ARTICLE

Paving Pompeii: The Archaeology of Stone-Paved Streets

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Careful survey of Pompeii's lava-stone pavements reveals a complex history of their origin, their repair, and the municipal administration that oversaw them. Our paper first examines two processes that inform our survey's methodology: the laying of a stone pavement and the subsequent patterns of wear that degraded it. We describe the five forms of evidence from Pompeii's streets that resulted from these processes and allow for the identification of individual sections of paving. Using both relative and absolute chronological evidence, we order these sections of paving into eight phases of development. Finally, a detailed analysis of the frequency and extent of these individual paving events sheds light on a pavement's expected life-span as well as implications for the administrative and financial upkeep required to maintain a street network.[1]

INTRODUCTION

From almost the moment of their initial discovery, the streets of Pompeii have been a subject of academic interest and a wellspring for the public's imagination of the past (fig. 1). Within a generation of the first excavations, Piranesi had drawn the paving stones of via Consolare in as much detail as the buildings along the street. Most famously, in the mid 19th century, Mark Twain bemoaned the deep ruts at Pompeii and "how for two hundred years at least the pavements were not repaired."[2] From the end of that century and into the first half of the 20th century, the orientations and intersections of streets were set in service of larger questions about the evolution of the urban grid.[3] More recently, research has focused on movement and the experience of streets, including both wheeled and pedestrian traffic as well as the social and economic life they generated.[4]

Despite more than 200 years of academic interest in the streets of Pompeii, we still lack the most basic understanding of the formation and life-span of the city's stone pavements. Our paper attempts to address this question

[1] We would like to thank Massimo Osanna, the Soprintendenza Archeologica di Pompei, and the custodians of Pompeii for many years of unfettered access to the site. Similarly, we are indebted to our anonymous reviewers for the *AJA* for their serious engagement with and important suggested improvements for this paper. Finally, we are grateful to Allison Emmerson for her edits, Jeffrey Veitch for bibliography, Janet Dunkelbarger for sharing her research on street drains, Walter van Roggen for his efforts to measure stepping-stones, Steven Ellis for sharing sections of his book while still in press, and the *AJA* for issues of timing. Additional figures and documents can be found online; a URL appears with each mention.

[2] Twain 1869, 328.

[3] Mau 1899, 32–3; Haverfield 1913; Carrington 1936, 21–7; von Gerkan 1940.

[4] Research on wheeled traffic: Tsujimura 1991; Poehler 2006, 2017; Kaiser 2011a; research on pedestrian traffic: Ellis 2004; Hartnett 2008, 2011, 2017; social and economic life of streets: Wallace-Hadrill 1995; Kellum 1999; Kaiser 2011b.

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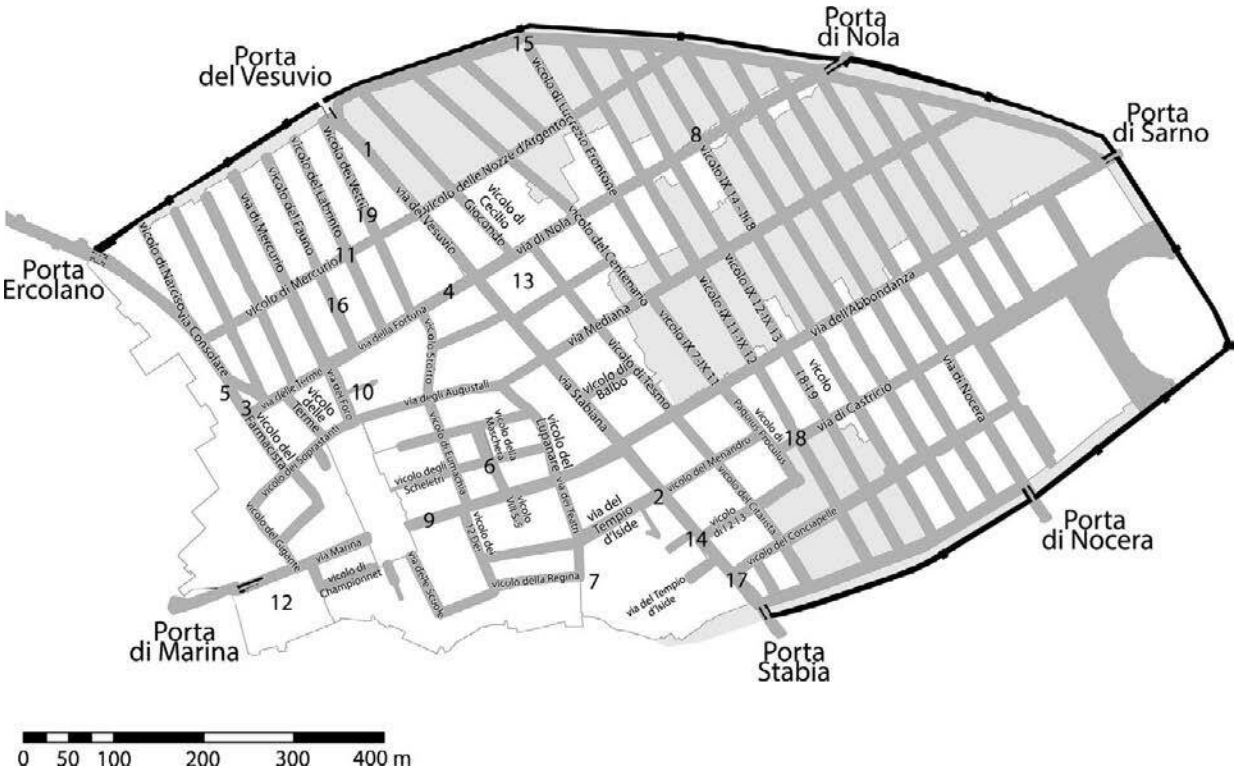

FIG. 1. Plan of Pompeii with streets and locations mentioned in the text labeled. Light gray areas are unexcavated.

by defining several new classes of evidence found in the streets and by developing a method for organizing that evidence first into a relative and then into an absolute chronological sequence. Using this evidence and method, we reconstruct a complete phased plan of Pompeii's street surfaces, from the initial efforts in the late second century B.C.E., through the Augustan floruit, to the delays and emergency procedures of the post-earthquake(s) period. Finally, we turn our archaeological history toward questions of administrative capacity and fiscal burdens required to create and maintain a paved street network.

At the outset, it is necessary to orient the reader to our organization of the evidence and where to find it. Our basic unit of analysis is the paving event (PE), a section of stone pavement defined by observable junctures with other paving events. These paving junctures often indicate a relative chronological relationship between paving events, while excavations and datable architecture offer opportunities to introduce absolute chronology. Each paving event and instance of stratigraphic evidence has been described (Supplementary Table 1 and Supplementary Table 2, respectively, at https://works.bepress.com/eric-poehler/). When appropriate, we list references to specific paving events in the footnotes with the abbreviation PE_[number]. We also refer to locations of these paving events using Pompeii's modern street names. The streets we refer to in the text are labeled in figure 1 (and in subsequent figures), as are specific locations in Pompeii that we discuss. These are labeled on figure 1 with numbers and referred to in the text as, for example, "fig. 1[1]." Finally, a note on stone types and terminology. The paving stones of Pompeii consist of a heavy, dark basaltic lava stone,[5] which we describe as "lava stone," or *silex*, using the general Latin term.[6] For local travertine stones, we use the common name, "Sarno limestone."

A BRIEF HISTORY OF PAVING AT POMPEII

Pompeii was never completely paved in stone. Instead, several different technologies of paving, including surfaces made of beaten ash (*battuto*), destruction

[5] See Kastenmeier et al. (2010), whose terminology we follow for lava and other stones.

[6] Although there are some observable differences in hardness of these lava stones, those differences are minor, few, diffuse within PEs, and never observable as a difference between PEs.

debris, river cobbles, and finally irregularly shaped pieces of dense lava stone, all coexisted over the life of the city (fig. 2).[7] The full variety of these surfaces and their sequence can be reconstructed from investigations within the long street that traverses the city from north to south, today called via del Vesuvio and via Stabiana. Remnants of the earliest known streets, from at least the fourth century B.C.E., were recovered at both the northern (Porta del Vesuvio) and southern (Porta Stabia) city gates on this route,[8] but a more complete picture of the street's evolution comes from the northern half of via del Vesuvio (see figs. 1[1], 3). Here, a thin beaten-ash surface was laid directly onto the ancient ground level and sloped down to the west into a small runoff channel beside the street. A second layer of *battuto*, laid on top of the first, created a much wider street with a steeply upward sloping westward side that now kept any water inside the street. The earliest version of a stone pavement at Pompeii, a surface of "granite pebbles . . . embedded into a thin layer of clay," however, was missing from this sequence in via del Vesuvio, found instead only near the gates.[9] These cobble surfaces are rare and fragmentary at Pompeii, but in all cases they fit between the beaten ash and the lava-stone surfaces and date, at the earliest, to ca. 300 B.C.E. The absence of this paving technique within the city suggests that it may have had limited adoption or that it was preferred as an extra-urban surface.[10]

The first known use of the familiar polygonal lava-stone paving at Pompeii was recovered at a depth of 80 cm below the current surface on via Stabiana (see fig. 1[2]),[11] which matches a similar sequence of lava-stone surfaces separated by 50 cm at the Porta del Vesuvio. Although the excavators only provide generalized dates,[12] we propose that this earliest lava-stone surface can be connected with confidence to the Oscan inscription documenting the paving of a via Pumpaiiana.[13] This connection dates the surface to the first decades of the first century B.C.E. (if not earlier) and provides a reasonable approximately 80- to 90-year life-span for the first lava-stone streets at Pompeii, which is double or triple the average life-span of *battuti*.[14] The final lava-stone pavement on via Stabiana, dated to the Augustan era, also lasted approximately 80 years, but those were harder years. Following decades of traffic after the Augustan economic boom, deep ruts had cut nearly all the way through the pavers (fig. 4), threatening to unravel the street like the frayed edge of a mosaic. In response, the southern half of via del Vesuvio, which had never been replaced and was likely more than 130 years old, was repaved in the middle of the first century C.E. By 79 C.E., the Augustan pavements, like those on via Stabiana, had also borne the post-earthquake(s) reconstruction traffic, which further increased wear on the arteries essential for that rebuilding. To keep these streets intact during reconstruction, the Pompeians took a different approach, attempting to fuse the street back together by filling the ruts and the gaps between paving stones with a molten iron and iron-slag slurry. How and why the Pompeians took this novel and counterintuitive step is the subject of another paper, though it is discussed briefly below. For the present discussion, it is enough to say that these repairs were occurring in the very last days of the city as iron droplets still present on the sides of deep ruts had not yet been worn away by traffic. Finally, it should be noted that these ancient ruts were not the last damage sustained by this long-lived street. In 1592, Dominico Fontana's aqueduct cut through via Stabiana, and in September of 1943 an allied bomb fell directly onto via del Vesuvio; each of these events left a remarkable scar in the pavement (Supplementary Figure 1: https://works.bepress.com/eric-poehler/99/; Supplementary Figure 2: https://works.bepress.com/eric-poehler/98/).[15]

THE PROCESS OF PAVING

How would the ancient Pompeians have repaired damaged stones or, more importantly, an entire street worn through by decades of traffic? To answer this, we must rely on the evidence from the few streets still under repair in Pompeii's final days. At the far western end of via delle Terme (see figs. 1[3], 5), the remnants of the repair of adjacent streets provide insight into the creation of paving stones. Several loose examples

[7] Poehler 2017, 53–76.

[8] Maiuri 1929, 186–88; Seiler et al. 2005, 218; Ellis et al. 2011, 11, fig. 22.

[9] Devore and Ellis 2008, 12.

[10] Nappo 1997, 95.

[11] PE_178; Rispoli and Paone 2011, 132–33.

[12] Maiuri (1929, 186–88) called the earlier surface "Roman." Rispoli and Paone (2011) offer no dates.

[13] See discussion infra n. 35, Phase 1.

[14] Excavations show beaten-ash streets replaced every 25–40 years. See Poehler 2017, 58–60.

[15] García y García 2006, 19–28; Harris 2007, 23–4.

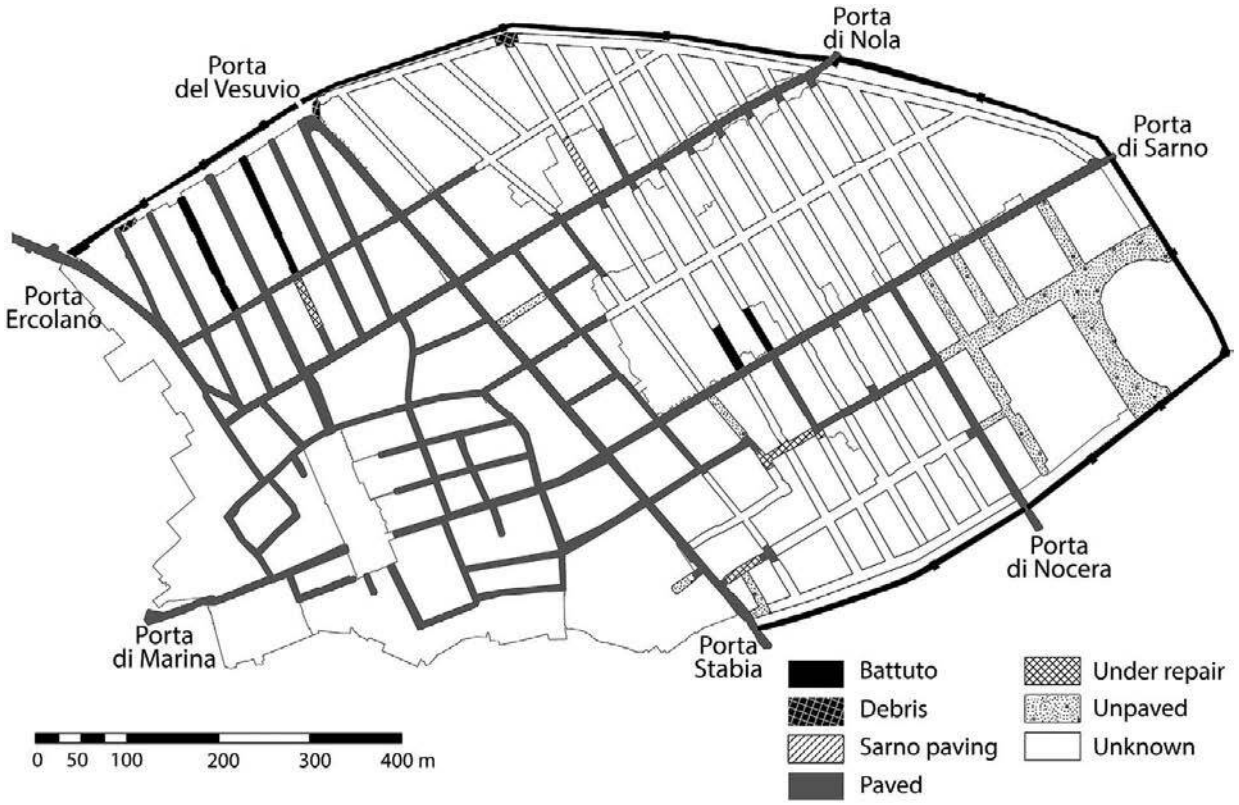

FIG. 2. Plan of paving styles at Pompeii: *black*, beaten-ash (*battuto*) surface; *black with cross-hatching*, street surfaces on debris mounds; *diagonal hatching*, polychrome stone paving (Sarno paving); *gray*, lava-stone pavement; *crosshatch*, streets dilapidated and under repair; *stippling*, streets known to have no paved surface; *white*, surface type unknown.

found here—like those recovered in piles scattered around the city—reveal that Pompeii's pavers were not flat flagstones but were instead either dome- or pyramid-shaped stones with an irregular outline on their flat, top-facing sides.[16] Street builders preferred these shapes for paving stones not only because they provided an efficient means of constructing a flat, functional street surface but also because it was relatively simple to create pavers from raw materials.

