Highways and byways in Mycenaean Greece: human-environment interactions in dialogue

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HIGHWAYS AND BYWAYS IN MYCENAEAN GREECE
Human–Environment Interactions in Dialogue[1]

Ann Brysbaert, Irene Vikatou and Hanna Stöger†

1. Introduction

From the later Middle Bronze Age (MBA) until the end of the Late Bronze Age (LBA) prolonged construction in the Greek mainland, on a monumental scale required a sustained human and animal effort (e.g., Shelmerdine 1997; Cavanagh – Mee 1999). Archaeological research in the Argive Plain (Figure 1) has focused intensely on the sites of Mycenae, Tiryns, and Midea, exploring their elite power as expressed through manifestations of monumental architecture such as fortification walls, citadels, roads, and engineering works. Equally, tombs of various sizes and cemeteries that dotted the landscape have been studied extensively (tombs: e.g., Cavanagh – Mee 1999; Fitzsimons 2006; 2011; citadels: Wright 1987; Küpper 1996; Tiryns dam: Balcer 1974). Mycenaean road network research with its bridges and culverts resulted in several more recent studies (beyond Steffen 1884: Lavery 1990; 1995; Jansen 1997; 2002; Iakovidis *et al.* 2003). The Mycenaean highways (M-highways) and the minor interconnecting roads (m-roads) form the core around which this study revolves.

Our paper focuses on the infrastructure required and provided for, for large and long-term construction processes, how and when the infrastructure of M-highways and, to some extent other roads, came into being within the Argive Plain. Several groups of people (farmers, builders, artisans) moved and travelled along paths, roads, and highways, some probably on a daily basis. We, therefore, focus on the interconnection of elite sites with its hinterland in the Argive Plain and surroundings. Find spots and features become static in the

[1] Hanna Stöger's untimely death in Aug. 2018 was a shock to us all and she is sorely missed.

archaeological record, but movement does not and the ephemeral evidence of this has, therefore, gone almost undocumented in the past (Garland 2014, 6–10). Nodal points between areas of supply, such as building materials but also agricultural produce to feed a labouring population, and areas of construction and consumption are of specific interest.

We combined material culture and landscape approaches to help understand (1) how and to what extent the large-scale building and ongoing agricultural activities impacted on the existing 'manipulated' landscape, and (2) the types of activities that influenced the development and usability of Mycenaean infrastructure over time. Direct and indirect evidence aids in reconstructing people's movements along paths, roads and highways and may suggest how and when the resultant road infrastructure was constructed. A holistic study of road trajectories is therefore crucial since the latter formed social and technical exchange hubs for skills, knowledge, and resources. Beyond the built environment of quarry locations, citadels and various tombs, the economic landscape for manufacturing and military activities are discussed. Chronology is of major concern since any unexcavated, undocumented road is notoriously difficult to date (see section 2.4.; Discussion). Finally, the Linear B tablets, often from Mycenaean citadels beyond the Argolid (e.g., Pylos, Knossos), give crucial information because they provide insights in aspects of movement; agriculture and land-use, taxation, food rations as payment and distribution, the use of oxen for agricultural work and animal husbandry, land boundaries and ownership, object production, and chariot construction (Carlier 1987; Hiller 1988; Halstead 1995; Lupack 2008; Kajava 2011; Nakassis 2013). A representative selection of Linear B tablets (section 4.4.) illustrate transport and mobility and are discussed in this paper. In the concluding discussion, the data on human–environment co-dependence at the end of the LBA in the Mycenaean cultural sphere is tied together. Infrastructure as a crucial resource, and how it was used in this region are highlighted.

2. State of Mycenaean road research: trajectories, usage, construction efforts, chronology

Current literature on Mycenaean M-highways and their interconnection with the manipulated landscape is full of confusion, as authors' opinions on several issues

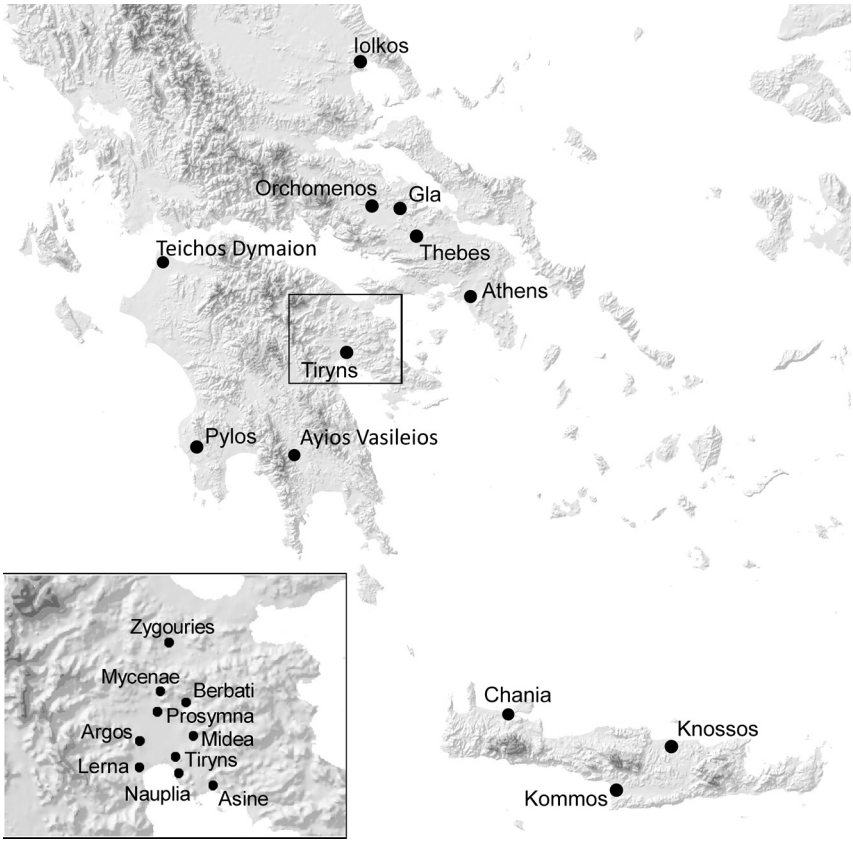

Figure 1: Map of Greece with most important sites mentioned.

vary or even contradict themselves over time. In this section, we highlight the information from these sources: the specific trajectory of each of the highways, their usage, the lack of any information concerning their construction, and especially the chronology of these M-highways.

2.1. M-highways, m-roads, and their trajectories

For Mycenae, Steffen's work provided the best topographical map. This was followed by others with the exception of Tausand (2006). Only Lavery's (1990;

1995) papers go beyond Mycenae but his maps were not topographical. Lavery's 2D sketches were taken over in part by Cherry – Davis (2001) who added some contour lines, and by French (2002), while the Mycenaean Atlas (Iakovidis *et al.* 2003) took Steffen's work as a base map.

Lavery (1990, 165) first categorized the Mycenaean road system in the Argolid as four M-highways likely constructed[2] through a state-organised workforce, and smaller roads/paths (m-roads). Until then, the main discussion revolved around the four Mycenaean highways, M1 to M4. All appear to start from the city's Lion Gate itself (but see Wace at al. 1953, 4–5); M1–M3 leading to the north towards Corinth; M4 south towards Prosymna and to where the later-dated Argive Heraion was built (see Steffen 1884; Mylonas 1966; Lavery 1990, 165; Jansen 2002; Jansen 2003 in Iakovidis *et al.* 2003, 28–31). Later, Lavery (1995, 264) also recognised and connected additional sections of M1–M4 and described m5, M6, M7, M8 and road Rho (trajectories in Table 1, Figure 2). Jansen (1997, 9, n.32) points out that these are based on topographical probability rather than actual remains while Hope Simpson – Hagel (2006) accept them. Mason's (2007, 37, figure 2) location of M7 does not agree with Steffen's indications, relating M7 to the site of Chania. Since Mason's map is more of a sketch, we tend to credit Steffen (1884) with the correct location of remains at Chania, and the trajectory of M7.

The m-roads/paths were often narrower, leading in a direct line to more distant locations. They were less well constructed, if at all, and often just worn into the slope through use. Their tracks could take steeper road gradients and run higher up the hill side (e.g., M4 compared to m4). They have been considered older than the M-highways (Lavery 1995, map 1), and were likely made by individuals who needed them.

[2] Through the cut-and-terrace technique and, where needed, including stone curbs, water drainage, and multi-layered surfacing (Mylonas 1966).

Nbr	From	To	Via	Joining
M1	Mycenae Lion Gate	Tenea (Corinth)	Stefani, Agionori, Klenia, Chiliomodi (Tenea), Solomos	M3 (near Solomos) M2 (at Kastraki)
M2	Mycenae Lion Gate	Zygouries-Kleonai (Corinth)	Ag. Vasileios, Kephalari plateau	M3 (at Kleonai) M1 (1.5 km from Lion Gate at Kastraki)
M3 M3W	Mycenae Lion Gate	Corinth	Nemea-Tzoungiza, Kleonai	M1, M2
M4	Mycenae conglomerate quarries	Tiryns	Monastiraki, Heraion	m5 (at Tiryns), M6 (Ag. Georgios bridge), M7
m4E	Mycenae	Heraion	West of Zara	
m4W	Mycenae	Heraion	Chavos/Chonia ravine	M4 (Ag. Georghios bridge)
m5*	M1	Tiryns	Berbati, Mastos, Dendra-Midea-Kastro	M4 (at Tiryns)
M6*	Aidonia	Heraion	Phlious, Ag. Georghios bridge	M4, M7
M7*	Mycenae Lion Gate	Argos (and Lerna)	Epano Pigadi, Chania, Vathyrema W	M4
M8*	Mycenae Lion Gate	Phichtia	-	M7 (at start point)

*Table 1: Known Mycenaean M-highways and m-roads reported by various sources (Tsountas 1888; Wace - Stubbings 1962; Mylonas 1966; Lavery 1990; 1995; Jansen 1997; 2002; Iakovidis et al. 2003; Hope Simpson - Hagel 2006). *New roads according to Lavery (1995).*

Tausand (2006) also refers to the Mycenaean M-highways of the Argolid, mainly to show their link to later roads. He was apparently not familiar with the work by Lavery, Jansen (2002), Iakovidis *et al.* (2003) or Hope Simpson – Hagel

(2006). This also results in Tausand confusing Lavery's original road numbering and other issues. M4 led from Mycenae over the Argive Heraion to Tiryns, after which a track from the Argive Heraion to Tiryns was noted (Lavery 1990), something we could not verify.

2.2. Functions of the M-highways and other roads

Bridges over waterways (e.g., Knauss 1996) with their associated M-highways (also Steffen 1884) have been discussed in terms of having several different but often single purpose(s) (Steffen 1884, 1–5; Mylonas 1966; Crouwel 1981; Lavery 1990, 1995; Jansen 2002; Sjöberg 2004; Tausand 2006). They may have been used by elite charioteers (e.g., Crouwel 1981), by farmers transporting agricultural produce (e.g., Lavery 1990; Kvapil 2012), by troops guarding and patrolling (e.g., Hope Simpson – Hagel 2006), and by builders transporting heavy stones, timber, and other large cargoes (Brysbaert 2020, 2021, in press-b). Mylonas (1966, 86) and Lavery (1990, 165) follow Tsountas' suggestion of using these M–highways for the passing of Heavy Goods Vehicles (HGVs). Lavery writes: 'some HGV is implied by the colossal stones of the citadel and tholoi'. A clay wagon from Palaikastro, east Crete (Crouwel 1981, 147; Jansen 2002, 139–141) illustrates that they were already known in the EBA. Depending on their width and construction, these M-highways may have been compatible with the use of two- or four-wheeled chariots, or of HGVs such as sledges, carts (2 wheels) or wagons (4 wheels) drawn by oxen, or pack animals. Lavery (1995) sees the agricultural needs of the region as the strongest purpose for which these were built. Jansen (1997, 10) does not recognize Lavery's (1995) m5 nor the importance of Berbati to Mycenae, but emphases the role of M1–3 going to the Kephalari valley and on to Corinth. The different uses of these M-highways versus the usually earlier (dated) m-roads seem to reside in the assumption that the latter were limited to pedestrians and pack animals (Mylonas 1966; but see Lavery 1990 on M2). In a different context, Fachard and Pirisino (2015, 141) illustrated that the reasons for travel affected the choice of roads taken; whether the traveller was accompanied by pack animals; whether they travelled with or without (heavy/large) cargo, or simply for speed.

