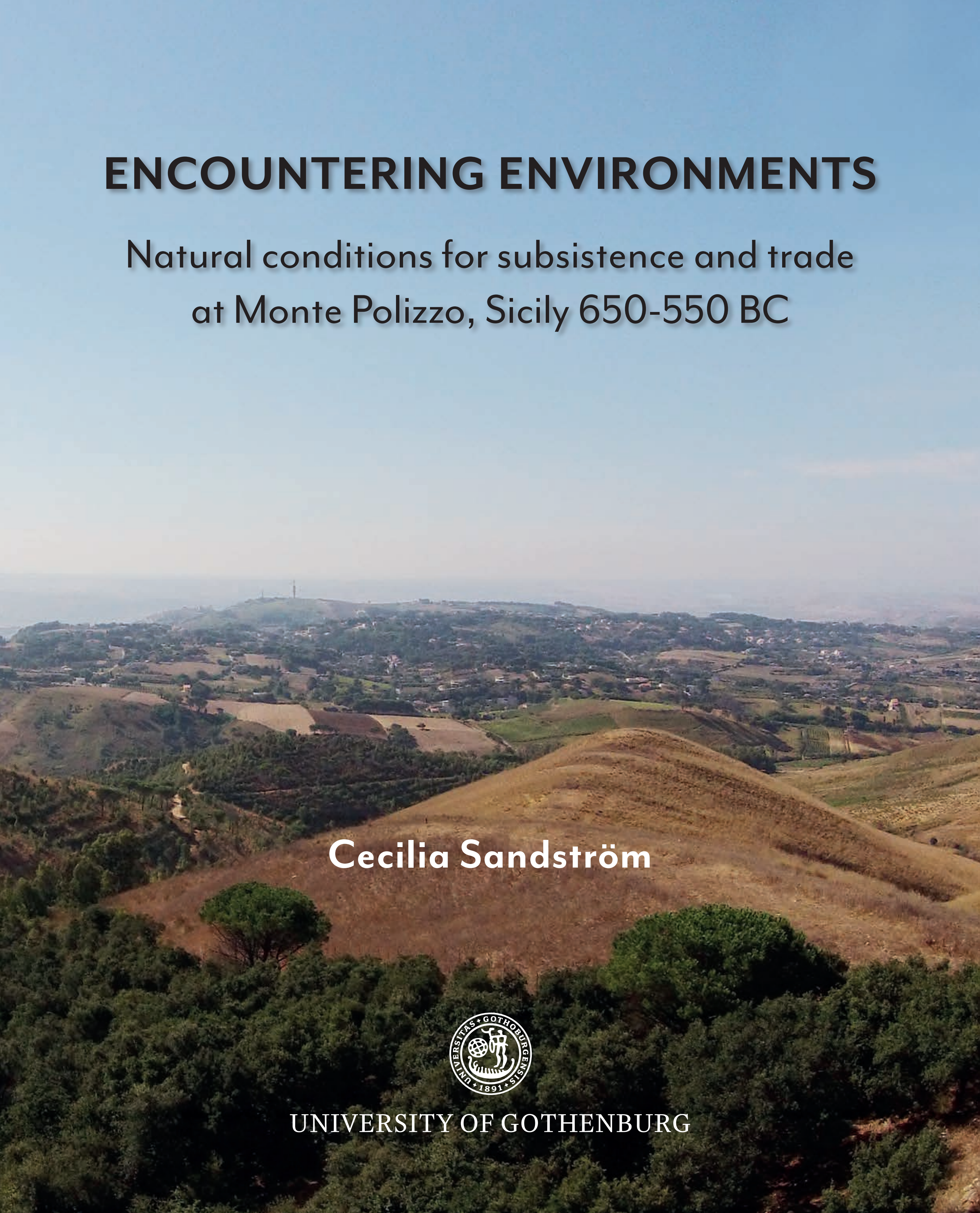

ENCOUNTERING ENVIRONMENTS

Natural conditions for subsistence and trade at Monte Polizzo, Sicily 650-550 BC

Cecilia Sandström

UNIVERSITY OF GOTHENBURG

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GÖTEBORGS UNIVERSITET

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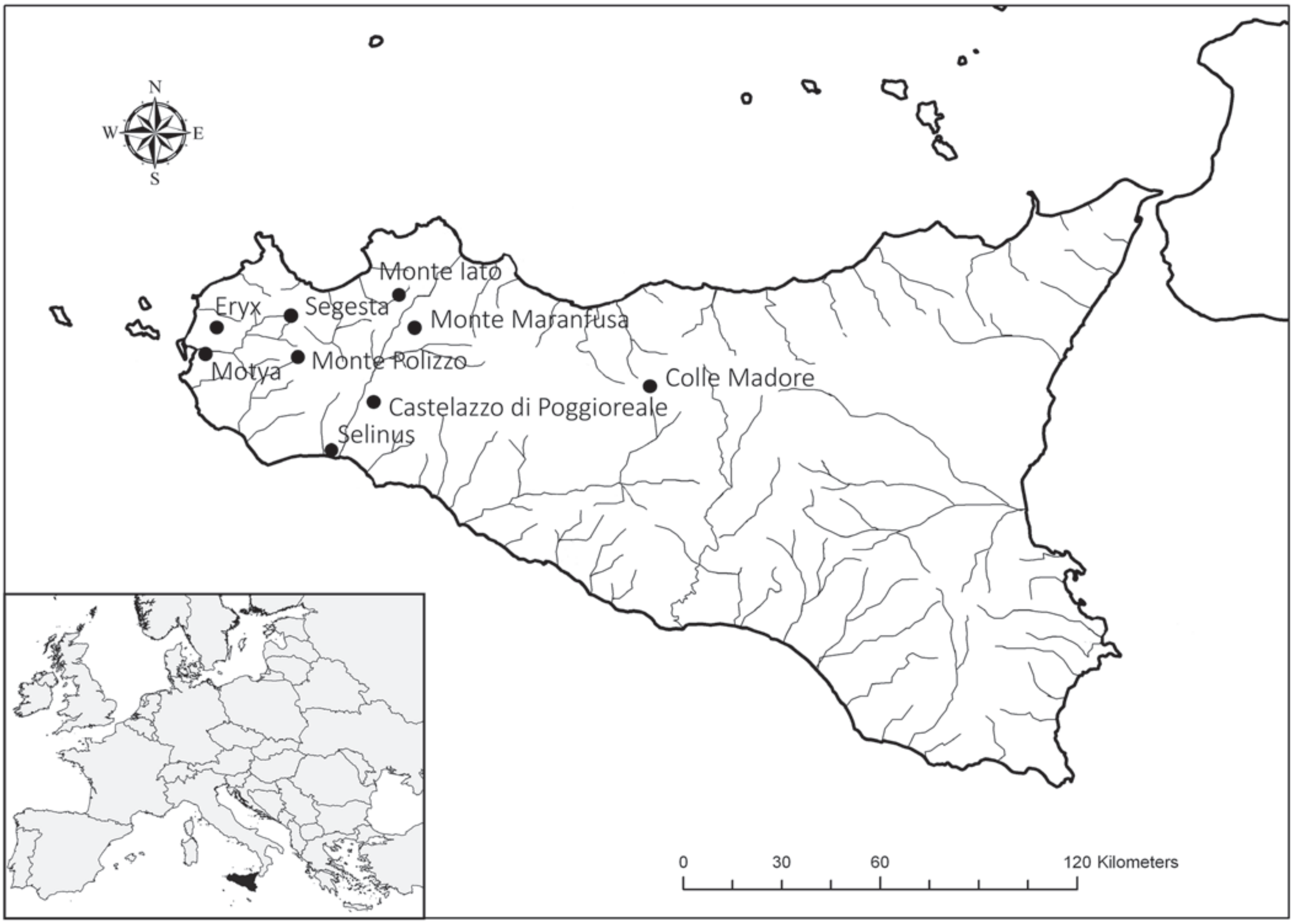
To my beloved mother in memoriam,
and to my wonderful daughter – the light of my life



Map of Sicily. Showing indigenous, Phoenician and Greek settlements mentioned in this thesis.

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Figures and Tales

CHAPTER 1

Introduction

Aims and questions

The overall aim of this thesis is to deepen our knowledge about indigenous western Sicilians commonly called the Elymians and, ultimately, to recognise them as independent actors in Sicilian history. A vital part of this endeavour will be to assess the Elymian role in regional trade and to evaluate the subsistence challenges they faced. Monte Polizzo, inhabited for just 75 years (625-550 BC), has been considered suitable as a model for discussing these topics. Situated in western Sicily it was strategically placed with an excellent vantage point between the Phoenician settlement of Motya, the Greek settlement of Selinus, and the indigenous settlement of Segesta.

The thesis begins by examining the full environmental context of Monte Polizzo and its surroundings, including geomorphology as well as palynological, faunal, and macrobotanical aspects. This section is fundamental to understanding settlement subsistence, local economy, land use, how inhabitants moved and connected with other people in the landscape. The second part focuses on archaeology with a specific focus on imported transport amphorae. These vessels are regarded as the best archaeological evidence of overseas and regional trade networks. Occasionally, they are believed to be products that the indigenous population did not acquired on their own but were gifts given from Phoenician or Greek elites. The contexts of the circa 40 imported transport amphorae found in the domestic area at Monte Polizzo will be used to evaluate these notions. The final part of the thesis will examine how these various archaeological and environmental components were shaping the Monte Polizzians' role in regional and global trade.

The questions this study intends to answer are:

1. What environmental conditions did the Elymians face when they settled at Monte Polizzo around 650 BC?
2. Were any of the rivers draining Monte Polizzo navigable; and, further, what was the role of rivers in terms of connectivity and transportation routes between Monte Polizzo and the coasts?
3. What was the settlement's subsistence strategy and the adjoining environment's carrying capacity? Moreover, can we find traces of land use?
4. What does the archaeological record tell us about Monte Polizzo's role in western Sicilian trade networks, and what could they have offered in return to these markets?

Problems

Monte Polizzo has been a target of research during the last couple of decades. Topics highlighted in various studies include, for example, religious expressions, acculturation of households, women, Holocene land use, identity, social changes, traditions, and material culture.[1] What is frequently lacking in these studies is an acknowledgment of the natural environment. It shapes nearly every action we take on a daily basis, yet it is seldom recognised as a vital part of how and why ancient people made choices that changed their economic situation, religious expressions, or social organisation.[2] This topic is especially important when studying a local economy, a territory's carrying capacity, and topography and geomorphological features as well as how they shaped inhabitants' trade patterns and connections with other societies. These previously overlooked aspects need to be integrated into the discourse to get a more holistic view of the society at Monte Polizzo specifically and of western Sicily generally. The underlying theory of this method will therefore consider a dynamic balance in the nature- human relationship and the various connections between the subsystems that comprise a society.

The other important topic not yet explored is the Monte Polizzian role in the regional and local trade network. To achieve a deeper understanding of regional trade, indigenous agency must be fully recognised. The Hellenocentric view needs to be balanced and revised.[3]

As a consequence of the traditional hellenocentric view in Sicilian research, indigenous societies have mostly been seen through the perspective of Greek Sicily, pre-Greek Sicily, and the non-Greek areas as a non-Greek population. For instance, the indigenous peoples are recognised as supplier of agricultural products to Greek settlements.[4] This notion is seldom, if ever, based on an actual evaluation of the indigenous settlement's own need for subsistence or informed by an initial assessment of the settlement's carrying capacity and possibilities for surplus production.[5] Instead, without the support of relevant environmental studies and a balanced perspective, such discussions are based solely on the Greek settlement in question and its need for imports.[6]

Are these common Greco-centric perceptions still largely accepted because of a lack of indigenous sources (archaeological and literary) or is it simply habit? General assumptions about indigenous economic, cultural, and social relationships with their overseas neighbours need to be jettisoned in order to arrive at a fresh take.[7]

About fifty documented indigenous sites in western Sicily were active in various ways during the sixth century.[8] This large number suggests a prosperous time for the local communities in the region.[9] It is a fact that indigenous sites often are poorly preserved due to weathering archaeological remains and eroding soils. But with limited archaeological evidence, is it even more important to maintain a balanced perspective regarding the different peoples of Sicily and their (inter)actions. A theory suitable for balancing these different perspectives in a first step is White's model of "the middle ground."

Thesis structure

The following chapter, *Settlement organisation at Monte Polizzo-an overview*, will present the settlement based on the general results of the Sicilian Scandinavian Archaeological Project of which I was part between 2006 and 2015. This chapter will set the scene for Chapter 3, *Theoretical framework and previous research.* The various methodologies applied in this work are presented within relevant chapters. The following three chapters are focused on studies of the environmental conditions in the area. Chapter 4, *Geomorphology of western Sicily*, presents the topological, geomorphological, and hydrological aspects. Chapter 5 evaluates the *Rivers as possible trade and communication routes.* Chapter 6

1 Heinzel 2004; Kolb and Speakerman 2005; Streiffert Eikeland 2006; Kolb 2007; Mühlenbock 2008; 2015; 2016; *in press*; Manning Urquhart 2010; Henzel and Kolb 2011; Balco 2012; Ferrer 2016; Buckingham 2019.

2 Walsh, 2004; Ashmore and Knapp 1999; Richards 1999.

3 See for instance Öhlinger 2015, 417; Morris *et al*, 2003, 275 ; De Angelis 2016, 21; Mühlenbock *in press*.

4 Stika *et al.* 2008; De Angelis 2016.

5 Cf. Mühlenbock 2008.

6 De Angelis 2016.

7 See for instance Mühlenbock 2008; Manning Urquhart 2010; Öhlinger 2015; Ferrer 2016; Hodos 2010; 2020; Mühlenbock *in press.*

8 Vassallo 2000; Morris 2003, 48.

9 Morris 2003.

presents *Natural environment of ancient western Sicily* and is focused on palynological information. Chapter 7 discusses *The "territory" of Monte Polizzo, land use and local economy* based on environmental evidence from the previous chapters and paleobotanical remains collected at Monte Polizzo. Chapter 8, *Ceramic evidence of trade and exchange*, presents the imported transport amphorae found at Monte Polizzo and further discuss their relevance in an indigenous context. Chapter 9, *Trade and exchange. Monte Polizzo in a wider context,* broadens the discussion about connectivity and networks to a Mediterranean and regional context. The last chapter offers *General conclusions.*

The thesis is followed by two appendices:

Appendix 1. *Catalogue-Imported transport amphorae*.

Appendix 2. *Assessment of ancient navigability of rivers sourced near Monte Polizzo, western Sicily.* By John L. Berry.

CHAPTER 2

Settlement organisation at Monte Polizzo- an overview

Monte Polizzo is located in the Trapani region in the westernmost part of Sicily. The mountain consists of interconnecting ridges that reach 725 meters above sea level (m.a.s.l.) and provide an excellent view of the surrounding area.

Modern roads of various qualities lead quite far up to the settlement but, eventually, most vistors must proceed on foot. (The truly fearless have no trouble driving all the way up.) It is not only the steepness of the mountain that makes Monte Polizzo a site difficult to access but also its modern vegetation. Before the 1950's, the highlands of Sicily suffered badly from erosion and soil degradation. A widely known saying is that Sicilian farmers were (and still are) ploughing bedrock, and this is by all means the truth. During the 1950's however, a soil conservation and deforestation campaign was launched in southern Italy and Sicily. In this part of the Mediterranean, under semi-arid climate conditions, various species of Mediterranean Pines such as *Pinus halepensis, Pinus pinea, Pinus pinaster* and as well as broad-leaved species like *Castanea sativa*, *Acer campestre*, *Quescus pubenscens* and *Quercus ilex* were planted in abandoned or degraded agricultural lands, areas vulnerable to erosion and soil loss.[10] Monte Polizzo is partly privately owned, and the reforestation campaign was executed on the eastern part of the mountain that is maintained by the *Forestale* and the *Assessorato territtorio e ambiente di Sicilia*. Terraces were cut into the bedrock and *Pinus* and *Quercus Ilex* were planted in rows clearly visible from a bird's eye perspective. Studies have shown that a mix of *Pinus - Quercus* forest is favoured under semi –arid conditions, hence the replantation of *Pinus* in modern times, though the species was not part of the area's natural habitat.[11]

Pinus are mixed with other shrubs, which in some areas on Monte Polizzo create rather dense and untraversable vegetation, especially on the southern slopes[12]. During the reforestation campaign, five large firebreaks were created all over mountain and some are visible on the mountain ridge in the photo above. They are maintained annually to prevent the fires from spreading uncontrollably in the arid landscape. Everyone who has spent some time in Sicily knows that special smell that hits you when you take your first deep breath: the mixture of warm asphalt, seaweed and forest fire.

Although a natural shrubland community thrives in a fire-frequent climate, the recurrent fires prevent the vegetation from recovering completely on Monte Polizzo. In some places on the northern slopes there is only conglomerate left after fire has had its course. Thistles that thrive in burnt soil and reeds that quickly recover, make paths which in previous years led up to the archaic settlement nearly impassable.

10 Barbera and Cullotta 2012, 560; Rühl *et al.* 2015, 173-184.

11 Peñuelas *et al.* 2017, 20.

12 A shrub is defined by never exceeding five meters in height.

The Sicilian Scandinavian Archaeological Project

In the 1970s Professor Vincenzo Tusa, Direttore dalla Sezione Archeologica, Soprintendenza ai BB. CC. E AA. di Palermo, initiated the first excavation ever conducted at Monte Polizzo. Located some 100 meters on the southern slope below the summit of the highest ridge, a sixth century building "The Tusa House" was brought to light.[13] Nearly thirty years later, Sebastiano Tusa, Direttore dalla Sezione Archeologica, Soprintendenza ai BB. CC. E AA. di Trapani, started a new project on Monte Polizzo. The aim was to do a large-scale study and to conduct large excavations on different parts of the site in order to get as complete a picture as possible of an Elymian settlement. The goal was not only to excavate but also to combine the archaeological results with scientific studies of the palaeo-botany and fauna in order to get a deeper understanding of the Elymian way of life.[14]

In 1996, Tusa and Kristian Kristiansen started the Sicilian Scandinavian Archaeological Project (hereafter referred to as the SSAP) and, together with Christopher Prescott, the Scandinavian team began excavations on the western ridge, expected to have once been a domestic area, in 1998.[15]

In 1999-2000, Tusa continued excavations in the Tusa House. They also began excavations on the eastern ridge called "Portella Sant' Anna," also focusing on domestic areas. During these early years, Michael Kolb conducted a surface survey around Monte Polizzo in order to get a sense of the extent of the settlement.[16]

Other indigenous mountain sites such as Polizzello, Montagnoli and Colle Madore had in recent years indicated that religious activities on these sites followed a general pattern and were centred on the highest summits.[17] In 2000, Ian Morris was thus invited to join the project to conduct excavations at the highest area of Monte Polizzo in what was expected to be the religious centre of the settlement. Another feature Morris excavated was an area called "the Profile," located roughly in the middle of the ridge oriented east west.[18]

The original goal with this large endeavour was that the different teams would share, combine and emerge all the results into a comprehensive database. However, during the course of work, it became apparent that this task was too difficult to fulfill. The grand project dissolved into three separate project, and the transparency between the research projects got lost somewhat.

The results of the Italian excavations at the Tusa house and Portella Sant'Anna during 1999-2000 have not been published. However, a magnetometry survey at Portella Sant' Anna was conducted during 2001 by members of the Stanford team, which gave some indications of the extent of the area, presented below.[19] The Stanford investigations on the acropolis were undertaken between 2000-2006. The excavation reports available are for the years 2000-2004, but a complete publication of the archaeological material has not yet been published.[20] The Profile is published in Cooper 2007.[21] The Scandinavian project continued under the flag of SSAP until 2006. Archaeological investigations have continued since then, conducted by the University of Gothenburg on a smaller scale between 2008- 2015.[22] A deeper analysis

13 Tusa 1972. See Figure 1.

14 Morris and Tusa 2004, 36.

15 Kristian Kristiansen Professor of Archaeology, University of Gothenburg, Christopher Prescott, Professor in Archaeology, University of Oslo.

16 Michael Kolb, Professor of Anthropology, Northern Illinois University.

17 For Polizzello, see for instance De Miro, E., "Gli' indigeni' della Sicilia centro-meridionale", *Kokalos* XXXIV/XXV (1998/1999), 24-34. For Montagnoli see Castellana, G.," L'insediamento di Montagnoli nei pressi di Selinunte", in G. Neci, S.Tusa, V. Tusa eds. *Gli Elimi e l'a'rea elima*. Palermo, 1988-1989, 326-331. Colle Madore, see Vassallo. *Colle Madore: un caso do ellenizzazione in terra sicana*. Palermo 1999, 24-29.

18 Ian Morris, Professor of Classics, Stanford University

19 Timble and Platt 2004.

20 Morris *et al.* 2002, 2003, 2004, 2005. Morris and Tusa 2004.

21 Cooper 2007.

22 See Mühlenbock and Prescott 2004, Mühlenbock *et al.* 2004. Mühlenbock and Prescott 2913.

of the houses excavated in the habitation area and its material culture is available in Mühlenbock 2008. The publications covering the archaeological material from the Scandinavian and Swedish area of Monte Polizzo is still work in progress. For studies regarding various aspect of local/indigenous life at Monte Polizzo and other places in Archaic Sicily, see for instance Streiffert Eikeland 2006, Manning Urquhart 2010, Balco 2012, Buckingham 2019.[23]

Summary of the main structures and general results from the Monte Polizzo archaeological excavations and investigations

The settlement proper is estimated to have been approximately 20-25 hectares, spread over the multiple ridges that compose the mountain. Traces from architectural and archaeological remains extend about 900 meters in an east to west direction, and about 500-700 meters in a north to south direction. Most of the remains are centred around the southern slopes and on the western and eastern ends of the ridge as well as onon the highest points of the mountain, the so-called acropolis 724-m.a.s.l. The northern part of the mountain is too steep to allow construction but served as a natural defence.

The supply and access to fresh water to the settlement is not yet attested. Surveys conducted within the SSAP project have found indications of a natural spring on the southern slopes of the mountain.[24] The only "natural" large structure that could hold a fresh water supply in the upper part of the settlement is called the *neve*. This is a deep pit approximately ten meters wide and four meters long located about fifteen metres down the southern slope of the ridge oriented east west. A small excavation revealed a channel which could be associated with drainage system or water transportation.[25] Tradition holds that the local communities used the *neve* for ice storage in the eighteenth and nineteenth centuries.[26] The earliest evidence of human presence at Monte Polizzo derives from the acropolis, a possible Palaeolithic tool, found on the surface during a survey of the southern slope.[27] There are also fragments of Bronze Age pottery scattered around the acropolis, which are dated between 1500-800 BC. However, no Bronze Age deposits have been found, which means that these fragments all came from Iron Age contexts. Whether these fragments bear witness to the presence of an earlier settlement destroyed by erosion or by the emergence of the Iron Age settlement is not yet known.[28] During the Scandinavian excavations of the habitation area on the ridge oriented east west, the remains of a circular structure of stones just west of an archaic building resurfaced. This circular form is typical of Bronze Age huts evident, for instance, at the Bronze Age settlement of Mokarta located about 7 kilometres southwest from Monte Polizzo.[29] There are, however, no pottery or other findings associated with this structure and it will not be discussed further in this work.

The earliest intact deposit on the settlement providing evidence of human activity pre-650 BC is found in the "Profile" (zone E) located in the middle of the ridge stretching east-west. The assemblage in this deposit consisted mostly of indigenous cooking ware, other domestic ware, the locally made fine and medium ware called *greyware*,[30] but also an Early Protocorinthian cup dated to 720-690 BC and a few Protocorinthian *kotylai* dated between 690-650 BC.[31]

The two largest excavation areas are located on the western summit called Area A, B, C and D (Swedish-

23 Streiffert Eikeland 2006, *Indigenous households : transculturation of Sicily and southern Italy in the Archaic period.*, Manning Urquhart 2010, *Colonial religion and Indigenous Society in the Archaic West Mediterranean c, 750-400 BC.*, Buckingham 2019, *Identity and Material culture in the interplay of locals and Greek settlers in Sicily in the early Archaic period*. Balco 2012, *Material responses of Social change: Indigenous Sicilian responses to external influences in the first millennium B.C.*

24 Kolb and Tusa 2001, 503. The exact locations of the mid- and toe-slope springs are not yet published.

25 Mühlenbock 2008, 35.

26 Morris 2004b, 247.

27 Morris and Tusa 2004, 38.

28 Morris *et al.* 2004, 251.

29 Tusa and Nicoletti 2000.

30 Cooper 2007, 144.

31 Cooper 2007, 129.

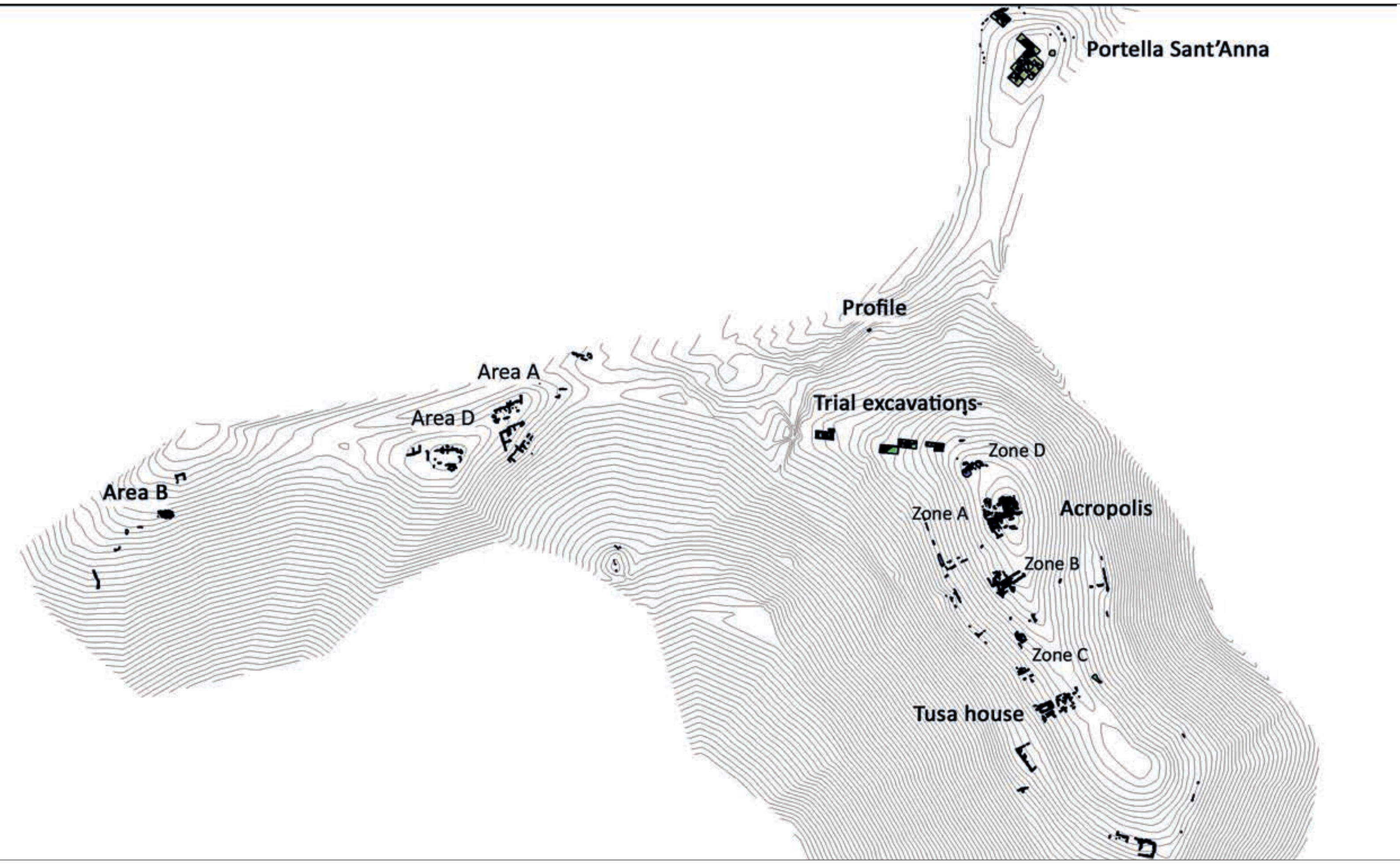


Figure 1. Map of the Monte Polizzo site and main excvation areas.

Scandinavian team) and on the acropolis Zone A, B, C, D (American team). A summary of these main structures will follow below, starting with the acropolis.

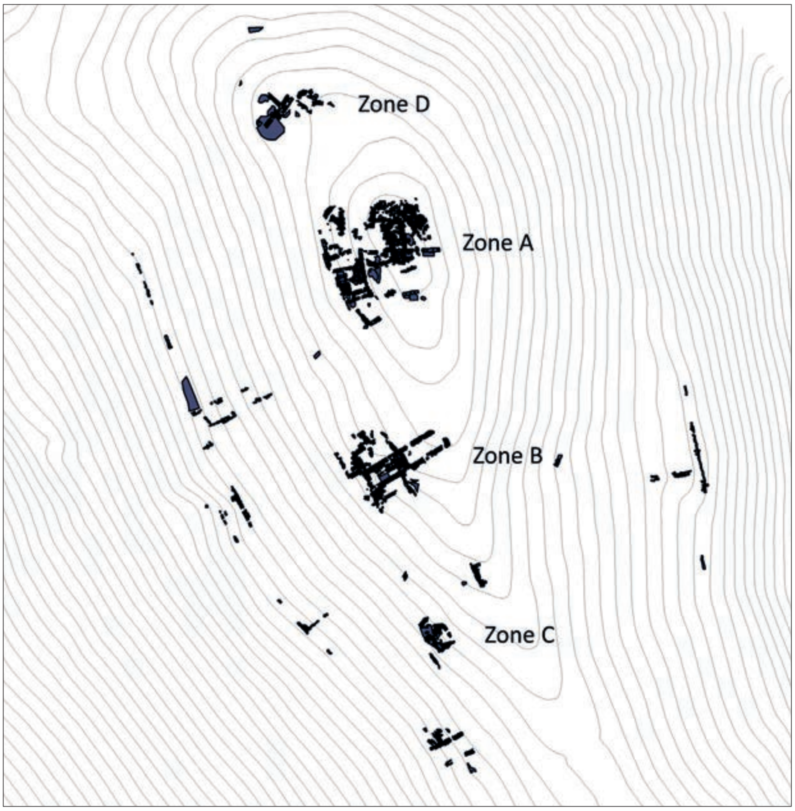


Figure 2. Acropolis Zones A-D.

The excavation on the acropolis

The chronological sequences of settlement activities differs between the two main excavation areas. Starting at the acropolis, two more deposits of eighth-century BC domestic evidence have been located. In zone C, a pit filled with cooking pottery dated to the eighth century was found during excavation of a structure (C1/1) built on a terrace cut into the western slope of the acropolis. The third deposit is found in zone A on the summit of the acropolis ridge, and it consists of a *pithos* set into the bedrock. Morris suggested that, based on these early deposits, the early seventh-century settlement may have covered 2-5 hectares, but the building operations and large scale terracing, which intensified at the acropolis during the sixth century, destroyed the earlier contexts.[32]

At the acropolis ridge there are parts of early sixth-century structures in zones A, B and C. In zone C, a structure C1/1 was built over the pit mentioned above, around 600 BC, and burnt down before 575. It has been interpreted as a room for food processing. The destruction layers were full with kitchen paraphernalia, such as a *pithos*, a mortar and a stone grinder, and various imported vessels mainly consisting of Corinthian and Ionic cups, but also an Early or Middle Corinthian *pyxis* lid. This room is the main structure on the acropolis from late seventh to early sixth century.

Above zone C in zone B, a well-built wall was located. It was constructed of large limestone blocks at least 6 meters long and 1,2 meters high, with a doorway 1 meter wide. Traces of a path leading up the hill towards this doorway may suggest, according to Morris and Tusa, that this doorway marked the end or beginning of a sacred area. The dating of the earliest use of this wall is associated with an Etruscan bucchero *kantharos* handle of around 600 BC and Corinthian sherds.[33] A small structure, B1, was also built during the last quarter of the sixth century on top of a dump of ash, storage sherds and antlers.[34] It has the same alignment as the Tusa house and structure C1. The function of this building is not known.

Further up the hill is structure A5 (zone A), a large rectangular building located on a terrace, running along the western slope of the acropolis. The building, reaching 6,6 metres wide by at least 12 metres long, was divided into four rooms and two small chambers. Based on Corinthian and Ionic B1 cups, the construction of the building is dated to 600-575 BC.[35] Only a few finds were preserved from this period because, around the middle of the sixth century, the inhabitants deliberately dismantled

32 Morris *et al.* 2005, 201.
33 Morris and Tusa 2004, 44.
34 Morris *et al.* 2004, 263.
35 Morris and Tusa 2004, 43.

the structures' walls and remodelled the building. A new clay surface was laid. This buried all the remains of the "old" building except for one chamber, whose floor was covered with large slabs, possibly to serve as a raised platform. The function of this building is interpreted as religious. Several pits, filled with ash, fragments of cups and animal bones, were dug into the clay surface. It is suggested that the centre of religious activity at Monte Polizzo shifted around 550 BC from this structure to the summit of the acropolis ridge. However, the clay floor partially paved around 525 and evidence of burning suggest a continuation of the sacrificial activities in the building.[36]

It must be noted, however, that this information is based on the preliminary excavation reports. The acropolis activities that are dated after 550 BC when the habitation areas are burnt down and abandoned should therefore also be seen as preliminary.

On the summit of the acropolis, on the relatively level bedrock around building A1 (zone A) interpreted as a sanctuary was constructed between 575-550 BC. It was later rebuilt several times until the end of sixth century. It was a one-room building with the external measure of 6,4 meters in diameter. The building was subdivided into three small chambers in which two pits and one clay hearth were probably constructed during its first phase. Smaller pits and hearths were also found outside the structure. Evidence of tiles suggests that it originally had a tile roof which was later removed. The roof was supported by a several courses high stone socle and mudbrick in the upper section.[37]

The areas around building A1 were also used for religious purposes. For example, during 550 BC east of A1, a trench was dug into the bedrock in which a single course of slabs was laid in as pavement. Between the pavement and building A1, a small stele was set into the bedrock.[38] Another sacral feature was found five meters south of building A1. This rectangular structure is 2x5 meters and is interpreted as an altar connected to the main religious building A1.

The last zone on the acropolis is zone D, thought to have been a storage area connected to building A1. Parts of two buildings, one room in each, have been uncovered. The first room, D1, contained fragments from large *pithoi*, several Etruscan and Punic amphorae and three large clay supports for a movable loom. It also contained fragments of fine ware such as a base from a Corinthian aryballos, a small Attic black glaze sherd and a lamp. The dating of these fragments suggest abandonment of this building around to around 525 BC.[39] The excavated room in the second building also contained storage wares such as *pithoi*, Etruscan, and Punic transport amphorae.

The chronological and general conclusion drawn from the acropolis investigations shows that the acropolis area was occupied from around the last quarter of the seventh century BC. Around the middle of the sixth century, the focus shifted from the large rectangular religious building on the western slope to the summit. The use of space went through rapid changes during these decades, and the sacral and ritual areas expanded between 550-525 BC. The last datable deposit in the sanctuary consists of Attic fragments, which suggests a date for the abandonment around 525-500 BC. By then, the pits and hearth were sealed and no complete artefact was left behind. The structure and the site was deliberately and completely abandoned.[40] However, the acropolis continued to receive visitors, as Morris puts it, across the periods of 500-350 BC.[41]

The investigations at Portella Sant' Anna on the eastern ridge

As mentioned above, the excavation area called Portella Sant' Anna is located on the eastern axis of the ridge oriented east west. There are no reports of these studies but walls from several buildings are still visible. A geophysical study was conducted during the season of year

36 Morris and Tusa 2004, 47; Morris *et al.* 2005, 203.
37 Morris *et al.* 2005, 209.
38 Morris and Tusa 2004, 48.
39 Morris and Tusa 2004. 53.
40 Morris *et al.* 2004, 258.
41 Morris *et al.* 2005, 217. For an overview of the Punic reoccupation of the acropolis during 350-300 BC, see Morris and Tusa 2004, 63-66.

2000 providing additional information to these remains. The investigation area was extended about 200 meters northeast from the excavations conducted by Tusa and 80 meters southwest. The survey was laid up in thirty grids of 10x20 meters. The grids were align with the firebreak from the eastern end of the summit towards the acropolis.

Magnetometry investigation is a method frequently used to measure magnetism of subsurface archaeological features. This project employed fluxgate gradiometry, a technique that detects pottery concentrations, kilns, hearths, destruction debris, and different kinds of metal and metal handling. Other features like ditches, roads, areas of building material or walls, can also stand out if they have a different magnetic susceptibility than the surrounding environment. However, walls or archaeological features built of the same geological component as the surrounding matrix, in this case conglomerate, limestone of other sedimentary rock with low magnetism make it more difficult to detect and differentiate from other subsurface features.[42]

Several features were detected in this survey. An area interpreted as a possible ancient road was detected. The "road" was four meters wide and runs in a north- south orientation. It is clearly visible for about 40 meters, until it runs out of the southern end of the survey area, towards southeast. The direction of the road indicates that is appears to bend uphill towards the acropolis.[43] Aligned with the road are what might be several buildings, which share the same east west alignment.

On the opposite end of the road at its northern end, a ten- metres long feature is running in a slight curve alignment on the west side of the road. A similar feature was also detected on the eastern side of the road. This feature is 1-1.5 metres wide, which indicate a substantial building of some sort. The material used for this building is not combatable with any other building material known in this settlement (during year 2000) based on the magnetometrical results. This feature may very well be part of the entrance area to the settlement.[44] In close vicinity to the south of this area are two other buildings in alignment with an east west orientation, both destroyed at some point by fire.

Northeast along the ridge sloping downhill from the settlement "entrance," several buildings built on the terraced hillside were detected. These buildings did not have a uniform use of space, nor did they share the same alignment as was evident among the buildings on the summit. And yet it was not possible to detect any special functional organisation among these buildings, like an industrial area, gardens, kiln or special buildings for animals. It is evident that nearly all buildings in the settlement and in this specific investigation area were destroyed by fire.[45]

Further down the hillside on the northeastern slope, detected building remains were more scattered. Timble and Platt conclude that this may indicate an outside of the densest area of the settlement. However, they did neither see any evident sharp break from the dense occupation to the more scattered area, nor any kind of boundary around the settlement proper. Important to note is that these kinds of investigations do not detect changes through time, but are an excellent match to archaeological excavations.[46]

The excavations of the habitation area on the western ridge - the Scandinavian excavations

This section will provide a short overview of the buildings excavated by the Scandinavian teams in order to get a sense of the settlement as a whole. The excavations of the domestic area on the western ridge have yielded a chronology of seventy-five years at the most. This chronology ranges from the earliest datable pottery around 625 BC to the abandonment of the domestic area due to the destruction by fire in c. 550 BC. All structures are built during this period and are renovated or reconstructed according to need. The houses are not built on

42 Trimble and Platt 2004, 319.
43 Trimble and Platt 2004, 322.
44 Timble and Platt 2004, 325.
45 Timble and Platt 2004, 332.
46 Timble and Platt 2004.

any grid plan. The builders instead followed the natural topography with an array of different layouts as result.

During the course of the SSAP 1998-2006, four structures were excavated on the western part of the main ridge oriented east west. Three other structures have been revealed during the years between 2008-2015. The following presentation will begin with excavation area A, which is located in a relatively open area of the mountain as we see it today after thousands of years of natural and human modification.

Area A, House 1

The first excavation on the plateau of the western ridge was conducted during 1998-2000 and a large building called House 1 was uncovered. The building was remodelled at least three times until it got the design we see today. It has an interior area of about 200 square meters divided into six rooms. There are three hearths in the house. The upper walls above the stone foundation were most likely built with organic material such as as wood, mud and wattle-daub and a matrix of stone mortar. This conclusion rests on the fired clay found in rooms I, III and V.[47]

The roof was constructed of oak tree, and remains of olive tree indicates that it was used either as building material or for furniture. Wooden pillars supported the roof and walls of room I and II. These two larger rooms were probably at least partially open to the south which indicates that one part of the house was more accessible and that the inner part, consisting of three smaller rooms, was the private area. Mühlenbock suggests that this arrangement with the two partially open-air front rooms also made it possible to have a hearth indoors.[48] This household is by far the wealthiest in the settlement

47 Mühlenbock 2008, 47.
48 Mühlenbock 2008, 49.

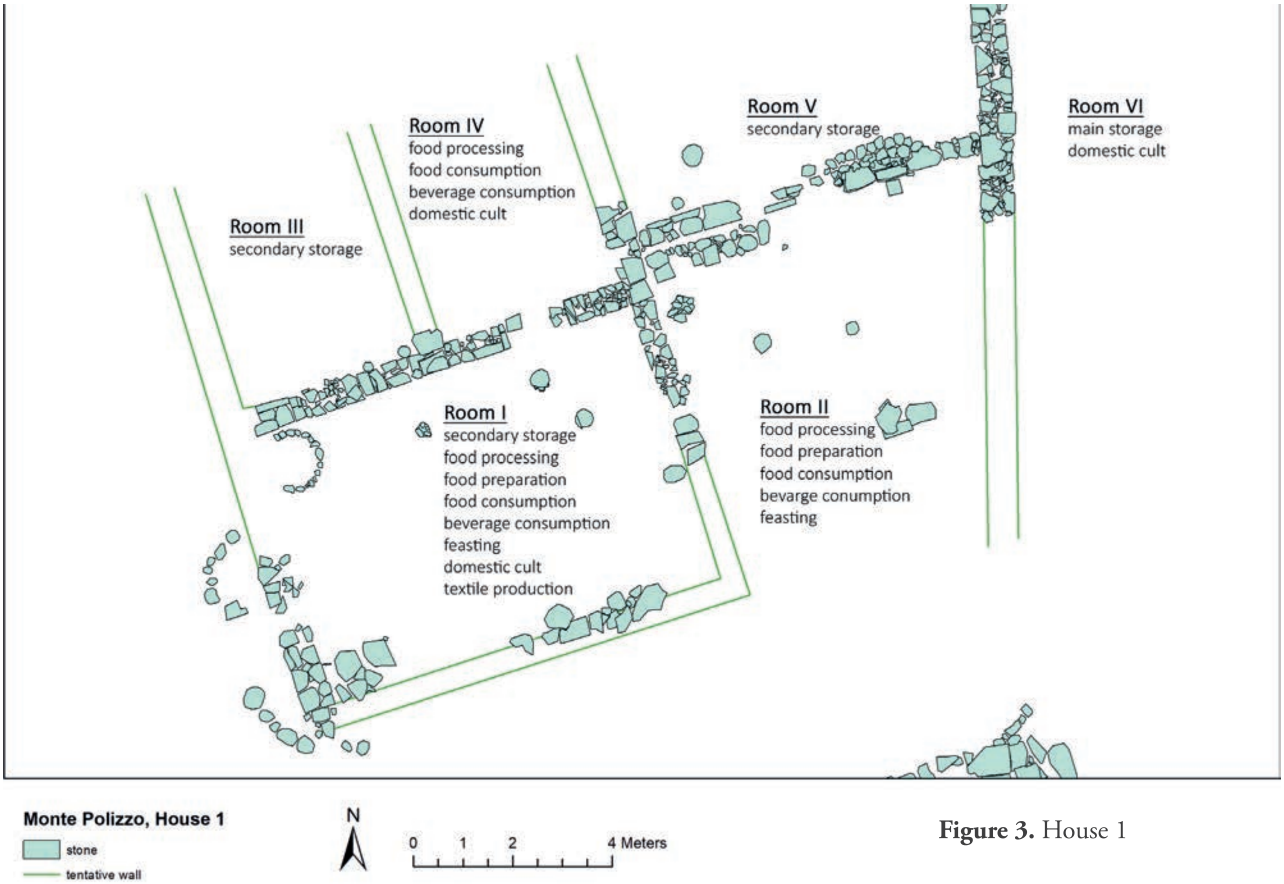


Figure 3. House 1

based on the size combined with the material culture excavated.[49]

House 2

In order to contextualise House 1 in its surroundings, the excavations continued during 2002, following the southern slope in from of the house. Aligned with House 1, another building emerged only two meters from latter. This building, House 2, was adapted to the natural topography and built on a terrace with its back walls resting on the bedrock rather than facing the common ground in between the two buildings. House 2 had at least three rooms and two hearths. Room III is interpreted as an open-air room designed as an activity area instead of a closed room with four walls.

As an extension of Room II, as a continuation of the wall orienting east west, is a stone clad platform with a rectangular shape. The platform is arranged with ten flat stones c. 5 cm thick, ranging in sizes between 16x18 to 65x72 cm. Raised limestones flank the platform, and the whole construction measures 1.5x1.5 meters. The archaeology indicates that the whole platform was covered by a wooden structure and wattle and daub, just as the roof of the connecting Room II. The flat stones covered a small drain dressed by stones, and its outlet was filled with a few pieces of bronze and ceramics. Bones and tokens appeared in relation to this structure, indicating that it was an area for rituals.[50]

House 3

This structure is located on a terrace just below House 2. The building is adapted to the topography, and the conglomerate constitutes its floor, part of its walls and its foundation. The building, House 3, was excavated during 2004-2006 and consists of three rooms. As opposed to the other houses, it only has one hearth.

49 Mühlenbock 2008. 128-144.
50 Mühlenbock 2008, 54.

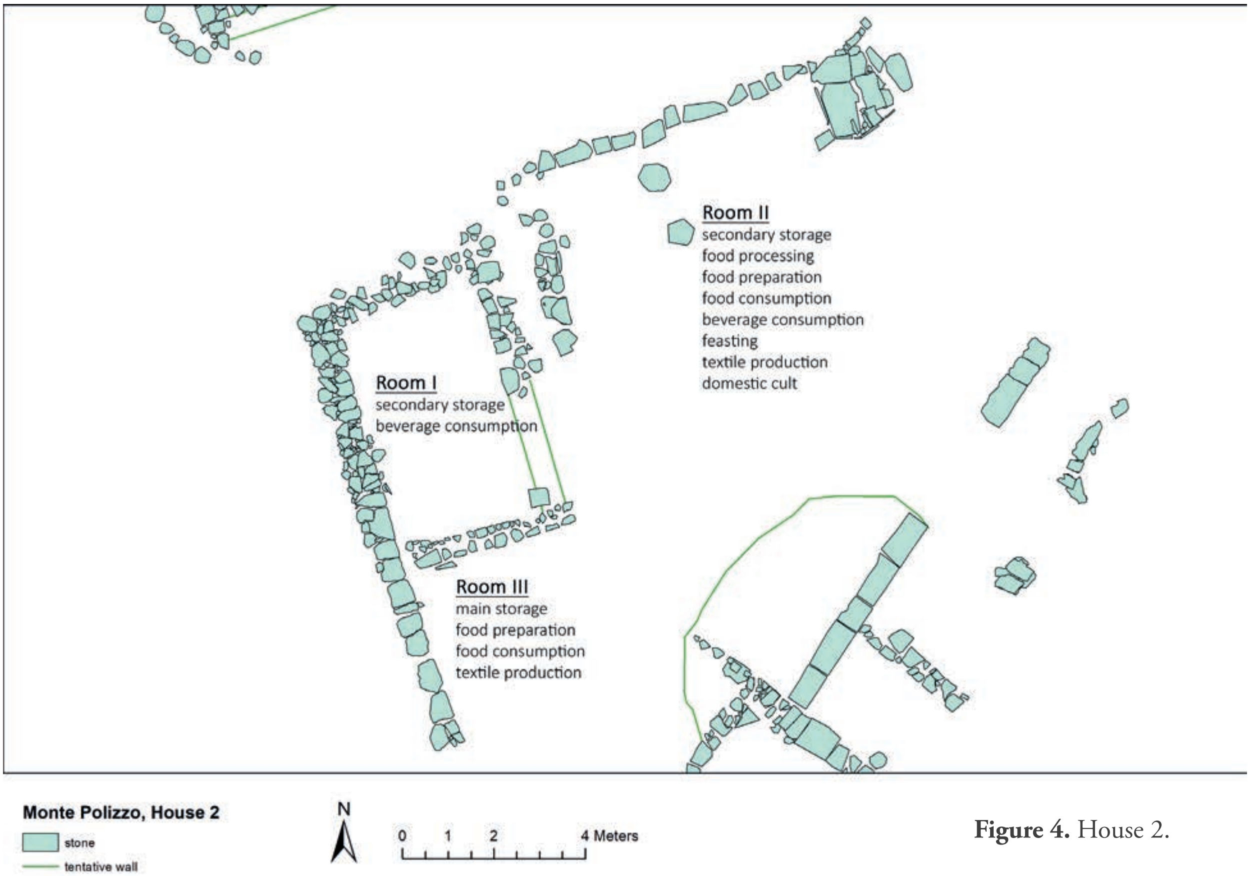


Figure 4. House 2.

One feature that really stands out among these buildings, is Room II, shaped in a semi-circle cut into the bedrock. The construction of House 3 was completed in several phases, with the semi-circular Room II the first one built. This round form is known from the sanctuary on acropolis, flirting with the Bronze Age past and its round huts. Both of these areas are inspired by a traditional Sicilian building practice. The best example in western Sicily of such structures, which constitutes of circular buildings, can be found in the habitation area of Bronze Age settlement of Mokarta. Similar Bronze Age structures are traceable at Castellazzo di Poggioreale and Montagnoli di Menfi.[51] The religious practice of manifesting traditional architecture as shared identity is evident in several other places in Sicily. The semi-circular room was eventually completely sealed off. The largest room in the House was Room I, probably built after Room II was constructed. This room was at one point divided in two by a wall. Interestingly, this wall was built on top of destruction debris, demonstrating that someone came to build it after the main abandonment of the habitation area. The semi-circular room, interpreted as a household sanctuary, was however, never reopened.[52]

Area B, House 4

Area B is located about 200 metres west of area A. This area was mainly investigated to get material references to the archaeology that appeared in area A. The structures in this area are considerably more worn and affected by erosion and mountain morphology. The building that was partly excavated here is called House 4 (B 1). It consists of one room but, considering the amount of building material scattered in the immediate area, it is likely to have had additional rooms or eroded walls from a nearby structure. The room is cut into the conglomerate bedrock, making part of the interior wall orienting

51 Sevara *et al.* 2020; Tusa 2000; Manning Urqhart 2010.

52 Mühlenbock 2008, 60.

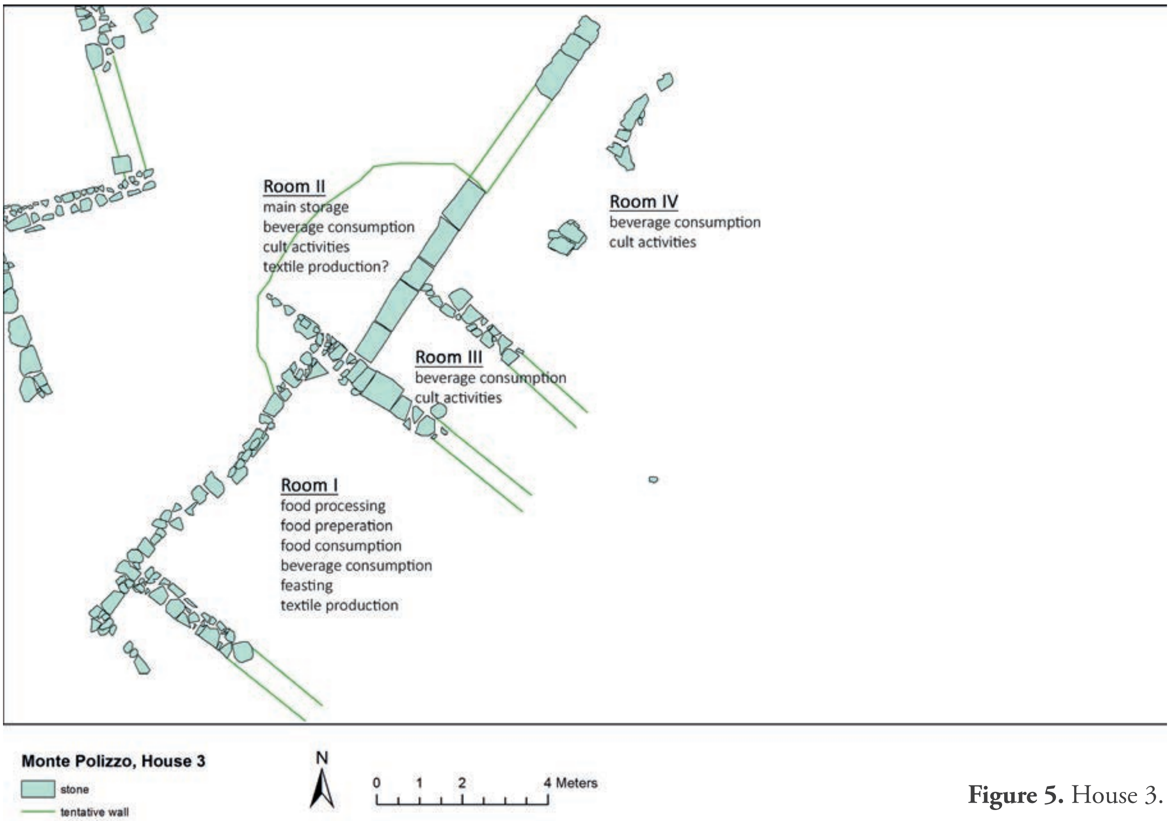


Figure 5. House 3.

northwest-southeast. This wall is abutted with two walls orienting approximately north-south, leaving the room open facing south.

The predominant find category from House 4 is storage vessels, such as *pithoi* and amphorae. These were found outside, in front of the building. The materials found insider are more varied. As in House 1, a concentration of loom-weights was found, almost stacked upon each other. The find-producing layer (ca. 10-15 cm thick) uncovered a circle-shaped location of in-situ coarse ware in the southwest part of the building. Fragmented parts of fine ware, such as bowls, pots, cups, jugs and bronze, were also uncovered as well as oil lamps and transport amphorae of Etruscan type. Together with the Etruscan amphora, an Ionic type B1 cup could date this structure to 620-580 BC., contemporary to the first phases in area A.[53]

In the same Area B, two more features were investigated. West of House 4, a structure referred to as "B 2," has been identified. This area has not produced any walls similar to the ones found in other locations on the site. However, a few distinct patterns are present in the disordered stone rubble spread out in a grid covering 64 square meters. The stone heap does have a regularity, which almost represents the shape of a quadrant, having the same alignment as the walls in House 4. There are also indications that a westward wall could have divided the plot from the neighbouring plot of House 4. Estimations, based on the amount of stones and the shape of stone rubble with a westward-slope alignment, show that the wall was probably around 1-1.5 meters high. The causes for the almost complete destruction of this wall are likely erosion and the underground watercourses that make this particular area unstable. If this wall is a divide between plots, it has no counterpart on the eastern side of the settlement, where no markers were found during the magnometry survey. No pottery or any kind of ceramic has been found in "B2".

The last structure in Area B is called "B 3." It is oriented 9 meters south of House 4 and "B 2." This structure has three walls with the same dimensions and align-

53 Mühlenbock 2004.

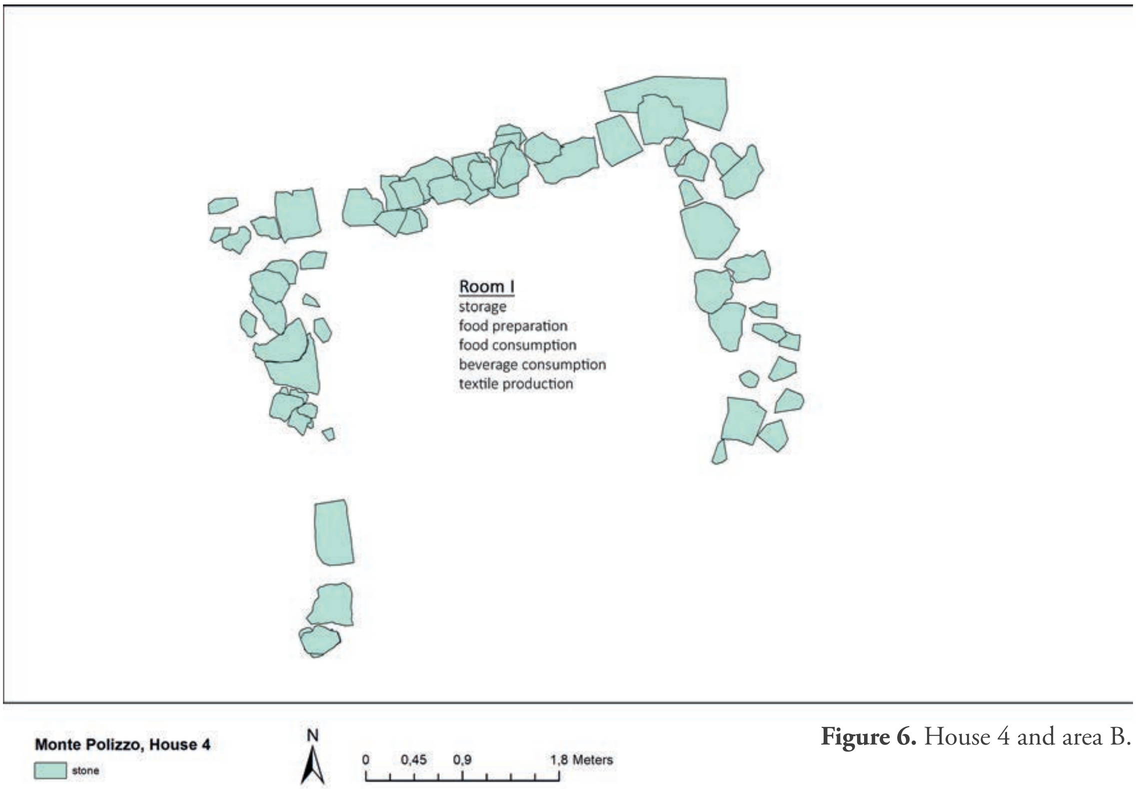


Figure 6. House 4 and area B.

ment as House 4. The area is more well-preserved than House 4, possibly due to the fact that "B 3" was built on flatter ground, further down the slope. It is likely to be contemporary with House 4, based on a rim of an Etruscan transport amphora, a fragment possibly from a Phoenician amphora, and a fragment from a B1 cup.

Area C

Area C was discovered in 2000 during the survey but was only partly excavated. It is situated almost at the bottom of the slope below Area B and covers a zone of about 20x20 metres. The slope is quite steep in this particular area and the major part of this structure was buried underneath a thick layer of soil. Further, the whole area is heavily covered with eroded building material. There are numerous walls that run in different directions. Some of the walls are substantial; one wall is almost one meter thick and runs in south-north direction. It is evident that there are several buildings at the site; however, the vast amount of building material makes it difficult to judge exactly where they are located.

A lot of material was discovered, in-situ, already on the surface, pointing towards a disturbed area. Left at the site are a vast amount of *pithoi* sherds immediately at the surface, and more continuing down into the undisturbed layer. The area contains at least four in-situ *pithoi* and one Etruscan amphora.[54]

A paved area was located in the most eastern part of the grid. The area constitutes of delicately thin stones, laid directly on the soil. Once constructed, the stones must have been properly put in place, since they easily break when put under pressure. The thin stones were found fixated immediately into one of the walls, with in-situ finds on top. This type of thin stone is only known in zone B and in building B1, where it is interpreted as slabs used as a covering on the building walls.[55] There are, however, paved areas of another kind found beside the round sacral area on the acropolis and a partly paved floor in building B1 in zone B, previously mentioned. A similar stone paved area as the one in Area C was found in front of the religious area at the indigenous settlement of Colle Madore.[56]

Excavations during 2008-2015 Area D, House 5

This house is located on the east west-fire break only ten metres to the west of House 1 and was excavated during 2008-2014. The structure was severely damaged, but it is clear that it had a somewhat different floor plan compared to the other structures. It had one large room with a stone-paved courtyard adjoined by a smaller space that was intended for storage. Contrary to the other houses, almost no storage containers were found here, nor were personal objects found in the building, such as trinkets, beads, fibulae etc.[57] A stone clad workspace was located immediately south of the house. In relation to the other houses, house 5 contained many grinding stones of various sizes.