Two huge, ovoid stones sit on via delle Terme's ancient, weathered surface, and their presence here helps us understand how such rough-hewn boulders were transformed into paving stones.[17] First, workers wedged off the boulder's rounded edges to create up to six dome-shaped pavers before splitting the remaining cubic core into two or possibly four pyramid-shaped stones.[18] To create a consistently flat top surface, further chiseling was necessary, a process evident on many paving stones that were either recently laid or were protected from wear. To fit against the irregular outline of those pavers already laid, masons shaped the next stone in place, carefully cutting and smoothing its edges to create a tight connection. The lower shape of the stone aided in making these tight joins by sloping away in a kind of anathyrosis. Additionally, dome- and pyramid-shaped pavers were preferred over flat-bottomed stones because, once the stones

[16] These piles of paving stones are found on streets not under construction (vicolo di Tesmo at IX 6, 3; via dell'Abbondanza at III 7, 1, and across from II 5, 2–3), on streets under construction (vicolo della Conciapelle at via Stabiana), and stored in locations where they otherwise do not belong (within the Central Baths; on vicolo IX 11–IX 12).

[17] Another such boulder rests next to a tomb (PE_25/33 North) just outside the city.

[18] Laurence (1999, 64) notes the same manner of splitting basaltic stone.

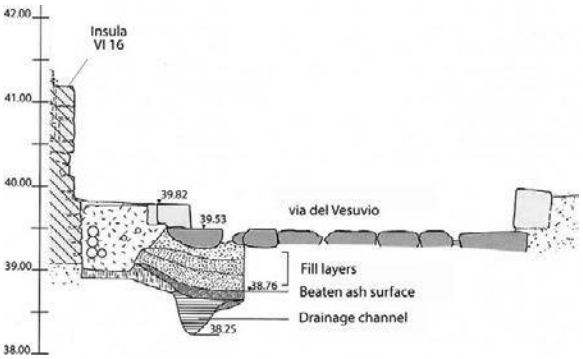

FIG. 3. Section of via del Vesuvio (PE_005); view to north (modified from Seiler et al. 2005, fig. 4).

FIG. 4. Deep ruts on via Stabiana (PE_006) between vicolo di Balbo and via degli Augustali; view to north.

were rutted completely through and the force of compression among them was removed, the greater mass of these stones would help (temporarily) prevent displacement.

Thus, these paving stone shapes held the street together by generating a still greater compression within the surface, as the projecting bottom shape displaced the fill layers below and prevented voids. Although fills could be relatively shallow,[19] streets under construction at the time of the eruption show that once an earlier surface was stripped away, the curbs were

[19] Shallow fills (ca. 40 cm): via del Vesuvio (PE_005; Seiler et al. 2005, 218, 231–33) and vicolo delle Nozze d'Argento (PE_073; Boman and Nilsson 2014); deep fills (ca. 80 cm): via Stabiana (PE_178; Rispoli and Paone 2011, 132–33).

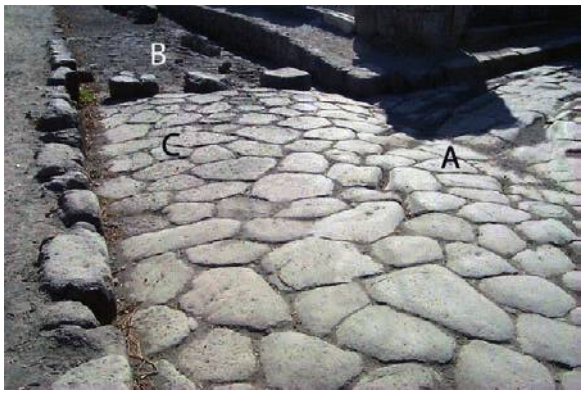

FIG. 5. Via delle Terme (PE_004), with via Consolare (PE_002) coming in at the right; view to west. Curving ruts at intersection cross the linear abutment (*A*) but avoid the Phase 1 pavement (*B*, PE_003) and wearless area (*C*).

(re)constructed and mechanisms were introduced to manage the bedding layers. Cross-walls, built in Sarno limestone a single course high, were set at very slight angles across vicolo del Conciapelle and vicolo del Fauno with the likely purpose of both retaining the fills and dividing the repaving process into sections. It is not yet known whether these cross-walls were removed or were modified and built over when the pavers were laid.[20]

IDENTIFYING PAVING EVENTS

Within Pompeii's 11 km of paved streets there are several varieties of evidence that can be used to identify different paving events (hereafter, PEs), including linear abutments, differential paving, terminating ruts, and wearless areas. These identifications not only establish the edges of different PEs but also distinguish them chronologically through their physical relationships. We describe each type of evidence here to make clear our methodology for identifying PEs at Pompeii and to make available a set of tools for use at other sites.

Linear Abutment

Because the polygonal style of paving creates an irregular pattern of seams between stones, it is rare to find more than a few pairs of stones that meet on the same alignment. Indeed, these innumerable junctions create weak points in the paving and are the primary

[20] Poehler 2017, 81.

reason (among several interdependent factors) why many ruts in Pompeii are short and discontinuous, appearing in one place, growing deep, and then becoming shallow and disappearing, often only to reappear a few meters farther down the street.[21] At 53 intersections across the city, however, there are 81 examples in which a sharp line is present between a series of stones precisely at the junction of two streets. These alignments attest to an abutment between two different events of paving, though determining which event responded to the other, and was therefore later, is not always straightforward. Similarly, the line between PEs is not always sharp and perfectly straight, especially at intersections where curbs are not aligned. Many abutments, like the line crossing between via Consolare and via delle Terme, are long, crisp, and further distinguished by changes in the street form itself, in this case the depth of rutting and the strong camber of via delle Terme as it meets via Consolare (see figs. 1[3], 5[A]).

Differential Paving

Linear abutments are regularly accompanied by differences in the two abutting surfaces, such as wearing, rutting, and the character of paving. Often, these differences can be attributed to the duration of time between the laying of one pavement and the next. Sometimes these differences are strikingly clear. Again, at the intersection of via Consolare and via delle Terme, a set of three stepping-stones marks the abutment of pavements with very different characteristics. To the east of the stepping-stones the new surface is rutted and made up of large stones fitted tightly together and with a distinct camber between the curbs. To the west, the stones are smaller, deeply weathered, and lie without camber at a slightly lower elevation (see figs. 1[3], 5[B]). Even if there were no clear line to distinguish them, these two pavements would still be so distinct that they undoubtedly belong to different chronological phases. This assessment is further reinforced by the wearless area also found here (see below).

The general variability in the depth and number of ruts is especially useful in distinguishing PEs and organizing them into a relative order of construction. In many cases, such a change is obvious, for instance on the easternmost section of via della Fortuna (see fig. 1[4]). Approximately 24 m west of its intersection with via del Vesuvio, via di Nola, and via Stabiana, an exceptionally deeply rutted pavement (fig. 6[A]) is replaced by a short section (ca. 15 m) of fresh pavement (see fig. 6[B]), before returning again to a state of disrepair (see fig. 6[C]). The stark difference in the character of these pavements and the immediacy of the change in rut depth make both the event of repaving and its extent obvious.

Terminating Ruts

The change in rut depth on via della Fortuna emphasizes a clear difference in the surface of the two pavements, because several deep ruts end at the very same location. Whereas differential paving is defined as the general change in character between pavements, terminating ruts distinguish pavements through the abrupt end of one or more clearly identifiable ruts. This form of evidence provides a definite chronological indicator because the ruts' sudden termination can only be explained by the removal and replacement of the previously rutted stones. It does not necessarily follow, however, that all traffic was halted at these locations after repaving. In fact, over time, terminating ruts acted as guides for additional rutting, and shallower ruts often continue directly onto the newer pavement.[22] The depths of such continuing ruts, however, are a benefit to interpretation as they provide some indication of the amount of time that had passed since the newer section was repaired. One of the best examples of this class of evidence is found at the intersection of vicolo del Farmacista and via Consolare, where a deep rut in vicolo del Farmacista dissipates precisely at the junction between worn and unworn paving stones (see figs. 1[5], 7). Clearly, the repair of via Consolare removed the earlier rut; thereafter, as the deep ruts in the via Consolare that curve southeast toward the via delle Terme show, traffic bypassed vicolo del Farmacista. The changed traffic pattern left a broad, pockmarked section of paving—a wearless area—where the via Consolare passes the end of the vicolo del Farmacista.

Wearless Areas

Evidence that new paving stones and other street features originally bore pockmarks abounds in Pompeii. For example, the pavement between the guard

[21] On rut formation, see Poehler 2017, 109–16.

[22] For example, PE_142 onto PE_144, PE_091 onto PE_090, PE_129 onto PE_090, PE_074 onto PE_075, and PE_033, PE_109, PE_179 onto (repaired intersection) PE_178.

FIG. 6. Differential paving on via della Fortuna; view to west. Area of exceptionally deep ruts (*A*, PE_091) meets short section of repair (*B*, PE_090), followed by another deeply rutted section (*C*, PE_129).

stones of a fountain on via Stabiana retains these marks even as the rest of the stone has been nearly worn through by the passage of wheeled traffic (Supplementary Figure 3: https://works.bepress.com/eric-poehler/100/). Because vehicles could not reach this space and pedestrians were rarely foolish enough to stand here, this small area was protected from most erosional forces. The tops and sides of stepping-stones exhibit a related phenomenon. Wear from human feet produces a lunette shape on each side of the stepping-stone, leaving the far ends unworn and pockmarked. In addition, on several streets with stepping-stones, the pavement directly in front of and/or behind the stepping-stones preserves a "shadow" of pockmarks where cart wheels could not wear them away without also colliding with the stone. A similarly pockmarked area can be seen along the edge of recently repaved streets.

Across all of Pompeii, however, there are only two places where a large area of pockmarked paving stones without ruts remained at the time of the eruption. These examples of wearless areas are the rarest forms of evidence for paving and repaving and demonstrate that these sections never carried sufficient traffic to smooth the pavement into its familiar form, let alone allow significant ruts to form. Even though this does not mean traffic never crossed these unworn areas, their distribution offers useful information about how and when *silex* was laid in Pompeii. Apart from the

FIG. 7. Terminating rut (*A*) on vicolo del Farmacista (PE_126) at the pockmarked wearless area on via Consolare (PE_002). View from above, to south.

wearless area at vicolo del Farmacista and via Consolare described above (see fig. 1[5]), the only other wearless area is found one block away, at the intersection of via delle Terme and via Consolare (see figs. 1[3], 5[C]). Bounded by a set of deep curving ruts, a large area of pockmarked paving stones demonstrates the absence of regular traffic moving through the southwest part of the intersection. The absence of traffic across both wearless areas is the effect of the construction of a large ramp and drain across the inter-

section one block to the west that bisected vicolo del Farmacista and by blocking that street turned its two sections as well as the western end of via delle Terme into dead ends. Most importantly, these wearless areas allow us to understand that the insertion of that large ramp and drain had to precede (or be contemporary with) the repaving of via delle Terme but could only have followed soon after the repaving of portions of via Consolare and vicolo del Farmacista.[23]

Continuous Paving

The absence of the four categories of evidence just described indicates that a pavement, one which otherwise might be expected to be divided into two or more segments, belongs to a single event. Occasionally, a segment of paving passes through an intersection, connecting two (or more) blocks of a street in a single event of paving. An example of this, the continuation of vicolo degli Scheletri across vicolo della Maschera (see fig. 1[6]), shows linear abutments on the northern and southern edges of the intersection and a concomitant depth of rutting throughout. In other places, pavements continue around the bend in a street, such as where vicolo della Regina turns north at the edge of the Triangular Forum (see fig. 1[7]). A section of more than three blocks of via di Nola shows a related example. This PE is a single, continuous surface intersected by four streets from the north and four from the south, only one of which is known to have had an earlier *silex* surface. At each of the four southern streets, via di Nola's pavement continues southward seamlessly for a few meters (see figs. 1[8], 8). These extensions indicate that these streets likely had only ever been given beaten-ash surfaces, since there was no earlier pavement to abut. At the same time, the extensions suggest the expectation that someday these streets would be paved in stone.[24] In all these examples (and others not mentioned), the characteristics of an uninterrupted paving event continue beyond the boundaries of one street and bind the surface of another street (or several streets) to it. Identifying continuous pavements is therefore of particular use in defining larger PEs, which reveal more ambitious activities of paving or replacement.

FIG. 8. Continuous paving of via di Nola at vicolo IX 14–III 8 (PE_131); view to south.

ANALYSIS, SYNTHESIS, AND INTERPRETATION

Our methodology for identifying PEs described above was applied on all of Pompeii's streets in repeated surveys between 2012 and 2016. These surveys yielded 217 identifiable junctions between 172 individual sections of stone-paved street surfaces.[25] While on site, Tsujimura's 116 sections of differently rutted pavements—the only other city-wide data on the pavements—proved invaluable, as it suggested where instances of differential paving or terminating ruts might occur.[26] Still, using Tsujimura's observations required careful reconciliation and, in some cases, correction. While her map of rutting suggested many locations of paving junctions beyond intersections, Tsujimura's locations of differing rut depths did not always correspond to places where we could identify paving junctures based on our criteria. For example, a clear linear abutment crosses the intersection where via Consolare and via delle Terme meet (see figs. 1[3], 5[A]), but Tsujimura's categorization shows no distinction, as both streets have deep ruts. Such a circumstance remains useful, however, as it suggests that the distinction in time between the laying of these two pavements was not sufficiently long to produce different results from what logic dictates was the same volume of traffic.[27]

[23] See infra n. 65.

[24] Additional examples include PE_157 and PE_160.

[25] This total excludes paving junctures of continuous or unknown type.

[26] Tsujimura 1991.

[27] Theoretically, it is possible that similar depths can be the result of one street with a high volume of traffic over a short duration meeting another street with a low volume of traffic over

After incorporating Tsujimura's results into our own, we analyzed the distributions of paving events and paving junctures around the city. Figure 9 graphs the number of each type of paving juncture found at Pompeii, including their co-occurrences, at intersections and outside of intersections. There are some obvious statistical and spatial correlations. For instance, linear abutments are almost always found at intersections, most often where a narrow, one-lane street abuts the pavement of a larger, two-way street.[28] This distribution of linear abutments suggests that the larger, primary streets were paved first and were then later abutted by newer pavements on the secondary streets. When main streets were repaired across intersections, the sequence of older pavements on the main streets and newer pavements on the secondary streets became reversed, creating a rutting pattern that cannot be explained by changes in driving practices.[29] At intersections, the number of vehicles turning onto, turning out of, or continuing through a street increased the pressure on the pavements. This often necessitated the replacement of the street surface within an intersection. Proof of this, of course, comes from the streets themselves, both in the form of intersections deeply worn with crossing and turning ruts and in those intersections where the damaged pavements had been replaced.[30] The best tool for identifying such a repair and placing it within the relative chronology is the most common type of paving juncture, differential paving. Differential paving commonly co-occurs with linear abutments (61 instances) and terminating ruts (51 instances), but even on its own there are more examples of differential paving (89 instances) than any other juncture type at Pompeii. Once again, most examples of differential paving are found on the largest streets.

