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The Impact of Aqueduct Construction on Demographic Patterns in Crete

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In this paper the Roman aqueducts of Crete will be presented for the purpose of exploring the effects of aqueduct construction on settlement patterns on the island.¹ The study will demonstrate the diversity and the extent to which Roman aqueducts feature within the Cretan landscape and explore how the distribution density relates to the enhanced requirement for water supplies inherent in Roman society.

In the Hellenistic period Crete was home to innumerable small city-states, which were generally located on high ground in the hills in response to the almost incessant warfare on the island. Though many of these cities survived into the Roman period changes in site location, or at least *aspect*, are apparent, whereby the centres abandoned their hillside perches in favour of lower ground. It will be argued that these shifts of settlement focus are directly related to the construction of aqueduct supply systems in the Roman period.

The island of Crete is probably most famous for its Minoan palaces, notably that of Knossos excavated by Sir Arthur Evans at the turn of the 19th century. The palace represents the mythic home of King Minos and its fabled Labyrinth designed by the architect Daedalus. The ancient site sets the stage for the adventures of Theseus, ill-fated Ariadne, Pasiphae and Icarus and holds a certain romantic allure for both scholars and tourists alike. In contrast, the Roman period on Crete has generally been neglected and the presence of Roman remains at many famous Minoan centres has not always been appreciated. This is well illustrated by Sir Arthur Evans' complaints that the presence of a Roman cistern over the western court of the Minoan palace at Knossos could only be removed after 'a long process of blasting' (*fig. 1*).² Despite such former disregard, serious scholarship has finally focused on Roman Crete in recent years.³

It is argued here that Roman aqueducts on Crete are impressive in their own right, forming an eclectic group, notable in both their profusion and in the variety of structures which they supplied prompting my study of the Roman aqueducts and baths of Crete.⁴ They range throughout the

island in terms of type, length and construction style. They can be categorised into the somewhat overlapping classifications of public, private, religious, agricultural and commercial, being defined by virtue of the types of structures and sites which they fed. From the distribution map of Roman aqueducts on Crete it is apparent that their construction was an island-wide phenomenon (*fig. 2*).

A basic definition of an aqueduct is instrumental in elucidating their ubiquity on the island. A Roman aqueduct by definition taps a source and functions on the principle of constant hydraulic motion. As the water flow is reliant on gravity, the constant slope of the channel floor is fundamental to the overall design. The aqueducts of Crete generally functioned on unspectacular substructures and low-profile contour channels which descended gently along river valleys.

Taramelli's description of the geology of Crete demonstrates the suitability of the landscape for the widespread implementation of valley-contour aqueduct construction:

'... from the southeast declivities of the higher range of Ida (now called Nida by the Cretans) there spreads a copious ramification of valleys, all very steep and rich in springs, which, uniting together a little above the village of Courtes ... form a pretty abundant stream, which flows by Potamitis and Vori and falls not far from Dibaki into the gravelly and muddy malarious marshes



Fig. 1. The remains of a large Roman cistern just north of the Western Court of the Minoan palace.



Fig. 2. Distribution map of Roman aqueducts in Crete (digitised contours courtesy of Jennifer Moody, distributions by Amanda Kelly).

