masonry or affixed to reused *catillus*, were installed near the kneading machine.[119]

Once the dough was kneaded, it was shaped by hand into loaves of various shapes and sizes. Most loaves were presumably of the prototypical Pompeiian form known as *panes quadrati,* and thus were scored with a knife after rising.[120] The process of shaping the loaves occurred at wooden tables, as depicted on both the 'Romolo' relief and the Tomb of Eurysaces frieze. This process likely involved a significant number of workers; the 'Romolo' relief shows

[115] Monteix (2016, 160-1) notes that the evidence in some bakeries for the use of the kneading machine consists only of holes in the walls, thus the exact number in use is unknown. Most of the bakeries included in this study preserve evidence of a kneading machine, only VI.2.6 clearly lacks kneading machines.
[116] Monteix 2016, 160.
[117] Bakker 1999, 7.
[118] Monteix 2016, 160; Thurmond 2006, 66.
[119] Monteix 2016, 162-3. Basins of this type are present in VII.1.36-37, IX.1.3/33, and IX.5.4.
[120] Thurmond 2006, 71.

three workers at one table and the Tomb of Eurysaces frieze shows eight workers at two tables (four per table) as well as one supervisor. [121] As each of these reliefs only show half the table, we can assume at least twice as many workers were shaping loaves at any given time, depending on the number of mills and the size of the table. Although the wooden tables do not survive, the stone table supports indicate the size and position of these tables. They are usually rectangular and located in the center of the room to allow people to work on all sides. They are often closely associated with wall sockets, indicating the presence of wooden shelves, on which the loaves were placed for rising.

[121] Wilson and Schörle 2009, 106-110. See fig. 17 and fig. 20.

Baking

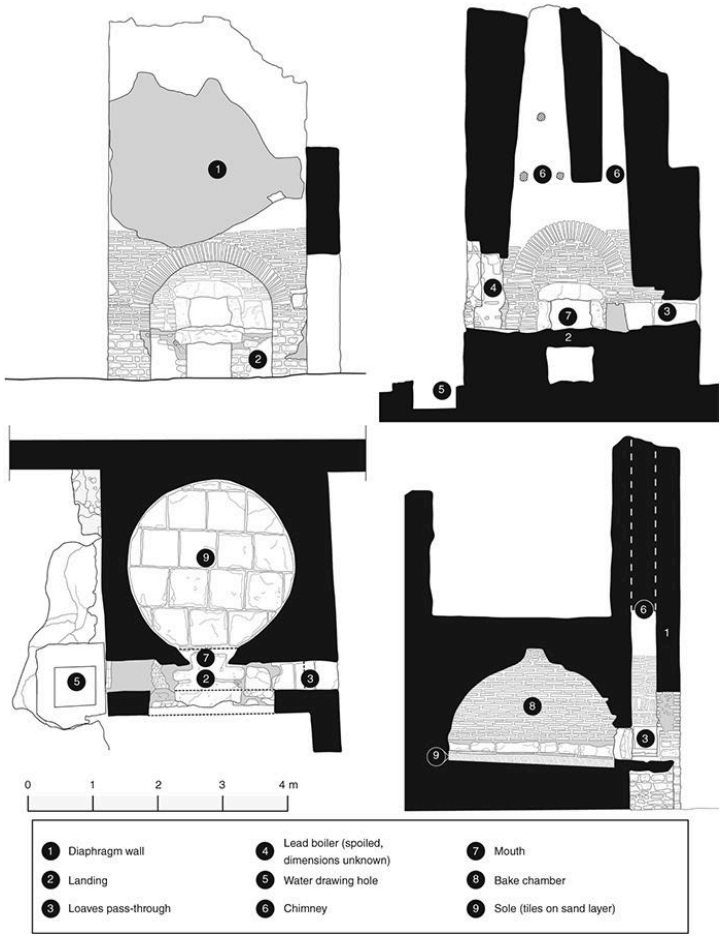

Fig. 4. Cross-sections of a Pompeiian oven. From Monteix 2016.[122]

The rooms in which the loaves were prepared are often located adjacent to the oven, and connected by a small passage through which loaves could be passed to the oven man – the *furnarius.*[123] The most common oven used in Pompeiian mill-bakeries – a *furnus* – consists of a domed baking chamber on top of a rectangular stone base. This pedestal was larger than the baking chamber, creating a shelf in front of the oven that was usually encased by a brick arch.

[122] Monteix 2016, 165.
[123] Thurmond 2006, 69.

This shelf often featured a small water basin on one side and the passage connecting to the preparation room on the other side. An iron door at the mouth of the oven separated this shelf from the baking chamber. In Pompeii, the floor of the baking chamber consisted of three layers: a layer of sand, a layer of basalt stones, and a layer of tiles or bricks. The sand prevented the oven from losing heat through the base while the basalt stored heat and released it slowly. The loaves were placed directly onto the tile or brick surface.[124]

This ubiquitous style of oven is still used today; the ovens used by Pompeiian mill-bakers are functionally identical to the wood-fired ovens that produce Italy's famous pizza. Modern restaurants serving tourists in Pompeii use the same technology that Pompeiian mill-bakers used to feed visitors to the city two thousand years ago. The operation of these ovens is as follows: first, the *funarius* kindles a fire in the baking chamber. The fuel used for baking varied; wood, charcoal, and olive pits were all used as fuel.[125] Once the baking chamber reached the desired temperature, around 250 degrees fahrenheit, the ashes were raked either to the sides of the baking chamber or into an ash pit at the front of the oven's base.[126] Then, the *funarius* used a wooden peel – similar to the tool used in modern pizzarias – to slide the loaves of bread into the oven. The oven door was then closed to retain heat and the loaves were left to bake. Once the bread was fully baked and removed from the oven, it was ready to be sold, either in a shop attached to the bakery or to an intermediary retailer.[127]

[124] Monteix 2016, 164-5.
[125] Thurmond 2006, 69; Monteix 2016, 168.
[126] Thurmond 2006, 69.
[127] Monteix 2016, 169.

The Bakers

It is necessary to note that most of this work, perhaps all of it, was being done by enslaved workers. Thus, their movement and patterns of social interaction were dictated not only by the spatial arrangement of the mill-bakery, but also by their social status. The slave-owners restricted their behavior through the violence that typically characterized master/slave relations in slave societies. It is also possible that the slave-owners physically restricted the movement of enslaved workers using shackles and chains, yoking the worker to the mill-bakery as tightly as the donkey was yoked to the mill. Even if they were not restricted, the watchful eye of the master influenced the kinds of social interaction that workers engaged in.[128] The spatial organization of the mill-bakery could limit or promote this type of supervision, and certain technological clusters would have been further removed from supervision and would have provided a greater degree of relative privacy to the workers engaging in those tasks.

Apuleius, a second-century CE author of Latin prose, described the miserable conditions of mill-bakery workers in his novel entitled the *Metamorphoses.* The protagonist of the novel, having been turned into a donkey, is put to work in a mill-bakery and observes how the human workers are clad in rags, covered in welts, with branded foreheads and chained feet. These characteristics are common in descriptions of enslaved people. However, the mill-bakery workers also had physical characteristics unique to their occupation. Apuleius describes how "their eyelids were eaten away by the smoky darkness of scorching murk" and "they were dirtily whitewashed with a floury ash."[129]

[128] Joshel and Peterson, 140.
[129] Apul. *Met.* 9.12.

For those visiting Pompeii in the twenty-first century, imagining what it would be like to work in a Pompeiian mill-bakery can be extremely difficult. The state of the sites – the lack of roofs and the shortness of the surviving walls – can lead to a false perception of these bakeries as light, open, and airy spaces. This false perception is further shaped by our experiences with modern bakeries; we imagine bakeries as clean and well-lit, warm but not stiflingly hot, smelling of sugar. In truth, Pompeiian mill-bakeries were none of these things. They were often poorly lit and poorly ventilated, smokey and stiflingly hot, filled with sweaty laborers and grain-dust. They probably smelled more like donkeys and burning fuel than baked goods. The work was repetitive and grueling, and done by enslaved laborers who likely had no choice in their position. This aspect of Pompeiian mill-bakeries will be discussed further in Chapter Four.

Chapter Three: Scholarly Approaches and the Methodologies of Spatial Syntax

The earliest scholarship on Pompeiian mill-bakeries was produced by the nineteenth-century archaeologists who excavated much of the site. This initial scholarship is very limited; it is often restricted to written descriptions of particular mill-bakeries with emphasis on the painting and decorative elements. The most extensive early descriptions of Pompeiian mill-bakeries were produced by Gisueppe Fiorelli in the 1870s and August Mau in the 1890s. Fiorelli provides brief written descriptions of several mill-bakeries excavated between 1861 and 1872 in *Descrizione di Pompei (Descriptions of Pompeii)* and *Gli Scavi di Pompei dal 1861 al 1872 (The Excavations of Pompeii from 1861 to 1872).*[130] Although Fiorelli does not deeply investigate Pompeiian mill-bakeries or the bread-making process, his descriptions are important to the study of Pompeiian mill-bakeries as he mentions details that are no longer present. Many of the decorative elements in Pompeiian mill-bakeries have degraded beyond recognition since they were excavated nearly two centuries ago. Thus, Fiorelli is one of the only sources of information on these inscriptions and decorative paintings that have since degraded. August Mau provides a general overview of the baking process in *Pompeji in Leben und Kunst (Pompeii, its Life and Art).* Although brief, his descriptions of the process and the technologies involved remain relevant and served as the basis for more in-depth studies of mill-baking technologies.[131]

The first systematic attempt to study Pompeiian bakeries was undertaken by Betty Jo Mayeske in her doctoral dissertation entitled "Bakeries, Bakers and Bread at Pompeii: A Study In Social and Economic History." Mayeske identifies and catalogs thirty bakeries, providing

[130] Of the bakeries included in this study, Fiorelli provides descriptions of VI.2.6, VII.1.36-37, IX.1.3/33.
[131] Mau 1973, 383-92.