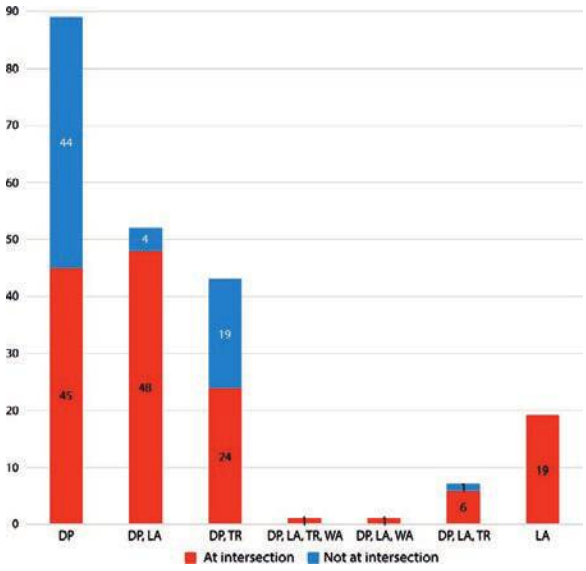

FIG. 9. Paving junctures by type and relation to intersections: *DP*, differential paving; *LA*, linear abutment; *TR*, terminating ruts; *WA*, wearless area. Combinations of abbreviations indicate co-occurrences of paving juncture types.

The basic analysis of these forms of evidence shows the remarkable number of changes to Pompeii's pavements that occurred. Still, to understand the totality of these events and how such action was organized, it is first necessary to reconstruct how much of the city was paved in each period of its history. Once this reconstruction is accomplished, it becomes possible to more accurately interpret the evolving choices that Pompeians were making to supply their city with this newly important form of urban infrastructure.

A CHRONOLOGY OF PAVING AT POMPEII

The arrangement of more than 170 different events of lava-stone paving into historical phases required a two-tiered approach that drew on the relationships among the PEs themselves as well as their associations with buildings and other features with published historical dates. Although applied to a different data set, our method is familiar to anyone who has ordered excavation data into phases. First, we built a relative chronology of the PEs based on their stratigraphic relationships, and then we further refined that chronology with material that can provide absolute dates. Thus, while linear abutments separate paving stones into distinct units and continuous pavement unites them,

a long duration. In practice, however, such a result is difficult to achieve and relatively easy to identify based on additional factors, including the different widths of these streets, weathering of the pavement, and the intensities of the facade use.

[28] Forty-five linear abutments exist where smaller streets abut wider streets, 11 exist between two wide streets, and two were found outside an intersection. In 23 locations, linear abutments exist where one narrow street abuts another.

[29] Most often, these changes matched with Tsujimura's observations, but in a few locations they did not. Even in those cases where there is a match, the size of repair represented on Tsujimura's map was sometimes larger than we observed on site, especially at intersections.

[30] Turning produced the greatest friction with the pavement, and turning ruts developed especially quickly in some places (PE_004, PE_075, PE_116, PE_118, PE_161).

terminating ruts and differential pavements define the sequence between events. Still, only with the introduction of well-stratified and dated archaeological information is it possible to assign each PE to a historical phase. This second step in our approach employed 97 instances of stratigraphic evidence from several classes of architecture—fountains (34), monumental buildings (15), and other structures (4)—as well as the information gleaned from 40 excavations within the streets and sidewalks (fig. 10).[31] These additional data helped refine our relative chronology and place those few PEs that remained out of sequence. As is common to all archaeological syntheses, the exact chronological position of a few segments remained ambiguous. In these cases, we were forced to choose between two phases based on the physical condition of the street and the more firmly established chronologies of surrounding segments.

Our synthesis of the evidence yielded eight phases of paving activity with approximate dates beginning at least in the first decades of the first century B.C.E. and ending on the day of Mt. Vesuvius' eruption in 79 C.E. These are:

Phase 1: Pre-aqueduct period (100–20 B.C.E.)
Phase 2: Augustan fountain period (20–1 B.C.E.)
Phase 3: Augustan drainage period (1–20 C.E.)
Phase 4: Early Imperial period (20–40 C.E.)
Phase 5: Middle Imperial period (40–62/3 C.E.)
Phase 6: Post-earthquake(s) period (62/3–79 C.E.)
Phase 7: Period immediately prior to eruption; new pavement partially laid, but unfinished (79 C.E.)
Phase 8: Period immediately prior to eruption; street in preparation for repaving (79 C.E.)

Phase 1: The First Monumental Paving Project(s)

Only a handful of the earliest pavements at Pompeii survive in the final streetscape (fig. 11), which is unsurprising considering they had borne traffic for as long as 170 years. The largest of these sections is the northern half of via del Vesuvio, which excavation has shown to be the first and only lava-stone pavement laid on this part of the street. As mentioned, however, this *silex* surface together with its many ad hoc repairs replaced a sequence of beaten-ash streets and very likely was the northernmost extension of an early lava-stone pavement covering several primary streets in the city.[32] The findings of previous excavation as well as results of the present research make it reasonable to interpret the entire thoroughfare of via del Vesuvio and via Stabiana as the "via Pumpaiiana" mentioned in the so-called Oscan Road-Maker's inscription from the late second or very early first century B.C.E.:[33]

> M (?). Suttius, son of M (?)., N (?) Pontius, son of M (?) [?], *aediles*, demarcated this street until the Lower [street] of Stabiae. The street has been demarcated by ten *perticae*. The same [men] have demarcated the street of Pompeii by three *perticae*, until the temple (?) of Jupiter Milichius. These streets and the street of Jupiter and the *dekkviarim* [-street], they have built [them] on the behalf of the magistrate of Pompeii, *imaden*. The same *aediles* have approved.

Certainly, the section of via Stabiana just inside the southern gate was named via Pumpaiiana as the inscription stood beside an earlier pavement within the Porta Stabia.[34] Previous scholarship, however, has not extended this named street farther north than the intersection with via del Tempio d'Iside and vicolo del Menandro because of the misidentification of the

[31] Three trenches yielded more than one observation, making the total number of observations from excavations 44. Eleven trenches, however, provided evidence for streets paved in beaten ash.

[32] Rut depth along via del Vesuvio (PE_005) is varied due to a few spot repairs that stood in for complete replacement. While several sections are deeply rutted, with paving stones having fallen out of place, other areas preserve fewer ruts and are characterized by a lighter-colored stone with less natural pitting. The clearest example of this patching is found between stepping-stones where the exceptionally deep ruts have been filled by these newer stones. It is the absence of stepping-stones elsewhere on this street that spread the wear from vehicles more evenly and permitted such a long duration of use. Indeed, curbstones on both sides of via del Vesuvio sit on the paving stones, showing the street was once wider still. Finally, repairs using iron (infra n. 83) were found throughout this street. On the northernmost extension of early lava-stone pavement, see Seiler et al. 2005, 218–19, 231–33.

[33] Translation according to Dupraz 2011, 103; see also Deutsches Archäologisches Institut 1874, 166–67, no. 20; Campedelli 2014, 148–49, no. 31. "m. siuttiis. m. n. púntiis. m [?.] / aídilis. ekak. víam. teremna / [t]tens. ant. hunttram. stafii / anam. víu. teremnatust. per(ekaís). / x. íussu. vía. púmpaiiana. ter / emnattens. perek(aís). III. ant. kaí / la. iúveis. meeílíkiieís. ekass. ví / ass. íní. vía. iúviia. íní. dekkvia / rím. medíkeis. púmpaiianeís / serevkid. imaden. uupsens. íu / su. aídilis prúfattens."

[34] The inscription was set at an elevation significantly lower than the current section of via Stabiana (PE_180, PE_181). See Ellis and Devore (2006, 13–14) for excavations of the equivalent level (Phase 3) on the east side of the Porta Stabia.

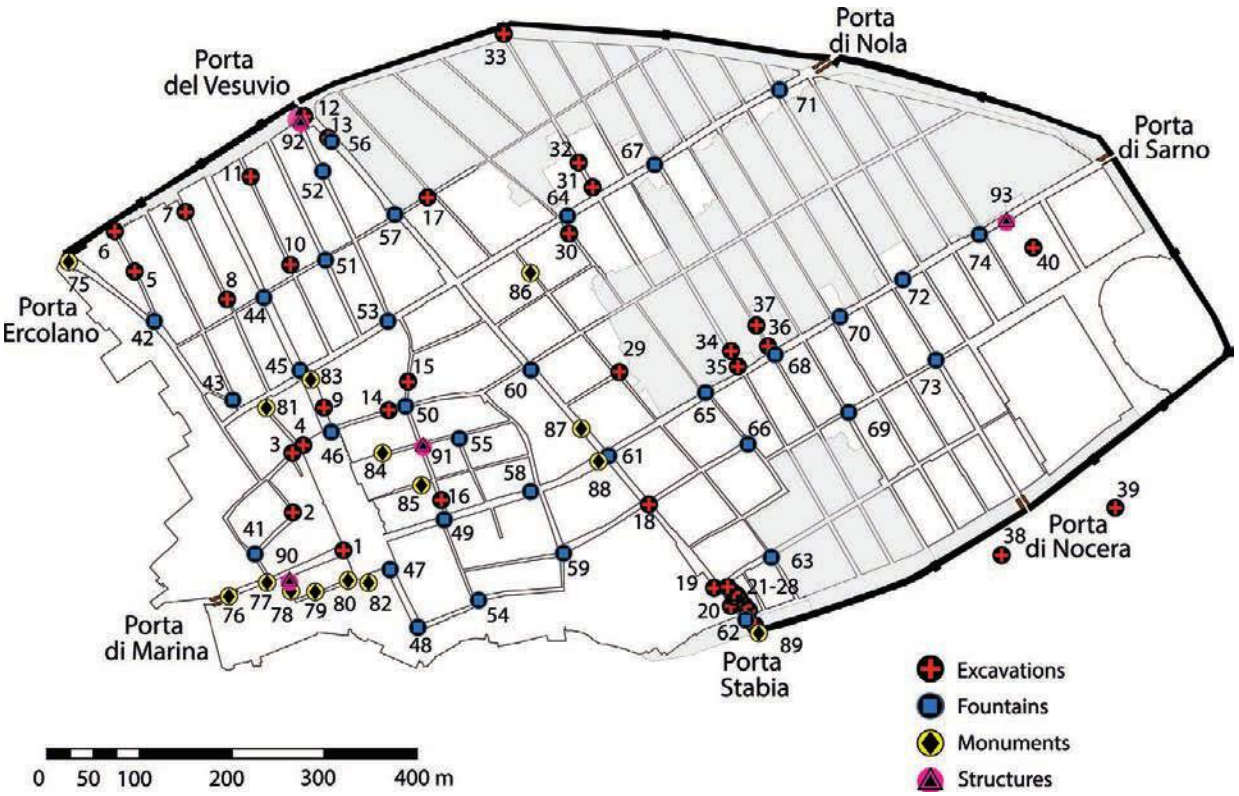

FIG. 10. Location of evidence for absolute chronology of paving at Pompeii. Information on each location is in Supplementary Table 2 at https://works.bepress.com/eric-poehler/).

Asclepion as the Temple of Jupiter Meilichios (see fig. 1[2]) mentioned in the inscription.[35] In the next line of the inscription, the via Pumpaiiana as well as others are said to have been built *imaden,* "from the bottom up,"[36] suggesting that they were not merely covered by a new layer of beaten ash but built up from bedding layers and surfaced, for the first time, with lava stone. For these reasons, in addition to the archaeological evidence for the very early surface on via del Vesuvio and the buried *silex* surfaces on via Stabiana and at the Porta del Vesuvio, we argue that the full length of via Stabiana/via del Vesuvio was paved prior to 80 B.C.E. and that this action was documented in this inscription.[37]

Other sections of early paving were not necessarily contemporaneous with via Pumpaiiana. It seems likely, however, that via delle Terme and via della Fortuna were, and we argue that via delle Terme/via della Fortuna comprised the *dekkviarim* mentioned in the Road-Maker's inscription as it is the 10th street meeting or crossing the via Pumpaiiana.[38] At the westernmost edge of the city is a remnant of a deeply weathered pavement set at a lower elevation than adjacent PEs, both factors indicating its antiquity (see figs. 1[3], 5[B]).[39] This interpretation is further reinforced by this weathered pavement's relations to adjacent PEs, specifically the northern segment of vicolo del

[35] See Onorato (1951) for a discussion of interpretations up to his time and an updated analysis by Dupraz (2011, 103–5). See also Farkas (2006, 211 n. 720) on uncertain words, Untermann (2000, 534–35) on *perek,* and De Caro (2007, 79–80) on the re-identification of the Temple of Jupiter Meilichios (VIII 7, 25).

[36] On *imaden,* see Buck 1904, 239–40.

[37] Phase 1 pavements intact in 79 C.E. on via del Vesuvio: PE_005. Phase 1 pavements subsequently replaced on via del Vesuvio: PE_127, PE_212, PE_213 (partial); via Stabiana: PE_006, PE_096, PE_097, PE_109, PE_139, PE_140, PE_177–PE_182, PE_207.

[38] Phase 1 pavements intact in 79 C.E. on via delle Terme: PE_003. Phase 1 pavements subsequently replaced on via delle Terme: PE_004; via della Fortuna: PE_017, PE_052, PE_090, PE_091, PE_121, PE_128, PE_129, PE_153.

[39] PE_003.

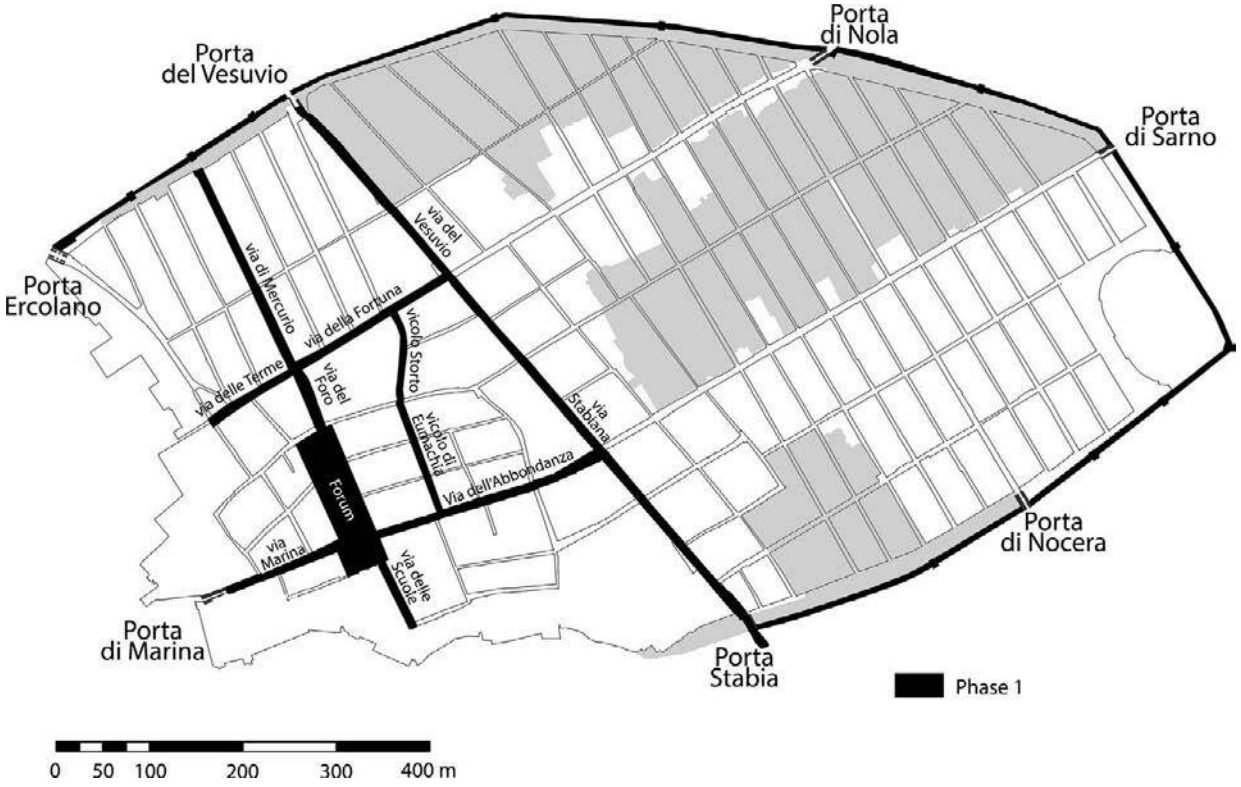

FIG. 11. Paving at Pompeii: Phase 1 (100–20 B.C.E.).