Figure 7. Area C with pavement

54 Mühlenbock *et al.* 2004, 15.
55 Mühlenbock *et al.* 2004, 14; Morris *et al.* 2003, 173.
56 Vasallo 1999, 34f.
57 Mühlenbock and Sandström *forthcoming*.

The many grinding stones and the absence of storage vessels suggests that this was a communal space, where people met and worked together, and brought the processed grain back home or to another storage facility. House 5 also contained slag and 76 loom-weights, which may indicate large-scale craft production.[58] Just as all other houses except for House 4, this building did also have evidence of cult activity. A small *arula,* a portable altar locally produced was found in the building within the same find context as the loom weights. The *arulae* are associated with domestic religious activities, and are often found in contemporary Greek contexts.[59]

A few metres down the slope south of House 5, a flat stone structure was located in 2014. The structure consisted of large flat stone slabs forming some kind of floor measuring 3x3 metres.

Infrastructure at Monte Polizzo

The road system has been target for specific investigations by SSAP with various results due to the changing morphology of the mountain. It has suffered badly from erosion since the beginning of human occupation. Only fragments of the road system remain intact.[60]

In the first field survey in 1998, the overall aim was to get a sense of the different visible features within and around the settlement. Some potential access roads were identified, and one of these in particular passes the archaic burial ground in the southern slope of the acropolis ridge. Except for the road leading from the northeastern part of the mountain towards the acropolis, identified by Timble and Platt, the settlement was reach by at least four other roads or cart tracks. The system is believed to have reached the entire settlement, with the east west ridge as the main communication route

58 For discussion of the different types of loom-weights found at Monte Polizzo, se Mühlenbock *in press.*
59 Mühlenbock 2020, 7; Hodos 2006, 105.
60 Aspeborg and Lund 2004.

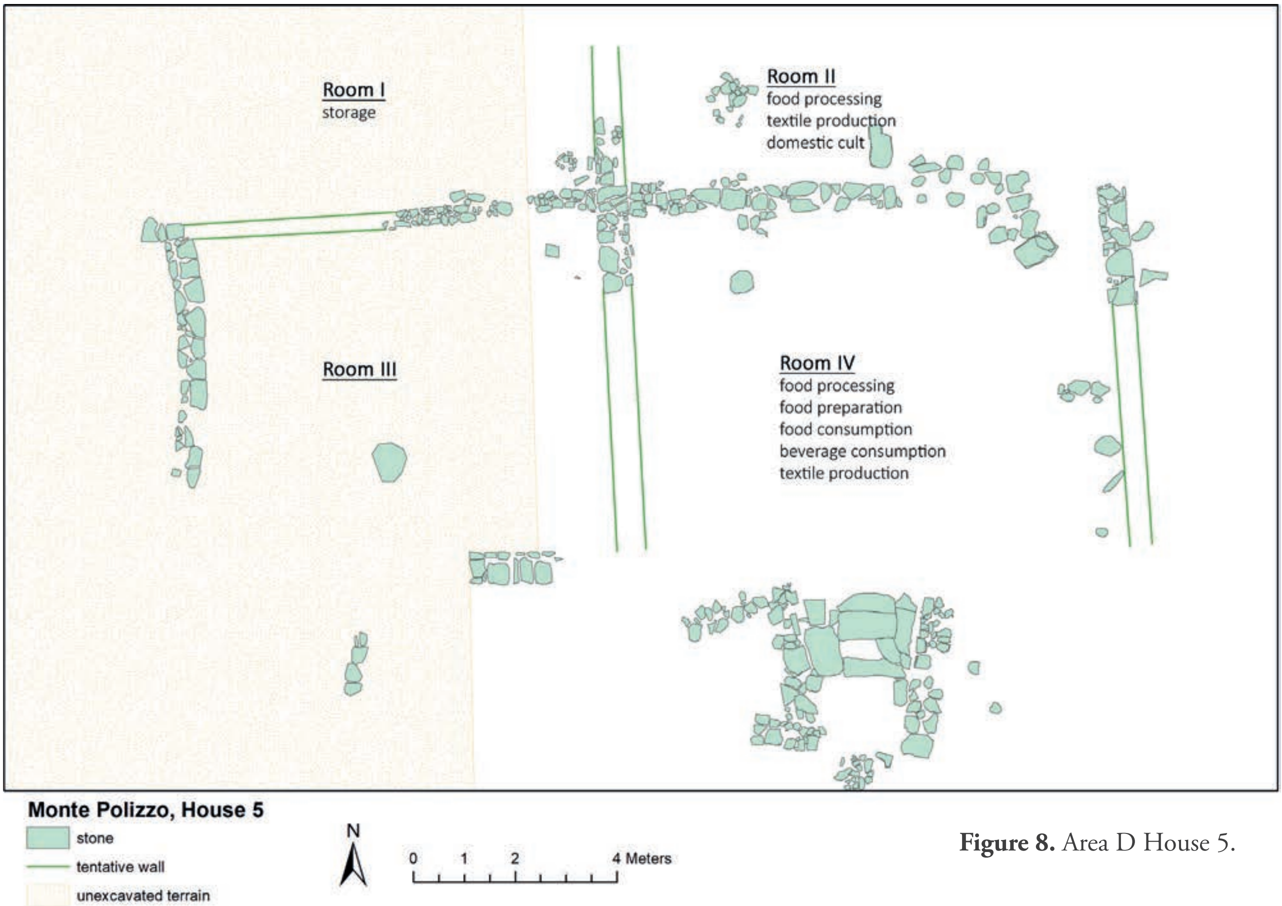


Figure 8. Area D House 5.

between the different parts of the settlement.[61] Roads and paths that followed the landscape, more than just cutting through it, were interpreted as of ancient origin.[62] The roads, particularly on the Acropolis, were presumably built during the seventh century BC. The elevation of all roads identified as archaic, were constructed to transport people and goods with the least possible effort, requiring a very low exertion to climb the hill.[63]

Monte Polizzo is naturally fortified with steep slopes. No human made fortification or defensive walls have yet been found around Monte Polizzo. This contrasts with other settlements in the region like indigenous Segesta, Monte Maranfusa, Eryx, Greek Selinus and Phoenician Motya, which all had completely or partially defensive structures put up during the sixth century BC.[64] However, semi–circular structures have been identified along one of the roads leading towards acropolis. Johansson and Prescott suggest that these features were either meeting points for people and carts travelling to and from acropolis or foundations for defence or outlook towers, suggesting that the highest point of the settlement was provided with some kind of defence structure.[65]

Concluding summary of the archaeological investigations at Monte Polizzo 1998-2015

The different archaeological investigations show a settlement first settled around the second part of the seventh century BC. The first archaic structure is found on the southern slope of the acropolis. Ceramic deposits made in the communal dump also attest the early seventh century activity. Even earlier deposits and remains of a round wall indicate that there was some kind of activity at the site already during the Bronze Age. The lack of more Bronze Age remains is probably best explained by the expansive activities of the settlers during the seventh century. During the third quarter of the seventh century, the westernmost part of the east west ridge was in the course of built up.

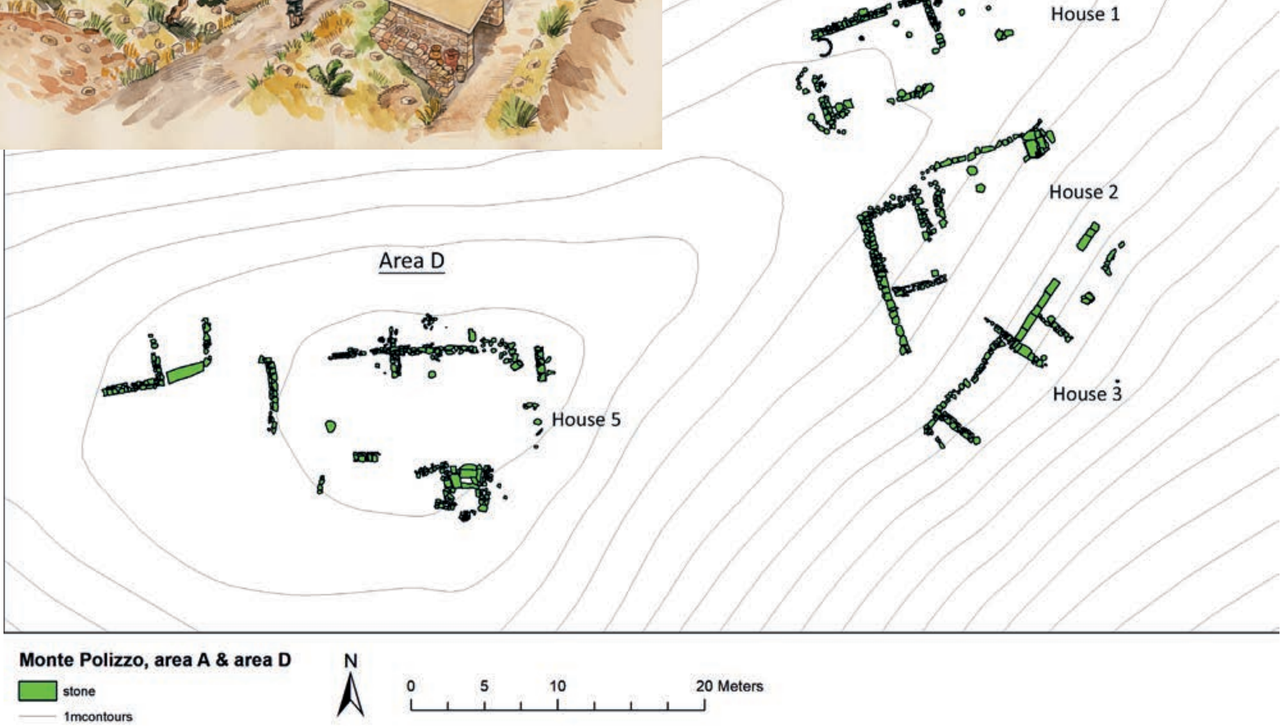
The excavated Domestic areas A and D show evidence of contemporary and similar activities in all buildings. They were, however, constructed during different periods. House 1 and 3 evolved during a few phases but were first built between during 625-600 BC, whereas House 2, 4 and 5 were constructed after 600 BC. Based on the archaeological findings, which will be contextualised and discussed in Chapters 7, 8 and 9, it is evident that households activities, weaving and spinning was performed in all contexts. House 1 and 2 are interpreted as households, but House 3 differs based on the semi-circular room interpreted as a shrine. In addition, House 2 is associated with some kind of ritual activity, based on the stone platform/altar abutted to one of the outer walls. House 5 also had other functions based on the amount of weaving equipment etc.

The domestic areas were located on the east-west ridge, on its slopes, and on the southern slope of the ridge orienting north south called the acropolis. At least five roads leading up to the main east west ridge and to the acropolis have been identified. Large wall foundations on both sides flank one road, orienting from the eastern slope leading west. This could be remains of an entrance to the settlement. Several buildings are aligned with this road, which seems to lead past the buildings excavated at Portella Sant' Anna and up to the acropolis. The only water resource known is a line of springs along the southern slope and the so-called *neve,* located 10 meter below House 3.

There is evidence of fire in all domestic buildings, and the habitation area on the western part of the settlement was completely burned down and abandoned around 550 BC. Although the buildings on the eastern part of the settlement also burned down, it is not possible to attest when this happened, since most of the buildings have not yet been excavated. However, it is likely that the whole settlement was burnt down during the same event. The religious area at acropolis is the only part of the settlement, to this date, that can show of continuous activities of this community after 550 BC.

61 Mühlenbock 2008, 35.
62 Johansson and Prescott 1999, 31.
63 Aspeborg and Lund 2004.
64 Mühlenbock 2008. 35; Spatafora 1997; Vassallo 2000; Albanese Procelli 2005; De Angelis 2003; Blake 2006.
65 Mühlenbock 2008, 35; Johansson and Prescott 2004, 34.

Figure 9. Domestic areas A and D.



CHAPTER 3

Theoretical framework and previous research

For nearly a century, archaeological theory has occupied a broad spectrum, from forms and periods to function and processes to meaning, agency and contexts. All these theories sprung forth as polarising entities.[66] The theoretical point of departure in this work is multi-layered. We often define a human society by cultural, political, economic, technological and social constructions. Nature plays a prominent role in all of these constructions. Understanding the relationship between people and their environment and between people with each other *within* a changing environment is of crucial importance before considering other dimensions that comprise a society. I will therefore apply a theoretical framework to this study that acknowledges the Human-Nature balance with a dynamic Non-linear adaptive system theory. The encounters between the Elymians and all the different peoples residing in western Sicily will be viewed though Middle-ground theory. This theory sprung out of a study of a colonial encounter between Europeans and indigenous Americans during 1650-1815. To apply this theory to the ancient societies in Sicily, it is important to set that theoretical approach in a wider context. A general discussion of the terms 'colonisation' and 'colonialism' and the use of the term 'colony' in an ancient context is also required.

I will also address the notion of trade and exchange networks and how I believe this was set into action within the archaic Mediterranean region.

The chronological sequence of this study is by the emergence and abandonment of the Monte Polizzo habitation areas. I am thus aiming to study a snapshot of history--about seventy-five years according to the archaeological evidence. The archaeological backdrop reveals houses and their material cultures, which all have generally the same chronology. We cannot see longer chronological sequences and changes in the inhabited part of the settlement, nor is it possible to perceive a cultural *longue durée*. In a way, we enter the settlement and its short history *in medias res.*

Greek and Indigenous visibility in Sicilian Archaeology

Mediterranean and Sicilian archaeological research has developed in close relation to modern classical studies. For nearly a century, the focus of Mediterranean archaeology has unquestionably been Greek colonisation, specifically colonial city-states and their elevated art, architecture and town planning.[67] The concept of the seventh-century *apoikía* as a fixed and founded city-state is evident and non-questionable.

Burgers exemplifies this by emphasising the Sicilian Greek settlement of Megara Hyblaea. It has long been viewed by scholars as a colony that, from its foundation in the late eighth century BC, had systematically subdivided *insulae* with public areas and private plots.[68] New

66 Nijboer, 1998, 24.
67 Burgers 2004, 253; Dunbabin 1948; Snodgrass 1987; Boardman 1964.
68 Burgers 2004, 262; Danner 1997.

research shows that the archaeological evidence does not support the theory of a city already completely built by the eighth century. What is archaeologically attested, however, is the beginning of a street network in the sector around the agora and on the southern plateau. The houses found on the western plateau suggest an extension of the site during the seventh century.[69] Because the notion of already fully formed Greek colonial city-states during the eighth century, it is easy to sometimes forget the complete context of these establishments. It actually took some hundred years both for Megara Hyblaea and for Selinus to settle properly to what we generally define as a Greek colony. During those hundred years, many negotiations among generations of Greeks and indigenous inhabitants occured, although this is rarely emphasised. Burgers hits on a key point when he argues that the formation of a Greek *chora*, for instance, makes the Greek context disproportionally visible compared to an indigenous territorial expansion that is more modest in the local material culture.[70]

It is difficult to understand ancient territorial boundaries, especially given the scarce information on how indigenous groups occupied their landscape. Burgers' point gets highlighted in De Angelis' discussion about the Selinus territorial boundaries when it becomes evident that the indigenous peoples are extracted from the territory in western Sicily. De Angelis concludes that, based on "indications in ancient sources, the western extent of this (read Selinus) territory seems to have been situated along the river Mazaros, beyond which is likely to have lain the Phoenicio-Punic territory controlled by Motya"[71]. Apparently, he does not consider that the Elymians could have controlled the territory around the Mazaro River, which has its headwater below Monte Polizzo. Nor does he provide any information where he found these "indications in ancient sources". De Angelis, in another article, concludes that we "do not know the exact sizes of the territories around native Sicilian communities in this period, such territories were most certainly small, in the tens of square kilometres in size in all likelihood, a day's walk to and from the centre to the edge." [72] He further states, "However much native Sicilians may have dreamed of owning and exploiting the island's landscapes beyond their immediate villages, it would seem indisputable that they could have only used and legitimately laid claim to a fraction of the available land in Sicily at the time" during the eighth century BC.[73] Interestingly, De Angelis makes these statements in relation to a discussion about land abundance in Sicily during this period in history. Why indigenous people would have needed to legitimately lay claim to available land in their own landscape goes, unfortunately, without explanation. As does, the question to whom they would have needed to lay these claims. The underlying assumption is, naturally, to the Greeks—even if they were not yet present on this part of the island.

Archaeological research about the indigenous regions seen from their 'own' perspective in the Mediterranean areas with Greek presence have consequently not been in fashion. It is also evident in the way we discuss these regions from a Greek perspective as the 'non-Greek' regions that they were (and still are by some) considered both socially and culturally underdeveloped.

Greek migration, colonisation and overseas settlements

The material culture at Monte Polizzo reveals a broad variety of imported trade goods, such as fine ware and transport amphorae, all evidence of a flourishing trade relation between the Elymians and their Greek and Phoenician neighbouring settlements. There is a continuous discussion amongst scholars about the diverse terminologies commonly used in classical scholarship to define ancient Greek and Phoenician overseas settlements. To distinguish these settlements we often use either *emporion*, *apoikíai* or 'colonies.' The choice of term defines not only the settlement proper but also the perception of it and its inhabitants' actions. These definitions reveal,

69 Tréziny, 2016, 172.
70 Burgers, 2004 275f.
71 De Angelis 2000, 133.
72 De Angelis 2010, 31.
73 De Angelis 2010, 32.

in effect, the way scholars view not only the Greeks and Phoenicians in relation to their indigenous neighbours but also how they view the indigenous peoples' relationship to their new neighbours.

The *emporion*, for instance, is a trading station or settlement with a primary focus on trade. It has a distinct economic function and is generally neither self-sufficient in terms of agriculture nor in control of the neighboured hinterland,[74] which often is instead believed to be organised by the locals. The *emporion* differs from the 'colony' in many aspects. Deriving from the Latin *colonia*, 'colony' is a term with connotations that have continuously changed over the centuries.[75] In anthropology, history, archaeology and postcolonial studies for example, colonialism, just as with culture, has become one of those common concepts where there is a general consensus regarding its importance but little agreement about its precise definition.[76] *Colonia* found its way during the fifteenth century AD in to the Greek contexts as a synonym for the Greek *apoikía.* Unfortunately, this also brought the overtones of Roman imperialism into the context.[77] The term 'colonialism' often intersects with 'imperialism' and 'colonisation'—each with equally fluctuating definitions.

Imperialism for example, can function as an umbrella for the whole spectrum of relations regarding a dominant power and subject societies. Within that spectrum, colonisation comprises a situation where the dominant group resides as a large population in the subject territory, while colonialism is synonymous with control exercised by a small alien group.[78] The small-yet-important distinction between colonisation and colonialism in an ancient context is debated, where the former term implies people moving to new places and whose norms and values set the new standard in their new overseas communities. Even though there is an interest in the people in these new settlements, the overall focus is in the broader processes that is habitually is colonisation, rather than colonialism. From this perspective, the term colonisation is more active and more concrete and emphasises the actual colonial settlement itself.[79]

Most scholars generally accept the use of the terms colony and colonisation, when discussing the emergence of the Greek overseas settlements during the eighth and seventh centuries BC. Dietler argues for instance that even though he recognises the deeply rooted connotations, you are certain to be misunderstood if you chose not to use these established terms since they are so generally accepted in modern parlance. However, he concludes that one must maintain "an ever-vigilant self-conscious wariness of the traps of implicit fusion and the dangers of anachronism."[80]

Osborne argues the contrary, that most scholars use the term 'Greek colony' as if just affixing 'Greek' before 'colony' removes all unwanted connotations. Colony is not a technical term one can chose to use randomly on overseas Greek settlement and, if someone would like to use the word, it should be with intention and with all its real-life associations and consequences.[81] Osborne highlights an important question when he asks, why do we have a habit of talking about 'Greek colonies' rather than 'Sicilian colonists from Corinth'? He believes it is intentional, an assertion of cultural superiority by focusing on where the settlers came from rather than what kind of communities they formed. This is a problem for modern scholarship when the vocabulary of ancient authors is translated into the language of modern colonisation, just as the term *colonia* mentioned above.[82]

Other examples can be found with the term *apoikía*, which generally in modern discussions implies a settlement politically tied to mainland Greece. Modern scholars refer to these settlements when the Greek *colonisation*

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74 Hodos 2006, 19.
75 Dietler 2010, 17. Note 43.
76 Dietler 2010, 15.
77 Hodos 2006, 19.
78 Dietler 2010, 15; Fieldhouse 1991.
79 Van Dommelen 2002, 398.
80 Dietler 2010, 18.
81 Osborne 1998, 252.
82 Osborne 2016, 23; Hodos 2006, 19.

is discussed, but ancient writers rather describe Ionian and Dorian *migration*.[83] Osborne uses Herodotus to straighten his arguments and notes that Herodotus is not using *apoikía* as a marker for a political culture. Instead, he used it to define ethnic belonging. When Herodotus is identifying people of a certain settlement, which they have built up, he is doing so to help explain their ethnographic or cultural habits. For example, "those who joined the campaign from the Black Sea are *apoikoi* of the Ionians and Dorians" with a shared ancestry (Herod. 7.95.2.).[84] The Black Sea Dorian and Ionian *apoikíai* established during the eighth century BC were 'home away from home' where Dorians and Ionians *apoikoi* had *settled* not 'a home away from home' Dorians and Ionians had *founded*.

Colonisation implies political unity and identity: a political body can issue territorial ownership and citizenship, as the Roman colonies did during the later empire. At this time, eighth to seventh century BC, there were no political unities or states to take such decisions; *apoikíai* were not yet created by 'mother cities' to achieve particular state aims. There is simply no evidence before the fifth century BC of the political term 'mother city' or colony, and the relationship of settlements from which men had migrated to settlement to which they have migrated.[85]

Osborne has been widely criticised for his arguments generally and for his conclusion that "A proper understanding of archaic Greek history can only come when chapters on 'Colonisation' are eradicated from books on early Greece".[86] Irad Malkin argues against what he believes is an approach to not only deny the terminology of colonisation but also the existence of Greek colonisation. He further argues that it *is* right to discuss Ionian migration during the Dark Ages but, from 750 BC., the proper terminology for overseas movement is colonisation. That includes the existence of a bond between mother cities, *metropoleis*, and colonies, *apoikíai*.[87]

This is a complicated yet interesting discussions of Greek migration and colonisation, which De Angelis paraphrases Braudel in calling 'a symphony of the deaf'. In other words, a debate that he believes without a doubt has had a detrimental effect on the advancement of knowledge.[88] In this work, it is important to recognise the discussion since this work represents a search for a deeper knowledge about indigenous Sicilian inhabitants through the lens of the Sicilian Greek historical record. And because the archaeological record is not yet sufficient. It is obvious that the general scholarly approaches to the relationship between the Greeks and the indigenous inhabitants in western Sicily during the seventh century BC is not always in balance. Neither is the visibility of the indigenous population in the overall encounters, both in modern literature and in the archaeological contexts. I am therefore using the term 'settlement' as a neutral term when I am discussing the Phoenician, Elymian and Greek settlements in focus in this study in order to create some equilibrium in the Archaic western Sicilian context.

Peoples in their new environment

Several postcolonial theoretical models have emerged which attempt to understand and illuminate indigenous populations' relation to, for example, Spanish or French colonialism during the sixteenth century AD and onwards. These models try to understand the relations between coloniser and colonised. And, they attempt to incorporate indigenous negotiations of colonial processes.[89]

However, the often-used term acculturation, for example, implies that identity or culture was a fixed form influenced by the meting and mixing of various types of other fixed forms, i.e. other cultures.[90] However, in the ancient context, the construction of the *polis* and the construction of the colony or *apoikía* was in a way

83 Malkin 2009, 373.
84 Osborne 2016, 22.
85 Osborne 2016, 24.
86 Malkin 2016a, 31; Osborne 1998, 269; Hodos 2006; Dietler 2010.
87 Malkin, 2016a, 25.
88 De Angelis, 2016, 98.
89 Trabert 2017, 19. See for instance Dietler 2010; Groover 2000; Paterson 2011; Godsen 2004.
90 Hodos 2006, 17.

a reciprocal affair. They developed simultaneously during the eight century. [91] This implies - it is important to acknowledge for the overall discussion of cultural adaptations and assimilations between indigenous and Greek populations - that it was not an already fixed Greek culture that founded these overseas settlements during these periods in history.[92]

Influenced by World-system theorists, Chris Gosden divides colonisation into three forms applicable to all societies from the era of Mesopotamia and onwards.[93]

The first is 'colonialism within a shared milieu,' a colonial relation between a state and a non-state society. It is not military power that defines this type. The limits of colonisation are defined by the area over which a particular culture is shared or spread. This type is distinguished by power relations played within pre-set norms of behaviour.

The second form is in *terra nullius*, defined by asymmetrical power relations between 'coloniser' and 'colonised' leading to mass appropriation of land and, often, the total destruction of existing social systems.

De Angelis sees *terra nullius* as the commonly applied to archaic Sicily by modern scholars. The traditional view among many is that the Greeks superior cultures causing the physical destruction and a complete assimilation of the indigenous inferior cultures.[94] Mühlenbock also highlights this in a quote from Erik Sjökvist from the 1970's:

> The excavations at Morgantina have taught us that certain fundamental principles can be traced unchanged even on the small acropolis in the mountains, situated far from the coast. The language was Greek, social and political systems, as far as can be judged from extant architectural remains, was Greek, the art was Greek, although it revealed many features showing its peripheral position in the Hellenic world. In Morgantina, at least, all this did not exclude the fact that a certain social and economic- and possibly also political cooperation was conceded to the indigenous Sicels. The Sicels transformed themselves rapidly and on their transformation became conformists. In their fields of art and architecture, no traces of indigenous influence are revealed.[95]

The last type of encounter Gosden believed could define the colonial relationship was in the so-called 'middle ground'.[96]

'The middle ground'

When Richard White first established the concept of middle ground in his study *Great Lakes region of North America* (1650-1815), he defined the idea as a spatial metaphor. The space he was discussing conflated with what he called a 'process of misunderstandings'. As he put it, the middle ground:

> …is the place in between: in between cultures, peoples, and in between empires and nonstate world of villagers… On the middle ground diverse people adjust their differences through what amounts to a process of creative, and often expedient, misunderstandings. Peoples try to persuade others who are different from themselves by appealing to what they perceive to be the values and practices of those others. They often misinterpret and distort both the practices and values of those they dealt with, but from these misunderstandings arise new meanings and though them new practices – the shared new practices of the middle ground.[97]

White identified specific elements necessary for the establishment of a middle ground. These included a rough balance of power limiting either side from forcing the other to change and a desire or a mutual need of what the other party possesses. The crucial element is mediation, since a middle ground cannot be maintained by force or violence.

White's middle ground was not created as a theoretical tool. Instead, it was a metaphor for how colonial situations could be worked out and how cultural misunderstandings led to transformative practices.[98] And yet, middle ground has evolved into a tool. It is often applied

91 Malkin 2016b, 289.
92 Hodos 2006,17.
93 Gosden 2004.
94 De Angelis 2010, 28.
95 Mühlenbock 2018, 14; Sjökvist 1973, 68.
96 Gosden 2004, 26.
97 White 1991, XXVI.
98 White 2006, 10.

to an actual location with the aim of understanding complex encounters between indigenous peoples and newly established ones.[99] Sanctuaries are such places where middle ground is frequently suggested to have emerged.[100]

What I believe is a key point in this model, a point which connects perfectly to my own point of departure, is the context of the encounters between the different peoples in White's study. The context was not the destruction of Indian peoples of later periods, nor vast territorial conquests, it was the long periods of when no single dictating authority existed in the areas of investigation. During the short period of interest in this work, in the region between Monte Polizzo, Motya and Selinus where I believe no dictating authority existed, a *i* emerged. Through these encounters, local or regional networks were formed, with many important links to long-distance Mediterranean networks.

Nature, environment, and dynamic Nonlinear adaptive system theories

Up to now, our theoretical discussions have focused on our perception of ancient social constructions and interactions between people, now defined as a middle ground. However, such parties also had to relate to the environment they were facing, whether known of old or as a new experience. The natural landscape played an important role in several spheres of society relative to the aim of achieving sustainable development. Such a goal demanded various technological solutions for survival and economic profit. To claim or maintain control of the landscape, people had to form suitable ideology, either to maintain or recreate a sense of communal spirit, a spirit working unconsciously as the glue in a given habitat.

In the 1960's and 1970's, the evident need for a more scientific approach to archaeology, inspired by natural ecological systems, influenced ideas of culture as a system. System thinkers including Clarke, Binford and Renfrew described the model like an organism comprised of different subsystems, all working in unison to keep the whole in equilibrium.[101] Inspired by ecological adaptive systems, Binford for example, argued that humans adapt though culture in an extrasomatic fashion. And that this system allows the analysis of how people as a group adapt and respond to a changing environment.[102] Processes were also a central part of the new archaeology. Now, instead of asking *when* a new pattern emerged on pottery, the questions was about the process by which craft development or trade networks emerged and how given artefacts could relate to them.

System theory's mechanical view of culture and its functional and processual explanations was widely criticised from the outset.[103] Functionalism did not explain why a culture changed just that it was changing at that specific period of time. In system theory, the individual was rarely present. In this fashion, individual thinking did not suffice to start cultural development of any kind. People in a specific society were seen as a body, reacting in unison to external stimuli. As such, external factors were always required to trigger cultural change.[104]

Nonlinear system theory

The dynamics of Nonlinear system theory and the complex adaptive system, or complicity theory, evolved in parallel to the processual school of thought. Essentially, this study acknowledges the fact that all systems are in dynamic disequilibrium and do not act in a predictable manner.[105] Opposed to processual thinking, nonlinear behaviour means that the actions of one single agent or a subset of agents in any system do not need to be in proportion to the behavioural response of the complex adaptive system. An agent may act individually and set off a flow of interactions among other agents that changes the entire system, or on the contrary, a group of agents set off a different action that has little or no lasting effect

99 Trabert 2017, 21.
100 Malkin 2011.
101 Clarke 1978; Binford 1964; Renfrew 1973; Flannery 1972.
102 Binford 1964.
103 Crumley 2005, 40; Shanks and Tilley 1987; Giddens 1984.
104 Johnson 1999, 75f.
105 Crumley 2005, 35.

on the system's behavioural path. Within this system, the same action made by the same agents may not trigger the behavioural system the same way twice. Predictions of systemic responses are therefore difficult to foresee.[106]

Implementation of a Nonlinear dynamic adaptive system model

The forces of nature and rhythms of life in Antiquity were closely linked to the rural calendar, with Hesiod's *Works and Days* the most distinguished example. Winter storms, spring floods and summer droughts are all important elements of the Human-Nature relationship. The effects of such events needed to be dealt with in the everyday life. Many concepts and theories have developed out of interdisciplinary studies in which human-environment interaction is investigated.[107]

To set the Monte Polizzo settlement, its environment, inhabitants and their actions in a theoretical framework, I am following a model where a dynamic balance exists between natural and cultural systems. The contexts of the archaeological material culture from Monte Polizzo clearly show a society where economy, nature and ideology were closely interwoven. It is therefore obvious to choose a theory with a holistic approach, through which I will view the settlements and its different engagements. In line with my own thoughts, with this model, all subsystems, such as techno-economic, socio-cultural or ideological, are given equal importance. (They cannot be separated from one another in a well-functioning societal construction.) Human reactions to different changes in a society do not happen mechanically. "Causation" is best viewed as "the result of a multitude of interrelated processes, none of them having dominance over the others and therefore making prediction difficult".[108] The theoretical framework evolved by Gumerman *et al.* in their inter-disciplinary study of the *Anazasi* culture on the American highlands, shows how an adaptive dynamic nonlinear system model can be effectively applied.[109]

The Anasazi model consistsof three variables applied to relate the perhistorical human adaptation and reaction to changing environmental conditions on the Colorado Plateaus. The three groups of variables considered are environmental, demographic, and behavioural. These variables are in turn related to the concept of carrying capacity, defined as "the maximum human population that can be permanently supported by a given economic system under particular environmental conditions".[110] Instead of trying to measure the environment as a static object that virtually is impossible to quantify in any archaeological situation, it is used as an integrative variable since it can rapidly increase or decrease its capacity depending on the other variables in the system.[111] There is rarely equilibrium in the Human-Nature relationship. In fact, disequilibrium is probably the natural state between the carrying capacity of the environment and the humans who live in it.[112]

In this model, the three variables mentioned above are emphasised, but other variables can be applied depending on the society under analyses. The model is balanced with boundaries, every variable adapting or reacting within its space. When one variable is stressed to the point of violating the boundaries that regulate the system, changes can occur and imbalance between population and resources must be adjusted by behavioural responses. That requires the society define new carrying capacity thresholds and create a new adaptive system. Hence systemic culture change evolves.[113]

Environmental variability is categorised by two different processes: 'low-frequency variability' and 'high-frequency process.' The former is identified by environmen-

106 Crumley, 2005, 15.

107 See (for instance) Wiman *et al.* 1998; Meyer and Crumley 2012, 111-112, for the concept of Historical Ecology and how complex adaptive systems is used within their toolbox. See (also) Balée 2006; Folke 2006; Izdebski *et al.* 2016; Walsh 2008, for other theories regarding human-environment interactions.

108 Gumerman 1988, 24.

109 Gumerman 1988.

110 Dean 1988, 26.

111 Dean 1988, 28.

112 Gumerman 1988, 13; On carrying capacity, see (for instance also) Winch on Malthus 1987; Kallis on Malthus 2019; Boserup 1990; Soby on Malthus and Boserup 2017.

113 Dean 1988, 28.

tal developments that follow time periods longer than twenty-five years, equivalent to one human generation. Such phenomena could be, for instance, erosion, sediment depositions or altering river courses. The overall social and economic adaptions in a society are made against the backdrop of the environmental conditions established by low frequency variability. Humans do not necessarily recognise and respond to these environmental variabilities immediately, if ever, and these slow-going fluctuations are likely to be perceived as normal stability until the environment is altered enough that a human response is inevitable.[114]

High-frequency processes occur on shorter timelines such as year-to-year climate variability, differentiation in crop outcome or variations in wild food resources.[115] It is more likely that these shorter environmental processes are recognised at an early stage since people respond differently to them. The most important factor for people to persist living in a given settlement is how close the system is to its carrying capacity. Is it possible to make short-term adjustments and temporarily expand farming areas or to increase the exploitation of wild plants? High-frequency environmental processes can be mitigated year-to-year if the population is well below the local carrying capacity. However, if these environmental fluctuations are prolonged, if a catastrophic event occurs, or if the population has grown closer to carrying capacity, the entire system can suffer serious effects.[116]

Demographic variability has generally been viewed as an important cause of culture change.I It is the second factor highlighted in the Anasazi behavioural adaption model. Behavioural practices related to population growth--expansion of agricultural land for instance--is seen as a way to raise the carrying capacity of an area.[117] Demographic variability is also divided in high- and low-frequency processes. The definition of a low process is how population size develops over fifty years or more (two generations). The high-frequency process can occur in temporary variations on the general population trend and can have the effect of altering general demographic development. Population growth is easier to foresee than low environmental fluctuations. However, if no action is taken to expand productive exploitation on site to match a future need, both low-frequency demographic variations and low-frequency environmental variations have the same eventual effect of lowering the carrying capacity on a site. When the population variable is approaching its balancing threshold, the more problematic it is if a high-frequency environmental fluctuation occurs and the buffer zone between population need and carrying capacity radically declines.[118]

In this behavioural adaption system, the cultural or behavioural factor is divided into the two earlier applied frequencies. As mentioned above, adjustments in a society are made by lower cultural frequency and by cultural buffering to cope with the given environmental variations at that particular site. Such an adjustment could be a "safe-fail" agricultural system of planting crops in both a riverbed and on surrounding slopes. If a strong flood caused harvest failure in the midstream area, crops planted at the margins flourish and vice versa.[119]

There are various behavioural adoptive strategies in the high-frequency cultural variability which allow any society to cause systemic culture change. If the adaptive system stretches enough and a threshold is within reach by demographic and or environmental variations, high-frequency behavioural variability can act as a buffer for near-term problems. This can be achieved by intensification of the agriculture of high yield variations of food plants, water and soil control, multi-cropping, and engagement in "safe-fail" farming strategies in fluctuating landscapes--all responses made by high-frequency behavioural adaptions.[120]

The final consideration of the behavioural-adaption model are factors presented as behavioural responses to stress in systems in disequilibria and how those responses

114 Dean 1988, 30. Se for instance Bonnier and Finné 2020, on climatic variability and socio-economic changes.
115 Dean 1988, 30.
116 Soby 2017; See Bonnier and Finné 2020, for Human-environment interaction in Northeastern Peloponnese.
117 See for instance Josephson *et al.* 2014. ; Krautkraemer 1994.
118 Dean 1988, 32.
119 Wiman and Faegersten for example of safe-fail system 1998, 429.
120 Dean 1988, 35.

create new organisational culture changes. Systematic stress can, according to this model, in the worst scenarios lead to settlement or society dissolution, where smaller units organise themselves in smaller areas or where smaller units emerge within larger, more highly organised societies. High-frequency behavioural responses to stress not only lead to changes in food procurement, but they can also require changes that put pressure on higher organisational skills, requiringin turn more people to be responsible for the society's interests. Factors that would have (re)organisational requirements include warfare and trade, for example. Trade is, in Gumerman's model, seen as a high-frequency adaptive response to systemic stress. Trade is needed to adjust the balance and to secure a buffer for future stresses on carrying capacity. [121]

The setting of the present study is special in many aspects. As explained at the beginning of this chapter, we enter this study in *medias res* the earliest archaeological layers of the Monte Polizzo settlement testify to an already ongoing trade of products deriving from all over the Mediterranean. Contrary to the Anasazi society, trade is not understood as a necessary cause to avoid a societal stress in order to sustain the Monte Polizzo settlement's carrying capacity. I acknowledge trade as a behavioural response to surrounding environmental and cultural changes in the broadest sense. However, societal stress could very well be the reason why the new-founded Selinus settlement engaged in the local trade network negotiated in the middle ground.

The holistic and fragmented Mediterranean

Although many classical scholars during the twentieth century argued for a split East-West Mediterranean highlighting the Graeco-Roman culture, Braudel wrote *La Méditerranée et le monde méditerranéen à l'époque de Philippe II* in 1949[122]. Opposed to the German school of thoughts as a leader of the *Annales*, Braudel reconfigured space by putting the Sea (in fact, the many seas) at centre stage, blurring the boundaries between East and West. Braudel's work emphasised geography, temporality, and the different spheres and wavelengths of time. The aims of historical research of the Mediterranean should not be political. Instead, he advocated for a socio-economic view, where the whole Sea shared a common destiny with common problems and consequences together with the conjunctions of long environmental rhythm, which he famously called the *longue durée.* [123]

Braudel did not believe in "the traditional geographical introduction to history that often figures to so little purpose at the beginning of so many books, with its description of the mineral deposits, types of agriculture and typical flora, briefly listed and never mentioned again, as if the flowers did not come back every spring, the flocks of sheep migrate every year, or the ships sail on a real sea that changes with the season".[124] According to his philosophy, a historian needed the knowledge to sail a ship or to understand techniques of ploughing or the effects of environmental changes as much as doing research in a library.[125]

Braudel's work on the holistic view on the Mediterranean region stood alone for some time; classicists were not too keen on revising their own research nor in relating to a holistic Mediterranean when the East–West divide was generally unquestioned. During the last few decades however, there has been a renaissance in the engagements with long-term pan-Mediterranean studies, or *Mediterraneansim*, what Harris calls "the doctrine that there are distinctive characteristics which the cultures of the Mediterranean have, or have had, in common"[126].

Several large books have been published with the aim of providing a Mediterranean context such as Grove and Rackham's *The Nature of Mediterranean Europe: An Ecological History*, Abulafia's *The Great Sea*, Horden and Purcell's *The Corrupting Sea*, Broodbank's *The Making of the Middle Sea*, and Manning's *The Open Sea.*[127] All

121 Dean 1988, 36.
122 Braudel 1949. The English version *The Mediterranean and the Mediterranean World in the age of Philip II*, published 1972.
123 Broodbank 2013, 18; Braudel 1972, 14; Morris and Manning 2005, 15.
124 Quote cited by Murray in Braudel 2001, xiii.
125 Murray 2001, xiii.
126 Harris 2005, 1.
127 Grove and Rackham 2001; Abulafia 2011; Horden and Purcell 2000; Broodbank 2013; Manning 2018.

of these books have a long-term perspective and, even though most of the authors provide a context for the relationship between economy, trade and the physical environment, they do not necessarily view the Mediterranean as a unity.

The most notable example of an opposite outlook to Braudel's environmental and economic *longue durée,* and long major distance navigation routes that connected the most important cities in the Mediterranean, are Horden and Purcell. They blur the importance of cities and advocate for local and micro-local levels of an extremely fragmented region. Instead of long environmental time lapse, they see short-term dramatic climatic instability as a primary reason for communication and 'connectivity'. As with the Anazasi model described above, Horden and Purcell believe that shortage of food, mono-crop culture and other shortages of resources forced regions or microregions to seek contact with others i.e. short distance exchange, to be able to maintain their levels of subsistence.[128]

Network and connectivity

The view of long-distance maritime traffic and of the Mediterranean as a highway with "sea lanes" and "routes" and "maritime zones of influence" is quite common among scholars. There is also a tradition put forward by Vallet and later Morel of regarding colonies, or over-seas settlements, as "strait colonies". They believe that pairs of colonies were founded deliberately, within a generation, across from each other on maritime straits. For instance, Rhegion and Zankle at the strait of Messina, Pantikapaion and Phanagoreia in the Crimean Borporos, or Cartage and Motya, just to mention a few. Establishing these settlements was a way of guaranteeing that the networks of long-distance routes were in play. [129]

Network theories that address maritime connectivity and its economic implications in archaeology are well explained by others, but Malkin has successfully employed the "small-world" dynamics for the Greek identity in the ancient Mediterranean world. [130] Networks are, according to social-network analysis, always growing, adding nodes, and creating new paths.[131] A basic principle is that local nodes are related or interlinked by connections or 'ties'. What passes between the nodes along the ties are 'flows'. Ties are either weak and less socially involved or strong ties and more socially involved. Weak ties exist in a 'low-density network' and are seen as a crucial link between the strong nodes of densely knit clusters of strong ties.[132] A social system lacking weak ties will not evolve and will stay fragmented, whereas a network that has the 'strength of weak ties' will extend and develop to large networks. Malkin exemplifies this with the Mediterranean region and the Black Sea, where the Greek settlements and their neighbours had a dynamic connectivity. These nodes were micro-regions and were tied only to the adjacent nodes.[133] The weak ties were the long-distance links between the micro-regions, thus creating larger connectivity network regardless of the long or actual distance.[134]

There is no doubt of the existence of long-distance trade networks connecting costal settlements along the Mediterranean and the Sicilian shores during the seventh century BC and onwards. The different settlements of western Sicily region can be seen as nodes in one of several micro-regions connected by the long distance overseas trade, but more interestingly in the context of this work is the micro-regional network in form of the short-distance maritime traffic of *cabotage*[135] Cabotage is a direct response to the morphological differences of the Mediterranean coasts. Natural ports like deep inlets facilitate navigability, countless islands provide trade

128 Horden and Purcell 2000, 123, 263; Bresson 2016, 80.
129 Malkin 2011, 153.
130 Collar 2013, 22-37; Collar *et al.* 2015; Tartaron 203-211; Malkin 2011, 25-41; See Granovetter 1973 for "The strength of weak ties" though which Malkin enabled the "small-world dynamics" Kowalzig 2018, 96-97.
131 Kowalzig 2018, 96.
132 Malkin 2011, 25-27.
133 Malkin 2011, 27.
134 Kowalzig 2018, 97.
135 Horden and Purcell 2000, 140.

opportunities, while fractured coastlines and steep cliffs make harbouring large ships difficult.[136]

Cabotage was not controlled by any institution, so this kind of connectivity opened up a market with more actors participating in different exchange networks. The local populations were not necessarily, as generally assumed, in the hands of the 'colonising' Greeks if they wanted to obtain imported goods.

In a similar, mode Horden and Purcell argue that cabotage united warriors, pirates, diplomats, pilgrims and traders in cargoes of any kind and were thus "the basic modality for all movements of goods and people in the Mediterranean before the age of steam."[137] Whatever the goods of high- or low-value carried by the caboteurs, they could easily connect with the western Sicilian inner landscapes utilising small vessels and potentially navigate further up rivers in order to connect to the networks of the Elymians.

136 Kowalzig 2018, 101.
137 Horden and Purcell 2000, 365.

CHAPTER 4

Geomorphology of western Sicily

Much of the paleoenvironmental work that has taken place in Mediterranean landscapes - were wetlands, such as rivers, deltas, lakes and marshes[138] are prominent - has an overall focus on the description and explanation of environmental changes and circumstances. The aim is not only to acknowledge that both nature and people can be considered as agents of certain environmental processes, such as vegetation clearance and erosion, but also to understand the connection between the ancient peoples and their environment.[139]

As this study will show, Monte Polizzo with its topographical position in the area, and the hydromorphological nature surrounding the settlement, is clearly a favourable place to settle. Four rivers originate from the mountain area, some of which humans have altered throughout history by straightening meandering sections or building damns in order to take charge of the rivers' stream.

One of these rivers, the Mazaro, is by nature a victim of stream capture, and its lower reach was once turned into marshland. The same river is today an object of the *Marrobbio* "mad sea phenomenon," sea oscillations, between Mazara del Vallo and Cape Bon in Tunisia. At times, it has devastating effects on fishing boats, when the oscillations are destroying the fleet against the edges of the harbour.[140] This phenomenon can be perceived as especially non-favourable conditions for harbouring, however, the oscillations can in fact be one of the reasons for why this estuary still has not silted up as many other rivers in the western part of the island.

Another hydromorphological feature which must have had some impact on people's lives, is the large karst area situated between Monte Polizzo and Segesta in the modern town of Vita. Based on the karst geomorphology, these landscapes were the breeding ground for the formation of the particularly fertile *terra rossa* soil worked by the ancient farmers. Such formations were also a prominent landscape backdrop in ancient Greek mythology.

Methodological framework for the environmental studies

To understand our ecological past, we need to focus on dirt. Soil not only helps us understand past societies by preserving traces of material culture, soil is also an ecological record of our planet through time. Often forgotten in archaeology, as a source on its own, soil is a physical

138 Definition of wetlands according to the Ramsar Convention for the Protection of Wetlands (Articles 1.1 and 2.1) "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres [.....] and may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands".

139 Walsh *et al.* 2017, 446.

140 Candela 1999, 2227. The Marrobbio, or 'mad sea phenomenon' is also called 'meteorological tsunamis' and is characterised as a regional gravitational phenomenon which is trapped to the local topography.

medium in which you find the most fascinating and complex interaction between the biosphere, lithosphere, hydrosphere and atmosphere. This is evident for example in the paleobotanical record found in the sediment analyses.[141] Indeed, soil is one of the most important features in searching for how people understood their landscape and how they engaged with all the elements that comprised their environment.[142]

However, archaeologists have only recently become interested in the “dirt” itself, rather than seeing it only as something to shovel away in order to get to more important matter.[143] The study of soils and other elements of the mineral world, such as stones, ores and minerals, often conducted with methods and theories derived from natural sciences such as geology, has evolved into the archaeological sub-discipline geoarchaeology, through which, as an overall approach, I have chosen to view this study.[144]

In the broadest sense, the primary components of geoarchaeology are aspects of geological and geomorphological environment, the paleoclimate, and the flora and fauna.[145] It offers a complementary dimension to archaeology, where modern scholars acknowledge the environment as more than just a backdrop to the ancient inhabitants. Instead, through the study of various aspect of physical landscapes and physiological processes through time, it can provide a deeper understanding of how and why the environment has affected ancient sites and the people living in them. The environment is thus an equally important factor as social constructions, religious and economic interactions. The following four chapters are therefore dedicated to various environmental components that I believe will provide deeper understanding of why the Elymians settled at Monte Polizzo and how they managed their subsistence. This approach is also in line with the theoretical view applied in this work, presented in the previous chapter.

The specific data that refers to the geological environment of the Monte Polizzo area, and the catchment areas of the rivers draining Monte Polizzo, is based on the geomorphological study conducted by John L. Berry in the Monte Polizzo River Report, if nothing else is referred. This report was commissioned to evaluate river navigability in the Monte Polizzo area, on the behalf of this study. See further presentation of this report in Chapter 5 and Appendix 2. No soil coring or other geological investigations have been applied in this study. However, to understand the different aspects of geomorphology presented in the report, a geomorphological landscape study around Monte Polizzo was conducted during the summer of 2016 with the guidance of John L. Berry.

The paleoclimate and ancient ecology is discussed based on published palynological reports of studies conducted during the last couple of decades in the area of investigation, see Chapter 6. The flora and fauna is understood though the paleobotanical and osteological studies conducted by SSAP, see Chapter 7 for further discussion.

Environmental temporal and spatial perspectives

Another methodological subject this study, like all studies that engage in landscapes and human, rests on is the issue of scales.[146] To integrate different types of paleoenvironmental data with archaeological evidence it is necessary to consider and assess both the spatial and the temporal scales operating in the frame of the study. Usually in geoarchaeological studies, rather than specific events, long-term environmental processes are highlighted.[147] For instance, these often include long-term studies of changing topographies due to sedimentation, erosion, or coast migration. On a spatial scale, archaeology can match human responses to these environmental changes, such as movement of a settlement due to river migration or flooding. During this short period of interest in

141 Evans and O´Conner, 2001, 13.
142 Walsh 2004.
143 Boivin 2013, 165.
144 Boivin 2013, 165; Walsh 2004.
145 Brown 1999, 45; Butzer 1982, 35-42; Rapp and Hill 1998, 2.
146 Walsh *et al.* 2017, 402.
147 Walsh *et al.* 2017, 402.

the present study, from about the seventh to the sixth centuries BC, one cannot speak of specific long-term environmental events to which the people of Monte Polizzo and their neighbours had to respond. However, in rare occasions, as this study will show, short-term environmental events or changes can be pinpointed and correlated with the archaeological timeframe specific to this particular context.

The Geomorphological context

The pre-historical landscape of Western Sicily cannot only be understood by analysing the present environmental settings. Although not all landscape details change with every change of economy and land-use through time.[148] In the quest to understand the ecological and environmental context of Sicilian history and the role of rivers in an ancient society, one must first recognise the geomorphological settings. The diversity in geomorphology and topography in the Mediterranean region generally and Sicily specifically is a key component for regional and local differentiation in weather conditions and ecological circumstances.[149]

Western Sicily is distinguished by its variety in sedimentary sequences, tectonic activities, and peculiar geological, geomorphological, and topographical settings with rocks, landforms, and landscapes.[150] It is partly underlain by evaporites, which are water-soluble

148 Rackham and Grove 2001,13f.
149 EEA 2002, The Med. Bio.reg., 7.
150 Di Maggio *et al.* 2017, 88., Basilone 2018, 1.

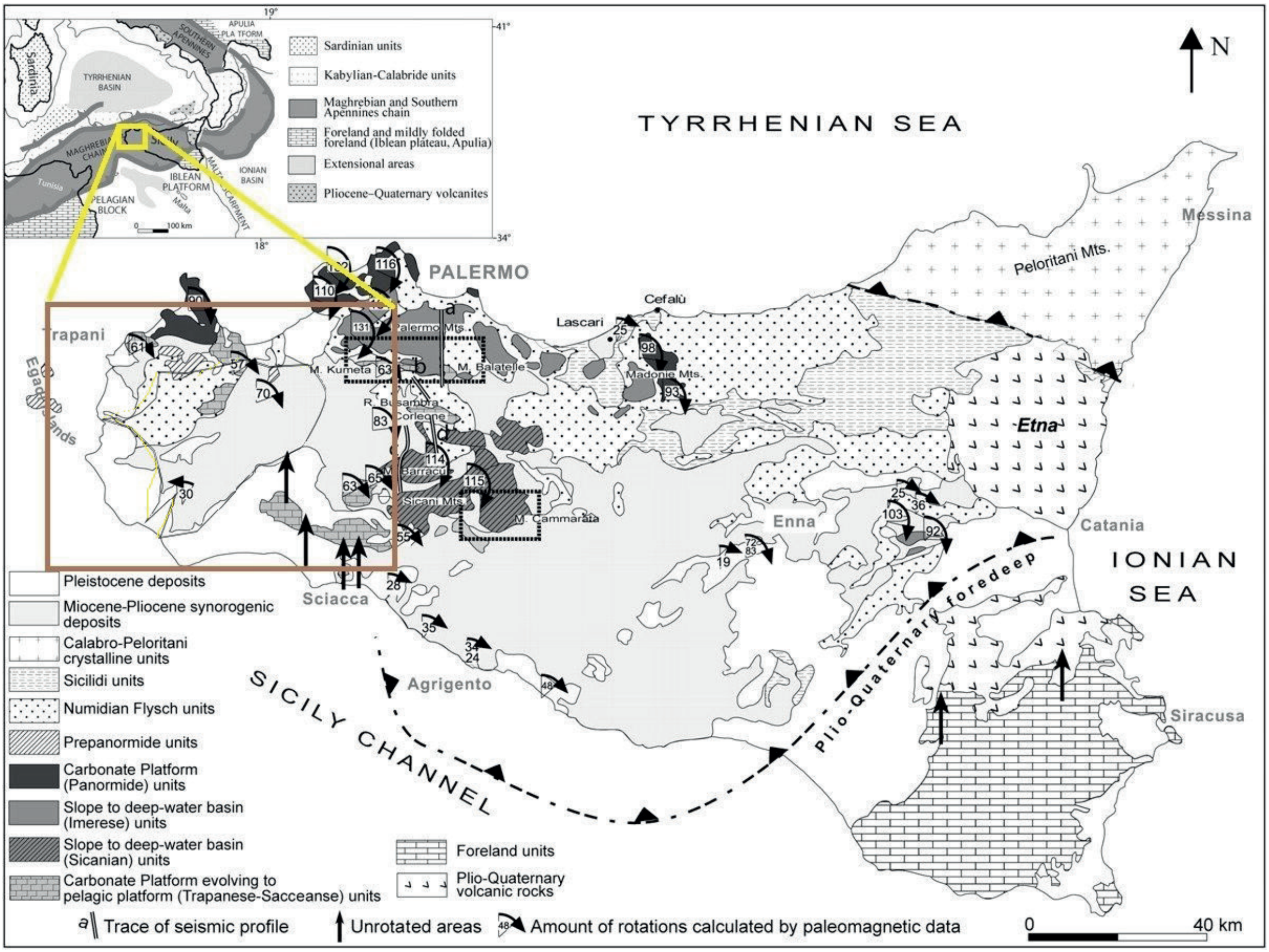


Figure 1. Geological map of Sicily. J.L. Berry

mineral sedimentary rocks, created by evaporation and crystallization of salt and limestone, which is composed mainly of calcium carbonate. Sicily's topography and geomorphology exhibits all of the geological diversity present in the Mediterranean; which is why it is, in fact, an essential area to study in order to understand the complex history of the region as a whole.[151]

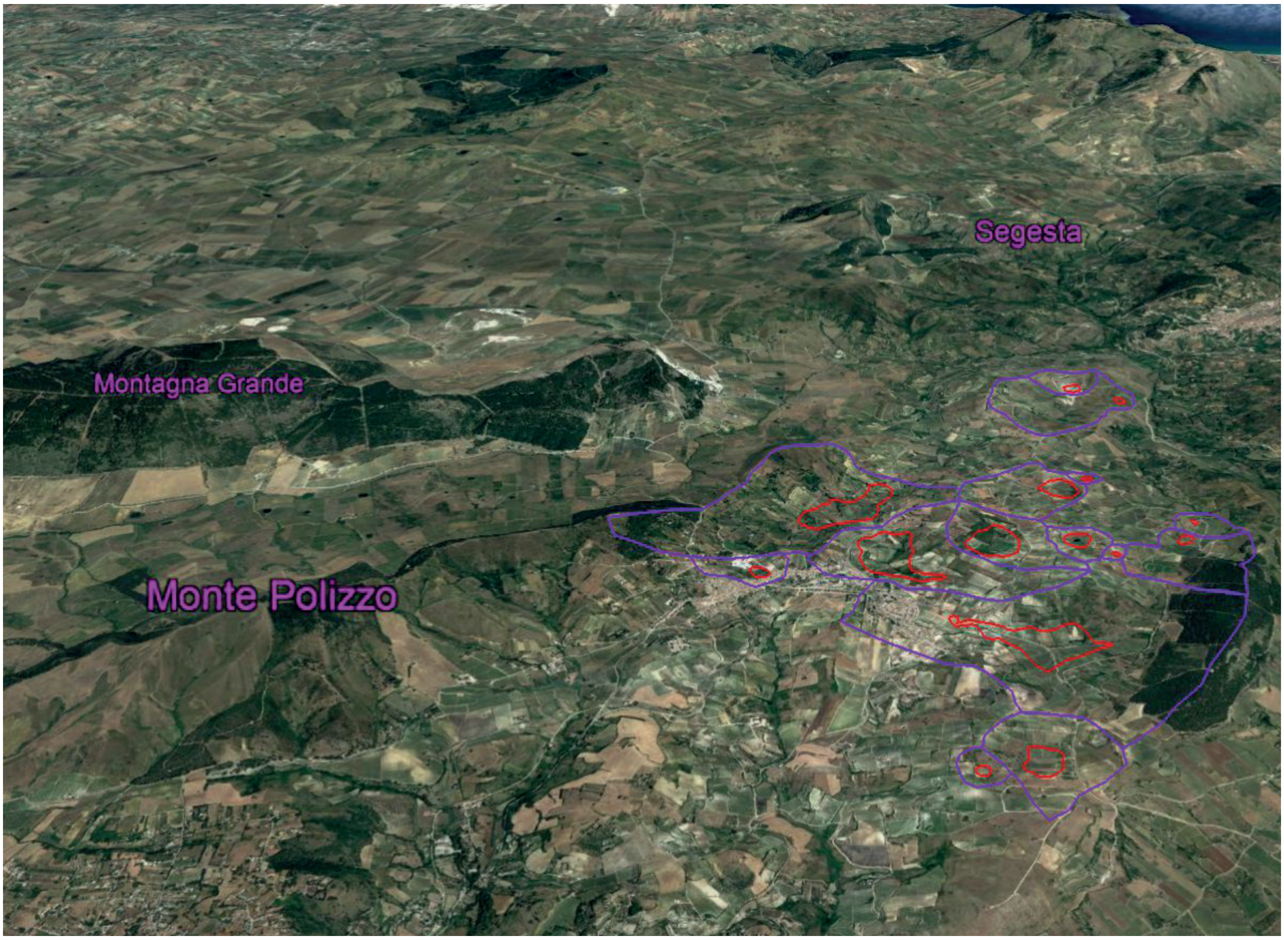
Monte Polizzo itself is composed by conglomerate of the Upper Miocene Terravecchia Formation, which represents a major sediment period throughout Sicily.[152] Conglomerate is also sedimentary rock classified as terrigenous clastic sedimentary rock, i.e. clasts derived from the land and often transported in rivers; most conglomerates are old riverbeds or beaches.[153]

The karstic landscape in the Monte Polizzo area

In many Mediterranean areas, karst landscapes are widely distributed. It dominates a large part of the Greek peninsula, Crete and the Aegean islands, western coastal Anatolia, the Balkans, Magna Graecia and Libyan Cyrenaica.[154] In Sicily, karst areas are evident locally around the Madione Mountains, north of Syracuse, the south-central area, at Palermo and east of Monte Polizzo.[155] The geological features that, since the 18th century, we

151 Basilone 2018,1; Di Maggio *et al.,* 2017, 80.
152 Heinzel 2004, 17; Heinzel and Kolb, 2011, 100.
153 Berry Personal communication.
154 Clendenon 2009, 251.
155 Di Maggio *et al.* 2011.