2.3. Construction issues

In prehistoric and subsequent periods, wheeled-vehicle transportation overland amounted to over three quarters of all transportation carried out (one quarter by foot and pack animal, Pikoulas 2007). Well-constructed roads would have been essential for land transport of heavy goods. Heavy goods would otherwise have sunk or been driven into softer and uneven road surfaces (e.g., Raepsaet 2002, 191–200). Before the construction of highways, existing tracks must have been carefully scouted and prepared along their entirety to ensure they were accessible, efficient, well-drained and that they maintained a low gradient. Mental mapping (for definition, see Ingold 2011) and a thorough knowledge of the topography by travellers were essential to be able to efficiently navigate between places. Once these routes were considered convenient, people may have developed and used them for centuries, even millennia. Hope Simpson (1981, 17) mentions the immense labour that would have been needed to finish M-highways from Mycenae to the Corinthia (see also Brysbaert in press-b). Hope Simpson – Hagel (2006) fear that repeated use of the highways by HGVs would have left the roads in a poor state. While they suggest the use of lighter chariots and smaller two wheeled vehicles as more appropriate for the surfaces of the M-highways, they do, however, use "road repair activities" to explain the late date of the sherds as part of a repair fill rather than for road construction (see section 2.4.).

2.4. Chronology issues

The M-highways may have been in use for at least 800 years. They were likely still in use in 468 BCE, the date of the Argive destruction of Mycenae (Lavery 1990, 165). It is, however, much harder to pinpoint exactly when these were built. Excavations would be required to determine this. On architectural grounds and looking at the Cyclopean-style bridge constructions with corbelled vaults (Lykotroupi and Kazarma bridges) some authors date these bridged highways to the mid-13th c. BCE (cf. sally ports and water access at Mycenae and Tiryns, galleries at Tiryns), since there was no major centre constructing in this fashion after LH IIIB in the region (Jansen 1997, 2, n. 7). However, larger, and more daring tholoi were constructed at Mycenae and beyond from the early Mycenaean period onwards using the corbelling technique and large stonework

(esp. Fitzsimons 2011). Midea's excavators used the argument of 'Cyclopean style' for the retaining wall to help date the road leading to the East Gate of the citadel to LH IIIB. This argument was strengthened by pottery finds (Demakopoulou *et al*. 2010, 22–23). Also terracing in agricultural fields may have had an influence on road construction technologies (Brysbaert in press-a). Terracing is known on Crete since at least LM I (Gournia: Watrous 2012) and in the Mycenaean context since LH III (Kvapil 2012; Fallu 2017).

Mylonas (1966, 86–87) mentions a tentative date for M1 as the second half of 13th c. BCE based on two decorated sherds found in his trial trenches (also Crouwel 1981, 30). Hope Simpson (1981, 15) cites the date for M1 as 'late in LH IIIB'. Later, Hope Simpson – Hagel (2006, 149) are no longer convinced by the context of the excavated sherds and suggest that they could have belonged to a supplementary fill from a later road surface repair. For them, there are good reasons to believe that the construction of M1 can be dated within the period of LH IIIA2 to LH IIIB1 when the Berbati valley was exploited by Mycenae (Schallin 1996, 124, 171–73; contra Jansen 1997, 10).

Located close to the M1 and with wells indicating water presence, Wells *et al*. (1990, 227) and especially Schallin (1996) postulate that the activity site of findspot 14 may have been in part military, as the primary view across the landscape would have allowed control of the valley below. Perhaps the site also doubled as a service station for people travelling to and from Mycenae (Schallin 1996, 123–34). Chamber tomb cemeteries (findspots 16, 18) may have also belonged to this location (Schallin 1996, 138, 140), indicated by the road network connecting nearby cemeteries. Dating of the sherds and a figurine found in findspot 14 coincides with Mylonas' latter half of 13th c. BCE.

Lavery (1990, 168) who summarizes the archaeological evidence for his tracing of the M-highways, is convinced that M2 is older than M1, perhaps even pre-dating the LH period. He considers m5 a continuation of M2 but his maps (Lavery 1990, 171; 1995, map 1) show m5 being linked to the M1 instead. He suggests that m5 may have had two arms, the right-hand track of which may have crossed the later M4. It continued in a direct line to the northern tip of the Tiryns citadel via Platanitis and Argoliko, avoiding all settlements, thus indicating its older age. The m5 (pre-LH IIIB: Lavery 1995, 264) is the shortest link connecting all three citadels (Mycenae, Midea, and Tiryns) to the sea, via the Berbati valley, the Mastos settlement and through the Dendra cemetery

(with tholos) (Lavery 1990, 168–69). Consequently, the larger highways may not be duplicates of smaller roads as some authors believe (Hope Simpson 1981, 17).

Mylonas (1966, 87) mentions a bridge that preceded the Aghios Georgios bridge (date: late 13th BCE). Whilst destroyed, the former bridge is still partly visible. It is connected to two older roads: one to Mycenae heading north and one heading south to Tiryns via Prosymna. These must be the remains of the m4 heading north and the M4 to the south, whereby the m4 coincides and continues with the M4 at the old bridge (also Lavery, 1995, map 1).

Dickinson (2003) argued that some roads predate LH IIIB (see Lavery 1990; 1995, Map 1, legend; Jansen 1997), this was mainly based on the topography. Lavery (1990, 165–66) and Mylonas (1959) suggest that the smaller parallel m-roads to M3 and M4 (m3 and m4), which run higher up the hillside, are likely older than the highways. The m-roads m3 and m4 both ascent from the south and descend to the north and follow the old ramp at Mycenae. They then seem to head towards the tomb of Clytemnestra, circling the west and south edges of Grave Circle A. This supports the hypothesis that they did not originate from the Lion Gate but led to an earlier gate set in the older west wall. The latter wall was rebuilt, changing direction from S–N to N–S during the citadel's greatest remodelling in LH IIIB (Mylonas 1959, 142; 1966, 26–28, figures 1, 3). This suggests these roads were constructed perhaps a century before the Lion Gate itself was erected in the 2nd half of the 13th c. BCE. Furthermore, m4 may also coincide with the route that the later M4 followed over the west bank of the Chavos ravine, just below the modern road since it otherwise would have run over tombs that were in use during LH IIIA–B (Wace 1932, 12–15; Verdelis 1964, 74–81; Jansen 2002, 48).

Mason (2007) elaborates on the dating of the M4 based on the architectural characteristics of the Cyclopean bridge and the Aghios Georgios bridge, that the M4 crossed. If correct, the constructed road network of M-highways around Mycenae is later than the first LH chamber tombs cemeteries and the early tholoi. That, however, does not imply the lack of roads near Mycenae before the LH IIIB; quite the contrary. It could very well be that the existence of the earlier smaller roads helped make areas with water and other resources more accessible, and facilitated communication between farms, crafting and market locations. This dictated the need for less elaborate roads which then formed the physical basis for and evolved into the area's main M-highway network.

3. Combined theoretical and practical methodologies

Roads are one of the oldest, sometimes persistent, landscape features used by both animals and people, especially in landscapes where the local topography restricted passes and crossings to specific locations. People remembered these routes (mental mapping, Ingold 2011) and transmitted this knowledge. Roads and paths are an essential media for the routing of social relationships. They connect spatial impressions with temporally inscribed memories (Tilley 1994, 31). The act of mental mapping, therefore, is crucial for longer distance travel in which water sources, resting places, landmarks, and important passes are essential features. Pikoulas (1995; 2007, 85) showed that some Roman roads followed earlier Greek ones. Mycenaean roads in Arcadia were used in Classical times even when their use was not continuous (Krigas 1987, 79–80), and Tausand (2006, 199–203) discussed Mycenaean roads in the Argolid that at times were seldomly used, at other times in constant use. Memory, practical needs, and the remains of earlier Mycenaean road networks were likely combined when deciding which road to reuse in later periods. This is supported by Lavery's (1990, 165) account of ancient authors (Diod. Sic. 11,65,2; Str. 8,6,19, 8,6,22; Hdt. 9,35; Xen. *Hell.* 4,4,19) on the role of territory, thus implicating the use of existing roads around Mycenae in the destructive events of 468 BCE. Moreover, where other activities were equally persistent over time (e.g., crop rearing and pastoralism, certain crafts related to local resources), communication lines and routes between activity areas and homesteads, made these routes a stable feature in that landscape (see also Schallin 1996, 166). The more a path has been shared by people and their experiences, the more important a path becomes and remains.

From a theoretical perspective, employing Costly Signalling Theory (CST) seems appropriate in this study. Several authors employing CST (Glatz – Plourde 2011; Conolly 2017; O'Driscoll 2017) have pointed out the potential strategies played out between: (1) the social groups (signaller) that initiated, sponsored, and sustained many large-scale works; (2) the actual construction itself (costly signal thus considered honest); and (3) the audience (signal receiver) that was meant to see and understand the signal as the signaller intended it. Of importance here is that not just the physical outcome of the signal itself should mutually impact the signallers and receivers, but *also the acts of producing it*,

the building processes themselves. In these one *could* read the dominant role of the signaller in being able to mobilise the necessary work forces since these people, when not building, are also capable of military combat, raiding, and large-scale agricultural production. In a more nuanced study, Drennan and Kolb (2019, 72–73) noted that more monumental building took place when Egypt was at war with powers beyond its borders, thus signalling to the population their internal strength, stability, and powerful pharaoh. This was, however, not the case when *internal* conflict disrupted Egypt and placed the pharaonic power under duress. Building to such proportions could, thus, also be a sign of waning power which then needed reaffirmation. Moreover, CST shows very clearly human collaboration across social boundaries, thus the co-dependence between elites and any other group. Such human collaborations and co-dependences can also be inferred from investigating the material remains through a cross-craft interaction perspective when combined with studying multiple *chaînes opératoires*, such as seen here in road contruction. This is also true for crafting, agricultural production, and monumental building (Brysbaert 2020; in press-a).

In practical terms, we collected data from the published literature on Mycenaean roads (e.g., Steffen 1884; Iakovidis *et al.* 2003) and through remote sensing of Google Earth and Google Maps. We tried to verify these data through extensive walks in the Argive Plain and surroundings, over several seasons. A range of published sites were visited: the quarries, M-highway remains, the tholoi in the Argive Plain and surroundings and, where accessible, the chamber tomb cemeteries. Our walks also served to get a keen grasp of the local topography in which the visited remains were located and through which the M-highway tracks ran. Topographical variety in the form of contour lines was often lacking on printed maps and sketches, thus is best observed in the field. Understanding this factor helped to see how it would influence the intervisibility of the different natural and built features in the landscape along these roads.

Published sites were recorded with a free GPS application, (GPS Essentials), installed on an Android smartphone. Afterwards, QGIS was used to plot the recorded points in a satellite Google Maps base map to better understand their spatial relationship to the road systems in the area. Later, Least-Cost-Paths (LCPs) between two points of interest were produced. This required a Digital Elevation Model (DEM) to generate a slope and a cumulative cost raster. The larger the resolution of the DEM (12.5 × 12.5 m, https://www.asf.alaska.

edu/), the more accurate the generated LCPs are. These slope and cumulative cost rasters are subsequently used as base maps to produce LCPs by employing the QGIS integrated GRASS tools, *r.walk* and *r.drain* (https://grass.osgeo.org/). Projecting the LCPs on the Google Maps base map provided a visualisation of the created LCP-network that can then be compared to the actual ground-truthed trajectories, in order to assess the usefulness of LCPs in this context.

4. Results

The terrain in the Argive Plain is topographically varied with fertile valleys and large fairly flat agricultural zones, surrounded by mountainous regions. Figures 3 and 4 (discussed below) illustrate how we traced Steffen's (1884), Lavery's (1995), and Iakovidis *et. al* (2003) road remains to the extent that the trajectories were recognisable and still walkable. Based on published tracks and roads, we hypothesized the continuation of some of these, when considering the goal of travel; the essential requirements for movement and transport in the given topography, and contemporary technological possibilities and efficiency. While our work confers with earlier published work on most trajectories, it does provide the first full topographical overview of where the M-highways were constructed and ran. This is depicted in a detailed georeferenced map of all M-highways and the m5 road from the Berbati to Tiryns (Figure 2, see also above). The plotted results (on Google Earth 3D maps) from our ground-truthing work provides the detail for each trajectory including topographical limitations.

We focused specifically on the infrastructure required to transport building materials between quarries and extraction places on the one hand, and building sites on the other (M3W, M4, M7, M8). We also provide evidence that support connections between Mycenae with the Corinthia detailing several routes (M1–3, M6) and with the Berbati valley (M2, m5) for agricultural and other economic purposes. Our results highlight the usage (many and varied) of the Mycenaean Highway and minor road networks. They also show that the use of many M-highway trajectories continued over time (see earlier Lavery 1990; Tausand 2006), some are still in use today.