Farmacista,[40] which was paved early in Pompeii's history but still significantly later than this segment. East of the forum, a winding route (or portions thereof) comprised of vicolo Storto and vicolo di Eumachia was also paved in Phase 1.[41] The conditions and associations of this winding route's pavement(s) with later Augustan era pavements make these segments the earliest-known stone surfaces within the Altstadt.

Although direct evidence for the paving of other streets in this phase remains to be found, a strong circumstantial case can be made for the paving of the western portion of via dell'Abbondanza, via Marina, via di Mercurio, and via del Foro, and possibly via delle Scuole in this early period.[42] First, no evidence of paving survives on any of these streets from Phase 2, when many of the remaining major thoroughfares were surfaced in stone.[43] In fact, it was not until Phase 5 that large sections of each of these streets were repaved, a surprising delay compared with via dell'Abbondanza's eastern section, which had been paved for the first time in Phase 2 and was already undergoing spot repairs in Phase 4.[44] This suggests that the streets named above needed complete replacement in Phase 5 because their surfaces were older than those of the nearby Phase 2 pavements. Such a hypothesis is preferable to the alternatives that require one to explain either why, if these relatively isolated streets were paved in Phase 2,[45] they

[40] PE_126.

[41] Phase 1 pavements intact in 79 C.E. on vicolo Storto: PE_059; vicolo di Eumachia: PE_019. Phase 1 pavements subsequently replaced on vicolo Storto: PE_150; vicolo di Eumachia: PE_108, PE_151.

[42] Phase 1 pavements subsequently replaced on via dell'Abbondanza: PE_007, PE_092; via Marina: PE_015, PE_141 (partial); via di Mercurio: PE_068, PE_214; via del Foro: PE_009; via delle Scuole: PE_028 (partial).

[43] On via Marina, see Arthur 1986; Poehler 2012, 107–8.

[44] Because of the long duration and obscurity of most Phase 1 pavements, it is likely that some streets in this phase were paved later than others, perhaps even late in the colonial era. Indeed, we argue that those streets that remain as *battuti* until Phase 5 were not part of the earliest PE(s) documented in the Road-Maker's inscription, an assertion that aids our understanding of their longevity.

[45] By the Augustan era, the western half of via dell'Abbondanza was blocked at both ends, while via delle Scuole and via

needed complete replacement in as little as 40 years or, alternatively, why such prominent thoroughfares remained in beaten ash until the middle of the first century C.E.

Furthermore, there is evidence of discontinuity between the final surfaces of these streets and features within them that suggest a previous stone pavement. For example, the deep wear on a set of via dell'Abbondanza's stepping-stones near the forum (see fig. 1[9]) does not correspond to the newness of the present paving stones or to the probable low volume of wheeled traffic here because of the blockage of both ends of this section of street (i.e., at the forum and at via Stabiana). Moreover, there is no evidence at Pompeii that stepping-stones were used on beaten-ash streets,[46] further suggesting a previous *silex* surface. Similarly, the wear on the stones that supported the gates within the Porta di Marina suggest significant earlier traffic on via Marina. The eroded character of the curbs along via di Mercurio indicate a far longer period of exposure than their Phase 5 and 6 surfaces would suggest, and so a Phase 1 pavement seems likely. Finally, a drain found under the eastern curb of via del Foro (see fig. 1[10]), dated to the first century B.C.E., let out onto a surface that once existed below the present pavement.[47]

Phases 2 and 3: The Augustan Expansion of Infrastructure

Phases 2 and 3 are examined together as they both belong to an intensive investment in urban infrastructure during the Augustan period (fig. 12). During these four decades, Pompeians witnessed the arrival of piped water via the Aqua Augusta (ca. 20 B.C.E.), which necessitated the creation of a city-wide surface drainage system (ca. 1 C.E.) as well as the introduction and proliferation of hundreds of stepping-stones.[48] Fortunately, the architecture of each water system provides important chronological markers for dating street surfaces. For example, the fountains and water towers that distributed aqueduct water often encroached on the space of the street. Some of these features overlap the pavements and are therefore more recent, while features abutted by other pavements predate them. Similarly, the surface drainage system instituted new blockages and ramps across many streets as well as small humps within the street itself to channel water toward particular routes. Each of these features provides a valuable piece of dating evidence to phase pavements.

After nearly a century of use, many sections of the initial project (Phase 1) to pave Pompeii's major thoroughfares were in need of repair, patching, or complete replacement. This is clear along via Stabiana, which was elevated (at least in some areas) and replaced in Phase 2.[49] Based on their elevation, deep ruts, and the phasing for their repairs, the great thoroughfares of the east—vicolo del Menandro, via dell'Abbondanza, via Mediana, via di Nola, and via di Nocera—were all first fitted with *silex* in Phase 2.[50] The early Augustan period also saw the completion of stone pavements in much of the Altstadt, including many that would survive until 79 C.E. Five sections of well-worn surfaces define a project (or several) to pave the arc of streets that circumnavigate the forum from just inside the Porta di Marina (vicolo del Gigante) to the entrance to the Triangular Forum (via dei Teatri). This effort was accompanied by the Phase 2 paving of the lesser routes both west and east of the forum.[51] In the north,

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di Mercurio came to a dead end at, respectively, the forum and city wall.

[46] Of 316 stepping-stones, only one is set into a beaten-ash surface, and it was likely expected to be embedded in an expansion of the lava-stone pavement being laid on the southern half of this street (vicolo del Fauno) at the time of the eruption.

[47] On this drain, see Arthur 1986, 37.

[48] On the Aqua Augusta: Ohlig 2001; Keenan-Jones 2010; on drainage: Nishida 1991; Poehler 2012; on stepping-stones: Poehler 2017, 85–94.

[49] Phase 2 pavements intact in 79 C.E. on via Stabiana: PE_006, PE_109, PE_179, PE_181. Phase 1 pavements subsequently replaced: PE_096, PE_097, PE_139, PE_140, PE_177, PE_180, PE_182, PE_207.

[50] Phase 2 pavements intact in 79 C.E. on vicolo del Menandro: PE_033; via dell'Abbondanza: PE_107, PE_111, PE_113, PE_115, PE_117, PE_119, PE_122, PE_125; via Mediana: PE_054 (partial); via di Nola: PE_074, PE_081, PE_132, PE_134; via di Nocera: PE_046, PE_095, PE_195, PE_197. Phase 2 pavements subsequently replaced on vicolo del Menandro: PE_202; via dell'Abbondanza: PE_008, PE_107, PE_110, PE_112, PE_114, PE_116, PE_118, PE_120, PE_123, PE_124, PE_190, PE_192; via Mediana: PE_204; via di Nola: PE_075 (partial), PE_104, PE_130, PE_131, PE_133, PE_135; via di Nocera: PE_047 (partial), PE_095, PE_159, PE_194, PE_196.

[51] Phase 2 pavements intact in 79 C.E. on vicolo di Championnet: PE_018; vicolo del Gallo: PE_013 (partial); vicolo del Granaio: PE_187; vicolo del Balcone Pensile: PE_021, PE_022; vicolo degli Scheletri: PE_060; vicolo del Foro: PE_186; via del Tempio d'Iside: PE_093. Phase 2 pavements subsequently replaced on vicolo del Balcone Pensile: PE_155,

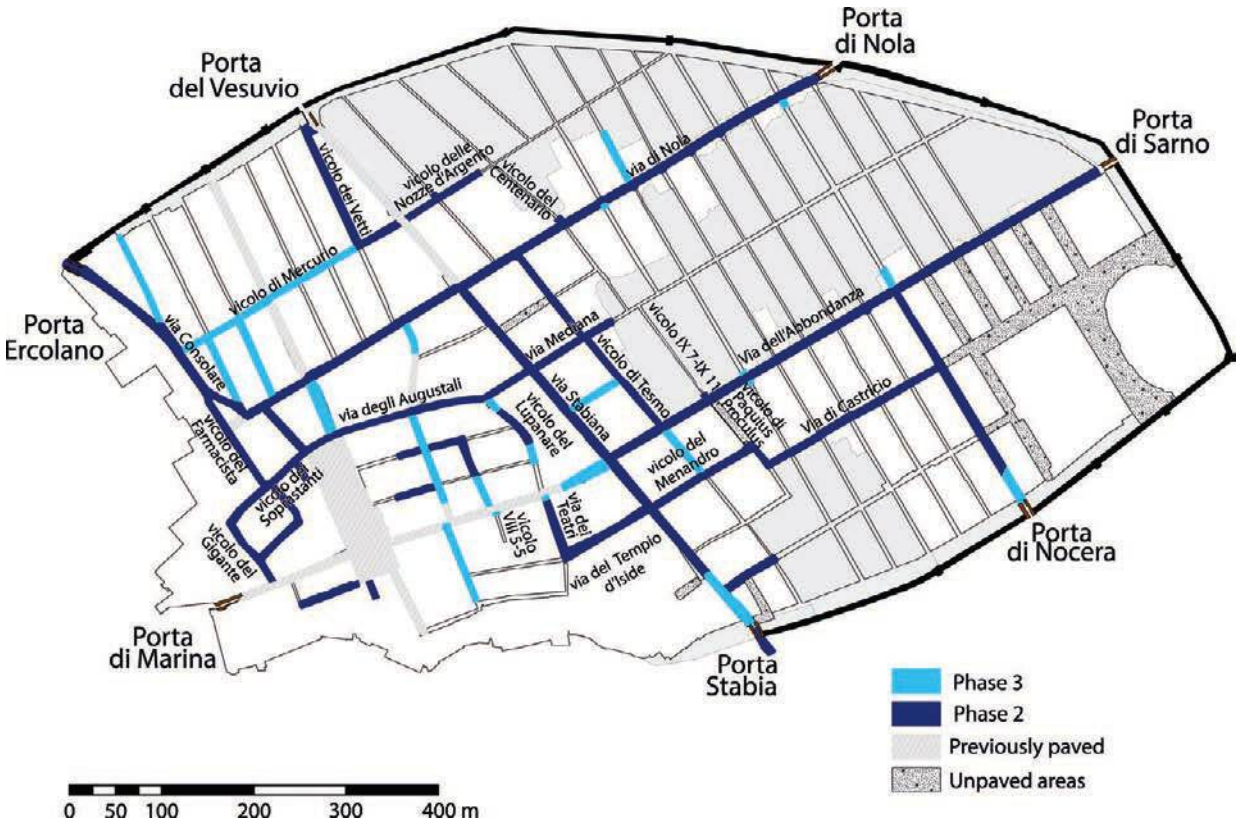

FIG. 12. Paving at Pompeii: Phases 2 (20–1 B.C.E.) and 3 (1–20 C.E.).

via Consolare and sections of the smaller but integral through-routes vicolo di Mercurio, vicolo delle Nozze d'Argento, vicolo dei Vettii, vicolo delle Terme, and vicolo del Farmacista were also paved.[52] In the east, *silex* was rare outside of the largest streets, and again only important through-routes were paved: via di Castricio, vicolo di Tesmo, and parts, if not all, of another route from vicolo del Centenario (north) through vicolo IX 7–IX 11 to the southern section of vicolo di Paquius Proculus.[53]

Thus, in the early Augustan era the larger, primary thoroughfares and the most important secondary streets were prioritized for paving. Only after this work, in Phase 3, did the many north–south streets of the city (particularly in the western part) begin to receive *silex*.[54] Most importantly, in Phase 3 we see for the first time shorter paving projects, especially pavements that relate to drainage such as the water management mechanisms at the Porta Stabia and Porta Nocera, at the northern end of vicolo del Lupanare, and along via dell'Abbondanza at its intersections with vicolo di 12 Dei, vicolo di VIII 5–5, via dei Teatri, and

PE_168; via del Tempio d'Iside: PE_029.

[52] Phase 2 pavements intact in 79 C.E. on via Consolare: PE_001; vicolo di Mercurio: PE_063; vicolo delle Nozze d'Argento: PE_073; vicolo dei Vettii: PE_055, PE_163; vicolo delle Terme: PE_010; vicolo del Farmacista: PE_126. Phase 2 pavements subsequently replaced on via Consolare: PE_002, PE_162; vicolo di Mercurio: PE_061, PE_062, PE_069 (partial), PE_089; vicolo dei Vettii: PE_156; vicolo del Farmacista: PE_012 (partial), PE_126.

[53] Phase 2 pavements intact in 79 C.E. on via di Castricio: PE_038, PE_158; vicolo di Tesmo: PE_053, PE_054 (partial); vicolo del Centenario: PE_077; vicolo IX 7–IX 11: PE_191; vicolo di Paquius Proculus: PE_138. Phase 2 pavements subsequently replaced on via di Castricio: PE_157, PE_183, PE_201 (partial); vicolo di Tesmo: PE_169; vicolo del Centenario: PE_076; vicolo di Paquius Proculus: PE_032, PE_201 (partial).

[54] Vicolo di Narciso: PE_064; vicolo di Modesto: PE_065; vicolo della Fullonica: PE_067; via del Foro: PE_009; vicolo di Eumachia: PE_151; vicolo della Maschera: PE_024; vicolo di Citarista: PE_030; vicolo dei Gladiatori: PE_080; vicolo III 10–III 11/via di Nocera (north): PE_071, PE_189.

via Stabiana.[55] These new pavements from the late Augustan period demonstrate a shift in paving practices whereby street surfaces were tailored to handle secondary functions, such as facilitating drainage, with only minor adjustments in form.