written descriptions based on the excavation reports published prior to 1972 and her personal observations in 1971.[132] Mayeske's work has significant limitations: first, she at times assumes the location of an object in 1971 reflects its location at the time of the eruption; second, her descriptions are occasionally unclear and her floorplans are illegible; and finally, she fails to go beyond merely describing the archaeological sites. Mayeske makes no arguments about the social or economic lives of those employed in these bakeries. Nevertheless, her seminal work continues to form the foundation for modern scholarship on Pompeiian bakeries and ancient bread-making. However, as it is a doctoral dissertation, it was never peer reviewed nor revised for publication. Thus, it has limited authority as well as being fifty years out of date. Despite these weaknesses, it remains relevant as a starting point for further study, as no one has produced an updated catalog of Pompeiian bakeries. Since Mayeske's thesis, Pompeiian mill-bakeries have rarely been studied by themselves; they usually only appear as a starting point for broader scholarship on ancient food technologies.[133]

The most recent in-depth scholarship on Pompeiian mill-bakeries has been produced by the archaeologist Nicolas Monteix. Beginning in 2008, Monteix re-excavated several mill-bakeries in order to provide more complete information about their evolution and operations.[134] Furthermore, Monteix has gone beyond simply describing mill-bakeries; his work analyzes the spatial organization of Pompeiian mill-bakeries by investigating "how they were designed specifically to accommodate the activity that took place within them."[135] His approach relies on the notion of the *chaîne opératoire* (operational sequence), which allows archaeologists

[132] Mayeske 1972, 82-165. Mayeske provides descriptions of all the bakeries included in this study.
[133] Monteix 2016, 154.
[134] Of the bakeries included in this study, Monteix re-excavated I.12.1-2, VII.1.36-37, IX.1.3/33, and IX.5.4.
[135] Monteix 2016, 153.

to "reconstruct the organization of a technological system at a given archaeological site."[136] This methodology was first developed by French archaeologists studying stone tool production in Paleolithic Europe.[137] Monteix applies the notion of the *chaîne opératoire* to Pompeiian mill-bakeries, a technological process well-suited to this methodology due to the fact that the basic process of bread-making remains the same across cultures and time periods. Furthermore, while the tools used in the production of bread vary across time and space, in first-century CE Italy the tools used to produce bread were mostly constructed out of permanent material such as stone and brick. This permanence, along with the unique preservation of sites like Pompeii, means that there is archaeological evidence of each stage of this process preserved in its original context. While for other technologies, such as the stone tools of Paleolithic Europe, the *chaîne opératoire* must be reconstructed based on little more than the finished products, the process of bread-making in the Roman Empire can be reconstructed in much greater detail.

Monteix's analysis of the *chaîne opératoire* within Pompeiian mill-bakeries reveals that the mill-bakeries were not arranged according to a strictly rational layout. Rather, the spatial organization of mill-bakeries varied. Since Pompeiian mill-bakeries were often built into existing structures, each workshop has a unique layout that attempted to mediate the tension between the technical requirements of the mill-baking process and the limitations on the owner's ability to transform the original structure – both architectural and financial.[138] Despite this variation, the *chaîne opératoire* of Pompeiian mill-bakeries is spatially arranged into technological clusters: typically, milling is spatially associated with the optional processes of sifting and tempering; the

[136] Sellet 1993, 106.
[137] Sellet 1993, 107.
[138] Monteix 2016, 169.

kneading of dough is spatially associated with the shaping of the dough; and baking is located separately from both of these clusters.

This study builds upon Monteix's approach of applying the notion of the *chaîne opératoire* to Pompeiian mill-bakeries. However, while Monteix's analysis focused on the economic implications of the spatial organization of the *chaîne opératoire,* this study focuses on the social implications. This study analyzes the spatial organization of the *chaîne opératoire* within these mill-bakeries and applies the methodologies of spatial syntax in order to determine patterns of social interaction within the mill-bakeries. The methodologies of spatial syntax were first developed in the 1970s by Bill Hillier and Julienne Hanson as a tool for modeling and analyzing architectural and urban space. In the decades since, these methodologies have been applied to numerous archaeological sites in order to reconstruct aspects of the inhabitant's lived experiences.[139]

The methodology used to represent, quantify, and interpret the spatial configurations of buildings is a method of syntactic analysis known as gamma or access analysis. The fundamental assertion of gamma analysis is that "buildings transmit social information through their interior structures."[140] As a result, all buildings represent a "certain mode of organizing experience" as well as spatially representing aspects of cultural identity.[141] Gamma analysis uses constructed access maps that describe the spatial configuration of a given building as the basis for mathematical calculations. These calculations enable analysis of how spaces are related to one

[139] For the application of the methodologies of spatial syntax, and gamma analysis in particular, to domestic space in Pompeii, see Grahame (1997, 137-64) and Longfellow (2000, 24-37).
[140] Hillier and Hanson 1984, 154.
[141] Hillier and Hanson 1984, 145.

another within a building and how the arrangement of spaces impacts the relationships and interactions between occupants and visitors.[142]

The process of creating an access map is straightforward: each space within a building (usually a room) is represented by a circle. The connections between cells, also known as "relations of permeability," are represented by lines linking the circles together. For example, a room with a single entrance is represented by a circle with a single line radiating out from it.[143] The exterior space, the space beyond the boundaries of the building, is represented by a single circle with a cross through it. The exterior is not a space within the structure but rather the space in which the structure is located; there can only be one exterior space.[144] From this access map, a 'justified' access map can be created by aligning all spaces with the same depth from a particular point while maintaining the "links of permeability."[145]

These maps provide the basis for mathematical calculations developed by Hillier and Hanson that enable the description and interpretation of a building's spatial organization. Each space within a structure has both local relations, relations with spaces immediately adjacent to it, and global relations, a space's relations with all other spaces within the structure.[146]

Local relations are expressed mathematically as the *control value*. Hillier and Hanson define the control-value as a measure of how much a space controls access to its immediate neighbors. Each space gives its neighbors $\frac{1}{n}$, with n being the number of immediate neighbors of the space; these values are then added together for each receiving space to determine the control

[142] Hillier and Hanson 1984, 143.
[143] Hillier and Hanson 1984, 147.
[144] Grahame 1997, 147.
[145] Grahame 1997, 147.
[146] Grahame 1997, 147.

value of that space. A control-value greater than one indicates strong control, while a control value lower than one indicates spaces with weak control.[147] A space with a high control value is called a *node*.[148]

The global relations of a space depend on how accessible the space is from any other space within the structure; this is expressed mathematically as the *relative asymmetry (RA)* value. Relative asymmetry is defined as a measure of "how deep the system is from a particular point with how deep or shallow it theoretically could be." Relative asymmetry is thus a measure of integration; low relative asymmetry (approaching zero) means that a space is highly integrated into the rest of the system while high relative asymmetry (approaching one) means that a space is segregated from the rest of the system.[149] To calculate the relative asymmetry of any space within a structure, one must first calculate the *mean depth (MD)* of the system from the space. The mean depth is calculated by "assigning a depth value to each space according to how many spaces away from the original space," adding these values together and dividing by the total number of spaces in the system (*the k value*) minus one.[150] Once the mean depth has been calculated, relative asymmetry is calculated using the following equation: $RA = \frac{2(MD-1)}{k-2}$. In order to compare the integration of spaces across systems of different sizes, the relative asymmetry value must be converted into the real relative asymmetry value (RRA). This is done by dividing the RA value by the D-value – the RA values for a diamond shaped system.[151]

[147] Hillier and Hanson 1984, 109.
[148] Grahame 1997, 153-4.
[149] Hillier and Hanson 1984, 108-9.
[150] Hillier and Hanson 1984, 108.
[151] Hillier and Hanson 1984, 112-3. The D-values for diamond-shaped systems can be found in table 3.

The intersection of the control value and the relative asymmetry value indicates the level of *presence-availability* – defined as "the degree to which social others are likely to be available for encounters" in a particular space.[152] Presence-availability is a more nuanced concept than the traditional approach to private/public spaces as it takes into account two types of relationships: the relationships among inhabitants as well as the relationships between inhabitants and strangers. Since the presence-availability of a space is defined more by its local relations than by its global relations, control values have a greater impact on presence-availability than RA values.[153]

Table 1: The levels of presence-availability as defined by the RA value and the control value.[154]

		Relative Asymmetry Value	
		Low	High
Control Value	High	*High*	*Moderately High*
	Low	*Moderately Low*	*Low*

Spaces with different levels of presence-availability tend to produce different kinds of social interactions. These social interactions fall into two broad categories: *occasions* and *gatherings*. Occasions are defined as prearranged social practices and rituals that occur in certain places deemed appropriate for that particular occasion at specific times. Examples of common occasions include the daily preparation and consumption of food.[155] Gatherings are loose and transitory impromptu meetings, such as bumping into someone or exchanging brief greetings in a hallway.[156] Spaces with a high level of presence-availability – that is, a high control value and

[152] Grahame 1997, 150.
[153] Grahame 1997, 150.
[154] From Grahame 1997, 150.
[155] Grahame 1997, 155; Longfellow 2000, 29.
[156] Grahame 1997, 155; Longfellow 2000, 29.

low relative asymmetry – tend to produce both gatherings and informal occasions. One exception to this is corridors with a high level of presence-availability; since they primarily function as conduits for movement, they are unlikely to be used as a location for occasions and are more likely to only produce gatherings.[157] In contrast, spaces with a low level of presence-availability – that is, a low control value and a high relative asymmetry– tend to produce mostly occasions as the chances of passing through these spaces during routine movement are not high. These spaces tend to be the most private spaces and may be used more infrequently than other spaces.[158] The most commonly used spaces with a low level of presence-availability are bedrooms.

By applying these concepts – relative asymmetry, control values, and presence-availability – to the spatial organization of the *chaîne opératoire* within Pompeiian mill-bakeries, this study analyzes how the layout of a mill-bakery impacted the ways in which workers experienced this space, thereby allowing us to reach a deeper understanding of the workplace dynamics of enslaved workers within a single critical industry in Italy during the first century CE.