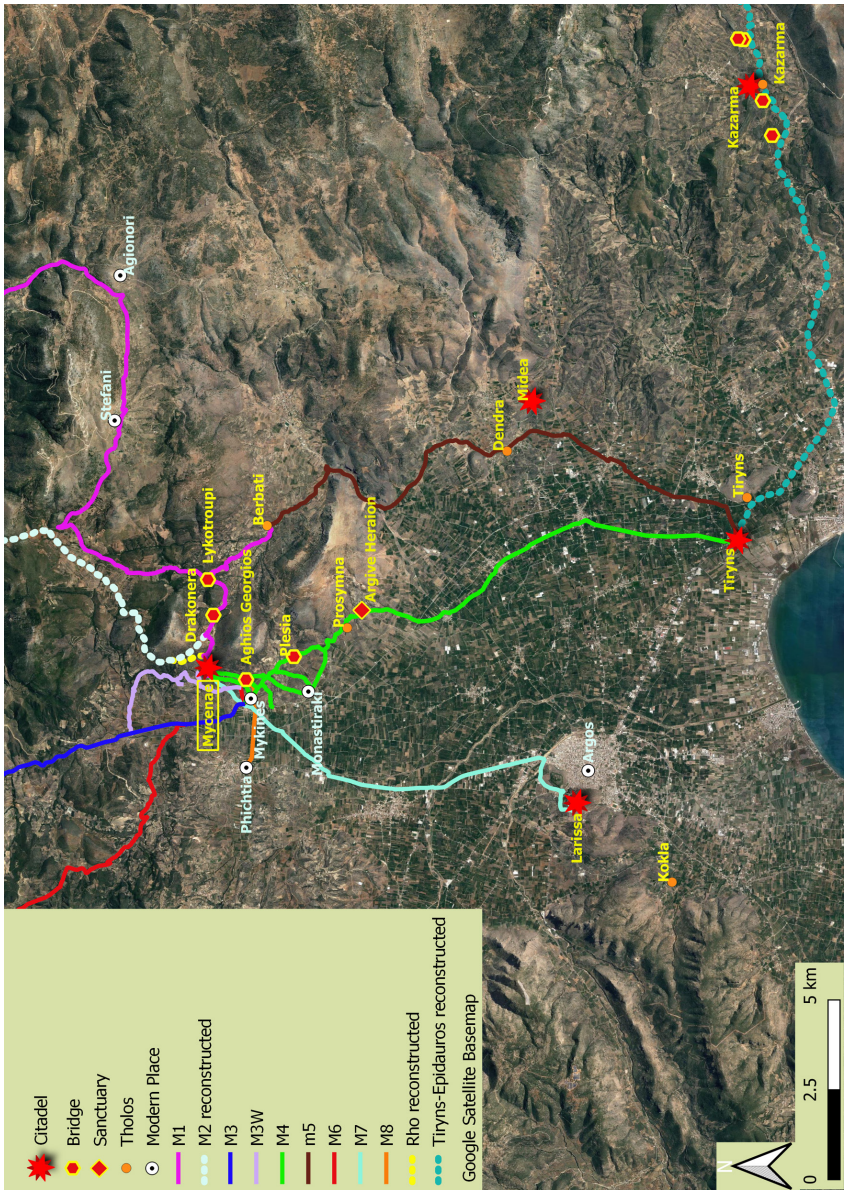

Figure 2: Mycenaean Road Network demonstrating the M-highways and the m5 road in correlation with important published sites.

4.1. Mycenaean Roads in the Argolid/Argive Plain linking material resources to building sites

4.1.1. Quarries and extraction sites

The construction materials employed in Mycenae are conglomerates, limestone and Poros stone, as well as the clay resources of Plesia and Asprochoma (Figure 3). While most stones employed in the construction of citadel fortification walls were of local extraction (100 m to 1 km), some multi-tonne blocks required long-distance transport to reach their final position. Several conglomerate blocks were transported from Mycenae to Tiryns (Maran 2006; Brysbaert 2015; Brysbaert 2021). These likely came from one of the following four locations: 1. the heavily quarried ridge starting at the modern car park running south along the Panagia ridge; or 2. from the Kalkani ridge further west; or 3. from the outcrop on which the Mycenae village at Charvati was constructed (Wace 1949, 27; Cavanagh – Mee 1999, 96; based on Schliemann 1880, 118, figure 191); or 4. from a site a few kilometres north of Mycenae (Santillo Frizell 1997 [1998], 629[3]). Poros ashlar, used in various tholoi at Mycenae, may have been found in the hills northwest of Mycenae towards Nemea (Wace *et al.* 1921–1923). Poros stone used in the demolished building preceding the Treasury of Atreus may have originated from near Monastiraki (Wace 1949, 130). Limestone was omnipresent. The maps of Iakovidis *et al.* (2003, maps 2–3, 6–8, 11) indicate the quarry sites.

Plesia clay was used as mortar in the Atreus, Clytemnestra and Aigisthos tholoi (Wace 1955, 196; Cavanagh – Mee 1999, 97). It was also applied as a flooring covering and in benches for private housing (Palaiologou 2015, 57). A similar material was recognised as pointing mortar in wall surfaces at Tiryns (Müller 1930, esp. 178–79). Figure 3 illustrates the accessibility to numerous quarries facilitated by M4 which runs down from the modern Mycenae car park, along the Kalkani ridge, to the centre of the modern village of Mykines (Charvati). Other quarries sit along the M7 and the M1.

4.1.2. Construction activity sites

The areas made accessible by M-highways in the Argolid seem to have been considered carefully: our GPS measurements verified Lavery's (1995) observation that the road trajectories ran at convenient and consistent heights, with the roads

[3] Not further determined where exactly.

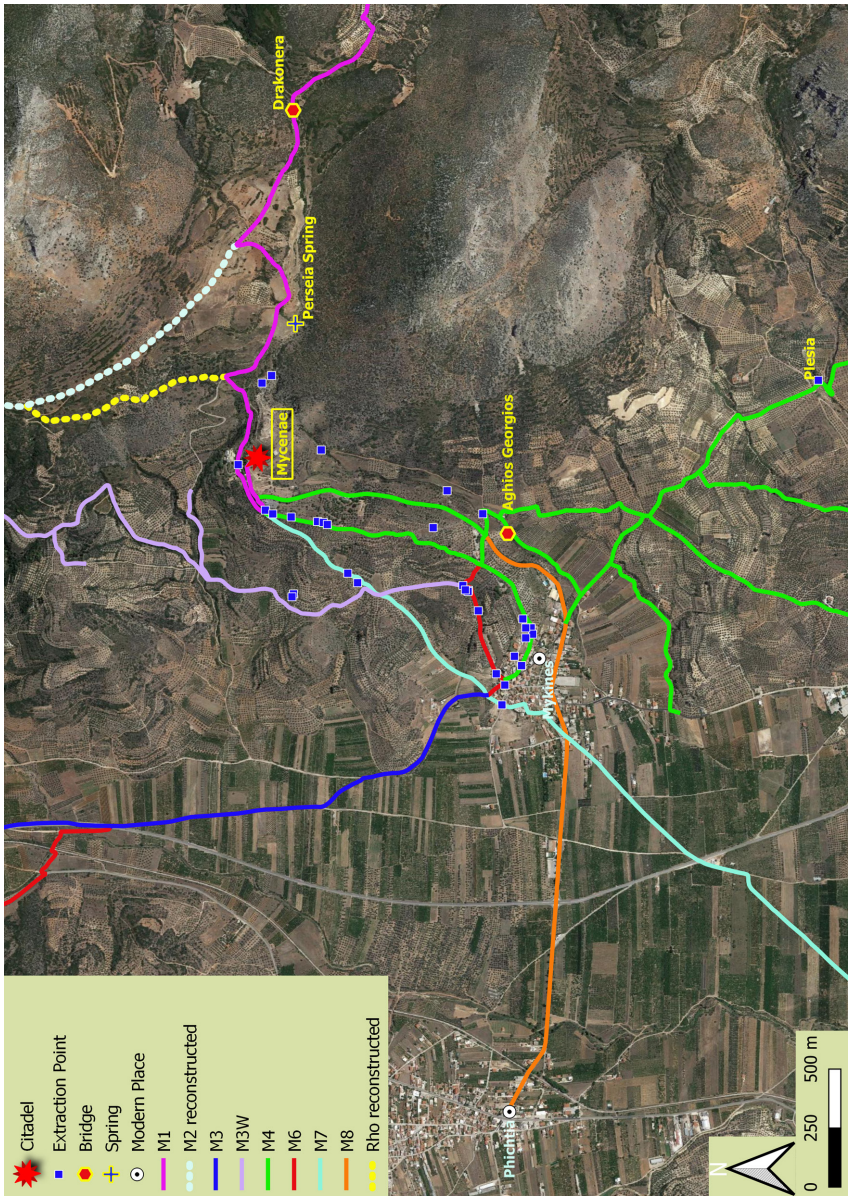

Figure 3: Map of Mycenae with known/published quarries and extraction points, and roads nearby.

built as even as possible in a topographically varied landscape (e.g., M4). The widths of the M-highways have been measured and range between 2.10–2.50 m, based on the road surfaces only. The reported width of 3.5 m included the outer kerbs (Hope Simpson – Hagel 2006, 150, n. 22; Crouwel 1981 quoted a width of 4.8 m). Some bridges have a width of 5.5 m kerbs included (Jansen 2002). Only the so-called cut-and-terraced M-highways (after Jansen 1997; 2002) were constructed beyond simple earth removal in the slope. Entire sections of M1 and M4 received strengthening. Massive unworked boulders were placed along the terraced edges to stop soil erosion and/or collapse. However, the remains of M-highway terracing are clearly related to the substratum on which they were built: only remains built on limestone survive, whilst erosion affected flysch and marl substrate resulting in subsidence or collapse of the cyclopean blocks (Wells et al. 1990, 237; Schallin 1996, 131). Such substratum was difficult to recognise elsewhere along the M-highways. Elsewhere, they were often cut in softer hill sides on soil and bedrock. Heavily reinforced sections only appear to be associated with M1 and M4. M1 had water runoffs to allow rainwater to drain downhill. Other M-highways were constructed over drainable layers that directed water into channels below. The drainage layers were cut into the slopes approximately 30–50 cm below the road surface. Water runoffs were recognized during recent surveys and testify to the efficient drainage of dozens of culverts and weepholes (Schallin 1996, 130–33 for the latter; Hope Simpson – Hagel 2006, 149, n. 20). Terracotta drainage pipes/channels along M1 ensured it remained useable throughout the year. Far less 'monumental' were sections of the retaining wall noted near the Prosymna tholos along M4.

The main M4 started at Mycenae and passed over the Aghios Georgios bridge on its way to the later Argive Heraion. This allowed the transport of multi-tonne conglomerate blocks along the route between the Mycenae–based conglomerate quarries and Tiryns (Brysbaert 2021) (Figure 4). We verified that the M4 highway remains between 110–133 masl from the Aghios Georgios bridge to the Argive Heraion, with a maximum road gradient of 2–3% (Brysbaert in press-b). Both the m3 and m4 paths are more exposed to heavy erosion higher up the steeper slopes but M3 and M4 avoid this entirely. M4 also seemed to have been connected where it crossed m5 linking Midea to the sea (Lavery 1990, 168–69, see 2.4. and discussion). We see this confirmed by the Greek–Swedish excavations (Demakopoulou *et al.* 2010, 22–23; Morgan 2010,

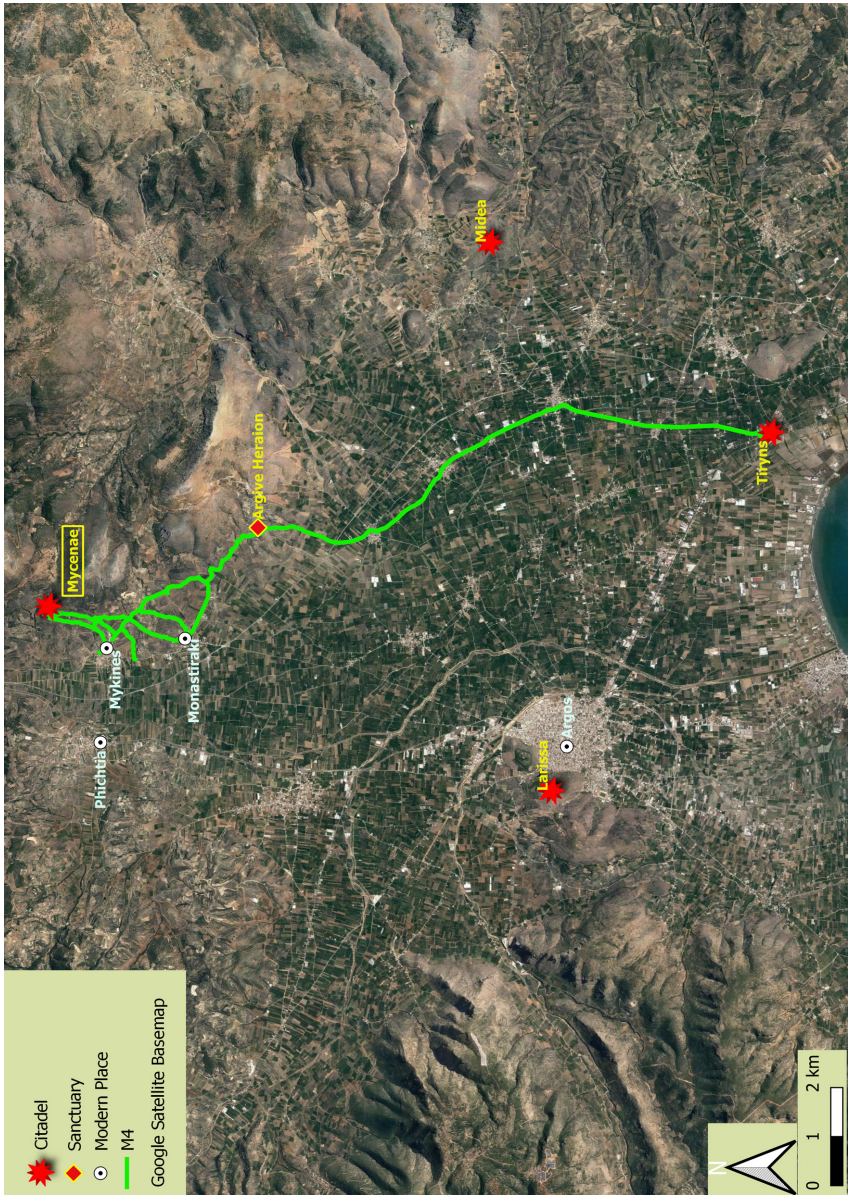

Figure 4: Map showing the M4 trajectory from Mycenae to Tiryns passing by the Prosymna tholos and the Argive Heraion.