Phases 4 and 5: Imperial Period Repairs, East to West

In the decades between the end of the Augustan era and the earthquake(s) of 62/3 C.E., Pompeians waged a campaign to repair and replace failing sections of their urban streets (fig. 13). In the east, mostly small repairs were made to older pavements along the main thoroughfares in Phase 4 (20–40 C.E.), while streets in the west continued to be paved for the first time. In Phase 5 (40–62/3 C.E.), large sections of the great western streets were resurfaced, while new pavements were few in the east. This distinction in attention between Phases 4 and 5 is best observed on via dell'Abbondanza, where six of the 13 intersections between the Sarno Gate and via Stabiana were repaired in Phase 4.[56] In the western section of via dell'Abbondanza, the repairs made in Phase 5 required the complete replacement of more than three-quarters of its surface.[57] A similar pattern occurs on via di Nola, where six of the 10 intersections east of via Stabiana were repaved during Phase 4, including a large section of the street that comprises three and a half blocks and four intersections.[58] To the west, several projects in Phase 5 repaved slightly more than three blocks of via della Fortuna and via delle Terme, or approximately 37.5% of those streets.[59]

As argued above, these repairs to the western part of via dell'Abbondanza, via delle Terme, and other streets almost certainly replaced ailing Phase 1 surfaces. This argument is strengthened by the fact that while via del Vesuvio's original Phase 1 section remained intact up to 79 C.E., its southern portion was resurfaced in Phase 4. Several other streets of lesser importance were paved now for the first time, including block-length pavements in Region VI and in Region VII.[60] Finally, a multistreet project paved three sections of streets in the south of Pompeii surrounding insula VIII 3. It is unclear whether the surface of via delle Scuole was a repair or a new pavement, but the southern section of vicolo dei 12 Dei and the western half of via della Regina were paved for the first time in Phase 5, lagging behind its eastern section (Phase 4) by some years.[61]

In the north, a large section of paving combined repairs of older *silex* with the construction of new pavements in Phase 5. The replacement of the deeply rutted surface on vicolo di Mercurio together with the initial paving of vicolo del Labirinto also gives us the best chance to identify those responsible for the pavement.[62] Several factors suggest that this project was supported by the owners of the Casa del Fauno, perhaps in cooperation with other wealthy property owners. First, this multistreet PE surrounds the Casa del Fauno, Casa del Labirinto, and part of the Casa dei Vettii on two sides (see fig. 1[11]). Next, the section of via della Fortuna to the south was repaired in the same phase while the vicolo del Fauno, on the house's western side, was being replaced at the time of the eruption.[63] Likewise, perhaps the owners of the Casa di Fabio Rufo and the Casa del Marinaio (among others) shared responsibility in the campaign to repave sections of vicolo dei Soprastanti, vicolo del Gigante, and vicolo del Farmacista in Phase 4.[64] We have assigned the first pavement on this large Z-shaped set of streets to Phase 2 based on the surviving segments at the north, south, and east ends that date to that period, and we place its repair in Phase 4 by a complex set of ruts and blockages at this western end of Pompeii.[65]

[55] Porta Stabia: PE_097; Porta Nocera: PE_194; vicolo del Lupanare: PE_146; vicolo dei 12 Dei: PE_210; vicolo di VIII 5–5: PE_209; via dei Teatri: PE_102; via dell'Abbondanza: PE_092.

[56] These repairs (PE_110, PE_112, PE_114, PE_116, PE_120, PE_192) were assigned to Phase 4 by the depth of ruts (Tsujimura's Shallow category) compared with other areas of less significant rutting (Tsujimura's Faint category) on the same section of street. Each repair was surrounded by Deep ruts indicating the differences in rutting were a function of time more than traffic volume. The same interpretative method was used on via di Nola.

[57] PE_007.

[58] PE_130, PE_131, PE_133, PE_135.

[59] Via delle Terme: PE_004; via della Fortuna: PE_017, PE_128.

[60] Vicolo di Modesto: PE_066; vicolo del Labirinto: PE_069 (partial); vicolo del Lupanare: PE_020; vicolo degli Scheletri: PE_023; vicolo del Panettiere: PE_149 (partial).

[61] Vicolo della Regina/via delle Scuole: PE_028; vicolo della Regina: PE_100.

[62] PE_069.

[63] Via della Fortuna: PE_017; vicolo del Fauno: PE_098, PE_099.

[64] PE_012. On evolution of this neighborhood, see Newsome 2009.

[65] This large, multiblock-length repair is dated to Phase 4 be-

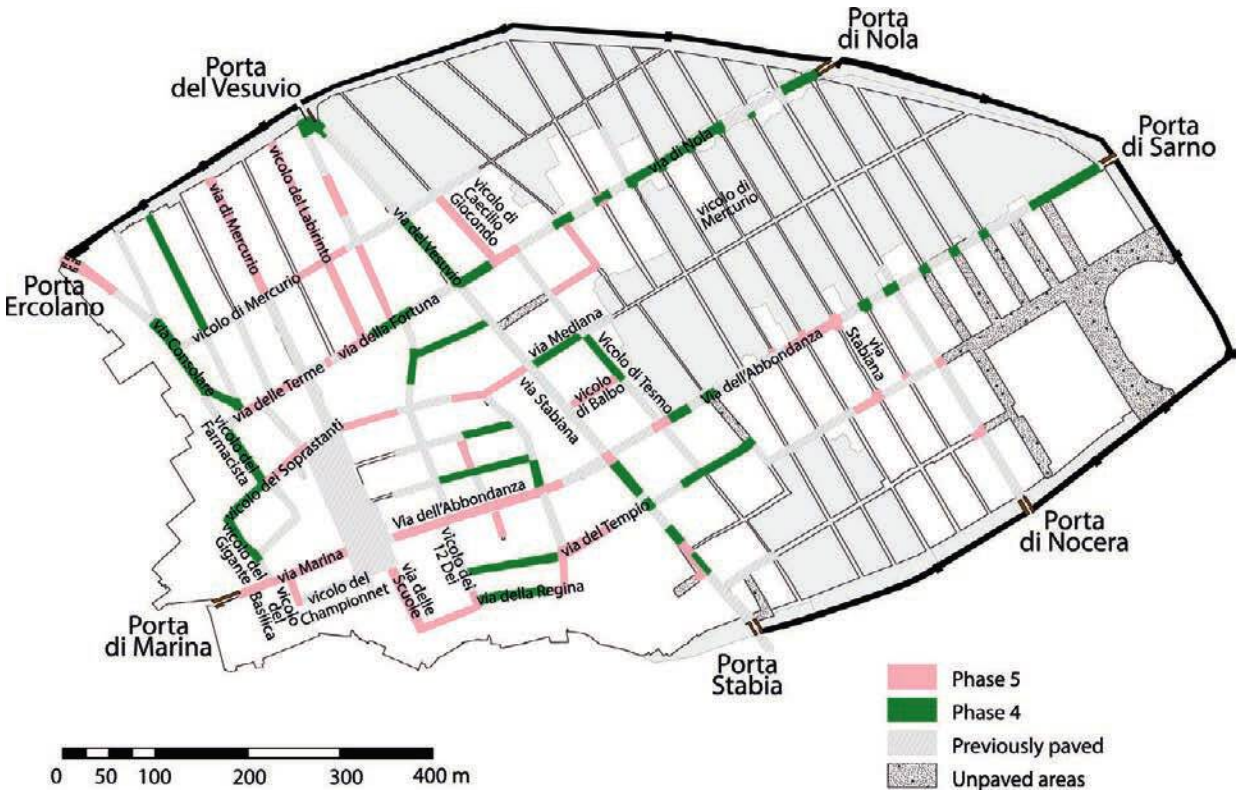

FIG. 13. Paving at Pompeii: Phases 4 (20–40 C.E.) and 5 (40–62/3 C.E.).

Via degli Augustali, which extends east from vicolo dei Soprastanti, also saw its Phase 2 pavement replaced in this period (Phase 5).[66] Similarly, via Marina, which also is presumed to have had an early pavement, was repaired in Phase 5.[67] That this occurred before 62/3 C.E. is established by the expansion of the Sanctuary of Venus (see fig. 1[12]), which cuts and overlies via Marina and vicolo del Basilica. Loose paving stones ripped out of vicolo del Basilica still sit on that street, which narrowed it beyond use for vehicles and, consequently, cut off vicolo del Championnet from the street network entirely.[68]

Elsewhere, other repairs occurred in Phases 4 and 5, particularly in similarly high-traffic areas. Thus, the western segments of via del Tempio d'Iside and via Mediana, the eastern two-thirds of vicolo del Menandro, and a portion of via di Castricio were all refitted with fresh *silex*.[69] So too were the northernmost parts of via di Mercurio and via Consolare.[70] Important sections of secondary streets, particularly those that functioned as high-traffic detours during repairs to other streets,[71] such as vicolo di Tesmo, vicolo di Balbo, and vicolo di Caecilio Giocondo, were also resurfaced.[72]

cause a newer pavement on vicolo dei Soprastanti (Phase 5, dated by coin finds) abuts this PE to the east and because the very light rutting across the wearless area on via Consolare as well as on southern vicolo del Farmacista indicates a very short duration of traffic use prior to the blockage at via delle Terme and vicolo del Farmacista. Moreover, the absence of any ruts through the wearless area on via delle Terme shows that no vehicles used the western section of this street in Phase 5, suggesting the blockage was already in place by this time.

[66] PE_011, PE_144.

[67] PE_015, PE_141.

[68] See Ohr 1991, table 7.3.

[69] Tempio d'Iside: PE_029; via Mediana: PE_204; vicolo del Menandro: PE_202; via di Castricio: PE_157.

[70] Via di Mercurio: PE_214; via Consolare: PE_162.

[71] On detours, see Poehler 2017, 183–87.

[72] Vicolo di Tesmo: PE_169; vicolo di Balbo: PE_056; vicolo di Caecilio Giocondo: PE_075 (partial). The dating of these sections can be established as prior to the post-earthquake(s) construction of the Central Baths (fig. 1[13]), which block vicolo di Tesmo and reverse the flow of traffic on the other streets.

Finally, on via Stabiana, an intriguing Phase 4 and Phase 5 repair project centers on the intersection of the street between insulae I 2 and I 3 (see fig. 1[14]) and extends half the length of each block.[73] In the middle of this section of repaving, the depth of ruts decreases to such a degree that one is compelled to interpret that the very center of the intersection was not repaired until Phase 5.[74] Interestingly, this repair also bonds with an expansion of the street space beside the Teatrum Tectum as a long ramp, which likely served as a parking area for carts.[75]

Phases 6–8: The Final Repairs and Countermeasures

The earthquakes that struck southern Campania in the early 60s C.E. devastated urban areas throughout the region, and Pompeii was hit especially hard.[76] For the ancient inhabitants of Pompeii, the impact of these disasters resulted in 17 years of nearly constant reconstruction. For archaeologists, however, this disaster provides a clear and widespread chronological marker. During these years the condition of the pavements, though deteriorating, was secondary to not disrupting the flow of traffic they carried, and only 12 PEs can be ascribed to Phase 6 (fig. 14). Yet, reconstruction not only dissuaded Pompeians from ripping up their streets to repair them but also encouraged them to find new solutions beyond the replacement of old paving stones with new ones. In some instances, this might have simply been a cost-benefit analysis to delay certain projects. For example, though Pompeians appear to have had plans to pave several streets in Region III, as suggested by the inroads made from the multiblock paving event on via de Nola,[77] the streets remained as beaten-ash surfaces until 79 C.E. In more extreme examples, such as on vicolo IX 11–IX 12 (and likely vicolo IX 12–IX 13, and possibly also vicolo I 2–I 3), such languishing turned to abandonment in the final period: excavators found this street littered with debris, including pottery, painted plaster, and the remains of animal bones, but no trace of traffic.[78]

The great quantities of destruction debris wrought by the earthquake(s) were also recycled to maintain the street network while at the same time clearing the city for reconstruction. Just beyond the fortifications, where debris and trash were traditionally deposited, new roads were built or rebuilt over deep layers of fill—some over 1.5 m high—around the northern and southern edges of the city.[79] Likewise, just inside the northern city wall at Tower IX (see fig. 1[15]), excavators recovered a beaten-ash street running on top of a 1.8 m high debris pile, including both crossing and turning ruts.[80] An earlier surface, found slightly below the last, attests to a desire to keep this street open despite the accumulation of material being deposited here. Another type of debris street was created on vicolo di Lucrezio Frontone by mortaring together cobbles of yellow Sarno limestone, red and purple pieces of volcanic cruma, and bits of dark lava to create a vibrant polychrome effect (Supplementary Figure 4: https://works.bepress.com/eric-poehler/101/).[81] Set atop a thick layer of debris, these stones are themselves likely remnants of pre-earthquake(s) walls, now relaid on the ground.[82] Although the streets were tasked with double duty as conduits for wheels and water, reconstruction and the removal of debris in the post-earthquake(s) period necessitated a third function, as a (possibly temporary) city dump.

For those well-worn streets of crucial importance to traffic that had not been repaired in over 60 years—parts of via Stabiana, via della Fortuna, and especially via del Vesuvio—the Pompeians developed a unique alternative to repaving that did not require a disruption of traffic. In a separate research project we have documented more than 430 instances of iron and iron slag that were used to repair the streets, particularly those in the greatest need of repair. In some instances, a solid piece of iron can be seen in the spaces between pav-

[73] By its condition and its blockage by a low curb, vicolo I 2–I 3 appears to have been abandoned by 79 C.E.

[74] PE_139. There is another scenario that might explain this situation. If we assume that this entire area was repaired in Phase 5, then the slightly deeper ruts on either side of the intersection (PE_096, PE_140) might be the effect of vehicles approaching this section from the still deeper ruts on either side of the repair, which facilitated the growth of ruts toward the intersection. This process, though with lesser effect, is described under Terminating Ruts, above. This "shadow" effect might also be recognized at via dell'Abbondanza's intersection with vicolo di Tesmo, which was repaired late in Phase 5.

[75] On ramps, see Poehler 2011, 197–201.

[76] Sen. *QNat.* 6.1–3.

[77] PE_131.

[78] PE_171. Berg 2008, 363, 369.

[79] Maiuri 1944, 276fc–81; Chiaramonte Treré 1986, 29, 57–96, table 8; Nappo 1997, 96.

[80] Etani et al. 1996, 55–9, fig. 8, pls. 5, 7; 1999, 124–26, fig. 3; 131–33, fig. 11.

[81] PE_078.

[82] Sakai and Iorio 2008, 405, fig. 8.