[157] Grahame 1997, 156.
[158] Grahame 1997, 156.

Chapter Four: A Selection of Mill-Bakeries for Examination

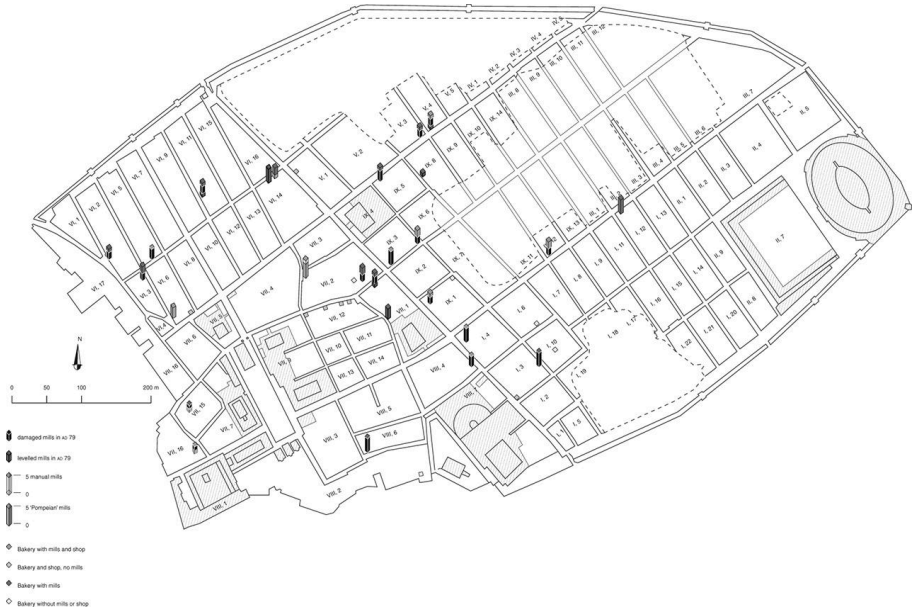

Fig 5: Locations of the bakeries in Pompeii, from Monteix 2016.[159]

This study does not aim to provide an exhaustive overview of every social interaction produced by the spatial organization of the *chaîne opératoire* in every surviving Pompeiian mill-bakery. Rather, it analyzes a representative sample of these bakeries in order to examine how different types of social interaction occurred at various steps in the mill-baking process due to the organization of the *chaîne opératoire* and how those interactions differed depending on the structure of the mill-bakery. Equally important, these case studies aim to demonstrate how the methodologies of spatial syntax can be used to evaluate social interaction within Roman

[159] Monteix 2016, 154. This map does not include the recently excavated mill-bakery located at IX.10.1, as discussed in Iovino 2023.

workshops, an especially attractive prospect, given, as previously mentioned, the dearth of evidence from other sources on this topic.

Since Pompeiian mill-bakeries were often built into existing structures and owners faced both architectural and financial constraints on their ability to transform the original structure, each workshop was organized in a unique way.[160] Thus, applying the methodologies of spatial syntax to the operational sequence of a single mill-bakery cannot produce a reliable model that is applicable to all Pompeiian mill-bakeries. In order to make broader claims about social interaction within Pompeiian mill-bakeries, this methodology must be applied to several workshops and the results compared. This study is limited to five mill-bakeries, each of which is representative of a broader typology: mill-bakery I.12.1-2 is a mill-bakery with an attached atrium house; mill-bakery VI.2.6 is a small mill-bakery without a shop; mill-bakery VII.1.36-37 is a mill-bakery in a converted atrium house; mill-bakery IX.1.33 is a L-shaped mill-bakery with an integrated shop; and mill-bakery IX.5.4 is a mill-bakery arranged along a single axis. For each mill-bakery, the reader will find a floor plan accompanied by a morphic map which, based on the theories of Hillier and Hanson, helps the reader to recreate the likely movements of personnel within each bakery. Although no two Pompeiian mill-bakeries have identical layouts, these broad typologies encompass a significant number of the mill-bakeries in Pompeii. Thus, this sample provides a rich opportunity to recreate the social experiences of workers within municipal bakeries in first century CE Italy.

[160] Monteix 2016, 169.

Fig 6: Locations of mill-bakeries included in this study.

Before moving to a consideration of the selected corpus of mill-bakeries, a procedural point is worth noting. Since there is very little recent scholarship on Pompeiian mill-bakeries, this study relies heavily on the author's own observations from visiting these sites in May of 2023, while also drawing upon recent excavations of Nicolas Monteix, original descriptions of the sites by Fiorelli, and Mayeske's corpus of Pompeiian bakeries. However, the limitations of these sources in recreating the workplace reality of mill-bakery personnel has necessitated the inclusion of the author's own observations throughout the analysis to follow. Finally, the plans and access maps of the mill-bakeries included here are entirely the author's own work, based on a variety of sources and observations of the sites made during the 2023 visit.

1. Mill-Bakery I.12.1-2

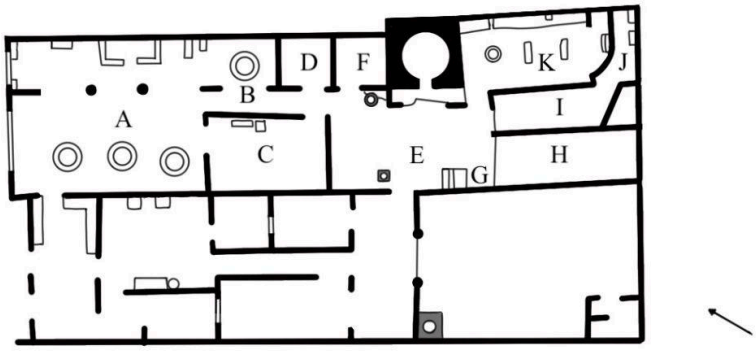

Fig. 7. Plan of mill-bakery I.12.1-2 with labels corresponding to table 2. Plan by author from Mayeske 1972 and Monteix 2016, details from visiting the site in May 2023.

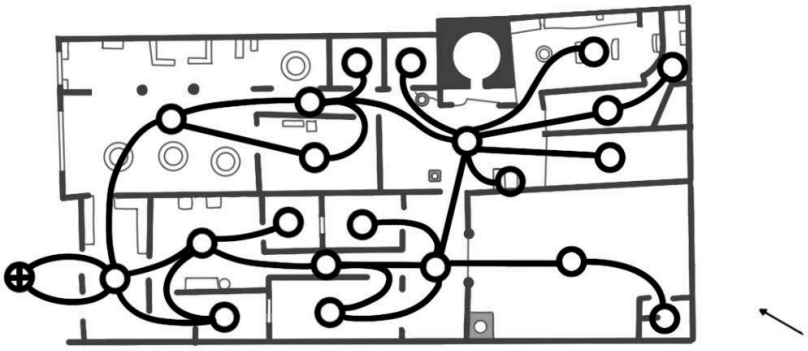

Fig. 8. Access map of mill-bakery I.12.1-2. By author.

The mill-bakery located at I.12.1-2 (Figs. 21, 22, and 23) was originally excavated in 1924; it periodically underwent further excavations, with the most recent occurring in 2011.[161] This mill-bakery is occasionally referred to as the "Pistrinum of Sotericus" due to the presence of

[161] Monteix 2012.

two election notices on the exterior wall of the mill-bakery – *Sotericus rog(at)* and *Soteric(us)*.[162] The bakery was built into part of a pre-existing two-story house; a central axis divides the bakery from the living quarters, punctuated with only two doorways providing through access. Both residence and bakery are entered through two doors on the Via dell'Abbondanza, an important thoroughfare in the town. The visitors entered into a small antechamber which contained two more doorways — one which led into the mill-bakery, the other into the attached living quarters. This antechamber immediately separated those frequenting the business from those with access to the household.

To the left of the antechamber is the mill room (A), where the technological cluster of milling and sifting was located. This was the largest room in the mill-bakery; it was created by combining several smaller rooms. There are four mills and associated basalt pavements; three of these mills are arranged in a row. The fourth mill, which was added last and lacks the pavement associated with the other three mills, is located in the corner furthest from the door. Two low, L-shaped walls are located on the wall opposite the entrance. These were likely used for sifting and storing grain.[163] Also located along this wall is a low stone bench beneath a rectangular wall niche. Two small windows on the exterior wall facing the street provided light for the mill room. The mill room was a highly transitory space; it has a low relative asymmetry, meaning that it was highly integrated with the rest of the building.[164] Furthermore, it is necessary to pass through the mill room to reach the other areas of the mill-bakery without passing through the private domestic space of the adjoined house. In addition to the significant amount of traffic through the

[162] *CIL* IV 7635; *CIL* IV 7432; Mayeske (1972, 86) gives this identification based on a method of ascribing ownership using text written on the exterior of buildings. This method of ascribing ownership has now fallen out of favor.
[163] Monteix 2016, 175.
[164] Hillier and Hanson 1984, 108-9.

mill-room, a number of people were working within the mill room during production periods. Assuming all four mill stones were operating, which is probable, there were between four and eight people and four donkeys working in this room at any given time. In addition, there also would have been at least one person sifting grain, or perhaps even two, as shown on the frieze of the Tomb of Eurysaces.[165] Thus, this room would have housed the largest concentration of workers. However, it would have facilitated limited social interaction due to the noise and constant movement both around the millstones and through the room. The nature of the tasks also limited social interaction, as they required significant focus within a work space that we can only imagine as being hot, crowded, and physically demanding.

The mill room is connected to the oven room by a narrow passageway (B), another highly transitory space with the second lowest relative asymmetry. The oven room contains entrances to several other rooms, including a doorway into the tablinum, which connected the living quarters and the bakery. To the left of this doorway is the remains of a staircase to the second floor (G) , which has not been preserved but may have been used for drying grain. The oven room also contains a large oven in the typical Pompeiian style with a projecting brick-faced arch, a rectangular ash pit, the opening to the baking compartment, and a small passageway connecting the oven to the room where the dough was prepared.[166] Located to the left of the oven is an elevated round basin, most likely for the water used in the bread making process. A second sunken basin located against the opposite wall may have also served a similar purpose.