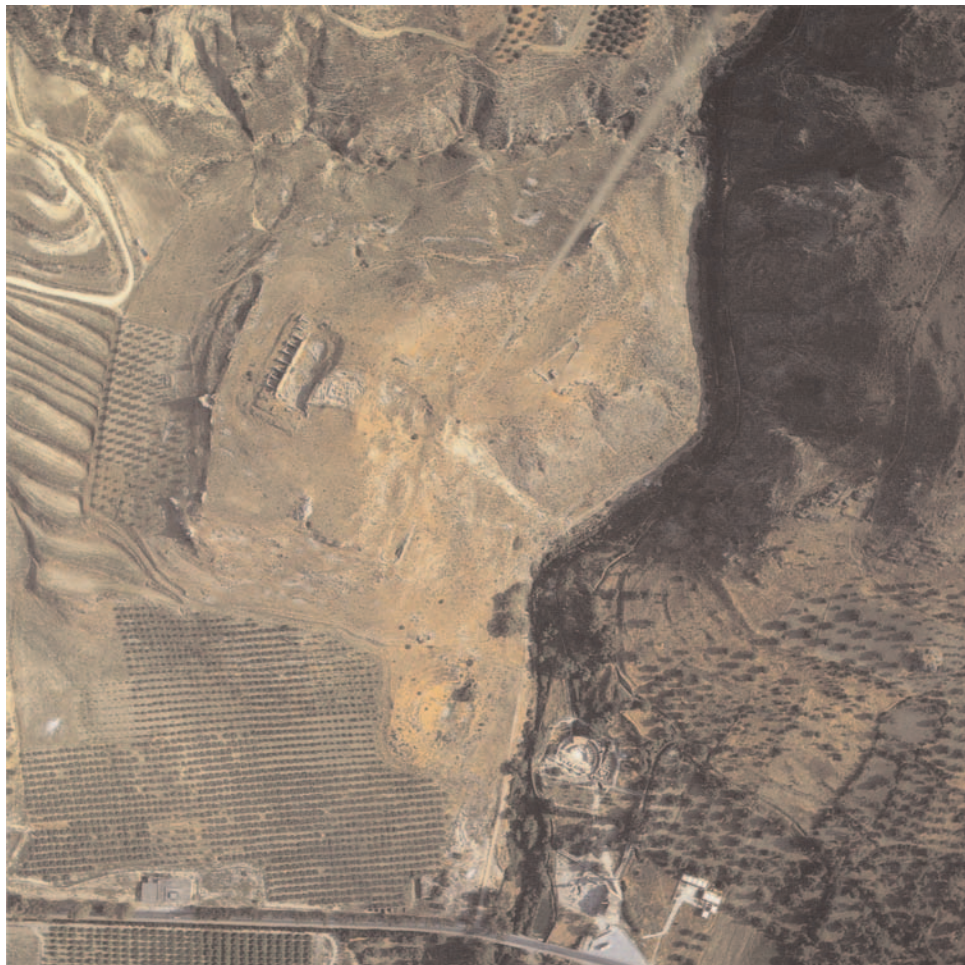


Fig. 3. Aerial view of the Mitropolianos River approaching the site of Roman Gortyna, the Odeion marks the point where the river enters the plain (courtesy of J.W. Myers, E.E. Myers and G. Cadogan, and University of California Press).

of the Geropotamos. The valley, which more than the others winds into the heart of the chain, cuts it most deeply, even to reaching the watershed of the island, is that which has for its chief town the smiling village of Zaro ... The salubrity of the place and also its relative wealth are due to the very remarkable abundance of water.⁵

These valleys are a common feature within Cretan topography and afforded swift, economic and widespread aqueduct construction throughout the island. Consequently, Roman cities on Crete were predominantly located, or relocated, near river mouths, where by virtue of their low-altitude they could benefit from a supply of water ensured by easy aqueduct construction along a valley contour.

POLYRHENNIA

A demographic movement from the inland acropolis city of Polyrhennia towards the coastal site of Kastelli Kissamou may be the result of such pragmatic considerations. Polyrhennia was a thriving city-state during the Hellenistic period yet fell into decline in Roman times when, in the early 2nd century AD, it was abandoned in favour of its port at Kastelli Kissamou.⁶ Indeed, the absence of a bathhouse (a key feature of Roman cities) at Polyrhennia attests to its demise, which coincided with the construction of multiple bathhouses at the coastal site. An aqueduct, tapping the springs at Polyrhennia, may have supplied the numerous bathhouses of Kastelli Kissamou and the conduction of the water would have been a major factor in the demographic flux towards the coastal site. It is likely that the attraction of the lower city (with its multiple bathhouses, fountains and sanitation) would draw inhabitants at the expense of the inconveniently-placed upper site.