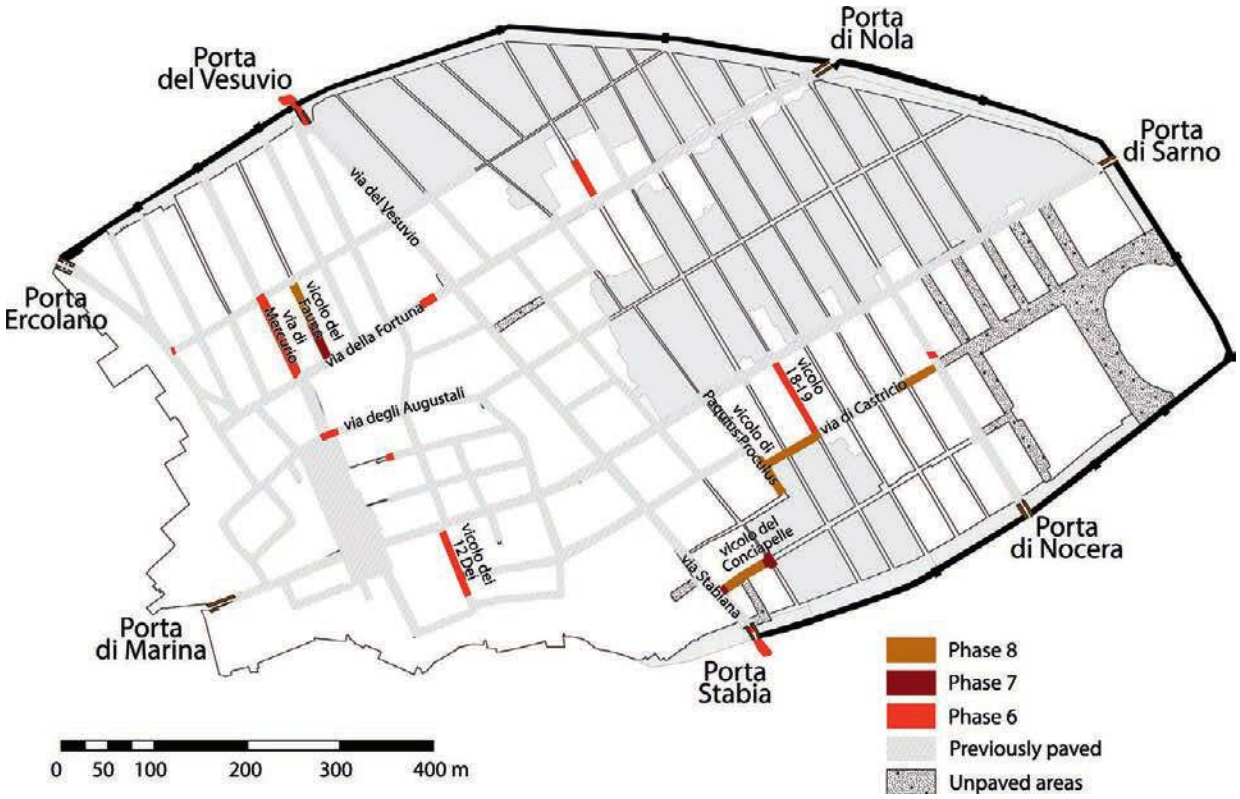

FIG. 14. Paving at Pompeii: Phases 6 (62/3–79 C.E.) and 7–8 (79 C.E.).

ing stones. In more than two-thirds of these repairs, however, there is clear evidence that iron and iron slag had been applied to the street in liquid form, including droplets (fig. 15a), splatters (see fig. 15b), and large stains found only at the seams between paving stones (see fig. 15c). This remarkable and controversial phenomenon is the subject of another publication; for the present discussion, it is sufficient to say that the evidence leads to a single conclusion that is as surprising as it is inescapable: in the final days of their city's existence, Pompeians poured a molten iron slurry into the streets to fill holes and deep ruts (see fig. 15d) and to fuse together those pavements in danger of unraveling by the absence of compression among the paving stones.[83]

Finally, in the hours before the eruption, at least four street sections were in the process of being repaved.[84] In the northwest, the southern half of vicolo del Fauno had been given a *silex* surface (see fig. 1[16]; Phase 7), while the northern half still had only its curbs and single-course retaining walls in place to guide its repaving (Phase 8).[85] A similar cross-wall exists on the east side of vicolo del Conciapelle, which was being resurfaced from both ends simultaneously.[86] At the western end (see fig. 1[17]), we can see the repair work taking place at the very moment of the eruption, which offers a rare opportunity to observe the process of repaving.

[83] This project is currently under consideration for publication as Poehler, van Roggen, and Crowther, "The Iron Streets of Pompeii." It is a common misconception that Romans could not melt iron because they could not achieve sufficiently high temperatures. They could and did melt iron, but because the resulting cast iron was brittle, they did not make use of it for tools. This distinction between achieving a temperature and creating objects was carefully parsed long ago by Forbes (1964, 205–6).

[84] We are grateful to an anonymous reviewer for the *AJA* for pointing out that, since the start dates of PEs in Phases 7/8 are unknown, it is possible that these are long-languishing events begun in Phase 6 or earlier. Still, if this were true, the fact that such repairs remained incomplete for decades (beyond being astonishing) would serve to deepen the impact of the decline in paving observed in Phase 6.

[85] PE_099, PE_098.

[86] PE_035, PE_136, PE_137.

FIG. 15. Evidence of iron used to repair the streets of Pompeii: *a,* iron droplet; *b,* iron splatter and mass; *c,* iron staining; *d,* iron "slurry" filling rut.

FIG. 16. Vicolo delle Conciapelle (PE_136) at via Stabiana (PE_097); view to east. Evidence for repaving in process: *A,* new paving; *B,* paving stone pile for reuse; *C,* paving stones recut into D-shaped curbstones.

First, the old, weathered stones were ripped up and split for reuse as curbstones on the same street, then new pavers were laid in place after the boundaries of the street were defined (fig. 16[A]).[87] The evidence for this process is remarkably clear: not only does a pile of loose paving stones now sit on the southern sidewalk (see fig. 16[B]), its curb made from characteristic D-shaped stones that result from splitting the pavers (see fig. 16[C]) but also one former paving stone on vicolo del Conciapelle was found with scoring marks along its bottom side in preparation for being split.[88]

Because of their small size and weathered condition, not all the old paving stones from this street would have been suitable for reuse. Instead, the pavers of other, ongoing repair projects could also provide recycled materials. Just east of its intersection with vicolo I 8–I 9, the ragged edge of via di Castricio's well rutted pavement—and the absence of any paving stones beyond that edge—shows that efforts to rip up and replace this street were underway in 79 C.E. (see fig. 1[18]).[89] This now-dilapidated section of via di Castricio continued west and around to the north, where a similarly rough edge shows the extent of the work to remove vicolo di Paquius Proculus' deeply rutted stone surface. These identifiable edges reveal that, at the time of the eruption, a repair project encompassing at least two and a half blocks was underway in the west while simultaneously another project to replace the easternmost block of via di Castricio's earlier Phase 2 pavement was in progress.

INTERPRETATION

Pompeii's city streets were a patchwork not only of different pavement types but also of different conditions reflecting a variety of ages. While the east remained mostly paved in beaten ash and debris streets were constructed in the north, the western half of Pompeii—together with the main thoroughfares in the east—saw the early introduction of *silex* in the Augustan period and, over approximately 50 years, the wearing down of those pavements. In 79 C.E., most vehicles were driving over surfaces laid in the Augustan

[87] As the work was in progress, it is easy to see the slight shift in elevation between the lower, older street and the new paving stones being laid. Although the newer street is not always higher, such elevation distinction can be seen at several junctions of completed repairs as well, such as PE_003, PE_009, and PE_214.

[88] Poehler 2017, 83, fig. 4.3. One Sarno limestone block on the southern curb has a distinct but wide and shallow curve—perhaps a rut—suggesting this stone may have once been a paving stone. If so, it is the only other example of non-lava-stone pavement outside of vicolo di Lucrezio Frontone and the cobblestone pavements of previous eras.

[89] PE_183, PE_201.

era but laced with repairs effected 40 to 80 years later. The earliest pavements survived only in a few places. The relationships and distributions of these remnants, replacements, and emergency procedures reveal several interesting facets of Pompeii's infrastructural and social history, including (1) the rates of paving and repair and (2) the fiscal, administrative, and social costs of paving a street.

Rates of Paving and Repair

Most of Pompeii's streets were paved in the Augustan phases, with 61.1% of the total area of pavement laid for the first time in this approximately 40-year period (20 B.C.E.–20 C.E.). Along with its monumental buildings and economy, Pompeii's infrastructural systems were radically transformed in the Augustan era.[90] The arrival of piped water and its accompanying architecture (fountains, pipes, and water towers), the surface drainage system, and an updated organization of traffic were all collocated in the space of the street, making a durable, *silex* surface all the more desirable, if not essential.[91] The Augustan paving of Pompeii was a massive infrastructural investment, but one that was unlikely to have been conceived of or instituted outside these regimes of water management. In fact, the link between the architecture of water supply and street paving in the early Augustan period is almost inextricable: of the 34 fountains located on streets, 85.3% are set within Phase 2 pavements (23) or are cut into or rest on Phase 1 pavements (6). This percentage rises to 94.1% when late Augustan pavements (3 from Phase 3) are considered.

Comparatively little was done in the following half century to continue the paving of the city, particularly to the east. In part, this is an effect of the lesser need of the eastern half of Pompeii,[92] but equally important was the diversion of resources to repair preexisting *silex* surfaces. In fact, during Phases 4 and 5, more than 87.6% of all PEs consisted of repairs to earlier surfaces.[93] Moreover, these phases demonstrate a notable increase in the rate of repair. Figure 17 shows the survivorship of PEs from Phases 1–3 and their replacement in approximately 20-year increments from 100 B.C.E. until 79 C.E.[94] Our best evidence indicates that Phase 1 pavements survived for at least 60 years and, with significant ad hoc repairs, some as long as 179 years.[95] During Phase 2, however, almost two-fifths (39.4%) of Phase 1 surfaces were replaced at an astonishing rate of 19.7% of its total area per decade. Thereafter, until 79 C.E., an average of 5% of the remaining Phase 1 pavements was replaced every decade. Phase 2 surfaces were replaced at twice that rate (12.1%) during these same decades, but, more importantly, this meant that their life-spans compared with those of Phase 1 dropped to just over half as long on average. While Phase 1 pavements replaced between Phase 2 and Phases 7/8 were 81 to 179 years old, Phase 2 surfaces were only 1 to 79 years old when replaced. Even Phase 3 pavements, never more than 39 years old, witnessed a replacement rate of 2% per decade between 40 and 79 C.E.

Such a reduction in the pavements' life-spans was caused by two compounding factors: (1) the increased levels of traffic during the early imperial era,[96] and (2) the continual compression of traffic into smaller and smaller portions of the street through the encroachment of sidewalks, the insertion of fountains and their guard stones, and especially the introduction of stepping-stones, which forced every wheel on a given street into spaces only 47.3 cm wide on average.[97] The proliferation of these amenities, particularly during the Augustan era, significantly reduced not only the actual life-span of *silex* at Pompeii but also its expected life-span. This reality even may have delayed the expansion of *silex* to the east as Pompeians in the middle decades of the first century C.E. were burdened by the repair of earlier streets. Certainly the earthquake(s) of 62/3

[90] Lomas (2003, 31–6) shows the related trend of entertainment structures supplanting temples and fortifications as the focus of civic construction throughout Italy.

[91] Jansen 2002, 24–57; Poehler 2012, 2017.

[92] Laurence 1994, 89–91; Poehler 2016, 186–97, figs. 6.8, 6.14.

[93] Calculation is by area: 1,374.2 m^2 of new pavement and 9,717.3 m^2 of repavement. By count of PEs, 74.6% were repairs in Phases 4 (27 of 34) and 5 (26 of 37). In 79 C.E. 65.2% of all PEs (by area) were repairs of an earlier PE.

[94] Survivorship graphs show the life-span of a population (usually animals, but in this case, pavements) by plotting the number of individuals relative to their age at death (in this case, replacement).

[95] Such survivals are not unparalleled. Some beaten-ash surfaces at Pompeii may have existed for 150 years (Befani 2008, 8–9, US 7; Sorriento 2008, 3–4, US 41) while sections of the via Appia seem to have survived for centuries (Procop. *Goth.* 5.14.6–11).

[96] On traffic volume, see Poehler 2017, 152–55.

[97] Measurement of 343 gaps between stepping-stones and the curbs shows 50.3% are between 40 cm and 54 cm.

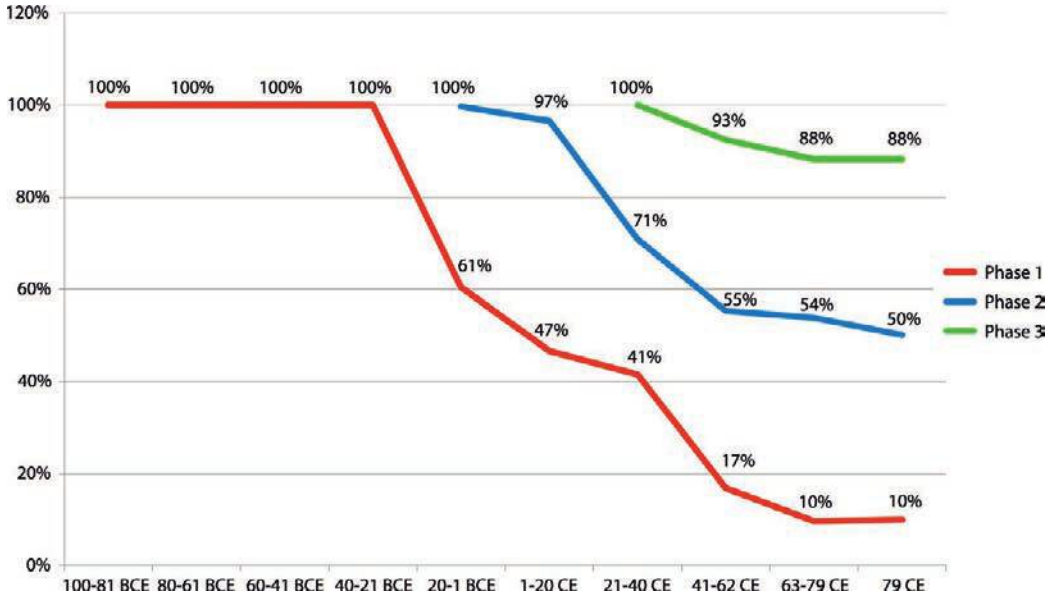

FIG. 17. Survivorship curve of paving events, Phases 1–3. Value represents the percentage of the original paved area remaining by time period.

C.E. (and after) delayed potential eastern expansions, but they also may have prevented other important repairs from taking place. In fact, repair rates for the final 17 years fell to 2.5% of all streets per decade, or just less than one-third the rate of Phase 5 (7.2%), the most intense (and immediately preceding) period of repair.[98] On the other hand, in the final days before the eruption (Phases 7/8), secondary streets were being paved and repaved at an especially rapid rate. In fact, the surface area of streets being replaced simultaneously on the day of the eruption was 75% of that which had been repaired during the entire post-earthquake(s) period, and more streets were being replaced, compared with the average, than in any other preceding year.

Fiscal, Administrative, and Social Costs of Paving

Although we lack evidence from Pompeii, the average cost of paving in *silex* has been estimated from Late Republic– and Early Imperial–era inscriptions that record both cost and length to be 22.5 sesterces (HS) per Roman foot.[99] Such a high cost—equivalent to 45 times a common person's daily bread consumption—is a reflection of the time and effort required to create *silex* pavers: good stone was not always abundant locally, and it was always hard, heavy, and difficult to work into a flat surface with smooth edges.[100] To calculate the cost for Pompeii, we first translated the costs for major external roads described in inscriptions into the varying widths of Pompeii's internal streets. To do this, we took 16 Roman feet (4.72 m) as the average width of an external road[101] and then multiplied it by the actual length of each PE in Pompeii. This provided a standard area against which to compare the actual area of each PE. Dividing the actual area by the standard area produced a percentage, which we used as a variable in calculating an adjusted cost. For example, PE_127 on via del Vesuvio is 91.28 m long, with an actual area of 282.58 m^2. If it were 16 Roman feet wide, this area would be 430.84 m^2, showing the current street to be 65.6% of that area. Multiplying the actual length by the linear cost (76.27 HS per meter)

[98] In Phase 6, remaining Phase 1 was replaced at the rate of 4.2% per decade, Phase 2 at 0.9%, and Phase 3 at 2.5%; in Phase 5, remaining Phase 1 was replaced at the rate of 11.17% per decade, Phase 2 at 7.1%, and Phase 3 at 3.4%.

[99] Duncan-Jones 1982, 124–25.

[100] The lava stone required to build one Roman foot (0.295 m) of a wide (wdth. 4 m) street, with an average depth of 0.35 m, would weigh (at 3,000 kg per cubic meter) 1,239 kg. On cost of daily bread consumption, see Duncan-Jones 1982, 244–45.

[101] Macaulay-Lewis 2011, 267.

and then by this percentage yields an adjusted cost of 4,567 sesterces.