The oven room (E) has the lowest relative asymmetry of any space within the mill-bakery, and thus is the most integrated space in the system. It also has the highest degree of

[165] Wilson and Schörle 2009, 105.
[166] Mayeske 1988, 1:153.

control over access to the surrounding spaces; most routes from one space in the mill-bakery to another pass through the oven room.[167] Thus, it has the highest level of presence-availability within the system. Furthermore, the oven room is at the deepest point of the largest ring when seen from the entrance. According to Hillier and Hanson, the space that occupies this position is the syntactic center of a building.[168] Thus, the oven room is a space of spatial solidarity, that is, a space through which informal movement builds connections between members of a group – in this case, the workers of the mill-bakery – by facilitating direct contact and encounters.[169] The kinds of activity that occur in such spaces tend to be informal, impromptu gatherings rather than pre-arranged occasions.[170] The tendency of this space to produce informal gatherings is reinforced by the nature of the work that occurred there; unlike the mill room – where a large number of people worked at a given time – only one person was needed to operate the oven. Thus, only one person would be working in the oven room for an extended period of time, rather than using it as a transitory space as everyone else did.

One of the entrances in the oven room connects the mill-bakery to the tablinum of the living quarters. This spatial connection between the business and the household mirrors the tablinum's function as the space where the business of the household was conducted.[171] The connection to the tablinum also reinforces the tendency of this space to facilitate impromptu gatherings rather than planned occasions. Any social interactions between workers within the oven room would have been overheard by the owner in the tablinum; thus we can suppose that

[167] Hillier and Hanson 1984, 109.
[168] Hillier and Hanson 1984, 158-9.
[169] Hillier and Hanson 1984, 145.
[170] Grahame 1997, 154-5; Longfellow 2000, 26-9.
[171] Wallace-Hadrill 1988, 85-89.

workers would have been less inclined to have meaningful or planned social interactions within this space.

To the right of the oven is the entrance to a large room used for preparing the dough (K). It contains a kneading basin, stone supports for a large table, and a series of holes in the exterior wall indicating the presence of shelves.[172] Many people worked within this room; artistic depictions of the mill-baking process – most notably the Romolo relief and the Tomb of Eurysaces frieze – both show groups of workers performing these tasks.[173] Notably, the table had previously been oriented perpendicular to the entrance, but was turned to parallel the entrance at the same time the fourth mill was added. Turning the table allowed for more workers to knead and shape bread at the same time, accommodating the increase in flour output created by the addition of the fourth mill.[174] The preparation room and the mill room would have employed a similar number of workers at a given time. However, unlike milling, kneading dough and shaping loaves of bread were both relatively quiet and repetitive tasks; thus it would have been much easier for workers to hold conversations and tell stories while working. Furthermore, the repetitive nature of this work may have also facilitated the singing of 'work-songs,' which both mirrored and enforced the rhythm and pace of the task.[175] To be sure, these types of longer, more meaningful social interactions were certainly the result of the nature of the tasks associated with this technological cluster, but we must not overlook the role that space itself played in forging these workplace connections.

[172] Mayeske 1988, 1:150-154.
[173] Wilson and Schörle 2009, 105-110. See fig. 17 and fig. 20.
[174] Monteix 2016, 175.
[175] Korczynski 2003, 315-318.

The relative privacy of the preparation room means that it was an ideal location for the workers of the mill-bakery to have longer, more meaningful encounters than the quick interactions that occurred in the highly transitory spaces associated with the other technological clusters. This room has the lowest possible control value and a higher RA value; thus it has a low level of presence-availability. Although it is not the space with highest relative asymmetry in the mill-bakery, it does have the highest relative asymmetry of the spaces associated with a technological cluster. This indicates that this room was one of the most private and least accessible rooms in the mill-bakery – it is unlikely that unplanned gatherings occurred in this space. Those who entered the preparation room did so for a pre-planned activity: the work of kneading and shaping loaves of bread. Adding to this privacy, the location and size of the doorway prevent a clear line of sight into the preparation room from anywhere other than directly within the doorway. Unlike the oven room, which would have been supervised by the owner in the tablinum, and the mill room, which was a transitory space easily accessible by guests and visible to passersby on the street, the preparation room was accessed only by the workers. Thus, this was the space in which they would have been most able to enjoy freedom from supervision by the owner and to have private conversations while they worked.

2. Mill-Bakery VI.2.6

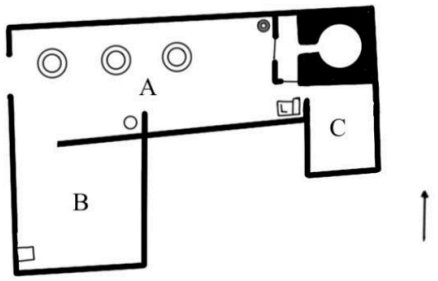

Fig. 9. Plan of mill-bakery VI.2.6 with labels corresponding to table 3. Plan by author from *Pompei: Pitture E Mosaici*, details from visiting the site in May 2023.

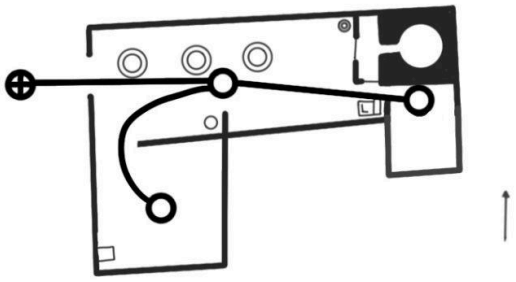

Fig. 10. Access map of mill-bakery VI.2.6. By author.

This small mill-bakery (Fig. 24) is located on the Via Consolare, adjacent to the House of Sallust (VI.2.4). Due to its location, this mill-bakery is often associated with the House of Sallust, also known as the House of A. Cossius Libanus,[176] and they were probably owned and

[176] Mayeske 1972, 93.

managed by the same person.[177] This is the smallest mill-bakery included in this study, although the number of mills indicate that its output was similar to that of mill-bakeries with a much larger footprint. Furthermore, this mill-bakery likely produced lower quality bread than the larger bakeries; there is no evidence that the optional processes associated with higher quality bread occurred here. There is no structure associated with either sifting or tempering and kneading was done by hand. This indicates that Pompeiian consumers not only had access to bread of various types, as demonstrated in Pliny and art from Pompeii, but they also had access to bread of various qualities. The main area of this bakery is a long room with three mills along the north wall (A). The mill closest to the entrance is unusually close to the wall; the rubble base of the mill is only 16 inches (40.5 cm) from the front wall.[178] This may indicate that this mill was turned by an enslaved person, rather than a donkey. The oven is located against the back wall of this main room. Unlike most of the other ovens in Pompeiian mill-bakeries, the chimney is visible and not enclosed by the brick-faced arch that creates the separate baking area and ash-pit. A terracotta funnel is clearly visible protruding from the top of the chimney. As a result of the oven's unusual shape, a person cannot stand in the baking area in front of the oven. To the left of the oven is a water basin.[179]

Because all other spaces within this mill-bakery can be accessed from this main room and these other spaces are not connected to each other, this simple mill-bakery is an example of an asymmetrical non-distributed system.[180] The relationships between the other spaces in this

[177] Fiorelli 1875, 85.
[178] Mayeske 1972, 93. This is smaller than the distance of 18 inches which Moritz (1958, 82) claims to be the smallest distance between a mill and a wall. In 2023, the author of this paper measured the distance between this mill and the wall to be 16 inches.
[179] Fiorelli (1875, 85) notes the presence of two water basins; Mayeske (1972, 94) states that there is only one basin. In 2023, only one basin is present.
[180] Hillier and Hanson 1984, 265.

system exist only because of their relationships with the main space, which has a relative asymmetry of 0 and exercises complete control over access to the other spaces. As a result of this arrangement, this space has a high level of presence-availability and produced both occasions and gatherings. The occasions which occurred in this space include the work associated with two technological clusters: milling and baking. When the mill-bakery was in operation, between four and seven people would have been working in this room. This room would have been an unpleasant work environment. There are no windows, and although the entrance is relatively wide, the door would have blocked the movement of both air and light. The presence of the oven in the same room as the mills would have made the already laborious process of milling even more miserable; without significant ventilation, this room would have been plagued by the smoke and excessive heat produced by the oven.[181]

To the right of the oven is a small passageway for passing bread and a door to the rear room which may have been where the dough was prepared (C).[182] Next to this doorway and opposite the passageway to the oven are the remains of a staircase. The mill-bakery also has a third room located to the right of the entrance (B). Fiorelli states that this larger room contained a hearth and a latrine; these features are no longer present.[183] Dough may also have been prepared in this room.

Both of these rooms have a low level of presence-availability and thus tended to produce mostly occasions. This tendency towards occasions is reinforced by the non-distributed nature of this system; to reach another space in the system, a person must exit these rooms and pass through the main space (A). The exact types of occasions that occurred in these rooms is

[181] Nissin 2022, 637-39.
[182] Mayeske 1972, 94.
[183] Fiorelli 1875, 85.

unknown; dough must have been shaped in at least one of them, but there is no evidence of shelving or tables in either room. It is possible that room B was a shop, but is unlikely due to the fact that shoppers would have had to pass through the main work room to reach it.[184] Since these rooms were quieter than the main room, they would have facilitated more meaningful and private conversations between workers. Workers would have also enjoyed relative freedom from supervision; since there are no direct connections between the mill-bakery and the adjacent home of the elite owner.

3. Mill-Bakery VII.1.36-37

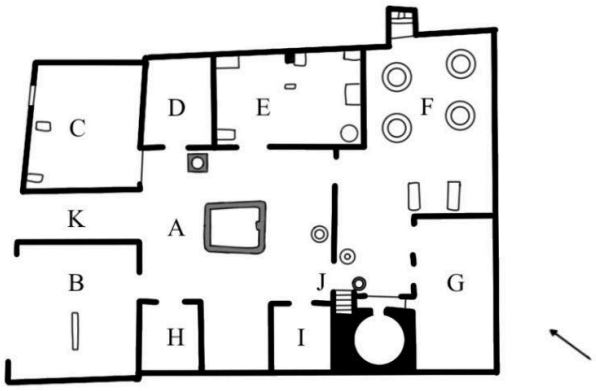

Fig. 11. Plan of mill-bakery VII.1.36-37 with labels corresponding to table 4. Plan by author from Monteix 2015, details from visiting the site in 2023.