GORTYNA

At Gortyna, the capital of the joint province of Crete and Cyrenaica, and also the largest site on the island, these dynamics are also detectable but perhaps more subtly so. In the Roman period, while the city essentially maintained the same location as before, the *aspect* of the site changed considerably. Prior to the Roman period the city spilled off its *acropoleis* to occupy the lower ground to the immediate south, but in the Roman period, the site expanded substantially over the plain as a direct result of its being watered by two aqueduct tracts (and possibly a third, as argued by La Torre⁷) which tapped the copious springs at Vota-

mos. This water was conducted down the intervening river valley in a pair of parallel conduits that flowed along the valley contours towards the city (*fig. 3*). The sudden growth of the city throughout the plain stretched ca 1.6 km to the south and ca 1.6 km to the east from the vicinity of the Odeion (the former civic focus). The discovery of the city's amphitheatre in the neighbouring modern village of Aghioi Deka is clear testimony of the city's dramatic expansion.⁸ Indeed, Gortyna remains the only centre on Crete where a broad range of hydraulic architectural types has been identified encompassing two of the largest bathhouses on the island, *nymphaea* and latrines. This major urban expansion was afforded by the construction of the aqueducts and the strategic location of the embryonic Roman city at a point where the Mitropolianos River emerged from the Psiloriti foothills and emptied into the plain.

TARRHA

Similar hydraulic considerations could be responsible for the relocation of the Roman site of Tarrha (despite the fact that no aqueduct has yet been located in association with this centre), as an aqueduct would have been a crucial facility for the operation of the considerable Roman glass factory at the site. It is particularly significant that an intensive survey of the region has demonstrated that in the Roman period the centre of settlement moved from 1 km inland down to the coastal river delta leading the surveyors to refer to Tarrha as an 'itinerant site'.⁹

KNOSSOS

At Knossos a Roman colony (Colonia Iulia Nobilis Cnosos) was founded late in the 1st century BC.¹⁰ The centre's aqueduct is impressive, skirting the contours from the Archanes region towards the city, again along a river valley. The route along the Katsavas River (the ancient Kairatos River), followed by the Roman aqueduct to Knossos, was so thoroughly suitable for long-distance water conduction that it was also favoured by the Venetian and Egyptian aqueduct surveyors.¹¹ The notable distinction between the aqueducts of these different periods is that the subsequent examples incorporate impressive bridges to traverse the natural gullies in the terrain whereas the Roman aqueduct circumnavigates the valley contours (*fig. 4*). This Roman characteristic creates a meandering trajectory demonstrating a preference for low-profile contour types (*fig. 5*).



Fig. 4. The Venetian Aqueduct Bridge crossing the Katsavas River just south of Knossos.



Fig. 5. The Roman aqueduct channel is indicated by the arrow in the foreground while the high substructure wall is that of the Egyptian aqueduct.

Elsewhere on Crete, certain Roman cities were compelled to maintain their fixed locations from Hellenistic times due to overriding economic benefits in their original positioning. However, obstacles encountered when designing the civic water supplies of these particular cities prompted interesting strategies for their efficient operation.

ELEUTHERNA

Eleutherna is one of the aforementioned inland cities whose placement did not change in the Roman period. Its economically strategic position was maintained in order to control traffic along an ancient inland route which flourished under Roman control. Eleutherna's position mid-way along this transit corridor was central to the city's prominence as the thoroughfare effectively linked Gortyna with the temple of Diktynna.¹² Contact with the temple of Diktynna was of considerable benefit to any developing Roman city in Crete as the temple treasury was a major source of public

funding in the 2nd century AD as is attested by numerous dedications throughout the island (IC IV no 334).

In order to water the bathhouses at Eleutherna two rock-cut subterranean cisterns (each with a capacity of 5,000-6,000 m³) were cut into the acropolis, thus forming the complex with the greatest combined water capacity on the island. These cisterns essentially acted as settlement tanks along the aqueduct supply line, being fed by an aqueduct which tapped a spring to the west of the acropolis and drained by an underground tract which tapped the cisterns at a high point in their back wall (fig. 6). The water was conducted to a point east of the acropolis, just above the three baths and the several elaborate town-houses located there.¹³