35) in which a large retaining wall of a road leading to the east gate of the Midea acropolis has been uncovered. These remains likely led to the northwest of the Midea acropolis in one direction and connected to the Mycenae–Tiryns highway M4 at the other. The excavators suggest that the construction of the road likely coincided with the fortifications of the Midea acropolis, dated to LH IIIB. M7 which ran from Mycenae to Argos may have provided the necessary track to provide conglomerate blocks to the citadel at Larissa (see Crouwel 2008).

4.1.3. Roads and the mortuary landscape

Numerous publications focussed on issues revolving around the construction and chronology of tholos tombs (Stamatakis 1878; Schliemann 1880; Tsountas 1888;[4] Wace *et al.* 1921–1923; Persson 1931; Blegen 1937; Mylonas 1966; Pelon 1976; Fitzsimons 2006; 2007; 2011; Galanakis 2007). A recent study by Galanakis (2017–2018) presents nearly 1700 discoveries of tholos and chamber tombs from a total of 207 sites. The nine tholos tombs found around Mycenae (Table 3, Figure 5) constitute the most impressive constructions of the necropoleis and indicated the high status of the elites which built and used them (Mee – Cavanagh 1990). These examples of monumental architecture stood out in the landscape for later generations to remember and worship (Boyd 2015). Figure 5, based on our data points and ones provided by Iakovidis *et al.* (2003), mark the locations of the nine tholoi and the chamber tomb cemeteries associated with them (for the remaining chamber tomb cemeteries: Efkleidou 2019). When investigating how burial sites were integrated within the wider landscape, we focussed on how their access was facilitated for internments, subsequent tomb visits, and for *tomb construction*. Therefore, the way heavy stone blocks were moved from extraction points to construction site also concerned us here. Tombs *are* often found along roads and are useful in finding the remains of roads, even when little of them remain (Hope Simpson 1981; see also Young 1956, 95 for later periods). Iakovidis *et al.* (2003, 45; and earlier Tsountas 1888, 123) observed a correlation between quarries, chamber tombs, and the roads. During our walks we noted that most of the cemeteries *with their associated tholoi*, lie close to at least one M-highway,

[4] The year 1888 refers to the date the *Ephemeris* volume was written and differs from the 1889 publication year, in 1889. To be consistent with publications referring to the former, we preserve the same format.

sometimes two (Figure 5, Table 2). Table 2[5] also illustrates the chronology of Mycenae's (LH) chamber tomb cemeteries and tholoi, excavated by Tsountas (1888) and Wace *et al.* (1921–1923) in the slopes surrounding Mycenae. The chronology of most of the chamber tomb cemeteries predates both the associated tholos tomb and the M-highways. The chamber tombs cemeteries at the 3rd km and Aghios Georgios illustrate this very well along with the associated Treasury of Atreus. This pattern is not only observed near Mycenae: the Prosymna tholos sits along M4, the Kazarma tholos on the road from Tiryns to Epidauros, and several tholoi lined the presumed highway between Pylos and Rizomylo in the region of Messinia (Hope Simpson 1981, 143).

Name	**Type**	**Location/ Vicinity to road**	**No. of chamber tombs**	**Date of construction/ range of use**
Group I: Early LH IIA				
Cyclopean tomb	**Tholos**	600 m SW of Citadel/E of M6		Early LH IIA/ Geometric, Hellenistic periods
Epano Pigadi/ Fournodiaselo	ChT cemetery	W of M6 and E of M3W	**Ca. 16** ChT., min. **9** unexcavated, uncertain if they belong to that cemetery	LH II-LH IIIB
Epano Fournos	**Tholos** associated to Epano Pigadi/ Fournodiaselo	150 m E of Cyclopean Tomb/W of M3W		Early LH IIA/ Early Geometric period

[5] We follow Wace's (1949, 17) chronology and three-group-system for the tholoi which is accepted by numerous scholars: Pelon 1976, 1990; Cavanagh – Mee 1998, 58; Wright 2006, p 58 n. 57; Fitzsimons 2007, n. 23, 101–02; 2011, 93; Galanakis 2007. For chamber tomb chronology we follow Iakovidis *et al.* 2003.

Tomb of Aigisthos	**Tholos**	100 m W of Lion Gate/SE of M3W		Early LH IIA/ Hellenistic period Remodelled between LH IIB and LH IIIA
Group II: LH IIA-IIB Late				
Panagia tomb	**Tholos**	150 m NW of Atreus tomb/E of M7		LH IIA-IIB/ Late-Geometric, Classical periods
Panagia	ChT cemetery	E of M6 and of M3W	**Ca. 12** ChT., **1** cist tomb, **4** unexcavated	LH IIA-LH IIIC
Kato Fournos	**Tholos**	500 m W of Acropolis/E of M6		LH IIA-IIB/ Late-Archaic period
Kato Fournos	ChT cemetery	NE of M6 and W of M3W	**10** ChT, min. **2** unexcavated	LH II-LH IIIB
Lion Tomb	**Tholos**	100 m N of Lion Gate/S of M3W		LH IIA-IIB/ Late-Geometric, Hellenistic periods
Group III: LH IIB-LH IIIB1				
Tomb of Genii	**Tholos** linked to Epano Pigadi/ Fournodiaselo (see above)	50 m N of Cyclopean Tomb/E of M6		LH IIB- LH IIIA1/ Geometric or Archaic periods

Tomb of Atreus	**Tholos** also linked to Panagia ChT (see above)	500 m SW of Lion Gate/E of M7, W of M4		LH IIIA2-IIIB1/ Archaic period
3rd km	ChT cemetery	Along M4	**6** ChT.	LH II-LH IIIC
Aghios Georgios	ChT cemetery	E of M6 and M4 (Kalkani branch)	**10** ChT.	Early LH II-LH III
Tomb of Clytemnestra	**Tholos**	100 m W of Lion Gate/SE of M3W		LH IIIA2-IIIB1/ Geometric until Hellenistic periods

Table 2: Mortuary landscape of the tholoi which are linked to a chamber tomb (ChT) cemetery in the vicinity of Mycenae with nearby M-highway indications. Each tholos is linked to the cemetery mentioned in the cell below.

Name	**Dromos Orient-ation**	**Dromos and Stomion stone**	**Stomion lintel stone, nbr**	**Lintel finish**	**Relieving triangle**
Group I: Early LH IIA					
Cyclop-ean	W – E	Dromos: in the soft rock, not lined with masonry. Stomion: of large, unworked limestone and conglomerate boulders	Conglomerate, 3	Possibly naturally shaped Top walls of doorway levelled with the slope's original inclination	No

Epano Fournos	S – N	Dromos same as Cyclopean tomb. Stomion: undressed conglomerate and limestone,	Conglomerate, 5	Cut along the side to fit, rough flat slabs	No
Aegis-thus	S – N	Dromos: semi cut into the earth and into the sidehill soft rock. Lined with rubble masonry held tight with clay served as mortar. Stomion: rubble blocks mortared with Plesia clay.	limestone, 2-out conglomerate, 3 -in	Short and barely overlapping the sidewalls of the doorway	No
Group II: LH IIA-IIB Late					
Panagia	W – E	Dromos: rubble blocks mortared with yellow clay. Stomion: conglomerate blocks regularly laid in courses	Conglomerate, 2	Lintel slightly overlaps conglomerate jamps and stomion side walls to a long extent	Yes
Kato Fournos	W – E	Dromos: poros blocks joined with stucco. Stomion: fine-grained conglomerate covered with stucco	Conglomerate, 3	Overlaps the doorway side walls	Yes

Lion	N – S	Dromos: ashlar poros blocks of poor quality. Stomion: large rectangular conglomerate blocks.	Conglomerate, 4	Overlaps the doorway walls.	Yes
Group III: LH IIB-LH IIIB1					
Genii	NW – SE	Dromos: wall constructed of rubble and bound with yellow clay. Crowned with limestones Stomion: conglomerate pointed with stucco	Conglomerate, 2	Inner one large. Good overlap with sidewalls.	Yes
Treasury of Atreus	E – W	Dromos: Conglomerate, rubble wall with plesia clay, poros blocks (with mason marks) at closure dromos entrance and rubble revetment. Stomion: ashlar hard conglomerate	Conglomerate, 2	Cut, sawn, polished, perfect fit between both	Yes

Clytem-nestra	S – N	Dromos: Conglomerate, cut, dressed, clay behind, support wall behind Stomion: conglomerate	Conglomerate, 3	Cut, sawn, polished, perfect fit between both	Yes

Table 3: Architectural characteristics of the nine tholoi in Mycenae.

Finally, the location of seven[6] more tholoi; Berbati (1), Prosymna (1), Dendra (1), Kazarma (1), Kokla (1), and Tiryns (2) (Persson 1931; Blegen 1937; Müller 1975; Pelon 1976; Demakopoulou 1990; Galanakis 2012; Demakopoulou – Aulsebrook 2018), and their vicinity to the M-highways and their settlements are illustrated in Figure 2 and Table 4. Apart from the Prosymna cemetery near the later Argive Heraion, all other necropoleis were located some distance from their main settlement. Dendra as the cemetery of Midea lies approximately 1 km away (Persson 1931; Pelon 1976) and, together with Kokla, are the only cemeteries, beyond Mycenae, that contain the tholos and chamber tombs at the same location. However, the Kokla burial site has not yet been associated with a settlement. This will probably be found nearby in an area yet to be surveyed, 300–400 m north of the site (Demakopoulou – Aulsebrook 2018). The chamber tomb cemetery at Tiryns is located 1.5 km east from the citadel on the east slope of Profitis Ilias, whereas the two tholoi[7] are 1 km away in the foothill west of Profitis Ilias (Müller 1975; Pelon 1976). The Berbati chamber tomb cemetery and its tholos are located about 1.2 km northwest of the settlement at Mastos (Georgiadis – Gallou 2008). Tiryns and Prosymna tholoi sit close to M4. The Dendra cemetery with its tholos is facilitated by m5 and the Berbati tholos lies close to two main roads: M1 and m5. The Kokla necropolis does not appear to be directly linked to any of the M-highways. It seems then that road access (whether M-highway or m-road, see below) to cemeteries and associated tholoi

[6] Fitzsimons (2006, 145 n. 467) mentions another tholos in Midea under 'the kafenion' but to our knowledge it has not been published.

[7] Here we only refer to the published tholos at Tiryns. The Tiryns tholos construction date is debated because of its complete looting (Müller 1975; but see now Brysbaert *et al.* forthcoming).