[184] Fiorelli 1875, 85.

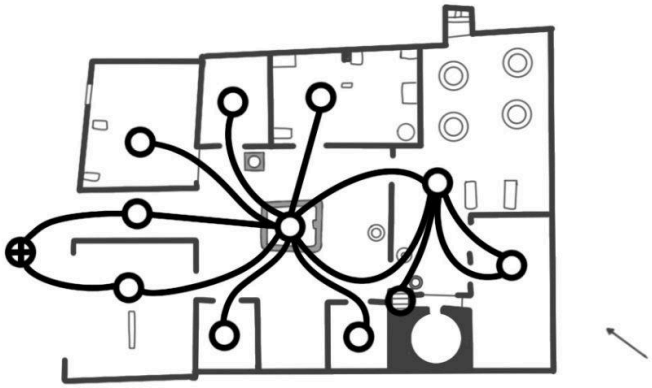

Fig. 12. Access map of mill-bakery VII.1.36-37. By author.

The main entrance (36) of this mill-bakery (Fig. 25) is located on the Via degli Augustali with a secondary entrance (37) to the right of the main entrance. According to Fiorelli, the phrase *"MODESTUM AED"* was written near the entrance; thus, this particular bakery is often referred to as the "bakery of Modestus."[185] Also located near the main entrance of this bakery are four stone plaques. On the pilaster located on the eastern side of the main entrance is a stone carving of Priapus above a plaque featuring a geometric mosaic. On the western pilaster is a stone carving of a phallus above a second, more simple geometric mosaic.

The mill-bakery itself is built into a converted atrium house, and thus retains many of the features of the typical atrium house. For example, entrance 37 opens into a front room used as a shop (B), presumably for the products of this mill-bakery, a typical feature of the atrium house. Entrance 36, the main entrance, opens into a long hallway which leads into the atrium (A). Although this structure has been converted from a residential space into a work space, its form is

[185] Fiorelli 1875, 171.

instantly recognizable. This is an example of transpatial solidarity; a form of solidarity in which membership in a group is realized through "the local reproduction of a structure recognisably identical to that of other members of the group" who remain spatially separated from each other.[186] The conversion of this structure into a workshop did not significantly change its form; it retained the form associated with a respectable household despite its change in function.

In the center of the atrium is a converted impluvium, a rectangular courtyard basin or pool into which rainwater is collected, with stone walls that were about 31.5 inches (80 cm) tall at the time of excavation.[187] Unlike a traditional impluvium, this basin was fed by a lead pipe connecting this bakery to the broader water system of the city. Other pipes made of terracotta were added to collect rainwater and allow the basin to be drained.[188] This basin was used for tempering the grain; tempering was associated with higher quality bread. Also located in the atrium is the mouth of an underground cistern surrounded by a rectangular stone. On the wall opposite the main entrance are the remains of a kneading machine, although this is probably not its original location. Like in residential atrium houses, the atrium is the space with the highest level of presence-availability. Thus, in addition to the occasions associated with the technological processes of tempering and possibly kneading, this space would have produced a significant number of gatherings. Many of these gatherings would have occurred as part of the bread-making process; this process required workers to travel through this space at least four times from raw materials to finished products. Despite the heavy traffic, this room would have felt open and airy due to the open roof of the compluvium. Just as in a residential atrium home, this would have provided most of the light and air within the mill-bakery.

[186] Hillier and Hanson, 145.
[187] Montiex et al 2015.
[188] Montiex et al 2015.

This space would have also been heavily surveilled by the owner or the manager when they were present, as its central location provided line of sight to many of adjoining rooms. However, it is unlikely that a wealthy owner was supervising everything and everyone in the mill-bakery, since the formerly residential spaces in the mill-bakery were all converted into workspaces and it is not attached to a larger house. It is far more likely that the owner or manager of this mill-bakery was not an elite and would have been working in the mill-bakery alongside enslaved people.

The rooms surrounding the atrium would have served a variety of purposes, some of which can be determined from the archaeological remains. In the northwest corner is the doorway to the front room that connects to the street via entrance 37 and served as a shop (B). A wall in the center of this shop divided the public facing shop from a storage space.[189] The bread would have been displayed and stored on wooden tables. In the northeast corner is a similarly sized room with a window facing the street; Fiorelli identifies this room as a stable (C).[190] This room contains two rectangular stones which may have been table supports.

Also accessible from the atrium is the preparation room (E). Five masonry blocks are arranged along the walls of this room. These stones would have served as table supports for wooden boards used for preparing the dough. In the southwest corner of the room is a broken catillus, likely reused as the base of a rising basin.[191] While the tasks associated with this technological cluster tend to produce longer, more meaningful conversations and encounters between workers, the arrangement of the preparation space would have mitigated the workers ability to have these conversations. The arrangement of the table supports against the wall, rather

[189] Possibly a half wall, however the state of preservation is such that it is impossible to tell.
[190] Fiorelli 1875, 171.
[191] Montiex et al 2015.

than in the center of the room, means that workers would not be able to face each other while working. The arrangement of the tables against three of the four walls prevented workers from seeing non-verbal social cues and limited their ability to hear each other. It created a sense of isolation; they could hear each other, but could only see their task and the wall in front of them. Additionally, this space had very little relative privacy, as it was closely linked to the widely trafficked atrium.

From the atrium, there are two entrances into the room containing the mills and the oven (F). This space at the back of the building was originally occupied by a peristyle or garden before being converted into a workshop.[192] The entrance in the southwestern corner of the atrium connects directly to the oven space. The oven is of the conventional Pompeiian type with a "recessed rectangular niche with a pedimental top" located above the arched opening to the baking chamber.[193] When this mill-bakery was originally excavated, the iron door to the inner opening of the baking chamber was intact. Eighty-one loaves of carbonized bread were found inside the oven; this incredible find demonstrates roughly how many loaves of bread could be produced by the larger Pompeiian mill-bakeries at once.[194] To the right of the oven is a stone water basin and the remains of a stairway. Fiorelli argues that this stairway led to the roof, where after tempering the grain, the bakers would spread it out in the sun to dry and whiten.[195] To the left of the oven are two entrances to a large back room, probably used for storage (G).

Against the wall separating the atrium from the mill / oven room are the remains of a terracotta dolium, which may have been connected to the water system that supplied the

[192] Mayeske 1972, 109.
[193] Mayeske 1972, 109.
[194] Mayeske 1972, 109; Fiorelli 1875, 171-2. See fig. 1.
[195] Fiorelli 1875, 171-2.

impluvium.[196] To the east of the oven is the second entrance connecting this room to the atrium, as well as the milling area. The milling area contained four millstones and two wide masonry blocks, which may have been table supports or part of a structure for sifting. Along the eastern wall of the mill room is a small latrine. At the time of the eruption, this mill-bakery seems to have been in the process of replacing worn mill-stones or expanding their capacity; two metae were found near the main entrance to the mill-bakery.[197]

4. Mill-Bakery IX.1.3/33

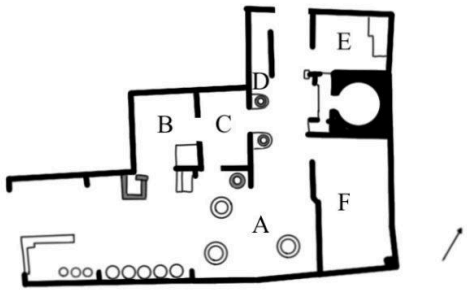

Fig. 13. Plan of mill-bakery IX.1.3/33 with labels corresponding to table 5. Plan by author from Monteix 2015, details from visiting the site in 2023.

[196] Fiorelli 1875, 171-2; Monteix et al 2015.
[197] Fiorelli 1875, 172.

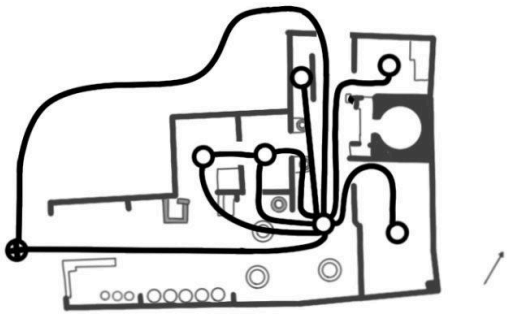

Fig. 14. Access map of mill-bakery IX.1.3/33. By author.

This mill-bakery (Fig. 26) has a primary entrance facing the Via Stabiana and a secondary entrance on the Vicolo di Balbo. It was originally excavated in two phases: from the Via Stabiana entrance in 1852 and from the Vicolo di Balbo entrance in 1866.[198] Unlike most of the mill-bakeries included in this study, this mill-bakery has a very well-preserved shop, where the products of the mill-bakery were sold. The main entrance on the Via Stabiana is wide; roughly half of the doorway is blocked by an L-shaped counter facing the street. This marble-faced counter allowed customers to purchase their daily bread from the sidewalk. Behind the counter and against the southern wall of the mill-bakery are the remains of terracotta urns. Fiorelli notes that these jars were engraved with the phrase "VITALE GALLICI."[199] A pilaster separates these urns from a set of five larger urns. It is likely that these urns contained both milled and unmilled grain. Above these urns, holes in the plaster indicate the presence of two

[198] Monteix et al 2015.
[199] Fiorelli (1875, 367) notes the presence of three urns in this area of the mill-bakery, although only two are intact in 2023.

shelves. Shoppers could see their bread being made as they shopped, and perhaps had to shout over the din of the donkeys and the millstones as they haggled with the shopkeeper.