LYTTOS

At another inland city, that of Lyttos, the need for a constant incline to facilitate water conduction by aqueduct was also particularly problematic. The site is set on an elevated spur incorporating an acropolis. Onorius Belli writing ca 1596 observed that the hill ridge had a small amount of level space and altogether the worst topography of any site he had ever seen.¹⁴ Regardless of this, the Roman city teetered on its perch in order to control the pass into the Lasithi Plain, a most lucrative area in terms of viticulture and wine production.¹⁵

The aqueduct of Lyttos is obliged to depart from the contours of the mountains to traverse a lower col or ridge (near the aptly-named village of Teixos) which connected the hilltop city with the mountains (figs. 7, 8). If the aqueduct proceeded here using only gravity flow, its height would have been at least 35 m, which although certainly a feasible height, is not commonly associated with aqueduct bridges.¹⁶ The drum of a stone pipe found nearby would suggest that the city was served by a siphon formed of a series of stone pipes of a similar nature to that of Patara in Lycia.¹⁷ Moreover, the toponym 'Terazi' (a Turkish term relating to a water tower or, more specifically, 'scales for water') corresponds to the area at the start of the siphon - where we would expect to see a pressure tower - lending credibility to such an interpretation.

It should be emphasised that the unusual arrangement of the public water systems at both Lyttos and Eleutherna were designed in direct response to the difficulties in watering these inland elevated cities. Their aqueducts represent atypical examples and contain unusual features (at



Fig. 6. The aqueduct at Eleutherna.

least within the Cretan repertoire) such as inverted siphons and underground tracts which, although perhaps common elsewhere, play only a very minor role in aqueduct designs on Crete. The preference for low-profile valley-contour aqueduct construction on Crete is common to public, private (i.e. the residences at Minoa and Pachyamos), religious (i.e. the sanctuary at Lebena) and commercial sites throughout the island.

CONCLUSION

In conclusion, although the number of Roman aqueducts on Crete might initially seem surprisingly high, it is not difficult to explain their profusion. The increased demand for water in Roman cities required a rethinking of the provision of that water. As aqueducts function on the basis of gravity flow their operation is concomitant with the slope of the terrain which in itself has obvious major, but often-overlooked, implications for site placement.



Fig. 7. The mountainous tract of the Lyttos aqueduct. The arrow indicates the rock-cut terrace containing the channel.



Fig. 8. The Lyttos siphon at Teixos.

Firstly, it appears that the Cretan landscape fulfils all the fundamental prerequisites for ease of aqueduct construction. These needs are relatively basic but they are also landscape-specific. Naturally, the aqueduct source has to be higher than the destination to be watered. Consequently, the ulti-

mate criterion of whether a site can be supplied by aqueduct is its altitude, relative to the water source. But once this stipulation is met, and it is relatively easily accomplished in most cases, then the process can be fine-tuned.

Aqueducts built along valley contours afford the easiest, most economical and rapidly-executed constructions. Therefore, intervening valleys between the source and destination of the water are ideal, in terms of aqueduct construction. Fortuitously, in Crete perfect topographical conditions exist lending to an almost purpose-built landscape for aqueduct construction. These conditions further affected the location and relocation of cities in the Roman period. Only in the few instances whereby the topography was unsuitable for this technique were siphons and tunnelling necessary.

This apparent ease of aqueduct construction, and hence plentiful provision of water, naturally contributed to the large number of bathhouses on Crete. The correlation between baths and aqueducts (although by no means absolute) ensured a partnership of these monuments at many Roman cities on the island. The survival of many of the Hellenistic city-states into the Roman period (albeit with a shift in their centre of gravity) was correlated with the construction of Roman baths throughout the island as the presence of a bath can represent a definitive feature of a Roman city and the ensuing multiplicity of baths in major centres could only be sustained efficaciously by an aqueduct supply.