In addition to cost, issues of transportation and stone working would make laying more than a few linear Roman feet per day impossible. If workers were able to pave five Roman feet (1.475 m) per day—that is, two to three rows of pavers across a 3.5 m wide street per day—a 90 m long street would take 61 days to complete.[102] We also see paving in progress at both ends of vicolo del Conciapelle,[103] indicating that gangs were working toward each other, which would halve the time needed to finish. Undoubtedly, one or two months of roadwork, even on lesser streets, would have caused many disruptions, delays, and detours. Table 1 gives a sense of the disruptive impact of paving in each phase by dividing the number of PEs by the number of years in that phase. This simple statistic (average number of PEs per annum), and the calculations that descend from it, paints an interesting picture of daily life across the streets of Pompeii, where, on average, the inhabitants endured more than 1.5 street repairs every year that lasted, in total, almost three months. Measured in both money and in time, paving the length of a single block of via del Vesuvio would cost over 4,500 HS and might take one to two months to complete. Extrapolated to the city as a whole, Pompeians paid more than 360,000 HS to pave their city and nearly another 250,000 HS to maintain those pavements.

Admittedly a rough yardstick, MacMullen's estimate of the cost of major constructions for a city the size of Pompeii, approximately 9 million sesterces, provides some measure of context for these figures: paving Pompeii makes up 7% of the entire city's monumental elaboration.[104] When an individual act of paving is compared to known costs of building, concession, and honorifics, such costs come into even sharper focus. The adjusted cost of the average PE is 2,260 HS,[105] which is almost half what G. Melissaeus Aper and M. Statius Rufus approved to update the Forum Baths (5,250 HS), roughly two-thirds of what M. Holconius Rufus and C. Egnatius Postumus paid for the right to build a wall for the Sanctuary of Apollo (3,000 HS), and very close to what the city paid to honor Terentius Felix and Aulus Umbricius Scaurus with burial expenses (2,000 HS).[106]

Thus far our discussion has focused on chronology, but a close examination of the distribution of paving event lengths reveals much about how Pompeians decided what areas would be paved or repaired, who was authorized to make such decisions, and how those acts would be financed. The final map of PEs (fig. 18) shows that, while some PEs occupy only the space of an intersection or a short section of a street, others run the length of an entire block, extend beyond a block, or even curve around more than one side of a block. Figure 19 shows the proportions of these different lengths for Phases 3–8.[107] Some important trends can be gleaned from this graph. The first is that block and multiblock PEs make up nearly half (42.6%) of all length types, indicating that paving very often extended far beyond the facade of a single building. The graph also shows that the repair of intersections only occurred in Phases 4 and 5, while at the same time multiblock PEs became more prevalent. Still, even as larger projects became more common over time, the predominance of partial-block PEs shows an overarching desire to limit paving to the shortest possible sections.

Who commissioned and paid for these different lengths of paving? To approach this question, we are fortunate to have the text of the so-called Tabula Heracleensis, on which the *lex Julia Municipalis* was inscribed.[108] The text is late Republican or Caesarian in date, and although it describes the city of Rome, its discovery at Heraclea suggests that the legislation, or provisions therein, may have been adopted by communities outside the capital.[109] The text includes regulations over street maintenance at several points

[102] We assume this rate to be closer to the maximum than the minimum. For some context on other, if imperfectly parallel, work rates, see Delaine's works on marble and mosaic floors (1997, 180–1) and on building whole insulae (2000, 127). If opportunistic quarrying below the streets accompanied the repair, resurfacing would take longer still; see Clément 2016, 159–60.

[103] PE_136, PE_137.

[104] MacMullen 1974, 142–45.

[105] Median cost is 1,660 HS. Most paving events cost less than the average due to the prevalence of intersection repairs and drainage-related pavements.

[106] Update of Forum Baths: *CIL* 10 817; wall for the Sanctuary of Apollo: *CIL* 10 787; burial expenses: *CIL* 10 1019, 1024, and p. 967.

[107] We exclude Phases 1 and 2 because later repairs made it impossible to determine the pavements' original length types.

[108] For the full English translation and Latin, see Supplementary Document: the lex Julia Municipalis at https://works.bepress.com/eric-poehler/.

[109] Crawford 1996, 1:358–62.

TABLE 1. Rates of paving at Pompeii, Phase 3 to Phase 8.

Phase	Years in Phase	Average No. of PEs per Annum	Average Lgth. of PEs Constructed per Annum (m)	Average No. of Days Between Start of PE and Start of Next PE	Average No. of Days per Annum with Streets Under Construction
Phase 3	20	1.35	61.56	270	41
Phase 4	20	1.70	92.57	215	63
Phase 5	22	1.68	93.65	217	64
Phase 6	17	0.71	24.92	517	17
Phases 7/8	1	4.00	327.60	91	222

Note: Phases 1 and 2 are excluded because later repairs make it impossible to determine the original number of PEs.

(particularly lines 20–55) and provides an important window onto the magistrate's power over and responsibility for the streets, both their existing surface and repairs.[110] Most maintenance likely referred to the day-to-day removal of the refuse that obstructed movement, especially standing water (lines 22–3).[111] When more serious intervention was required, the aediles not only were charged to repair (*reficiundas*) and pave (*sternendas*) the public streets (*vias publicas*) within their jurisdiction (lines 25–6), but also to require that a stone surface be maintained on any lesser path (*semita*) onto which a building faces (lines 53–5).[112] The text is also explicit in describing how the magistrate was to determine the streets in need of repair and who, property by property (lines 32–45), was responsible for the costs. When a street determined by the aedile to require maintenance was not maintained by the adjacent property owners, that aedile let a public contract for the entire pavement and assigned proportional liability to each property owner, publishing their name and responsibility in the forum. The law defined this liability as the portion of the street directly in front of the property, an area measured by the length of the building and half the width of the street (lines 37–9).[113]

In the *lex Julia Municipalis*, we can see a centralized process of assessing proportional liabilities to property owners that was administered by the aedile and quaestor who, when appropriate, contracted construction crews and supervised the work in the defined sections of street. Although it is not beyond doubt that the law applied to Pompeii, there are good reasons to believe that it did. In the first instance, we can see the concept of civic (rather than individual) authority expressed in the similar relationships of responsibility beyond Rome in Siculus Flaccus' discussion of extramural roads: public highways fell under the jurisdiction of the *curatores viarum*, village officials saw to local roads, and private landowners were proportionally responsible for the maintenance of local and private roads.[114] Likewise, research by Saliou at Pompeii has demonstrated that the expectation for proportional responsibility for curbs and sidewalks is visible in the physical remains. Saliou's careful reading of the law and its relationship to curbstone materials and sidewalk spaces led her cautiously to believe that the *lex Julia Municipalis* did apply at Pompeii.[115] Recently, in his fulsome treatment of the social space of the Roman street, Hartnett also endorsed this view.[116]

With these legal provisions described and their applicability to Pompeii established, it is now possible to

[110] Crawford 1996, 1:363–65, 373–74.

[111] See also lines 68–72; *Dig.* 18.6.13(12)–14(13), 43.10.1.2. Papinian (*Dig.* 43.10.1.2) echoes these responsibilities two centuries later.

[112] We differ with Crawford on the translation of *lapidibus* as "gravel" rather than stone, but agree with the ambiguous shading of *semita* as "footpath" rather than only "narrow street" or "sidewalk." Interestingly, the drafters of the statute chose to define how a street was to be paved in the clause addressing smaller paths rather than in their earlier dictates on the larger *vias publicas*. Perhaps the pavement of these lesser routes was often more variable in form, requiring the explicit statement of stone pavements here.

[113] Proportional assignment of liability is explicit in two sections: lines 29–31, on shared public vs. private responsibilities, and lines 37–9.

[114] Siculus Flaccus, *De condicionibus agrorum* 110.6–15, 111.6–10; Chevallier 1976, 65–6.

[115] Saliou 1999, 198–200.

[116] Hartnett 2017, 123–25.

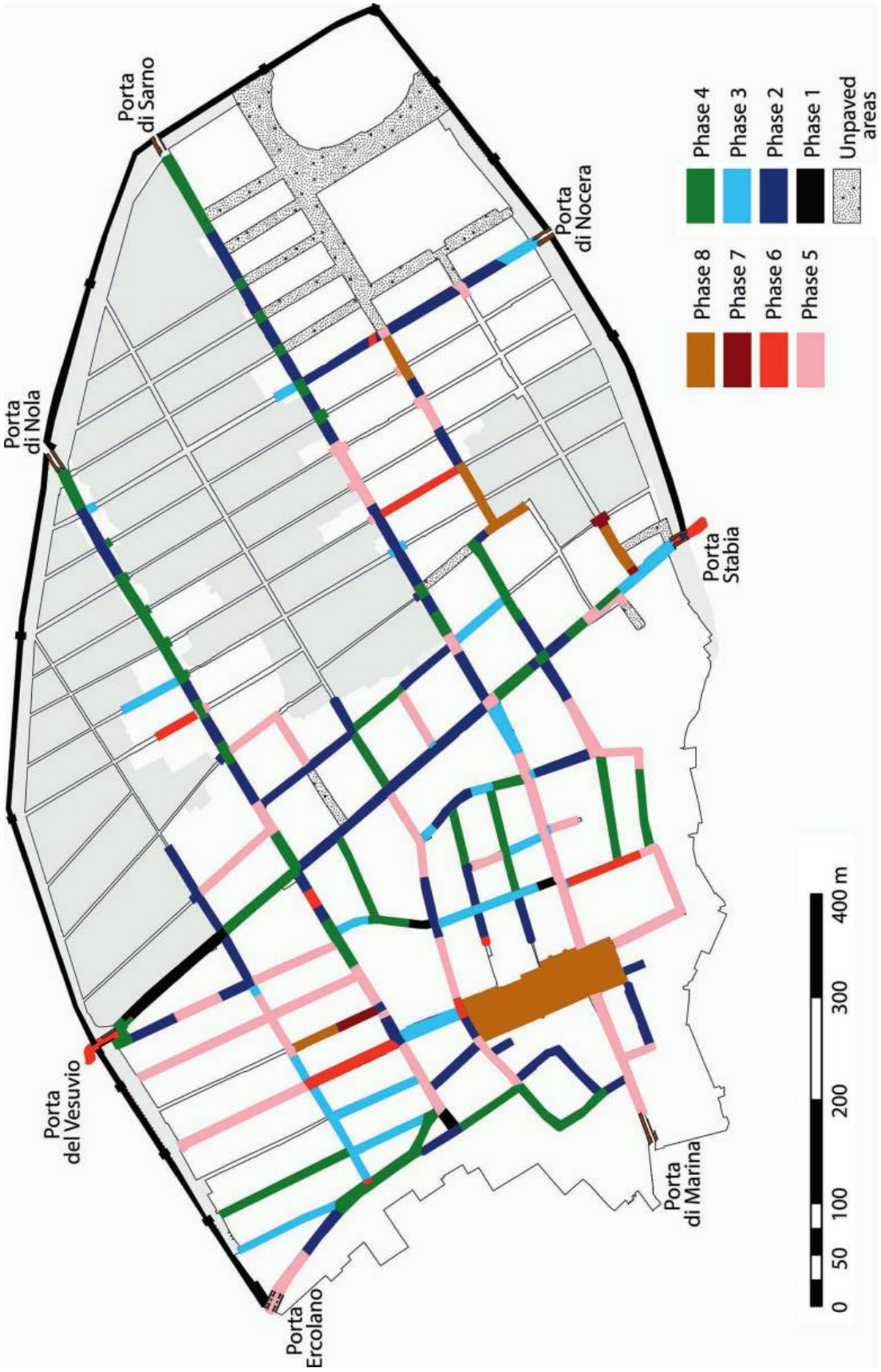

FIG. 18. Map of all paving events at Pompeii, color-coded by phase.

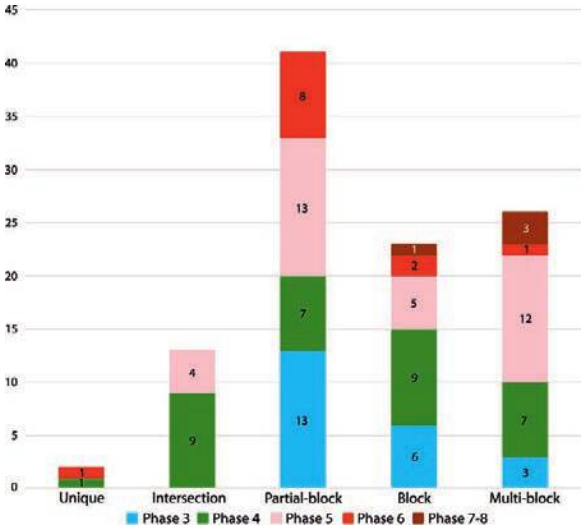

FIG. 19. Length types of paving events, Phases 3–8. Phases 1 and 2 are excluded because later repairs make it impossible to determine the original length types.

compare them to the archaeological results and assess their agreement. Indeed, there are a few examples that directly accord with the regulation, such as those PEs that coincide with (or are less than) the length of public buildings, indicating they were under aedilitian authority.[117] The repair of intersections and the interior of gates,[118] since no property actually borders them, must also have been the magistrate's responsibility. On the other hand, because the plurality of Pompeii's PEs are less than a block in length, it might be expected that property owners took it upon themselves to repair the street. This would seem to accord with many previous interpretations of the *lex Julia Municipalis*, which suggested that with the responsibility for repair came the right to take initiative for that work.[119] Kaiser has gone further, arguing from the variability in ruts and from legal sources that "with the responsibility to maintain a street came a right to control it."[120] Not a single PE, however, matches the extent of an individual private property. The closest match is a section of vicolo dei Vettii equally bordered by both the Casa dei Vettii and Casa degli Amorini Dorati (see fig. 1[19]).[121] In this case, however, the deep ruts here, which are not present in adjacent PEs, suggest that, if the owners exercised any power, it was to exempt themselves from the maintenance levied on their neighbors.

Despite the great number of small acts of paving, we cannot identify even a few individuals acting from their own initiative. Instead, the qualities of the pavements themselves suggest there was consistent oversight by the civil authorities in matters of street paving. Consider the condition we should expect to find the streets in if every property owner independently were to undertake construction or repair: many street sections would languish by the owner's neglect or poverty; many sections would be repaired only from the curb to the street center and not across the entire street's width; and many sections would be paved using different materials or construction styles.[122] Of these expected forms reflecting individual action, only one, a very small number of unmaintained streets, is evident at Pompeii. Instead, there is an absolute uniformity of material and its arrangement across the 11 km of lava-stone surfaces that seems impossible to accord with the whims of the hundreds of Pompeian property owners. Such uniformity in the paving stones is all the more informative in contrast to the variety found in curbstones and sidewalks, where owners were able, and indeed desired, to enact a significant—though not absolute—level of control and personal expression.[123] Again, we

[117] These include PE_009–PE_011, PE_015, PE_018, PE_020, PE_029, PE_060, PE_092, PE_096, PE_104, PE_106, PE_139, PE_141, PE_147, PE_153, PE_186, and PE_212.

[118] For instance, a pair of *duoviri* oversaw the paving of the area around four city gates in Sinuessa (Deutsches Archäologisches Institut 1899, 142, no. 565).

[119] Crawford et al. (1985, 78) found a street at Fregellae repaired differently on each side (one side surfaced with pebbles, the other with broken tiles) that may well reflect private initiative. This surface, however, far antedates (ca. late third century B.C.E.) the *lex Julia Municipalis*, and, although the surface might reflect pre-existing practice, it seems equally likely that preventing such a patchwork of pavements of differing quality was the impetus for centralizing authority for action within the magistrates. Robinson (1992, 59–69) places the onus on the frontager but expects somewhat more proactive oversight than others.