On the northern wall of this room (A), across from the urns, a doorway is framed by two stone structures. To the left of the doorway is a rectangular structure framed by low stone walls; this is probably a structure used for sifting grain, since there is no evidence of the water-proofing used for water basins of a similar type. On the right side of the door are the remains of a staircase. The doorway leads to a small room, the southeastern corner of which is taken up by a large stone structure, possibly a table or warming table (B). This room also contains a doorway to another smaller room which is connected to both the milling area and the oven area (C). These two rooms were probably used for dough preparation. The original location of the kneading machine, currently located near the doorway connecting the second of these rooms to the milling area, is unknown but may have been one of these rooms.[200] Unlike those working in the main room (A), those working in these rooms would not have been visible to shoppers or passersby on the street. Thus, they were awarded a degree of privacy that the other workers lacked. However, because they could not leave these spaces without coming under surveillance, this privacy was effectively a form of containment. While their interactions were much less limited than those working in the main room, their movement was just as restricted.[201]

The milling area, connected to the shop and highly visible from the street, contains the remains of three mills. However, the masonry base that surrounded one of the millstones is absent and the original position of this millstone can only be determined by the placement of the basalt paving stone. Although the masonry base is absent, the meta and the catillus are both

[200] Monteix et al 2015.
[201] Joshel 2013, 114.

present and currently located against the southern wall of the mill-bakery. Since the meta shows signs of wear but the catillus appears to be unused, Monteix suggests that the millstone was in the process of being replaced at the time of the eruption.[202] This indicates that these mills were continuously operated until they were too damaged to use, and that owners had to reinvest repeatedly in new equipment in order to compete in such a high volume industry. With so many bakeries located within such a small urban space, having even one mill out of commission for an extended period of time could have a significant impact on an owner's profit, as another bakery could easily take over their market share.

The oven is also located in this main room, although the shape of the room prevented shoppers from having a direct line-of-sight to the oven. The oven has two passageways: one in front of the oven, perhaps for the storage of fuel, and one on the side of the oven, for passing dough to the oven. At the apex of the brick-faced arch is a sculpture of a phallus. Opposite the oven are two stone bases containing terracotta tubs, probably used for the first rising of the dough. Above these tubs were rectangular niches, only one of which survives. Fiorelli identified these niches as shrines of the Penates.[203] These two niches frame the entrance to the preparation room discussed previously.

The concentration of so many technological clusters in a single room is unusual, although the L-shaped room did create some sense of separation between the clusters. This space has a remarkably high level of presence-availability; in fact, it has a relative asymmetry of zero. Although each technological cluster is physically separated from the others, they would have been both visible and audible to each other at all time. This space produced both occasions

[202] Monteix et al 2015.
[203] Fiorelli 1875, 367.

associated with the mill-baking process and gatherings that occurred as people and products moved through the process. Not only were the workers visible and audible to each other but they were also visible and audible to outsiders at all times: those purchasing their daily bread in the shop and passing by on the Via Stabiana, one of the most trafficked roads in Pompeii. Thus, the behavior of workers was monitored not only by their owners and managers, but also by the public at large. Although this supervision and judgment must have made their labor feel like a performance, the workers could take solace in the fact that at least their workspace was well-ventilated. The same structures that produced the high degree of visibility also allowed for significant airflow through the bakery.

Adjacent to the oven and at the rear of the bakery is a room plausibly identified by Fiorelli as the stable (F).[204] There are two other rooms located near entrance 33 in the back of the mill-bakery. To the left of entrance 33 is a narrow latrine (D). To the right of entrance 33 is a room containing a stone bench or table along the northern wall and the passageway to the oven along the eastern wall (E). Entrance 33 would have functioned as a back entrance, and would have allowed workers and grain purchases to enter the workshop without disturbing customers purchasing bread at entrance 3.

[204] Fiorelli 1875, 367.

5. Mill-Bakery IX.5.4

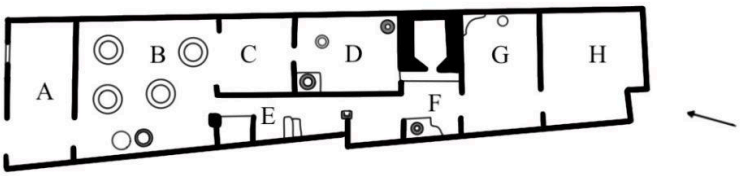

Fig. 15. Plan of mill-bakery IX.5.4 with labels corresponding to table 6. Plan by author from *Pompei: Pitture E Mosaici* and Monteix 2012, details from visiting the site in 2023.

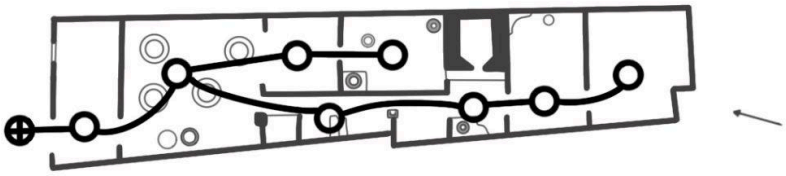

Fig. 16. Access map of mill-bakery IX.5.4. By author.

This mill-bakery, located on the Via di Nola (Fig. 27 and 28), is entered through a doorway in the western corner of the bakery's facade. To the east of the doorway is a small window, which provides light to the front room (A). Mayeske identifies this front room as a shop, although there is no archaeological evidence confirming this identification.[205] On the south wall of the front room, parallel to the entrance to the mill-bakery, is a doorway to the mill room

[205] Mayeske 1972, 134.

(B). The mill room contains the remains of four mills. The mill-stone located in the northeast corner of the mill room was added during an expansion of the mill-bakery which may have been ongoing at the time of the eruption. Along the western wall of this room are an overturned meta and a catillus.[206] This room has the lowest relative-asymmetry of any space within the mill-bakery, however the very asymmetrical layout of the mill-bakery means that the relative-asymmetry of even the most integrated space in this mill-bakery is quite high when compared with other mill-bakeries. Also as a result of this asymmetry, all of the workers in the mill-bakery had to pass through the mill room in order to reach the other technological clusters.

Also in the mill room is a wide doorway that provides access to two preparation rooms. Located in the northeast corner of the mill room, the first of these rooms may have been used as a stable (C); it currently contains the remains of two catilli.[207] Through this first preparation room / stable is a second preparation room (D). This room contains the basin of a kneading machine, as well as a catillus built into a stone foundation and a terracotta vessel sunk into the floor of the room. The catillus featured a basin used for the first rising with a lead sheet as the bottom.[208] On the southern wall of the room is a tall niche located next to a small passageway connecting to the oven. There is no evidence for stone tables in this room; Monteix suggests that potential reconstructions assume the use of wooden furniture.[209]

This preparation room has a very low level of presence-availability; it has a high relative-asymmetry value and a low control value. Thus, it is probable that it would have only

[206] Monteix et al 2012.
[207] Mayeske (1972, 134) states that this room contained a kneading basin in 1971. This is no longer present; Monteix (2012) asserts that the kneading basin was originally located in the preparation room to the south of this room. The kneading basin is currently located in the position indicated by Monteix's excavation.
[208] Monteix 2016, 163-4.
[209] Montiex et al 2012.

been entered for specific occasions associated with the preparation of dough. The high mean depth also increases the relative privacy of this room. Thus, this room would have been a place where workers had meaningful interactions facilitated both by their tasks and the spatial organization of the mill-bakery. The relative privacy of this space would have allowed workers to mix work and pleasure through singing and story-telling. Work songs would have helped workers keep their rhythm and work more effectively while also "taking the mind of the singer away from the place of the action."[210] Although the exact layout of this room cannot be reconstructed due to the impermanence of wooden structures, it is likely that it was laid out in a way that facilitated encounters. The wooden tables could have also been moved dependending on the tasks being performed and the workers performing it.

The mill room also contains the entrance to a narrow hallway running the length of the two preparation rooms (E). At the entrance to this hallway is a slightly raised rectangular structure with partial walls on two sides and the front open to the hallway. This structure is similar in form to structures in other mill-bakeries identified as tools used for sifting the milled grain. This hallway would have been a highly transitory space with a moderate level of presence-availability. Most of the gatherings that occurred in this space were produced by the layout of the operational sequence which required workers to move through this space while moving materials between steps of the bread-making process. However, the passageway connecting the preparation room to the oven would have prevented workers from having to carry the unbaked loaves through multiple other rooms.

[210] Korczynski 2003, 319-20.

This hallway connects to the oven room (F). Against the west wall of the oven room is a dolium built into a stone base. A vertical gutter made of ceramic pipes protected by tile fragments allowed rainwater to flow into this dolium.[211] The eastern side of the oven room contains a rather unusual oven. An arch about 20 ft deep curves over the baking chamber, which is only about half as tall as the arch.[212] The entrance to the baking chamber is also far closer to the ground than is typical of Pompeiian ovens. Beyond the oven room are two more rooms (G and H), the first of which contains a low, curved structure and sunken terracotta vessel against the eastern wall. The purpose of these two back rooms is unknown; they may have functioned as storage rooms, stables, or housing for enslaved workers.

Although this mill-bakery is almost arranged in a completely straight line, with workers having to pass through nearly every space in the mill-bakery in order to reach the back, the mill-baking process is not arranged in a straight-forward way. For raw materials to be turned into bread, they had to double-back through spaces they have already been through instead of the process being laid out in a straight line. Although a straight line might have been more efficient, the existing structure of the building as well as technical and financial limitations prevented this arrangement. Instead, the owners arranged the mill-bakery in the most efficient way possible given these constraints.

[211] Montiex et al 2012.
[212] Mayeske 1972, 135.

Conclusion

This study first arose out of an interest in an underappreciated group of people and the understudied archaeological sites associated with them. One of the primary goals of this work is to increase scholarly awareness of Pompeiian mill-bakeries and mill-bakers by providing updated descriptions and diagrams of these sites. Due to the dearth of scholarship on these sites, particularly English language scholarship, they are difficult to study without visiting them in-person. This has contributed to the continuous lack of interest in Pompeiian mill-bakeries. By providing these descriptions and diagrams, this study provides scholars with the tools to analyze Pompeiian mill-bakeries without needing to go to Pompeii.