Figure 2. Karst area between Monte Polizzo and Segesta. Dolines identified and mapped by J.L. Berry.



call karst landscapes were in some aspects well-known by Greek writers during the time when the ancient peoples of this study were traversing their landscapes and for many centuries to follow.[156]

Generally, karst topography is a geomorphological product characterised by chemical, physical and biological processes, which eventually results in dissolution of surface and subsurface rocks, causing a ground-surface collapse.[157] East of Monte Polizzo around the modern town of Vita lies an impressive area of karst topography, developed on Messinian evaporites. Here, the karst landscapes were formed when the surface rocks of Sicily were thrust, by the convergence of Africa and Europe, from the north across these evaporite deposits, brutally deforming them and pushing them closer to the earth´s surface.[158]

When evaporites are close enough to the surface they are exposed by rainwater and dissolve rapidly, forming underground channels and caves. Dolines form when the evaporite caves collapse and they become surface depressions in the landscape. The karst area of Vita is situated in between Monte Polizzo and Segesta. The whole area features 15 dolines/depressions, with a total area of c 11 km².[159]

Depending on their formation, the depressions when located below a mountain, can form springs and can serve as an excellent source for fresh drinking water. Crouch argues that during the eighth- to fourth-century BC, the

156 Biswas 1972.
157 Clendenon 2009, 251.
158 Berry 2016; Basilone 2018, for those who wish to indulge in Sicilian lithography.
159 Berry 2016.

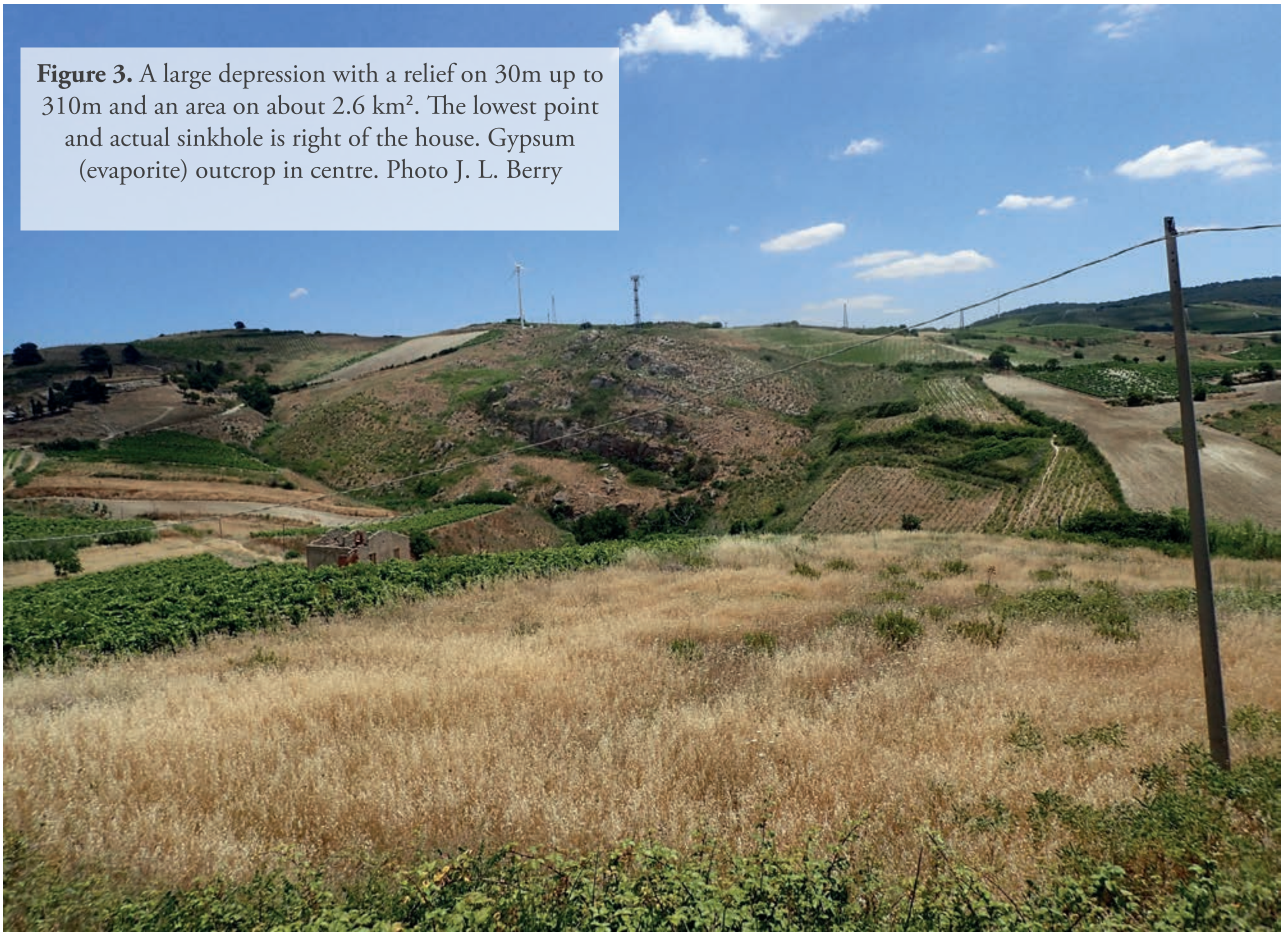


Figure 3. A large depression with a relief on 30m up to 310m and an area on about 2.6 km². The lowest point and actual sinkhole is right of the house. Gypsum (evaporite) outcrop in centre. Photo J. L. Berry

colonising Greeks, in their search for potential places to settle, deliberately went looking for karst terranes which they had learned to manage in their homeland.[160]

In this area, the largest depressions have streams within them that usually end at a grove of trees, i.e. trees free or nearly free of undergrowth. All the rainwater falling onto this area disappears into underground passages to large springs at lower elevations. The water could travel kilometres before it resurfaces again. Which streams profit from the extra water is impossible to say.[161] Berry suggests that the groundwater from Vita most likely travels north because of the ground level and because the streams slope more steeply north than they do south. The very deep circulation of groundwater could explain the hot springs on the Caldo River below Segesta.[162]

The environmental complexity in the landscapes of Monte Polizzo is evident. Caves, sinkholes, groves of trees that mark where the water disappears underground in dolines, rivers and mountains, marshes and forests can all also be found in the repertoire of the ancient Mediterranean religious landscapes.[163] Even though special features in the ancient wilderness were sacred, they could also be considered ominous and an unsafe place for humans. However, in this dramatic topography and changing climate, as opposed to a uniform landscape, the contexts of every cultural and social environmental outlook could certainly be different from one another.[164]

Soils of western Sicily. Palaeosols and Terra Rossas

Palaeosols are important indicators to consider in the search for evidence of past climate and environmental changes.[165] The thickness and degree of compaction of soil cover is extremely important in providing base flow in rivers, thus a central variable to consider in this study.[166] Different soils form on different rocks and different crops and/or natural vegetation thrive in different soils.

Palaeosols were generally formed on past landscapes and mostly on sedimentary rocks during the Tertiary Period or during the tropical conditions of the earliest Quaternary c. 2.5 ma (million years ago).[167] Palaeosols can provide detailed insight into ancient landscapes and their evolution. Their spatial distribution can reflect the different forms of ancient landscape. They can be indicators of landscape stability. And based on the geomorphic past processes operating in them, they can give us indications on previous climate conditions present during the soil formation.[168]

The palaeosols developed widely in the karstic landscapes western Sicily area with high internal drainage and on limestones and marls. They are traditionally called *Terra Rossas,* but are also technically known as Chromic Luvisols[169]. A characterisation of terra rossa soils is that they are relatively well-drained, although heavy and clay-rich.[170] Terra rossas are very fertile, but do not blanket the bedrock in a continuous fashion. Instead, the thickness can easily range from a few centimetres up to several meters, due to karstification of the underlying rock surface. Generally, one can assume thicker soils on soft marls and thinner soils on hard limestone.[171] In the mountainous areas in western Sicily where the landscape is dominated by limestone outcrops and where the karst landscapes are prominent, due to erosion, accumulated thick terra rossas with clayey texture have been found

160 Crouch 1993, 66.
161 Berry 2016
162 Berry 2016.
163 See (for instance) Edlund 1987; Brewster 1997; Clendenon 20099; The ancient perception of nature will be a subject for further research.
164 Horden and Purcell 2000, 411.
165 Hall 1983, 130.
166 Berry 2016, 20.
167 Durn 2003, 84.
168 Kraus 1999, 40; Heinzel 2004, 33.
169 Constantini and Dazzi 2013.
170 Vingiani 2018.
171 Berry 2016.

in karst depressions and between beddings in limestone cracks.[172]

There are many important aspects to consider choosing a place to establish a settlement. As mentioned in Chapter 2, archaeological evidence of Bronze Age human presence at Monte Polizzo is plentiful and, even though there is not much evidence of their presence nor a continuity to the Iron Age, it is clear that this mountain was a favourable place to settle. The previous sections have established that the geomorphology in the area was creating thick layers of soils, rich in humus. This information increases our understanding why the Elymians choose to live in these landscapes.

Next, we must understand the ecology and climate. What type of vegetation nourished these rich soils? What can the pollen record show us in terms of land use, vegetation, and climate in the area? This information is not only vital to understanding the possibilities for a settlement to sustain its subsistence but equally to assessing river navigability, all of which will be discussed in the following chapters.

172 Bellanca *et al.* 1996, 58; Durn 2003, 83.

Figure 1. Rivers draining Monte Polizzo west

CHAPTER 5

Rivers as possible trade and communication routes

The karstic landscape at Vita described in Chapter 4 was not only the backyard for the Elymians at Monte Polizzo. It was also a landscape that had to be traversed, either by a river or by land, in order to reach further inland. The easiest way to reach Segesta from the western coast, for instance, was to follow the river Arena Délia Grande from the coast moving northeast up to Monte Polizzo, bypassing the karstic landscapes and continuing along the valley of the river Caldo. The Monte Polizzo area feeds four rivers: the Caldo runs to the northeast; the Cúddia Birgi and the Mazaro run to the west; and, the Grande Délia Arena to the southwest. These rivers--and what they potentially offered in terms of connectivity--must have been one of the most important factors the Elymians considered when they decided to establish the settlement on Monte Polizzo.

Geological approach and the methodology of river assessment

One aim of this project is to assess the navigability of the rivers draining the Monte Polizzo area and how the ancient Sicilians could have transported themselves and their goods. Sicilian rivers are usually acknowledged as a main alternative of ancient communication routes between inland settlements, but their navigability is rarely if ever questioned.[173] Frisone argues, for instance, that instead of sailing around the island to other Greek settlements along the coast, the Greeks used the river mouths as harbours and the river systems to travel across the mountains from coast to coast, establishing connections with the inner landscapes along the way.[174]

In order to get a geologically valid evaluation of the rivers and their navigability in my area of investigation, I commissioned a study from geologist John L. Berry, who agreed to evaluate the rivers draining the Monte Polizzo area. Initially, my focus on river navigability concerned the Mazaro River with its outlet through modern Mazara del Vallo. However, the three other rivers sourced in the Monte Polizzo area are equally important to evaluate; Berry added the two of these to his report. The river Caldo was factored in since the focus in this work is foremost between Monte Polizzo and its coastal neighbours. Berry received an initial field report with calculations of the Mazaro riverbed made for my benefit by my colleague Anders Blomqvist during our field season on Monte Polizzo in September–October 2015.

The questions I sought to answer with the river study were:

1. Were the rivers navigable during the Iron Age and Monte Polizzo's occupation (c. 630-550 BC)?
2. Were they wide and deep enough to carry small boats or rafts?
3. Is it possible to evaluate if there was a place along the middle courses of the rivers that was broad and deep

173 Se for instance Bianchi *et al.* 1984, 10; Frisone 2012; Crouch 2004; Di Vita 1996; Mertens 1996; on their approach on the Sicilian rivers.

174 Frisone 2012, 96.

enough for docking, loading, and unloading--i.e. a trading post?

Answers to these questions would partly answer one of the main questions in this thesis: What was the role of rivers in terms of connectivity and transportation routes between Monte Polizzo and the coasts?

Methodology–river assessment

A complete account of the methodology applied by Berry to calculate the navigability of ancient rivers and his use of Manning's equation, an empirical hydrological formula relating current speed to hydraulic radius, stream gradient, and channel roughness [175] is found in Monte Polizzo River Report Appendix 2. An overview of important variables to consider when assessing river navigability is provided below.

Understanding a river's morphology over time requires considering several fundamental aspects including the river's gradient, water volume, and persistence of its base flow. These variables control the river's width, depth, and the velocity of its flow. The gradient of a river depends, in turn, on the lithologies over which it flows, tectonic activity, and the rivers' age. A stream profile matures by becoming more and more smoothly concave upwards. It means that the stream works its way head-wards (backwards) to its source located at the most elevated area. Thus, the stream becomes steeper and narrower the closer it gets to its headwater, the quantity of water decreases. In its highest reach, the mature river becomes too steep, too narrow, and the water flows too fast for it to be navigable. [176]

Much can change during a river's life: in these western Sicilian landscapes the rivers were once strongly meandering but have now been canalised and straightened. Since these human alterations change the gradient, width, and depth--all of which reduce navigability--calculations must thus be made to estimate by how much river courses have been shortened. For Berry's calculations of this, see p 14 in appendix table 2.

To calculate river gradients, the rise in elevation is measured in metres rise in elevation per horizontal kilometre in relation to the distance from the river's mouth to its source. Berry plotted the gradients and stream profiles with 100x vertical exaggeration. The plotted profile is divided into short segments that are left disconnected. This method is applied to be able to understand different changes in stream channels. Sharp changes in gradient in a stream profile are known as 'knickpoints.' They represent a discontinuity or sharp change in gradient. A waterfall is an example of a knickpoint. The steep change in gradient at the point of 20 km mark of the Mazaro is another.

To calculate navigability, a lower limit of channel size must be set. Berry has arbitrarily taken the smallest navigable channel as one 2 metres wide and 0.87 metres deep, and the fastest navigable flow as 2.5 ms-1 (5.6 mph, or 1 ½ times a brisk walking speed). A narrow boat roughly the size of a canoe, about a metre wide and 50 centimetres deep, could pass through such a channel in the downstream direction.[177]

In channels of this size, vessels used in cabotage for instance could be dragged upstream if needed to meet demand or create new trade opportunities. Cabotage will be discussed further in Chapter 9.

A stream can be arbitrarily divided into 'reaches.' A reach can, for instance, be a section of a river that shares similar hydrologic conditions such as depth, gradient, or discharge. It can also refer to a particular length of a stream with varying hydrologic conditions. In this study, the rivers are divided into lower, middle, and upper reaches. The lower reaches are estuaries and coastal plains. The upper reaches are the headwaters near Monte Polizzo. And, the middle reaches are the areas in between.

Another important variable in calculating navigability is 'hydraulic radius'. Hydraulic radius controls the amount of water discharge and its ability to move sediment. The hydraulic radius R is defined as the ratio of the cross-sectional area of the flow, A, to the length of the wetted perimeter P (the area of the stream bed/

175 Barnes, 1967.
176 Berry 2016, 5; Brown 1997, 320f.
177 Berry 2016, 8.

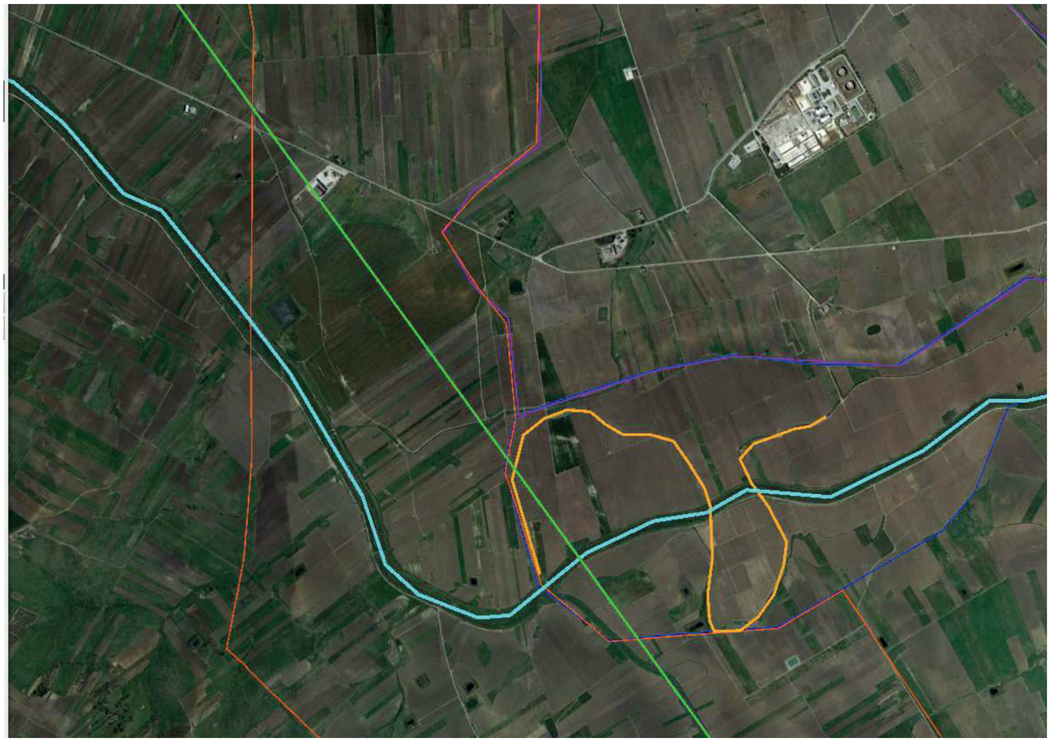


Figure 2: The extreme degree of shortening in part of the Cúddia valley, as well as outlining of old meanders by land-use boundaries. J. L. Berry.

Figure 3. River profiles of the Mazaro, Cúddia and Arena Délia Grande. Digitalised by T. Ekholm after drawing by J. L. Berry.

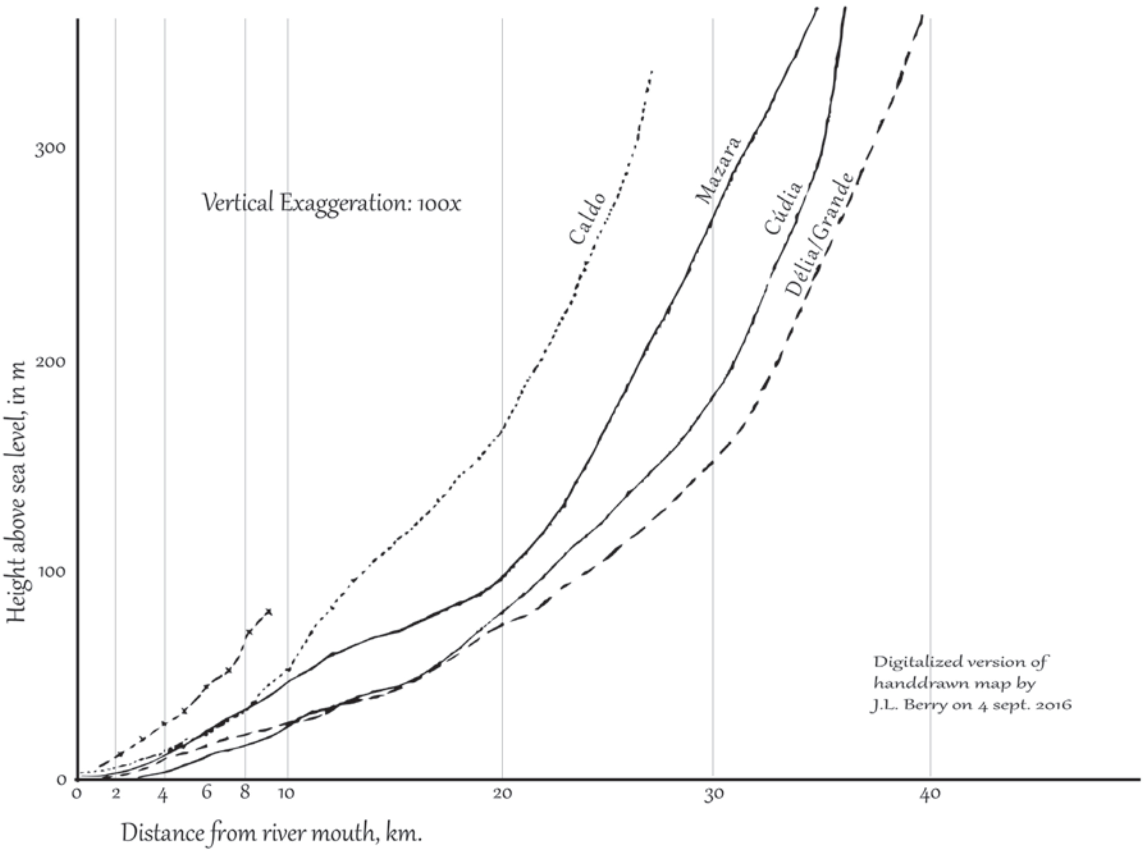


Figure 4. Boat in Portugal serves as an example of the size of boat used to calculate navigability. Provided by J. L. Berry.

bank which is constant in water). Thus R=A/P (R equals A divided by P).[178]

Channel shape is a crucial variable to calculate hydraulic radius. An arbitrary channel shape, for instance circular, trapezoidal, rectangular, or square can be used for such purposes. In curved stream reaches--as many reaches of the rivers in this study show--a triangular channel cross-section is typically chosen.[179] However, these channel shapes are only representative of the lowland reaches with vegetated channel beds and banks consisting of clay or sand. They are not representative of the upland streams on rocky beds, which tends to be wider and shallower. For the main body of calculations in this study, Berry therefore used examples of real stream shapes found in Barnes 1967.[180]

Water volume

There is prominent variation in the mean annual precipitation and temperature on the island. It ranges today from the north-eastern mountainous area facing the sea from about 1500-1700 mm with an annual temperature of c. 8-10oC to no more than 350-500 mm in the southern coastal area with a mean annual temperature of c. 18-20oC.[181] The paleo-climate data reveal substantial regional differences between the uplands and coastal vegetation, which can be explained by the difference in precipitation. While the evergreen *Quercus ilex- Olea* forests expanded around 5500 BC in the coastal areas, the uplands had already been covered with deciduous-evergreen mixed forests for three millennia.[182] The correlation between precipitation and forest cover is evident not only by comparing the coast with inland, but also by comparing the south-western coastline with the south-eastern one. The Gorgo Basso area was more densely forested during 5000-850 BC than the lake Biviere di Gela located in the south-eastern part of Sicily, for instance, although both areas had forest expansion during this period. Since the annual rainfall is 650 mm near Gorgo Basso but only 350 mm at Biviere di Gela, precipitation offers an explanation for varying forest evolution. Tinner points out that even the drought-resistant *Quercus ilex* requires an annual rainfall of at least 400 mm.[183]

Iron Age precipitation

To calculate the flow of a river to the Iron Age climatic conditions is, as Berry recognises, an approximation. To assess navigability, rainfall variation cannot be ignored in a climate such as Sicily's. Precipitation not only differs between various altitudes and locations, but it nearly doubles near Monte Polizzo compared to the coast. The pronounced seasonality of rainfall also differs from one month to another. This is clearly visible when the soils dry out in summer but are saturated during the rainy season. In this area in an average year about 30-45% of precipitation occurs between October and December.[184] However, based on climatic studies made in the Eastern Mediterranean including Sicily and in comparison with the studies conducted in Lago Preola (see next chapter), Berry set the precipitation during the Iron Age at 10% higher than today. [185]

Persistence of base flow

The volume of water available to a river and the water flow depends on the area of its catchment. Catchment areas are the landscapes surrounding and feeding a stream or river[186].

The amount of water volume supplied by a catchment area depends fundamentally on rainfall, evapotranspiration, and the absorptive capacity of the soil and bedrock through which the water travels.[187] Groundwater

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178 Brown 1997, 320.
179 Berry 2016, 8.
180 For the application of Hydraulic Radius in Manning's equation se Berry p.8 – 12. Stream shapes Barnes 1967.
181 Barbera and Cullotta 2012, 543.
182 Noti *et al.* 2009.
183 Tinner *et al.*, 2009, 1504; Sadori and Narcisi 2001.
184 Berry 2016, 16.
185 Berry 2016, 25 -27; Finné 2014; Calò *et al.* 2012..
186 Berry 2016.
187 Evapotranspiration is the collective name for all water evaporated from the ground and transpired by the leaves of plants. See Berry 2016, in appendix 1 for how this formula is calculated.

catchment areas do not necessarily coincide with surface catchments, thus groundwater may drain to a river other than the one that drains the surface catchment. In other words, a river can both lose and gain water underground to or from nearby streams.[188] In lower reaches, streams may in turn gain flow from the groundwater.

Geological circumstances are important. When heavy precipitation occurs, steep terrain and impervious soil or bedrock can cause higher and earlier peak discharge (when a river reaches its highest flow).[189] In parts of the Mazaro and Vita drainage areas, where permeable evaporitic or limestone bedrock underlie the rivers, reaching peak discharge can take longer because the rivers lose flow to underground channels.

Vegetation

The pollen record in Chapter 6 will show that this region had a habitat of mostly *Quercus Ilex*, *Olea,* and *Pistacia* on the coastal plains. In areas at an elevation above 600 m a.s.l., such as around Monte Polizzo, and due to the temperature difference at the higher altitude, a mix of deciduous and evergreen *sclerophyllous* trees generally covered the mountains. In these types of mixed forests, there was nearly no undergrowth and a thick mixture of leaves and other organic material covered the ground underneath the vegetation. This decaying organic matter turned into a humus-rich top layer, acting like a sponge holding large amounts of water and protecting the underlying 'Mediterranean brown soils' from densification. The soil also worked to slow erosion by increasing the amount of water filtering into the ground.[190] In a saturated soil and bedrock, water flows very slowly to the stream (perhaps traveling only 10 m to 100 m through rocks each year[191]) thus providing a stream with a steady discharge of water. In unsaturated soil with no vegetation holding the water, heavy rainfall will cause run-off and flooding.

During an average year, the navigation season on the rivers of western Sicily during the archaic period would have been roughly from late-November to late-February. This is based on the fundamental factors presented above, but it is worth noting that rainfall is irregular from year to year. Since the record of the last three months of an average year have the highest rainfall, navigability was therefore first possible in late November. This is due to the time interval between the peak of the rainfall and the amount of time needed for a full water discharge in the river. With more rain and thick enough soil, it could have retained substantial moisture and, as mentioned above, held the water longer, providing the river with water and base flow for a longer period of time. This means that anyone who wished to ship people, products, or timber to the south-western coasts from the Monte Polizzo area needed to do so during the winter months.

The above sections have highlighted some important aspects that need to be established to assess a river's morphology over time as well as its navigability. This chapter continues with a presentation of the rivers draining Monte Polizzo as they have been estimated for the Archaic period. Factors that can or have changed the rivers' morphologies will be highlighted.

The Mazaro River

The primary focus in the beginning of this study was to assess the navigability of the Mazaro. Of the three rivers running towards the western coast, the Mazaro is the one that can possibly be recognised in various literary and cartographic sources. Most famous is the narrative of Diodorus Siculus. In his description of the destruction of Selinus by Hannibal Mago and the Carthaginians during 409 BC, Diodorus mentions a great port of the Selinus settlement located at the mouth of the Mazaro (Diod. Sic. 13.54). This narrative is often considered testimony of territorial boundaries in the area, and modern writers generally consider the Mazaro as a natural divide between the territory of the Selinuntines and those whose territory is on the other side. It is generally acknowledged, however, that during the Archaic period the territory of Selinus was much smaller than during the Classical

188 Berry 2016, 15.
189 Berry 2006; Brown 1997, 38.
190 Berry 2016.
191 Permeabilities of 10-6 to 10 -7 mD (millidarcies) Berry personal communication.

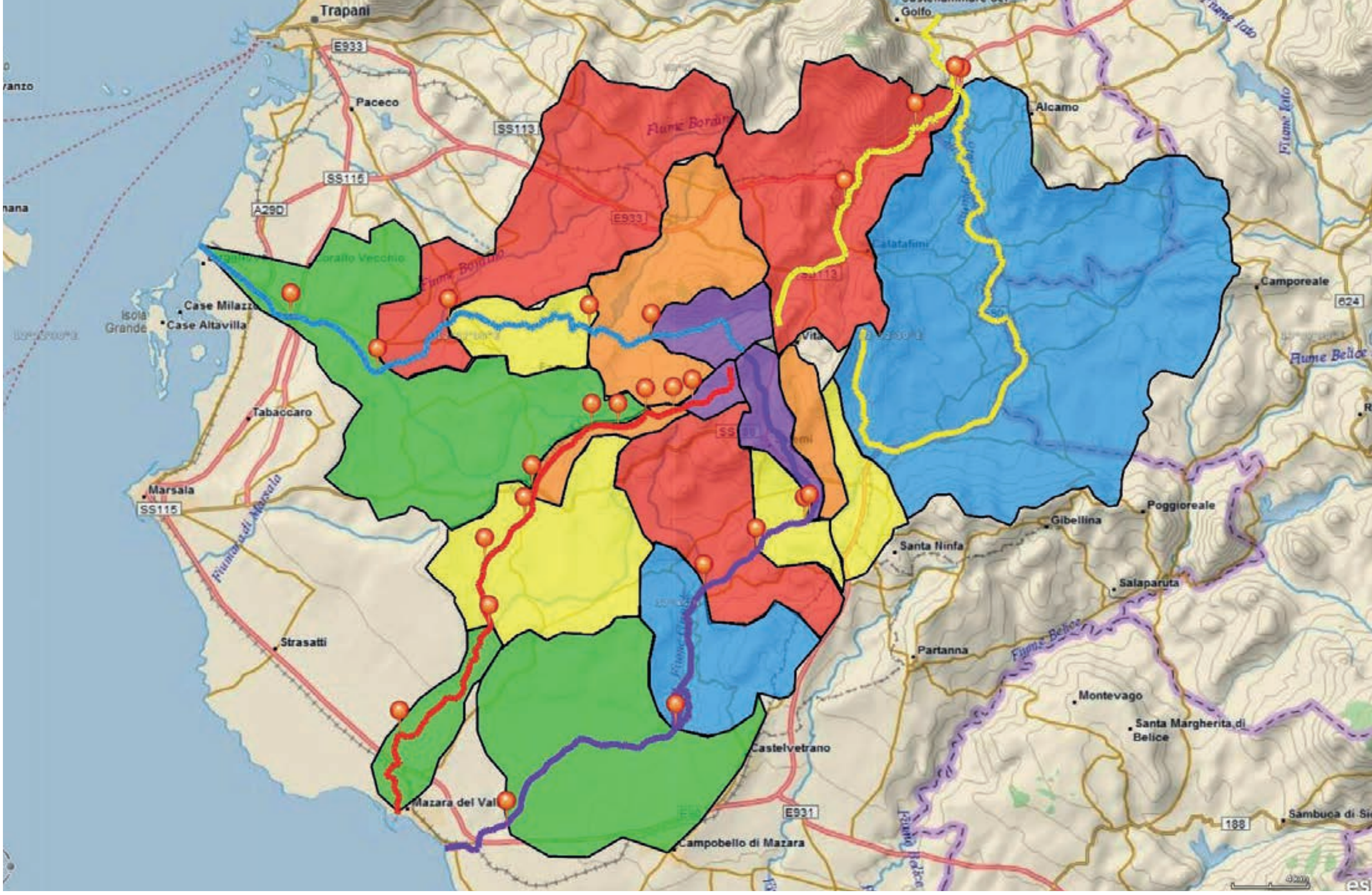


Figure 5. The Rivers' catchment areas J. L. Berry

Figure 6. Mazaro catchment area. J. L. Berry

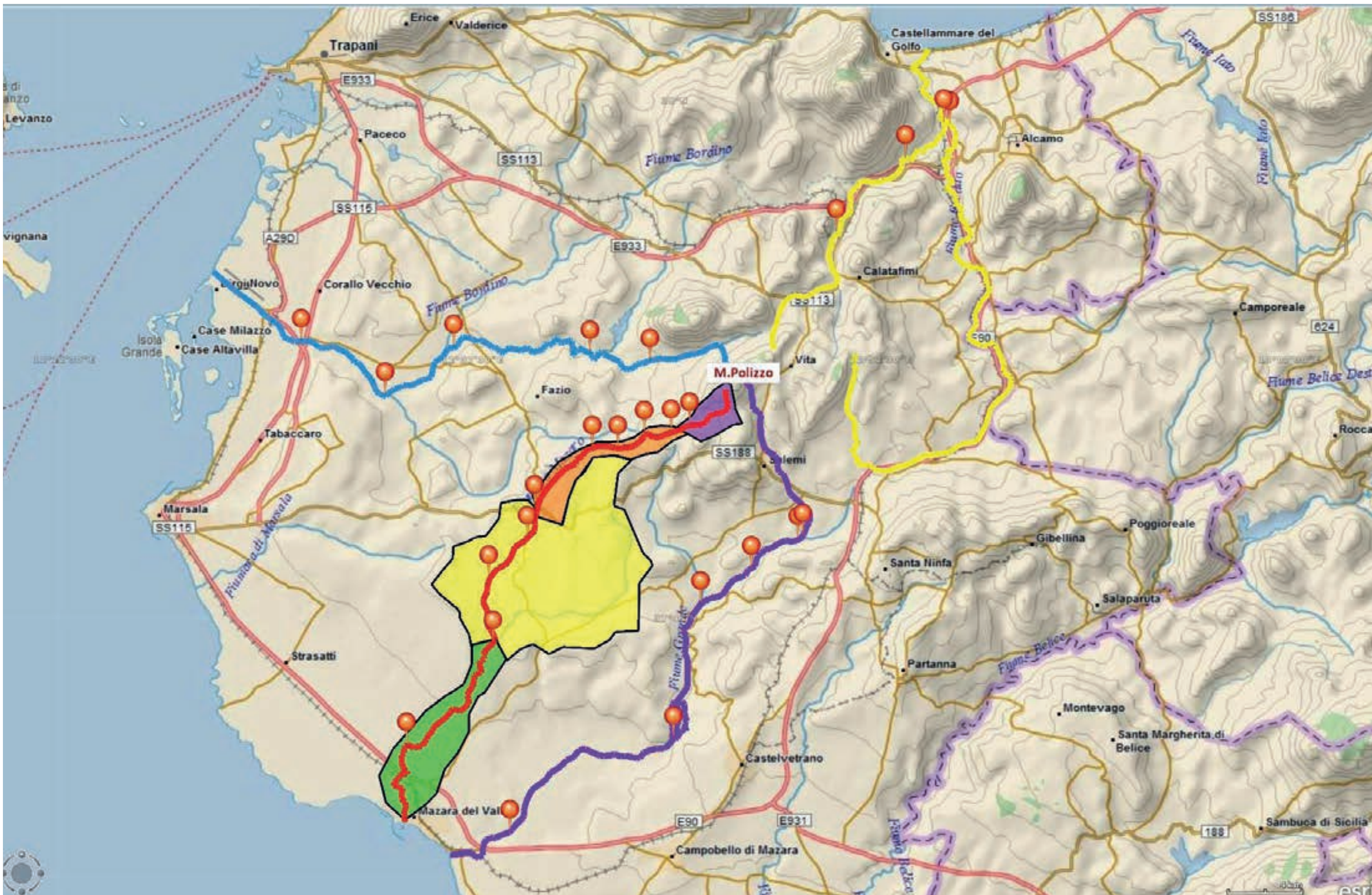


Figure 7. The Mazaro River showing a point of imminent stream capture just above Km. 32. J. L. Berry

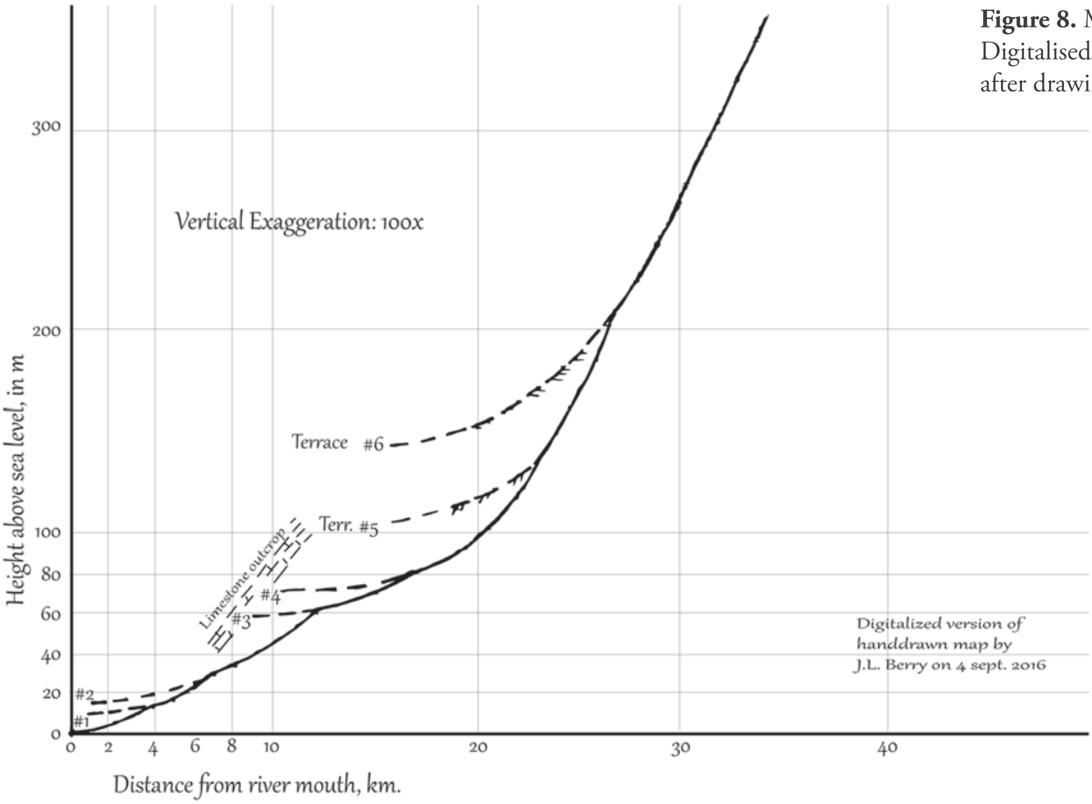


Figure 8. Mazaro River profile. Digitalised by Thomas Ekholm after drawing by J. L. Berry

period[192] and did not reach as far as the Mazaro. Even if these landscapes are not considered to be Greek, the controlling party of this 'territory' is however never considered to be the Elymians.

In Mazara del Vallo, the Mazaro's estuary today harbours one of the most important fishing fleets in the Mediterranean.[193] As mentioned in the beginning of Chapter 4, the estuary is well known for sea oscillations. How this meteorological phenomenon was acknowledged during antiquity is not known. However, the absence of sedimentation suggests two things; that the Mazaro cannot carry enough sediment to fill the estuary and that the oscillations may have transported the sediment out to sea instead of silting up the rivers' mouth, as is evident in other river estuaries along the coast. The modern Modione and Cotone Rivers flanking the Selinus settlement are completely silted up but are both examples of rivers said to have had harbours during antiquity, although no remains are visible today. These oscillations should not therefore be disregarded since they maintained an estuary deep enough for harbouring and, hence, made it a favourable location–perhaps the most favourable location on the south-western coast for large-scale trading purposes during antiquity. This will be discussed further in Chapter 9.

The Mazaro's morphology and navigability

As described above, all other things being equal, the base flow of the rivers in an area is determined by their catchment areas. The Mazaro River is 30 km long. Its catchment area is clearly atypical, as is evident by comparing it to the other rivers' catchment areas draining Monte Polizzo. The Mazaro drainage is much narrower, particularly in the third of its length in the north-easternmost headwaters. In this section, the river flows within 200 m of the northern edge and 500 m of the southern edge of its catchment. Analysing this narrow section, it becomes evident that the river is losing its drainage underground to its neighbours, especially to the Ricalcata, a tributary of the Cúddia River situated north of the Mazaro.[194]

The rivers' stream profile in the higher reach is very steep and shows that the course of the Mazaro is consistently at a higher elevation than the courses of neighbouring rivers. The main reason for this: the Mazaro flows over harder bedrock and, once a river is flowing at a higher elevation than other rivers in the area, it becomes subject to 'stream capture'. This occurs because the Mazaro is flowing along the axis of a syncline floored by a relatively hard limestone, whereas its neighbours are flowing on shale and marl and at a lower elevation. The headwaters of these neighbouring rivers erode the soft shale rapidly and undercut the limestone that forms the divide between them and the Mazaro drainage, forming cliffs. These cliffs then erode backward towards the Mazaro, robbing it of drainage and therefore of water.[195]

Since the Mazaro valley is floored by soluble limestone and gypsum in places, underground leakage can feed its waters to the groundwater system in the surrounding valleys, further reducing its flow. Possible sinkholes have been observed at several places, for example on the right-hand side of the river in the picture below. At a point in the higher reach, about 10-12 km from the river source (21.7 km from the outlet), the stream flow disappears and is possibly diverted underground. Due to the stream capture and the sinkhole, Berry estimated that the Mazaro loses (and has always lost) 80% of its flow at this point in its course.[196]

The rivers we see flowing in today's landscapes do not necessarily run at the same speed and in the same river channels as they did during antiquity. The middle course of the Mazaro and of all three rivers flowing south and west (Cúddia, Mazaro and Délia) were strongly meandering in the past. These rivers have been straightened and canalised to dry up the area, although the old scars

192 De Angelis 2003, 125; Spatafora 2012.
193 Candela 1998, 2210.
194 Berry 2016, 24.
195 Berry 2016; A similar phenomenon of 'stream piracy' is for instance found in the ancient Strymon River in Macedonia. Clendenon 2009, 275; Higgins and Higgins 1996.
196 Berry 2016, 24-25.

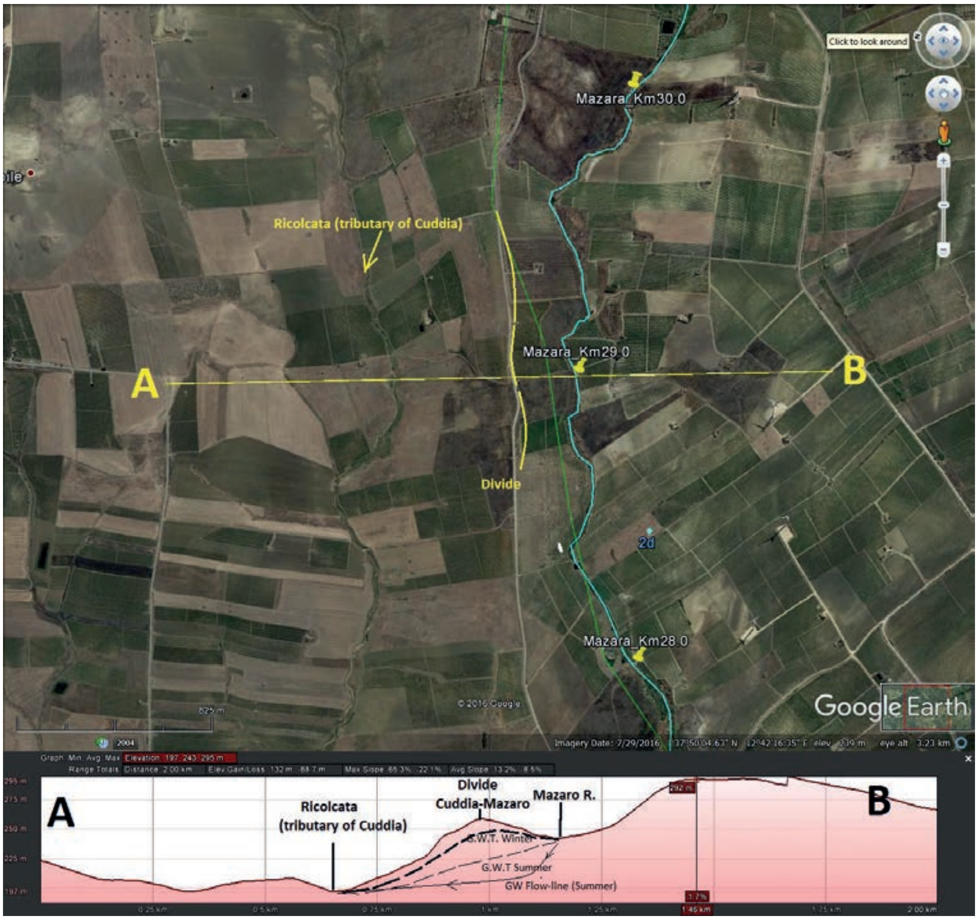


Figure 9. *Above*. Illustrating the syncline and the Mazaro "high and dry" J. L.Berry

Figure 10. *Left*. Possible sinkhole to the right along the Mazaro. J. L. Berry.

of a meandering river are still visible in the landscape as abandoned river courses.[197]

Sicilian marshlands

Marshlands existed along the Sicilian coast during antiquity, and the presence of marshes in this area is not only attested to in the pollen record (see following chapter), but also in the geomorphological record as well as in ancient literary sources and coinage, discussed below.

At some time in the geomorphological history of Sicily, the middle reaches of the Mazaro and the Cúddia Rivers were impeded by dense vegetation and formed into extensive marshes traversed by these meandering rivers. A river's characteristics can change for several reasons. Human modifications of the landscape such as deforestation of hillslopes causes changes in the rivers' flow, making the rivers more "flashy", decreases base flow and increases the flood height and increases the chances of flooding in the lowlands. Hilltop run-off can also cause a change in water table by an increase of water in the lowlands, and eroded soils can choke the stream channel and possibly lead to the development of marshlands. Human population growth supported by new extensive agriculture systems can, in turn, alter lowland vegetation and disturb a river's characteristics. [198]

A river can suffer from allogenic changes caused by climatic or sea level changes by erosion in the catchment area or neotectonic movements. An example given by Brown is the River Po in Italy with its long record of extensive river channel change caused by tectonic uplift. [199] Meander erosion often modifies a river's original channel. The river tends to migrate and flow faster in the outer curve, more slowly leaving new deposits in the inner curve. Eventually, the river can cut off a channel by the meander's neck to shorten its course, creating a small lake in the loop. These lakes can either silt up, or dry up and form marshes, eventually leaving meander scar visible in the landscape as they have different vegetation or none at all.

Negative evidence is problematic in environmental archaeology in general and especially so in alluvial archaeology. Depending on degrees and the processes of floodplain evolution, any scatter from a settlement (a hut circle is used as an example by Brown) would be completely destroyed or deeply buried by sediment with a periodicity of about every 1000-2000 years, highlighting the natural forces of alluvial landscapes.[200] For prehistoric settlers, different types of floodplains and channel systems offered possibilities or problems in habituating on the alluvial lower landscape. Natural causes mentioned above such as meander migration, catastrophic flooding, or flooding caused by groundwater levels can all be major risks.[201] All these factors are equally important when assessing a river's importance in a given landscape.

The landscape in which the middle reach of the Mazaro had its course was thus at one point in time turned into marshland. This wetland environment, in addition to the loss of stream flow mentioned above, made the Mazaro impossible to navigate. This was notably not an environmental development isolated to this specific area of the Mazaro and Cúddia. Ancient marchland has been confirmed further west in the coastal area opposite Motya[202] as in the southern landscapes of the Arena River. Here, the evidence of wetland is found in the local pollen record from Gorgo Basso, which shows an increase of trees, wetland, and water plant taxa in the area around the lake between 650-250 BC.[203] These pollen records indicate a lake-level change or/and eutrophication in the area as well as a local change towards a marshier landscape.

When studying a specific geographical area in antiquity with environmental features shared by different peoples, one suppose that some boundaries or territorial

197 See appendix 1, page 14
198 Sallares 2002, 103.
199 Brown 1997, 31f.
200 Brown 1997, 42.
201 Brown 1997, 38.
202 Nigro, 2013, 52, note 85. The Rome La Sapienza Expedition also engaged a geologist to investigate the geomorphology on the site and the closest environment. No specific details were however disclosed.
203 Se following chapter.

Figure 11. Wetlands western Sicily J. L. Berry

limitations must have been set amongst them. Rivers are often considered as methods of connecting people between the coastal areas and the inner landscapes, but they also work as symbolic divisions between territories. The ancient Sicilian marshlands are interesting features to consider when assessing peoples' land use, territorial boundaries, trade, and movement.

A major modern reclamation campaign in the beginning of 1900, which later also included straightening a large number of meandering rivers to increase the river flow, finally dried up the Sicilian landscapes. [204] However, ancient marshes in this region are rarely discussed, nor are the consequences they might have had on the people living and working in these areas. However, some ancient literary sources highlight the effects of what marshlands could have had in the region during the Archaic and Classical periods.

Marshlands and 'mal'aria'

Sickness arriving over the air was a common belief in Mediterranean antiquity. Hot, dry south summer winds were associated with bad air and fever by Theophrastus and other ancient writers.[205] In Sicily specifically, Empedocles of Akragas, famous for his medical skills and a pupil of Pythagoras, is said to have blocked a mountain gorge with flayed mule skin in order to prevent the pestilential wind from bringing illness to pregnant women and disease to the plain surrounding Akragas. [206] To eliminate the bad air, Empedocles diverted two rivers located in the Selinus region:

204 Majori 2012.
205 Sallares 2002, 73. Note 74-77.
206 Kingsley and Richard 2009.

> We are told that the people of Selinus suffered from pestilence owing to the noisome smells from the river hard by, so that the citizens themselves perished and their women died in childbirth, that Empedocles conceived the plan of bringing two neighbouring rivers to the place at his own expense, and that by this admixture he sweetened the waters. When in this the pestilence had been stayed and the Selinuntines were feasting on the river bank, Empedocles appeared (Diog. Laert. VIII 70-71.)

This drainage endeavour is documented on a fifth century coin from Selinus. Another coin, also from Selinus, depicts the river god Selinus on one side and, on the reverse, Artemis and Apollo side by side. The picture is interpreted as Apollo discharging his arrows in order to slay pestilence, while Artemis represents women suffering from malaria.[207]

These marshes existed and were under development during the Archaic period. It is important to note, however, that they may not have been present at the beginning of Monte Polizzo's occupation. Wetlands--or at least patches of it--covered a substantial part of the coastal plains from western to southern Sicily. Akragas and Camarina are both mentioned in literary sources as infested by malaria in the fifth-century BC.[208] According to Diodorus Siculus (probably via Thucydides), for example, the Athenian camp outside Syracuse in 413 BC was afflicted by malaria.[209] Grmek suggests that the Syracusan general deliberately drove the Athenian forces to an area he knew was affected by malaria--and then let the malaria do its job.[210]

It is evident that during antiquity, bad air and disease were eventually connected to still standing water in lower plains and marshes seen as the cause of fever and 'mal'aria'. According to Russel, Vitruvius, Augustus' military engineer had said it better to select a hill site for your house "away from marshes, the poisonous exhalations of which exert a morbid influence of man".[211]

Descriptions of the wetland itself are scarce. Pliny the Elder did describe the Pontine Marshes on the Italian coastal plain as marvellous with beautiful flowers and plants, but he did not put those descriptions in a wider ecological context. Neither did Pliny the Younger who also briefly described the beauty of the marshes of Lago di Bassano.[212]

The perception of ancient marshlands, which for some reason tend to extract and create an idea of only positive ancient attitudes towards that specific type of wetland, is often seen as extremely fertile arable land, full of fishes and animals to hunt. Sallares questions modern scholarship and these perceptions and believes that any positive feeling towards marshes that could be extracted from literature, were constructed by outsiders, who did not have first-hand information about their extreme environmental conditions. Nor did they suffer through endemic malaria or live or work close to an area that was so afflicted.[213] A description of the Pontine Marshes from 1884 by Tito Berti certainly contradicts the modern view criticised by Sallares:

> The Pontine forest creates fear and horror. Before entering it cover your neck and face well, because swarms of large bloodsucking insects are waiting for you in this great heat of summer, between the shade of the leaves, like animals thinking intently about their prey… and here you find a green zone, putrid, nauseating, where thousands of insects move around, where thousands of horrible marsh plants grow under a suffocating sun.[214]

These descriptions of Roman and modern Italy could most probably be correlated to the ancient marshlands of Sicily.[215] As shown by the high rates of Malaria in Sicily until the 1930s, the geomorphological evidence described previously, with less frost and a shorter cool

207 Russel 1955, 160. Fig 15. This coin displayed in the British museum online collection.
208 Sallares 2002, 38. See note 33.
209 Diod. Sic. 13. 12.
210 Sallares 2002, 37; Grmek 1979, 150-61. It has also been suggested that it was the *falciparum* malaria, the same type that infested modern Italy.
211 Russel 1955, 127.
212 Sallares 2002, 172.
213 Sallares 2002, 172.
214 Sallares 2002, 170; Berti 1884.
215 Berry personal communication. For studies of the Pontine region, see for instance Attema and De Haas 2005.

season than mainland Italy, and a dense vegetation, provide combined evidence of a malaria infected environment. That should not be ignored when discussing ancient land use, territorial boundaries, and agriculture.

Returning to the Mazaro River, it is evident that ancient Sicilians could not use either the higher or middle reaches to transport themselves or their goods. Nature thus blocked that particular exit to the Mediterranean. The lowest reach of the river, a few kilometres up the estuary, was however navigable as far as the end of the "gorge" and the beginning of the marshes. The estuary could therefore have been used as a transportation route along the gorge, a shelter, or a port as it is today--but not as a gate to reach the inner surrounding landscape.

The Cúddia River morphology and navigability

The Cúddia River has its headwater in the Cúddia valley between Monte Polizzo and Montagna Grande. It is the most north-western river from the Monte Polizzo area. Soft shales and marls underlie the Cúddia River, which is today about 30 km long. It merges after 23 km into the Bordino River, which originates in the north. The Bordino later turns into the Mercanzotto which, in its final reach, is called the Birgi River. Just to the south of the Montagna Grande, the Cúddia branches to the south along the Monte Polizzo and Montagna Grande and to the north where it changes its name to the Fastaia. About 30 meters along the Fastaia, a reservoir called the Rubino was built 1967-1970 and all water flowing into the Fastaia flows into the Rubino leaving the modern Cúddia with the drainage from the southern branch.

Even during the archaic period, there was not enough base flow for navigation in the upper reach. The Ricalcata tributary, whose catchment lies alongside that of the Mazaro, and probably receives water underground from beneath the Mazaro catchment, supplied the Cúddia in the lower catchment from about 12 km from its outlet.

As described above, the former meandering middle reach of the Cúddia has been shortened and straightened during modern times even more than the Mazaro, in order to dry up the extensive marshes located south of the merger with the Bordino River. This area and the wetland area documented on the coastline opposite Motya create a natural boundary between the inner landscapes of the Elymians and the peoples on the coast. However, during favourable seasonal periods, navigability was possible up to the point of 17 km-- about half way to Monte Polizzo.

Arena Délia Grande River morphology and navigability

About three kilometres south of the Mazaro inlet and roughly 30 kilometres north of Selinus settlement following the coast is located the Arena Délia Grande estuary. This river is 43 kilometres long today and changes name three times. The River is called Fiume Grande at its higher reach, Délia in the middle, and Arena in its lower reach. Its catchment areas stretch over eight different municipalities all in the region of Trapani. In contrast to the Mazaro with its anomalous drainage basin, the catchment area of the Arena is 316 km^2, which is of a significant size concerning its water volume (the Mazaro catchment area is 116km^2, while the Cúddia is 452km^2)[216].

The geomorphology of the area is uniform, with a mild hilly relief. The landscape is, on the other hand, characterised by extensive gullying, a landform created when running water, in the form of a river or stream, sharply erodes the soil and creates gullies (ravines) that can measure tens of meters in height and width both.[217] Gullies can form on hillsides where no natural vegetation is present as well as on extensively cultivated or disturbed areas. This type of gully erosion often expands by working its way head-ward in an upstream migration. This expansion proceeds uphill until it encounters hard rock, such as harder overlying lithology or a fault that brings hard rock to the surface. (For instance on the course of the Mazaro where the river flows over harder limestone but the surroundings are underlain by softer bedrock.) Then the gully (or water) keeps eroding the soil and softer bedrock, creating knickpoints, even perhaps a waterfall.[218]

216 See Berry table 3 for a complete calculation of the watershed areas

217 Bacino Idrografico Arena 2007, 3.

218 Berry personal communication.

On the course of the Arena Délia Grande, there are two possible knickpoints showing that gullying erosion occurred along this river some time in history. Berry's assessment presented in detail in Appendix 2 for the Arena Délia Grande shows that this river is the one river on the western side of Monte Polizzo, which was navigable up to a point of 27 km from the sea and only 7 km from the Monte Polizzo settlement. One question asked in this study was whether there was a place along any river that could have been used as an *entrepôt* between the different exchange systems of the inner landscapes and the Mediterranean. About 13 kilometres up the Arena from the coast, below the reservoir Lago della Trinitá constructed in 1959, the river was broad enough for loading small trading vessels, such as Portuguese Rabelo vessels.

In the Archaic period, the Arena estuary reached 2.7 kilometres up the river. However, there may have been extensive lagoonal areas behind the river's bar. These lagoons could offer shelter for larger ships, while the smaller vessels sailed up the river, either loaded with various goods, or emptied to collect goods arriving on the river from the inner landscapes. (These lagoons may account for the "lake" shown on 16th century maps.)

While marshlands possibly acted as boundaries between the coastal settlements and the hinterland during various periods, the rivers connected them during the winter months. The river Cúddia was navigable from its inlet to at least half its course making access easier for the Phoenicians at Motya to reach an Elymian inner market. Arena Délia Grande River was probably the most important river in the sense that it connected Monte Polizzo to the Mediterranean. It was the only river in the western region, which was navigable from the Monte Polizzo area to the western coast. This river could, therefore, provide direct access to and from the settlement and the sea.

The Caldo River valley landscapes – a gateway to Segesta

One of the aims of this study is to get a deeper understanding of the trade relations between the Monte Polizzians, the Phoenicians and the Greeks on the western coast. The three rivers discussed above all 'connected' the Monte Polizzians to the western coast. The trade opportunities that followed these venues will be discussed further in this thesis. The Caldo River, although draining the Monte Polizzo area, flows northeast towards the inner markets and landscapes and has therefore not been assessed for this study.