[120] Kaiser 2011b, 185–86, but cf. Poehler 2017, 17–9.

[121] PE_055.

[122] Research on medieval urban streets not only shows that these were precisely the effects of individualized maintenance but also that, even with an individualized system, municipal oversight was required. Jørgensen 2008, 554–56.

[123] Saliou 1999. It is noteworthy that none of Saliou's sections of curbstone materials matches the extent of a partial-block or multiblock PE. Indeed, they seem to show a disjunction between the time when street surfaces and curbs were made and remade, and/or the people involved in the process. Conversely, some block-length PEs and block-length similarities in curb ma-

see no contradiction between the aedile's powers of compulsion within the street and the frontager's opportunity for expression within the boundaries of his ownership along the sidewalk.

Instead, we argue that the archaeological evidence closely mirrors the language of the *lex Julia Municipalis*. It is instructive that throughout the 28 relevant lines of text that discuss street repair, the individual property owner is the subject of only two clauses. In all others, it is the magistrate (or the contractor he hires) to whom the law ascribes responsibility and authority. In the first of these clauses, the owner is still subordinate: he is being required to pay a contractor (plus a 50% fee) for repair work ordered by the magistrate that he failed to complete (lines 32–45). In the second, the law charges him with maintaining a "footpath" (*semita*) in front of his building (lines 53–5). Yet even in this context, which at Pompeii likely relates to the owner's sidewalk, the law expects the active agent—the property owner—to be acting "according to the decision of that aedile whose care of roads shall lie in that part [of the city]" (lines 54–5). Thus, while the archaeological evidence contradicts the previous interpretations of the *lex Julia Municipalis* that argued for private initiative in paving and repair, it seems to fit perfectly with the terms of the law that empower a city's aediles to oversee paving. Indeed, only the few lines concerning footpaths speak directly to an individual autonomy that we are able to match with any variability in the forms of paving.

Further support for this interpretation of the magistrate's authority to initiate (or delay) street repair and for collective action and responsibility for paving comes from inscriptions beyond Pompeii. Whether among elected officials, Augustales and *liberti*, a father and son, the emperor and local landholders, or urban property owners and a collegium, collective action was the driving force behind 40% of all the commemorated acts of paving known in Roman Italy.[124] Moreover, of the 98 inscriptions compiled by Campedelli that describe a paving event, 29 record that either the decurions or the city council authorized the work, while 45 were initiated at the behest of a municipal magistrate. Even those who commissioned pavements privately needed public approval for the project.[125] Such private commissions demonstrate that individuals or groups could seek permission to pave a street and likely did so not only for practical purposes but also for the prestige that *silex* might afford to their properties, the neighborhood, and/or their city. Vicolo di Narciso, among others in Region VI, fits this prestige model for street development; as an early stone pavement that could expect very little traffic or wastewater by virtue of its position in the street network, the vicolo di Narciso was probably commissioned privately. Conversely, such costs, or even the specter of them, might well have stymied the spread of *silex* to all of Pompeii. Indeed, if we see the paving of the long, unpaved streets in Pompeii's east as a potential liability for property owners there, then stopping even a gift of stone pavements might become an active political goal.[126]

Whatever the impetus for paving (or its forbearance), the liabilities and costs for its construction and maintenance could have significant consequences for social and economic relationships along that street. In fact, if (as stated in the *lex Julia Municipalis*, lines 32–45) the length of a building's facade were the only factor used to calculate cost, the smallest properties would often be assessed the greatest liabilities for repair. Consider, for example, the 30 properties (defined as functionally separate entities) along the repaired southern section of via del Vesuvio representing five categories of use (fig. 20). Table 2 shows the total facade lengths and total property areas for each building type, their relative proportions, and the estimated repair costs in sesterces, as well as a cost-to-area ratio. Because shops are shallow spaces with wide frontages

terials do match, but we cannot determine if these matches are meaningful or coincidental. Curbstone height, however, seems to have been mandated. Van Roggen (2015, 63) found an average height of 34.5 cm and a minimum of 8 cm. On the 45 elevated sidewalks, see Hartnett 2011, 154–55; 2017, 132–44.

[124] Regarding elected officials, most commonly these were members of the same office, *duoviri* or aediles, although pairs of *quattorviri* are not unknown. Regarding Augustales and *liberti*, commemorations by freedmen attest to many participants: four (*CIL* 1(2) 2946; 5 2116; 11 3083), five (*AÉpigr* 1984, 295), six (*CIL* 11 5040–1), or even 13 (*CIL* 11 6126); also, a father and son (*CIL* 11 3126), the emperor and local landholders (*AÉpigr* 1930, 122; *CIL* 9 6074–75; Gatti 1897), and urban property owners and a collegium (*CIL* 9 5438).

[125] For paving inscriptions, see Campedelli 2014; on private commissions specifically, see nos. 50, 59, 65, 104–6, 108, and 120; see also Lomas 2003, 39.

[126] Such a situation is reminiscent of the car-prize fiasco on "The Oprah Winfrey Show" in 2004, when audience members were suddenly given a new vehicle and a ca. $7,000 tax bill (Banoff 2004).

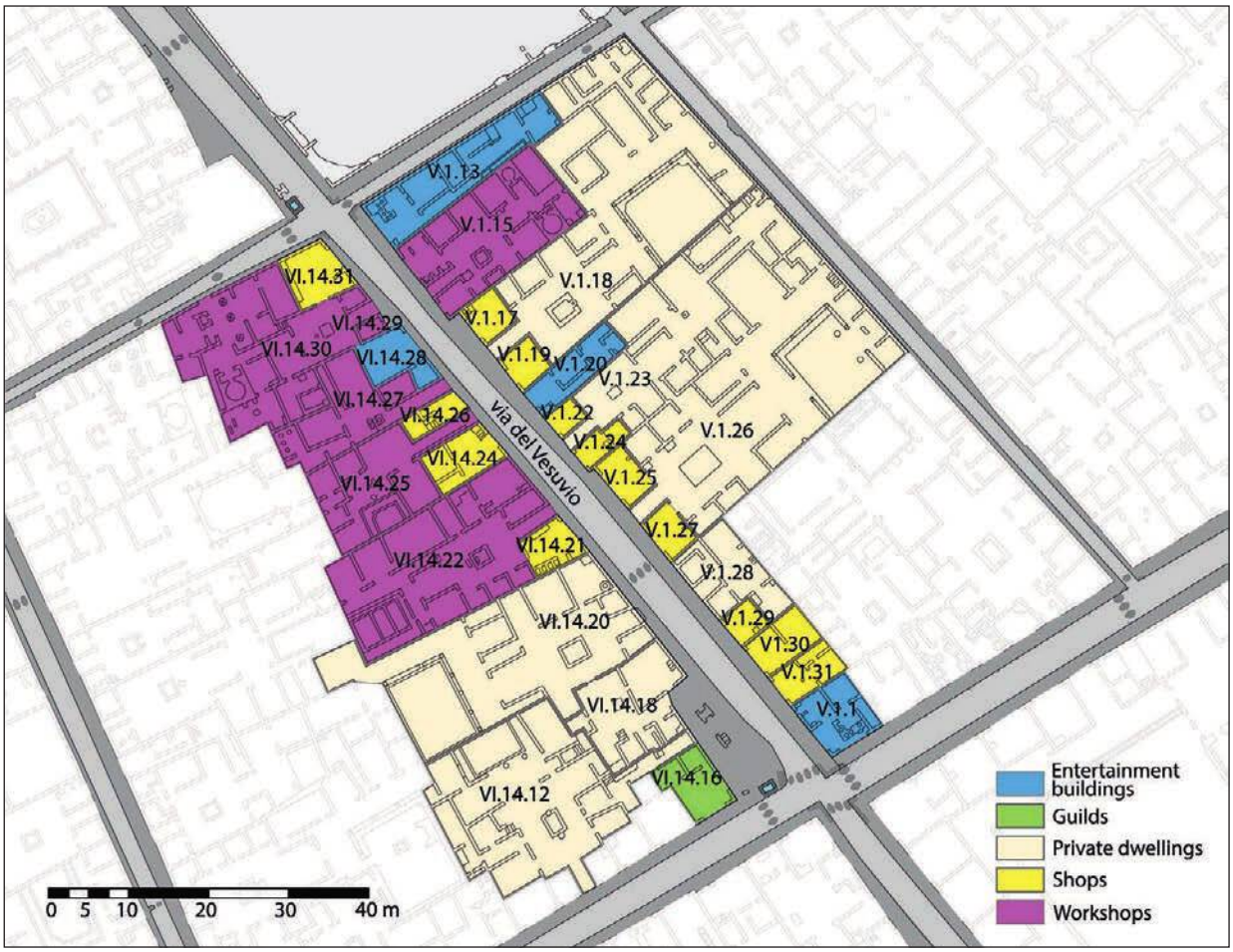

FIG. 20. Buildings by function along via del Vesuvio.

TABLE 2. Facade lengths, property areas, and costs for the southern block of via del Vesuvio, east and west sides combined (PE_127).

Property Type	Facade Lgth. (m)	% of Total Lgth.	Property Area (m^2)	% of Total Area	Cost (HS)	Cost:Area (HS/m^2)
Shops	67.49	38.1	421.73	8.7	1,688.02	4.00
Workshops	31.48	17.8	1,280.74	26.3	787.30	0.61
Entertainment buildings	27.61	15.6	326.03	6.7	690.66	2.12
Private dwellings	42.00	23.7	2,776.92	57.1	1,050.59	0.38
"Guilds"	8.70	4.9	55.27	1.1	217.62	3.94
Total	177.28	–	4,860.70	–	4,434.20	–

while residences present only a narrow entranceway onto the street, there is an inverse relationship between property size in area and the length of its facade, which in some circumstances would cause the responsibility for street maintenance to fall disproportionately on small, commercial establishments.[127] In fact, per square meter, shops along this part of via del Vesuvio would have had 10 times the potential liability of their neighboring atrium houses, if we follow the letter of the law.

These fiscal disparities raise intriguing social questions, whether or not they can be answered conclusively by these data. To be explicit, we do not know if street-front shops were owned by the proprietors, by the owners of the larger houses in which they were embedded, or by an entrepreneur with a wider real-estate portfolio. Nonetheless, it is intriguing to consider what happened in a neighborhood if suddenly the proprietor of a one-room shop like that at V 1, 22, were faced with a tax bill equivalent to nearly four months' salary for a magistrate's attendant (messenger), while next door the famous banker L. Caecilius Jucundus, owner of a luxurious, double-atrium house with running water, owed only 6.6 sesterces more.[128] Considering this was one of four such shops on the front of his house, we might begin to wonder how, if Jucundus owned these shops, he would manage the tax burden. Would he simply pay the bill? Or might selling off or changing the rental terms for his commercial frontage in advance have been a tax-avoidance strategy for when the aedile called for the repair of the street? [129] Indeed, because Jucundus was also responsible for the street behind his house, shifting the burden to shop owners would more than offset his other liability.[130] If he paid for the pavement outright, perhaps Jucundus did so to expand or deepen his *clientelia*, turning a once-in-a-generation tax bill into lasting social obligations.

To address these hypothetical scenarios, we can attempt to establish ownership through the interconnection of shops with the adjacent properties to which they were attached.[131] Doors connect the two southern shops to the atrium of house V 1, 26, suggesting a direct relationship to Jucundus, while the northern two shops do not communicate with the second atrium at V 1, 23. Complete physical independence, however, was uncommon for shops at Pompeii, and instances of independent, owner-operated shops must have been rare.[132] Literary sources indicate that rental markets were strong and profitable, legal sources show that rents were high and due annually in large lump sums, and epigraphic sources reveal that entire suites of shops (as well as other residential dependences) were available in Pompeii as elsewhere.[133]

For these reasons, even the physically independent shops were likely rented out and the property owners—whether inhabiting the adjacent residences or connected only by an investment portfolio—would have been ultimately responsibility for the costs of repaving. Of course, landlords may have passed along some of those costs or attempted to reap some benefit from the situation. Financially, it would have been simplest to increase the rent on the shops at the annual renewal of leases, but legal mechanisms of seizure and forfeiture of property were available to unscrupulous owners wishing immediately to recoup their costs.[134] Socially, however, the tenants of these rented shops might well represent opportunities for interpersonal relationships of equal or greater value. Freedmen, for example, made up a significant proportion of Pompeii's population—as well as the witnesses to contracts found in Jucundus' archives—and they are the most likely candidates to have rented his shops, either as proprietors or as middlemen.[135] If these were Jucundus' own freedmen, shouldering the cost of repaving might have offered an opportunity to deepen his extant ties. If not, Jucundus might have sought to widen his social and economic relations, taking the opportunity to tap into the political and economic networks that we

[127] Note that the total length of PE_127 is 2.64 m greater than that of the facades, leaving 131.80 HS of the repair's cost unaccounted for.

[128] For annual salary of a magistrate's messenger (300 HS), see line 35 of the *lex Ursonensis* (Crawford 1996, 1:400, 422).

[129] According to the Digest of Justinian (43.10.3) renters could be held liable by the aedile for general maintenance and even repair if the property owner failed to do so, but they were able to deduct such expenses from the rent.

[130] The 28.23 m segment of vicolo di Caecilio Giocondo behind his house would have cost Jucundus 485.4 HS, while the total liability for the four front shops was 493.9 HS.

[131] On the interconnection between domestic and commercial space, see Robinson 2016.

[132] Pirson 1999, 139.

[133] On profitable rental markets: Frier 1980, 30–4; high rents due annually: Frier 1977, 34–6; 1980, 34–9; suites of shops: *CIL* 4 138, 1136; see also Pirson 1997.

[134] Frier 1980, 105–35.

[135] Mouritsen 2001, 1–5. See also Ellis (2018, 85–125), who discusses the interwoven social and economic motivations shaping Roman retail landscapes.

know—again from his own archive—spread beyond Campania to the far reaches of Rome's empire.

CONCLUSION

Although we end our discussion by imagining the financial and social costs of paving or repaving in a particular neighborhood, such speculation is undergirded by a wealth of archaeological evidence. From linear abutments between paving events to excavations beneath them, Pompeii's streets show that the evidence necessary to describe how, where, and when paving occurred is readily available. Yet these speculations are necessary, as paving is not merely a physical event. Paving is also embedded within a series of interlocking economic, political, and social processes, without which no stone would ever be laid. Such processes are more difficult to discern from these data, but what they reveal about life in this ancient city can be even more interesting. Still other questions have yet to be addressed. For example, why, despite the scores of PEs created in the decades between the first paving of the via Pumpaiiana documented in the so-called Road-Maker's inscription and the external road mentioned in an imperial inscription, did no Pompeian claim credit for paving a street when an increasing number of Romans at other (less well preserved and less fully excavated) ancient cities did?[136] Additionally, as Romans transformed their cities in the second and third centuries C.E., how streets were designed—and consequently how they were paved—also changed. How did this impact the life-span of pavements? Of course, the answers to these questions lie beyond Pompeii and beyond the specific evidence described here. Nonetheless, we believe this research has demonstrated the value of such studies at Pompeii and offers the tools to conduct them elsewhere.

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[136] Supra nn. 33, 125. Two other, fragmentary inscriptions exist that antedate the Roman colony (Campedelli 2014, 147–50). Campedelli (2014, 147) suggests the inscription attributed to the Augustan era (*CIL* 10 1064) dates as late as post 62 C.E. For inscriptions that commemorate paving from other Roman cities in Italy, see the catalog in Campedelli (2014).

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