In addition to increasing awareness of Pompeiian mill-bakeries and mill-bakers as a subject, an equally important goal has been to demonstrate how the methodologies of spatial syntax can be used to evaluate social interaction within Roman workshops – particularly bakeries – in order to better understand the people who worked in them. By applying these methodologies to a representative sample of Pompeiian mill-bakeries, this study gives us a new understanding of the daily lives of mill-bakers by reconstructing how they interacted with each other and within their work-spaces. Within Pompeiian mill-bakeries, the tasks associated with each technological cluster and the space associated with that cluster produced different kinds of social interactions. However, since each mill-bakery has a unique layout, the same technological cluster does not necessarily correlate with the same kinds of social interaction across bakeries. Gamma analysis confirms that the spatial organization of each Pompeiian mill-bakery is unique; there are few clear trends in the real relative asymmetry and control values of spaces associated with technological clusters. In fact, the only clear trend is that spaces associated with the

technological cluster of kneading and shaping dough tend to have low control values and are thus relatively isolated from the rest of the *chaîne opératoire.* Despite each mill-bakery's unique spatial organization and resulting patterns of social interactions, it is evident that the workers in many Pompeiian mill-bakeries had many shared experiences. No matter which mill-bakery they worked in, the work was grueling, the heat from the oven was stifling, and the owners were demanding. In each mill-bakery, the social interactions produced by the spatial organization of *chaîne opératoire* connected the workers to each other, creating a shared identity. By applying the methodologies of spatial syntax, this social aspect of working in Pompeiian mill-bakeries has been illuminated for the first time. This provides new insight into a critical industry of the ancient Mediterranean and the underappreciated workers employed in this sector.

Pompeiian mill-bakers are nearly completely anonymous, forgotten by history once they were buried beneath layers of ash in 79 CE. Yet without these anonymous individuals, who left almost no names or writing behind, the most famous town in Roman Italy would have starved. Their historical importance vastly exceeds the frequency of scholarly discussion about them. By analyzing what they did leave behind – the archaeological remains of their workplaces and the tools that they used – we can now more fully appreciate the importance of mill-bakers as critical providers in the complex Roman food supply system. No less important, by recreating the social space of the ancient bakery, we have helped mill-bakers to emerge from historical obscurity in ways that leave us better informed about their lived reality within a vitally important trade that continued long after these sites were buried by the ashes of Vesuvius.

Additional Figures

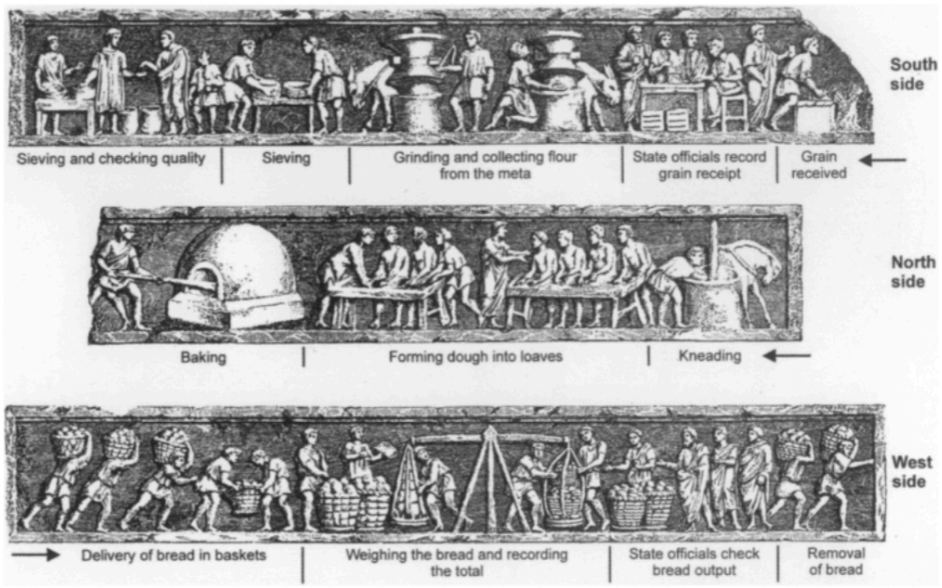

Fig. 17. Illustration of the frieze of the Tomb of Eurysaces with steps labeled. From Wilson and Schörle.

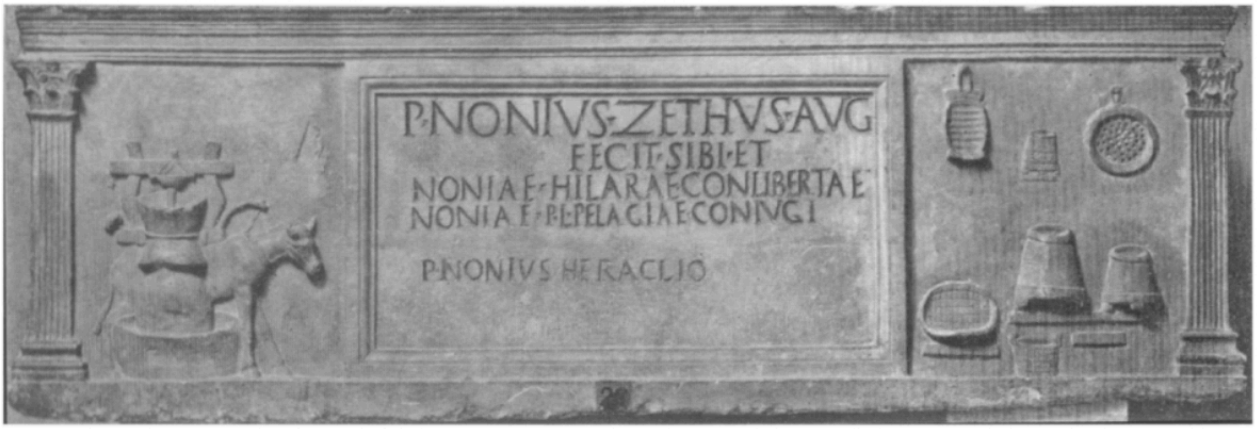

Fig. 18. The funerary monument of P. Nonius Zethus from Ostia. The left panel shows a mill with wooden superstructure and donkey, the right panel shows sieves and other baking implements. From Wilson and Schörle.

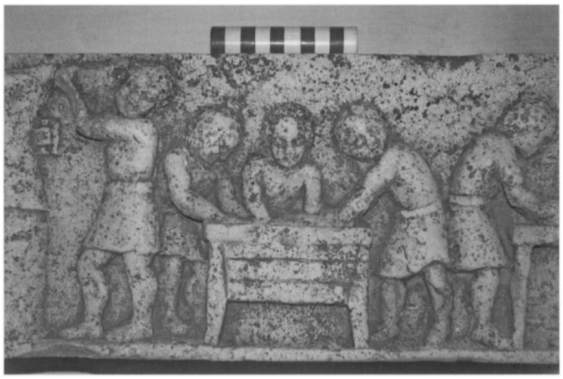

Fig. 19. Portion of the ‘Romolo’ relief showing three figures kneading dough within a kneading chest. From Wilson and Schörle.

Fig. 20. Portion of the ‘Romolo’ relief showing three figures forming loaves. From Wilson and Schörle.

Fig. 21. Mill room (A) of mill-bakery I.12.1-2. Photo by author.

Fig. 22. Oven room (E) of mill-bakery I.12.1-2. Photo by author.

Fig. 23. Preparation room (K) of mill-bakery I.12.1-2. Photo by author.

Fig. 24. Mill and oven room (A) of mill-bakery VI.2.6. Photo by author.

Fig. 25. Atrium with tempering facilities (A) of mill-bakery VII.1.36/37. Photo by author.

Fig. 26. View from shop entrance toward milling area (A) of mill-bakery IX.1.3/33. Photo by author.

Fig. 27. Mill room (B) of mill-bakery IX.5.4. Photo by author.

Fig. 28. Oven (F) of mill-bakery IX.5.4. Photo by author.

Tables

Table 2: Mill-Bakery I.12.1-2					
Room	K-value (# of spaces)	MD (Mean Depth)	RA (Relative Asymmetry)	RRA (Real Relative Asymmetry)	E (Control Values)
Mills (A)	22	2.76	0.18	0.84	1
B	22	2.38	0.14	0.65	1.97
C	22	3.05	0.21	0.96	0.58
D	22	3.33	0.23	1.08	0.25
Oven (E)	22	2.10	0.11	0.51	4.95
F	22	3.05	0.21	0.96	0.14
Stairs (G)	22	3.05	0.21	0.96	0.14
H	22	3.05	0.21	0.96	0.14
I	22	2.95	0.20	0.93	1.14
J	22	3.91	0.29	1.36	0.50
Prep. Room (K)	22	3.05	0.21	0.96	0.14

Table 3: Mill-Bakery VI.2.6					
Room	K-value (# of spaces)	MD (Mean Depth)	RA (Relative Asymmetry)	RRA (Real Relative Asymmetry)	E (Control Values)
Mills / Oven (A)	4	1	0	*n/a*	3
B	4	1	0	*n/a*	0.33
C	4	1.67	0.66	*n/a*	0.33

Table 4: Mill-Bakery VII.1.36-37					
Room	K-value (# of spaces)	MD (Mean Depth)	RA (Relative Asymmetry)	RRA (Real Relative Asymmetry)	E (Control Values)
Atrium (A)	12	1.27	0.06	0.19	6.33
B	12	2	0.20	0.70	0.63
C	12	1.71	0.14	0.50	0.13
D	12	1.71	0.14	0.50	0.13
Prep. Room (E)	12	1.71	0.14	0.50	0.13
Mills / Oven (F)	12	1.82	0.16	0.56	2.13
G	12	2.73	0.35	1.23	1
H	12	1.71	0.14	0.50	0.13
I	12	1.71	0.14	0.50	0.13
Stairs (J)	12	2.73	0.35	1.23	1
K	12	2	0.20	0.70	0.63

Table 5: Mill-Bakery IX.1.3/33					
Room	K-value (# of spaces)	MD (Mean Depth)	RA (Relative Asymmetry)	RRA (Real Relative Asymmetry)	E (Control Values)
Mills / Oven (A)	7	1	0	0	5
B	7	1.66	0.27	0.79	0.66
C	7	1.66	0.27	0.79	0.66
D	7	1.83	0.33	0.97	0.17
E	7	1.83	0.33	0.97	0.17
F	7	1.83	0.33	0.97	0.17

Table 6: Mill-Bakery IX.5.4					
Room	K-value (# of spaces)	MD (Mean Depth)	RA (Relative Asymmetry)	RRA (Real Relative Asymmetry)	E (Control Values)
A	9	2.63	0.46	1.45	1.33
Mills (B)	9	2	0.29	0.92	1.50
C	9	2.63	0.46	1.45	1.33
Prep. Room (D)	9	3.50	0.71	2.25	0.50
E	9	2.25	0.36	1.14	0.83
Oven (F)	9	2.50	0.43	1.36	1
G	9	3.13	0.61	1.92	1.50
H	9	4	0.86	2.71	0.50

Bibliography

Antonelli, F., G. Nappi, and L. Lazzarini. "Roman Millstones from Orvieto (Italy): Petrographic and Geochemical Data for A New Archaeometric Contribution." *Archaeometry* 43, no. 2 (2001): 167–89.