Whether navigable or not, the Caldo river valley is particularly interesting since it connects, by only a few hours walk, the Monte Polizzo settlement to Segesta. A settlement that came to be the most powerful Elymian settlement known to us during the sixth-century BC. Tusa and Morris suggest there were three levels in the settlement hierarchy in Archaic Western Sicily: small villages with fewer than 1,000 inhabitants; towns with up to 3,000 inhabitants like Monte Maranfusa, Mote Iato, and Colle Madore; and finally, small cities like Eryx, Entella and Segesta with 3,000 or more inhabitants. Based on the archaeological remains found at Monte Polizzo, its population is estimated to between 1,000-3,000 inhabitants around the time of the abandonment of the habitation area circa 550 BC.[219]

It is very difficult to estimate how big these societies really were during the seventh and sixth centuries and how they were connected. Most of the indigenous settlements in western Sicily were abandoned sometime during the final part of the sixth century BC.[220] Speculative proposals for this abandonment of Elymian settlements are of course plentiful. Vassallo suggests that a serious population decline could be explained by the battle of Himera in 480 BC and how war disturbed the delicate balance between the Greeks, Phoenicians, and Elymians. This would have had a negative effect on the indigenous economy and ultimately created a crisis and decline of the population.[221] However, as Morris and Tusa point out,

219 Morris and Tusa 2004, 79.
220 Morris and Tusa, 2004, 78; Vassallo 2000, 983- 1008.
221 Vassallo 2000, 983-1008.

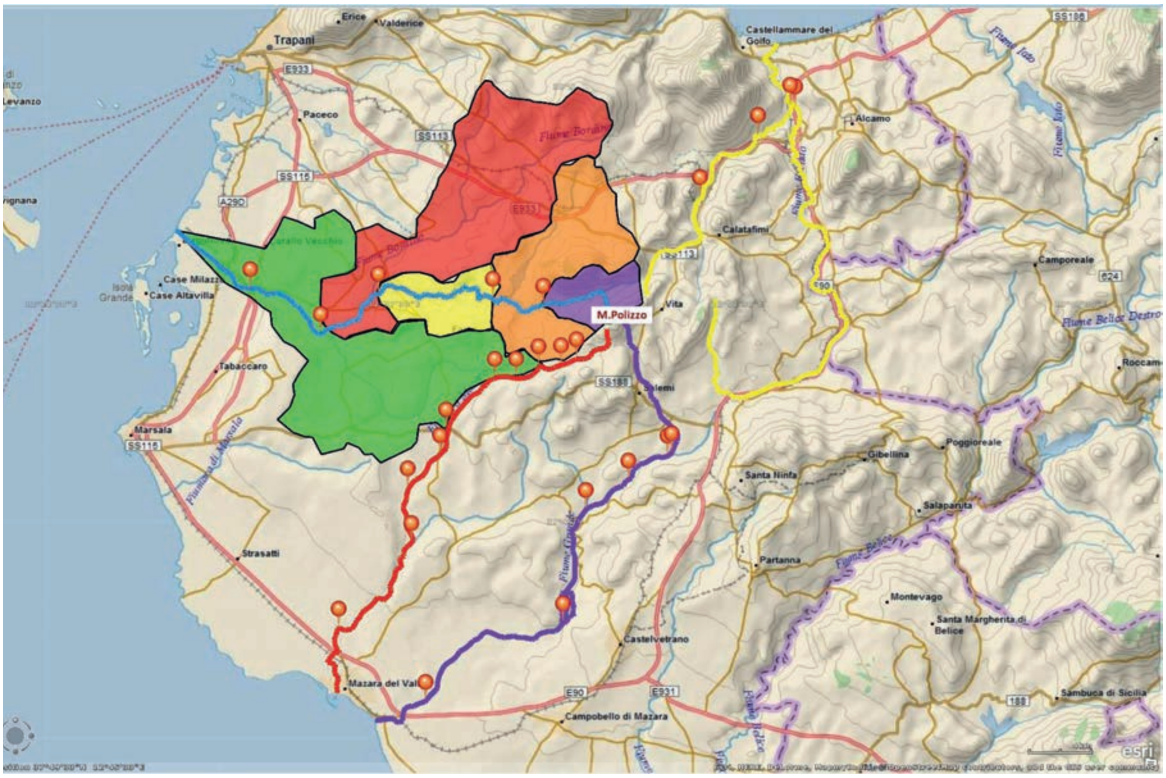
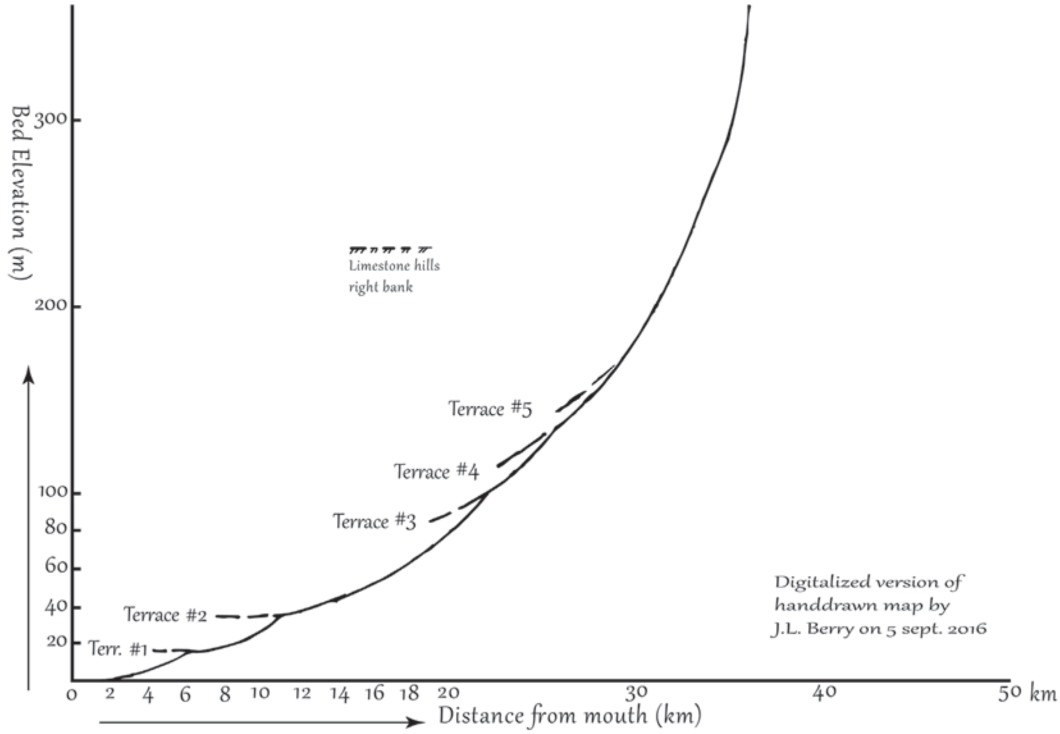


Figure 12. Cúddia River catchment area J. L. Berry

Figure 13. Cúddia River profile. Digitalised by Thomas Ekholm after drawing by J. L. Berry



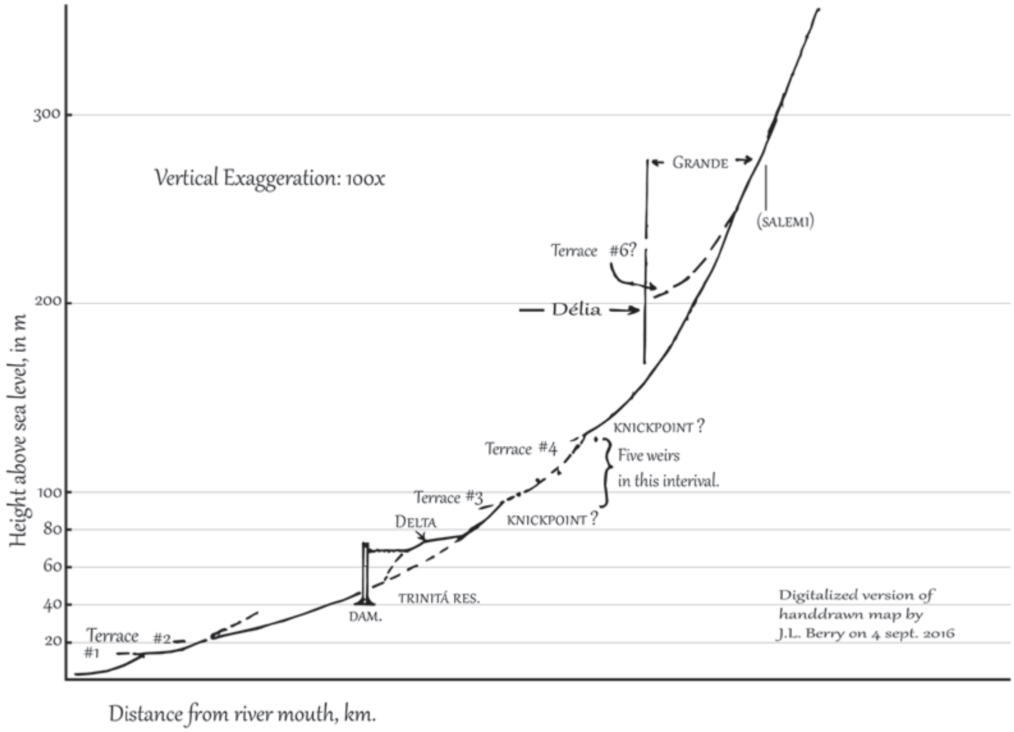
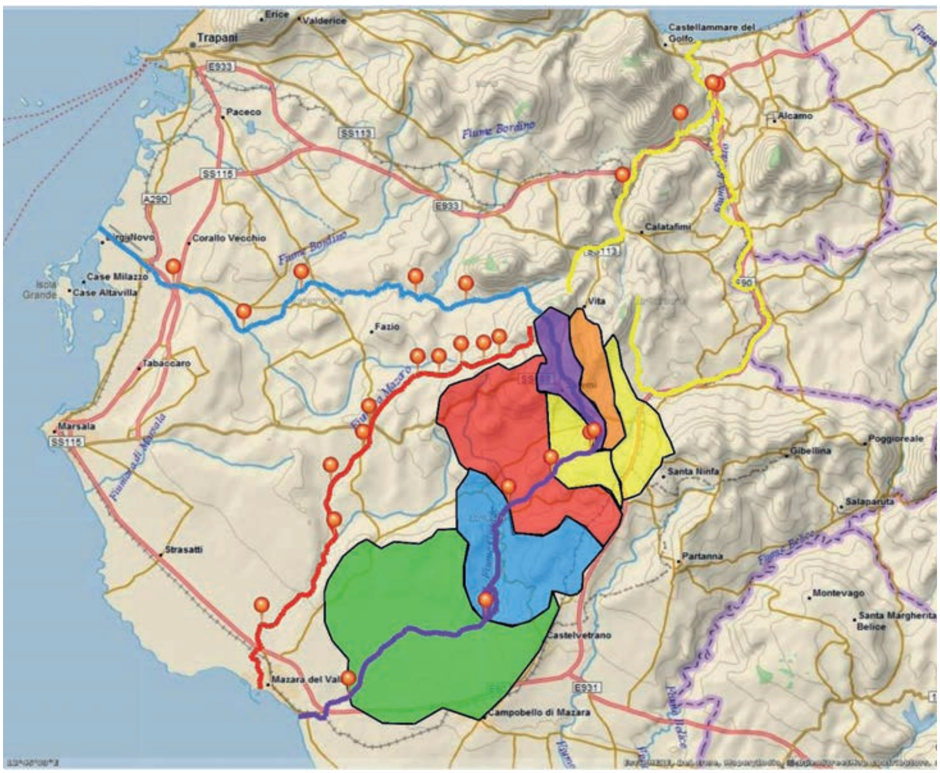


Figure 14. Arena Délia Grande catchment areas J. L. Berry

Figure 15. Arena Délia Grande profile. Digitalised by T. Ekholm after drawing by J. L. Berry



the settlement abandonments in the region had already started more than 50 years before the battle of Himera.[222]

Apart from the abandonments of these sites, we do not know whether there is a correlation at all between that phenomenon and an assumed population decline among the Elymians. Another plausible theory is that the indigenous population from smaller towns all over the region regrouped by *synoikismos* in Segesta. As opposed to other settlements, Segesta shows no signs of either economic disaster or a decline in population. [223] On the contrary, the city was thriving during 500 BC, and Segesta was a major player in Sicilian politics, with both the Athenians and the Carthagians as allies (the latter also eventually their conqueror Diod. Sic. XII-XIII. Thyc. VI.8). The Doric temples built in the fifth century BC are a manifestation of Segesta's power. Even though the very limited archaeological evidence from the archaic settlement cannot either support the theory of a demographic increase or decrease in the settlement during this period, the river Caldo connected Segesta with Monte Polizzo and, in turn, the western coast via the Arena Délia Grande. Monte Polizzo could control the route to and from Segesta, an aspect that further demonstrate the important location of the settlement.

The archaeological evidence at the acropolis, which demonstrates a continuity at the site even after the main habitation area was abruptly abandoned further supports this notion. Based on the geographical location and the continued activities around the sanctuaries, Monte Polizzo sustained an important role in the Elymian landscape. After 550 BC, the site could very well have continued to serve as a checkpoint on the route to the western coast. Monte Polizzo had the prospect of not only controlling the final distance of the route towards the inner landscapes; just below Lago della Trinitá, the river was at one time in history broad enough for loading and unloading, suggesting that this was an ideal location for a trade station. Standing on the highest location south of the lake, Monte Polizzo and Salemi are both visible on the horizon, giving one an excellent vantage point in the landscape to control any shipments and travellers going up and down the river--all while in visual contact with the mother settlement.

222 Morris and Tusa 2004, 78.
223 Morris and Tusa 2004, 79.

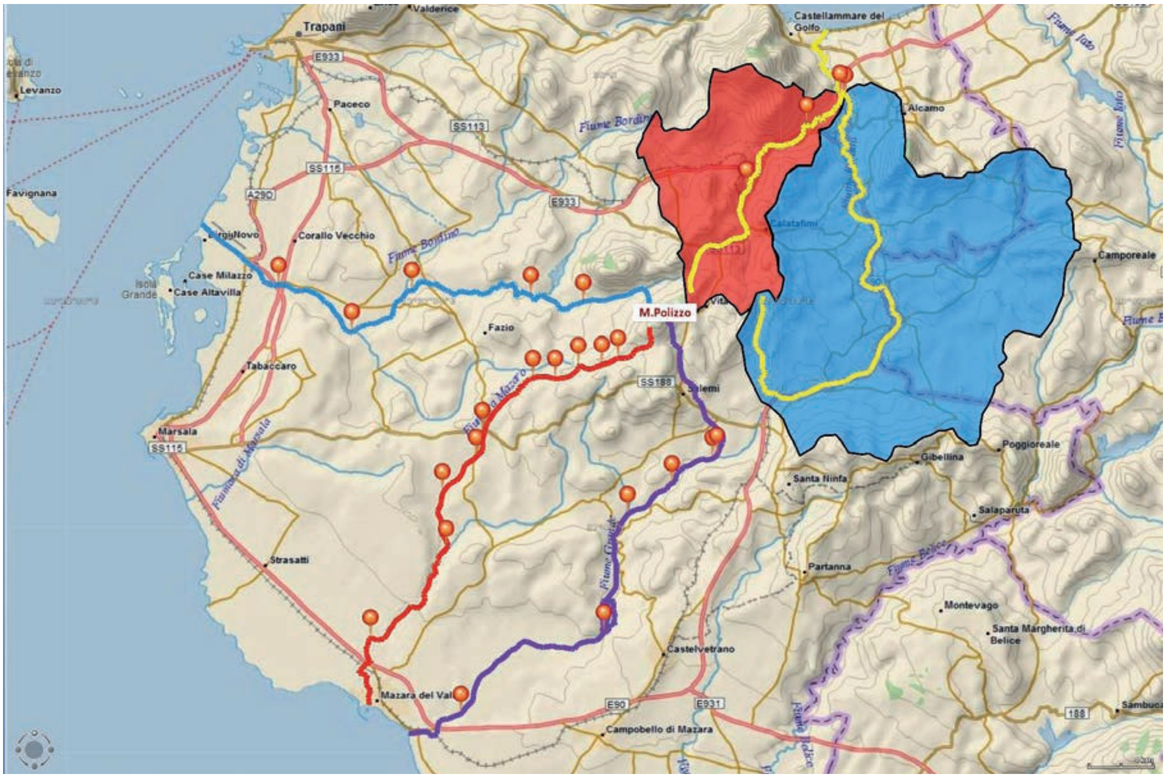


Figure 16. Caldo River catchment area J. L. Berry

Figure 17. Photo from Lago della Trinitá. Monte Polizzo in the background centre left.

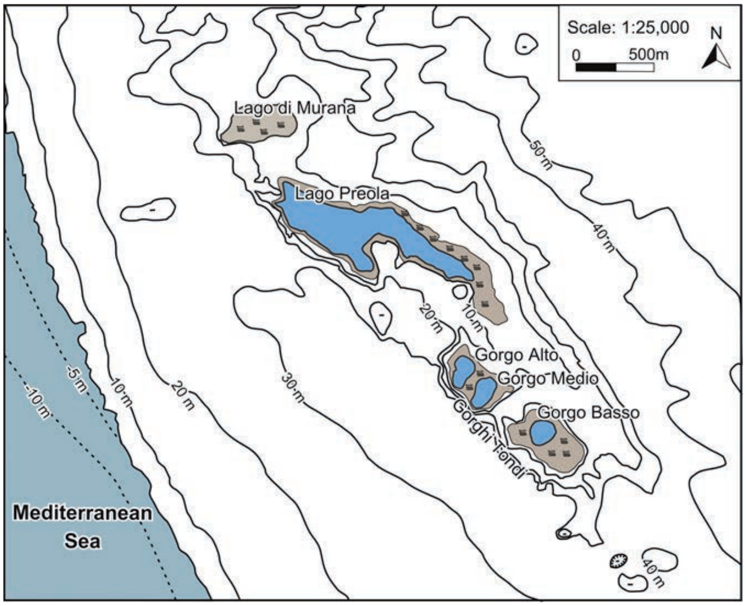


Figure 1. Detailed map of the Nature Reserve "Lago Preola e Gorghi Tondi" with the location of the study site Gorgo Basso. With the courtesy of W. Tinner)

CHAPTER 6

Natural environment of ancient western Sicily

There is a limit to how much information it is possible to extract from archaeological sources about the surrounding contemporary western Sicilian natural landscapes. The local ecological conditions prevailing during the occupation of Monte Polizzo is unfortunately impossible to assess with all certainty. But in this study, where the chronology of the archaeological record is short, pollen data can provide information on a longer temporal scale. This data indicates specific long-term changes in the environment such as forest decline as well as increases of cultivated and wetland taxa.

In order to evaluate pollen data, one needs to know the pollen source and disposition, pollen production and dispersal, pollen preservation and the relationship of fossil pollen and former plant communities.[224] Since no pollen coring or sampling has been executed within the framework of this study, the data discussed in this chapter is provided from different publications regarding sedimentary investigations. Results from the macrobotanical samplings conducted on Monte Polizzo within the SSAP project will be presented in Chapter 7 after the regional context has been provided in this chapter. This will set Monte Polizzo in an ecological context.

Macrobotanical data can provide valuable information as to what was going on at the settlement in a spatial scale at that specific time and place. The complied paleoecological information can further be matched with analyses of river morphologies and sedimentation in river deltas, offering insight into agriculture and human-caused deforestation. Sedimentation as a source of information will be discussed in a following chapter. These types of data can not only provide local ecological and environmental context through time but also with evidence of human presence (or absence) in the area. These topics will be discussed when analysing possible land use and territory boundaries.

Pollen records of ancient western Sicily

There are few open wetlands in Sicily and no lake in the direct vicinity of the Monte Polizzo area. The lack of lakes and mires are related to the dry climatic conditions, and there are only a handful paleosites that can provide a Holocene record of the vegetation history of the island.[225]

There are substantial long-term environmental differences between the Sicilian coast and the uplands, which is evident in the sediment record received from the coastal lake Biviere di Gela (located in the southern Sicily), and the mountain lake Lago di Pergusa, (located in the uplands in the center of Sicily 667 m a.s.l.).[226] For instance, pollen analyses show that the evergreen trees and shrubs that dominated forest vegetation in the Mediterranean expanded in the coastal region circa 5050 BC, almost three millennia later than their mixed deciduous evergreen counterpart forests covering the uplands.[227]

224 Lowe and Walker 2014, 190.
225 Tinner *et al.* 2009, 1504.
226 For Biviere di Gela see Noti *et al.* 2009; for Lago di Pergusa see Sadori and Narcisi, 2001; Sadori *et al.* 2008.
227 Sadori and Narcisi, 2001; Sadori and Giardini, 2007.

In this study, vegetation history will be discussed based on the two sedimentary investigations that have been conducted during 2009 and 2012 in two karstic lakes in the "Riserva Naturale Integrale Lago Preola e Gorghi Tondi" located on the western coast of the island. The palynological data is published in Tinner *et al.* "Holocene environmental and climatic changes at Gorgo Basso, a coastal lake in southern Sicily, Italy",[228] and Calò *et al.* "Spatio- temporal patterns of Holocene environmental change in southern Sicily"[229]. The two sampled lakes are Gorgo Basso, a small karstic lake (3 ha and a max. depth of 8m) about 2.2 km from the sea, 30 km from Monte Polizzo and Motya respectively, c. 3.5 km from the Délia River and c. 20 km from Selinus. The second, larger lake is Lago Preola (33 ha and a max. depth of 2m) located 1.5 km from the sea and just one km to the north of Gorgo Basso. The lakes and neighbouring swamps, mires and ponds are all wetlands protected by the Riserva Naturale.[230] The reserve includes five primary endorheic wetlands and lakes in dolines. The lakes were formed in collapsed surficial early Pleistocene bioclastic limestone known as the "Calcarenite di Marsala".[231]

The pollen influx in a given lake depends upon the size of surface area of the lake, and its relation to the immediate vegetation. A small lake has a smaller catchment area and the local surrounding vegetation will dominate the pollen record. This is even more significant if the lake is surrounded by a dense forest. A larger lake has a larger catchment area and will therefore have a larger pollen influx from a wider regional area. If the surrounding landscape is open, the catchment area is even wider.[232] Lago Preola has a catchment area of 17 km^2 and a higher influx of pollen and answers questions about the environment in a larger regional scale.[233] The pollen influx in Gorgo Basso demonstrates a more local environment (a calculated catchment area of Gorgo Basso is not provided). The adjacent lakes have therefore been used by Calò *et al.* to separate local from regional vegetation dynamics, which is interesting to consider for the present study.[234]

To determine the catchment area of a given lake, or pollen source, is one of the fundamental problems in palynology.[235] There are several models to understand the pollen-plant abundance relationship and pollen source area, of which the 'Prentice model' is the most comprehensive and flexible.[236] It has been suggested that a small woodland hollow or lake about 50 metres in radius has a catchment of about 300-400 metres and a lake of 250 meters in radius has pollen accumulated from an area of 600-800 meters.[237]

There are, however, several factors to consider when analysing the composition of the pollen deposited. Not all plants produce the same amount of pollen nor do they disperse it uniformly. *Etnomophilous* species--plants pollinated by insects--release less pollen than *anemophilous* plants, which spread pollen through the atmosphere, such as *Quercus*, (oak) for instance. *Triticum (*wheat) does not release a vast amount of pollen in the air since it self-pollinates.

Another important factor is the pollen's transportation from its point of origin to deposition. Generally in a forest region, pollen finds its way to a lake or mire in various ways, via small waterways for instance or borne by the wind or rain. Moreover, factors such as the thickness of forest cover, wind speeds, differences in pollination cycles and the size of and proximity of a given lake all play parts in pollen deposition. [238]

Studies of contemporary wind-born dispersal in forests show that pollen is usually deposited within an area only

228 Tinner *et al.* 2009.
229 Calò *et al.* 2012.
230 Tinner *et al.* 2009, 1499.
231 Curry 2016, 69.
232 Lowe and Walker 2014, 192; Giesecke and Fontana 2008.
233 Magny *et al.* 2011, 2460
234 Calò *et al.* 2012, 111; Se for instance Hofstetter *et al.* 2006 for similar study at Balladrum.
235 Sugita 1994, 882.
236 Sugita 1994, 882; Prentice 1995.
237 Lowe and Walker 2014, 192.
238 Lowe and Walker 2014, 190.

a few kilometres from its source.[239] Naturally, there are exceptions where pollen has travelled considerable distances, like the arboreal pollen found in the Arctic ice cores or the Greenland tundra.[240] This correlation between lake size and its catchment suggest that the catchment area of Lago Preola does not reach the vicinity of either Monte Polizzo or Motya. Nevertheless, even though the pollen record from the two lakes does not reveal the absolute local ecology around Monte Polizzo nor the neighbouring settlements, it offers information about long-term environmental changes and land use in the various ecological habitats within the region.

Tinner *et al.* have used pollen and microscopic charcoal from lake sediments of Gorgo Basso with the aim of reconstructing Holocene vegetation dynamics and regional fire history in the evergreen vegetation belt of coastal Sicily. They have compared the results with other paleoenvironmental and paleoclimate reconstructions made by data from pollen assemblage and from stable isotope archives from Sicily and elsewhere in the Mediterranean region. These comparisons achieved sufficient temporal resolution and chronological precision to understand the effects of climate and fire on vegetation dynamics over the past 10,500 years.[241]

Two parallel cores in Gorgo Basso were taken two metres apart in June 2004. The two cores were visually correlated according to the lithostratigraphy. The 14C ages were measured on terrestrial plant macrofossils extracted from sediment samples, and their dates were converted to calibrated ages (years cal yr BP, AD, BC)(BC is used continuously in present study).[242] The pollen diagrams were subdivided into local pollen assemblage zones (LPAZ) The mean sampling resolution for the pollen and microscopic charcoal was 14+/-9 cm (corresponding to 199+/-54 yr).[243]

Laboratory code	**Core**	**Depth (cm)**	**Material**	**14C age (yr BP)**	**Med. ages (cal yr BP)**	**C.I. ages (cal yr BP)**	**Ages cal yr BP in diagram (GAM)**	**C.I. ages cal yr BP (GAM)**
Poz-14738	GL3	79-76	PE, TW	200±30	178	303- -2	180	634- -53
Poz-14739	GL3	286-283	W, C, Cyperaceae CF, Apiaceae S	1930±30	1878	1947-1820	1881	2138-1616
Poz-14740	GL3	413-407	C, W, PE	2605±35	2744	2786-2548	2624	2999-2248
Poz-14741	GL3	506-491	C	2800±40	2903	3000-2790	2925	3270-2580
Poz-16195	GL3	614-600	Quercus BS, C, L	4020±50	4495	4804-4318	4562	5129-3994
Poz-16178	GL3	637-632	Quercus BS, C	4470±80	5117	5308-4874	5339	5840-4837
Poz-16179	GL3	700-696	W, L, C	6440±40	7364	7427-7279	7247	7504-6989
Poz-14742	GL3	744-741	TW, PE, W, C	7350±40	8160	8307-8030	8197	8597-7799
Poz-14744	GL3	997-1001	W, PE	8190±50	9144	9288-9015	9182	9610-8753
Poz-14745	GL3	1132-1101	C, PE, L	8690±50	9642	9887-9541	9700	10212-9193

Table 1. Radiocarbon dates Gorgo Basso. BS = bud scale, C = charcoal, CF = charred fruit, L = leaf, PE = periderm, S = seed, TW = twig, W= wood BP = Before Present (AD 1950), cal = calibrated, C.I. = 95% confidence intervals, GAM = generalized additive model, Med. = median. With the courtesy of W. Tinner

239 Lowe and Walker 2014, 192.

240 Bourgeois *et al.* 2001.

241 Tinner *et al.* 2009, 1499; Biviere di Gela, Noti *et al.,* 2009; Lago di Pergusa, Sadori and Narcisi 2001; for Eastern Mediterranean Kotthoff *et al.* 2008; for southeastern Spain Pantaleon-Cano, 2003. Roberts *et al.* 2008; Colombaroli *et al.* 2007.

242 Tinner *et al.* 2009,1500.

243 Tinner *et al.* 2009, 1500, using the zonation method of optimal partitioning. Birks and Gordon, 1985. from GB-1 at 8250-7800BC, GB-2 at 7800-4950 BC (subdivided in GB-2a and Gb-2b), GB-3 4950-800 BC, GB-4 800-150 BC, GB-5 150 BC-450 AD, GB-6 450-2000 AD.

The main aim of the study conducted by Calò *et al.* in Lago Preola was to examine human and climatic impacts on vegetation dynamics in Sicily during the Holocene. The first task was to separate the local landscape dynamics from Gorgo Basso from the regional scale presented in the record from Lago Preola. As mentioned above, since Lago Preola and Gorgo Basso are located only 1 km apart, differences in pollen taxa would relate to local versus regional-scale differences in vegetation. However, differences in climate or disturbance history cannot be provided.[244] The local regional pollen variation is also compared in a broader regional spatial scale to the costal lake Biviere di Gela, situated about 160 km south of the "Riserva Naturale". In addition to the pollen and charcoal data collected form the lake sediment, they also analysed ostracodes collected form the same sediments as a proxy for hydrological changes (lake-level changes) in order to identify vegetation-independent data of changes in moisture availability and to help refine pollen-inferred studies.[245]

Two parallel cores, one in the littoral zone (LPA), and the other (LPBC) located in the center of the lake, were taken in June 2008. The mean sampling resolution was taken from sediment every 16 cm (above 844 cm from core LPBC) corresponding to 120 yr/ sample +/- 20. The minimum number of pollen grains, excluding water plants and spores, counted per slide was 400. The pollen accumulation was subdivided into local assemblages according to LPAZ.[246] The LPBC core was used for the extraction of the ostracodes and for the high temporal-resolution lake-level reconstruction.[247]

CORE	DEPTH (cm)	Radiocarbon date	Calibrated age at 2sigma range	Material	Lab. reference
Core LPA	44-45	1600±30 BP	1546-1410	peat	Poz-27885
Core LPA	157-158	4120±35 BP	4821-4527	peat	Poz-30094
Core LPA	234-235	5140±40 BP	5990-5751	Carex seeds and wood fragments	Poz-27886
Core LPA	310-311	5340±40 BP	6271-5998	peat	Poz-30095
Core LPA	461-462	6220±40 BP	7252-7007	peat	Poz-30096
Core LPA	602-603	7940±50 BP	8990-8634	peat	Poz-32423
Core LPA	673-674	8930±50 BP	10227-9906	peat	Poz-30097
Core LPA	808-809	9360±60 BP	11063-10265	peat	Poz-33875
Core LPBC	131-132	2280±40 BP	2353-2158	wood fragments	Poz-33867
Core LPBC	401-402	4400±40 BP	5267-4858	peat	Poz-33870
Core LPBC	493-494	5160±40 BP	6095-5748	peat	Poz-33871
Core LPBC	735-736	7610±40 BP	8538-8345	peat	Poz-33874

Table 2. AMS radiocarbon dates obtained from cores LPA and LPBC, Lago Preola. With the courtesy of W. Tinner)

244 Calò *et al.* 2012, 111.

245 Calò *et al.* 2012, 111; Ostracodes are a class of bivalved, aquatic Crustacea that conceal a small (0.1 to > 2-mm long) calcitic shell that is commonly fossilised. Because of their small size, ecological sensitivity, well-known biology and shell chemistry, they are used widely in paleoclimatology and the reconstruction of marine and non-marine paleoenvironments long stratigraphic range, Cronin 2009; Lake-level changes are driven by different parameters. It can be a variety of factors such as non-climatic phenomena as geomorphology, hydrology of the catchment area, human disturbance on vegetation cover, or climatic factors as evaporation and precipitation Magny *et al.* 2011, 2471; For the ostracode analysis and lake-level reconstruction see Magny *et al.* 2011.

246 Calò *et al.* 2012, 113-114. LP1 8500-7500BC, LP2 7500- 6200BC, LP3 6200-5100BC, LP4 5100BC-500AD, LP5 500-2000AD,

247 Calò *et al.* 2012, 115.

The present work acknowledges the difficulties in sorting out the varied environmental drivers of ecosystem change over time due to the fact that, factors such as climate, natural disturbance and human activity operate simultaneously.[248]

The aim of this chapter is not to evaluate the significance of pollen data for climatic changes. The lake-level reconstruction has been correlated to the pollen archives in the study performed by Calò *et al.*, and will therefore not be highlighted here. The aim is, rather, to understand the ecological setting and fluctuations in the area during the period of interest as well as whether pollen data can be correlated to human activities such as agriculture. Since forest decline and pollen influx is visible in a more long-term perspective compared to the activities at Monte Polizzo, for example, the following sections acknowledge the pollen data from the Early, Middle and Late Holocene.

Long-term environmental and ecological changes based on pollen influx

The oldest sediment from Gorgo Basso and Lago Preola record the Early Holocene.[249] The dominant taxa in both lakes during this period (8250-7800 BC.) was herbaceous communities such as *Peucedanum*-t., *Cichorioideae, Artemisia, Poaceae, Brassicaceae* and *Urtica dioica-t*. The latter is associated with plants that are characteristic for open and/or ruderal environments and, since it is favored by anthropogenic nitrogen enrichment, it relates to human activities. [250] *Cichorioideae* and *Artemisia* are also important since they too can characterise a human-altered environments and an archaeological site.[251] Evergreen trees like *Quercus ilex* (stone oak), *Quercus suber (cork oak),* and deciduous *Quercus* and shrubs like *Erica* and *Pistacia,* were present but only sporadically during this period.[252]

Sediments from 7600 BC give us an image of a *Pistacia* shrubland partly replacing the open field herbaceous communities. In Lago Preola, an increase of more than 60% of the pollen sum was from *Pistacia*.[253] Local circumstances like precipitation were probably a driver for *Pistacia* expansion. *Quercus ilex* and deciduous *Quercus* were still uncommon in the coastal areas, but they dominated the lower uplands. The definition of lower uplands are 600- 1200 m a.s.l.,[254] which include Monte Polizzo at 730m a.s.l. During 7500-5000 BC the *Pistacia* marquis decline and pollen from *Quercus ilex* and a first presence of *Olea* is evident but low in influx.

The first signs of human agricultural activity in the region is evident during 5500 BC when *Ficus carica, Cerialia-* t., and *Rumex* weed, often associated with the first stage of human disturbance of the natural environment, and *Plantago lanceolata*, a common weed type, which are particularly palatable to grazing animals, are present in the pollen collection. [255] *Plantago* is also associated with trampled and ruderal places, and their distribution in a territory depends mainly on the presence of human beings and herds of herbivores.[256]

During this time, the pollen record changed significantly in both lakes. At Lago Preola, a landscape of *Olea europaea* and *Quercus ilex* expanded after 5500 BC and these taxa reaches almost 60% of the pollen sum, demonstrating afforestation and the existence of forest and woodland in the surrounding region of Lago Preola. However, the *Pistacia* pollen also increased after a period of decline.[257]

On the contrary, the type of habitat in the Gorgo Basso area at 5350 BC indicates an open landscape with

248 Deza-Araujo 2020, 2; Weiberg *et al.* 2016 ; Nelson *et al.* 2006.

249 Tinner *et al.,* 2009, 1501. For the sake of uniformity is BC used instead of cal, yr. BP, the latter is more common in this type of analyses.

250 Ellenberg 1996, Tinner *et al.,* 2009, 1501.

251 Mercuri 2013, 146.

252 Tinner *et al.*, 2009, 1501. Also *Tamarix, Juniperus, Corylus avellana* at Gorgo Basso and *Phillyrea augustifolia* at Lago Preola.

253 Calò *et al.* 2012, 115.

254 Tinner *et al.* 2009, 1505.

255 Calò 2012, 114-115; See Stewart 1996 for *Plantago* as forage.

256 Mercuri *et al.* 2013, 149.

257 Calò *et al.* 2012, 115.

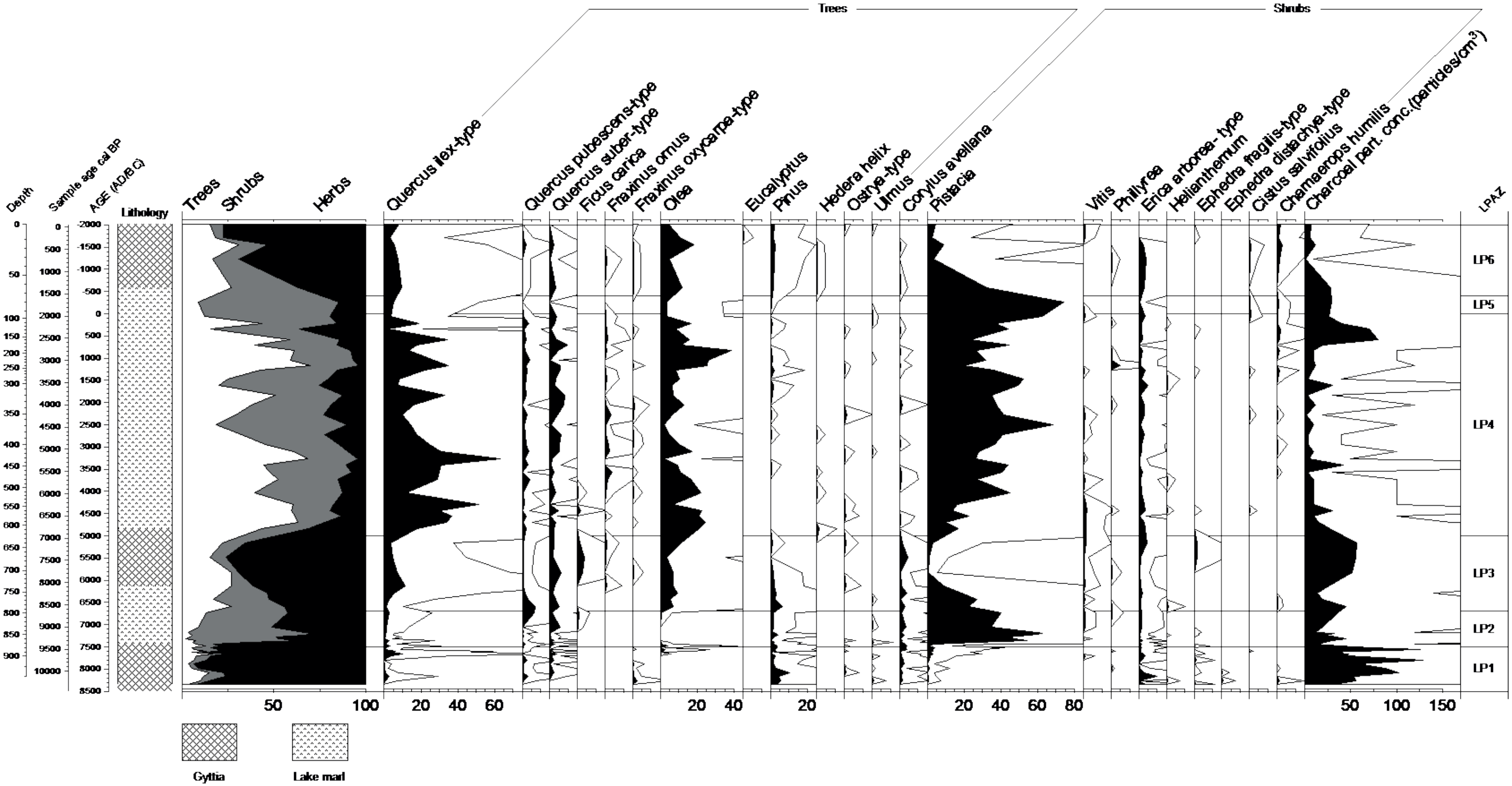
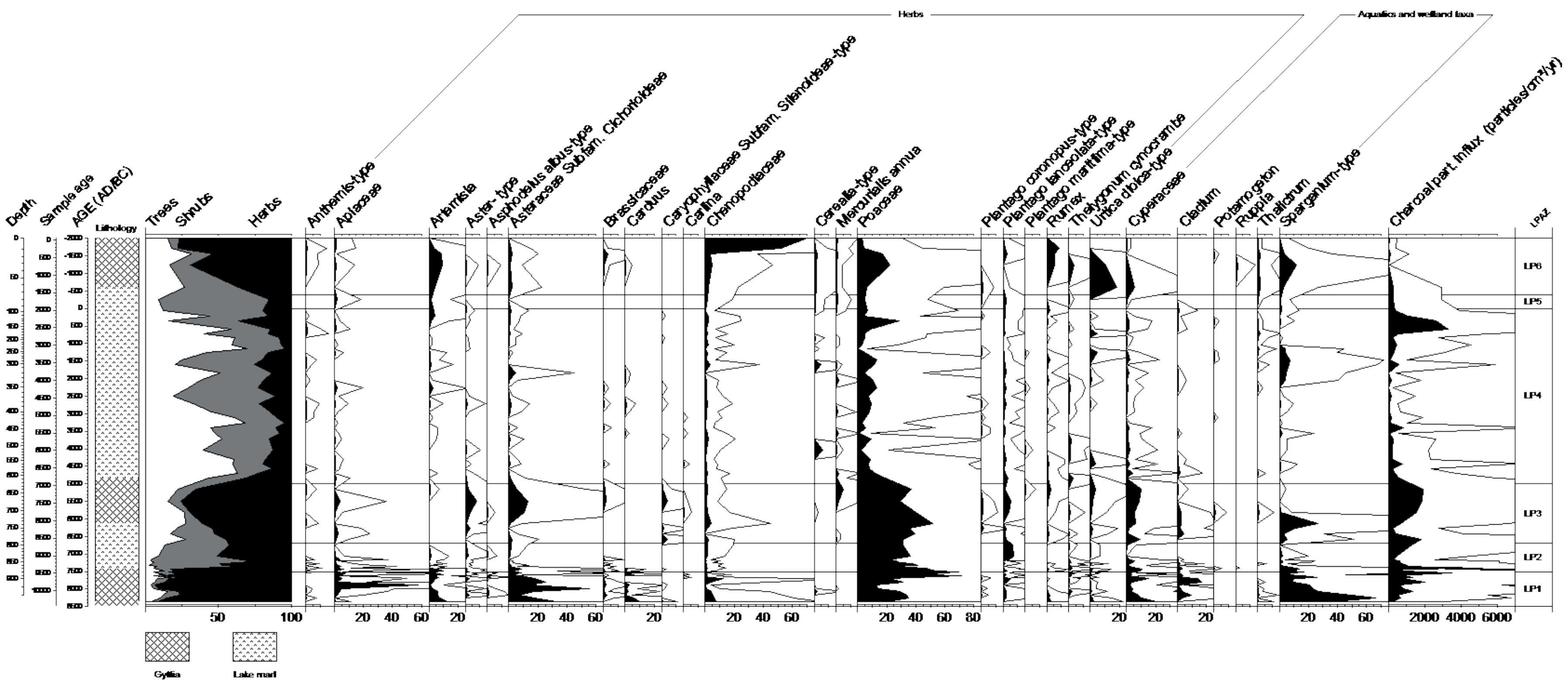
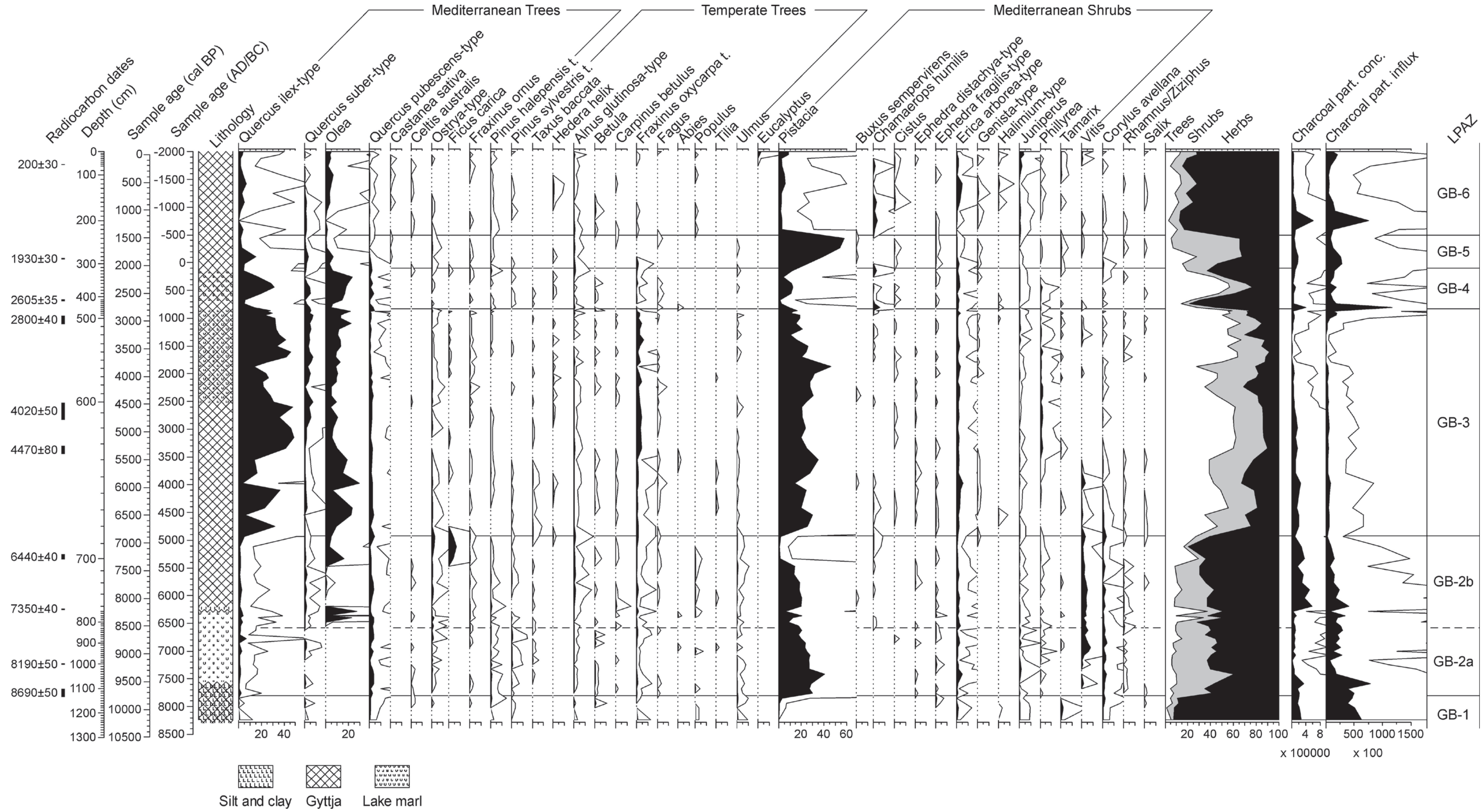


Figure 2. Selected arboreal pollen percentages and charcoal concentration of core LPBC from Lago Preola. Empty curves show 10x exaggerations. LPAZ = Local Pollen Assemblage Zones. With the courtesy of W. Tinner

Figure 3. Selected non arboreal pollen percentages and charcoal influx of core LPBC from Lago Preola. Empty curves show 10x exaggerations. LPAZ = Local Pollen Assemblage Zones. With the courtesy of W. Tinner





Fiureg 4. Arboreal pollen percentage and charcoal influx diagram of Gorgo Basso. Selected pollen types only. Water plants and ferns are excluded from pollen sum. LPAZ ¼ Local Pollen Assemblage Zones. Empty curves show 10 x exaggerations. With the courtesy of W. Tinner

no forest, not unlike the shrub landscape of *Olea- Pistacia* marquis present in Sicily today.[258] Instead of signs of afforestation in the pollen influx, we find human disturbance in the natural shrubland. This is based on two different factors, first a decline of *Olea – Pistacia* stands and, second, the increase of pollen indicators of the first agricultural activities in this area in Sicily just mentioned above. Tinner *et al.* suggest a special kind of Mediterranean Neolithic farming system in this area where figs and grains were the predominant crops cultivated in patches of open landscape.[259]

Four centuries later in 4950 BC, a significant change of the pollen stratigraphy of the Gorgo Basso occurs. The herbaceous taxa and many of the above-mentioned types declined in favour of arboreal pollen, which suggests that the landscape changed from open to a rather dense evergreen *Quercus-Olea* forest, as evident in Lago Preola.[260] The sudden abundance of arboreal taxa is also evident in the pollen record of Biviere di Gela, the largest coastal lake in Sicily, located on the southeastern part of the island.[261] When the forest expanded and the patches of open landscape disappeared, Neolithic farmers may have been driven to relocate.

The charcoal influx shows that regional fire activity, which had been rather high in the open herbaceous environments, abruptly decreased in correlation to the expansion of the *Quercus-Olea* forest. The change in the fire record at Gorgo Basso should not be seen as a result of the disappearance of the Neolithic farmers, because it is also consistent with the fire frequency at Lago di Pergusa in central Sicily, in which the charcoal influx also declined in correlation with the expansion of the mixed deciduous evergreen forests.[262]

Iron Age pollen and charcoal record

The *Quercus-Olea* forest, with *Pistacia* shrubland strands occupying dry habitats, remained stable until 800 BC when frequent regional fires suddenly peaked. Tinner *el al.* show that a "general characteristic of this charcoal record is that the lowest fire incidence always correspond with the highest *Quercus Ilex* pollen abundances" with less than 10.000 charcoal particles cm-2 yr-1 or 3.3mm^2 cm-2 yr-1. In the charcoal archives from 800 BC, charcoal particles were up to 116,967 particles cm-2 yr-1 or 33.3mm^2 cm-2 yr-1. This increased fire activity could correspond to the establishment of the Phoenician settlement at Motya and the emergence of the numerous Elymian settlements in the region.[263] The pollen record from Gorgo Basso and Lago Preola demonstrate a substantial reduction of the forest, with the lowest arboreal influx around 750BC.[264] These events are strongly associated with an agricultural presence in the area. This is not only suggested by the fire disturbance, and the arboreal pollen decrease, but the increase and expansion of what Mercuri *et al.* call "anthropogenic pollen indicators" (API)[265], such as *Cerealia*-t., *Artemisia, Cichorioideae, Plantago lanceolata-t. Urtica membranacea-t.*, *Mercurialis annua,* all of which are recurrent in spectra from 26 different archaeological sites in Sicily and of the Italian peninsula.[266]

Around 650 BC, the pollen record of Gorgo Basso shows an influx *of Quercus–Olea* forest pollen, indicating a partially recovering forest until 250 BC when it drastically decreases again.[267] In 700 BC the total pollen sum was 15% tree pollen, 5% shrub taxa and 80% herbs (including the grass, flowers and weeds associated with human disturbance). The total sum of pollen during 600 BC was approximately 50% trees, 45% herbs, and 5% shrubs. In 400 BC, by comparison, the total sum of

258 Tinner *et al.* 2009, 1501.
259 Tinner *et al.* 2009, 1507.
260 Tinner *et al.* 2009, 1501.
261 Noti *et al.* 2009, 371.
262 Sadori and Giardini, 2007.
263 Tinner *et al.* 2009, 1502.
264 Tinner *et al.* 2009, 1504.
265 Mercuri *et al.* 2013, 143.
266 Mercuri *et al.* 2013,146. *Carduus, Chenopodiaceae, Brassicaceae* were also included in the pollen influx, but do not qualify as anthropogenic human indicators since they are ambiguous and less informative in a general context.
267 Tinner *et al.* 2009, 1501.

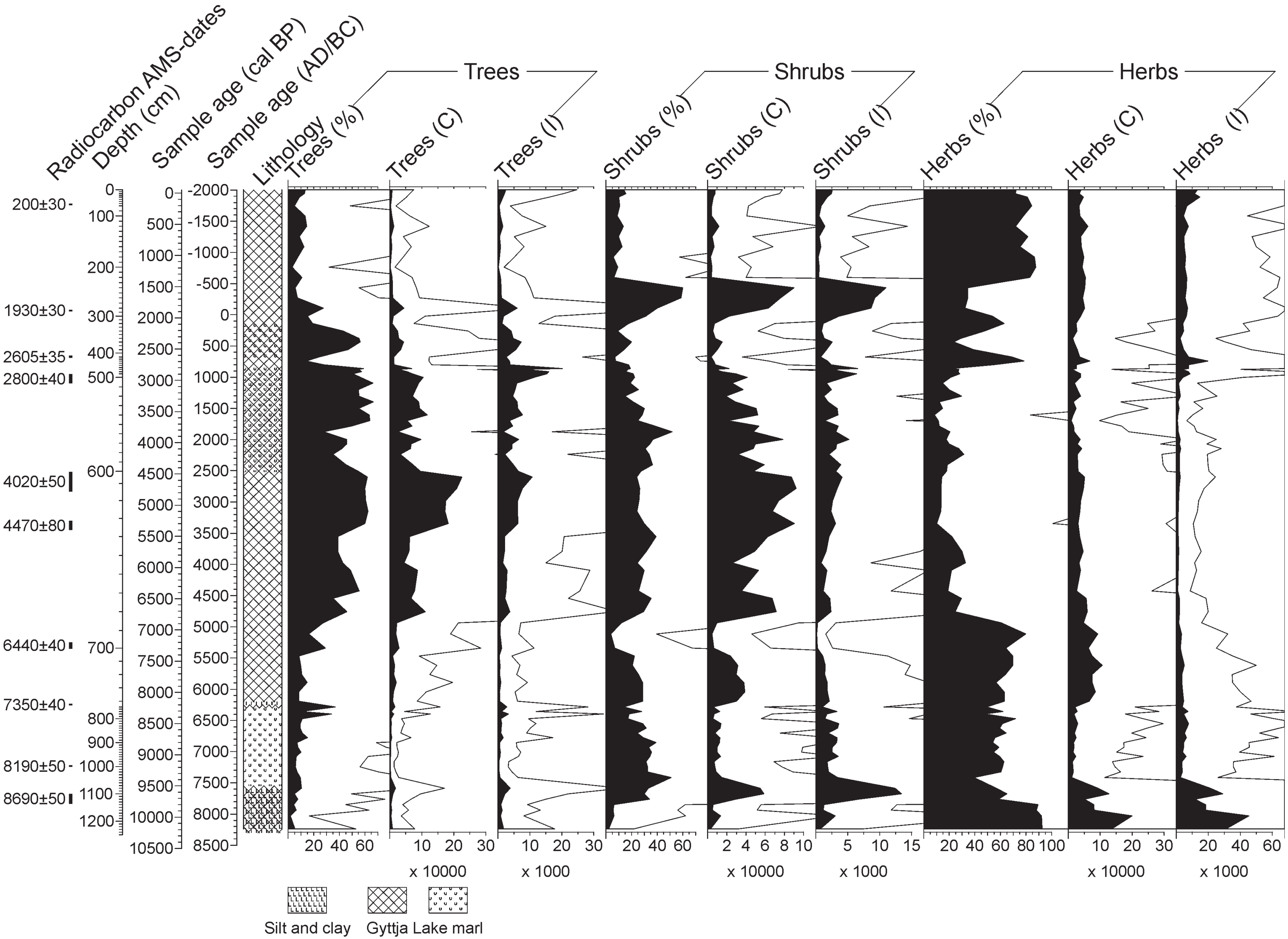


Figure 5. Comparison between pollen percentages, concentrations and influx of selected pollen sub-sums (trees, shrubs, herbs) of Gorgo Basso. Empty curves show 10x exaggerations. With the courtesy of W. Tinner)

tree pollen was at 65%, (similar to the percentage influx around 1000 BC at 70%) herb pollen had decreased to approximately 20% and 15% shrub, followed by a steady decline of tree pollen influx.[268]

The increasing richness of wetland plants such as *Cyperaceae, Cladium mariscus, and Ceratophyllum, Potamgeton* and *Ruppia* during this period, in combination with the increasing forests, suggest that the human disturbance in the local area around Gorgo Basso temporarily declined. In addition, the pollen data indicates a lake-level change and possibly eutrophication in the area, which can occur as a consequence of erosion and land clearing.[269]

At a regional scale, the tree pollen sum from the larger catchment area at Lago Preola was circa 60% during 600 BC, while the herb influx was about 13% and the shrubs 27%. In 500 BC the total amount of tree pollen had decreased to about 38%, herbs had increased to 23% and shrubs to 39% of the total pollen sum. The decrease of trees continued during 450 BC when it recorded about 13% of the total amount of pollen, while herbs had increased to 35%, and shrubs to 52%. [270]

In sum, the combined pollen record of these two sites thus suggests that the evergreen forests that developed in the region during 5500 BC persisted until around 750 BC when a substantial reduction of the forest occurred and an increase of anthropogenic pollen indicators is visible in the pollen data. While a local change in the pollen repertoire occurred around Gorgo Basso, the abundance of human pollen indicators and a more open shrub environment continued to increase after 600 BC at a regional scale.

268 Tinner *et al.* 2009, 1504.
269 Tinner *et al.* 2009, 1501. Eutrophication. When a body of water becomes overly nourished.
270 Calò *et al.* 2012, 116.

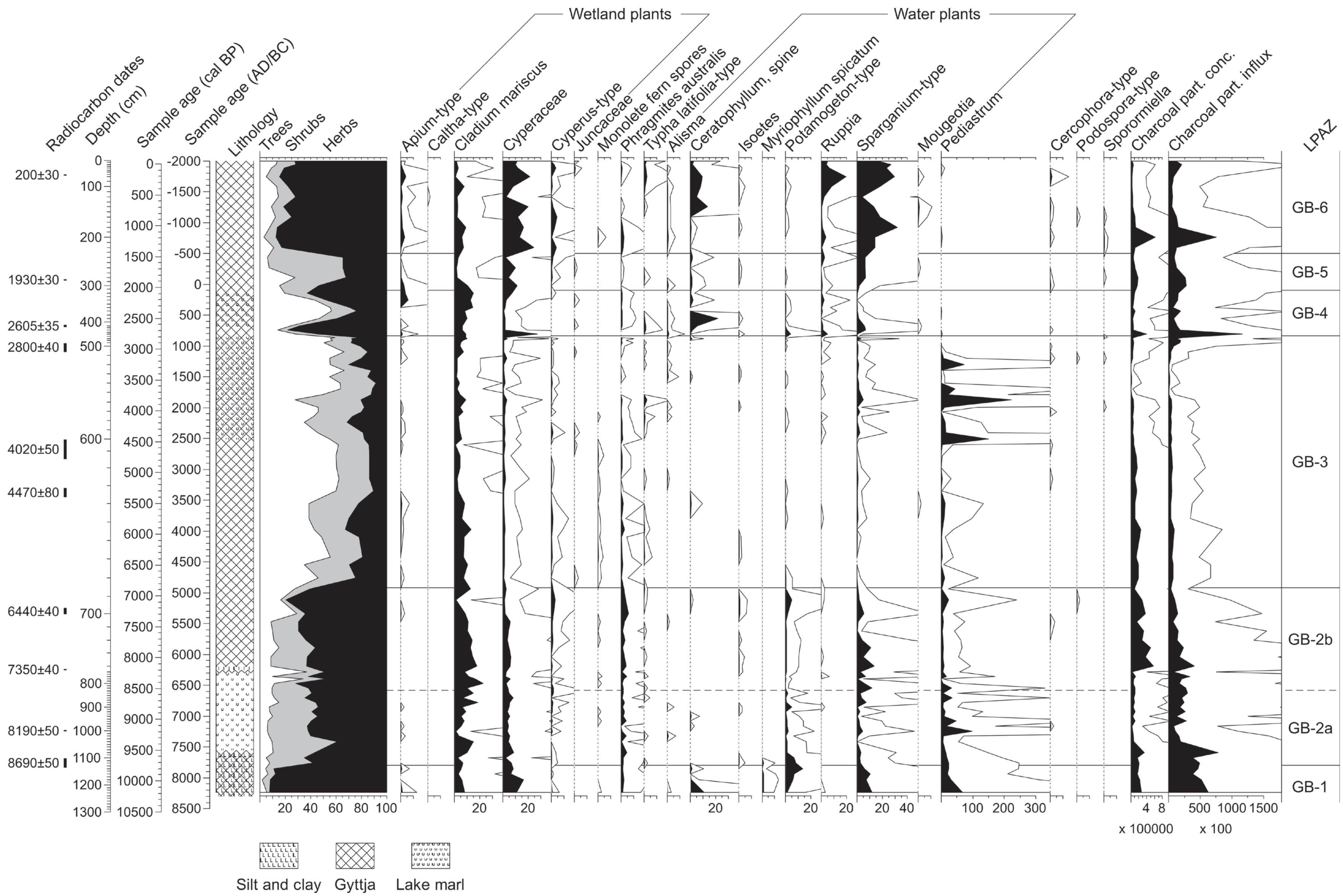


Figure 6. Pollen percentage and charcoal-influx diagram of Gorgo Basso, wetland and aquatic plants. Selected pollen and spore types only. Water plants and ferns are excluded from pollen sum. LPAZ = Local Pollen Assemblage Zones. Empty curves show 10x exaggerations. With the courtesy of W. Tinner

CHAPTER 7

The "Territory" of Monte Polizzo, Land Use and Local Economy

This chapter will first briefly discuss the concept of territory, specifically the possibility of understanding boundaries between Monte Polizzo and the landscapes facing west and southwest towards Motya and Selinus during the Archaic period. A settlement's territory is an important factor to consider in establishing whether it had enough arable land to avoid exceeding its carrying capacity. The archaeological remains found in the immediate landscape around Monte Polizzo will be presented in this context. The discussion will continue with an assessment of how the local economy was structured based on the macrobotanical and faunal investigations conducted within the SSAP. Further, this discussion will consider how inhabitants could have organised themselves given the landscape and highlight other aspects of life that were closely integrated in the societal structure at Monte Polizzo.