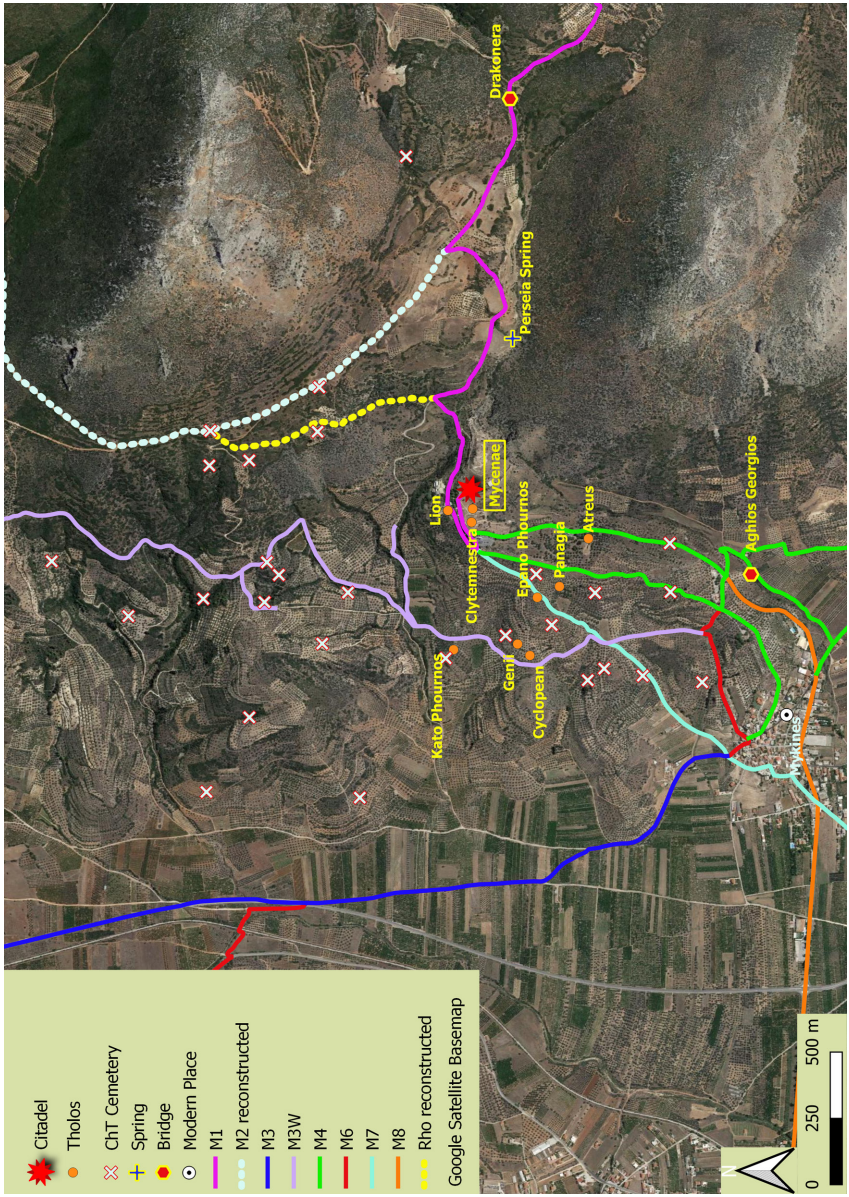

Figure 5: Distribution of the nine tholoi and their associated chamber tomb cemeteries around the Mycenae citadel, and their nearby M-highways.

also provide relatively good access to known settlements too. The tholoi and necropoleis close to Mycenae are often situated near two M-highways contrary to the cemeteries in the rest of the Argolid which are generally close to a single M-highway. This is mainly due to a higher concentration of M-highways originating from Mycenae. However, it does not exclude the existence of secondary (m-)roads pre-dating the M-highways, which provided access to these locations. The use of (older) secondary roads could be supported by the fact that the chamber tomb cemeteries of Prosymna, Kokla, and Dendra predate the nearby tholos construction. This mirrors the correlation of the Atreus tholos tomb to the 3rd km and the Aghios Georgios chamber tomb cemeteries. The road accessing both chamber cemeteries could have been extended to access the Treasury of Atreus during its construction. Any pre-existing routes, once they were widened, were no longer visible.

To summarise, prior to the monumentalization of the M-highways, smaller pre-existing roads most likely led to the chamber tomb cemeteries. Crews of tomb diggers would have required access to the site, and funerary processions needed easy access for ceremonies (Boyd 2016; also Turner 2020, 78–79). Those older routes facilitated access to these cemeteries and, where possible, to the settlements. Such m-roads were less elaborately built, so much harder to trace, and often, therefore, no longer visible (see Discussion).

Name	**Location**	**Vicinity to Roads**	**Date of construction, Date of usage**
Argive Heraion/ Prosymna	Tholos tomb: 1 km W of sanctuary and chamber tomb cemetery, dromos orientated W. Chamber tomb cemetery: N and NW of the Argive Heraion	Along M4	LH II Chamber tomb cemetery: LH I-LH III

Berbati	Tholos tomb: NW close to Kastraki, 500 m from Mastos Chamber tomb cemetery: 1,2 km NW of Mastos	Near to M1 to the S and N of the m5	LH I-LH IIIA, Geometric period Chamber tomb cemetery: LH IB-LH IIIB
Midea/ Dendra	Tholos tomb at Dendra cemetery: SE of Midea acropolis, dromos orientated W Dendra chamber tomb cemetery: 1 km W of Midea acropolis	Near m5	LH III Early Chamber tomb cemetery: LH I-LH III
Tiryns	Tholos tomb I: 800m E of Tiryns Citadel, dromos orientated to the W Tholos tomb II: SE from the latter, not published Chamber tomb cemetery: E slope of Profitis Ilias hill	M4	Tholos tomb I: LH III* Chamber tomb cemetery: LH I-LH III
Kokla	Tholos tomb at Kokla cemetery: 5 km SW from Argos and 8 km NW from Lerna, dromos orientated to the E Chamber tomb cemetery: 5 km SW from Argos and 8 km NW from Lerna	Not in the vicinity of any M-highway	Tholos tomb: LH IIB-LH IIIA1 Chamber tomb cemetery: LHI-LH IIIB

*Table 4: The five chamber tomb cemeteries and their associated tholoi in the Argolid. Dates according to Pelon 1976; 1990. Kokla date: according to Demakopoulou 1990.**

4.3. Roads in the economic and military landscapes

Müller's (1930, 178–79) mention of Plesia clay mortar, used at the Tiryns citadel, suggests its transport from Mycenae along M4 to Tiryns since Varti-Matarangas *et al.* (2002) did not find a source locally. Jansen (1997, 11; 2002, 17–18, 131) and Wace (*et al.* 1953, 17–18) mention roads giving access to the Plesia clay pits along M4, and the quarries of Profitis Ilias and Asprochoma. Experimental work by Mundell (2009, 82–91) and Mundell *et al.* (2009, 205) have indicated that minimally 21% of a well-constructed limestone-based drystone wall can be accounted for as voidage. If we were to consider a minimum of 20% voidage for each wall surface constructed Cyclopean style – solid, strong, with tight joints, including small in-fill stones but still with gaps – a large volume of Plesia clay, used as a lubricant and gap filler (Evely 1993, 210, n. 41), would require transportation. Stones for building had to be moved (see 4.1.1.). Pollen evidence (e.g., Jahns 1993) suggests that also timber was in heavy use in the LBA, in monumental construction activities. Finally, entire ship cargoes with raw materials, agricultural produce (Jansen 1997; 2002 on M1–M3), and crafted goods must have made it across the Argive Plain arriving and leaving from Tiryns, Mycenae, Midea, Argos, the Berbati valley, various locales towards the Corinthia, and other areas of production and consumption. Agricultural produce came from the valleys to the north of Mycenae (Stefani, Kephalari, Tenea and Kleonai) and to its east (Berbati). Donkeys carrying storage jars were depicted in Phaistos (Jansen 2002, 129), and oxen were used in agricultural work and transport, as documented in the Linear B tablets (tablet PY Ch 897: Chadwick 1987, 38, figure 19; see also section 4.4.). Indirect evidence of HGVs in agriculture includes the need for oxen as draught and plough animals (Lavery 1990; Cavanagh – Mee 1999; Brysbaert 2013). The EH II baked clay model of oxen from Tzoungiza (Pullen 1992) illustrate bovid use early on.

Additional military usage could justify the efforts in building the M-highways but direct evidence for this is scarce (Crouwel 1981, 79; Jansen 2002, 53m n. 66; Tausand 2006, 199). Indirect evidence comes via iconography and Linear B documents mainly from Knossos and Pylos (Crouwel 1981, 30–31). Drews (1993, 82) sees offensive warfare tactics taking place, the chariots being driven by elite archers. This is doubted by Dickinson (1999, 22). Linear B refers both to chariot wheels and parts, and to place names associated with chariots (e.g., Amnissos on Crete), indicating that their use extended beyond the

palaces and citadels. Schallin (1996) discusses some architectural remains along M1 as possible lookout-posts due to their prime location. We can confirm that the view from several places along M1 is excellent, especially along the stone-built stretch that covered the entire Berbati valley. Finally, Wace *et al.* (1953, 4–5, nbrs 12–13, figure 1), mention a road, possibly running from the House of the Oil Merchant towards the Lion Gate, but not following the modern road. It may have run in front of the dromoi of both Clytemnestra and Aigisthos tholoi and then zigzagged up to the citadel using the Mycenaean terrace walls (see Mylonas 1959). As the road ran immediately below the west side of the Gate, prior to the construction of the Lion Gate, it would have been perfectly located and could be used for look-out and defence purposes.

4.4. Roads and the Linear B evidence

Table 5 contains all the known tablets from Tiryns on landownership and oxen. Tablets from Pylos, Knossos and Thebes were selectively chosen for the potential parallels in the Argolid, since large tracts of land and oxen were likely assigned to specific (elite) people. However, regional differences between the Mycenaean polities certainly existed: the Argolid being a special case, as the different palatial centres likely recorded only what was of exclusive interest to them. The tablets from Pylos, Knossos and Thebes, therefore, can only be understood fully within their own context. Any comparison made to the situation in the Argolid, where substantial tablet information is lacking, needs to be treated with caution.

It is unclear who owned which parcel of land in the region of the Argive Plain where three citadels were located. For the Pylian state, land seemed to have been held by religious personnel, by the *dāmos*, as well as by the palace, whose tablets recorded limited details of the land in its kingdom (Carlier 1987, 72). It is even possible that all land was in the hands of the *dāmoi* (Bennet 2013, 247) since they leased it out. Such a scenario may not have worked for the Argive Plain and its surroundings. Similar conclusions were reached for bronze workers and the distribution of bronze in the different Mycenaean regions (Palaima 1989, 94–95; but see Blackwell 2018). What these tablets indirectly illustrate is the need for intense circulation of goods and services (wheels, wheel parts, TI SI) in an environment in which the economy is based on agriculture (TI Ef 2, Ef 3). People, animals and materials travelled and moved (PY Ch series; PY Cn

418a) for different work-related purposes, especially for agriculture (PY An 830, 907a; KN C 902; KN Ce 59), construction (PY An 35, An 18a?; PY Fn 7; PY Vn 46&879), crafts (PY An 1282; KN Sc 223), palatial monitoring and control (PY Nn 831; PY An 656), and taxation (PY An 1). Among the elite, several people, performing various roles, imply an individual's need for travel and movement of their goods and livestock (PY Un 267). Oxen may have been used for the transport of building materials (PY An 852a) and the palace, who owned many, kept them in good health (PY Aq 64). Bovines and ass, as transport aids, also appear on festive menus (Dabney *et al.* 2004). Sacrificial animals sometimes travelled (over 50 km) to their final destination, as did the 'international' collectors who prepared the feasts (Palaima 2004, 226, n. 61). There was a clear level of military presence connected to the palatial sphere for (at least some of) its influence, such as the reuse of bronze, implying weapon production and use (e.g., PY Jn 829), and in the control of military manpower (PY Cn 418a). Chariots certainly were used on the roads when traveling from place to place (KN Sc 223). Finally, many remunerations were recorded, consisting of both agricultural produce that had to be collected and delivered (TH Fq 247; PY Un 1322), as well as land plots that were accessed by third parties (PY En/Eo series; PY Na series).

Tablet name	**Topic**	**Description**	**Comments**	**Main refs**
TIRYNS				
TI Cb 4		Oxen (with names?)	Named = palatial	Godart - Olivier 1975, 51–52 Kajava 2011; 2012
TI Ef 2	*qo-u-ko-ro* – GRA 6	Oxherd x large landholding. Land amount in relation to amount of grain to sow	Possibly part of large and survey, see PY Ea & Eb series	Palaima 1989, 98 Shelmerdine 2008, 148 Foster 1981, 105
TI Ef 3	*ke-ke-me-no*	Communal land	Possibly part of large and survey, see PY Ea & Eb series	Godart - Olivier 1975 Foster 1981, 105

TI S1 8–10		Wheels but not with spokes	From carts?	Godart - Olivier 1975
PYLOS				
PY Ch series		Palatial oxen loans to *dāmos*	to be kept in good condition	
PY Ep/Eb series	*ke-ke-me-na ko-to-no-o-ko*	Land administered & owned by *dāmos* through it council		Lupack 2008
PY En/Eo series	*ki-ti-me-na*	Land associated with *dāmos* and granted to local elites (te-re-ta)		Lupack 2008
PY Na series		Military service people with landholdings. Some landholders own oxen, provide workers to palace		Nakassis 2012, 269–72
PY An 1		Taxation through rowing service, rowers connected to land holdings		Nakassis 2012, 269–72
PY An 18a	*te-ko-to-na-pe to-ko-do-mo*	90 oxherds associated with carpenters, wall builders, service men	Oxen used to transport timber and stone?	Palaima 1989, 100, 115–18
PY An 35	*to-ko-do-mo*	Building work in both provinces	Builders traveled, being attracted as skilled workers	Duhoux 2008, 296–98