Apuleius. *Metamorphoses.* Translated by J. Arthur Hanson. Cambridge: Harvard University Press, 1989.

Bakker, Jan Theo. *The Mill-Bakeries of Ostia: Description and Interpretation*. Amsterdam: Gieben, 1999.

Banducci, Laura M. *Foodways in Roman Republican Italy.* Ann Arbor: University of Michigan Press, 2021.

Carratelli, Giovanni Pugliese. *Pompei : Pitture E Mosaici*. Rome: Istituto della Enciclopedia Italiana, 1990.

Donahue, John F. *Food and Drink in Antiquity.* New York: Bloomsbury Academic, 2015.

Erdkamp, Paul and Claire Holleran, eds. *The Routledge Handbook of Diet and Nutrition in the Roman World*. London: Routledge, Taylor & Francis Group, 2019.

Fiorelli, Giuseppe. *Descrizione di Pompei.* Napoli: Tipografia Italiana, 1875.

Fiorelli, Giuseppe. *Gli Scavi di Pompei dal 1861 al 1872.* Napoli: Tipografia Italiana, 1873.

Flohr, Miko, and Andrew Wilson, eds. *The Economy of Pompeii*. Oxford: Oxford University Press, 2016.

Frankel, Rafael. "The Olynthus Mill, Its Origin, and Diffusion: Typology and Distribution." *American Journal of Archaeology* 107, no. 1 (2003): 1–21. http://www.jstor.org/stable/40026564.

Garnsey, Peter. *Food and Society in Classical Antiquity*. Cambridge: Cambridge University Press, 1999.

Geracci, G. “Feeding Rome: The Grain Supply." Translated by Claire Holleran. In *A Companion to the City of Rome*, edited by Claire Holleran and Amanda Claridge. Hoboken, NJ: John Wiley & Sons, Inc., 2018, 219–245.

Grahame, Mark. “Public and Private in the Roman House: the *Casa del Fauno.”* In *Domestic Space in the Roman World : Pompeii and Beyond,* edited by Ray Laurence and Andrew Wallace-Hadrill, Portsmouth, RI: *Journal of Roman Archaeology*, 1997, 137–64.

Hillier, Bill, and Julienne Hanson. *The Social Logic of Space*. Cambridge: Cambridge University Press, 1984.

Instituto di Corrispondenza Archeologica. *Bullettino dell'Instituto di Corrispondenza Archeologica per l’Anno 1884.* Rome: Salviucci, 1884.

Iovino, Gennaro et al. *“*La Disciplina Dell’Odiosa Baracca: la Casa con il Panificio di Rustio Vero a Pompei (IX 10,1).” *E-Journal Scavi di Pompei* no.8 (2023). https://pompeiisites.org/wp-content/uploads/E-Journal_8_08122023.pdf

Jones, Nathaniel B. “Exemplarity and Encyclopedism at the Tomb of Eurysaces.” *Classical Antiquity* 37, no. 1 (2018): 63–107. https://www.jstor.org/stable/26497646.

Joshel, Sandra R., and Lauren Hackworth Petersen. *The Material Life of Roman Slaves*. New York, New York: Cambridge University Press, 2014.

Joshel, Sandra R. “Geographies of Slave Containment and Movement.” In *Roman Slavery and Roman Material Culture*, edited by Michelle George, Toronto: University of Toronto Press, 2013, 99–128.

Korczynski, Marek. “Music at Work: Towards a Historical Overview.” *Folk Music Journal* 8, no. 3 (2003): 314–34. http://www.jstor.org/stable/4522689.

Laurence, Ray. *Roman Pompeii: Space and Society*. New York: Routledge, 2007.

Longenecker, Bruce W. “The Cross in a Pompeii Bakery.” In *The Cross before Constantine: The Early Life of a Christian Symbol*, Minneapolis: Fortress Press, 2015, 121–48. https://doi.org/10.2307/j.ctt13wwwf3.9.

Longfellow, Brenda. “A Gendered Space? Location and Function of Room 5 in the Villa of the Mysteries” In *Villa of the Mysteries: Ancient Ritual, Modern Muse*, edited by E. Gazda, Ann Arbor: University of Michigan Press, 2000, 24–37.

Mau, August. *Pompeii: Its Life and Art*. Translated by Francis W. Kelsey. Washington D.C: McGrath Publishing Company, 1973.

Mayeske, Betty Jo. “A Pompeian Bakery on the Via dell’Abbondanza.” In *Studia Pompeiana & Classica, In Honor of Wilhelmina F. Jashemski*, edited by Robert I. Curtis. Vol. 1 (1988), New Rochelle: Aristide D. Caratzas, 149–66.

Mayeske, Betty Jo. “Bakeries, Bakers and Bread at Pompeii: A Study In Social and Economic History.” PhD Dissertation, University of Maryland, 1972.

McGovern, Patrick E., *Ancient Wine : The Search for the Origins of Viniculture*. Princeton: Princeton University Press, 2019.

Meyer, Frederick G. “Carbonized Food Plants of Pompeii, Herculaneum, and the Villa at Torre Annunziata.” *Economic Botany* 34, no. 4 (1980): 401–37. http://www.jstor.org/stable/4254221.

Monteix, Nicolas. “Contextualizing the Operational Sequence: Pompeian Bakeries as a Case Study.” In *Urban Craftsmen and Traders in the Roman World*, edited by Andrew Wilson and Miko Flohr, Oxford: Oxford University Press, 2016, 153–80.

Monteix, Nicolas et al. “Pompéi, Pistrina.” *Chronique des Activités Archéologiques de L’École Française de Rome*, 2012. https://doi.org/10.4000/cefr.328

Monteix, Nicolas et al. “Pompéi, Pistrina.” *Chronique des Activités Archéologiques de L’École Française de Rome*, 2013. https://doi.org/10.4000/cefr.954

Monteix, Nicolas et al. “Pompéi, Pistrina.” *Chronique des Activités Archéologiques de l’École Française de Rome*, 2014. https://doi.org/10.4000/cefr.1242.

Monteix, Nicolas et al. “Pompéi, Pistrina.” *Chronique des Activités Archéologiques de L’École Française de Rome*, 2015. https://doi.org/10.4000/cefr.1380.

Moritz, L.A. *Grain Mills and Flour in Classical Antiquity*. Oxford: Clarendon Press, 1958.

Nissin, Laura. “Smellscape of a Pompeian Neighborhood.” *Journal of Roman Archaeology* 35 (2022): 621–53.

Oberhofer, K. “Die Bäckerei VII, 2, 22 in Pompeji.” In *Akten des 11. Österreichischen Archäologentages in Innsbruck 23.-25.März 2006*, edited by Gerald Grabherr and Barbara Kainrath, Innsbruck: Innsbruck University Press, 2008, 205–214.

Peacock, D. P. S. “The Mills of Pompeii.” *Antiquity* 63, no. 239 (1989): 205–214.

Petersen, Lauren Hackworth. “The Baker, His Tomb, His Wife, and Her Breadbasket: The Monument of Eurysaces in Rome.” *The Art Bulletin* 85, no. 2 (2003): 230–57. https://doi.org/10.2307/3177343.

Pliny the Elder. *Natural History.* Vol. 5. Translated by H. Rackham. Cambridge: Harvard University Press, 1961.

Pliny the Younger. *Letters*. Translated by Betty Radice. Cambridge: Harvard University Press, 1969.

Rowan, Erica. "The Sensory Experiences of Food Consumption." In *The Routledge Handbook of Sensory Archaeology,* edited by Robin Skeates and Jo Day. New York: Routledge, 2019, 293–309.

Sellet, Frédéric. "Chaine Operatoire; The Concept and its Applications." *Lithic Technology* 18, no. 1/2 (1993): 106–112. http://www.jstor.org/stable/23272868.

Thurmond, David. *A Handbook of Food Processing in Classical Rome: For Her Bounty No Winter.* Leiden: Brill, 2006.

Wallace-Hadrill, Andrew. "The Social Structure of the Roman House." *Papers of the British School at Rome* 56 (1988): 43–97. http://www.jstor.org/stable/40310883.

Wilson, Andrew, and Katia Schörle. "A Baker's Funerary Relief from Rome." *Papers of the British School at Rome* 77 (2009): 101–123. http://www.jstor.org/stable/25754011.

Zaccaria Ruggiu, Annapaola et al. "Le Indagini Archeologiche Dell'università Ca' Foscari Di Venezia Nella 'Regio V' (2008-2009)." *Rivista Di Studi Pompeiani* 21 (2010): 112–38. http://www.jstor.org/stable/44291761.

Zanker, Paul. *Pompeii: Public and Private Life*. Translated by Deborah Lucas Schneider. Cambridge: Harvard University Press, 1998.