Naturally, no single dynamic prevails exclusively in determining shifts in site placement and there are of course many components at play but, equally, none can be overlooked. Undeniably, an increasing sense of security was also an important factor in this creeping into the lowlands, Wilson attributes the widespread abandonment of Sicilian hill-towns (characteristic of the transitional period between the late Republic and early Empire) to the 'lack of adequate water supplies, together with the inconvenience of life on a mountain when military security was no longer an issue'.¹⁸ Moreover, Marangou attributes such displacement from elevated settlement towards the plains, to the centripetal magnetism of the port and the development of agricultural and commercial skills.¹⁹ This model is popular for Crete, being favoured by both Sanders and Raab who attribute this downslope shift to the island's increasing security and participation in Mediterranean-wide commerce.²⁰ This argument is bolstered by the fact that many sites along the south coast of Crete

had little or no good agricultural land (e.g. Souia and Lissos) and their prosperity is thereby explained in terms of trade. Undeniably, trade made coastal locations most attractive and lucrative. Sites on the south coast certainly benefited from the trade routes that ran along the coast of Crete from Egypt and Syria to Rome. However, if the coastal predilection of Roman settlement on the island can be assessed in commercial terms, this does not preclude other narratives or motives for such site placement.

I argue that it is not the coast itself but the contours descending to it that are the ultimate determinants of site placement, thereby contributing to site success in the Roman period. It is clearly easier to water a coastal city specifically because it is low-lying while the positioning of Roman cities near river mouths (the preferred location for coastal Roman cities on Crete) would accommodate aqueduct contour-line construction. Therefore, the shift can be better understood in terms of altitude and valley-contour aqueduct construction rather than purely inland-coastal commercial dynamics. The two concerns can coexist and are not mutually exclusive. The crosshairs of the river and coastline pinpoint the greatest benefits to a site in terms of commercial activity, agricultural land, hydraulic engineering and irrigation. This cause and effect is evident at Souia where the aqueduct descends to the coastal site along a contour parallel to the river. Consequently, the site spreads around the fan of the river mouth where it could benefit from the south coast trade, the traffic along the valley thoroughfare, and an efficient water supply.

Nonetheless, the riverine association is so strong that in cases where the mouth of the valley occurs inland (i.e. the mouth of a tributary river in an inland flood plain) the site foregoes its coastal primacy in favour of the topographic benefits of a location near the mouth of the inland valley. This dynamic is attested at Roman Knossos, which although traditionally perceived of as coastal (and indeed benefited as such), it is notable that the central area i.e. the *forum* of Roman Knossos, is located 5 km inland from the harbour at Herakleion.²¹ It seems as though a coastal setting was relinquished in preference for a position adjacent to the Minoan ruins which formed the focus of the Roman colony. It has been suggested that the location of the Roman colony was initially more symbolic than economically viable since connection with the past, rather than direct access to the coast, determined the location of the *forum*. However, the fact that the Roman colony was founded at this spe-

cific location is perhaps more pragmatic than previously thought as its positioning seems to have been determined by the fact that it represents the point where the Kairatos River departs from the mountains on entering the coastal plain. Roman land surveyors were perhaps not as prone to the romantic allure of Minoan sites as the average modern scholar.²²

In a nutshell, the specific characteristics of the Cretan aqueduct group are that they are relatively less monumental than those found elsewhere in the empire, yet they are particularly commonplace. Both of these factors are merely a response to both pre-Roman settlement patterns and topographical conditions; factors which are both regionally and historically specific to Crete.