PY An 656	*o-ka* tablet	*di-wi-je-u*'s seat of authority near the bay of Navarino	Same person is inspector on PY Cn 3 tablet, highly mobile	Palaima 1989, 114–16
PY An 830 + 907a	*ko-re-te-re ke-ke-me-no*	Oxherds and ox pasturers (*qo-qo-ta*) of the *dāmos* that own communal land	Oxherds located in 3 regions	Palaima 1989, 100
PY An 852a		oxherds associated with carpenters	Oxen used to transport timber?	Palaima 1989, 115–18
PY An 1282		Men brought in to make chariots	Administrators, skilled and unskilled labour from various locations	Schon 2007, 136
PY Aq 64	*a-qi-zo-we*	Fodder given by palace to landholders who borrowed oxen	Palatial measure to keep oxen in good health	Halstead 1999; 2001, 40 Killen 1992–1993 Nakassis 2013, 209–10
PY Cn 3a	*jo-i-je-si di-wi-je-u*	Men with military association (*o-ka* tablets) sent/offered oxen to inspector *di-wi-je-u*	If sent, distant movement is implied along a main route in Messenia	Palaima 1989, 104, 114, 116–17
PY Cn 418a	*a-ko-ro-we-e we-da-ne-u*	Fattened oxen *we-da-ne-u* as important lifestock manager located in 7 places, controls military manpower	Needed extra fodder in hard working periods	Palaima 1989, 104–05, 114
PY Ea 781a		Single landplot owned by oxherd		Palaima 1989

PY Ea 270a, 305a, 757a, 802a	*ke-ke-me-no*	Landholdings possessed by ox pasturers		Palaima 1989
PY Fn 7 (An 7 + Fn 1427)	*to-ko-do-mo* *pi-re-e-te-re/si* *pa-te-ko-to*	Builders and sawyers with food rations Carpenter of all work		Melena 1998; Nakassis 2012, 275
PY Nn 831	*po-me-ne* *qu-o-ko-ro*	Oxherd as landholder and with supervisory status, other supervisory artisans as landholders	Landholders pay tax in flax on flax-growing land	Palaima 1989, 101–04 Foster 1981, 106–07, 121
PY Un 267	*a-ko-so-ta*	Pylian collector, land inspector (PY Eq 213), controls raw materials, distributes male workers (PY An 435)? Owned large flocks spread over both provinces	Involvement with Pylos administration in planning, monitoring, controlling & distributing involves mobility	Nightingale 2008, 576–86 Nakassis 2912, 279 Nakassis 2013, 200, 233–34
PY Un 718, Er 312	*te-re-ta*	Elites provided service in return to own/manage allocated plots	Service possibly of military nature	Lupack 2008, 44–85, esp. 69–72
PY Un 1322		Large food rations as salary for weavers, net makers	Part-time in palatial service	Chadwick 1964, 20–21, 25
PY Vn 46 & 879	building materials	Repair on megaron	Materials needed moving	Baumbach 1972, 385

KNOSSOS				
KN Ce 59	*we-ka-ta(-e)*	'working' oxen with names	In pairs for the work, neutered Named oxen likely palatial	Palaima 1989, 89, 91 Killen 1992-1993, 101 n. 2, 102
KN C 902	*ko-re-te-re*	Oxherds associated with ko-re-te-re and fodder rations Ko-re-te-re associated with sacrificial bull	Pylian kingdom with spread of oxherds over minimum five locations	Palaima 1989, 100
KN L 480	*qo-u-qo-ta*	Ox pasturers		
KN Sc 223		Bronze used for chariot assemblies	Chariots on roads	Palaima 1989, 93
KN Sd 4401 & Sf 4428	*ke-ra-ja-pi*	Chariot making involving horn fittings	Horns possibly of bovines?	Palaima 1989, 88
THEBES				
TH Fq 247	*te-ka-ta-si*	Carpenters	Receiving wine and wheat rations	Montecchi 2011, 171–72, 182, 184

Table 5: Linear B tablet data from Tiryns, Pylos, Knossos and Thebes on oxen, chariots, weapon production, food rations, and other agricultural produce and activities that individually or combined refer directly or indirectly to transport and movement via roads (full details in Palaima 1989; see also Brysbaert 2013, 61–71).

5. Discussion: interactive spheres of life

Due to the suggested functions (often contradictory) of the M-highways and roads, their trajectories, issues of chronology, and their need for maintenance,

as presented in the scattered literature and summarized in section 2, discussion of these factors is given below. It is given in light of our own findings, our explorative walks and the Linear B evidence. The often cross-crafting processes and interactive practices that were played-out in the landscape of the Argive Plain have been reflected by 'dots on the rural map' (after Cherry 2003, 147–48). They are meant to narrate the richness of people's itinerant stories from within an equally varied ecological and cultural landscape. Chronology is a crucial issue as it is linked to all other matters. Next, we discuss the link between tomb orientation and road access, the road trajectories, their use, functions, and finally, but briefly, the use of LCPs in studying these M-highways and m-roads.

5.1. Chronology of road construction

Without proper excavations, further hampered by their state of preservation, it is impossible to determine a very precise chronology for the M-highways and the m-roads, but not all is lost. Considering the cross-craft association between agricultural expansive activities such as terracing and road building it is unlikely that all m-roads and M-highways were built in one go through a central palatial power in LH III. Instead, we believe that road construction formed a gradual process of roads-and-farming development, one growing next to the other. This culminated in a sudden monumentalization of existing roads into M-highways from LH IIIA2/IIIB1 onwards and into LH IIIB. Jansen (2002, 131) postulates that this gradual process of road construction had possibly started in the late MH shaft grave period, just as Mycenae started to profile itself as an important power. As a result, the use of m-roads may have become more frequent. Interestingly, this also coincides with the construction of the first larger tholoi towards the end of this period. The monumental M-highways were constructed during Mycenae's largest expansion period (LH IIIA) (Schallin 1996; Hope Simpson – Hagel 2006, 149) or in the decades thereafter. It is likely that at around the same time many terrace constructions were established to enlarge land use capacity. Kvapil (2012) and Fallu (2017) could not date the terrace constructions at Korphos–Kalamianos and Mycenae, respectively, closer than LBA or LH IIIB. We cannot be sure, therefore, what came first and how the M-highways and the terraces are linked. In any case, the m-roads that were cut/formed in the steep hill sides, may have needed retainers and well-packed threads along part of their trajectories

suggesting that the technique of cut-and-terrace may have existed prior to the M-highways. Sitjes (2016) showed clearly that techniques of road construction were likely based on terrace construction and usage. Early terraces are known from LM I Crete at Gournia (Watrous 2012). Finally, Pikoulas warns us (2007, 80) that simple footpaths and pack animal pathways were always formed in the same way and, as such, do not permit secure dating, all-the-more, as they remained in use for centuries, or even longer.

5.2. Links between tombs and road access

Numerous studies conducted at Mycenae have focused on exploring the orientation of the tombs in relation to the landscape. The consensus reached is that the topography, especially the natural contours of the landscape, the easy access to resources from nearby quarries, and water dictated the location of the cemeteries as well as the orientation of the dromos (Mee – Cavanagh 1990; Maravelia 2002; Mason 2007; Georgiadou and Gallou 2008). It is worth noting that the Genii tholos tomb has a larger inclination to avoid cutting into the ancient road that passed nearby. Mason (2007) elaborates extensively on the location and orientation of the Treasury of Atreus. The site was chosen specifically to constitute an "eye-catching" landmark, a costly signal, visible across much of the land surrounding Mycenae. It was probably not coincidental that it also sat close to both M4 and M7.

As indicated in Tables 2 and 4, and section 4.1.3., most of the tholoi *along with their associated chamber tomb cemeteries* appear to be close to one of the M-highways or m-roads. Tomb construction and site visits happened all year round so access had to be free of obstacles which implies road maintenance. On this basis, we hypothesize that at least m-roads were constructed leading to places such as tombs as soon as the need required. This would also facilitate the tombs' prolonged use throughout the LH period. Turner (2020, 78–79) came to the same practical conclusion for the Mycenaean chamber tomb cemeteries in Achaia. Equally, when the M-highways were planned in the landscape, community leaders may have spotted a good opportunity to signal their status along the roadside by letting the M-highways pass as near to the tholoi as practically possible. This would also conveniently facilitate processional access to these monuments by large crowds.

The chamber tomb cemeteries around Mycenae often consisted of numerous unaligned tombs, spread out along the hillsides; these were grouped in clusters (Tsountas 1888, 123, figure 1; French 2002, fig. 25). Tsountas was the first to observe the relationship between the cemeteries and routes to them, a theory opposed by Mee – Cavanagh (1990, 228). The latter pointed out that, with few exceptions, none of the major cemeteries around Mycenae appear to be in the vicinity of any of the main Mycenaean routes. They suggest that the clusters of tombs might have been created due to the formation of small-scale political alliances, an opinion we do not reject. They conclude that the Atreus Treasury was built in a significant position, as well as the Prosymna tholos, probably reflecting the important social status of their owners. The Atreus Treasury is situated at an eye-catching location in the vicinity of M4 leading to Mycenae from the south, but also visible from the north-eastern part of the settlement along M1 and M2 (Mason 2007). The literature, along with our own observations highlight that there was indeed a clear relation between the initial use of smaller roads which, when needed, were later widened and monumentalised. This was to facilitate easy access for new constructions but also to impress potential passers-by.

5.3. Trajectories

In addition to the four known M-highways, we support Lavery (1995) who recognised m5, M6, M7 and M8 as such, contra to Jansen's view (1997, 9, n.32). These additional trajectories can be substantiated since they ran near to or connected several places of importance. As mentioned, m5 connected with M1 close to the Berbati tholos tomb and ran, via the Mastos settlement in the Berbati valley to Tiryns via the Dendra cemetery and tholos and the citadel of Midea. As such, it could have provided a direct line of transport for Mycenaean pottery from Berbati to Tiryns for the export to c. 350 east Mediterranean destinations during LH IIIA1–LH IIIB, without the need to pass through Mycenae. Cyprus and the Levant saw a sharp rise of Mycenaean imports from LH IIIA2 onwards (van Wijngaarden 2002, 13–21). This was perhaps facilitated by secure transport links along the highways within military-protected cargoes.

Highway M6 from Mycenae to Aidonia showed clear evidence of the importance of the latter LH settlement (the Bronze Age site Ai2, Hachtmann 2015, 405–6, fig. 2). As the builders of the large chamber tomb cemetery, they

were receivers of imports such as Aiginitan and Kean pottery and andesite millstones, not to speak of the imported wealth in the tombs. Earlier roots of the site date to the MH (Hachtmann 2015, 405–7). The Bronze Age site Ai2 also shows evidence of ramps, terraces, Cyclopean-style fortifications, and roads. All are hard to date but the latter two cannot be later than LH III since the settlement sees a sudden end and abandonment in LH IIIA2, even before the cemetery fell out of use (Hachtmann 2015, esp. 412). It seems then that building M6 was Mycenae's strategy to stop Aidonia competing in the region, and so take control.

Highway M7 ran past a large mansion with substantial storage capacity close to the citadel of Mycenae, at Chania (Palaiologou 2014; 2015), and at least one multi-tonne conglomerate lintel block[8] has been found in the Mycenaean levels of the Larissa at Argos (Crouwel 2008, 267–68). Conglomerate does not exist near Argos and needed to be brought 290 m uphill. Highway M8 connected Mycenae to Phichtia which had a Mycenaean settlement and chamber tombs (Wace 1949).

5.4. Usage and functions

5.4.1. Agricultural

Illustrated by Figure 3, one necessity for building highways from LH IIIA onwards seems to have derived from the need for Mycenae to tie local farming communities economically and politically closer to palatial control because of the importance of their fertile lands (Jansen 2002, 60). The M1 and M3 highways were constructed leading towards the regions of Stefani and the Kephalari valley (Lavery 1995; Jansen 2002, 133–34), perhaps even connecting Korphos–Kalamianos. This allowed agricultural produce on farm vehicles, pedestrians, animals and other cargoes to travel between fields, citadels and settlements. Oxen owned by the palace were hired for use by non-palatial members of society. Landholders, who could not afford oxen, could borrow from those who could, and share them to plough and collect the harvest, at their own risk (Halstead 1995, 17). The movement of oxen between plots and the collected harvest suggests sturdy, wide roads enough to let a yoked pair pass (c. 1.5–2 m wide, with oxen, excluding cargo). The extent of the M-highways from LH IIIA onwards, indicate the growing opportunistic regional power boundary shift of Mycenae, showing the potential for extending further (Jansen 2002, 130).

[8] Lintel block dimensions: (0.85 × 0.85 × 3.85) × 2,400 as mass of conglomerate = 6,676 tonne in total.

However, we agree with Fotiadis (2011, 282), Dickinson (2003, 245–46) and Hope Simpson – Hagel (2006, 146) that the investment and level of engineering works required for these highways is excessive simply to collect the harvest, especially as this had originally been achieved using smaller roads and since no such roads are known from Boeotia. Boeotia was also a large central node with great engineering works. Dickinson postulates that Boeotian wealth must have been based on agricultural surplus control (with the well-drained Kopais basin as the major region), as was the case with Mycenae. We are also not convinced that all fields, including the terraces which are suggestive of the intensification of cultivation in LH IIIB (Halstead 1992; Kvapil 2012; Fallu 2017), were all served by these M-highways, as the M-highways appear to have been constructed after the terraces. As already stated, harvesting was undertaken long before any M-highway had been constructed. We do not deny that from LH IIIA onwards (Lavery 1990; Schallin 1996) these roads will have facilitated such transports from fields in close proximity. However, as M-highways tended to follow a specific contour to keep the road gradient as low as 2–3% (Brysbaert in press-b), terraced fields could only be partially served. Many farmers would have had to transport their harvest up or down to the highways in carts, via smaller roads and pack animals. That seems a lot of extra effort for no additional benefit.