During the past decades, models sprung out of various disciplines have contributed to different perspectives on archaeological research about territory.[271] The rational usage of territory assuming the existence of accepted and recognisable boundaries or markings is a feature of modern geopolitical thought in the West. Boundaries are drawn with the purpose of preventing access to those who should be excluded.[272] For some, "territory is a material medium that both enables and restrict human subsistence and that bears little relevance to questions about political life".[273] However, if territories are seen as fixed containers for social, economic, or political life, all boundaries are at risk to be treated equal.[274] Ethnographic and historical examples show that territorial boundaries were not fixed in both time and space. Instead, within a given territory, definitions of boundaries and the need for defence varied depending on different parameters.[275]

Zedeño suggests that human territoriality[276], with all its social, economic, political, and ritual dimensions, is enacted in three ways:

> (1) the formal or material dimension, which refers to the physical characteristics of land, resources and human modifications;
>
> (2) the spatial or relational dimension, which encompasses the loci of human action, as well as the inter-active links that, through the movement of actors connect loci to one another, and

271 See for instance Soja 1971; Binford 1982; Sack 1986; Bettinger 1991; Rosenberg 1990; Rossignol and Wandsnider 1992; Kohler *et al.* 2000; Heilen and Reid 2009; Giddens 1984; Golden 2010; Elden 2013.

272 Zedeño 2008, 211.

273 Vanvalkenburgh and Osborne, 2012, 14; See also Vita-Finzi and Higgs 1970, on different economic territories.

274 Vanvalkenburgh and Osborne, 2012, 10.

275 Vanvalkenburgh and Osborne, 2012, 11. An example given by Vanvalkenburgh and Osborne is Lee's research of the !Kung from the Kalahari desert, and how they treat the social space among them. Lee 1979.

276 Sack 1986, The concept of Human territoriality, according to Sack as "by an individual or group to affect, influence, or control people, phenomena, and relationships, by delimiting and asserting control over a geographic area" Territory as something invented in order to get social control when needed.

Figure 1. View from Monte Polizzo towards the western coast

> (3) the temporal or historical dimension, which is characterized by sequential links resulting from successive use of land and resources by individuals and groups.[277]

In Chapter 3, I discuss the visuality of the Greek settlements and their *chorai* in the landscape and in modern scholarly literature, compared to the invisibility of indigenous settlements and their landscapes. The modern perception of Elymian territories is that they were most certainly small. Would this assumption really hold for the Monte Polizzo settlement? A question that is highly relevant in the context of this work is, of course, if there were any territorial boundaries between the indigenous settlements in western Sicily during the seventh century BC when the mountain settlements that we know of started to emerge? Except for natural markers, such as rivers, mountains, and the sea that can provide an idea of how far territories extended, we do not actually know if the concept of enclosing a part of nature in order to claim possession over it even existed in the indigenous societies of archaic western Sicily. If not, when were boundaries deemed necessary to be drawn? Different rules may have been applied to different parts of the boundaries, depending on the territorial factors in question.[278] The rules themselves for acknowledging territorial boundaries sometimes fluctuate. Resource distribution, such as access to fresh water or hunting grounds, require alternative territorial strategies with neighbours than strictly fixed boundaries. Social and religious principles may also circumvent boundary-crossing regulations, giving people access to various important places, acquired, controlled, or owned by others.[279] These are all factors that need to be considered in the present discussion.

With land in abundance in Archaic Sicily, as De Angelis puts it (see discussion in Chapter 3), a trigger was perhaps needed to start enclosing and securing parts of

277 Zedeño 2008, 212; see also Zedeño 2000.
278 Vanvalkenburgh and Osborne, 2012, 11. A modern example is for instance the American border where the Canadian border is on the other side of the spectrum comparing to the wall that mark the border towards Mexico.
279 Zedeño 2008, 212.

the environment. Such a trigger could have been when others laid claim to the land, threatening subsistence.[280]

The most common method of recognising a settlement's territory is to collect portable artefacts and analyse their distribution since material culture signals ancient territoriality. Beyond scattered material culture, shrines, megalithic rock art, and other types of monumental architecture can also signal territorial boundaries, as will be discussed below. The seasonal fluctuations in weather and hence the ability to traverse the environment is another factor to consider. In addition, natural settings can themselves play an important role in land use and the formation of territory.[281]Purcell argues that nature, particularly pathless forests, nutrient-poor deserts, and hostile mountains, is often represented as alien space in Greek and Roman philosophy. He suggests that ancient people perceived these forms of nature frighteningly hostile because of the difficulties they pose to the traveller attempting to navigate such landscapes. If an area of wilderness did not have paths or lines of communications passing through it, the Romans cordoned it off.[282] This notion is interesting since the landscapes discussed in this work nurtured marshes, which very well could have served as hostile zones and consequently helped shape natural territorial boundaries.

The lower landscapes between Monte Polizzo and Motya

The evidence of Elymian manifestations in terms of enclosure--endings or beginnings--of their territories are scarce to non-existent. The concept of visibility in the landscapes, however, was a tradition amongst indigenous peoples. This is evident given the simple fact that they settled on hilltops. The expansion of Elymian territories is, for the most part, invisible in ancient literary sources. One must carefully read between Thucydides' lines to find a rare acknowledgement of Elymian territory. He explains why the Phoenicians moved to the western part of Sicily, and one can understand Thucydides' view of the Phoenician-Elymian 'alliance' as a reciprocal agreement respecting Elymian territory:

> But when the Hellenes began to arrive in considerable numbers by sea, the Phoenicians abandoned most of their stations, and drawing together took up their abode in Motye, Soloeis, and Panormus, near the Elymi, partly because they confided in their alliance, and also because these are the nearest points, for the voyage between Carthage and Sicily. (Thuc. 6.2.6.).

Archaeologically, there are no visible remains indicating territorial boundaries between Motya and Monte Polizzo. The settlement of Motya is located at the island of San Pantaleo, which is situated within the Stagnone Lagoon, just outside the coastline between Trapani and Marsala. The settlement was linked to the coastline with a now submerged causeway since the sea level near this part of the island was about 0.8-1 m lower than it is today.[283] The causeway led up to the mouth of river Birgi, making it easy to reach rural landscapes and make contact with the Elymians at Eryx located to the north and, eventually, onto Monte Polizzo on the other end of the Birgi/Cúddia River. The settlement never extended to the mainland on the other side of the lagoon, however, aside from the necropolis at Birgi.[284]

It is generally accepted that the Phoenicians were not hungry for new territory. But Aubet argues that the Elymians' dominating agricultural presence in the area prevented Motyan territorial expansion.[285] The landscape between Motya and Monte Polizzo has not yet been studied extensively enough to support such a notion, but a 112-square kilometre block of the land area between Motya and Lilybaeum (located further south) has been surveyed by Blake and Schon.[286] The western limit of the survey area was only about 12 kilometres from Monte Polizzo. The project revealed nearly no identifiable archaeological material and neither

280 Vanvalkenburgh and Osborne, 2012.
281 Bradely 2000; Williams 1982.
282 Purcell 2003, 15.
283 Nigro, 2013, 41.
284 Nigro 2013.
285 Aubet, 2001, 233.
286 Blake and Schon 2008.

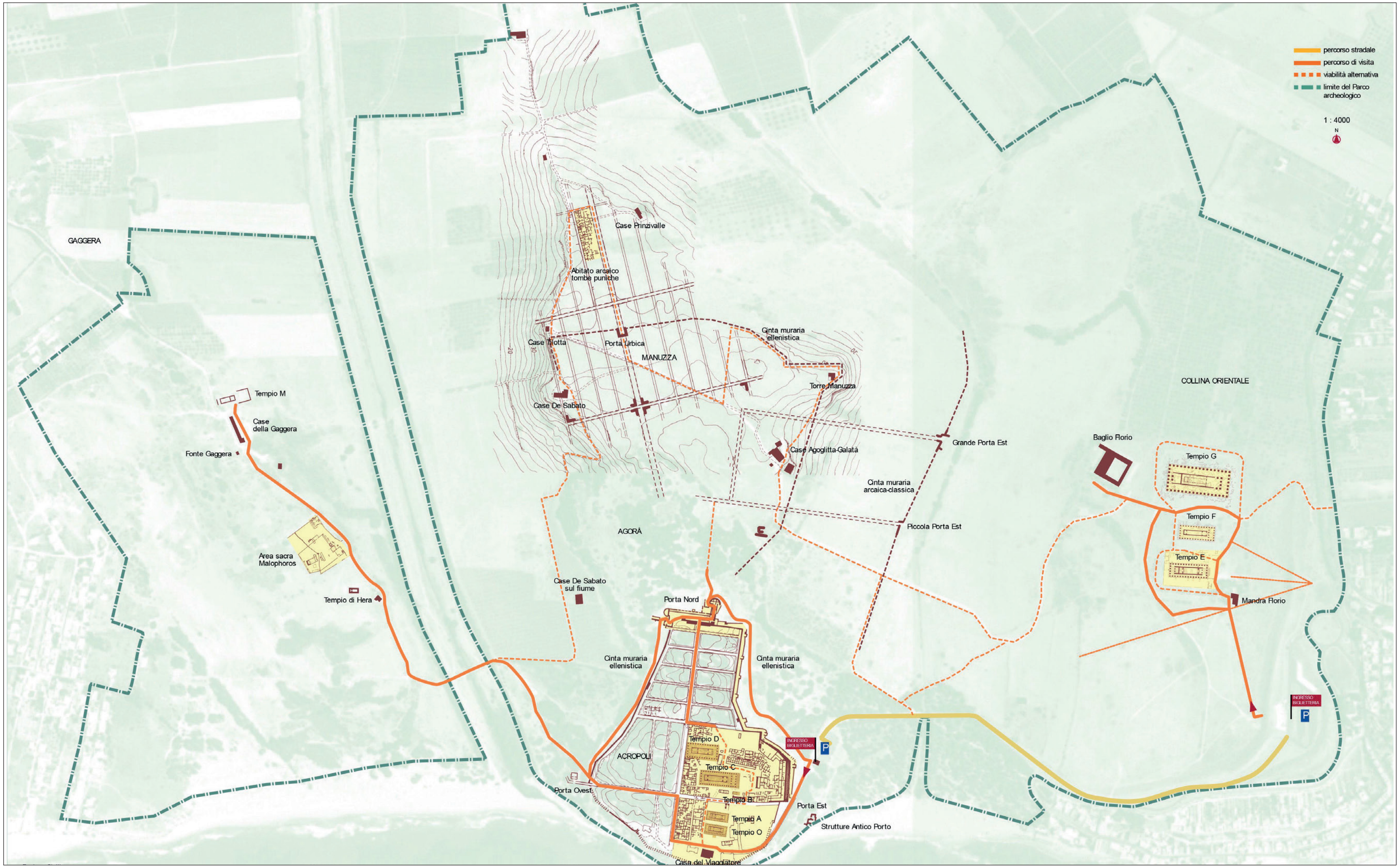


Figure 2. Map Selinus settlement. (Grafimated by Antonio Pirrotta e Alessandra Ragusa, downloaded from visitselinunte.com)

Phoenician nor any Greek pottery or archaeological features from the eighth to the mid-sixth century BC. The only possible evidence of any activity was found in the northern-most unit (closest to the inland and the river Cúddia) where a few indigenous greyware sherds were found. In the investigation's unit closest to the sea, at the Roman site of Genna, an indigenous assemblage was located, indicating some kind of indigenous Iron Age or Archaic presence at the site. However, this is only based on the concentration of sherds found. Blake and Schon conclude that this area was never inhabited during the Iron Age and Archaic period as a settlement, neither by Phoenicians nor Elymians.[287]

The southwestern landscapes

Since it is difficult to establish the parameters of the Monte Polizzian territory based on territorial markers, it is worth acknowledging the potential territory of the neighbouring settlement of Selinus. The Greeks were, contrary to the Phoenicians, considered territorially expansive. Strategically placed Greek architectural manifestations of territory can offer clues to the unknown area in between as well as to the relationship between the different inhabitants in the area.

It was vital for newly arrived Greeks to settle in a place to manifest the presence in the landscape. The establishment of sanctuaries, especially of the non-urban variety, was used to define a new territory and hence the attendant political space. Generally, both non-urban and urban sanctuaries were planned according to spatial factors and built during the first generation of settlement.[288] This is evident at Selinus, where the initial main settlement on the Manuzza Hill and its territory were defined as stretching from the Demeter Malophoros sanctuary in the west to the archaic acropolis just south of Manuzza Hill, where two temples (C and D) may have existed, and temple E to the east. All of these were built—at least in their earliest incarnations--during the last quarter of the seventh century when the settlement was initiated. [289]

The first Demeter Malophoros sanctuary built is believed to have been cross-cultural and constructed during the late-seventh century, creating a literal middle ground between the different peoples active in the area. To support such a notion, the sanctuary should be considered in the context of an earlier Elymian presence. Human disturbance of the natural environment occurred in the area from at least 750 BC when human indicators emerge in the pollen records as discussed in Chapter 6. This presence was archaelologicaly established by a round stone structure associated with an indigenous hut at Manuzza Hill (the first habitation area at Selinus) discovered in the earliest layers during the excavations there.[290] This structures shows that there was an indigenous establishment at the location before the Greeks settled. In relation to the stone foundation, there were benches, a hearth, and ceramics. The earliest layers dated to the eighth and seventh centuries contained only indigenous ceramics. During the late seventh century, Greek ceramics started to appear. Tusa suggests that this indicates a mixed group of people living there or that the indigenous and Greeks lived side by side during an initial phase of the Greek establishment at Selinus.[291]

The Demeter Malophoros sanctuary, first built as an altar, was located close to a spring. This is acknowledged by Malkin, who suggests that it may very well be the reason why the Greeks chose the location.[292] Considering Tusa's suggestion of a cross-cultural sanctuary, and the earlier presence of the Elymians in these landscapes, it is possible that this site was already considered a sacral place before the establishment of the Malophoros sanctuary.[293] However in this study, one 'origin' is as plausible as the other, and both possibilities should be recognised.

287 Blake and Schon 2008, 55.
288 Malkin 1987, 175.
289 De Angelis 2003, 129-130.
290 Tusa 1982.
291 For Malophoros see Tusa 1982, 111-117; Manuzza Hill, see Rallo 1976-1977, 720-733; 1984, 81-96; and for Acropolis see de la Genière 1975, 83-84.
292 Tusa 1986; See also Malkin 1987, 175.
293 See Polignac 1984, for a general discussion about the assimilation of indigenous and Greek sanctuaries.

The cross-cultural middle ground established around the Malophoros sanctuary vanished along with the co-existence during the turn of the seventh century. In the early sixth century, new fixed boundaries might have become more important to manifest. Probably when Selinus' subsistence strategy needed to be considered, as Diodorus Siculus' text below might be indicating. The ancient writer recounts a story about the territorial tension that occurred with the Greeks and the Elymians around 580 BC:

> …Pentathlus sailed to Sicily to the regions about Lilybaeum, where they found the inhabitants of Egesta and of Selinus at war with one another. And being persuaded by the men of Selinus to take their side in the war, they suffered heavy losses in the battle, Pentathlus himself being among those who fell. Consequently the survivors, since the men of Selinus had been defeated in the war, decided to return to their homes; and choosing for leaders Gorgus and Thestor and Epithersides, who were relatives of Pentathlus, they sailed off through the Tyrrhenian Sea (Diod. Sic. 5.9)

During the course of a generation, several other sanctuaries and temples were established on the territory that faced the Phoenicians and Elymians in the northwest. On Gaggera hill, a sanctuary dedicated to Hera dated to the first quarter of the sixth century was located west of the sanctuary of Demeter Malophoros. About 300 metres northeast of the Malophoros, there are remains of a temple M. The temple is dated to 570-560 BC and was probably dedicated to Heracles.[294] These new temples show that the social and religious principles that predated boundary-crossing regulations were perhaps over-ridden by a more important agenda than giving various people access to important places.

The monumental buildings manifested a Greek presence, but they do not reveal how the Greeks organised themselves in the landscape during the seventh and sixth centuries. A survey with the aim to understand the limitations of the Selinuntian territory was conducted during the 1990's.[295] The investigation was limited by the Modione River to the west, the Belice River to the east, and by the calcarenite bank of the so-called Cave del Barone rises, beyond which, through a continuous series of hilly chains and vast plateaus, one enters what Bianchi *et al.* call the internal Elymian territory. The studied area thus covers about 25 square kilometres. The investigation revealed that the elements relating to the archaic phase were scarce and difficult to read. Nevertheless, it seems to suggest that there was some form of population along the plateaus north of the settlement.

The oldest inhabited area identified in the rural area outside Selinus, is dated to the first quarter of the sixth century BC. This site is located about 3.6 kilometres from the settlement proper, at the central part of a wide plateau that extends from the Belice river valley to the east to the Latiome Maggio valley to the west. The diffusion of ceramic surface finds attests that the area covered by the settlement was quite extensive already (about 2 hectares) in the Archaic period.[296] Interestingly, the flat areas between this area and the settlement centre appeared almost devoid of human action until at least the fifth century BC, since the archaic activities were centred exclusively in the 'peripheral' and hilly areas.[297]

Bianchi *et al.* believe that the distance between the Selinus and its rural settlement could have prevented the landowners from going to work the fields within a day and, thus, they stayed in the countryside. The fact that a rural population was settled some kilometres away, is suggested to be a sign of a division between the agrarian and 'city' population.[298]

Around the middle of the sixth century BC, facing the Elymian territory, a northern territorial boundary of Selinus has been suggested. [299] This idea is based on a stele dedicated to Heracles found outside the indigenous settlement of Castellazzo di Poggioreale, situated in the mid valley of the Belice River about 30 kilometres from Selinus. (see map above) The stele was found in a context interpreted as a place of worship for Heracles

294 De Angelis 2003, 135; Tusa 1983; 1986.
295 Bianchi *et al.* 1998.
296 Bianchi *et al.* 1998, 133. The site is identified as S33 Fermata Latiome.
297 Bianchi *et al.* 134.
298 Bianchi *et al.* 1998, 133.
299 Piraino 1959, 160-161; De Angelis 2003, 102.

and, since the inscription was written in a Selinuntian alphabet, it has been presented as a territorial marker for Selinus' northern limit.[300] There are, however, two other possibilities for the presence of this stele deserving of a short digression.

First, one should consider that the Elymians could have made this dedication with the purpose of marking their territorial boundary. The stories of Heracles' deeds had surely reached the indigenous population since dedications to Heracles are known from other indigenous sites (which will be discussed below). Heracles' journey though Italy and his circuit around Sicily is especially interesting in this western Sicilian context (Diod. Sic. 4.22.6.). Diodorus Siculus, who prefers a mythological perspective on natural phenomenon, narrates how Heracles set out for Eryx and its eponymous Elymian ruler. Along Heracles' way, the Naiad nymphs created warm baths (hot springs) to gash forth for Heracles recreation (Diod. Sic. 4.23.1.). The two hot springs accounted for were located by the ancient Greek settlement of Himera and the Elymian settlement of Segesta. Both springs were named after the nymphs Himeraea and Egestaea respectively, which in turn were named after the settlements (Diod.Sic. 4.23.1.).[301] This story thus accounts for how the hot springs in Segesta came to be (with water derived from the karstic area at Vita). It also accounts for Heracles' contact with the Elymians, his movement in the Elymian landscape, and perhaps the reason for the Elymian acknowledgement of the hero.

The second possibility for the presence of the Heracles stele in the Belice valley relates to Heracles' role as protector of herds, both of cattle and sheep and in effect over transhumance and cattle-commerce.[302] The presence of Heracles in pastoral contexts is also understood as a symbol for the organised side of the pastoral life, such as cattle markets and the economic subsistence the animals could secure. This is evident of the many sanctuaries dedicated to Heracles at the cattle markets of Rome, for example, at Ara Maxima and Aedes Herculis Invicti. Along Via Tiburtina, a transhumance route leading between the coast of Rome and the mountains of Abruzzo, many of the cult places are dedicated to Heracles.[303] The find location of this particular stele in the Belice valley might thus indicate that this area was dedicated to the herds and the practice of transhumance, protected by Heracles. It might as well have been a territory without boundary regulations and used by herd keepers from various places leading their animals to pasture.

Another interesting stele dedicated to Heracles that supports this idea is found at the indigenous settlement of Colle Madore located about 30 kilometres inland, southwest from Himera. This stele depicts Heracles collecting spring water in an amphora.[304] This scene draws attention to the amphora and its provenance, the fountain and

Figure 3. Stele of Heracles at Colle Madore. (Adapted after Vassallo 1999, 207)

300 Piraino 1959, 160-161; De Angelis 2003, 102.

301 Diodorus narratives of Heracles and the springs of Himera and Segesta and the hero's importance in Sicily is also discussed by Vassallo 1999, 203-206.

302 Santillo Frizell 2009, 45.

303 Santillo Frizell 2009, 45. See also fig. 2 on page 41 for a model of a transhumance route in Rome.

304 Vassallo 1999 203-206.

its function, the central figure and his attributes, which all are discussed by Vassallo in publication.[305] However, in the current context, a plausible suggestion is that the stele depicts Heracles as the protector of herds. The water he fills in the amphorae is not for himself, but for the herds in the pastoral landscapes. In this respect he is also the protector of the economy that the pastoral activities can bring to the settlement.

To close this digression, it is safe to say that regardless of who dedicated and organised the placement of the Heracles stele in the Belice valley, the inhabitants in this area must have had a peaceful understanding with their Greek neighbours. This can be seen in comparison to the visual manifestation of the monumental religious buildings erected by Selinus facing the western landscapes of Motya and Monte Polizzo. They show a completely different attitude towards those neighbours. Manifesting a settlement by erecting monumental temples is, of course, a symbol of Greekness in its own right. Contrary to mainland Greece, where the gods were connected to the soil, "the holiness belonged to the place itself" as Nilsson wrote.[306] The location of temples and sacred areas in the newly-founded Greek settlements was generally strategically placed by decision of the *oikist.*[307] Whether they were built in the heart of the settlement or in the *chora*, they were seen as a statement of possession--and as protection from neighbouring peoples.[308]

The Monte Polizzo Survey

The potential territory of Monte Polizzo has only partly been investigated archaeologically. The survey conducted by Blake and Schon did not aim to understand the territory of Monte Polizzo specifically. However, based on spatially distributed material culture in particular portable artefacts, it can be used to map an Elymian 'space' and the landscapes 'in between' the known settlements.

Regarding the immediate space around Monte Polizzo, Kolb conducted a number of intensive surveys in a 25 square kilometres area of the valley floors between Monte Polizzo and Montagna Grande, located just 4.5 kilometres north of Monte Polizzo on the other side of the Cúddia River valley.[309] Kolb's team found artefact scatters covering an area about 80 hectares, at a distance of three kilometres from the main settlement. The surveys did not indicate that the settlement proper extended down into the lower landscape. Four small clusters of what was interpreted as residential areas, could give us an estimation of the closest rural activities. The exact locations of these clusters, however, were not provided in their article. [310] Scattered ceramics were also found up to five kilometres west, along Cúddia River.[311]

The surveys on Montagna Grande revealed five different concentrations of Iron Age ceramics along the ridgeline called Poggio Roccione. A small excavation of the largest concentration later followed the survey. Unfortunately, recent ploughing and reforestation had probably destroyed any possible building remains, and no structures were detected.[312] The excavated area of 20 square meters almost only revealed coarse ware. The near absence of both cooking ware and tableware suggests that this was not a domestic area, rather an outbuilding or other location for off-site activities. Additional ceramic concentrations were located along the southwestern slope of Montagna Grande. Kolb suggests that these could be archaic farmsteads or residential areas.[313]

In sum, based on the archaeological evidence registered in the surveys around Monte Polizzo and Montagna Grande, the immediate surroundings were used for rural activities. Outbuildings or other types of buildings were scattered in the surroundings up to a distance of

305 Vassallo 1999 203-206.
306 Nilsson 1969, 9.
307 Malkin 1987, 185.
308 Polignac 1995, 103.
309 Kolb and Tusa 2001, 503.
310 Kolb and Tusa 2001, 503.
311 Kolb 2007, 180.
312 Kolb 2007, 179.
313 Kolb 2007, 180.

about 3 kilometres from the settlement proper. This is approximately the same distance as the rural population of Selinus had to its settlement proper. These contexts suggest a similar societal structure of space for Monte Polizzo and Selinus during the early seventh century. [314]

Another method which could be used to detect tentative territorial boundaries is to assess the settlement's land use and to estimate how much land the inhabitants of Monte Polizzo needed for their own subsistence. The condition of the local environment is vital for a settlement to prosper economically. With the following sections, I aim to present the archaeological evidence of the palaeobotanical samples collected on site. It is, however, vital to acknowledge that these macro botanical samples may not reflect the total range of flora present during the time of occupation. But they can support the discussion of what trade goods produced on and around the settlement the inhabitants on Monte Polizzo could offer during encounters with their neighbours. In addition, they can help us understand the local preference in imported goods.

Local ecology in the Monte Polizzo area

During the first years of excavations on Monte Polizzo, Stika and Heiss conducted statistical macrobotanical sampling around the site on different locations with the aim of getting a general idea of the paleobotanical circumstances in the immediate environment of the settlement. Samples were taken in the archaeological layers of House 1 and in specific archaeological contexts there, such as charcoal concentrations, inside transport amphorae, and from inside a hearth. [315] In addition to House 1, statistical sampling was conducted on the Monte Polizzo summit in the supposed communal dump called the "Profile" and around the acropolis. The macro fossil remains at Monte Polizzo are in general scarce. The main part of *Cerialia* remains found on site was listed as *Cerialia indeterminata* because of the bad preservation.[316] However, the workable macro remains contained charred (carbonised) ancient seeds, fruits, cereal grains, chaff, weeds, and charcoal. The presence of chaffs and weeds are indicators of crop processing activities in the settlement.[317]

The collected archaeological evidence from the Monte Polizzo settlement Houses 1-5 show that all houses included in this investigation contained material of household production, storage, preservation, and preparation of agricultural products. This can best be exemplified with House 1 since the material culture can be correlated with the macrobotanical results. House 1 was divided into 6 rooms of which rooms I through V are interpreted as the living area while room VI was separated by a large stone wall and served as the storage room.[318] This division of living and storage space is also evident in House 5 and House 2 where room I and II contained large *pithoi*. While the larger vessels were placed outside the living areas, smaller storage vessels were often located inside the buildings.[319]

The densities of the extracted charred plant finds in House 1 were, unfortunately, very low. In a house context, sediments collected from the floors represent a longer period of time--frequent cleaning can explain their scarcity. Just as the samples collected from the Profile, three main crops can be identified: *Triticum aestivum/T. durum* (wheat), *Triticum dicoccum* (emmer wheat) and, with a clear dominance, *Hordeum vulgare* (barley). Chaff in the form of glume bases of emmer appeared in the samples, although more infrequent than the grain itself.[320] The dispersal of these finds suggests that crop processing took place in rooms I, II, III and IV based on the distribution of cereal chaffs. The similar dispersal of wild flora supports that suggestion. The wild flora (weeds), such as *Chenopodium* cf. *album*, *Sherardia arvensis*, and *Silene gallica*, grow in ruderal and segetal (in fields of grain) habitats and human waste. These weeds

314 See Hansen 2006a for city densities.
315 Stika and Heiss 2013, 81.
316 Stika 2003, 305.
317 Stika 2003, 305.
318 See Mühlenbock 2008 for a complete discussion of all functions in this house.
319 Mühlenbock 2008.
320 Stika *et al.* 2008, 144.

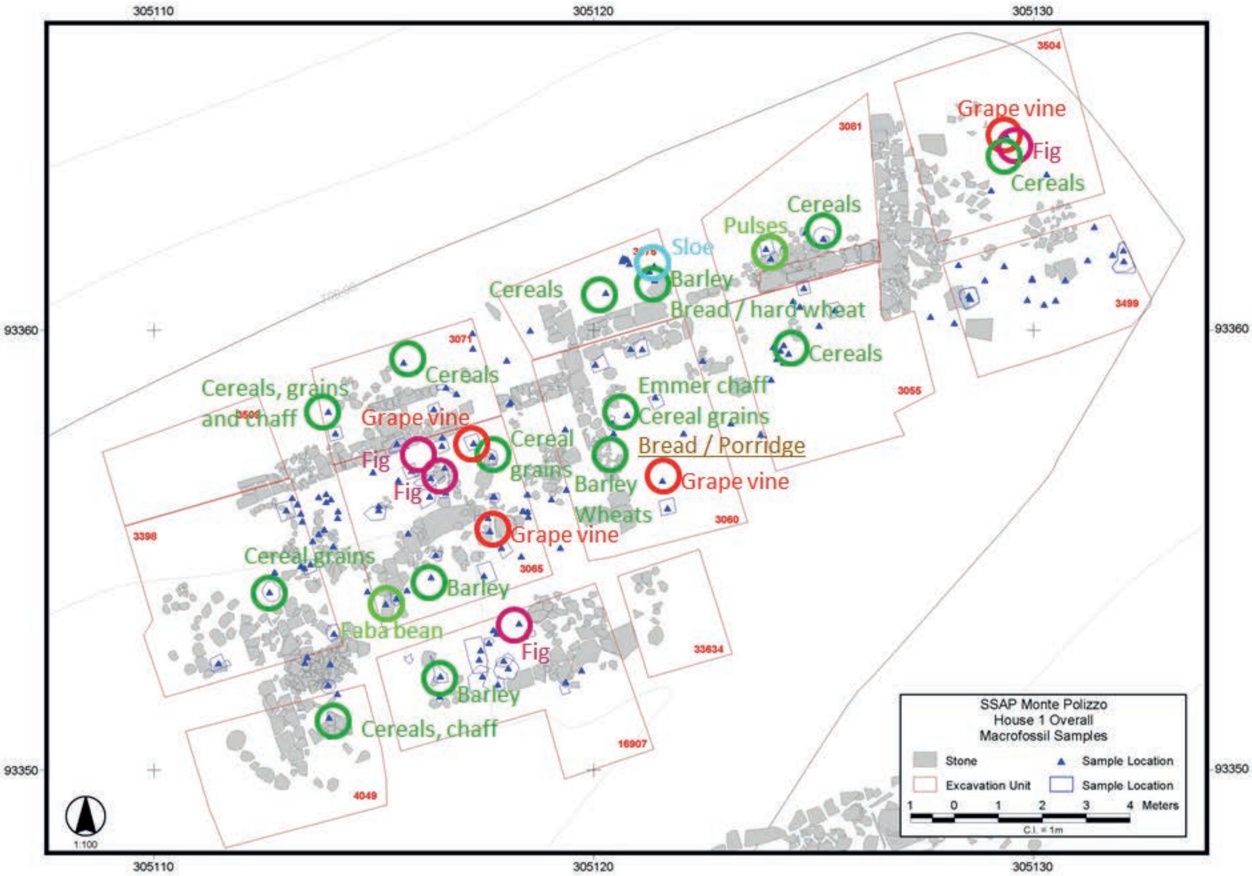
are nutrition-demanding, and their presence indicates that the crops they imposed on grew on high quality soils. Their presence offers valuable information about the vicinity and its cultivation capacities. [321] This information suggests that the crops (and weeds) were brought to the settlement unprocessed and stored as spikelets in the large *pithoi* in the storage area until it was time to use them.[322] The different cereal types also establish that the inhabitants were engaged in a multi-cropping fail-safe system to ensure that the settlement could hold its carrying capacity if environmental changes occurred.

Mühlenbock calls the storage room in House I a micro-cosmos of the house itself. This notion is based on the different types of findings that were placed in that particular space. Besides the large storage vessel containing crops, figs and grapes were also stored there according to the macrobotanical samples. In addition to the grains and fruits, an Etruscan transport amphora, an Ionic type B cup, an iron fibula, and the extraordinary *capeduncola* interpreted as an anthropomorphic image of a fertility goddess were stored.[323] The presence of the *capeduncola* in this context clearly show the link between nature, ritual and everyday life. As Mühlenbock puts it, the storage room was like a transit zone. With the *capeduncola*, the grains transferred from the earth and entered the human domains.[324]

In addition to the grains, the dominating non-cereal crops visible in the settlement were *Vicia faba* (faba bean)

321 Stika *et al.* 2008, 144.
322 Mühlenbock 2008, 135; Stika *et al.* 2008, 146.
323 Mühlenbock 2008, 135.
324 Mühlenbock 2008, 135.

Figure 4. House 1 with macrobotanical findings (C. Mühlenbock)



and *Ficus carica,* both present in the Profile and House1. Less represented on site are *Vitis vinifera* (grape wine) and *Linum usitatissimum* (flax/linseed) and *Prunus dolcis* (almonds). Moreover, a single remain of *Papaver somniferum* (opium poppy), *Coriandrum sativum* (coriander), and *Pimpinella anisum* (aniseed) each were identified.[325]

Grasses and weeds in addition to those mentioned above were *Aegilops* sp., *Lolium* cf. *temulentum*, *Lolium* cf. *remotum*, *Phalaris* sp., and unidentified *Poaceae.* These are important to consider because of their tendency to grow as weeds in cultivated fields. All of them were identified in the samples and distributed in Rooms I- through IVs chaffs and grains. Of the grass assembly, *Phalaris,* or caryopses thereof, is most interesting because of its toxicity to grazing cattle and sheep. Its natural habitat is both dry and wetlands, and it thrives in high quality soils. Both young and well-established pastures have been associated with neurotoxicity. *Phalaris* toxicosis among cattle and sheep is commonly known as phalaris 'staggers' and phalaris 'sudden death'. Goats, however, seem to be less vulnerable to the toxin than sheep.[326] In this work, it is difficult to assess whether this toxin ever affected the grazing animals at archaic Monte Polizzo. But it could suggest that they did not lead their cattle to pasture in the immediate surrounding agricultural areas.

Charcoal evidence

Bits and pieces of *Quercus-Olea* forest covering the landscape during the seventh century BC were clearly present in House 1 in the form of charcoal remains of roof beams. These finds correlate with charcoal finds analysed from Acropolis A, C, E, the Profile, and the Saggio S (also known as the Tusa house), of which the eleven samples of carbonised objects were identified as roof beams.[327]

A major part of the identified charcoal, in relation to both weight and number of fragments, was *Quercus* sp. Both evergreen and deciduous oak species could clearly be distinguished. However, identification down to a species level during the macro botanical project was impossible.[328] All of the *Quercus* charcoal contained tyloses and thus was derived from mature parts of a thick stem.[329] This confirms that the trees used to construct the houses were old and came from a forest that had been growing in the area for a long time. This also confirms the results from the sediment analyses and the soil studies discussed previously; that higher altitudes in western Sicilian landscapes were covered by evergreen and deciduous forests during the time of settlement establishment.

325 Stika *et al.* 2008, 144.
326 Alden *et al.* 2014, 2.
327 Stika and Heiss 2008, 141.
328 Stika and Heiss unpublished report.
329 Stika and Heiss unpublished report. "Tyloses are bubble like protrusions that grow in to vessels from adjacent cells during heartwood formation, thus blocking them. They serve a protective purpose in heartwood by keeping fungi and bacteria from proceeding through vessels, and consequently slow down decay. As heartwood is only found in matured part of the stem, we have evidence that all of the analyzed Quercus charcoal fragments from House 1 originated from trunks or thick branches."

Location	Saggio S		Acropolis A		Acropolis C		Acropolis E		House 1	
Number of samples	**5**		**1**		**4**		**1**		**22**	
Taxon	**N**	**weight [g]**	**N**	**weight [g]**	**N**	**weight [g]**	**N**	**weight [g]**	**N**	**weight [g]**
Olea auropaea	-	-	-	-	1	2.03	-	-	22	3.92
Quercus sp. (deciduous), cf. subgen. Cerris	1	6.88	-	-	-	-	-	-	28	2.87
Quercus sp. (deciduous), cf. subgen. Quercus	1	9.56	-	-	1	0.81	-	-	-	-
Quercus sp. (deciduous)	3	18.11	-	-	2	3.28	-	-	147	5.12
Quercus sp. (evergreen), cf. subgen. Sclerophyllodrys	-	-	-	-	-	-	1	0.80	-	-
Quercus sp. (evergreen)	-	-	1	1.93	-	-	-	-	14	0.42
Ulmus sp.	-	-	-	-	-	-	-	-	22	3.43
indet. (broad-leaved wood)	-	-	-	-	-	-	-	-	11	0.05
indet. (bark)	-	-	-	-	-	-	-	-	1	0.01
Sum, deciduous oak	**5**	**34.55**	**-**	**-**	**3**	**4.09**	**-**	**-**	**175**	**7.99**
Sum, evergreen oak	**-**	**-**	**1**	**1.93**	**-**	**-**	**1**	**0.80**	**14**	**0.42**
Sum, other wood	**-**	**-**	**-**	**-**	**1**	**2.03**	**-**	**-**	**56**	**7.41**
TOTAL SUM	**5**	**34.55**	**1**	**1.93**	**4**	**6.12**	**1**	**0.80**	**245**	**15.82**

Table 1. charcoal remains from Monte Polizzo (adapted from Stika *et al.* 2008 supplementary material)

The charcoal samples also contained a minor part from *Olea europea* and an even lesser part from *Ulmus* sp. Olive wood was frequently used as charcoal during antiquity but, considering the economic value of the fruit, it has been suggested that the burning of olive wood generally was restricted to prunings or wood from wild or unproductive trees.[330] The olive charcoal was found at the acropolis associated with the open-air stone altar A2. The altar was probably built before but was, at some point, contemporary with the round sanctuary A1. The interpretation of its presence proposes that it was used for burned animal sacrifices.[331] Morris suggests that when autumn turned to winter, hunters set off in the northern forests for deer.[332] The seasonal transition manifested by deer sacrifices at the acropolis was also the period when the river Arena Délia Grande finally had enough base flow for those who wished to transport themselves or trade goods. It is plausible to suggest that these events, one a force of nature and the other sacrifices associated with nature, were connected.

The whole animals were then carried back to the settlement to be dismembered at the altar. In association with the altar, an iron cleaver was found, which might have been used to cut up the sacrificial animals. An iron arrowhead which could have fallen from a dead animal was also located immediately west of the altar. About 84

330 Gale and Cutler 2000, 173; Zohary and Hopf, 1993.
331 Morris *et al.* 2003, 278; Stika *et al.* 2008, 146.
332 Morris *et al.* 2003, 282. The timing of the killing is confirmed by faunal analyses.

percent of the burned bones collected from the acropolis came from the area around altar A2 (located in Zone A see figure 2 Chapter 2).[333] The abundancy of olive trees in western Sicily during this period suggests that there is no need to see it as an exotic element at the site. This context indicates that olive wood could have had a special function since it was used in ritual sacrificial burning. The olive tree has a pleasant odour when burnt, which further supports its presence as a ritual element in the sanctuary. It can even be used as kindling when still green.[334]

As opposed to oak wood, olive is not the ultimate wood to use in construction purposes because of its high sensitivity to weather. [335] It was nevertheless used in all contexts on Monte Polizzo, likely including as construction wood. The wood is very strong and dense and famous for its beautiful golden colour and fine texture. What is extraordinary is the fact that not one single olive stone was found in the samples taken from House 1 and from acropolis. In comparison, the macrobotanical samples collected in Selinus within the same study in order to get a regional paleobotanical context show only six olive stone fragments and two fruit flesh fragments.[336] The samples in Selinus were collected in the agora and in adjoining houses and covered a period from late seventh to the third century BC.[337] The absence of abundant olive stones in the palaeobotanical material is striking. One can appreciate that they do not occur in abundance in household contexts since they are quite large and were probably swept up or thrown away during daily cleaning. However, one could have expected to find them in the communal dump at Monte Polizzo or around the agora in Selinus. One explanation could be that they collected the stones and used them for different purposes. It has been established, for example, that not only wood and charcoal were used during antiquity as fuel, but other material such as chaffs, dung, animal fat, and olive stones and pomace were used—and often in pottery production.[338] Monte Polizzo's ceramic production site has not yet been located so that notion will not be explored any further in this work.

Within the SSAP project, gas chromatography was done on different vessels such as table amphorae, cooking vessels, *pithoi,* and from small indigenous grey ware closed vessels and bowls deriving from the acropolis areas.[339] The preliminary analyses showed no traces of olive oil. Instead, these vessels contained a large percentage of animal and milk fats.[340] Even though it is important to acknowledge that these samples should not be treated as representatives for the entire settlement, they could be an indication that the Monte Polizzians did not enjoy the olive fruit according to their local preferences, either as foodstuff or work stuff. In order to extract 200 litres of olive oil, one ton of olives needed to be collected,[341] which could mean that the Monte Polizzians preferred to put their energy into other time-consuming work. Whatever the local culinary preference was, or whatever the basis of the local economy, olive oil was used at Monte Polizzo. The oil lamps and the amount of imported transport amphorae found in all houses demonstrate this fact. The imported transport amphorae will be explored further in the next chapter.

Household economy

The amount of storage vessels located in association with the different houses provide an idea of how much grain each household could store. The variety of vessel sizes found at Monte Polizzo ranged from a *pithos* at 1.70 metres high found at Portella Sant' Anna, to about the medium sizes at 66 cm high found in House 1. The size is generally difficult to assess since the containers are extremely fragmented, but a few have been restored.

333 Morris *et al.* 2003, 282.
334 Gale and Cutler 2000, 173.
335 Gale and Cutler 2000, 173.
336 Stika *et al.* 2008, 143
337 Stika *et al.* 2008.
338 Rowan 2015, 465.
339 Agozzino 2004, 244.
340 Agozzino 2004, 244.
341 Rowan 2015, 466; Niaounakis 2011, 414.

The 66 cm *pithos* could hold a content of about 80-90 litres of grain or other foodstuff. Based on calculations conducted of this medium-sized *pithos* and on the weight of the storage ware fragments located both inside and outside the houses, the estimated storage capacity was: House 1 2500 -3250 litres; House 2 1300 -1775 litres; House 3 350 -470 litres; and, House 4 750 -1000 litres.[342] It should be noted that this calculation is estimated on a minimum number of vessels due to the fragmented state of the pottery and the possibility that a substantial amount of fragments are lost through the taphonomic process and other disturbances. The total amount of storage capacity based on this particular fabric ware only (transport amphorae are not included), between the four houses was 4900-6500 litres. The storage capacity of House 5 is not yet completely understood. *Pithos* fragments were found in what seemed to be a storage unit, but the storage area probably extended beyond the boundaries of the excavation. It does nevertheless confirm that each house seems to have had large storage capacities.

Based on various calculations of average intake of calories and estimations on the amount of food necessary for a household subsistence, a storage capacity of 800-1200 litres of grain is thought to have potentially been enough for a household of five to sustain a year's supply.[343] In addition, other types of fresh food stored in perishable containers also contributed to the household ability to subsist. However, this amount of grain did not suffice to cover years of bad harvest or other catastrophic events. Of all houses in this study, only House 1 and 2 had enough storage to secure periods of bad environmental events. House 1 had the capacity to store grain for a household of five for at least two to three years or for one to one and a half years for a household of ten.[344]

Storage vessels have also been found in abundance at the acropolis. However, their contexts are completely different from that of the domestic area. At the acropolis, three large deposits of *pithos* fragments, ash, and antler have been located. North of altar A2 discussed above, a large deposit of storage vessels was found (deposit 2). The deposit contained at least 20 *pithoi* and several amphorae, bones, and antler fragments. When altar A2 eventually went out of use, the area may have turned from a sacral area to a dump for the A1 sanctuary.[345] Another storage ware deposit was located in zone B (deposit 3). Hundreds of *pithos* rim and base fragments were mixed with other types of pottery and ash, suggesting that this area also had turned into a dump. Just as in deposit 2, the bones and antlers found were severely fragmented suggesting these were secondary deposits and that the bone fragments were dumped after clearing another space.[346] Deposit 1, located north of A1, contained storage ware, ash (as deposit 3 but not deposit 2), and a large amount of antlers. The main difference from the other two deposits is that the antlers here are not as fragmented. Morris *et al.* suggest that they were found in their primary discard or storage location and were therefore in a more intact state.[347]

It is rather interesting that the 'used' bone and antler fragments from the sacral area were not finally discarded in the dump or in nature somewhere, but instead collected into the nearby standing *pithoi*. Perhaps this indicates that the antlers still carried a sacral value and the best place to put valuables, whether grains or antlers, was inside a *pithos*.

These different find contexts at the acropolis make it very hard to establish whether these storage vessels ever were used as a central grain storage for the settlement, as the number of *pithoi* implicate. The connection between the sacral and the storage of food is evident in the storage space in House 1 where the *capeduncola* possibly was used to scoop up grains. It is therefore plausible that the largest storage of communal grains was located at the largest communal sanctuary. Their function could have changed in harmony with the establishment of new rituals or sacral areas in zone A during the sixth century. The macrobotanical analyses of the ritual deposits showed no evidence of botanical offerings among burnt antlers,

342 Mühlenbock 2008, 84.
343 Christakis 1999, 12; Foxhall and Forbes 1982, 71.
344 Mühlenbock 2008, 84; see also Christakis 1999, 13 for this types of calculations.
345 Morris *et al.* 2002, 169, 158.
346 Morris *et al.* 2004, 210.
347 Morris *et al.* 2004, 211.

for instance, which suggest that they (eventually) had a different function than grain storage.[348] A micromorphological sediment study conducted at the deposit north of A2 confirmed that there were essentially no microscopic charred plant remains, ashes, burned aggregates, phytoliths, or any other anthropogenic debris in the sample, indicating that this deposit included little occupation debris other than pottery sherds.[349]

The large amount of *pithoi* at the acropolis is, to this date, the only assemblage of storage ware that suggest a communal storage capacity for grain in the settlement. The evidence of the *pithoi* in the four houses instead suggests that the households had to rely on their own ability to secure themselves in the event of a bad harvest or in order to maintain a surplus for trade. These results indicate a system of individual household economy based at least in part on agrarian production.[350]

Land use

How much land was needed for agrarian activities to avoid exceeding the settlement's carrying capacity? A general consensus based on calculations of diet by factoring a complete spectrum of items consumed is that a household of five would need about three to four hectares of land for their own subsistence.[351] Morris estimated around five or six hectares for the inhabitants of Classical Attica so, to be on the safe side, the estimation here will be calculated on six hectares.[352] Based on surveys conducted during the first years of excavation, the settlement proper is assessed to be about 20 hectares, with a population of about 2,000. This estimation is in line with Hansen's Shot Gun method that has calculated a general population density classical Greece of 150–200 people per hectare.[353] Hansen suggests that for territories below 200 square kilometres (20,000 ha) the population of a settlement is divided by two-thirds residing in the town and one-third in the countryside.[354] According to this idea, if the land required for a (n environmentally) sustainable economy did not exceed 200 square kilometres, about one thousand more inhabitants located in the countryside would be added to the population of the Monte Polizzo territory. The surveys discussed above concluded that scattered clusters of building remains are believed to have been situated around the immediate territory and, based on those investigations, an additional thousand persons will be added to the total population of Monte Polizzo. Assuming the inhabitants residing at the Monte Polizzo settlement proper was 2,000 persons and that each household was on average a 'family' of five, 400 households or units covered the slopes of the mountain. The 400 units times six hectares equals 2,400 hectares or 24 square kilometers. If a potential of 200 units are added to the calculation, consisting of for instance a thousand rural inhabitants, 1,200 hectares in addition to the 2,400 hectares will be needed to maintain collective subsistence for a year. In addition to these 3,600 hectares, an equal amount of land would be essential to leave fallow after each cycle. The total amount of arable land necessary would be about 7,200 hectares. This area could be outlined wherever in the surrounding landscapes that suited the Monte Polizzians. Assuming they wanted to keep their work (and for some people, their homes) as close to the main settlement as possible, this area of 72 square kilometers, would stretch about 3-5 kilometers from the mountain in any direction and in the river valley of the Cúddia, between Monte Polizzo and Montagna Grande. This calculation does not consider the local ceramic production, which require additional usage of timber.

In addition to the immediate territory around the settlement, the lower landscapes between the Cúddia and the Mazaro Rivers can also be considered suitable for land use. Approximately an extra 30,000 hectares

348 Stika *et al.* 146.
349 Matthews 2003, 298.
350 Mühlenbock 2008, 178.
351 Osborne 1987, 44-46; Gallant 1991 60-92; De Angelis 2000, 118; Lancaster 2017, 211.
352 Morris 2006, 33.
353 Hansen 2006a, 22; For further examples of population calculations see Horden and Purcell 2000, 92-96; De Angelis 2016. 142; and for a discussion of Hansen's shot gun method see Lancaster 2017, 81-85; Muggia 1997.
354 Hansen 2006a 23-24.

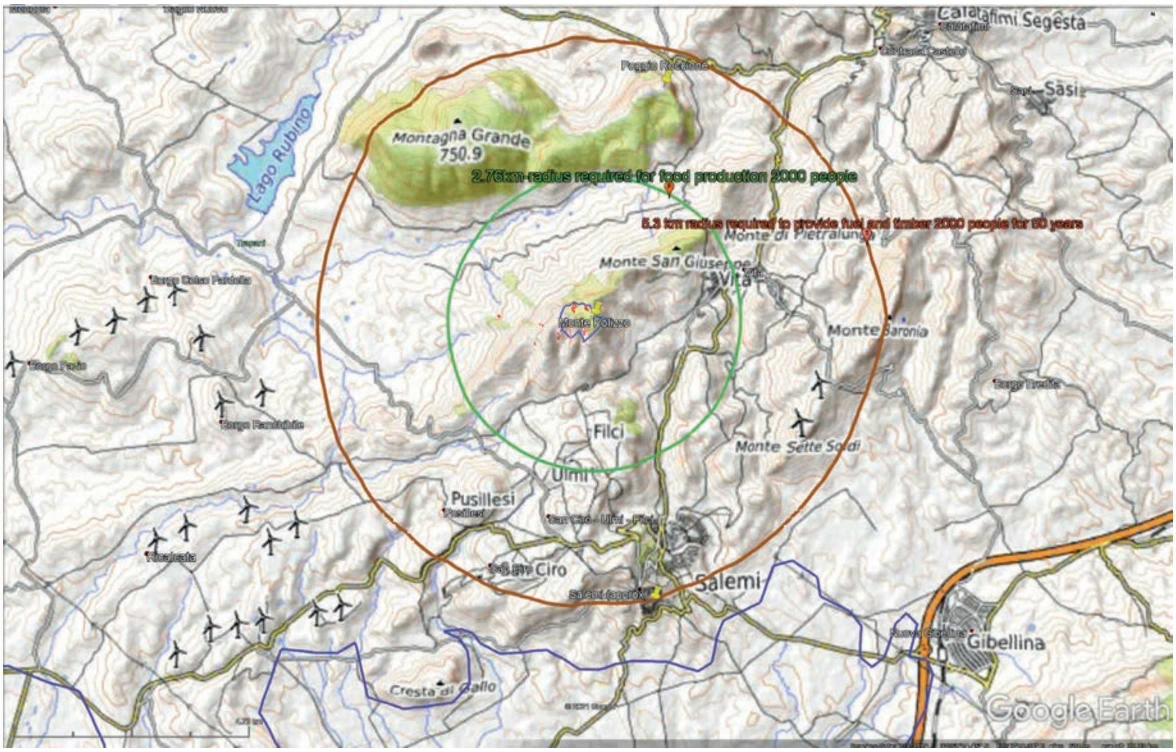


Figure 5. Land use and timber requirement for 2000 inhabitants during 50 years at Monte Polizzo.

Figure 6. Water sources and requirement for the settlement. J.L.Berry

of land and additional 20,000 hectares of land between the Mazaro and the Arena Délia Grande Rivers could have been at their disposal counting only the possibilities of using the arable landscapes located to the west of the settlement. It is thus plausible to assume that the opportunity was at hand, if the work force was available, to cultivate enough grain for both a settlement surplus and for trade in the seventh and sixth century. It would certainly have been enough land to avoid exceeding the carrying capacity for the additional one thousand rural inhabitants according to Hansen's model above. As discussed earlier, the marshlands in these lower landscapes might have evolved during the seventh century. This environmental change possibly occurred as a response to higher water table or changing river characteristics but also because of human disturbance as deforestation and intensive agriculture.

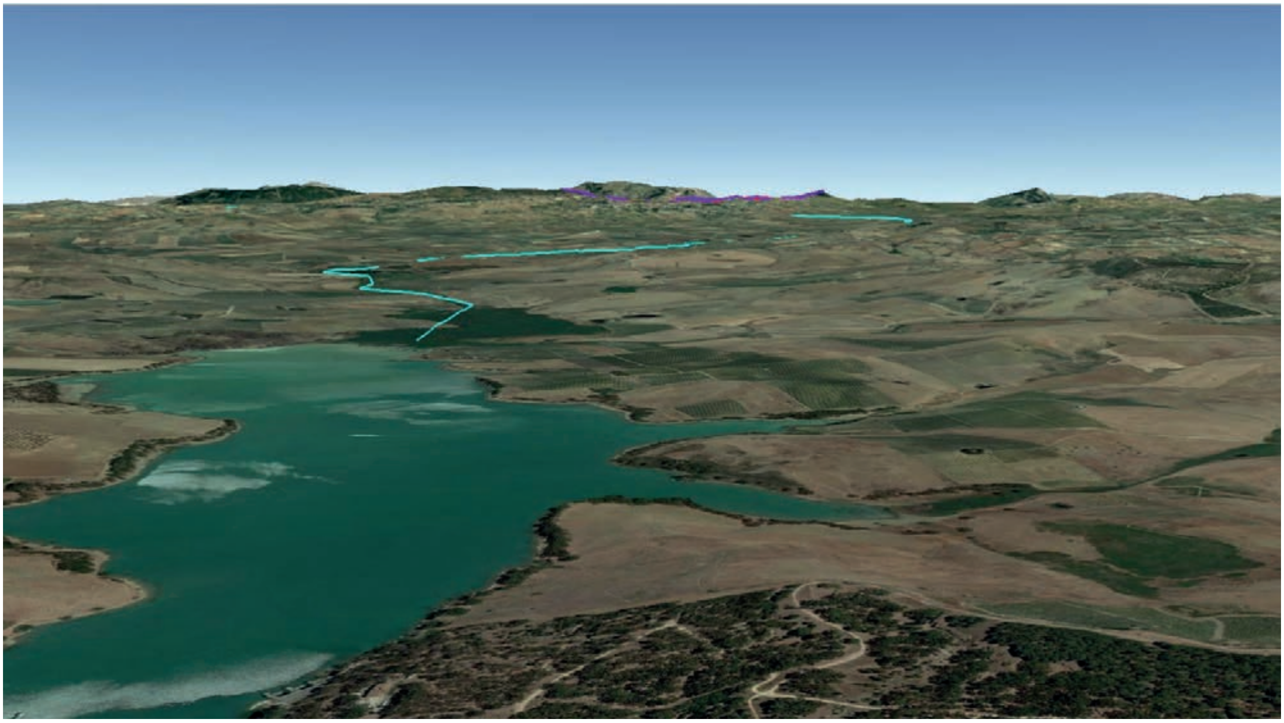
Soil erosion in the Délia Grande valleys

Setting hypothetical discussions of the Monte Polizzo territory aside, deforestation and use of land around Monte Polizzo during the seventh century and onwards has left its mark in the soils. Below follows a digression from the main discussion about land use and local economy that emphasises how ancient land use is still visible in the landscapes of western Sicily today.

The catchment area of Délia and Grande (the Arena is located below the reservoir) constitutes about 185 km^2. Since the construction of the Lago della Trinitá reservoir, a vast amount of eroded soil, originating from the upper Délia and Grande watershed below Monte Polizzo, has accumulated in a delta built out into the reservoir. Any model for calculating potential soil loss from an area must deal with a large number of variables. Such parameters could include agricultural management, vegetation, soil, topography, and climate.[355]

355 Amore *et al.* 2004, 101; For different models of calculating soil erosion se for instance Renschler and Harbor 2002; Wischmeier and Smith 1965; Flanagan and Nearing 1995.

Figure 7. Trinitá Reservoir viewing north towards Monte Polizzo



Two different studies have been made on these soils. Tamburino *et al.* measured the volume since the construction of accumulated soils in 1981.[356] The soils were later analysed in 2004 by Amore *et al.* with the specific aim of evaluating different models of hilltop soil loss.[357] Soil erosion is often associated with human-caused deforestation, and these studies can thus offer valuable information of the gravity of human interference in these landscapes during the course of history.

Amore *et al.* concluded that based on the sediment accumulated over the 22 years between 1959-1981, the amount of soil eroded from the catchment area was about 6.11 million m^3 (Mm^3) having a dry bulk density of 1440 kg/m^3 .[358]

To make these soil analyses relevant for present study, Berry used these numbers to reconstruct the amount of soil that once blanketed the mountain under the forest-covered Monte Polizzo area. Berry corrected the density difference of the catchment area to 1,300kg/m^3 instead of the 1,440kg/m^3 that Amore *et al.* suggested. The calculation for the thickness of soil removed from the ground in the upper Délia and Grande valleys was made as follows: by dividing the amount of soil 6.11 (Mm^3) by the catchment area 185 km^2, times the amount of dry density soil 14,40 kg/m^3, divided by 1,300 kg/m^3 to correct for the density difference (6.11/185 x 1.440/1.300) equals = 0.0365 m or 0.001663 metre soil loss per year.[359] In equilibrium, it takes about one million years to form one metre of soil,[360] which means that the soil loss in the Délia Grande catchment areas is equivalent to 1,663 m/Ma (metre/million years), 1,663 times as fast as the soil forms.

Depending on the topographical circumstances--whether the soil cover was over steep slopes or soft rocks or flat areas and hard rocks--up until today the amount of soil presented above equals a soil loss during 2,670 years of 4.4 metres over the catchment area. This means that based on the geomorphology of the Monte Polizzo area facing the Grande River, it has lost an average 4.4 metre of thick soil cover. During the period of main occupation of Monte Polizzo, deforested areas would have lost a minimum of 17 cm of soil, and this would have included all of the surficial, water-retentive, organic humus. [361] Soil loss does not occur at a constant rate, and it is therefore likely that the soil was lost much more quickly immediately after the main period of deforestation, especially if the areas were turned into agricultural landscapes.[362]

The human occupation of Monte Polizzo is not only visible in the amount of eroded soil once flown down the Grande Délia Rivers, but also in the soil records on the opposite side of the mountain in the Cúddia River valley. The amount of soil loss and erosion deriving from Monte Polizzo and Montagna Grande has been studied by Heinzel and Kolb with the aim of investigating soil erosion and landscape destabilization in the Cúddia Valley.[363] Radiocarbon dating of the fluvial stratigraphic record of the Cúddia River, consisting of a massive clast *or* clay-supported quartzite conglomerate layer to 600-380 BC, showed charcoal and Elymian ceramic artefacts present in the conglomerate layers. [364] These artefacts in the fluvial record further indicate that Elymian land use was widespread.

One can argue that it is almost impossible for us to understand short period of local environmental history because we rarely have a sediment record that gives us the much-needed information required.[365] Nevertheless, based on the sediment data collected in 1981 in the delta

356 Tamburino 1989; 1990.
357 Amore *et al.* 2004, 104; Berry 2016, 23-24.
358 Amore *et al.,* 2004, 105. Dry density soil- soil with no water- is the best way to measure the exact amount of soil accumulated or collected in field.
359 Berry 2016, 23.
360 Scarciglia *et al.* 2006.
361 Berry 2016, 23.
362 Berry, personal communication.
363 Heinzel and Kolb 2011.
364 Heinzel and Kolb 2011, 104, do not specify whether it actually is clast or clay-supported quartzite conglomerate layer. It cannot be both (personal communication J. L. Berry).
365 Walsh 2004,227.