NOTES

- 1 I must thank Betsey Robinson, Deirdre Stritch and Patrick Taylor for reading earlier drafts of this paper and thereby improving its content considerably. Thanks are also due to James Wilson Myers and Eleanor Myers who generously allowed me to include their aerial photograph of Gortyna (originally published in Myers et al. 1992). Professor P. Themelis (University of Crete) has also been particularly generous with the Roman material from Eleutherna.
- 2 Evans 1902/03, 106. Evans' recourse to dynamite in his removal of Roman structures which encroached upon the Minoan centre seems to conflict with his observations that the palace had been left largely free of occupation in the later periods as if 'some surviving tradition of the religious aspect of the Minoan building in its function of Sanctuary as well as Palace may have served to protect the site. It may well, indeed, have been included in some later temenos like that of the Grove and the Temple of Rhea.' (1903/04, 51).
- 3 Notably Sanders 1982.
- 4 Kelly 2004.
- 5 Taramelli 1902, 122.
- 6 Sanders 1982, 28, 31.
- 7 La Torre 1988/89, 321.
- 8 The survival of the amphitheatre was secured through its incorporation into the basilica of Aghioi Deka, effectively enshrining the arena where the Ten Martyrs were executed in the reign of Decius in AD 250 (Di Vita 1986/87, 327-347, map XXVII; 2000, xlv, fig. 22). The external dimensions of the amphitheatre (120 m x 91 m with a central arena of 68 m x 39 m) indicate a large structure which could accommodate 18,000 spectators (Ricciardi 1986/87, 348).
- 9 Moody et al. 1998, 89.
- 10 The establishment of the colony was preceded narrowly by a land grant to the people of Capua in 36 BC (Sanders 1982, 14). This land was compensation for Capuan territory which Octavian pledged to his mutinous soldiers in Sicily in 36 BC (Cassius Dio XLIX xiv 5). This Capuan land was distinct from that of the colony at Knossos as revealed by a later boundary dispute of AD 84 concerning a citizen of the colony who owned land adjacent to that of the Capuan territory (Ducrey 1969, 846-852; Rigsby 1976, 324). The find-spot

of the inscription at Karnari, near Archanes, suggests that the Capuan plots lay deep in the valley to the south within the outlying territory of Knossos. It has been suggested, given the economic importance of the fertile hinterland of Knossos in the Roman period, that Archanes was important for the Cretan wine trade (Sakellarakis/Sapouna-Sakellarakis 1997, 43). Capua's share of territory at Knossos proved to be extremely lucrative, amassing an income of 1,200,000 *sestertii per annum* (Velleius Paternulus II 81, 2).

- 11 The most conspicuous section of the latter is a great Gothic arch at Knossos, probably a work of the 1830s (Gerola 1932-40, IV, 14; Spanakis 1950, 26). Mohammed Ali of Egypt arrived at the Sultan's request and reduced the island to submission in 1824. France, Great Britain and Russia (the Allied Powers) agreed that Crete was ceded to Egypt when Greece gained her independence in 1832. Crete was returned to Turkey in 1840.
- 12 Baldwin Bowsky 2001, 272.
- 13 Themelis 2002, 60-80.
- 14 cited in *The Builder* 7/12/1901, 499.
- 15 Wine amphorae, bearing the insignia of Lyttos, have been discovered at both Pompeii and Herculaneum (Chaniotis 1988, 75; De Caro 1992/93, 307-312; Baldwin Bowsky 1995, 50 and 57). In fact, Marangou (1999, 271, 278) contends that Crete held a leading position in the wine trade for the first three centuries of the Empire with Cretan amphorae representing more than a third of Aegean and Eastern imports in Ostia in the 2nd century AD. Juvenal is a notable exception in rating Cretan wines poorly and lambastes the ancient Cretan docks where such unpleasantness was collected (XIV 270). Of course, Juvenal is not an unbiased observer and his disdain of all things Greek is keenly expressed in *Satire III* (58-80).
- 16 O'Connor (1993, 154) contends that few Roman bridges exceed 30.5 m; the Pont du Gard representing the exception rather than the rule.
- 17 Oikonomaki 1984, 75, pl. 6.
- 18 Wilson 2000, 18.
- 19 Marangou 1999, 270.
- 20 Sanders 1982, 31; Raab 2001, 31.
- 21 Cadogan (1992, 125) considers Knossos to have been sufficiently far from the sea in the Minoan period that people could prepare for, or escape from, enemies attacking from that direction. Sanders (1982, 152) gives Herakleion and Knossos two separate entries in his gazetteer of Roman sites. The shift in focus towards Herakleion seems to be a subsequent development and the discovery of some private Roman residences in this modern coastal city seem to represent outlying satellite sites to Knossos. In the Venetian period an extension of the traditional aqueduct route from Archanes to Knossos was constructed north of Knossos in this direction (Catling et al. 1982, 59-64).
- 22 Although Evans (1909, 109) observed that Nero's personal fondness for the Tale of Troy and his 'mad progress' through Achaia lend credence to the alleged discoveries at Knossos during his reign.

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