5.4.2. Military

Crouwel (1981, 150) and Jansen (1997) express the military usage for the M-highways, whilst linking them with other purposes and vehicle types. They maintain that foot traffic would have used the more direct m-roads (see also Lavery 1995). At first, Jansen (1997, 7–8; 2002, 108–09, 128) sees chariot use predominantly for elite display. Later Jansen (2002, 110, 132) contradicts himself by referring to the *o–ka* tablets (Ventris – Chadwick 1973, 188–93) which mention chariots and followers in units of coastguards enlisting up to 800 men. This then confirms the military use of chariots (Krigas 1987, 78–79; but see Dickinson 1999, 25). Tausand (2006, 199) uses the width of the M-highways and the wheel ruts to argue for chariot use but gives no references for the figures. Jansen (2002, 53, n. 66) refers to wheel ruts of c. 1 m in Boeotia. Crouwel (1981, 79) relates the axle length to the width of M-highways, and that the chariot axles were made of wood. Crouwel (1981, 145, 150) mentions both military and civil uses for chariots: hunting, processions (religious/funerary) and racing.

Knauss (1996) assigns both economic reasons (transport of food stuffs), and defence (allowing mobilization of troops, equipment, controlling access at strategic locations) for M-highway construction. He also suggests that certain bridges may have acted as water dams (e.g., Chavos bridge: Knauss 1996, 9). Lavery (1990, 166–69) called Mycenae the western point of the 'golden triangle', a series of fertile upland plateaus now dominated by the modern town of Stefani with the Trikorpho ridge to the northwest, and a long running mountain range (c. 800–1000 masl) between Aghios Vasilios and Agionori to the northeast. These mountains formed a 'boundary fortification' that was easily controlled against potential raiders. They protected the fertile rich plateaus below (Figure 6). We suggest that around harvest time, such places could have been further protected with the addition of control measures and patrols provided by the Mycenaean administration. This would deter food thieves, and guarantee transportation of goods to the citadel.

On the one hand, the theory that military requirements did not play a *major* role in the development of M-highways might explain the lack of evidence for more M-highways leading to the south of Mycenae, towards Tiryns and Midea/Nauplio. By c. 1400 BCE both were likely to be under Mycenae's rule. These would perhaps only require roads to accommodate communication, transport of stone, timber and other resources, and the trade of goods.

On the other hand, in a region modified over time by agricultural activities, especially in the low-lying parts of the Argive Plain, Mycenaean roads of any type would be very hard to trace. The argument can be turned around: Tiryns was so important to Mycenae, as its harbour gave access for goods from both near and far (on its exotica: Rahmstorf 2008), one would expect the roads to be guarded ensuring the precious cargoes would arrive at Mycenae safely. The *o–ka* tablets from Pylos are a reminder of such coastal protection, whether this was purely military – in expectation of invading troops or to protect incoming cargoes, maybe both. The second half of the 13th c. BCE *was* a troubled period (e.g., access to water and artisanal quarters secured within citadel walls, the need to enlarge fortification walls to include archery shooting holes and embrasures, Maran 2010, 728), so excluding military usage of M-highways or any road is not justifiable.

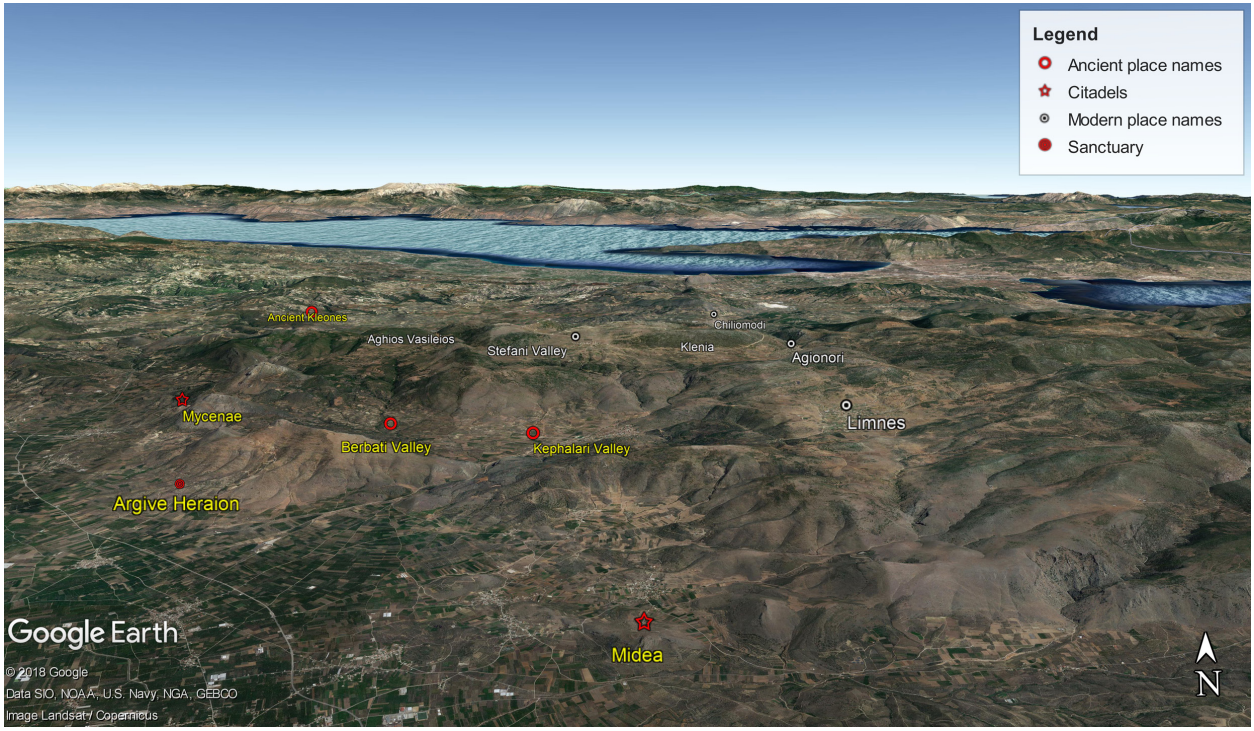

Figure 6: Google earth 3D view of the topography in the region of Mycenae towards the regions it likely accessed for agricultural produce and crafted goods.

5.4.3. Crafts

The Linear B tablets suggest that artisans were recruited from their home villages by the Pylian palace to produce prestige items (Voutsaki 2001), implying the use of existing travel infrastructure (Table 5). Both palatial and religious 'collectors', but also the local elite and owners of substantial resources (labour, food resources and building materials), were using the roads to generate their income. Local transactions with the *dāmos* (Lupack 2008, 165) and contact with the palatial administration over the latter, ensured that access to these resources could be maintained. Raw flax fibre was collected in many smaller villages, rather than from district centres (Foster 1981, 68).

The tablets suggest that a food surplus was required by the Pylian palace to pay food rations for its artisans' personnel, as well as for military forces (*o–ka* troops, rowers), members of the administrative bureaucracy, and political and religious officials. Similar groups in the Argolid would need access to roads, but not necessarily only M-highways. Hiller (1988, 61) calculated that 4,000 people on the tablets depended on the Pylos central bureaucracy, of which one third were supported by direct food rations. The remainder supported themselves through assigned landholdings. Additional pressure on the road network was created by the need: (1) to exploit the forests for shipbuilding, chariots and building construction, the firing of pottery and metallurgy work; (2) for foraging land for livestock (wool, meat, hides); (3) to farm lowland for flax and cultivate vines, tree and field crops; (4) to build and extend settlements to house the increasing population during the LH IIIA–B (Palaima 1989, 112–13). Again, access to roads (of different types) was crucial in facilitating all these activities.

5.4.4. Construction

The connecting places using routes on an even contour, such as Mycenae and Tiryns suggest the use of HGVs. Before the LH IIIB expansion of the Tiryns citadel, roads such as m-roads and others were likely to have been used for the transport of boat cargoes arriving at Tiryns for Mycenae and beyond (Brysbaert 2021), and for return cargoes requiring shipping from Tiryns elsewhere (e.g., pictorial pottery: Sjöberg 2004, 139). It is possible that a section of the right arm of Lavery's older m5 (1990, 168; section 2.4.) was the forerunner of M4. But when required in LH IIIB, this arm was perhaps enhanced to allow the transport

of massive blocks from Mycenae to Tiryns (Brysbaert 2021) among other larger supplies (timber, clay).

The so-called 'duplications' (section 2.4., Hope Simpson 1981, 17), refer to the M-highways that duplicate the m-roads. 'Duplication' by itself is, to our understanding, enough evidence that these M-highways were constructed with wheeled HGVs in mind, and perhaps chariots, as well. Hope Simpson – Hagel (2006, 146) also believe that some of these may have run over flat plains with sufficiently raised road surfaces protected by kerbs. Mylonas (1966, 87) calls the duplicating M-highways a sign of great prosperity and strength of Mycenae. This can be doubted, considering their construction in the later part of the 13th c. BCE when Mycenae's power was already waning although we do question this date for all M-highways (see above). Hope Simpson (1981) explains that the duplicated roads would enhance the deployment of large numbers of troops when required. In a different context, Glatz – Plourde (2011, 62) sees the constant construction upgrading as a potential sign for the socio-political and economic troubles ahead. Seen in such light, 'duplications' could be construed as the elite's signal to assert themselves and reaffirm their dominant role in material expressions, especially in view of the events around 1200 BCE. Also, their use as 'one-way roads' is a valid point which is supported in this paper as HGVs would not have been able to pass each other with a maximum road width of only 2.50 m. This is supported by Pikoulas' work (2007, 82) on later cartwheel road tracks. We do not believe that the M-highways were duplicates of smaller roads (section 2.4.). Instead, M-highways replaced earlier m-roads to allow access for HGVs, since these required shallow gradients and roads durable enough to limit wear and erosion. Smaller roads led to most of the cemeteries many of which were in use by LH I–II (Iakovidis *et al.* 2003).

Vicinity to water was crucial and appears to play a double role in the region: cleansing rituals (Georgiadis – Gallou 2008) in the case of the cemeteries, and that of serving the daily needs of the community at the settlements. It would, therefore, be logical to suggest that roads would serve the settlements and provide easy access to cemeteries for the re-use of tombs, and to perform ceremonies in which water was a need. Chamber tomb cemeteries were in use until the LH III B–C period. Many chamber tomb cemeteries were in use before the tholoi were constructed. Construction of the tholoi demanded a wide and easily accessible road to transport the large stones at least for the stomion area (Table 3). The likely

presence of a forerunner of M7 between the Panagia and Kalkani ridges (see also Lavery 1995, map 1), running west of the Atreus Treasury, could have served the Epano Fournos and Panagitsa tholos tombs. The Kato Fournos, Genii and Cyclopean tombs were likely served by a forerunner of M3W. Such needs will not have led *directly* to the construction of all M-highways but perhaps to the initial widening of existing roads. Moreover, paths and roads leading to cemeteries would have been maintained because of regular access to the tholoi during and after the Bronze Age. These suggestions are supported by the fact that the five tholoi, which are not in the immediate vicinity of Mycenae's citadel, lie close to one of the roads connecting them to conglomerate resources (of the Kalkani and Panagia ridges). Some appear to have been in use up until the Hellenistic period (see Table 2, Figure 4). Both the literature and our own observations relating to the location for all tholoi, confirms Tsountas' (1888, 123–24) initial observation that they lie close to a road, albeit perhaps not an M-highway, based on their date of construction.

5.4.5. Multiple uses

The multiple use of most of the M-highways and many of the smaller roads can be asserted given that many different spheres of life (and death) were connected by them; it appears that no road was constructed just for a single use. A similar conclusion was reached by Fachard and Pirisino (2015, 139–41) in their study of the roads within Attica. *If* the M-highway use was mainly agricultural we wonder why then more of them were not constructed to and from Tiryns, especially after 1200 BCE when population substantially increased – or at least nucleated – there. At the same time, several of the day-to-day spheres of life cross over, either regularly or on occasion. For example, the area of Grave Circle A at Mycenae, a former burial ground, was venerated in later periods by the opportunistic elite who embedded the Grave Circle, both symbolically and physically, in their daily life. In doing so they built on the power of ancestry to claim their land. They built a stronghold there and physically enclosed the Circle within the fortification wall during the second half of the 13th century BCE. Ceremonial visits to Grave Circle A will have been carried out on specific occasions, with limited access given to the citadel itself for the select few. As today, roads can temporarily and partially be closed off for special events (e.g., the visit of an important political leader, road repairs, demonstrations). Control (or the lack thereof) of closing and reopening

the roads would then lie, most often, in the hands of authorities, but may also fall to the hands of the people themselves.