Figure 8. Cúddia River valley. Drone photo taken from Monte Polizzo viewing northwest towards Montagna Grande

behind Lago della Trinitá, evidence of local short- term environmental change which had a most disturbing effect on the Elymian landscape can now be provided. Based on the amount of sediment eroded from the Monte Polizzo area from c 650 BC and onwards, it is clear that the Elymians were modifying the natural landscapes on Monte Polizzo according to their needs during the main settlement period. Sediment analyses from the Cúddia valley also confirm an extensive erosion from the settlement on the opposite side of the mountain during the main habitation period and onwards.

During the Iron Age, the conglomerate underlying Monte Polizzo had an average of 5 meters of soil cover blanketing the mountain. During the 75 years of main settlement habitation deforestation and pastoral activities caused a loss of, in effect, nearly all the rich water-retentive organic humus and with a large part the remaining soils' water storage.[366] During just a couple of generations, the mountain area transformed from a fertile forest underlain by high- quality soil to a deforested landscape covered by soil with nearly no capability to retain the much-needed water storage that kept erosion and water flow in check and provided vegetation with water.

Wiman and Faegersten suggest that a gradual environmental change could hypothetically go on unnoticed, without new cultural investments such as evolving land use practices for instance. However, as gradual environmental changes possibly could pass by, an unexpected drastic climatic change or event could in contrast cause land abandonment.[367]

Based on the remains of the domestic areas on Monte Polizzo and the Elymian building technique implemented, it is evident that residents had the know-how to build their settlement in a terraced fashion. It is, however, very difficult to determine whether they used terracing as an overall method to master the mountain including specific land use practice or just as an engineering method for building houses on hill slopes. The erosion record from the southern and northern side of the mountain suggest the latter and, except for their own modification of their

366 Berry 2016.
367 Wiman and Faegersten 1998, 418.

environment, there were no climatic changes during this noticeably short period of settlement to cause the development of that kind of labour-intensive operations.

Plato, in his famous passage in *Critias*, described the changes on the environment due to soil erosion in his homeland Attica:

> …the soil which has kept breaking away from the high lands during these ages and these disasters, forms no pile of sediment worth mentioning, as in other regions, but keeps sliding away ceaselessly and disappearing in the deep. And, just as happens in small islands, what now remains compared with what then existed is like the skeleton of a sick man, all the fat and soft earth having wasted away, and only the bare framework of the land being left. But at that epoch the country was unimpaired, and for its mountains it had high arable hills, and in place of the moorlands, as they are now called, it contained plains full of rich soil; and it had much forest-land in its mountains. (Plato Critias 111B-D)[368]

The correlations between soil erosion and land clearing and human's impact on, or destruction of, nature though history have been a subject of debate for decades among paleo-environmentalists.[369] Today, the Mediterranean forests extend over 85 million hectares of land. It translates to only 9.4 percent of land area of the Basin, and the rest is more or less in different stages of soil degradation or deforestation.[370]

The environmental evidence of overgrazing, the reduction of natural resources and, most of all, deforestation leads to different interpretations and contradictions in the debate.[371] It is commonly accepted, however, that humans have had a most detrimental effect on Mediterranean forests. The reduction of environmental resources made slowly yet efficiently is best described as the most obvious consequence of human action through history.[372] One cannot dispute the white patches, just like a skeleton of a sick man as Plato put it, in the landscape proving that the Sicilian farmers of today are essentially ploughing limestone or marl bedrock as a result of land use since the beginning of human occupation. Horden and Purcell argue in *Corrupting Sea* that they believe it is important to emphasise that the irreversible destruction of soil-cover, even though locally devastating, might just have a local effect and not a catastrophic role in history.[373] However, it is rather odd to cut out the local effects of environmental changes from history and, in effect, all people, as Walsh notes, in that particular local landscape that needed to negotiate with these changes on a daily basis. [374] Even if these environmental problems appear to be local, environmental degradation occurs when population density gets larger than the carrying capacity of the land--more people are likely to be affected than not. By ignoring the local effects of environmental change and only focusing on the bigger environmental scene as a *longue durée,* people become anonymous if not invisible.

Nevertheless, long-term environmental changes--or a macro-scale discourse--are easier to recognise than short-term changes in history, since a more fundamental change would be more likely to show up in the archaeological record. Smaller variations in climatic conditions could easily get lost in the environmental record by various cultural coping strategies conceived in order to deal with harsher conditions.[375] However, for the people who experience these environmental changes and whose lives are closely linked to nature, there is no doubt whether

368 φελλέως – fields of stoney soil, lava or porous stone translated as moorland. A better translation to "Moorlands", which in British English means rocky, peaty, with hydrophilic vegetation and standing water, should be "Heathlands" which means wasteland with vegetation of Broom plants *Cytisus spp, Genista spp* and *Ulex,* which are Xerophytes and found in the Mediterranean. Berry personal communication.

369 Sallares 2009, 168.

370 Blondel and Aronson 1999, 203; The Mediterranean Basin – a very wide concept covering the sea and all land adjacent to the sea (north, west, south, east). Often used to denote a geologic concept. The Basin consists of parts of three continents (Europe, Asia minor and Africa). Definition made by the European Environmental Agency

371 Grove and Rackham 2001; Bonnier and Finné 2020.

372 Sallares, 2009 168; Blondel 2006; Attenborough 1987; McNiell 1992; Naveh and Dan 1973.

373 Horden and Purcell 2000, 310.

374 Walsh 2004,227.

375 Wiman and Faegersten 1998, 418.

Figure 9. Grape wine cultivation on bedrock on the slopes of Montagna Grande. Photo J.L.Berry

they notice environmental differentiation over the course of an individual lifetime.[376]

Husbandry

Pastoralism and especially the grazing of goats can also cause soil erosion. It was also included in the local economy at Monte Polizzo. The archaeological contexts of the domestic areas at Monte Polizzo show a clear picture of everyday life of spinning and weaving, practices requiring raw materials.[377] Based on the faunal material studied by Vretemark from Houses 1-3 and the 'Profile' during the excavation campaigns of 1998-2004, *Ovis a./ Capra h.* (goats and/or sheep) were the most important livestock in the settlement, followed by *Bos taurus* (cattle) and *Sus* (pig).[378] Just as with the ceramic material, faunal evidence was severely fragmented. Altogether, about 28 kg or 12,000 fragments of animal bones were collected in the habitation area. In addition, Hnatiuk identified about 30,579 fragments of bone from the layers around the Acropolis.[379] Of these, 8,486 fragments were identified as belonging to domestic mammals such as *Ovis/ Capra, Bos* and *Sus*.

The bone fragments from House 1 display parts of the animals with most meat, such as the upper legs and torso, demonstrating ordinary kitchen waste. The ultimate age for animal slaughter in a system where meat production is important is when the animal one-to-two years old, just completely grown but not yet being used for reproduction. [380] The majority of sheep or goat and pig dental fragments show that this slaughter system was implemented on Monte Polizzo. 40 percent of the adult sheep or goats that were kept until the age of six were male, which suggests that ongoing wool production was important. The young sheep or goats were kept until around the age of between one to two years. About 30 percent of the cattle were kept until old age as milk producers, as part of the settlement's diet demonstrated by the gas chromatography results discussed above. 20

376 Wiman and Faegersten 1998, 425; Harding 1982.
377 Mühlenbock 2008, 139; Mühlenbock *in press.*
378 Vretemark 2003.
379 Hnatiuk 2003, 294.
380 Vretemark 2003.

percent of the cattle fragments were oxen, which suggest that these animals were used as traction power.[381]

The small bone fragments spread all over in House 1 indicate, as just mentioned, kitchen waste and a regular meat consumption, while the larger bone fragments were discarded in the communal dump. That is also evident when analysing the few wild animal fragments inside the domestic area., Thirteen bone fragments from various part of *Cervus elaphus,* Red deer, such as legs and torso have made their way into the kitchen waste, but there is no evidence of the non-edible antler for example.[382]

At the acropolis, the use of the animals is most evident in a context near the sanctuary in Zone A, where 5,347 antler fragments from at least seven Red deer were found.[383] Their religious context has been noted above, but the antler finds themselves do attest to religious activities. Some antler fragments (82 all in all) contain chop and/or cut marks at the end of fragments of tine (the smaller section of the antler), suggesting that the antler may have been worked into objects. Morris' suggestion that the animals were brought in whole to the site after the kill is supported by cut marks that indicates that the antler was separated from the skull of the deer, since the cuts were mostly found at the base/skull attachment area. The antlers were thus not found in nature and brought back as a token to the settlement.[384]

Contrary to the domestic waste at House 1 and the Profile, the bone fragments from domestic animals at the acropolis mostly consist of crania and body parts with lesser or no meat, suggesting a different kind of use than consumption. Most of the cattle fragment came from mature animals. The minimum number of individuals was two adults and one calf.[385] The sheep or goat fragments counted to five adults mostly of old age and one kid. Four pigs were also sacrificed, of which none survived longer than the age of 17 months, which correlates to the faunal material consisting only of young pigs from House 1 and the Profile.[386] Faunal fragments from domestic animals such as sheep, goats, cattle and pigs, have also been found in sanctuary contexts for instance at Megara Hyblaea and Leontini, and rooster bones in Demeter Malophoros context at Selinus, which indicates that the usage of domestic animals in sacrificial contexts are evident in several sites.[387]

Pastoralism and transhumance

When assessing the settlement's usage of the immediate and distant landscapes, pastoralism and short-distant transhumance is a very important consideration, as discussed earlier with the examples of Heracles. The faunal evidence shows that the settlement was engaged in a local agro-pastoral economy. Agriculture and pastoralism are traditionally closely integrated in Sicilian land use. De Angelis argues that this system already was prevalent in the Archaic period. Fallow lands were utilised by the herds to graze and, in turn, the animal manure fertilised the depleted soils. Further, large animals like cattle and oxen could be used to plough or work the land in various ways when the human labour fell short.[388]

However, at Monte Polizzo the agro-pastoral system might have been different. As described above, the macrobotanical investigation in House 1 shows the presence of *Phalaris* weed often growing in human-disturbed soils and poisonous for the grazing animals. This might indicate that the Monte Polizzians needed to keep their animals away from the settlement's agricultural lands. Since the plant is toxic during its entire cycle it is likely that their grazing animals must have been affected by the toxin in various forms if they were kept around the cultivated areas.

There were, however, other grazing systems for keeping livestock. Transhumance, as mentioned earlier, is also seen as a traditional Sicilian way of life.[389] Montagna

381 Vretemark 2003.
382 Vretemark 2003.
383 Hnatiuk 2003, 296
384 Hnatiuk 2003, 297.
385 Hnatiuk 2003, 296.
386 Vretemark 2003; Hnatiuk 2003, 296.
387 See Gras *et al.* 2004 for Megara Hyblaea; Bouffier 2003, 54, for Selinus.
388 De Angelis 2016, 238.
389 Russo *et al.* 2014.

Figure 10. Grazing sheep at Monte Polizzo

Grande opposite from Monte Polizzo could for instance very well have served as pasture. The location only a few kilometres away keeps the livestock within close distance of the settlement. Five different concentrations of Iron Age ceramics along the ridgeline, presented above, indicated shelters of some kind, which could have been used by the herd keepers for seasonal housing for instance. Osborne suggests that instead of seeing small rural sites as farms, they could very well have been seasonal shelters (in southern Argolis).[390] By acknowledging that idea, the small sites (as the sites at Montagna Grande) could be indicators of intensity of land exploitation. The river valley of the Mazaro would also have been excellent for pasture and short-distance transhumance. As are the landscapes discussed above, between the Cúddia and the Arena Délia Grande to the west of the settlement.

In fact, De Angelis suggests that well-watered pasturelands, including marshland, was highly suitable for the raising of livestock, mainly sheep, goat, pig, and cattle.[391] The movement of herds is yet another topic that motivated people to negotiate territorial boundaries or to maintain fluctuating access. A modern example is the Sarakatsani people in northern Greece who, with traditionally no land of their own, negotiated winter grazing rights with lowland landowners and then returned to their summer pastures in the highlands.[392] This area around the Mazaro River, which is generally mostly considered to have belonged either to the Phoenicians or to the Greeks (but never the Elymians), could very well have been used as agricultural land in the eighth and early seventh century, as indicated by the pollen influx change from arboreal pollen to cereals. When some areas in these lower landscapes changed to marshier conditions, the agricultural activities could have been phased out in favour for pastoralism (given that *Phalaris* did not grow in these areas). Such areas could very well have been places where the different inhabitants in this region negotiated with neighbours to keep livestock in landscapes that possibly belonged to someone else.

Wool production at Monte Polizzo

The faunal evidence of old sheep indicates that wool production was a vital part of the economy. This is also apparent in the archaeological material record. A

390 Osborne 2004, 170; See also Foxhall 2004, 267; Hansen 2007, 72.
391 De Angelis 2016, 236
392 Forbes 1992, 187; Koster 1976, 19-28.

total number of 166 loomweights have been found, unevenly distributed between the five houses. This vast number suggests that wool production took place in the domestic sphere and was a large part of everyday activity.[393] Contrary to the rest of the archaeological material, loomweights were mostly found in a complete state. However, rectangular lumps of clay were found during excavations of the destructions layers that could indicate that additional loomweights were present at the site.[394] It is impossible to know how many more loomweights might originally have been present as Lawall notes in general regards to the amounts of loomweights found in different contexts.[395] The distribution of loomweights in House 1-3 is quite similar, with 19 pieces found in a cluster in House 1, 15 in House 2, and 17 in House 3. House 4 contained only five examples, while House 5 stands out with 76 loomweights discovered in two concentrations. The rest of the weights were scattered.

Mühlenbock suggests that, based on this large collection of loomweights in House 5 and the fact that other objects associated with domestic practices such as grinding stones of various sizes, as well as slag, that it was used as communal space. In addition, no personal objects such as beads, trinkets, or fibulae were found. However, a small portable, locally produced house altar shows that elements of ritual activities were present in this context.[396]

In addition to the loomweights at the habitation area, an extra 13 loomweights were found at the southern slope of acropolis. These were found in the so-called Tusa house (see Chapter 2) and are particularly interesting since six of them differ significantly in terms of weight and style from the rest of the assemblage at Monte Polizzo. While the average weight ranges from 185-281 grams, these six have an average weight at 50 grams. Their shape is pyramidal, while the dominant shapes for the others are trapezoidal and rectangular. Similar pieces in shape and weight can be found in Selinus.[397] What is worth highlighting is that the spinning whorls, which are often found in the context of the loomweights, are almost absent in the archaeological material. Similar contexts of lacking whorls are found at Selinus where at the Manuzza Hill more than 400 loomweights were found in an archaic building. The context is dated to 600-550 BC and is contemporary with Monte Polizzo. At Monte Maranfusa, notably, the amount of spindle whorls is one for every five loomweights and, at Colle Madore, there are 3.5 loomweights for one spindle whorl.[398]

The absence of spindle whorls suggest that the first step of wool production at Monte Polizzo (and Selinus) took place elsewhere, perhaps by other people than those who produced the fabric, whereas the complete wool production at Monte Maranfusa and Colle Madore was conducted at the same place.[399]

In addition, weaving, as it seems in House 5, was conducted on a group level, which very well can suggest that the local economy of wool production was standardised. Some members of the community led the sheep to pasture in the countryside. Other members of the rural population took care of the first steps of wool production, while the fabrics were created inside the settlement. Mühlenbock suggests that this division into well-defined tasks--possibly socially organised at Monte Polizzo--is a sign of high-level specialisation.[400] This might indicate that they practiced textile production beyond the needs of individual households or the entire settlement itself. Similar contexts at the Aegean Halos have shown that in the various houses scatter of loomweights are uniform with 5-14 weights in each house. At one particular house, the number of weights were instead 100 pieces. This

393 Mühlenbock 2015, 56.

394 Mühlenbock *in press*.

395 Lawall 2014, 171.

396 Mühlenbock *in press*. Mühlenbock and Sandström *forthcoming. Arulae,* house altars are often found in Greek contemporary households, and associated with religious activities in the domestic sphere; See Hodos 2006, 105.

397 Mühlenbock *in press;* Quercia and Foxhall 2014.

398 De Simone 2003, 350-361; Tardo 1999, 243; Mühlenbock *in press.*

399 Quercia and Foxhall 2014, 82, believe that the absence of other textile implements at Selinus suggest that spinning was preformed elsewhere.

400 Mühlenbock *in press*.

discrepancy is interpreted as an indication of a site of textile production for an external market.[401]

Considering the 'shotgun method' – the trade with Gypsum

With a shotgun, one will probably never hit the bull's eye. With a shotgun, the chances of hitting many targets (or anything at all) is more likely.[402] Hypothetical ideas of the actions of past peoples must be considered in this work as well as generally accepted hypothetical calculations of population growth or the Greek exports of the Sicilian grain, for instance. One of the long-shot aims on this study is determining the possibility of a gypsum trade having existed. This is a tentative suggestion of how the inhabitants of Monte Polizzo could have used what their close environment provided in terms of trade possibilities.

Gypsum is one of the various rocks that constitutes the geomorphology of the Monte Polizzo area. During antiquity, mud, lime, and gypsum were traditionally the most common binder types in construction. The diverse components aggregate with other materials creating adhesion and are therefore used as glue to strengthen mortar.[403] The study of ancient mortars and plasters provides important information about their use during different periods in history. In combination with a geomorphological study of a specific region, the identification of mortar and plaster components can also provide information of whether the gypsum could have been mined near the settlement in question, or if it was necessary to look for it elsewhere. The use of gypsum as a commodity in antiquity is best attested in Egypt.[404]

Since gypsum is, to some extent, water-soluble, it is unsuitable for external use in damper climates—as plaster on external walls or for solid ground floors for example.[405] Gypsum has been identified as mortar and for ornamental construction in several places in mainland Greece and on the islands of Kephallenia and Zakynthos.[406] It was rarely used as building blocks, however; the Palace of Minos at Knossos is one known example where gypsum blocks and slabs were used.[407]

Several factors made gypsum especially favourable as a building construction component, which makes it especially interesting for this study since it can be found in the Monte Polizzo area. To pulverise gypsum, which is composed of calcium sulphate dihydrate (CaSO4.2H2O), it is heated to approximately 130^{0}C – 160^{0}C, a comparatively low temperature (limestone needs to reach 880^{0}C for the same process).During heating, water is driven off and calcium sulphate hemihydrate (called by the modern name of Plaster of Paris) is formed. By grinding the baked stone block, it pulverises and, when mixed with water, reforms as crystalline gypsum that can be used as plaster.[408] The plaster sets within minutes, as Pliny the Elder notes that "gypsum when moistened should be used instantly, since it coheres with great rapidity. However, there is nothing to prevent it from being pounded and reduced again to a fine powder" (N.H. 36.182-83).

The low temperature required makes gypsum favourable to use, since it does not entail a complicated kiln. In effect, it can quite easily be produced in areas where there are limited sources of timber. Wall plaster was found during the excavation of House 1, but no analyses of the material has yet been done. However, the easy access to gypsum in the area, and the favourable ways of creating gypsum plaster, suggest that it was used for such a purpose.

Limestone, in contrast, requires a specialised limekiln to reach temperatures of 900^0-1000^{0}C to produce lime or quicklime. These kilns were massive furnaces sometimes several metres high. By adding wood or charcoal, the kilns needed to be fired for days in order to process

401 Lawall 2014, 172.
402 See Hansen's definition of the Shotgun method 2006,1.
403 Tsakiridis and Toumbakar 2010, 374; Elsen 2006.
404 Martinet *et al.* 1992.
405 Henry and Stewart 2011, 51; See also Ferrarese *et al.* 2002, 38, for an example of the crystalisation of a dry gysum wall due to oversaturation.
406 Gale *et al.* 1988; Rapp 2009, 131.
407 Evans 1964, vol II part II; Rapp 2009, 260.
408 Henry and Stewart 2011, 50. Commonly known as plaster of Paris.

Figure 11. Locations of large Gypsum outcrop sources in the Monte Polizzo area J.L. Berry

Figure 12. Gypsum outcrop at Montagna Grande J.L. Berry

limestone.[409] This procedure required about four to eight tons of wood for processing the amount of quicklime required to construct just one building.[410] Once quicklime started to be commonly used as a building component during antiquity, it is evident that in a new settlement with a need for new buildings the result was serious impacts on the environment.[411]

In the light of the benefits of gypsum, the use and trade of this material in Sicily will have to serve as a possible area of future investigations. Nevertheless, since one of the aims of this study was to understand the environment around Monte Polizzo and what possibilities nature served for its people, this was a tentative addition to the future discussion.

Up until this chapter, the main part of the thesis has focused on understanding the regional environment, its changes during the time span of this study, river navigability, the natural surroundings and the ecology that provided the basis for Monte Polizzo to maintain its carrying capacity, subsistence, and trade. The palynological data display a region where the arboreal pollen decreases from 750 BC and onwards in favour for pollen from human-impacted landscapes. Soil erosion records from the Trinitá reservoir further established that the settlement during the seventh century deforested the surrounding area facing west and south. The study of the palaeobotanical and faunal material found in the settlement has revealed that their local economy was based (at the least) on a multi-cropping strategy and pastoralism. The contexts of many of these findings establish the closely interwoven spheres of nature, ideology, and economy in line with the theoretical outlook of this work. The following part of the thesis will focus on the archaeological material found at the settlement that establishes it was a part of pan-Mediterranean trade.

409 Williams 2004.

410 Artioli *et al.* 2019, 162.

411 See for instance Redman 1999; or Rollefson and Kohler-Rollefson, 1992 for examples from the Levant.

CHAPTER 8

Ceramic evidence of trade and exchange

The archaeological evidence in this work will testify to a broad import of goods from the many places in the region, offering traces of larger east and west Mediterranean trade networks which reached to inland Sicily and Monte Polizzo. The ceramic material will also demonstrate trade and exchange within the region itself, as economic transactions in western Sicily during 650-500 BC took place in different spheres.

To distinguish not only the Monte Polizzians' taste for imported liquids of various types but also the wider exchange network in the area, transport amphorae offer an excellent starting point. Transport amphorae are the most significant material evidence of ancient economics and trade. Transport amphorae are also the only ceramic type not traded as wares in and of itself but for their contents. The study of amphorae represents a significant amount of work, incorporating production, transportation, and importation.[412]

Archaic transport amphora

It is generally accepted that the morphological evolution of transport amphorae occurred in line with the development of long distance trade. The morphology of the vessel varies from cylindrical, conical, ovoid or any form and size based on the pottery-maker's technique. For instance, if the amphora is taller than 35-40 cm, it needs to be thrown in several section on a pottery wheel, due to the height limit required of clay to defy gravity.[413] The larger the cargo, the taller and more cylindrical the amphorae. The first type of transport amphora that circulated the Mediterranean, providing evidence of long-distance trade during the Late Bronze Age, is the Canaanite Jar from the Levantine. This type of amphora was clearly designed to be transported long distance, based on its strong standardised construction, the two handles, short narrow neck, and round pointed thick base. [414] The Canaanite Jar continued to evolve to the elongated 'torpedo' amphora parallel to the Phoenician transport amphorae that appeared later during the Iron Age, which will be discussed below.

Chronologically, there is a distinct difference between the archaic shorter and ovoid or globular amphorae and the longer, leaner amphorae produced later during the Classical and Hellenistic period. The same design is visible when viewing the shape of the bases, which during the eighth and seventh centuries BC were often flat, ring based or slightly pointed. In contrast, during the sixth century they were equipped with a nob to provide a steady grip when handled. An exception to this evolution is the Attic SOS amphora that continued being produced in its original shape. The differences between early archaic transport amphora and a storage vessel are, therefore, often blurred. Both share similar forms for three essential components: mouth, body and base. All are specifically adapted to purpose, keeping liquids or other substances inside the container during storage and transportation.

412 Whitbread, 1995, 9.
413 Knapp and Demesticha 2017, 38.
414 Knapp and Demesticha 2017, 36.

Flat-based storage jars or amphorae are suitable for fixed storage but not on top of each other as cargo. Studies show that flat-based vessels were less resilient to vertical forces, making them unsuitable for layered storage.[415] The Etruscan amphorae from the seventh century provide a perfect example of one type with flat base for storage or domestic use, mostly in rotation within Etruria, and one round base type for transport.

Transport amphorae circulating the Mediterranean region during the eighth to sixth centuries were, generally, not yet standardised to fit large cargo. Knapp and Demesticha seem to have noted a pattern that split the Aegean types of transport amphorae in two stylistic traditions. The Attic SOS transport amphora, the amphorae from Samos and Lesbos, and amphorae produced in the Thermaic Gulf all seem to stylistically derive from the *domestic* amphora, a common vessel in the Geometric Greek Aegean. While the Corinthian Late Geometric transport amphora, which also appeared during the same period, followed by the Corinthian type A, was adapted from the *storage* vessel. [416] This indicates that the development of transport amphora style evolved from traditional local pottery to maritime transport. These local pottery traditions in the Aegean continued during the archaic period to shape the styles of transport amphorae into trademarks for their specific agricultural products. Accordingly, transport amphora found at an archaeological site can offer clues to its provenance.

Amphora provenance

Studies in amphora research traditionally accept that an amphora shape serves as a trademark for its city of origin and, consequently, to advertise the local products. The form had nothing to do with function as long as the mouth was narrow enough for pouring and sealing, handle, neck and toe provided sufficient grip. The sty-

415 Radic Rossi 2006, 164-168.

416 Knapp and Demesticha 2017, 146f; See also Williams and Fisher, 1976, p. 101, pl. 17.

Figure 1. Corinthian type A found in House 2

listic design was made after local tradition and, perhaps most importantly, to either distinguish the type from the competitors—or to imitate them.[417] A famous example illustrating the importance of form is the Chian amphora. This amphora was so closely linked to its city of origin that an illustration of its bulging neck was depicted on Chian coinage. In the third quarter of the fifth century BC, however, the bulging shape of the amphora changed in favour of a more straighten neck. The new amphora type was stamped with a coin illustrating the 'old' bulging form, a way of maintaining the city's brand and its agricultural product.[418] As the Chian amphora show, the stamp provided the seller and the buyer with a guarantee of the origin of the product. The frequency of stamp impressions on the vessel developed over time in the transport amphora production. However, it did not appear until the end of the Archaic period and then only modestly by a letter, a thumb print, or in the form of a decoration.[419]

Research conducted during the past decades shows, that attempting to determine a vessel's origin based solely on form can be problematic.[420] During the late Archaic period, it is evident that Chios, Athens and Thasos used a very specific type of amphora only produced in a narrow region. This differs from, for example, the Clazomenian amphorae. These exhibit a wider range of fabric, indicating a broader production area and multiple workshops. Lesbos amphorae seem to share styles with the adjacent mainland, and the northern and south-eastern Aegean generally shared a broad variety of styles.

Amphora contents and reuse

It is evident that transport amphorae contained and transported different kinds of foodstuff. Nevertheless, it is generally accepted among scholars that ancient transport amphorae mostly contained wine and, less commonly, olive oil. This assumption is often based on the amphora's stylistic components. A narrow neck, wider body, and nob to hold when pouring is usually indicative of any kind of liquid. A globular body with a stable base and thick rim with a groove or ridge below, in contrast, was commonly used for olive oil. [421]

Finding evidence of trade in agricultural products is more complex. Dry commodities such as nuts, grain, or spices would have been transported in lighter packaging, such as sacks, baskets, and boxes. Panagou argues, however, that grains transported in bulk in organic containers during longer journeys would be exposed to rats, mould, or parasites feasting on the containers' contents. The amphorae, conversely, provided a waterproof container to secure the products.[422] Even though it is attested that dry goods were often shipped in organic containers, it is evident that transport amphorae were used and reused for both dry and liquid contents.

Another more plausible suggestion for the use of transport amphorae in shipping dry commodities could be that the amphorae functioned as ballast. Reusing and filling emptied stackable amphorae with various commodities may have been perfect for such a purpose. Emptied amphorae were probably available in abundance in any port. For an entrepreneur, these amphorae could easily be collected, reused, refilled, and sold with either similar products as the original content or some other foodstuffs—without the costs of amphora production. It is a widespread assumption that the Athenians were large producers of olive oil during Archaic and Classical times. Yet after the early fifth century, the Attic SOS and 'à la brosse' types completely disappeared in circulation. Albanese Procelli interprets the disappearance of the Attic amphorae in Sicily as a result of a local Sicilian production of olive oil meeting demand.[423]

Another suggestion is that with the wide scale distribution of different transport amphorae across the Mediterranean and the Black Sea came also eventually an equal number of empty amphorae. A smaller village,

417 Lawall 2011a, 45.
418 Lawall 2011a, 46.
419 Dupont 1998, 145.
420 Dupont 2020, 52.
421 Foley *et al.* 2012, 391. Regrading stylistic components, se for instance the Clazomenian types for wine and olive oil in Dupont 1998, 155.
422 Panagou 2016.
423 Albanese Procelli 1996; 1997.

a marketplace, or residential area eventually shared this 'problem' of empty amphorae to either be reused, recycled or discarded.[424]Lawall suggests that a large-scale reuse of amphorae at one time imported to Attica could explain the disappearance of the region's own amphora production. [425]

Amphorae found in various shipwrecks do testify to a variety of contents and are often evidence of reuse, such as olives in 'wine' amphorae, almonds in 'oil' amphorae, pitch filling in 'wine' amphora, and cattle ribs in 'wine' amphorae.[426] The Archaic and Classical Chian wine was famous for its impeccable taste, but Hellenistic papyri witness of Chian amphorae filled also with hazel nuts, honey, and olives.[427] Most of these examples are from shipwrecks of either the late-Classical or Hellenistic periods. [428]

There are well-documented shipwrecks from Archaic and early-Classical periods as well. Relevant for this study is the Etruscan shipwreck, dated to 580 BC and found near the island Giglio off the northwestern coast of Tuscany.[429] The largest part of the cargo consisted of Etruscan wine amphorae. Some of these amphorae offer an insight into reuse. Although all amphorae were coated with pitch—indicate wine was the original content—some of them contained olives. Two carried pitch, which had been poured out over the other cargo. Except for the Etruscan amphorae, the load consisted of at least six Samian amphorae, some Eastern Greek, Punic, and Corinthian A.[430]

The reuse of transport amphorae is also attested by DNA analyses made on residue found in ten Greek amphorae from the fifth to the third century BC. The analyses showed that all tested amphorae had during their lifetime contained more than one product.[431] Another possibility is even more interesting: that the amphorae were used only the one time, but the contents were more complex. The olive oil or wine could have been mixed with herbal additives, such as thyme, oregano, sage, or rosemary prior to shipping, as a flavour enhancer or for is antibacterial and anti-fungal properties.[432]

Reuse of transport amphorae can be found in necropoleis, and not only as grave goods, but serving as a final resting place for human remains in *enchytrismos* burials. See for instance the necropolis at Himera and Panormus.[433]

Methodology for the ceramic evidence

The amphora material found in the domestic area at Monte Polizzo is just like the general ceramic assemblage: extremely worn and fragmented. Due to this bad condition, there is no evidence of slip, paint, decoration, or resin on the amphorae fragment. No chemical or petrological investigation such as archaeometry, x-ray florescence (XRF), or x-ray diffraction, just to mention a few methods, has been conducted to gain more information about the vessels in order to determine the provenance of a certain amphora. Instead, the amphorae were classified by the traditional ways of classification. [434] This exercise was conducted by comparing the fragments' shape, form, colour, and clay with information, photographs, and drawings provided in literature commonly used as

424 Peña 2007, 62; Abdelhamid 2013.

425 Lawall 2011, 44; See also Peña 2007; and Riley 1979 for similar ideas. An attested example of large-scale reuse of transport amphorae and a decline in local amphora production is known in Hellenistic Egypt. For further discussion and examples of different kind of amphora reuse as for drainage, or wall constructions during the Classical and Hellenistic periods, see for instance Lawall 2011, 45; and as Roman door knobs or urinals see Peña 2007, 121-123.

426 Carlson 2003, 589-590. The Tektas Burnu wreck.

427 Lawall 2011, 43; See Panagou 2016, 323-324., for list of occurrence of amphora content in literature.

428 For amphorae contents in shipwreck see for example Panagou 2016; Foley *et al.* 2012; Carlson 2003.

429 Bound and Vallintine 1983; Bound 1991.

430 Bound 1991.

431 Foley *et al.* 2012.

432 Foley *et al.* 2012, 397.

433 For Himera see Vassallo 1991; 1999b; for Panormus see Di Salvo 2004.

434 See for instance. Riley' sourcebook on pottery analysis 1979; or Peacock 1977; Empereur 1982; Rice 1987; Dupont 1982; 1983; 1986; Whitbread 1995. All seen as front figures of the evolvement of methodological amphora studies.

aides for amphorae classifications.[435] The same method was applied to all ceramics found during excavations within the SSAP. Some amphorae identifications have been done with the guidance of Marc Lawall while he visited the department giving a lecture at Gothenburg University during 2007.[436]

Each amphora specimen in this study carries a spatial reference to an area of a maximum size of 4×4 meters. In some cases, find spots are determined in find units of an even more exact radius of 1×1 cm. Every find can be related to other objects, contexts, and rooms. However, the find location is not necessarily synonymous with the place of use. Fragments of ceramics do tend to wander around the site, either disappearing completely or being swept away from the place of the vessel's destruction.[437]

Quantification

The ceramic findings presented in this study are all derived from the domestic buildings House 1 through 5.[438] The total amount of ceramic assemblage accumulated in these houses is about 2,700 kg and more than 69,000 sherds (house 5 excluded since it is not completely analysed), of which 92 kg and 4,300 sherds are transport amphorae ware.

There are many methods to reconstruct a number of fragmented sherds into what once were complete amphorae. One has to consider the different prevailing circumstances of a particular site regarding contexts, number of sherds, and fragmentation of the material at hand. Not one single amphora was excavated intact, although a burned down wooden roof has preserved a complete but fragmented vessel *in situ* in one context.

435 See Dupont 1998 for East Greek amphorae, Whitbread 1995 for Greek amphorae, Gras 1985, or Py 1985 for Etruscan amphorae, Ramón 1995 or Bechtold 2011 for the Phoenician classifications. See also the FACEM project.

436 Personal communication between Marc Lawall and Christian Mühlenbock.

437 For the formation process see for instance LaMotta and Schiffer 1999; Goldberg *et al.* 1993; Backe-Forsberg 2005.

438 Mühlenbock 2008.

Figure 2. Etruscan amphorae found with the capeduncola in the storage area in House 1

It is evident that a large quantity of amphora sherds are lost as result of weathering and erosion. There is an important distinction between what Orton calls the 'life assemblage', which are the pots in use at a certain point in time, and the 'death assemblage', which are the pots disposed of from a certain place over a certain period.[439] The life assemblage, i.e. the sherds that are found during excavation, should only serve as an idea of the amount of pottery that once was used in the building or site during its 'lifetime'.

The methodology chosen for the purpose of assessing a possible number of vessel was to quantify the amphorae based on the diagnostic rim, base, and handles.[440] I have assessed the number of amphorae based on the total assemblage divided in groups based on the spatial limitation that each room in each house provide. The rim, base, and handle fragments from a specific type within a single room were cross-matched and if possible re-joined. The archaic transport amphorae present in the material were also in circulation during roughly the same time interval. Since the chronological time-span of the settlement is no longer than about seventy-five years, the fragments travel between the different archaeological layers within a room. It is also quite common to use both old and new fragments from broken vessels to level out floors or interior walls.

All rim fragments were measured with a standard diameter-measurement template in order to measure the orifice diameter and to estimate the percentage of the total vessel orifice circumference present. If several rim fragments of a specific type within the same context have the same diameter (and fabric and form, naturally), it has been assumed that they belong to the same vessel. However if, for instance, three rim fragments have the percentages of the total vessel orifice circumference present of 20%, 50%, and 80% respectively, they are from a minimum number of two complete vessels. [441] The template was also used, as above, to estimate base diameter and the percentage of total vessel base circumference present. Compared to the number of diagnostic fragments, the body sherds are surprisingly few, which means that the method of weighting sherds in order to make a quantification of the fragments would not add more information about the minimum number of vessels at the site.

Monte Polizzo transport amphora repertoire - spatial distribution

The following sections present the spatial distribution of the various amphorae types found in the habitation area. A short reprise of the different houses is found below. For a general overview of the various amphora types and production centres, and the Monte Plizzo amphora catalogue, see appendix 1..

Amphora assemblage House 1

House 1 is situated on the natural ridge that runs east from the Acropolis. The building structure is located in the centre of the settlement. Wall analyses show that, during the time of habitation, House 1 evolved from a rather simple structure to a more complex building consisting numerous walls and rooms. With its six rooms, it is the largest of all houses in Area A.[442] With a few exceptions, the majority of all finds from House 1, including the transport amphorae, can be placed in a chronological sequence from around 630 to around 550 BC. Because of the short period of activity, it is not possible to tie particular practices to specific phases of chronology.

Only a small number of vessels were recovered intact. The degree of fragmentation of the ceramic material is best explained by the collapse of walls and/or the roof. The sudden destruction of all houses, probably due to a fire, buried much of the material culture *in situ*, thus preserving a rich and varied ceramic assemblage. The total amount of various ceramic sherds found in House

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439 Orton 1993.

440 See for instance Johnston 1990; Lindhagen 2006, 44-48; Göransson 2007, 11-14; See also Orton 1993 for a review of the history of vessel quantification.

441 See Dawson 1971 who coined the method of 'possible numbers of complete vessels'. See also Rice 1987, 222-224 for further discussion of this technique.

442 For architectural presentation and interpretation of House 1, see Mühlenbock 2008, 40-49.

1 is 37,300 fragments with the total weight of 1347 kg, of which 43 kg and 1931 fragments are from amphorae.

The fragments have been identified accordingly as the methodology presented above, and a minimum number of amphorae found in House 1 is nine.

Spatial distribution

Room I: two Etruscan (art. 43333, 43644)

Room II: one Etruscan (art. 42243) one unidentified (40487)

Room V: There is one handle fragment of an Attic SOS type amphora in room V, which is the only fragment of this type in all of the amphora assemblage (art. 43020)

Room VI: two Etruscan (art. 42789, 43268), one Phoenician (art. 42780), and one "Corinthian B" type (art. 2265)

Amphora assemblage, House 2

House 2 is located on a terrace only two meters down the slope below House 1. Its backroom walls rest against the bedrock. The chronology of the material remains is consistent with House 1. However, the earliest phase prior to 600 BC is interpreted to be remains deposited before the building was constructed, indicating that House 2 was constructed after House 1.[443]

It is clear that the remains of the building have suffered modern disturbance consisting of deep ploughing evident in cut marks along the southern wall. However, destruction is far less extensive than House 1, since the stratigraphic layers run deeper. The building has a total area of 68.5 m² divided in three rooms, which makes this building nearly half the size of House 1. The total amount of ceramic fragments excavated is 12,855, with a total weight of 709 kg of which amphora fragments are 298 with the total weight of 13 kg. The minimal number of amphorae found in House 2 is ten:

Spatial distribution

Room II: one Lesbian (art. 40119) one "Corinthian B" (art. 40490), one Chian or Clazomenian (art. 45004), one East Greek possibly Chian or Clazomenian (Art. 40343), one Phoenician (art. 40752), three Corinthian A (art. 44987, 43787, 40506), one possibly East Greek or Parian (art. 40542)

Room III: one Corinthian A (art. 40682)

Amphora assemblage, House 3

House 3 is located just below House 2 following the naturally sloping topography to the southeast. This building differs from the other two in terms of building construction, with specific regard to a semi-circular room that constituted the earliest phase of this structure. The circular form is constructed solely by cutting out of the bedrock, leaving a natural surface without a built wall. Facing the semi-circular room is remarkable wall foundation worth highlighting, since the building blocks are not locally extracted but brought to the site from some quarry in the coastal area instead.[444]

The chronology of House 3 is consistent with the other structures. The eastern part of the building, consisting of room II and III, was constructed first in the second half of the seventh century BC. The earliest datable finds were found in this part of the building, in room III. The building was later (after 600 BC) expanded with another room, now with a total area of 55m². The total amount of ceramic fragments found in House 3 is 11,650 fragments with a total weight of 295 kg, of which the amphora fragments are 45 kg distributed amongst 1,312 fragments. The spatial distribution of amphora fragments in House 3, of the minimal number of amphorae of 16 is as follow:

Spatial distribution

Room I: three Etruscan (art. 40804, 41327, 41233), one Milesian (art. 41297) three North East Aegean/Samian or Milesian (art. 44684,44536, 44529), three Corinthian A (art. 44562,40885, 41320)

Room II: one Corinthian A(art44131) one Unidentified (art. 44267)

Room III; two Corinthian A (art. 44671, 44164), one Corinthian or Western Greek (art. 40668), one unidentified (art. 44650)

443 Mühlenbock 2008, 145. For discussion of household practices in House 2 se Mühlenbock 2008, 145-151.

444 An assumption made after discussing the wall with Martin Benz and on another occasion John L Berry, who both independently agreed to the resemblance of the stone quarried in Cave di Cusa, the quarry for Selinus.

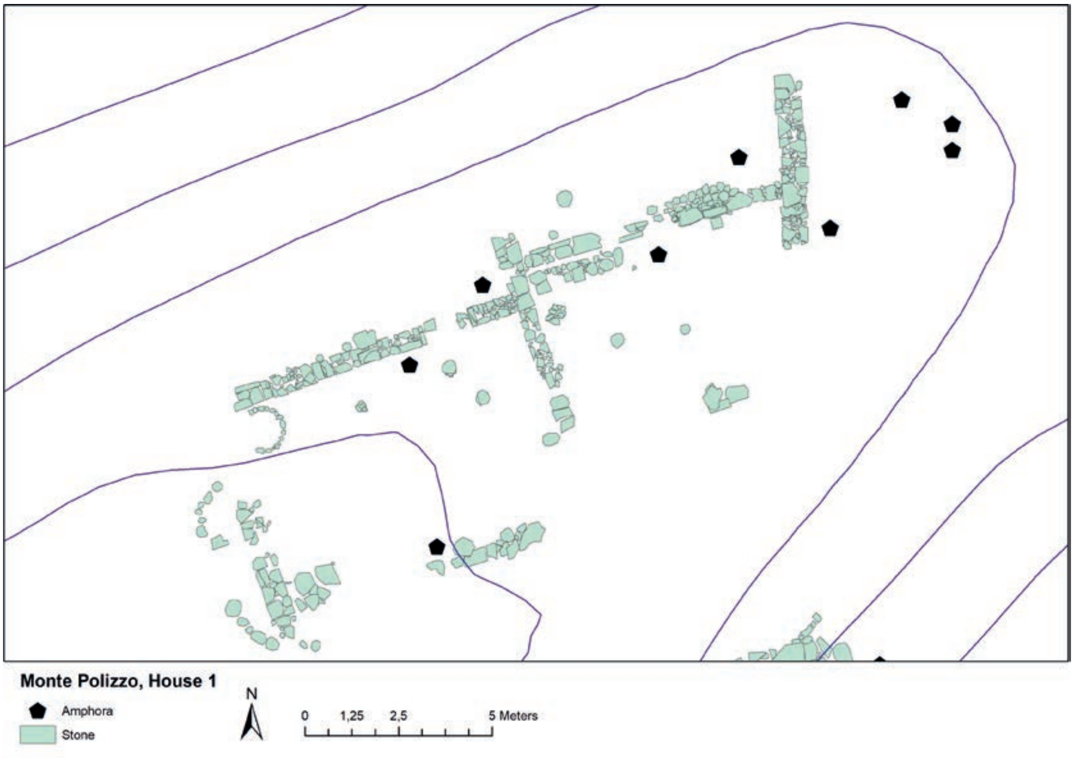
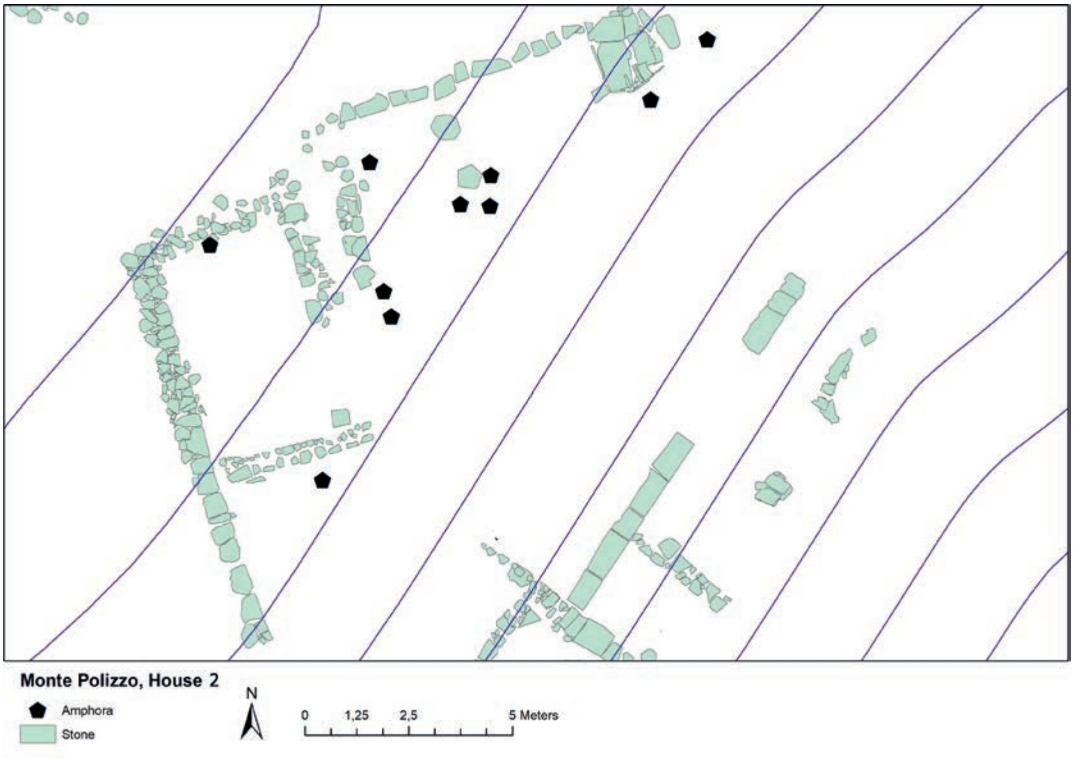


Figure 3. Transport amphorae in House 1, room division and find locations

Figure 4. Transport amphorae in House 2, room division and find locations



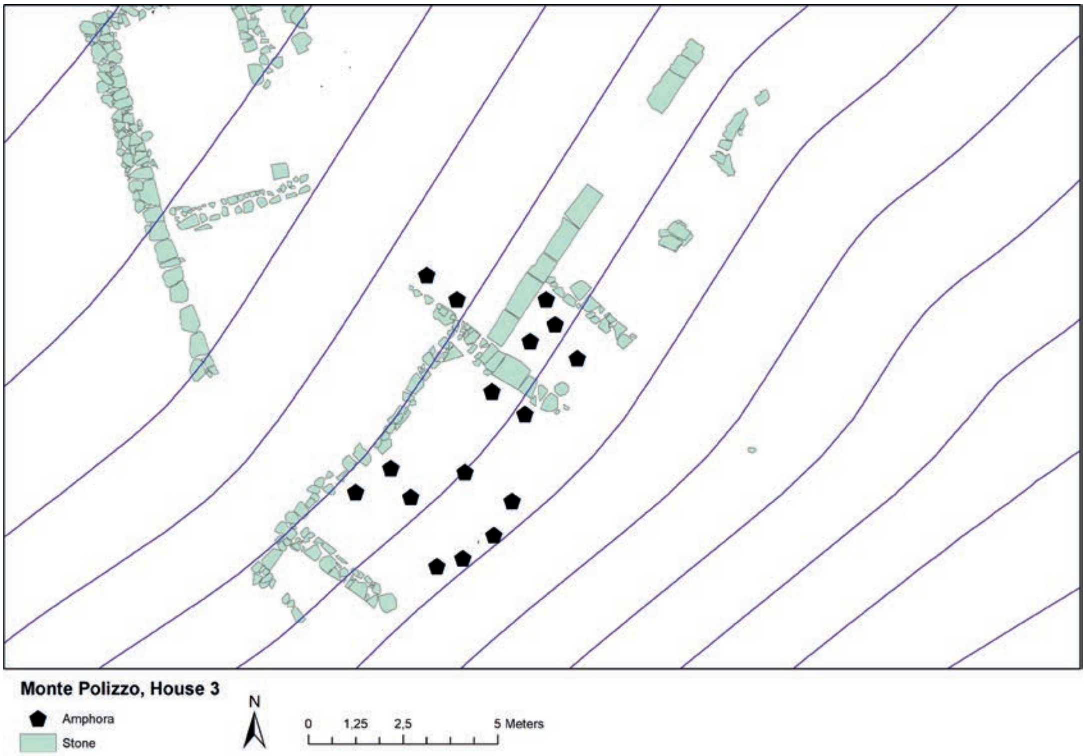
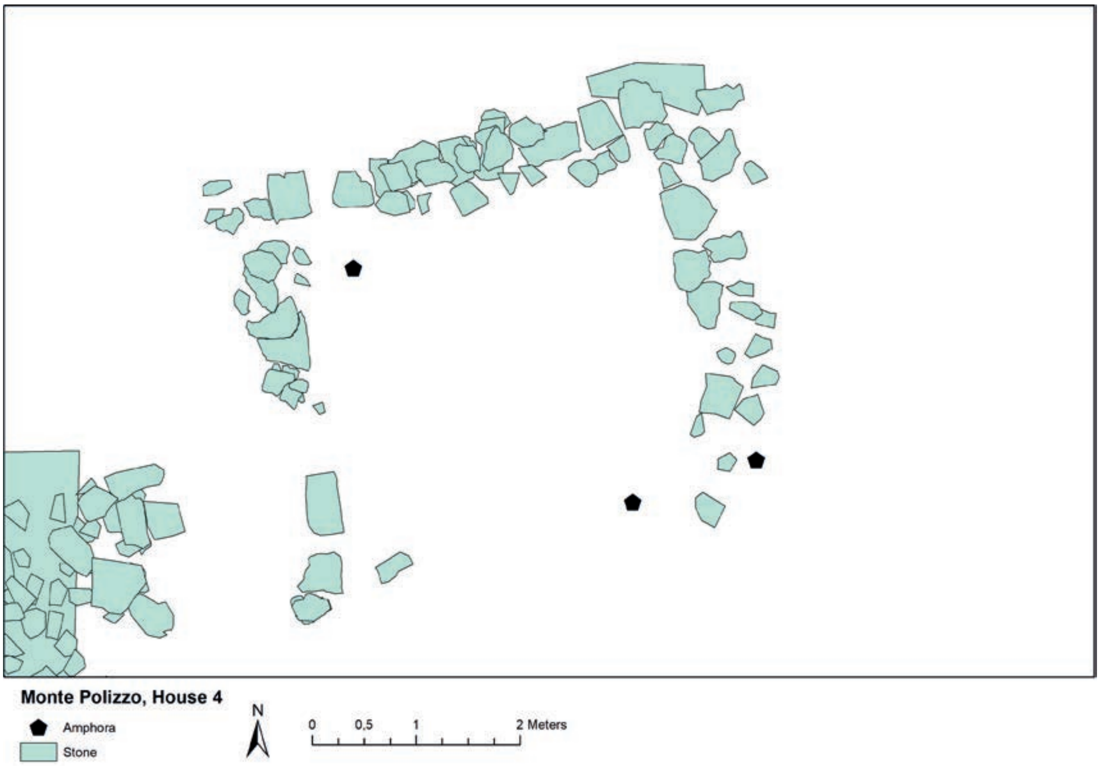


Figure 5. Transport amphorae in House 3, room division and find locations

Figure 6. Transport amphorae in House 4



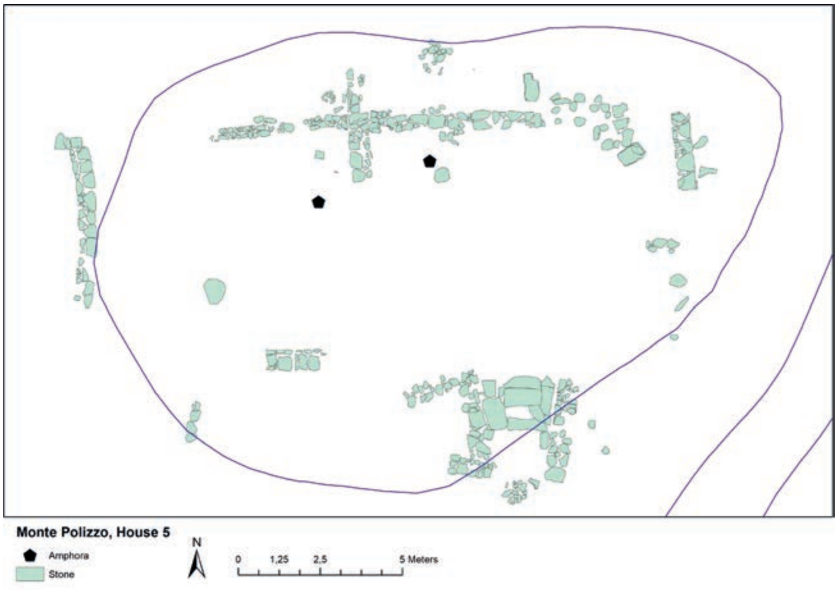


Figure 7. Transport amphorae in House 5, room division and find locations

Amphora assemblage, House 4

The total amount of ceramic fragments found in House 4 is 5,059 fragments with a total weight of 367 kg, of which the amphora fragments are 16 kg distributed amongst 751 fragments.

Three Etruscan amphorae were found in House 4 (art. 20179, 20018, 20159)

Amphora assemblage, House 5

House 5 although severely damaged, had a different floor plan compared to the other structures. It had one large room with a stone-paved courtyard adjoined by a smaller space that was intended for storage. This house was probably used as communal space. The total amount of ceramic fragments found in House 5 is not yet analysed. The amphora fragments consist of 2.2kg distributed amongst 97 fragments.

Two Corinthian amphorae were found in House 5 (art. 46035, 45920)

The amphorae in a settlement context

The minimum amount of amphorae identified form the fragments in the domestic areas of Houses 1, 2, 3, 4 and 5 are 40. An addition to the amphorae found in the habitation area, some were found at the acropolis. Both Etruscan and Punic/Phoenician amphorae were found at structure D1, located north of the summit and the sacral areas. No quantification of the fragments has been undertaken. However, Morris *el al.* write that "one of the Etruscan amphoras may be of Py's type 3 A/B" which indicates a number of more than one.[445] In zone C, fragments from a Corinthian type A and a Chian amphorae were found together with Middle-Late Corinthian cups and a few sherds from an Ionic cup.[446] In zone E next to the Profile, a few amphora fragments were found in addition to Corinthian fine ware sherds and quite an extensive collection of bronze fibulae fragments.[447] In zone A6 fragments discovered include ones from Ionic A2, B1, and B2 cups, a Corinthian *kotyle*, aryballos, and Type A transport amphora, sixth-century lamps, fragments of five bronze ornaments. In addition, a dozen Attic black glaze sherds were scattered across its surface.[448] In A1, about 22 percent of the sherds

445 Morris *et al.* 2004, 273.
446 Morris *et al.* 2003, 179.
447 Morris *et al.* 2004, 204.
448 Morris *et al.* 2004, 224.

excavated came from amphorae. In the Profile, only a few fragments from Corinthian, Chian and Phoenician amphorae were found.[449] That could indicate that the amphorae usually were not thrown away but used as containers once finished.

Focusing again on the domestic area, in addition to the amphorae, the archaeological record witnesses of a variety of imported goods just as shown at the acropolis. As the table shows, the total number of imported vessels found in the houses is 226, transport amphorae excluded. This number can be compared to the number of locally produced vessels of 370, cooking pot excluded. However, breaking down these numbers and vessels into specific categories it becomes clear that the imported wares are associated with specific practices. The largest category of local vessels is bowls, while the largest category of imported ware is drinking cups.

Some of these cups do also lay the groundwork to date the oldest layers in House 1, such as an A1 Ionian cup dated to a. 640-600/580 BC and a Proto/Early Corinthian *kotyle* dated to 640-600 BC, for example.[450] There are 21 *kotylai* of Corinthian manufacture and sixteen probably produced in the workshops in Selinus and Himera. The Ionic cups are the largest group of imported fine ware on Monte Polizzo, but they also represent at least five different clay types, indicating a range of production centres not only on the Ionic coast but also in Selinus, Himera, or possibly Motya.[451] Their large representation in the ceramic assemblage is consistent with a general pattern in the Mediterranean and the Black Sea during the seventh and sixth centuries BC: Ionic cups are one of the most widespread fine ware.[452] These cups were mainly produced in the production centres of Samos and Miletus and were thus a perfect complement to the shipment of transport amphorae from the same centres.[453] In addition to fine ware, there are nine oil lamps found in the habitation area, all but one of which are imported. The last one was probably made at the site from the local grey ware fabric. One lamp is attested to originate from Megara Hyblaia.[454]

Vessel type	House 1	House 2	House 3	House 4	House 5
Local cooking pots	36	29	16	6	1
Local table amfora/hydria	37	9	4	2	2
Local mixing vessels	6	0	0	0	0
Local bowls	138	43	51	5	32
Local pouring vessels	20	6	8	0	3
Local drinking vessels	1	2	1	0	0
Imported table amfora/hydria	2	3	7	0	0
Imported mixing vessels	0	1	3	0	0
Imported bowls	0	2	2	0	0
Imported pouring vessels	9	5	2	0	5
Imported drinking vessels	76	33	69	3	5
Transport amfora	9	10	16	3	2
Total	**334**	**143**	**179**	**18**	**50**
Percentage	**46**	**19.8**	**25**	**2.5**	**7**

Table 1. Local and imported pottery

449 Cooper 2007.
450 Mühlenbock 2008, 94.
451 Mühlenbock 2008, 93. Tardo 1999, 2000.
452 Fletcher 2007. Cook and Dupont 1998, 131.
453 Whitbread 1997, 123; Dupont 1998, Samian content 168, Milesian content 175.
454 Mühlenbock 2008, 100.

Fine ware is often associated with the shipment of transport amphorae, a way to maximise ships' loads during overseas journeys. The common conception is that ships during later Archaic and Classical times and onwards generally carried multiple products of various origins, as shown in the Giglio shipwreck mentioned earlier. This ship's cargo consisted mainly of Etruscan but also Samian and other amphorae, and the shipment included with a large variety of fine wares. Found in the wreck were Ionic oil lamps, Laconian *aryballoi*, mugs and bowls, Corinthian *kraters, aryballoi* and cups, and Ionian bowls.[455] The variety of goods transported in the Etruscan ship mirrors the ceramic assemblage on Monte Polizzo quite closely and further shows that Monte Polizzo was congruent with the Mediterranean mode. The relation of Monte Polizzo to the coastal settlements and the wider Mediterranean trade network will be explored further in the next chapter. But before adopting the wider perspective, reconnoitring contemporary indigenous settlements in the western Sicily region offers greater understand of the Monte Polizzo settlement in a regional context.

Archaeological evidence in a regional context

One aim of this study is to answer questions regarding what trade and exchange patterns in western Sicily the Monte Polizzo settlement was part of. What conclusions can be drawn from the Monte Polizzo transport amphora material in terms of diversity and quantity and, hence, trade activity? Is it possible to determine where the Monte Polizzians could have obtained their amphorae based on other settlements' assemblages? Compared to other indigenous settlements in the region, does the Monte Polizzo assemblage stand out?

A focus in this study so far has been the natural environment and the possibilities of transportation and trade between the coastal settlements of Motya, Selinus, and Monte Polizzo. In order to understand the wider significance of the amphorae repertoire, we must consider its archaic western Sicilian context and its relation to other indigenous contexts. An extended comparison of the indigenous settlements of Segesta and Monte Maranfusa is offered below in order to find some comparandum to the amphora assemblage of Monte Polizzo.

Monte Maranfusa is a well-studied settlement with a contemporary habitation area very much alike Monte Polizzo. The habitation area of archaic Segesta has unfortunately not been excavated as much. Only one small location interpreted as an archaic domestic building has been examined. There is however, more to a settlement than its habitation area and, in archaeology, there is always more of a site than so far discovered or understood. The theoretical holistic view of interwoven subsystems is also evident in the archaeological material. Transport amphorae, for instance, are evidence of both economic and social interaction and often found in religious contexts. In the search for trade patterns and imported goods, all contemporary amphora evidence, whether it is from a domestic or ritual context, will therefore be considered in this work.

The Elymian settlement of Monte Maranfusa and its transport amphora repertoire

The most studied indigenous settlement in western Sicily contemporary to Monte Polizzo is Monte Maranfusa. Although located further east inland from Monte Polizzo, it is a good settlement to consider. It is situated in the middle valley of River Belice Destro, between Palermo in the north and Selinus in the south. The Belice River is the largest river in the western part of the island. Its main source is located near Monti di Palermo and runs southwest as Belice Destro. Near Poggioreale, it joins with Belice Sinistro and has its outlet south of Selinus. The Belice is often considered as the river providing the Selinuntines direct contact to the inner landscape, local networks, and reciprocally providing the local population in that area access to the coast. However, as Spatafora points out, it is not yet attested whether the river was navigable during ancient times.[456]

The Monte Maranfusa settlement is located 487 m. a.s.l. situated inland circa 30 kilometres as the crow flies southeast of Monte Polizzo. Based on archaeolog-

455 Bound 1991.
456 Spatafora 2003,3.

ical material, it is evident that there has been sporadic human presence from Late Bronze Age or Early Iron Age. Continuing human activity is first established in the settlement from the seventh to the first half of the fifth century BC. The houses, built in terraces, consist of several rooms adapted to the natural environment. In that regard, they are similar to Monte Polizzo. The habitation area, Campo A, has three different occupation periods and building 1, consisting of three rooms, is the oldest with a chronology from the end of the seventh to the middle of the sixth century. [457]

The Monte Maranfusa transport amphora repertoire differs in both diversity and quantity from that of Monte Polizzo. There are only eight amphorae found in the habitation area, and all except one Samian amphora (dated between 560-530/20 BC) are produced later than the third-quarter of the sixth century.[458] These are one northern Aegean amphora identified as "Thasian circle", one Punic, and one identified as "pseudo-chiota". The other four amphorae are undetermined *greco-occidentale* Western Greek. Based on this modest archaic evidence, it is clear that other imported goods need to be taken into consideration as a reference to these amphorae in order to understanding the role of imported goods and trade to archaic Monte Maranfusa.

Other objects of trade

Nineteen oil lamps were found in the habitation area. As with all fragmented imported ceramics, it is difficult to determine a precise place of origin. The Monte Maranfusa lamps are classified as either *greco-orientali* or *fabbrica coloniale* produced in a Greek settlement.[459] Four lamps of the total assemblage are dated to 575-525 BC and two of them around 550. These are contemporary with the Samian amphora. The other lamps and amphorae are dated between 525-480 BC and are thusly beyond the chronological framework of this context.

There are, however, other imported fine ware associated with wine drinking which predate the transport amphorae, including about 20 Corinthian *kotylai.* Some of these are dated Early Corinthian (625-600 BC), some Middle Corinthian (600-575 BC), and some Late Corinthian (575-550 BC).[460] In addition, there are ten Ionic type B1 cups dated between 635 and 570/565 BC and 18 Ionic type B2 cups.[461] The same imported fine wares are evident in the Monte Polizzo repertoire consisting of 38 *kotylai* of both Corinthian and Colonial fabrication. In addition, there are 49 Ionian and Colonial B1 cups and 27 Ionian and Colonial B2 cups.[462]

The imported pottery at Monte Maranfusa indicates an early contact between people associated with an overseas network. Even though there is no evidence of a transport amphora that chronologically could match the earliest Corinthian drinking vessels at the site, it is always possible they transported liquid goods in biological containers instead of ceramic containers as discussed above. It is reasonable to think that liquid contents were refilled into smaller containers already in the marketplace. This, for example, could explain the absence of imported wine amphorae in earlier contexts at Monte Maranfusa.

The Elymian settlement of Segesta and its transport amphora repertoire

Contrary to the domestic areas of Monte Polizzo and Monte Maranfusa, little is known about the earliest phase of the archaic settlement of Segesta, the Elymian centre famous for its Doric temples, its theatre, and its alliance with both the Phoenicians and Athens against Selinus during the fifth century BC.[463] Segesta is located on Monte Barbaro, 50 kilometres southwest of Palermo and circa ten kilometres from Monte Polizzo as the crow flies. The settlement is clearly visible from the habitation area on Monte Polizzo. In 1978, the *Soprintendenza archeologica di Palermo* began excavating two trenches

457 Spatafora 2003, 33-64.
458 Fresina 2003, 277-279.
459 Denaro 2003, 301
460 Fresina 271-274.
461 Denaro 2003, 282-287
462 Mühlenbock 2008 tables 18 and 20.
463 Thuc. 6.6.

350-400 metres south of the Hellenistic theatre located on the top of Monte Barbaro in search of the archaic settlement.[464] The excavations revealed a rectangular room measuring 4 x 3 metres, interpreted as part of a bigger structure, of which the earliest activity is dated to the middle of the sixth century BC. The ceramic associated with the sixth century was seven Ionian cups, three Corinthian *skyphoi* one of which is miniature, one Ionian *kotyle,* three Attic *kylikes*—one dated to 540-530 BC and two to 530-520 BC, one Etruscan bucchero *kylix,* one Laconian krater, and various local Elymian ceramics such as big bowls, plates, and closed vessels. Notably in this context, only one transport amphora of Corinthian origin was found.[465] This material differs from the fine ware assemblage at Monte Polizzo which, except for the *kylikes* and Ionian cups mentioned above, consists of a Corinthian *aryballos*, a Corinthian *kothon*, four lids from Corinthian and Colonial *pyxis,* an Attic *lekanis,* and Colonial *lekythoi* [466]

In addition to the ceramic assemblage in the habitation context, the largest evidence of archaic activities in Segesta were found in the Grotta Vanella drain, located on the northeastern slope of the mountain. The archaeological material probably derives from a sanctuary located in the northern part of the acropolis, occupied today by the Hellenistic theatre. This context was investigated between the 1950's and the 1980's and rendered more than 100,000 fragments dated between the end of the seventh to the end of the sixth century BC.[467] The numerous artefacts are not associated with a domestic context per se. Instead, there is evidence associated with ritual practices, such as musical instruments, Attic painted kraters and vases, terracotta statuettes, and inscriptions made with the Greek alphabet but in Elymian language.[468] In this study, the fine ware found in the Grotta Vanella will not be considered as evidence of a specific Segestian flavour, since it could easily have been brought to the sanctuary from various places in the region. This material will therefore not provide the same indications of the settlements trade pattern as it would if it was found in domestic buildings. However, the presence of fine ware at Segesta shows that imported fine ware was accessible to the inhabitants in the region. Contrary to the fine ware, the transport amphorae are not as easily transported. Whether their original context, before they were deposited in the sanctuary, was Segesta or if they were brought from another place is impossible to know. However, as mentioned at the beginning of this chapter, they will be considered since they offer an insight of the transport amphorae in circulation in this part of the island.

The oldest amphorae in Segesta were found in the Grotta Vanella drain. These findings will serve as comparandum with the Monte Polizzo assemblages in order to get an idea of the prevalence of the various types. There are three Phoenician amphorae produced in Carthage, Malta, and Motya around the second half to late-seventh and early-sixth century BC. According to De Cesare, Phoenician amphorae are not attested to have been in circulation in Sicily before the end of the sixth century. This means that these examples, and thus the two Phoenician amphorae found in Monte Polizzo, are extremely rare.[469] Additional to the Phoenician examples, are two Attic (SOS?) amphorae, three Attic 'à la brosse', four Sybarite, one Etruscan, and one Aegean unspecified—all dated between the second- and third-quarter of the sixth century. There are also five transport amphorae of the Western Greek type.[470] The earliest two amphorae of Western Greek type are dated between the 550 to 500 BC and are attributed to Calabria. There are three additional Western Greek type amphorae produced in the southwestern Calabria and Locri, both of which started to produce transport amphora around the middle of the sixth century BC. There are about thirty transport

464 de La Genière 1988.

465 de la Genière 1988, 300-303. The ceramics is listed as fragments, for instance *"Fr. di coppa ionica"* but since she is giving the fragments different find numbers I am assuming they all belong to different vessels.

466 Mühlenbock 2008, table 21.

467 De Cesare 2020, 352. de la Genière 1988, 313. de la Genière and Tusa 1978.

468 De Cesare 2020,

469 De Cesare 2020, 36; See also Bechtold and Vassallo 2020 on Phoenician- Punic amphora circulation in Sicily.

470 De Cesare 2020, 367.

amphorae of the Western Greek type produced beyond the chronological scope of this study, mostly between 520-400 BC. These are still worth mentioning due to their various origin, such as Corcyra, Calabria, Agrigento, and Poseidonia, to mention a few.[471] Interestingly, due to their origins, none of these amphorae have been thought to have contained olive oil. The question remains open as to how and if they acquired it. The absence of amphorae containing olive oil in Segesta can be seen as a parallel to the absence of wine amphorae before 550 BC in Monte Maranfusa. Bechtold suggests that olive oil was instead produced locally or regionally and perhaps transported in other containers, explaining the lack of transport amphorae.[472]

Summary: the indigenous contexts in comparandum

The archaeological material highlighted from Monte Maranfusa and Segesta in the previous sections offer several interesting reflections. It is challenging to consider the archaic archaeological evidence from Segesta as a comparandum to that of Monte Polizzo. There is nearly no knowledge of Segesta's archaic settlement and its general structure, its domestic areas, or the activities of the inhabitants' everyday life. Segesta is, however, the closest settlement to Monte Polizzo geographically and possibly the settlement that the Monte Polizzians relocated to after they abandoned their homes in 550 BC. During the winter months, River Caldo offered an easy transport route and connected the two settlements. Otherwise, it was only a couple of hours' walk along the river valley.[473]

The contemporary transport amphorae assemblage at Segesta consists of three Phoenician amphorae (their presence will be discussed further in Chapter 9), two Attic (SOS?) amphorae, three Attic 'à la brosse', four Sybarite, one Etruscan, one Aegean unspecified, and two amphorae of Western Greek type dated between 550 to 500 BC. This collection differs both in quantity and variety of origin compared to Monte Polizzo. There is a large presence of the Etruscan and Corinthian amphorae at the latter site. While Segesta only had one Corinthian amphorae found in the house structure, Attic and Sybarite amphorae were the dominant types found at Grotta Vanella. This difference in taste between the settlements is evident in regards to fine ware as well, as shown above. The discrepancy can be explained by the fact that the chronology was longer in the Segestian house as shown by the Attic *kylikes* dated from 540 BC and onwards. Alternatively and more interestingly, that they had access to imported commodities by different trade routes and or distributers, as the different origins of amphorae found in the two neighbouring settlement show.

Both Segesta and Monte Maranfusa lack the amount of imported transport amphorae that was found at Monte Polizzo. Considering these assemblages, it is likely that if more houses were brought to light, more amphorae would be found. However, even if the amphorae from only one of the houses at Monte Polizzo were considered in comparison to the other sites, the quantity would exceed the Monte Maranfusa and the Segesta assemblages—by far.

In her studies of imported transport amphorae in Sicily, Albanese Procelli concludes that 58 percent of all amphorae attested to in Sicily derives from habitation areas and are found mostly in rooms intended for use as a kitchen or storage.[474] As at Monte Polizzo, the ceramics from all settlement contexts she explored were found in a fragmentary state. Less frequently, amphorae are found in sacred areas, and this has been noted in both colonies and indigenous centers. Only four percent are found in association with sanctuaries, 31 percent from necropoleis, less than three percent in rural settlements, and about seven percent from recoveries and underwater excavations.[475] Published amphora material from domestic contexts from the seventh to sixth century are nevertheless difficult

471 De Cesare 2020, 354; Savelli 2009, 113-114. Some of these western Greek amphorae were also found in contrada di Mango sanctuary, below a temenos from a Doric temple.

472 Bechtold 2020, 370.

473 Although not assessed in the report, based on the river's morphology today, it was probably navigable. Personal communication.

474 Albanese Procelli 1996; 1997.

475 Albanese Procelli 1996, 94.

to find. This can be explained by the fact that ceramic material in domestic contexts is usually very fragmented and the excavators have not incorporated this material in their repertoire or that the habitation areas and/or the domestic buildings are not, or not entirely, located or excavated. Another explanation is that worn amphora fragments scattered in archaeological layers have not been seen as especially interesting to study until fairly recently—and have been dispatched as waste. Strandberg Olofsson argues, for instance, that if excavators in Etruria had bothered to register all amphora material found in domestic layers, the conclusions about Etruscan amphora manufacturing and distribution patterns may have been entirely different.[476]

There are many reasons for the difference in quantity of transport amphorae in the archaeological material found in the three archaic contexts just presented. Archaeologically, this could be answered by the simple fact that the excavation areas are of different size, and the areas for amphorae storage–*if* there were any in Monte Maranfusa and Segesta— have not yet been found. Alternatively, perhaps the inhabitants discarded the amphorae after they were emptied or returned them to market. Wine or oil were perhaps commodities only used in special occasions and could therefore be bought in smaller containers. At Monte Polizzo however, there were nearly no amphora fragments in the dump, and a variety of amphorae were found in every house, in nearly every room. One interpretation of these facts that will be discussed in the following chapter is that Monte Polizzo had a different role in a wider Mediterranean trade network.

476 Strandberg Olofsson 2002.

CHAPTER 9

Trade and exchange. Monte Polizzo in a wider context

The aim of this last chapter is to zoom out from the immediate surroundings and to integrate the archaeological material presented in the previous chapter into a wider picture. I will evaluate different possible ways the Monte Polizzians acquired imported goods based, primarily, on the archaeological evidence. This study presupposes that the Monte Polizzians were active traders, even though this has not always been in line with scholarly tradition. It has been suggested that the indigenous population in general was uninterested in semi-luxury trade goods such as wine and oil.[477] The transport amphorae that did turn up in indigenous contexts were already in marketplaces emptied of their original content and refilled with other foodstuff. Alternatively, they did contain wine or oil but belonged to Greeks residing in the indigenous communities.[478] The wider implications of these arguments are that Elymians were not believed to have taken an active part in trade during the late seventh and early sixth centuries. Imported semi-luxury products were brought to interior territory by others. This view is problematic because emphasising models of inequality, based on a limited set of data, runs a huge risk of getting the wrong picture.[479]

Settlement organisation – the view of gift giving system

It is evident that the general conception is still that indigenous Sicilian societies' cultural, societal, and economic development was a unidirectional response to Greek and Phoenicians activity.[480] This view, in effect, turns the focus to the perception of how indigenous settlements were socially organised. Were they not an active participant in the political and economic development that took off during the seventh and sixth centuries? Identify the social structure of Monte Polizzo is beyond the scope of this thesis.[481] Nevertheless, it is necessary to highlight some relevant structural settings regarding the organisation of Monte Polizzo in order to continue the discussion about trade networks and exchange.

A societal structure often applied on Bronze Age and Early Iron Age clan societies—and on archaic Sicilian societies—is the theoretical concept of a "gift-giving system" between elites.[482] This model is applied to establish a given power structure between the indigenous elites and their counterparts among 'colonising' Greeks and Phoenicians. It is also used to clarify the presence of imported goods in indigenous contexts. Morris explains the general concept clearly:

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477 Albanese Procelli 1997, 14-15.
478 Albanese Procelli 1997, 14-15.
479 Mühlenbock 2008, 169; Osborne 2007.
480 Ferrer 2016, 901; Ferrer 2013.
481 See Mühlenbock 2008; Mühlenbock *in press.*
482 Mauss 1970.

> The aim of the gift economy is accumulation for de-accumulation; the gift economy is above all a debt-economy, where the actors strive to maximise outgoings. The system can be described as one of 'alternating disequilibrium', where the aim is never to have debts 'paid off', but to preserve a situation of personal indebtedness.[483]

Giving luxurious gifts was deeply rooted in the Phoenician way of life and was systematically employed to regulate affairs between rulers and elites.[484] Phoenician traders, for instance, used gift giving to secure trading rights and to obtain permission from indigenous rulers to trade within their territories.[485] Homer illustrates this in his description of the Phoenicians presenting a silver mixing bowl to Thasos to seek permission to trade unhindered at Lemnos (Hom. *Iliad* 23.740-749). Similarly, Etruscan and Phoenician members of the elite held banquets in order to regulate a common system of trade and exchange in Etruria during the ninth and eighth centuries.[486]

One can understand why this concept would be an attractive one to apply to the different societies of western Sicily. However, can the archaeological record support such an idea of indigenous settlement organisation? Can it really attest a gift-giving system between elites in these societies?

The reason this discussion is relevant in this context is that scholars advocate for the gift-giving system based on the presence or absence of imported transport amphorae in indigenous settlements and sacral contexts.[487] According to this idea, transport amphorae in indigenous contexts are regarded as prestige goods, reserved for the (male) elite to share. It means that the contents of transport amphorae were not something that 'ordinary' inhabitants could acquire on their own. The Phoenician transport amphorae at Grotta Vanella sanctuary at Segesta (discussed previously) can serve as an example. De Cesare suggests that these amphorae were given to the Elymians as prestige gifts by members of the Phoenicians elite when they frequented the acropolis sanctuary. They were brought there as part of a gift giving exchange.[488] These amphorae were not yet in circulation during the turn of the seventh century and are therefore regarded very rare. As discussed in Chapter 7, it is a reasonable assumption that the Greeks, Elymians, and/or Phoenicians shared common ground at sanctuaries.[489] A parallel is visible in another setting in Selinus where Phoenician amphorae of early production were found in the context of the foundation of Temple R (590-580 BC).[490] The presence of Phoenician amphorae in this sacral context is interpreted as evidence of cultural interaction and, perhaps, socio-political congregation between the different leading groups in the region.[491] Returning to the amphora at Segesta, interpreted as a gift given between elites, but what was the political or economic purpose for such a gift. One could argue that the gift giving was part of seeking trade permission to operate in Elymian territory. However, there is to this date no literary or archaeological evidence that Phoenicians were controlling the trade to the inner landscapes of western Sicily around this time. Another important question is, why assume that the Phoenicians would come with (only) semi-luxury goods such as olive oil or wine to the Elymians, when the Phoenicians were famous for their luxury products, such as silver, gold and other valuables? Commercial goods as such are very rare if not absent in most indigenous western Sicilian societies. One can argue that they brought their luxury products with them, when they abandoned their settlements, as most of the indigenous inhabitants did by the turn of the sixth century BC.[492] However, at Monte Polizzo, personal ornaments such as

483 Morris 1986, 2; Gregory 1982; 1984.
484 Aubet 2001; Von Alfen 2015.
485 Aubet 2001, 55; Peacock 2011, 11; Van Alfen 2015, 9.
486 Nijboer 2012.
487 De Cesare 2020.
488 De Cesare 2020, 370.
489 Tusa 1982 for Malophoros; See also Marconi *et al.* 2015, 324-338. for Phoenician, Etruscan, Greek and Elymian pottery in association to Temple R at the main unban sanctuary of Selinus.
490 Orsingher *et al.* 2020, 275.
491 De Cesare 2015, 310-313; Orsingher *et al.* 275.
492 Morris and Tusa, 2004, 78; Vassallo 2000, 983-1008.

fibulae, and other valuable objects were left behind.[493] These findings further support the idea that the Monte Polizzian abandoned their settlement due to some kind of catastrophe and not by choice.[494]

How do these ideas of an elite based gift giving society fit into the model of Monte Polizzo? By extension, was the Monte Polizzian trade organised by an elite? To approach these questions a short summary of the settlement's overall structure is in place.

Even though the settlement was not spatially organised according to any visible planning, many aspects confirm that it was organised according to some kind of societal structure. It was quite a large settlement with at least 2,000 inhabitants. An additional 1000 inhabitants might have lived at least partly in the surrounding hinterland. The economy was manly based on multi-cropping and husbandry. However, gypsum was a possible product for export, such as surplus timber. More than 20 *pithoi* at the acropolis possibly served as a communal storage for grains before it was transformed into a dump for sacral waste. In addition, all excavated domestic areas had large storage vessels.[495] House 5 is interpreted as a communal production centre. Analyses of the archaeological material suggest that the wool production was divided between several actors both in the settlement and in the rural surrounding.[496] The wool production was organised in a large scale and perhaps for commercial purposes. The local pottery production is not discussed in this work. However, it is important in this context to highlight that the settlement had a large-scale pottery production. Kolb and Speakerman suggest that Monte Polizzo was one of the main distribution centres of grey ware ceramics in the region, which further point to a centralised organisation of production and redistribution.[497] Other important functions in need of centralised organisation were infrastructure, managing of communal dumps, quarrying, water management and the ritual organisations around acropolis.

It is a discrepancy between the houses in the habitation area regarding their sizes and the volume of archaeological material. House 1 is not only the largest; it contained the highest number of artefacts in almost all categories, such as personal items, communal drinking vessels and tableware assemblages. It also had the largest number of imports, transport amphorae excluded.The find contexts of the Phoenician amphorae at Monte Polizzo differ significantly from the sacral contexts of Segesta and Selinus. The meaning of a pot do change depending on context.[498] There are no indication that the Phoenician amphorae were in any way considered more valuable, compared to the other amphorae found in both domestic and sacral contexts in the settlement, as discussed in previous chapter. Based on the archaeology, House 1 is the wealthiest house excavated to this date.[499] Wealth is here defined by the capacity of grain storage hence production capacity, and variation of imported goods. The latter category is not defining wealth by the specific products *per se*, but for the trading network, they imply.[500] If the inhabitants regarded the Phoenician amphorae with the specific connotation of a prestige gift, they would all been found in House 1, or in the round domestic sanctuary in House 3. House 1 did contain one Phoenician amphorae out of eight in total. The specific find spot for the Phoenician amphora was in the storage area together with storage vessels and two Etruscan and one Corinthian amphorae. In House 2, one Phoenician amphorae was found in a context of seven other amphorae of various origin. Further, outside the main habitation area Phoenician or Punic amphorae were found in the storage area of zone D at the acropolis. The evenly distributed transport amphora – and imported fine ware- among the different contexts at Monte Polizzo

493 Mühlenbock 2008.
494 Gumerman 1988.
495 Mühlenbock 2008.
496 Mühlenbock *in press.*
497 Kolb and Speakerman 2005; Brorson 2007; Mühlenbock 2008, 172.
498 Mühlenbock 2008, 97; Osborne 2001, 280.
499 Mühlenbock *in press.*
500 Mühlenbock 2008, 171; Smith 1987, 320.

reveals that most inhabitants had access to foreign gods such as amphorae and drinking cups.

Another important aspect regarding settlement organisation, raised by Ferrer, is the evident bond between the household practices and ritual activities at Monte Polizzo acropolis.[501] This is based on 67 *pignatte,* local cooking pots, found at the sanctuary. These *pignatte* are of the same type and size (13-40 cm in diameter), as those found in the domestic areas. They were designed for slow cooking such as cereal porridges. This type of food was probably the base of a daily diet. Ferrer suggests that the same women (or men) that cooked these meals in their households brought the same pots to the acropolis with meals later shared at communal events and ceremonies.[502] This idea is further straightened by the evidence of at least 27 *pignatte* found in House 1, which suggest that the household had resources to share food for communal meals.[503] In addition, the same types of faunal remains were present at both House 1 and at the acropolis, as discussed in Chapter 7. This indicate that the offerings were shared between the sanctuary and the households. Women, wine, meat, porridges, men, households, and rituals were all closely interlinked. This view does not neglect a social or economic hierarchy. Instead, it shows that the agency of the local population was more multifaceted than restricted to male elite, submitting to a gift giving system.[504]

The local agency is also evident in regards to power and wealth within the community. Imported goods are often associated to exclusiveness, and to the higher stratum of a society. At Monte Polizzo other objects are attached to the concept of gifts, power and wealth. The Monte Polizzians valued things acquired from a different type of exchange that was performed outside the boundaries of direct trade, and beyond the influences of other people.[505] Mühlenbock argues that some objects that at one time circulated in ancient trade networks, were charged with a life history of their own, and became subjects of inalienable wealth.[506] In this society, the object was a Neolithic-Early Bronze Age stone axe found in House 1, and two smaller similar axes found at Portella Sant' Anna. The owner of such an old object was believed to be given prestige and power transmitted from past owners, sensu Gell. The object's life, filled with histories of ancestors and mythological events become part of the owner's identity and thus power.[507] The *capeduncola* is another object that can be regarded in a similarly fashion.

The keeping of traditions and activities once performed in the past is an evident practice at Monte Polizzo. As discussed earlier in this work, the round structures associated to ritual practise in House 3 and at the acropolis, the sacred sealed pits, and the incised grey ware pottery, all show of important active links to earlier indigenous societies and practices.

In sum, based on the archaeological material at Monte Polizzo it is evident that there were different levels of economic resources among the houses. There are no evidence of artefacts typically associated to gift giving of prestige goods given by others outside their own community. Based on the archaeology only, it is not possible to either confirm or refuse the idea of an elite based settlement organisation. It is evident that they had well-functioning structure regarding the actions of everyday life.[508] The large number of imported transport amphorae found in a domestic context is rare, for a settlement of such a short period of habitation. Based on the evidence at hand, that all excavated houses had access to imported goods –especially Etruscan transport amphorae, I suggest that trade was probably a large part of their economy. I suggest further that this settlement had a trade-based organisation, and was involved in different local and regional networks. The last part of

501 Ferrer, 2016, 910; Mühlenbock 2008, 85.
502 Ferrer 2016, 910.
503 Mühlenbock 2008, 87.
504 Ferrer 2016, 916.
505 Mühlenbock 2008, 180; Bohannan and Bohannan 1968.
506 Mühlenbock 2008, 80; Mauss 1990; Appadurai 1986.
507 Mühlenbock 2008, 180; Weiner 1985, 210.
508 See Lancaster 2017 for architectural energetics and econometric calculations on eastern "Greek" Sicily; see also Fitzjohn 2013 for similar discussion at Megara Hyblaea.

this chapter will discuss what possible trade networks and venues were accessible to the Monte Polizzians, and different perspective of how to approach archaeological material indicative for trade.

Tracing the trade routes

Can complied archaeological material from various settlements be used to trace a product's journey from one site to another? In a "global" perspective, examinations of comparable material culture from various sites across the Mediterranean can lead to an understanding of links between 'nodes' or sites.[509] Based on the quantity of similar items found in different locations, connections can be drawn between them. The higher number of shared artefacts the closer affiliated and stronger the attraction between the two nodes.[510] In such studies, possible trade routes can be identified between settlements. In a regional or local perspective with fewer nodes, it can be more difficult to detect trade patterns and distribution routes. In the geographical context chosen for this work, with a focus on only one inland settlement 'connected' to two others facing the Mediterranean, a comparison between their material cultures would not necessarily suffice to identify through which gateway the inhabitants at Monte Polizzo acquired their imported goods.

There were many possibilities for the indigenous populations to acquire products from the Mediterranean market. Regarding the earliest Greek trade, with Corinthian A amphorae as an example, Albanese Procelli suggests that is was conducted through a direct link between the 'motherland' and its 'colony', during the seventh century.[511] These types of transport amphorae found in the inner landscapes, were thus according to that model distributed directly through the Greek settlements. This is in line with a general assumption that the Greek and Phoenician coastal settlements would serve as intermediators between the pan Mediterranean traders and the indigenous populations, as the latter did not supposedly have their own direct link to production centres across the Mediterranean.

The transport amphorae found in Selinus at the archaic shopping street of the agora, show of some similarity in the variety of types found at Monte Polizzo that could support the idea that Monte Polizzian merchants went to Selinus for Mediterranean goods. In a particular building, interpreted as a room in a shop or a warehouse, sixteen well-preserved transport amphorae and one indigenous storage vessel were found.[512] Stored in a row, the amphorae were of various production centres, as Corinth, Samos, Chios, Miletus, and six examples can be connected to the Western Greek- Sicilian production, all dated to the first half to the middle of the sixth century. The local storage vessel probably reached Selinus from the Sicilian hinterland.[513] In the same context, additional 21 fragmented transport amphorae were found. Ten of these were Corinthian type A1, one Attic á la brosse, four from Miletus and one possibly Clazomenae, five of Western Greek-Sicilian production, and one origin undetermined.[514] Neither Etruscan nor Phoenician transport amphorae were present in the material, which can indicate that these types were distributed through other channels. It has been attested above that the Phoenician early types were not in a wider circulation, but what about the Etruscan amphorae? At such a location, even though the Greeks might have preferred their own products, one supposes that a variety of contemporary amphorae accessible to the Sicilian market would be present.[515] A similar situation is evident in Motya, where little is known of the Etruscan transport amphorae of these early types.[516]

509 Malkin 2011.
510 Malkin 2011; See also Arthur *et al.* 2018 for "affiliation network".
511 Albanese Procelli 1996.
512 Dehl von-Keanel, 2003, 438.
513 Dehl von-Keanel, 2003, 440; See Vassallo 1991, 102., for example of the indigenous storage vessel no 115,116.
514 Dehl von-Keanel, 2003, 41. Se note 176 for comment on Etruscan amphora. This variability correspond with the amphorae found in the habitation area at the Manuzza Hill, although Punic amphorae of later kind is also added to the assemblage; Adorno *et al.* 2016, 75.
515 Dhel-von Kaenel 2003, 442.
516 Py types 1/2 and 3 produced during the last quarter of the seventh century, Albanese Procelli, 2004, 298.

Contrary to these settlements, at Monte Polizzo, 11 Etruscan amphorae were found in Houses 1-5. In addition, numerous Etruscan amphorae are present across the settlement in every excavated context. It is evident that the content of this amphora type was widely appreciated by the inhabitants. I am assuming a general original content of wine, although other content should not be excluded, with regards to the Giglio wreck discussed in the previous chapter.

The presence of Etruscan products in Sicily in the seventh and sixth centuries demonstrate the existence of trade links between the two areas. This link is most evident in the fine ware material. There are, for instance, a number of *bucchero kantharoi* found mainly in Greek funerary contexts such as Himera, Megara Hyblaea, and Selinus.[517] The contexts of *kantharoi* in Selinus, however, show that the usage of these vessels differs to what is generally attested in 'Greek' Sicily, where they are most commonly represented in the funeral sphere. In Selinus, in addition to funerary contexts, they are found in association of the Malophoros sanctuary and Temple R. Since *kantharoi* have deep connotations with wine consumption, they probably had a particular significance in votive offerings.[518] Access to Etruscan goods must have been the same, if not better, for the Phoenicians whose relationship with the Etruscans goes back to the late ninth and eighth centuries.[519] Yet only a few Etruscan *kantharo*i were found in the Phoenician/Punic settlements of Marsala, Panormus, Solunto, and Motya. *Kantharoi* were also found to a lesser extent in the indigenous sites of Colle Madore, Monte Castellazzo di Poggioreale, and Monte Iato.[520] Etruscan *bucchero* presumably reached Sicily in the company of Etruscan wine amphorae.[521] However, evidence of Etruscan transport amphorae and fine ware is generally scarce compared to the Greek products. At Megara Hyblaea, for example, 200 vases of Etruscan *bucchero* were found. Compared to the 2,000 Attic and the 17,000 Corinthian vases from the same site, it is a small number.[522] At Camarina, in the presence of hundreds of various Greek transport amphorae, the 20 or so Etruscan transport amphorae in the assemblage were definitely in the minority.[523] Similarly, in Himera necropolis, the Etruscan amphorae represent only six percent (four percent in Camarina) of the total amphora assemblage, even though the settlement is located in the trade orbit of the lower Tyrrhenian Sea.[524] These amphorae range chronologically from the beginning of the sixth to the second half of the fifth century BC, a period during which Etruscan trade to Sicily apparently diminished greatly.[525] The relatively modest quantity of Etruscan wares suggests a small-scale—compared to the Etruscan trade to southern Gaul for instance—yet long-term interest of Etruscan products from the Sicilian market. The venues through which Etruscan trade was executed is difficult to establish.

A single Etruscan amphora was found among 21 Greek amphorae in the Corinthian shipwreck of Punta Braccetto (Ragusa) dated to the first half of the sixth century BC.[526] Albanese Procelli suggests that it might therefore be possible that traffic in Etruscan goods was controlled by the Greeks.[527] It has also been suggested that Phoenicians or Greeks returning from Etruria brought products *back* to

517 Gras 1985, 497.
518 Marconi *et al.* 2015, 330.
519 Nijboer 2017, 909; Trade and exchange between Etruscan, Euboean and Phoenician merchants even led to the adoption of the alphabet and to the usage of specific metrological units. An illustration of this is the metrological units found in the Giglio wreck, see Bound 1991 for excavation details.
520 Albanese Procelli 2017, 1658; See Dehl-von Kaenel 1995, for publication of the Demeter Malophoros sanctuary; Vassallo 1999, for two bucchero kantharos fragments from Colle Madore dated to the second half of the 6th century BC; Isler 2004; and Kistler and Mohr 2016 for the kantharos at Monte Iato.
521 Albanese Procelli 2016, 1659.
522 Gras 1985, 527; Vallet and Villard 1964.
523 Gras 1985 529; Pelagatti 1978; Albanese Procelli 1996.
524 Albanese Procelli 2017, 1661; Vassallo 1999b, 358.
525 Pelagatti 1976-77, 525-526, tav. LXXVII 1-5; Albanese Procelli 2017, 1660.
526 Di Stefano 1993-1994, 118. The Etruscan amphora was of type 3b Py/EMC Gras.
527 Albanese Procelli 2017, 1661.

Sicily.[528] However, other networks could have taken part in the distribution of Etruscan amphorae. In Phoenician settlements of southern Iberia, Aubet suggests that a profound reconstruction of the trade network occurred during the late seventh and early sixth centuries BC.[529] This is evident by the increase of homogenous assemblages of East Aegean products in circulation, both in Phoenician and indigenous Iberian settlements. These assemblages generally contain amphorae from Chios and Samos, *hydrae* from Samos, Ionian cups and so-called "bird bowls". Interestingly, the find contexts of these Ionian products were strongly associated with Etruscan goods, such as transport amphorae, *bucchero kantharoi,* and *oinochoai.* In the indigenous settlement of Huelva and the Phoenician Cerro del Villar (Mainake), Etruscan and Eastern Greek pottery was located in a concentration to one particular zone in respective harbour areas. This suggests the goods had not yet been circulated at the site, that they were stored for future distribution.[530] It may also indicate that the Eastern Greek and Etruscan products arrived in the same shipment. The same import pattern is evident in other settlements in Iberia, such as at Malaka, Toscanos, and Ibiza but also, for instance, at Carthage, Palermo, and Solunto. Motya has not been highlighted among the settlements fitting this pattern.[531]

Aubet suggests that this was a reciprocal affair between Etruscans and East Aegean merchants. Etruscan pottery of significant quantities, *bucchero* in particular, has been found at both Miletus and Heraion of Samos, further strengthening this idea of a joint endeavour.[532] The Phoenicians were clearly part of the Etruscan-East Aegean commerce. Prestige goods from the Gadir (founded by Tyre) production area excavated at Heraion of Samos further point to Phoenician involvement.[533]

Shipwrecks and network activities

In the context of this discussion, shipwrecks can offer additional knowledge of trade connections. Their cargo is often used as an ideal resource for the discussion of network activity.[534] One interesting wreck that will serve as an example of the complexity in understanding archaic overseas trade pattern is the sixth century Pointe Lequin 1A wreck discovered in 1985 off the coast near Marseilles.[535] The wreck is dated to the late sixth century, so it is possibly beyond the timeframe of this work but certainly relevant to the immediate discussion. The cargo contained transport amphorae from Miletus, Samos, Chios, Clazomenae, Lesbos, the northern Aegean, Athens, Corinth and Corcyra, Massalia, and Etruria. In addition, it contained about 1,500 Ionian cups and more than 700 black-figure Athenian cups. If one hypothetically regard fine ware only, the ship's voyage was perhaps, as Green proposes, originating from an east Greek port, such as Phocaea the mother city of Massalia, with a destination of Athens via Massalia where the ship sank. However, if one adds the amphorae deriving from multiple manufacturing origins, the evidence suggests a longer journey with stops at multiple ports.[536]

There are two generally accepted models of ancient overseas trade pattern. The first is the idea of ancient Mediterranean trade conducted by an absolute predominance of *commerce en droiture,* direct sailing on the open sea. Trade was conducted at a particular destination and the ship returned to its starting point. This idea was referenced above by Albanese Procelli regarding the direct trade of the early Corinthian type A amphorae to the Greek Sicilian settlements.[537] The second model is that of cabotage and tramping.[538] These two concepts are every so often assimilated to a third model where the idea of

528 Micozzi 2017, 936; Albanese Procelli 2001.
529 Aubet 2007, 448.
530 Aubet 2007, 450; Aubet *et al.* 1999.
531 Aubet 2007, 453; For Malaka see Gran Aymerich 1991; Toscanos see Arteaga 1988; Carthage see Docter 2001; Ibiza see Costa and Gomez Bellard 1991; Palermo see Merra 1998; and Solunto see Tardo 1997.
532 Aubet 2007, 457-8.
533 Aubet 2007, 458; Freyer-Schauenburg 1966, 104-110.
534 Green 2018, 132.
535 Excavated from 1986 to 1993. Long, Miro, and Volpe 1992; Krotscheck 2008, 2015.
536 Green 2018, 135.
537 Arnaud 2011, 61; McCormick 2001; Albanese Procelli 1996.
538 Casson 1971; Horden and Purcell 2000.

direct open sea sailing is combined with coastal sailing as a secondary step in the overseas exchange network.[539]

The Mediterranean Sea, however, was not particularly suited for *commerce en droiture*. It has been suggested that a day's sailing distance during antiquity had a limit of about 600-700 stades, or approximately 105-125 kilometres.[540] It was not only trade possibilities that determined these routes. Prevailing seasonal winds were the most important factor to consider in overseas sailing, since they were both the strongest and the most reliable during the sailing season. However, other environmental factors had to be considered. Storms, currents, and other hazardous phenomenon as well as the difficulty of returning in contrasting winds were all factors that challenged ancient sailors.[541]

In contrast, the most secure route was from cape to cape, *capotage* (used in eighteen-century French sailing vocabulary with the direct meaning of sailing from cape to cape).[542] Any cross sailing that did occur was probably combined with *grand cabotage*, 'international' coastal commerce, and started and finished with c*abotage*, commerce along 'national' coasts.[543] Evidence of these kind of journeys is often visible in cargoes, as in the Giglio wreck, the shipwreck of Punta Braccetto, or the Pointe Lequin 1A wreck off the coast of Massalia, presented above.

Analyses of the cargo of the latter ship offer an additional spin on the discussion of network pattern and voyages. Chemical analyses of the Ionian B2 cups consignment from Pointe Lequin 1A, suggest that they were produced in Sicily or southern Italy, rather than in production centres from the East Aegean. The analysis showed that even the comparative material consisting of Ionic B2 cups from Massalia, Emporion, (a 'colony' of Massalia in the northeast coast of Spain), and a sixth century shipwreck Cala Sant Vicenç outside Mallorca, all were produced at the same centres in Sicily or southern Italy. [544] The question one must ask with this information at hand is if the Pointe Lequin 1A ship ever sailed as far as to the eastern Aegean?

With this in mind, it seems necessary to return to the Etruscan-Eastern Greek-Phoenician network proposed by Aubet.[545] There is of course a significant time discrepancy of about 70-100 years between her "long-distance" trade network and the Italic trade centres suggested by Green based on the origins of the "Ionian" cups just discussed. It is however plausible that the "Etruscan-Eastern Greek-Phoenician trade network" was based in southern Italy. The Etruscans, for instance, expanded into southern Italy as far as the coastal strip near Salerno during the ninth century, with its centre at Pontecagnano. During the middle of the eighth century, Etruscan, Greek, and Phoenician networks merged into a joint trade and exchange a system at Pithecusae, which became a centre for commerce in the region. Thus, trade networks between the Eastern Mediterranean and Tyrrhenian Sea, with its centre at Pithecusae, were already established. Along with these developments and the emergence of Greek settlements on the Campanian coast, an integrated cultural and economic system evolved. [546] This could have facilitated larger ports along the southern Italic coast, serving as major network hubs providing possibilities for traders arriving from various places in the Mediterranean to open new venues to sell their goods.[547] It is possible that the "long-distance" network actually was a shorter distance network, with particular cargoes suited after a specific homogenous demand from the Phoenician settlements along the Iberian coast or various settlement in Sicily. There is however nothing that contradicts the

539 Arnaud 2011, 61.

540 Arnaud 2005, 74-87; Leidwagner 2013, 3302; Broodbank 2000, 345.

541 Leidwagner 2013, 3303-3304; Morton 2001, 51-53.

542 Arnaud 2011, 62.

543 Arnaud 2011, 62.

544 Krotscheck *et al.* 2009.

545 Aubet 2007.

546 Cinquantaquattro and Pellegrino 2017, 1360-1394. The Etruscan political and cultural hegemony is evident due to the broad diffusion of bucchero and the Etruscan language in this region until the turn of the fifth century BC; For Pithecusae see Buchner *et al.* 1961.

547 Green 2018, 135; See also Arnaud 2005.

possibility that these two system were active simultaneously during the Archaic period.

Western Sicilian gateways

How do these different networks and sailing routes effect the inlet of goods to western Sicily in general and to Monte Polizzo specifically? If one regards the archaeological material only, it is not convincing that either Motya or Selinus served as distribution centres for the Etruscan amphorae in the western region during the turn of the seventh century. Instead, one could argue that the archaeological evidence suggests that Monte Polizzo was the main node for Etruscan wine import in this part of the island during this period. All the different amphorae in the Monte Polizzo assemblage, with origins spanning across the entire Mediterranean, clearly suggest that the inhabitants favoured products shipped from centres along any of the trade axes just discussed.[548]

Seeing beyond the Greek and Phoenician settlements and their markets, there are several other possibilities by which Mediterranean trade goods could reach the interior.[549] One of the main questions in this work was to assess river navigability of rivers draining Monte Polizzo and, in effect, the possibilities of connectivity and movement they might have offered the Monte Polizzians. Not only could the inhabitants use the rivers to transport themselves and their goods, but rivers also offered avenues for trades beyond the control of institutions or settlements we know of.

It is, for instance, possible that already during the seventh and sixth centuries the outlet of the River Caldo in modern Castellamare del Golfo could have been used as harbour for Segesta. This would open the possibility that the Elymians at both Segesta and Monte Polizzo had direct access to the lower Tyrrhenian trade circuit. Harbour or not, on the river or in association to the river, they could surely have gotten access to these goods through the 'proletarians of the sea', as Braudel called the caboteurs.[550] They sold their services cheaply, loaded their small tonnages, and "were off at the first puff of wind".[551] The scarcity of amphorae at Segesta does not necessarily indicate that the supply for imported goods was low or that they did not have access to trade markets –which they very well did have by the river. Contrary to Monte Polizzo, it might as well be what Albanese Procelli suggested above: that there was yet no particular demand among the inhabitants for such products.[552] Wine might actually have been a product only used in ceremonial contexts during the turn of the seventh century, as just discussed. This shows that different indigenous settlements in the region did not respond identically to pan-Mediterranean economic influences and should therefore not be regarded as one indigenous unit.

In addition to the northern Mediterranean gateway through the Caldo estuary, there are at least two other important trade venues for Monte Polizzo on the western part of the island that must be considered. Mazaro and Arena Délia Grande Rivers could provide direct access between the Elymians and overseas traders. The Mazaro's anomalous morphology, presented in Chapter 5, established that this river could not have been used to reach the inner landscapes. There are other functions for a river than to transport people and goods. When searching for possible links to the Mediterranean trade, a river's estuary is essential. The Mazaro's estuary was about 3.5 kilometres long. It was wide and deep and could provide excellent shelter for ships. Harbouring ships was thus the main advantage of this location. Merchants could load and unload their products buyers or sellers arriving by terrestrial routes or by smaller vessels. This location is therefore an optimal venue for large-scale and small-scale trade and exchange in the western region.

Arena Délia Grande is located to the south of Mazaro. This river must have been important to the Monte Polizzians given the fact that they could navigate from Monte Polizzo to the western coast during the winter

548 Except for Athenian products that are nearly absent. However, the Athenian fine ware are usually present at sites that have a longer chronology.
549 See Hodges 1988 42-52, for gateway settlements.
550 Braudel, 1972, 296.
551 Braudel, 1972, 296.
552 Amphorae as semi-luxury products, see Foxhall 1998, 207.

months. In the middle reach, where the Trinitá reservoir now is located, the river was wide and deep enough for smaller vessels to dock for loading and unloading. This could have been for the site of a small trading station controlled by the Monte Polizzians. By this river, they could transport surplus foodstuffs produced during summer and autumn. One important product that has not been given much space in this work is timber. The autumn months were the best period for felling and seasoning timber.[553] Seasoning timber may take many months to years, depending on climate.[554] The transport possibilities on the Arena Délia Grande during the winter months made it possible to float the newly felled timber to a desired location along the river or down to the estuary.

The fact that the river's navigability was limited to the winter months should not be seen as obstacle for trade and exchange. Coastal sailing and trading from port to port could be conducted year round using smaller vessels, about 10-12 m in length, the same size of the vessel used in this study for the assessment of river navigability. [555] In the Archaic period, the Arena estuary reached 2.7 kilometres up the river. However, there may have been extensive lagoonal areas behind the river's bar. These lagoons could offer shelter for larger ships, while the smaller vessels sailed up the river, either loaded with various goods or emptied to collect goods arriving on the river from the inner landscapes.

While long-distant trade on the "open sea" was restricted to certain months of the year (April to November),[556] docking ships in the Mazaro estuary or near warehouses in the surrounding "harbour" area could very well have been used as long-term storage for overseas products. The caboteurs or capoteurs could then stand for the supply to the demands from various peoples along the coast and on navigable rivers over a longer period of time. The inhabitants of Monte Polizzo were therefore not restricted to acquiring trade goods through the markets of Selinus or Motya. In fact, it is plausible that at least the Mazaro served as the main node for all settlements in the western region. For instance, both Modione and Cotone Rivers—the latter supposedly served as harbour to Selinus—had drainage problems at times.[557] Perhaps so much so that the estuary could not accommodate larger ships. During the fifth century, the Mazaro estuary was a trading station and according to Diodorus Siculus under the control of Selinus (Diod.Sic.13.54.). However, during the turn of seventh century and during the first half of the sixth, it might have been evolving to a place for trade and exchange conducted and balanced with power of the middle ground.

In this chapter, two main topics have been stressed. The first was different ideas about indigenous settlement organisation. Some relevant structural settings were emphasised in order to understand Monte Polizzo and its role in a wider trade network. At Monte Polizzo, most inhabitants had access to imported goods such as amphorae and drinking cups. Scholars tend to assume that the transport amphorae were brought to the indigenous settlements by others. To date, no objects found at Monte Polizzo support a theory of a gift-giving system between elites. Although this pattern can not be demonstrated, an elite-based organisation can not be rejected.

The second topic was both global and regional trade networks. This discussion was based primarily on archaeological material and the ideas of Mediterranean long-distance and short-distance networks. Shipwrecks were used as examples of how trade actually could have been organised in a wider Mediterranean context. The Greek and Phoenician settlements were evaluated as possible gateways for imported goods. The final section discussed the possible physical trade routes available for the Monte Polizzians, in terms of river navigability, as well as how the estuaries could have served as nodes for regional networks.

553 Hes. *WD* 414-20; Lancaster 2017, 72.
554 Lancaster 2017, 72; Adam 2013, 91.
555 Knapp and Demesticha 2017, 10.
556 Knapp and Demesticha 2017, 10.
557 Mazza 2016, 184.

CHAPTER 10

General conclusions

The overall aim of this thesis was to deepen our knowledge about indigenous western Sicilians commonly called the Elymians and, ultimately, to recognise them as independent actors in Sicilian history. The first step on this path was to balance representations of various ancient peoples and their actions. The theoretical approaches applied--White's concept of the middle ground—brought the focus to how peoples in the region interacted. This approach bypassed Greco-centric discourse in favour of approaching the archaeological record from the Elymian perspective. The Monte Polizzians' role in the regional trade system was thus emphasised, as well as an evaluation of the opportunities and challenges to subsistence faced by inhabitants of the settlement. A holistic theory about nature-human interaction and the functions of various subsystems implemented in the settlement structure was applied. An important factor here was understanding in full the environmental complexity of the site and its surroundings. The methodology used to address this compiled available palynological and geomorphological information. In order to understand the significance of and navigational possibilities of the rivers draining Monte Polizzo, a geomorphological river assessment was also commissioned.

Secondly, I evaluated the imported archaeological material found at the site--with specific regards to faunal and palaeobotanical analyses--as well as imported transport amphorae. The significance of the Monte Polizzo amphorae assemblage was compared in quantity and variety to other indigenous settlements in the region in order to understand the trade network in a wider Mediterranean context. This included gateways through which the Monte Polizzians acquired imported products. The analyses of faunal and palaeobotanical remains helped answer questions about the local economy and what products the Elymians offered in return to trade markets.

Monte Polizzo occupies a strategic position in the landscape. Its location in between Segesta, Motya, and Selinus offers an excellent vantage point. Four rivers run down the mountain, each flowing in a different direction. The adjoining river valleys were used for agriculture, as pastures, and short distance transhumance. I concluded that the inhabitants initially had enough land for the settlements to subsist within a radius of about 5-10 kilometres.

The Monte Polizzians were engaged in a multi-cropping system to secure subsistence if environmental changes occurred. This was established by macrobotanical findings of wheat, emmer wheat and, with clear dominance, barley. Barley, as well as faba beans, is considered to be a crop resilient to both colder climates and nutrient-deficient soils, thus confirm this strategy. Wheat is best cultivated in the areas with nutrient- and humus-rich soils, such as the terra rossa blanketing the lower elevations and karstic area east of the mountain. Wheat was the less abundant crop in the domestic analyses. This might suggest that wheat was used in the trade with Selinus, for example. Analyses of the archaeological material further suggest that wool production was organised at a large scale, possibly for commercial purposes. A very interesting factor is that the Monte Polizzo area was rich in gypsum. Therefore is it logical to assume that the local population made gypsum plaster for trade.

An overall analysis of the archaeological material at Monte Polizzo shows there were different levels of economic resources in different domestic contexts. Nevertheless, the large number of imported transport amphorae from Etruria, Corinth, and Eastern Aegean production centres found in all the domestic and communal contexts suggest that trade was a vital part of this society.

It has been suggested by other scholars that the indigenous population acquired wine or olive oil as gifts from Greek of Phoenician elite. This work shows that the inhabitants of Monte Polizzo were not restricted to acquiring overseas goods through such gift exchange systems. The most evident example of the Monte Polizzian's active role in regional trade is the Etruscan amphorae. While this type was not particularly abundant in Sicily during this period, Etruscan amphorae were found in every domestic and communal context in the settlement. This indicates a trusted supplier from the Tyrrhenian circuit. It further suggests an active choice of product according to taste. The geomorphological study of the rivers draining the mountain shows that, during the winter months, the Arena Délia Grande River was navigable from the settlement to the southwestern coast. The Mazaro River, flowing west, and the Caldo River, flowing northeast passing Segesta towards the coast, were likely to be navigable as well. Based on this fact, it is evident that the Monte Polizzians were not limited to trading in the markets of Selinus or Motya. Instead, rivers were an important component in how they connected with overseas traders and other various networks. The Mazaro River, however, was not navigable due to geomorphological anomaly. It might however have had another important function since its estuary was large enough to have served as a node for trade in the western part of the island.

The fact that the rivers' navigability was limited to the winter months should not be understood as obstacle for trade and exchange. Late autumn was the best time to cut timber, which could have been easily transported down the rivers to waiting markets. The Monte Polizzians could connect with coastal sailors arriving from both the north and the south who provided for the demands from various peoples along the coasts and on navigable rivers. Such trade could be conducted all year round while long distant trade was dependent on prevailing winds.

This investigation has demonstrated that the Monte Polizzians exceeded the settlement's carrying capacity only in 75 years. This is based the on combined results of environmental studies exhibiting considerable ground on which to draw such a conclusion. For example: deforestation due to increasing need for timber, degraded soils due to pastoral activities, and a constant evolvement towards marshier landscapes and possibly, consequently, malaria. These factors combined to result in less land for agricultural and pastoral usage. The safe-fail system might not have been a strong enough strategy to maintain subsistence. The fire that ruined the settlement in 550 BC might have been just one catastrophe out of many long- and short-term environmental changes that caused the permanent abandonment of the area. If that was in fact the case, then this final blaze was not merely something that *happened to* the Monte Polizzians but an event that arose – like much else this work has shown – out of a complex of decisions made by an active and engaged people.

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Catalogue- Imported transport amphorae at Monte Polizzo

The transport amphorae repertoire on Monte Polizzo is quite extensive when it comes to variety of types. Regardless of the variety of methods and traditions used to analyse the enormous variants of transport amphorae and the places of their manufacturing and origin, it is evident that there is no absolute truth. This is highlighted in Dupont's recent article about East Aegean amphorae, where he overturns past, generally accepted, classification theories.[1] Both new and 'old' discussions and reservations regarding the different amphora types and their places of origin will be discussed in short. However, there are those amphorae which fit the descriptions of a specific group according to the general characterisations, or at least to the general area of provenance for example 'East Aegean' or 'Western Greek' according to the common model often used in Sicilian archaeology.[2] There are some amphorae, which will remain of uncertain provenance. There is also only one handle of an Attic SOS amphora, a type, which interestingly is one of the most widespread amphorae in the Mediterranean.

The minimum number of amphorae identified in the domestic areas of Houses 1 – 5 are 40. The transport amphorae found at the acropolis are not represented in this section. As described in Chapter 2, the different projects within the framework of SSAP were conducted independently, and the different documentations of finds were not shared, incorporated in a large database, or to this date published. However, the amphora information provided in the preliminary reports published by Stanford University will be included in the discussion.

In the following sections after the catalogue, an overview will be presented of the different provenance of the amphorae found in the Monte Polizzo assemblage from the habitation area House 1-5 which circulated the Mediterranean during the eight to the sixth centuries BC.

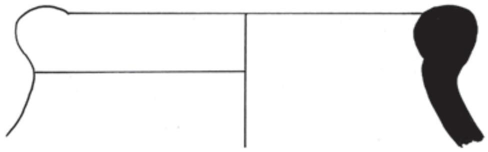
1 Dupont 2019.
2 Se for instance Albanese Procelli 1996; Vassallo 1999.

Transport Amphora Catalouge

Etruscan transport amphorae

Art. 43268

House 1 room VI
Rim fragment est. diameter: 13 cm
Munsell soil chart, colour surface: Pinkish grey, light brown to brown77.5YR 6/3-4, 5/3-4
Munsell core: 7.5YR 6/3-4, 5/3-4
Typology: The fragment is too small to determine type. Base on the chronological window probably PY 1/2 or 3A/ Gras EMA, EMC.
Date: In circulation from late 600 to 550/525 BC.
References: Py 1985, 74-78, fig 3 and 4; Gras 1985, 328-335, fig. 46b. Rizzo 1990.

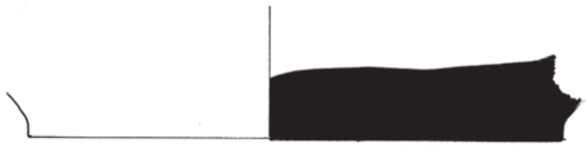


Art. 42243

House 1 room II
Round base
Munsell surface: Pinkish grey, light brown to brown7.5YR 6/3-4, 5/3-4
Munsell core: Brown to light brown 7.5YR 6/3-4, 5/3-4
Typology: Py probably 3A or 3B/ Gras EMC.
Date: Late 600 to 550/525 BC.
References: Py 1985, 74-78, fig 4 and 5; Gras 1985, 328-335, fig. 46b. Rizzo 1990.

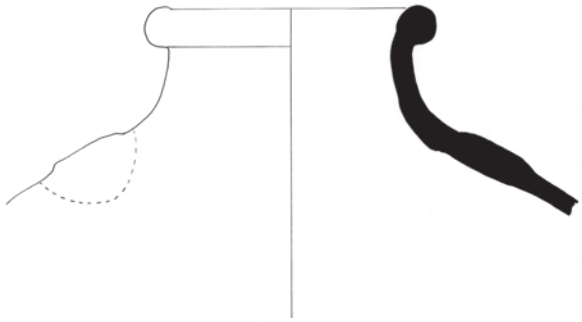
Art. 43333

House 1 room I
Flat base est. diameter: 19 cm
Munsell surface: Pinkish grey, light brown to brown7.5YR 6/3-4, 5/3-4
Munsell core: 7.5YR 6/3-4, 5/3-4
Typology: The larger diameter suggests that this could be an Etruscan amphora of type "Tolle" instead of PY: 1/2 and 5 groups of flat base transport amphora (Gras EMA). These containers are believed to have had the same function as transport amphorae. Traces of carbohydrates and pitch residue on the walls of some specimens, connects this type to a local production of wine. A commercial framework in the ancient Chiusi area appears evident.
Date: This amphora type was in circulation during the sixth century. B.C.
References: Paolucci, 2006, p.428 Fig. 3 anfora: tomba 251 di Tolle; Paolucci, 1992, fig. 5 anfora Chianciano T., Museo Civico Archeologico



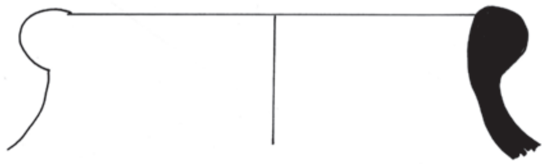
Art. 42789

House 1 room VI
Rim, ovoid-shaped body and handle (not attached and round in cross section) rim diameter: 13cm
Munsell surface: Light brown 7.5YR 6/3-4
Munsell core: Brown 7.5YR 5/3-4
Typology: Py probably 3A/ Gras EMC. In circulation from late 600 to 550/525 BC.
Date: Late 600-550/525 BC.
References: Py 1985, 74, fig 4, type 5; Gras 1985, 334, fig. 46a, type 6.



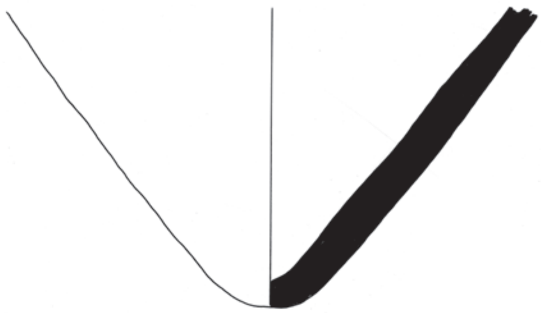
Art. 43644

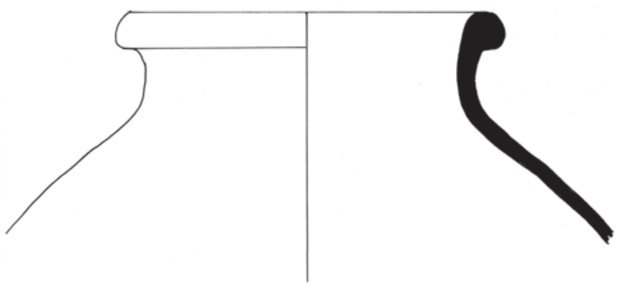
House 1 room I
Rim and handle fragments. Est. diameter rim: 14,5cm
Munsell surface and core: Dark reddish grey to dusky red 2.5YR 3/1-2.
Typology: The fragment is too small to determine type. Base on the chronological window probably PY 1/2 or 3A/ Gras EMA, EMC.
Date: Etruscan late 600- 550/520 BC.