Lavery (1995, 265) postulated that the M-highways M1–M3 serviced the landlocked but rich agricultural plains of Phlious, Kleonai, Tenea and Berbati providing access to the sea (at Tiryns, M4) and their markets. All but M4 passed through the storage mansions of Mycenae so he suggested a confederacy of Mycenae (as a clearing house) and Tiryns (as harbour outlet) from perhaps late MH III onwards (similarly by Darcque – Rougemont 2015, 567; also Sjöberg 2004), may be even earlier. We agree with this suggestion as soon afterwards a surge of monumentalization started, which culminated in the construction of tholoi and citadel walls, and the widening and strengthening of existing roads to carry HGVs. This progressed through LH III (e.g., Lavery on M2). Moreover, it also indicates that the roads were not intended *just* to serve Mycenae. This may well have been the major purpose, but they also *connected several other important places*, whether via Mycenae or not. These notions make clear that previous studies over–emphasize the importance of Mycenae at the expense of the surrounding region.

5.5. The use and meaning of LCPS

Least Cost Paths (LCPs) indicate the most cost-effective route to traverse a landscape between two points. Recreating the Mycenaean road network based only on LCPs demonstrates in most cases a clear deviation between the LCP and the ground-truthed trajectories (Figure 7, Table 6). The LCPs deviations usually indicate substantially shorter distances than the ground-truthed trajectories. They did not take important architectural remains such as bridges and tholoi into account or height deviations. Moreover, LCPs do not consider intervisible locales. Despite these observations LCPs should still be used when studying archaeological remains of ancient road networks as, even though least-cost was not the main drive for the routing of M-highways, they can still suggest useful trajectories (Table 6). As Fachard and Pirisino observed (2015, 141) LCPs often indicated alternative (perhaps longer) roads (in distance) that were accessible by foot providing speedy travel (in time), and traversable using pack animals carrying small loads. During such travel topographical variety was less a hinder than it would be for larger cargoes. In the case of M2 the generated LCP followed

the route of the actual M2 at the start before it joined M1 and M3. However, routes M1 and M3 clearly demonstrate that the Mycenaeans also followed alternative routes to reach Corinth. They invested greatly in infrastructure to make these routes safe and easy to traverse (see the M1 with its numerous culverts and two bridges and the M3 bridges: Steffen 1884).

The human ability to manipulate the landscape to suit their travelling needs and to demonstrate power and status, should not be underestimated either. An excellent example is provided by the M4 which, according the LCPA should have ran straight to Tiryns from Mycenae, along the flat land of the Argive plain (Brysbaert 2021). However, the architectural remains (e.g., Prosymna Tholos and the Aghios Georgios bridge), suggest otherwise. This trajectory, along the later Argive Heraion, offered the traveller both the opportunity to admire the largest tholos in the Argolid after leaving Mycenae (Hope Simpson – Dickinson 1979) and to pass by the settlement (Hope Simpson – Dickinson 1979). Equally, funerary processions leading to any tomb would defy the LCPs as other, more social factors, drive these routes (Boyd 2016, 66–67). Efkleidou (2019) came to similar conclusions when testing her LCPs for Mycenae itself.

Least Cost Path	**Starting Point**	**Ending Point**	**LCP Distance**	**Real Distance**
M1	Mycenae	Corinth	30.384	40.378
M2	Mycenae	Corinth	23.466	39.951
M3	Mycenae	Corinth	28.964	37.492 (excluding M3W)
M4	Mycenae	Tiryns	15.353	22.959
M5	Berbati Tholos	Tiryns	14.123	17.689
M6	Argive Heraion	Aidonia	25.151	28.853
M7	Mycenae	Larisa Argos	11.147	13.760
M8	Mycenae	Phictia	3.065	3.890

Table 6: Full distances covered by real trajectories (including overlaps) and their correlated LCPs.

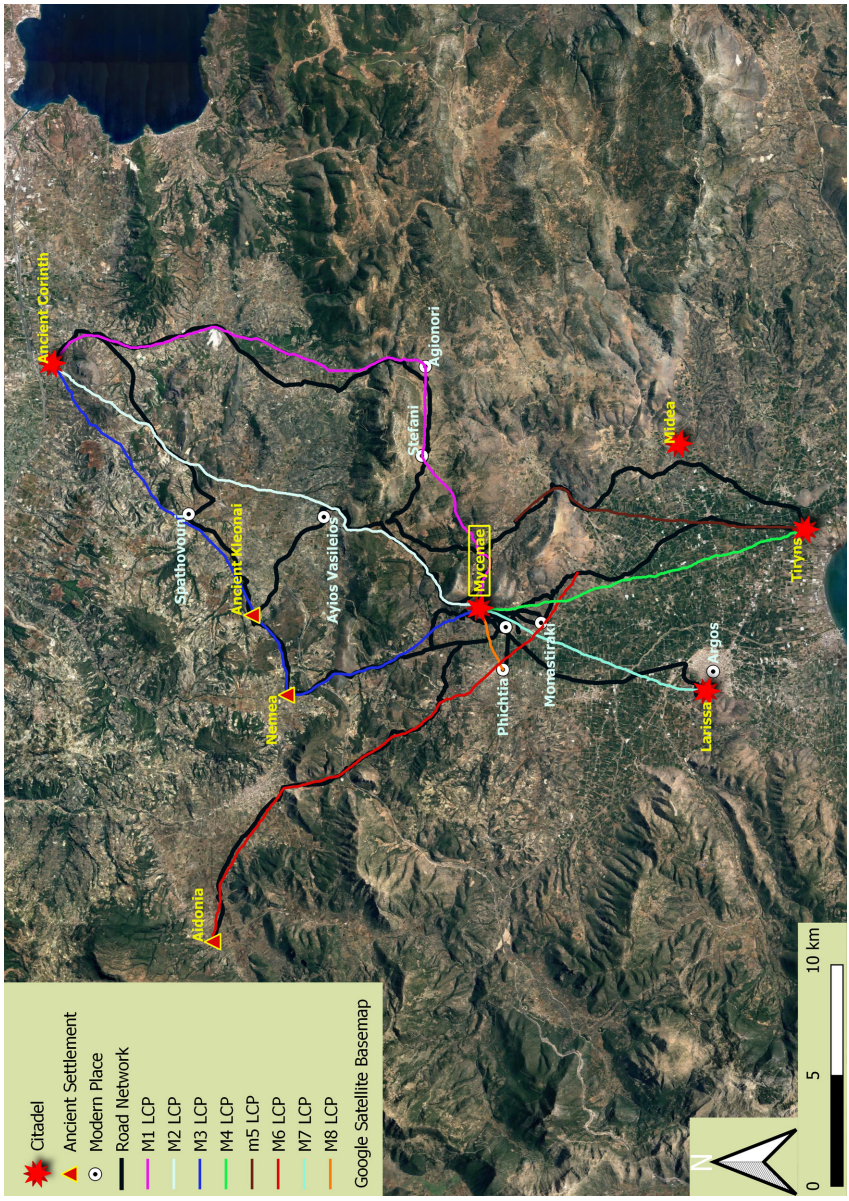

Figure 7: Mycenaean road network (black) with superimposed LCPs (colour-coded).

6. Conclusions

The combination of road construction, developing agricultural terracing, and transporting building materials and agricultural goods from cultivated fields to the consumer seems clear for economically productive and fertile regions known around Mycenae and beyond. It has also been testified in other contexts such as at Choiromandres on Minoan Crete (Chryssoulaki *et al.* 1989). On this basis, Brysbaert (2013; in press-a) argued that farmers could temporarily support or be the builders when they could be spared from their agricultural activities. A farmer's skills, knowledge of terracing techniques and the skills in working efficiently with traction animals (ploughing) and perhaps also sledges (threshing) could easily cross over into the transportation of building blocks and large timbers through the landscape.

Constructed Mycenaean Highways	**Distance (km)**
M1	40.376
M2	17.940
M3	34.182
M3W	5.810
M4 (including extension of outcrops in Charvati)	25.122
m5	17.689
M6	21.856
M7	13.760
M8	2.688
Rho	0.920 (excluded from calculations)
Total constructed length	**179.423**

Table 7: Net length of Mycenaean constructed road network based on Iakovidis et al. (2003) and recorded points. Total length includes all alternative routes comprising the M4 at the height of Monastiraki and excludes substantial overlaps between M1-M2-M3, M3-M6, M4-M6, M4-M7, and M4-M8.

Remains of the Mycenaean M-highway network discussed here covers a combined length of approximately 175–180 km of constructed highways. This distance takes into account all possible routes but excludes overlaps that occur between M-highways (Table 7). Jansen (2002, 55–57) refers to the M1 remains not being traceable for more than a maximum of 4 km from the citadel or 2.5 hours walking time from Mycenae into the Kephalari valley. The three remaining M-highways to south and north, Jansen assigns 1.5 hours to walk their combined length. This way, he supports his 'circulation model' rather than a 'communication model' showing the sphere of Mycenaean influence that is inferred from the ancient road network remains (beyond the omnipresent dirt tracks and smaller roads). We believe that this is a rather limited view of the highway network since M4 from Mycenae to Tiryns alone covers more than 20 km. Moreover, a road which is only traceable in part is, therefore, not necessarily out of the Mycenaean sphere of influence, especially if important cargoes were transported (and guarded) along it. Protection of cargo shipments may also have taken place along M1, M2 and M3 which can be traced up to Nemea, Phlious and Tzoungiza, which likely still fell under Mycenaean influence. This influence, possibly since the Shaft Grave period (but see the graves at Aidonia), was of specific agricultural importance to Mycenae in LH II–III (Cherry – Davis 2001). In bringing this land under their control, Mycenae could also harness labour for their agricultural and building activities alike and signal this clearly.

Perhaps one thing can be agreed: roads wide enough for HGVs were constructed with effort and thus needed some form of organized labour dispatchment to achieve this *and* in subsequent maintenance requirements. A similar understanding of what it takes to keep roads 'open for use' are visible on Crete's hiking paths, even to this day (Brysbaert, personal observation and experience). Maintenance activities were also known in Roman times. When that ceased, in the fourth and fifth c. CE, roads gradually became inaccessible and fell into disrepair (Pikoulas 2007, 84). The large-scale landscape modelling required for construction projects and for the road network layout stopped around 1200 BCE. If Mycenae and the other elite powers in the region had counted on these costly activities signalling their political power in the region, through mobilization of their workforces, then that signal certainly waned and failed to be received as such by the population at that moment in time (after Glatz – Plourde 2011; Connolly 2017).

Based on Linear B information (Nakkasis 2012, Table 5, all with references; Brysbaert 2013; 2020), Krigas (1987, 75) referred to the cartwright of the Pylos palace who also owned a *o–na–ta* of land, and who was able to grow (at least in part) his own crops. Many of the tablets indicate that people, especially those employed by the palace, including artisans and sometimes even elite members, also had a life outside its walls, mostly as farmers, landowners, and land managers. This means that many people may have been using the roads, for different purposes depending on the seasonal demands over the year. Some of the trips people undertook along these roads will also have involved visits to family and friends elsewhere, and remembering the dead with visits to the cemetery. During uncertain times, several of the roads may have been patrolled to safeguard against incoming dangers. Finally, Argos was connected to Lerna (Mason 2007, 36, figure 1). Pritchett (1980, 140) found evidence of one road leading from Lerna towards Sparta crossing the Hellenikon mountains and a second one through Anthana and Neris (also Krigas 1987, 81). Travel to the north, for building materials and other necessities through the Corinthia and beyond, is now in evidence (Brysbaert in press-b). This shows that the local and regional road network and M-highways tied in with a much wider road/M-highways network system beyond the Mycenaean territories (contra Jansen 2002, 27, 132–35; and critiqued by Fotiadis 2011, 282). Such networks would have facilitated people travelling over long distances within and beyond the Peloponnese for a multitude of reasons.

Mycenaeans were clearly very mobile and their very existence, viability and survival strategies depended largely on their movement patterns. Free movement meant an economic means of survival, the supply of food, access to resources and work, development of skills and knowledge. It resulted in a higher tolerance during periods of strife, longer-term unstable conditions, and during times of conflict. For Classical Greece, Purcell (1990, 44) even noted that itinerants were very ubiquitous in the Greek world due to the relative scarcity of human resources in the Mediterranean world. This subject has not been explored in this paper but is doubtlessly important in the LBA period as the Amarna tablets (and to some extent the Linear B tablets) testify.

Freedom of movement by the Mycenaeans resulted in stability which led to the sustainability of their society as-a-whole. This was strongly influenced by the topographical variability. People from each of the micro-regions had to negotiate

their surroundings and understand how to 'traverse it' to capitalize on the opportunities available to them from their environment (Horden – Purcell 2000, 385). In some cases, as we have seen, easy access was not necessarily straightforward.

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Leiden University

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