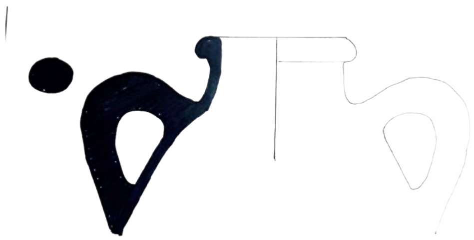
Art. 40804

House 3 room I
Complete round base and rim. Est. rim diameter: 13cm
Munsell surface: Reddish yellow, yellowish red 5YR 7/6, 6/6, 5/6
Munsell core: Brown 7.5YR 5/3, Grey 5YR 6/1-5/1
Typology: Py probably 3A, type 5/ Gras EMC based on the ovoid shape, the longer neck and round base.
Date: Etruscan late 600 to 550 BC
References: Py 1985, 74, fig 4, type 5; Gras 1985, 334, fig. 46a, type 6.





Art. 20179



House 4
Rim, handles, base. Est. rim diameter: 14cm
Munsell surface: Light brown 7.5YR 6/3-4
Munsell core: Brown 7.5YR 5/3-4
Typology: Py probably 3A, type 5/ Gras EMC based on the ovoid shape, the longer neck and round base.
Date: Etruscan late 600 to 550 BC

Art. 41327 (No illustration)

House 3 room I
Etruscan complete round base.
Munsell surface: Light brown to reddish yellow, 7.5YR 6/4-6/6, Strong brown to brown7.5YR 5/4-5/6
Munsell core: Dark reddish grey2.5 YR 3/1-2/1

Art. 41233 (No illustration)

House 3 room I
Rim and handles. Est. rim diameter: 12cm
Munsell surface: Light brown 7.5YR 6/3-4
Munsell core: Brown 7.5YR 5/3-4
Typology: Too small/short fragment to determine.

Art. 20018 (No illustration)

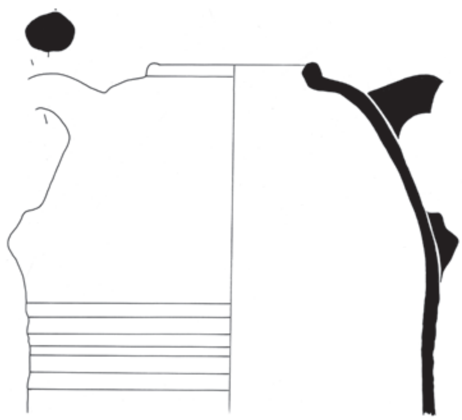
Rim est. diameter: 13 cm.
Munsell surface: Light brown 7.5YR 6/3-4
Munsell core: Brown 7.5YR 5/3-4
Typology: Too small/short fragment to determine.

Art. 20159

House 4
Rim, round handle and body sherds.
Munsell surface: Light brown 7.5YR 6/3-4
Munsell core: Brown 7.5YR 5/3-4
Typology: the round handle suggest Py type 3A, but fragments too small/short to determine.

Phoenician transport amphorae

Art. 42780

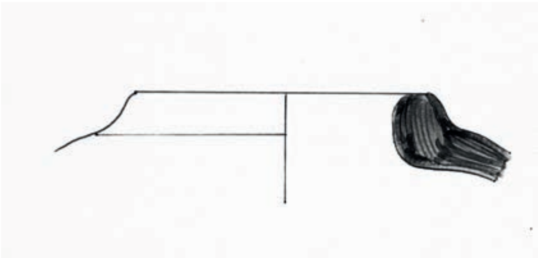


House 1 room VI
Rim diameter: 10,5cm
Rim and large part of body with part of handle attached. Short distance between rim and handle. Horizontal grooves on the body just below the lover part of handle. Vast amount of body sherds but no base,
Munsell surface: light reddish brown 2.5YR 7/4 to light red 10R 6/8
Munsell core: 2.5YR 7/4, 10R 6/8

Typology: Ramon Torres type T-2.1.1.2. Possibly Motyan production. See Ramon Torres 1995, 261 for discussion this type. See also p. 515 Fig 152 type 75 and p.516 fig 153 type 80
Date: Early sixth century BC.

Art. 40752

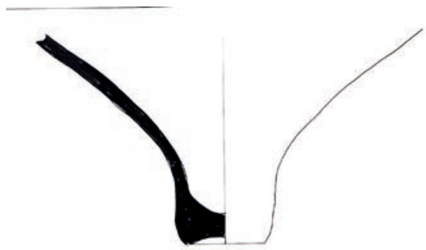
House 2 room II
Complete rim with two handles and part of body. The find has been exposed to fire, which makes it difficult to assess the exact colour scheme.
Munsell surface: 5YR 7/6 to 5YR 6/6
Munsell core: close to 5YR 7/8
Typology: Not possible to determine



Corinthian type A transport amphorae

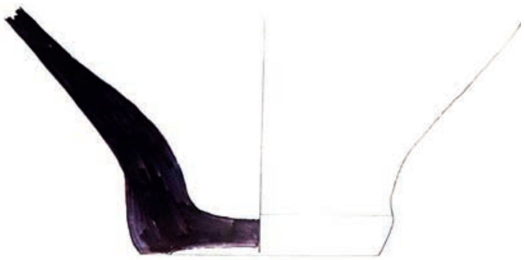
Art. 40885

House 3 room I
Complete base diameter: 7cm
Typology: During the sixth century, the shape of the Corinthian A changes gradually towards a more tapering body and a narrower base, as this example show.
Date: around the mid- 6th century BC.
Munsell surface: 10YR 8/5, 5YR 7/8, 7/6, 6/8
Munsell core: 7.5YR 7/1-7/4 5/2, 6/2
Reference: Koehler, 1981, 451, plate 98, d. C62-644, and e. C53-222; Brann 1956, 365. Plate 58 fig.59.



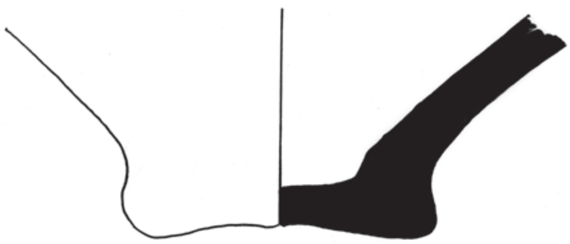
Art. 44562

House 3 room 1
Flat base with diameter: 10cm
Munsell surface: 7.5YR 8/2-3
Munsell core: 5YR 7/6,6/6. 7,5YR 8/2-3
Typology: Corinthian type A. Early type based on the spherical lower body and wide heavy base.
Date: Turn of the seventh century BC
References: Pelagatti 1976-1977, table. LXXVI, 1; Koehler, 1981, 451, plate 98, c. C62-644; Amyx and Lawrence, 1975, p 157-158, An 306.



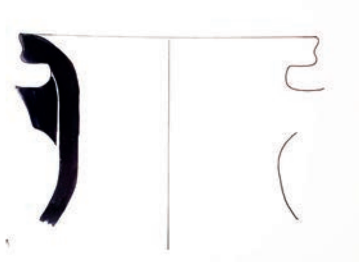
Art. 44131

House 3 room II
Base flat diameter: 8,5cm
Typology: Corinthian A. The base is slightly rounded but without the characteristic marking on the foot, possibly due to weathering. The vessel has been exposed to fire.
Munsell surface: 10YR 8/2, 7/1,7/2.
Munsell core: 10YR 7/2-3, 8/2
Date: First half of the sixth century BC



Reference: A similar type is found in Selinus, see Dehl- von Kaenel, 2003, 439, SL 19324 no. 26.

Art. 44671



House 3 room III
Rim fragment. Est. diameter: 12cm
Munsell surface and core: 7.5YR 8/4,7/4
Date: Second half of the 7th to first quarter of the 6th century BC.
Reference: Metaponto 2018;2, 890, PZ Amp 01; Albanese Procelli 2003, 48 Table I, 1. Koehler, 1981, 451, plate 98, c. C62-644.

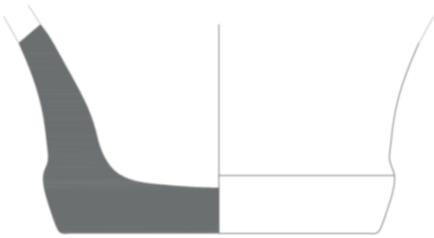
Art. 44164

House 3 room III
Base and a large part of the wall. Base diameter: 9cm
Munsell surface: 7.5YR 8/4, 7/4
Munsell core: 10YR 8/2, 7.5YR 8/4, 7/4
Date: first quarter of the 6th century BC.
Reference: Koehler, 1981, 451, plate 98, d. C-1977-12.

Art. 41320 (no illustration)

House 3 room I
Base est. diameter: 7cm
Munsell surface. 7.5YR 7/6
Munsell core: 2.5YR 4/1-5/1
Typology: Corinthian A.

Art. 45739

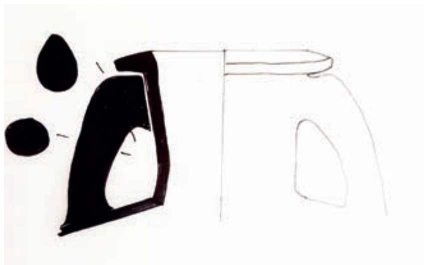


House 5 room 3
Base diameter: 10cm
Munsell surface and core: Yellow 10YR 8/6
Typology: Corinthian A

Art. 45920

House 5 room IV
Base diameter: 8cm
Munsell surface and core: Pink 7.5YR 7/4
Typology. Corinthian A

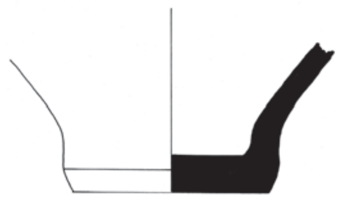
Art. 43787



House 2 room I
Rim, attached handle both on neck and body.
Munsell surface: 7.5YR 7/4, 7/6
Munsell core: 7.5YR 7/1, 6/1
Typology: Corinthian A, early type based on the slanting shape of the rim, and shape of the handles.
Date: first half of the 7th century.
References: Koehler, 1981, 451, plate 98, b; Pelagatti 1976-1977, table. LXXVI, 1; Rizzo 1990, 49-50 figs. 41, 344.

Art. 40506

House 2 room II
Flat base diameter: 8cm
Munsell surface: 7,5YR 8/3-4, 7/6,7/4.
Core: 7,5 YR 8/6,7/6,6/6.
Typology. Corinthian A

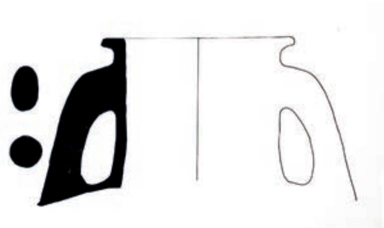


Art. 44987 (no illustration)

House 2 room II
Base flat. Diameter: 10cm
Munsell surface. 7.5YR 7/4 7/6
Munsell core: 7.5YR 7/4, 4/1, 3/1
Typology: Corinthian A

Art. 40682

House 2 room III
Rim, neck and handle. Rim diameter: 15cm
Munsell surface: 7.5YR 7/4, 7/6
Munsell core: 7.5YR 7/1, 6/1
Typology: Corinthian A with shorter leaner rim.
Date: mid- 6th century BC.
Reference: Koehler, 1981, 451, plate 98, e. C 53-222.



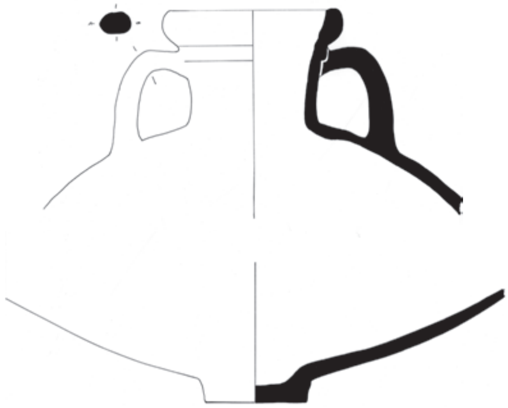
Corinthian type "B" and/or "Western Greek"

Art. 40490

House 2 room II
Rim with neck, handle and base. Est. diameter rim: 13cm; base 8cm
Munsell surface and core: 7.5YR 8/4, 7/6
Typology: Archaic Corinthian B type based on the rounded rim and the groove around the top of neck, flattened handles and beveled cap toe.
Date: earlier than 550 BC based on the archaeological context.
References: see below for discussion about this type.

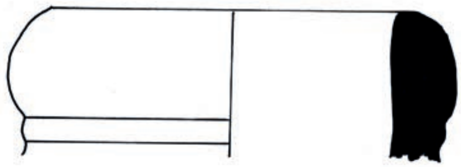
Art. 2265

House 1 room VI
Rim, neck with attached handles. Diameter: rim 12cm; base 8cm
Munsell surface core: very light brown 10YR 8/2-4
Typology: Corinthian type "B" based on the rounded rim and the groove around the top of neck and flattened handles. The unusual flat base with a very short 2 cm toe turns into an almost globular body. This might suggest another classification, but no other match has been found so far.
Date: earlier than 550 BC based on the archaeological context.



Art. 40668

House 3 room III
Rim est. diameter: 10cm
Munsell surface: 10YR 8/4, 2.5YR 8/4
Core: 10YR 7/3, 6/3-2, 8/3
Typology: Only one of this kind. Possibly of Western Greek origin. Unidentified.



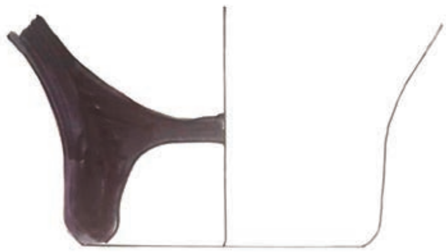
Eastern Greek transport amphorae

Art. 40119

House 2 room II
Base and large part of body. Diameter: 8cm
Munsell surface: Pale brown to brown. Probably exposed to fire in parts. 10YR 6/3, 5/3, 4/3
Munsell core: Dark grey 7.5YR 4/1
Typology: possibly of Lesbian origin.
Date: early to mid- 6th century
References: Dupont 1998, 156-157, fig.23.4,b; Whitbread 1995, 158; Pelagatti, 1976-1977, 525; table LXXVI, 13-15.

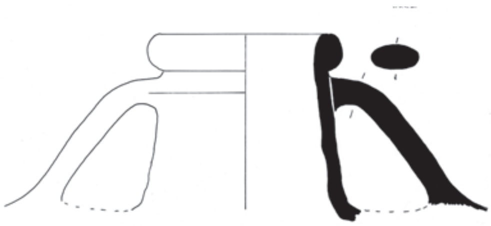
Art. 45004

House 2 room II
Hollow base diameter: 7,5cm
Munsell surface: 7.5YR 6/4, 6/6, 5/4, 5/6
Munsell core: 7.5YR 6/4, 6/6, 5/4,5 /6.
Typology: possibly Chian or Clazomenian based on the hollow ring foot.
Date: turn of the 7th century BC for Clazomenian type, or mid- 6th century BC for Chian type.
References: Dupont 1998, Clazomenian 151-153, fig. 23.3, b; Dupont 1998, Chian 146-151, fig. 23.2, a.



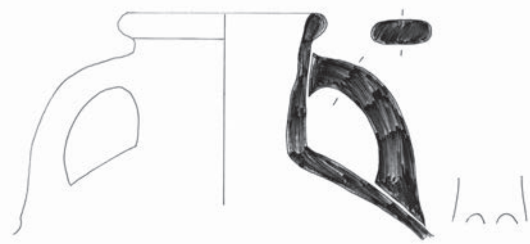
Art. 40542

House 2 room II
Rim, neck and handle. Diameter: 14cm
Munsell surface. 7.5YR 8/4, 10 YR 8/3
Munsell core: 7.5YR 8/4, 10 YR 8/3
Typology: East Greek, possibly Parian based on the inwards slanting neck and the flattened handles.
Date: 645-550 BC. The reference from Cartage is dated to 645-630 BC
Reference: Bechtold and Docter 2010, 113, fig 6: 13; Docter 2007, 661 fig. 361.



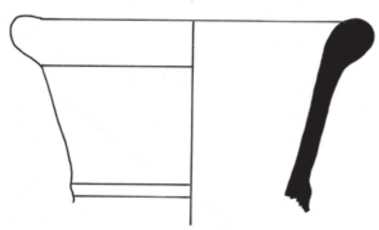
Art. 40343

House 2 room II
Rim, neck and handle. Est. diameter: 12cm
Munsell surface and core: Light red 2,5 YR 7/8, 10R 6/6.
Typology: East Greek. Possibly Chian or Clazomenian based on the shape of the rim, neck and handles.
Date: Chian - Second half of the 7th century BC. Clazomenian-turn of the 7th century to the first quarter of the 6th century BC.



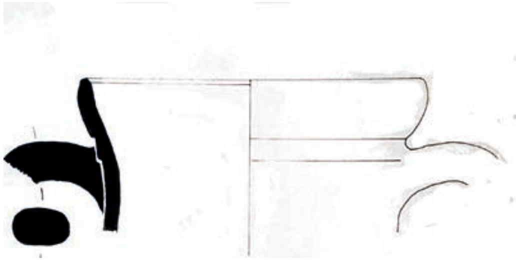
References: Dupont 1998, Clazomenian 151-153, fig. 23.3, a, b; Dupont 1998, Chian 146-151, fig. 23.2, a; Rizzo 1990, 56 fig 55. See also Johnston 1990, 47-48 fig. 7: 99, 105, for examples classified as East Greek with fingermarks at the lower join.

Art. 44684



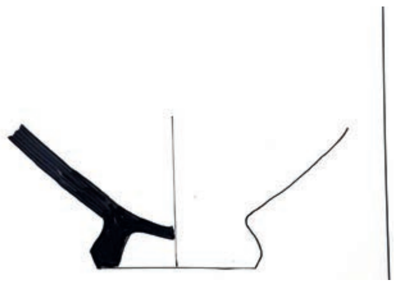
House 3 room I
Rim est. diameter: 10cm
Munsell surface and core 7.5YR 7/4, 7/6
Typology: East Greek. Possibly Samian based on the shape of the rim and the markings on the lower neck.
Date: 630-550 BC based on the archaeological context.
References: Dupont 1998, Samian 165- 166, fig. 23.6e.

Art. 41297



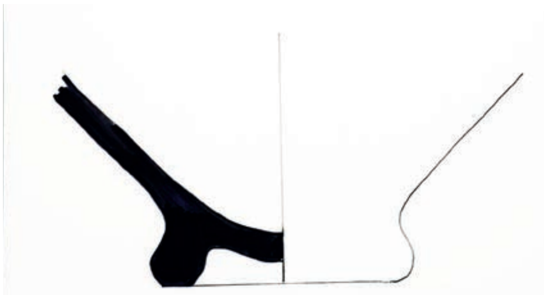
House 3 room I
Rim est. Diameter: 13cm
Munsell surface and core: 5YR 7/8- 7/6
Typology: possibly from Miletus based on the thin and convex lip profile.
Date: turn of the 7th century to the first quarter of 6th century.
Reference: Dupont 1998, 170, fig. 23.7, a; Dehl-von Kaenel 2003, 441, 439 fig.32: 30, 31.

Art. 44529



House 3 room I
Base diameter: 8cm
Munsell surface and core: 10R 7/6-7
Typology: East Greek possibly Milesian or Samian. Ring foot beveled at its base.
Date: turn of the 7th century to the first half of 6th century, or around mid-6th century if Samian.
Reference: Dupont 1998,172 fig. 23.8; Samian standard types 23.6; See also Polizzi, 1999 fig.221: 398 Samian amphora at Colle Madore.

Art. 44536



House 3 room I
Base diameter: 10cm
Munsell surface core: 10R 7/7, 7/6
Typology: East Greek possibly Milesian or Samian. Ring foot beveled at its base. Low ring and the body dips.
Date: turn of the 7th century to the first half of 6th century, or around mid-6th century if Samian.
Reference: Dupont 1998,172 fig. 23.8; Samian standard types 23.6; See also Polizzi, 1999 fig.221: 398 Samian amphora at Colle Madore.

Art. 43020 (no illustration)

House 1 room V
Handle
Typology: Attic SOS handle. The piece is quite worn, black and red painted. The only fragment of this type.
Date: 630-550 BC based on the archaeological context

Unidentified

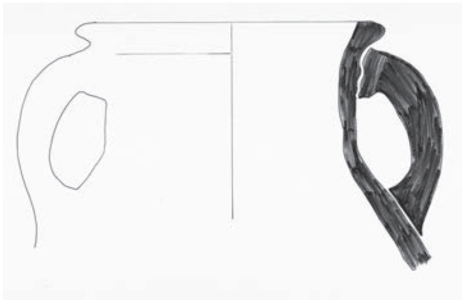
Art. 44267

House 3 room II
Rim est. diameter: 20cm
Munsell surface and core 7.5 YR 7/4, 7/6
Typology: Unidentified. Possibly other kind of storage vessel.

Art. 44650

House 3 room III
Handle and part of neck. Unidentified
Munsell surface and core. 5YR 7/6

Art. 40487



House 2 room II
Rim, neck and handle. Est. diameter: 19cm
Munsell surface: 5YR 7/6, 7/8
Munsell core: 7YR 5/1
Typology: Unidentified
Date: 630-550 BC based on the archaeological context.

Archaic transport amphorae in circulation

East Aegean transport amphorae

Until some time ago, the term 'Ionian' amphorae was generally used for a large and diverse range of transport containers, some of which were manufactured in East Greece and a large portion manufactured elsewhere on mainland Greece or in Western Mediterranean colonial workshops.[3] Now, after many years of progress, the bulk of Archaic 'Ionian' transport amphorae are classified into several distinct groups. Some are provenance determined, for example the Chian, Lesbian, Milesian, Samian, and Clazomenian series. Others have still unidentified or uncertain production areas.[4] However, even though the provenances are determined, a few amphora types are also suggested to have been manufactured at several places but carried the 'same' content. See for instance the discussion of the Lesbian amphorae below..

It is obvious that the East Aegean amphorae were shipped and distributed on long distance trade routes to different markets and are traditionally believed to have exported agricultural staples as wine and olive oil.[5] Dupont shows, for instance, that in the Western Mediterranean, East Aegean amphorae were in the minority compared to Attic, Corinthian, and Etruscan counterparts. Conversely, the Black Sea market was all-in for the Eastern Aegean products, while the findings of imports from mainland Greece are evident only in small numbers. It is further evident that the distribution of different East Aegean types varies in different part of the Mediterranean. Interestingly, Dupont notes that the proportion of East Aegean amphorae types are generally similar in Etruria and Sicily. The Samian and Milesian (sometimes referred to just as Samian) traditionally believed to have contained mostly olive oil represent 50 to 60 percent of the consignments from Ionia found in Sicily and Etruria respectively. While the wine import from Chios are in second place.[6] One must note that this valuation is based not only on the archaic material relevant here but on a general estimation of ceramic material from several centuries of established trade.

Chian or Clazomenian amphorae

Without conducting the various scientific analysis mentioned above, identifying the production site of an amphora can be quite difficult, whether assessing a complete jar or even more so a fragment. Dupont shows in a recent article that the traditional typological classification of assessing shape, colour, fabric, and form is not sufficient in these types. Even with all technical advances, it could still be quite a task to determine origin.[7]

This problem is evident in the present work. Based on the difficulty of distinguishing them typologically from each other, it will remain of uncertain provenance and thus classified as either Chian or Clazomenian. The only settlement in western Sicily that has published archaic amphorae from Chios or Clazomenae is the Greek settlement of Himera. Two amphorae of each origin were found in the necropolis, with the exception of one from Chios that was found in the sanctuary of Athena. As a comparison, the Greek settlement Camarina in the eastern part of the island has yielded 27 Chian archaic amphorae in the necropolis.[8]

Chian

The amphorae from Chios are, with the exception of Etruria and Sicily, the widest spread transport amphora in the archaic Mediterranean and Black Sea region. And

3 Dupont 1998, 142.
4 Dupont 1998, 142. See for instance Zeest, I.B.," Keramicheskaia tara Bospora", MIA 83, 1960., Grace, V., "Samian amphoras", Hisperia 40, 1971, 52-95., Boitani, F. and Slaska, M,´., and Rizzo M.A. respectively in *Le anfore da trasporto e il commercio etrusco arcaico I.*, Rome, De Luca Edizione d'Arte, 1990.
5 Dupunt 1998, 144.
6 Dupont 1998, 143.
7 Dupont 2019, 52.
8 Albanese Procelli 1996, 105-106. For examples in Camarina se Kokalos 1976-77, 525. Pelagatti tav. LXXVI, 5. In Vassallo Himera 1993-94, 1249, Abitato: santuario di Athena, example from between second half of the seventh century to early sixth century.

they most likely contained the famous wine from Chios mentioned both by Athenaeus (1, 29., 31-33) and Pliny (N.H. 9. 73). As mentioned above, these amphorae have been found with other contents, specifically during The Classical and the Hellenistic periods. In the following sections, the traditionally assumed content of each type will be presented and a further discussion of amphora reuse will be provided.

The morphological evolution of this type is split into two different series, of which the oldest is most relevant for this study. This series consisted of white-slipped amphorae decorated with a specific type of horizontal and vertical bands and a large horizontal S on the shoulder. The dating on this series puts them at the third quarter of the seventh century down to the third quarter the sixth century BC. The shape of this series evolved during the century it circulated. Examples found in Etruscan funerary contexts dated to 650-630 BC, are without the white slip. They have large broad-bellied vessels with half round, or beak-shaped (in section) rims, squat necks, and cylindrical ring feet.[9] A second quite rare type, but found in both Ukraine and Sicily, circulating during the second haft of the seventh century, was a smaller squat-bellied amphora, resting on a wider foot.[10] During the second quarter of the sixth century, another type with a slightly slender neck emerged. The foot is more deeply hollowed and the decoration more modest.[11]

Clazomenian amphorae

The Clazomenian amphorae are believed, like the China type, to have contained wine. They were mostly distributed in the Black Sea area and not particularly widespread in the western Mediterranean, as mentioned above. They are not as well known and quite similar to the Chian amphora, therefore frequently identified as the Chian type. The Clazomenian amphora has a flared out foot, an ovoid body with a cylindrical neck, and a torus shaped rim. It is decorated with horizontal painted bands and, like the Chian décor; it has a vertical band running down the handles.[12]

Lesbian amphorae

The chronology of the Lesbian amphorae spans from about eight or seventh century down to the second half of the fourth century BC. The typology and origin of Lesbian amphorae is somewhat controversial. After the work of Zeest in the 1960's followed by Clinkenbeard in the 1980's, the term Lesbian amphora was first only used for a type of vessel with very special features. The earliest type is grey in colour, ranging between light buff grey to grey though red to almost black. It has a rounded and broad body, which tapers to a foot with flat base. Its massive cylindrical handles end by the lower attachment with a rat-tail lying in relief down the shoulder.[13] In addition to the homogeneously grey series containing both wine and oil (resin-coated jars or not) several buff coloured variations similar in shape have now been confirmed. [14] The Lesbian amphorae repertoire consists of more than the grey series. The other type of amphora is similar in shape, but instead of grey is the clay oxidised to a reddish colour.[15]

The 'red' type falls into two separate chemical groupings. The Sestos and the Troas regions are considered to have belonged to the Lesbian 'zone', and it is quite

9 Dupont, 1998, fig. 23.1 p. 147.

10 Dupont 1998, 146. Whitbread 1995, 135-137. For Sicily se Bernabó Brea-Cavalier, *Mylai* Novara 1959: Milazzo Necropoli, example from the second half of the seventh century, 110-111 tav. XLVIII, 1-2; XLIX, 1-2.

11 Dupont, 1998, 148, fig 23.2 p. 150. The capacity of the early white-slipped Chian amphorae are not completely clear, but according to Dupont, the range is from between nearly forty litres in the oldest ones, to about thirty litres in the most recent.

12 See for instance from Vulci, first half of the sixth century in Rizzo 1990, 105 fig 197-198. Camarina form the sixth century in Pelagatti 1976/77, 525, tav. LXXVI, 11., or Himera end of seventh to the end of sixth century, Vassallo 1993/94, 1249.

13 Dupont, 1998, 156., Zeest 1960., Clinkenbeard 1982, 250 provides with Munsell Y8/1 to N5 to YR5/4 and N3, with the N5 "dull medium grey" as a good description in most cases.

14 Dupont 2019, 61.

15 Zeest 1960, 74., Clinkenbeard 1982,251. This type comes with two different names given first by Zeest who called it the 'tumbler-bottomed' amphora, and then the 'fractional red' type amphora by Clinkenbeard. Clinkenbeard believed her 'fractional red' to be a Lesbian and Thasos business arrangement where the amphorae were manufactured in Thasos but carried Lesbian wine. Clinkenbeard 1986, 354.

likely that they had production centres under the Lesbian trademark. The question is whether they only produced the amphorae ware or if they also produced wine branded as Lesbian. The manufacturing origin of the other 'red' group is not yet determined but was likely on the mainland opposite Mytilene. The grey wares not originating from the Hellespont have been matched to manufacturing centres both in the eastern and western part of Lesbos.[16]

Samian and Milesian amphorae

Samian amphora production spanned from late-seventh century to early-fourth century based on a typology put forward by Grace.[17] The earliest archaic type is from the end of the seventh to the first half of the sixth century. It has a globular- to pear-shaped body with a rounded ring foot. The rim is protruding with a short neck and either oval or delicate flat and quite thin handles set close to the neck.[18] This early type is attested to be of Samian manufacture. The fabrication, however, differs notably in the examples. They can be of various types of clay, forms, textures, and colours ranging from light buff to orange-brown. The different shapes also separate them into two closely related series. The globular one is massive with a short either flaring or straight neck, a protruding rim, oval handles, slightly slanting at the base, as if to fit the top of an egg into a little ring, as Grace put it.[19] The second series is of thinner fabrication, and the pear-shaped body has a short swollen flaring neck with less of a thick rim. The handles are thinner and their attachment is positioned further down the neck.

Milesian amphorae

The Milesian amphora is foremost characterised by its high, thin, convex lip. Below, round the top of the straight and sometimes flaring neck, there is usually one or several ridges. The handles exhibit various designs. Some are oval, others double-reeded. The body is ovoid and bulging and rests, like the Samian counterpart, on a low-flaring ring foot and is bevelled at its base. This type of Milesian amphora was in circulation around the late-seventh century to the early-sixth century BC and was, also like the Samian type, widely distributed.[20] However, it was not as widespread as its Chian and Clazomenian counterparts, probably because the latter two contained wine. Both Samos and Miletus were engaged in olive production.

The production centres of the canonical Milesian amphorae were probably situated around Miletus and its *chora* but could maybe also have incorporated Caria, considered an olive growing region.[21] During the mid-sixth century, a new attribute is evident on the Milesian amphora, which could have a functional purpose when poring oil. This attribute took the form of a fold by the joint of the neck and body, and in combination with its high lip and horizontal ridges, it could prevent dripping.[22] This new fold is one way to distinguish the Milesian type from other south Ionian production centres. Green *et al.* discusses for example whether some of the amphorae found in the Pabuç Burnu shipwreck, which are made in the typical Halikanarssos clay, could be of Milesian manufacture due to this stylistic attribute.[23]

Corinthian and 'Western Greek' amphorae production centres

Corinth was a major centre for ceramic production during the Archaic period. The earliest Corinthian transport amphorae came from one single production centre and was one of the first type of transport amphora that circulated the Mediterranean. Koehler classified the Corinthian amphora repertoire into two series based on vessel fabrication and forms, the Corinthian A and Corinthian B types.[24]

16 Dupont 2019,62-64
17 Grace 1971, Dupont 1998, 164f.
18 Grace 1971, 71-72.
19 Grace 1971, 72.
20 Dupont 1998, 174f.
21 Dupont 2019, 55-56.
22 Dupont 1998, 175.
23 Greene *et al.* 2008,690.
24 Koehler 1978., 1979., 1981., 1986., 1992.

Corinthian A amphorae

The production of the Corinthian type A transport amphora began during 700 BC. Its unusual shape, with flat base, spherical body, and a broad neck and heavy overhanging rim, is a stylistic leftover from the handmade storage vessels in use during the end of the Geometric period. The handles are short and thick. Aside from its shape, the Corinthian A amphora is easily recognised by its beige to orange clay, with large red and grey quite sharp inclusions. This type was in circulation from the last quarter of the eight century down to the sixth century, during which it gradually changed in shape. [25]

Corinthian B type

Type B differs in several ways compared to type A. The archaic vessel has a squat or turnip-shaped body with a short neck. The rim is rounded and, below it, a ridge of bands runs around the neck. The handles are vertically arching and oval in section. The earliest forms have a rather small cylindrical base. While type A was without a doubt manufactured in Corinth, the origin of type B has been a controversy. In addition to Corinth, the origin has generally been attributed to the Corinthian colony Corcyra, modern Corfu.[26] It has been attested further that the city of Apollonia in modern Albania, located on the mainland opposite Corfu, was a site of Corinthian B manufacturing, as have several places in Sicily. But these were established beyond the timeframe for this work.[27] The fabrication of Corinthian type B is divided in four classes according to Whitbread's petrological study, and the colour ranges from pink or commonly pale brown core, to pale brown or reddish brown. [28]

The Corinthian B type appeared in circulation in Western Mediterranean around the last quarter of the sixth century BC. However, as Koehler notes, the early type B amphorae share many stylistic features with other types of transport amphorae found in France, Italy and on Sicily that predate the Corinthian B. This is evident from examples found in Camarina and some collected from the sea off Corfu. The stylistic similarities are the broad-shouldered body, short handles with vertical sides, the shape of the rim and band below the rim. Koehler further notes, however, that the fabrics of these earlier examples differ from the clay of the Corinthian B, which she believes is smoother and finer. They also vary individually in shape and handle profiles, suggesting a variety of manufacturing sites.[29] It is possible that these early French-Italic-Sicilian types served as a stylistic model for Corinthian B.[30] Based on the chronological aspect of the "Corinthian B", the examples found at Monte Polizzo are probably of these predating early types. One of the amphorae is fragmented but nearly complete. This example differs in form with a nearly circular body instead of the turnip-shaped body that characterise the type.

Etruscan transport amphorae

The production sites of the Etruscan amphorae are not archaeologically attested. The Etruscan transport amphora has either flat base or round base, and it is suggested that the flat based type, which are most abundant in Vulci, could be manufactured there and the round-based ones at another location, perhaps Cerveteri.[31] Strandberg Olofsson argues that this assumption is made on amphorae found in burial contexts, which may not be representative for the settlement itself. Further, she argues that the fragmented amphora material, which often appears in domestic contexts, has not been the most acknowledged material in the ceramic assemblages on the different sites. If this material should be properly

25 Koehler 1981, 451. See example of evolution in Koehler 1981 in plate 98 e and f. During the early fifth century a parallel transport amphora called by Koehler Corinthian A', appeared. This type distinguished itself by its more ovoid shape and eventually also by a different coarse beige fabric. Se Koehler 1992 for this type.

26 Koehler., Whitbread 1995, 260. Add ref

27 Desy and De Paepe 1990, 215-216. See Göransson 2007, 88-97 for an in-depth discussion of the "Corinthian B" amphora.

28 Withbread 1995, 274. Se chapter five for the study of ceramic classes.

29 Koehler 1981, 453.

30 Amphora production in Sicily and elsewhere of Greco-Italian production is well attested during the Hellenistic period. Not only is the manufacture Corinthian type B on various sites, but the widespread MGS, (Magna Graecia and Sicily) a type identified by Vandermersch 1994.

31 Py 1985, 88. Gras 1985, 326-328.

analysed and then compared to the amphorae found in burial contexts, another picture may come to light.[32] Studies that are more recent suggest that not only Vulci but also Caere were places of amphora manufacture, with Gravisca and later Pyrgi as their staging ports.[33]

The Etruscan transport amphora is hard, well-fired, and gritty with mica. The clay is usually reddish yellow to reddish brown with a grey core. The rim is rounded on a short neck and an ovoid body. The vertical handles are round and short and placed just below the rim. The base is either round or flat. There are several typological variants made of the Etruscan transport amphorae. These typologies are mainly based on finds from southern Gaul, and the most recognised typology of that specific material is the one made by Py.[34] In this typology, the amphorae are divided in eight different classes, of which type 3A, 1/2 or possibly 5 are chronologically relevant in this study.[35] Another recognised typology, by Gras, is made on amphorae found in southern Etruria. These classes are labelled EM, Etruria Meridionale.[36] Type 3A is equivalent with EMC, type 1/2 and 5 equals EMA. The type 1/2, has a flat base and appears in circulation in Gaul between 625 and 575, and was in used until after 550 BC.[37] Type 5 is the second type with flat base but it is slightly thicker than on 1/2. This type appears later around 550.[38] The 3A type has a round base and is dated to the same period but appears to be in use in Gaul until 525 when it disappears.[39] The flat-based types are rare in find context out of Etruria. Out of thirty find context in Gaul, the type 1/2 or and 5 are only present in five. [40] This could indicate that the flat-based types primarily were manufactured for a terrestrial transportation and not for longer overseas shipping, as mentioned previously above in this chapter. Another suggestion provided by Gras is that the Etruscan round-based transport amphora EMC (3A by Py) is in fact a copy of the Phoenician transport amphora type Cintas 268 that appeared in Etruria during the second haft of the seventh century.[41] Gras also suggests that the flat base EMA (1/2 or 5 by Py) is a direct stylistic transfer from the Phoenicians due to the flat base and the neckless body, and the production of these types were perhaps even overseen by Phoenicians.[42]

Phoenician transport amphora

The Phoenician amphorae are the only type of amphora within the chronology of this work that possibly are manufactured on Sicily during the turn of the seventh century BC. Three main production centres are evident on west and northwestern Sicily, namely Motya, Palermo and Solunto and to a lesser extent Lilybaeum.[43] Bechtold shows that the Phoenician-Punic[44] transport amphorae produced on the different centres did not circulate contemporaneously but subsequently. Settlement deposits in Carthage and Pantelleria show exports from Motya between seventh to the fifth century, while the amphorae from Solunto and presumably Palermo are evident from

32 Strandberg Olofsson 2002, 125.
33 Riva 2010, 220. Morel 2006.
34 Py 1985., the other typologies are made by Bouloumié 1980, Carduner 1981, Marchand 1982. A comparanda between the four is found in Py 1985.
35 All classes in the typology: ½, 3A, 3B, 3C, 4, 4A, 5, 6?. See Py 1985 for further discussion.
36 Gras 1985. EM is distinguished by adding letter A, B, C, D, or E.
37 Py 1985, 74.
38 Py 1985, 81.
39 Py 1985, 74.
40 Py 1985, 73, fig 1.
41 Gras 1985, 319.
42 Gras 1985, 329.
43 For chemical differences between amphorae from Motya and Solunto, see Alaimo *et al.* 2002.
44 I follow Aubet and her chronological changing terminology of the Phoenicians (although they did not call themselves Phoenicians) "since all these words nowadays have clearly defined cultural connotations". 'Canaanites' are the Phoenicians of the second millennium BC, the Phoenicians of the first millennium in the east, and of the eight to sixth century in the west are called 'Phoenicians' and the western Phoenicians from the middle of the sixth century BC onwards 'Punic'. Aubet 2001, 13.

the second half of the fourth to the first half of the third centuries BC.[45]

The site of Motya is in fact the most well-documented Phoenician-Punic amphora production centre in the Mediterranean world. The earliest local type of amphora dates from between the second half or late eighth century to the seventh century BC. Production was ongoing down to the fourth century.[46] During 1995, Ramón developed the extensive typology of Phoenician and Punic amphora found or produced in central and western Mediterranean.[47] The difficulty of distinguishing one type of amphora from another, even when evaluating complete vessels, is evident from previous examples above. Artefacts deriving from household contexts are generally fragmented. Often, in an extensive classification system, this leads to advanced guesswork. Consequently, Toti has outlined a complementary system with a specific typology for the Motyan produced amphora findings.[48]

Several kilns have been documented on Motya. One area with five kilns is located in the north of the island in area 'K' and 'K EST' within the city wall. These were in use from the seventh century to the fourth. Contemporary to these kilns are two others found in 'Luogo di arsione', located south of the archaic necropolis.[49] The raw material used for ceramic production was probably extracted from clay deposits along the alluvial fan near the river Birgi (which eventually turns into Cúddia). Two different amphora fabrications are evident, one coarser composition used for the archaic amphorae and one finer-grained fabric in use from the fifth century and onwards. The examples found at Monte Polizzo fit into the first category. The shape of the earliest Phoenician amphorae types, Ramon T-3.1.1.1/2 / Toti T1, Ramon T-2.1.1.1 / Toti T2 3. T-2.1.1.2 / Toti T3 previously called Cintas 268, are as mentioned above very similar to the archaic Etruscan transport amphorae type Py 3A/ Gras EMC.

45 Bechtold 2011, 11.
46 Bechtold 2015, 58.
47 Ramón 1995.
48 Toti 2002, 275. For the complete system.
49 Bechtold 2015, 60; Spanò Giammellaro 2002, 549-50.;Falsone 1981

APPENDIX I - REPORT

ASSESSMENT OF ANCIENT NAVIGABILITY OF RIVERS

APPENDIX 2

ASSESSMENT OF ANCIENT NAVIGABILITY OF RIVERS SOURCED NEAR MONTE POLIZZO, WESTERN SICILY

by

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ABSTRACT

Cecilia Sandström, Ph. D. student at the University of Gothenburg asked me on 5th July, 2016, to assess the navigability of the Mazaro River (Fig.1) of western Sicily during the Iron Age and the period of Greek colonization.

For a river to be navigable, it must have a certain minimum channel width and depth, and the speed of its current must not be too great. Furthermore, it must have a sufficient and reliable enough "base flow" – flow that is constant and not related to brief rainfall events – that it can be used for a substantial part of the year.

At first glance there is little chance that the river was navigable: at present much of its central part dries up in the summer (Blomqvist, in Sandström, 2016): in other words, there is no summertime base flow. In addition, a cursory examination shows that the gradient of the river would be too steep for practical navigation even if it were to have water. Furthermore, data acquired in the field for Ms. Sandström, and the local geology and geomorphology, show that the river loses approximately 80% of its potential flow to the subsurface in the reach between approximately 27 km and 32 km from its mouth. In this reach its drainage divide with the Ricalcata stream, a tributary of the Cúddia River, is often within 200 m laterally and 6 m in height above the Ricalcata, and there are signs of sinkholes beside the Mazaro River bed.

Since the climate and vegetation cover were different in the Iron Age, and since other rivers in the area seemed to have possibly more potential for navigation, due to lower gradients and larger watersheds (Fig.1), it seemed worthwhile to examine the literature on the past climates of Sicily, and to plot the profiles and watersheds of all of the rivers sourced near Monte Polizzo, rather than just that of the Mazaro.

The results show, indeed, that the Marcanzotta/Cúddia/Collura and the Arena/Délia/Grande Rivers would have been more desirable as potential trade routes both because they have lower gradients than the Mazaro, and because they have larger watersheds, especially in their headwater regions, and thus more flow. Climatic conditions may also have favored navigability, especially at the beginning of the Iron Age.

The area was almost entirely forested at the beginning of the Iron Age but was largely cleared during its course and that of the early Greek colonial period, with resulting loss of soil cover by erosion. Soil cover is a major factor in sustaining base flow in streams, and it has been severely degraded since the beginning of the Iron Age. I estimate that the soil profile was probably twice as thick on the average in the Iron Age as it is now: the part of the profile surviving is more clay-rich, and therefore less amenable to infiltration, than the upper parts that have been lost. One can guess that the soil retained water for about twice as long in the early Iron Age as it does now, thus smoothing out the flow of the rivers.

As part of this project a general method of estimating stream flow or navigability from gradient of the river and the channel width has been developed, using approximations derived from Manning's Equation as a basis. I also suggest a general approach to estimating the loss of storage capacity in a watershed due to soil loss, using soil age, rate of profile development, and present-day erosion rate as inputs. These methods are applicable wherever in the ancient world suitable (i.e., small, with channel width-to-depth ratio of about ten to one) rivers and soils are available.

All the conclusions in this report really need testing by suitably focused field work, and by checking against hydrological data sets maintained in Sicily.

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APPENDIX 2, FIGURES FOLDER

This contains Figures 1 through 57.

1. INTRODUCTION

The navigability of a river depends fundamentally on its gradient and the volume and persistence of its base flow. These variables control the width and depth of the river and the velocity of its flow.

The volume of water available to a river depends on the area of its watershed above the point of measurement, the rainfall and amount of evapotranspiration[1]. The volume of its base flow[2] is, however, strongly affected by the variability of the rainfall, the infiltration capacity of the soil and the storage capacity of the soil and bedrock. Certain aspects of the local geology, such as the presence of cavernous limestones and faults, may affect both the total quantity of water carried by a river and its base flow. These may be important in this part of Sicily since it is partially underlain by evaporites and limestones (Fig. 2).

1.1: Stream Morphology

The gradient of any river depends on the topography through which it flows (basically, the difference in elevation and the horizontal distance between its source and its mouth), and on the tectonic activity affecting the ground over which it flows, as well as the age of the river.

A fundamental fact of geomorphology is that, as a stream matures (“becomes graded” or “approaches equilibrium”), its profile approximates more and more to a concave-up exponential or logarithmic curve (Fig. 3, from Snow and Slingerland, 1987). All the streams in this study strongly illustrate this behavior (Fig.4). Since water flows faster in a steeper channel, and the quantity of water in a stream decreases towards the headwaters, there is a point at which the channel becomes too small and the speed of the water too great for even the most intrepid of navigators. I have arbitrarily taken the smallest navigable channel as one 2m wide and 0.87m deep, and the fastest navigable flow as 2.5 ms^{-1} (5.6 mph, or 1 ½ times a brisk walking speed). A canoe, or small bundle of logs, or narrow boat could pass through such a channel in the downstream direction (Fig.5), but would have to be dragged back upstream.

Given this constraint, the volume of water required and the maximum permissible stream gradient can be calculated using Manning’s equation.

1.2: Sea Level:

This and the next three topics are closely interwoven. In order to estimate the river flow in the Iron Age we need to adjust the current flow volumes of these rivers for changes in climate, vegetation and human land-use. One of the key indicators of global climate is eustatic sea-level (Fig. 6), which has varied throughout earth history due to changes in the volume and temperature of seawater, and changes in the average depth to the seafloor. In the Holocene (the last 10,000 years) the main control on sea level has been changes in the amount of ice in polar ice caps and mountain glaciers and, to a lesser extent, the changes in the average temperature of the ocean. In any given area, particularly one so tectonically active as Sicily, measurements of past sea levels must be adjusted for actual up or down movements of the

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[1] Evapotranspiration is the sum of the moisture lost from the soil surface directly by evaporation and indirectly by transpiration from the pores (stomata) of plant leaves.
[2] The amount of flow in a stream derived from the seepage of groundwater. That is, the level of sustained flow in a period of dry weather. In this report I will be focusing on the winter-time base flow, because in the Mediterranean climatic regime of hot, dry summers and cool, wet winters, there is often no base flow during the summer – the streams dry up.

land. In general, though, low sea levels mark cooler climatic episodes, and high sea levels mark warmer ones. Three thousand years ago, world sea level was about 1 m lower than today (Antonoli et al., 2002 and 2004, Lodolo, et al., 2020)**,** but NW Sicily has been rising at about 1.4 mm/yr., so the land there has gone up 4.2 m in the same time, outpacing the rise in sea level. Therefore, a marine terrace or wave notch at 3.2 m above sea level in this part of Sicily would be about 3,000 years old (Antonoli et al., 2002).

1.3: Climate:

Sicily lies at the boundary between the Arid and the Mediterranean climatic zones. A slight cooling of the climate will move the boundary southward (Fig.7) and create much more humid conditions in Sicily: thus periods of high rainfall, which are marked by the development of paleosols in Sicily, should correspond with periods of lower sea level. Periods of higher sea-level, during which the Arid - Mediterranean Zone boundary is shifted northwards (Fig. 7), should correspond to arid times in Sicily, and these are marked by the accumulation of desert sand blown in from Africa. These alternating layers of soil and sand have been excavated and dated at Selinunte (Fig.8) (Ortolani et al., undated.).

1.4: Vegetation:

Northwest Sicily lies in the Mediterranean Division and in the extreme south of the Tyrrhenian province of the Italian ecoregion classification system (Blasi, et al. 2014): under natural conditions it is characterized by evergreen oaks (*Quercus ilex* and related species) and by coastal Mediterranean maquis with pistachio *Pistacia lentiscu),* juniper (*Juniperus oxycedrus* phoenicea and related plants), Mediterranean fan palm *(Chamaerops humilis)*, and olive (*Olea europea* var. *sylvestris)*. At higher elevations deciduous forests with a varying degree of evergreen component, including thermophilous oak forests with *Quercus virgiliana* and related species as well as mesophilous forests with beech (*Fagus sylvatica)* and holly (*Ilex aquifolium)* occur widely, and at the summits there are areas of temperate assemblages.

As climate warms up and becomes more arid the maquis will move to higher and higher elevations, and as it cools down and rainfall increases, the water-conserving deciduous forests will spread to lower elevations, as will the remnants of temperate forests. Thus, as climate cools in this region a series of forward feedback mechanisms begin to act: rainfall increases, evaporation decreases, and more water-conserving species cover more of the landscape: all of these factors would have made the rivers more navigable in the Iron Age than they are now.

1.5: Geology:

Monte Polizzo itself is composed of conglomerates of the Upper Miocene Terravecchia Formation (Heinzel & Kolb, 2011, and unit 2.6 on my Figure 9), but otherwise the headwaters area of the rivers draining Monte Polizzo is underlain by massive Mesozoic to Paleogene limestones (Fig.9) which may have extensive subterranean drainage. The Terme Segestana hot springs on the Caldo River are perhaps evidence for this, and the name of the Freddo River suggests that it is partially fed by large cold springs. In addition, there is an impressive area of karst topography (Fig.9: green area of unit 2.4 east of Monte Polizzo), developed on Messinian evaporites, around the town of Vita. Rainfall in this area will disappear into underground passages and issue again from the ground at much lower elevations. There is evidence for sinkholes, developed in late Miocene gypsum or in Plio-Pleistocene shallow-water limestones, along the Mazaro River, which is dry in summer below the reach (27.0 – 32.0 km) with sinkholes (Fig.10).

The middle courses of the rivers flowing south and west, other than the Mazaro, are underlain by soft shales, gypsum and marls (Units 2.2 and 2.3 in Fig.9) of late Miocene to Pliocene age, which are in some areas covered by much younger and thinner alluvial or lacustrine deposits. Both units are easily erodible and have subdued topography (Fig.11). These rocks have very low infiltration capacity, so that rainfall travels rapidly overland to the rivers without sinking into the ground. Figure 11 also shows two older, higher erosional surfaces that are now being dissected by small streams.

Even the younger rocks of the area are folded, and the Mazaro River flows along the southwest-trending keel of a syncline in which limestone is preserved (see transverse profile, Fig.12). The river thus loses a lot of its flow through the limestone to the neighboring rivers, tributaries of the Vélia-Grande and especially of the Cúddia.

The lower courses of most of these rivers cut gorges through uplifted and tilted terraces of very young (mid-Pleistocene) shallow-water limestone: these now form ridges breached by the stream gorges (Unit 2.2 on Fig.9, and Fig 13). At some time in the past, they may have dammed up the rivers to form lakes, which evolved into extensive marshes traversed by meandering rivers. The marshes have since been drained and the rivers straightened (Fig. 14).

1.6: Soils

Soils on limestones and marls in this climatic zone are *terra rossas*. They are heavy and clay-rich, but are relatively well-drained soils. Banerjee and Merino (2011) have recently put forward a coherent explanation for the development of these soils, which involves the downward movement of a reaction front at which authigenic kaolinite replaces limestone. The kinetics of this reaction suggests that the front moves downwards “a few meters per million years”, and this order of magnitude is supported by several other lines of evidence, which they describe in their paper.

Although this area is still tectonically active, the rocks in most parts of the area have been exposed to the weather for about 2 million years (since the late Pliocene), so one could expect to find from 10-20 m of *terra rossa* soil blanketing the limestones, with thicker soils on soft shales, sandstones and marls, and thinner soils on quartzites such as those comprising Monte Polizzo (see Appendix 1, note 2.).

These soils if they existed, would do much to buffer against the irregularity of the Sicilian rainfall, and provide a steady base-flow for the streams and rivers, but they do not generally exist, as discussed in the next paragraph.

1.7: Human Interference:

Human modification of the landscape began in prehistoric times with the extensive use of fire to clear upland areas for agriculture. In the early Bronze Age, and in the early Iron Age, there is evidence for extensive forest clearance, which caused a great deal of erosion in the Cúddia valley, where it has been studied (Heinzel and Kolb, 2011). A further pulse of intense erosion occurred in late Roman times (Heinzel and Kolb, 2011), and the practices that caused it have continued more-or-less continually to the present.

There is also evidence in the land-use patterns for a much more recent but fairly long period of swamp drainage and stream straightening. If Sicily is similar in this respect to other parts of Italy, such as the Valdichiana in Tuscany, drainage began in the 15th century and has continued to the mid-20th century: since there was a major land reform in the Mezzogiorno in 1946, the last major pulse of reclamation may have taken place then (Fig. 14).

Much of this activity, particularly forest clearance, can increase the total volume of flow in a river, at least temporarily, but this is generally offset by a reduction in base-flow with an accompanying increase in storm flows.

Finally, all the lowlands in our area of interest are now under intense cultivation of (in order of hectares under cultivation in the Province of Trapani) vines, cereals, olives, vegetables, pulses and citrus, all of which require irrigation (Giambrone, Lia and Roberto Foderà, eds., 2006). This has lowered water-tables in the area and hence led to the diminution of, or even complete seasonal absence of, river flow.

2. METHODOLOGY:

2.1 Calculation of Navigability:

2.1.1. Arbitrary Lower Limit of Channel Size

This was set so that a narrow, shallow draft vessel such as a canoe, skiff, or narrow raft could pass: a channel of triangular cross-section 2m wide and 0.87 m deep at its deepest. In general, a vessel of 1 – 1.5 m beam and 40-50cm draft could navigate such a reach if it were clear of major obstacles. The triangular channel cross-section was chosen because it is typical of curved stream reaches and it leads to easy computation (Fig.15) of the Hydraulic Radius, a variable that depends on the shape of the channel, and knowledge of which is essential for the calculations below.

However, in such a small stream the boat or load might have to be pushed or portaged across the bars between meanders, as they are typically wider, shallower and faster. I found, after doing the calculation in Section 3a, that these arbitrary shapes are not representative of upland streams on rocky beds, but are representative of lowland streams with vegetated fine-grained (clay or sand) beds and banks: real upland streams tend to be wider and shallower than the arbitrary shapes in Fig.15, and I used examples of real stream shapes, from Barnes (1967) for the main body of the calculations.

2.1.2. Arbitrary Maximum Current Speed:

This was set at 2.5 ms^{-1} (meters per second), or 5.6 mph (equivalent to a ~11 mins/mile or 6.7 min/km running pace). This is 1.5 times a fast walking speed (16-minute miles or 10 min/km)): anything above this, in my experience, causes severe problems when a boat or raft becomes crossways to the current.

2.1.3. Note on Mathematical Notation and approximation used for stream slope.

In what follows, "*" is the sign for multiplication, and "/" is the sign for division. Exponents are typed as superscripts (x^2) unless the software does not allow it, in which case I have used x^2. A negative exponent, as in the unit m^3s^{-1} ("cubic meters per second"), represents 1/s, e.g., m3s-1. When working with Manning's Equation in this paper I have ignored the difference between bed slope, water surface slope and energy gradient, as in practice they are usually close to the same and our results are going to be rather approximate due to some other simplifying assumptions. However, the user should try to take measurements in areas of uniform bed slope where possible.

2.1.4. Manning's Equation:

Manning's equation is an empirical hydrological formula relating current speed to hydraulic radius, stream gradient, and channel roughness (Barnes, 1967).

$$V = R^{2/3} * S^{1/2} * n^{-1} \quad \text{.......... Eq. (1)}$$

where: V = stream velocity in ms^{-1}

R = hydraulic radius in m = Area of cross-section/Wetted perimeter

S = stream gradient: meters vertically downward per horizontal m.

n is Manning's roughness coefficient = $k^{1/6}/30$, where k is the channel roughness (Charbeneau, undated).

2.1.4a: Maximum Permissible Stream Gradient for Navigation:

Re-arranging the terms to solve for the slope (because I have fixed the minimum hydraulic radius and the maximum permissible current velocity above):

$$S^{1/2} = nV/R^{2/3} = (k^{1/6}*V)/(30*R^{2/3})$$

or $$S = (k^{1/6}*V)^2/(30*R^{2/3})^2 \quad \ldots\ldots\ldots \text{Eq. (2)}$$

Since I have fixed $V = 2.5\ ms^{-1}$ and $R = A/P= 0.867/2.732$ (Fig.15), and k can be estimated at 15 cm (0.15m) (Charbeneau, undated)

$$S = (0.15^{1/6}*2.5)^2 / (30*(0.3^{2/3}))^2 \quad \ldots\ldots\ldots \text{Eq. (3)}$$

Yielding: $S = 0.0184$ km/km = ~20 m/km (very approximately).

This is the critical maximum stream gradient for navigability: if it is exceeded either the stream will flow too fast for navigation, or the channel will become too narrow and shallow. It imposes an absolute upper limit for a stream gradient for even the most rudimentary sort of navigation anywhere in the world. The value of this number is very insensitive to the roughness that is chosen, but is very sensitive to the maximum current speed and somewhat sensitive to the hydraulic radius, and hence to the channel shape.

2.1.4b: Derivation of Equation for Stream Width given the Flow Volume of Stream and Gradient:

In order to know whether a river was navigable in the past, we need to estimate the stream's width and depth, given that we can estimate a flow volume, and can measure the stream gradient.

The flow volume, Q, is obtained by multiplying the stream velocity by the area of cross-section:

$$Q = AV = AR^{2/3}*S^{1/2}*n^{-1} \quad \ldots\ldots\ldots \text{Eq. (4)}$$

Now, cross-sectional area is, by definition, the width times the average depth of the stream:

A = W*Đ, where Đ represents the average depth of the stream in the cross-section (Đ substitutes for "D-bar", the mathematical shorthand for a statistical mean. D-bar is not available in MS Word)

Substituting in Manning's equation we obtain:

$$Q = AV = W*Đ*R^{2/3}*S^{1/2}*n^{-1} \quad \ldots\ldots\ldots \text{Eq. (5)}$$

We can estimate Q, the flow volume, by examining measurements of present-day flow volume for these or similar watersheds, and adjusting for changes in climate and land use, and we can measure the stream gradient, S. If we are very lucky, we can measure the width of a stream, W, in the past by finding cropmarks representing old meander scars, or by excavating abandoned river courses. But we have no good way of independently estimating past stream velocity, V, hydraulic radius, R, depth, D, or roughness co-efficient, n. We therefore need to be able to estimate the past width and depth of a stream (i.e., its navigability) knowing only Q and S. Re-arranging Manning's equation we get

$$W = Q*Đ^{-1}*R^{-2/3}*S^{-1/2}*n \quad \text{Eq. (6)}$$

To make this equation useful we must be able to express Đ and R in terms of W, and we must have a way of estimating Manning's roughness co-efficient, n. Fortunately, the United States Geological Survey has compiled roughness coefficients and stream shapes and hydraulic radii for over 50 stream reaches in the United States (Barnes, 1967), and this enables us to use W = 10Đ (or $Đ^{-1}=10W^{-1}$), and $R^{2/3} = 0.022W$ (or $R^{-2/3} = 1/0.022W = 45.45W^{-1}$). See Table 1, Columns 9 and 10, and Section 2.2.2a below for details.

2.1.4c: Calculation of Nomograph for Flow Volume of Stream given the Gradient:

Substituting the values $Đ^{-1}=10W^{-1}$ and $R^{-2/3} = 45.45W^{-1}$ in Equation (6) we have:

$$W = Q*10*W^{-1}*45.45*W^{-1}*S^{-1/2}*0.032 \quad \text{Eq. (7)}$$

$$W^3= 14.544*Q*S^{-1/2} \quad \text{Eq. (8)}$$

$$W = 2.4407*Q^{0.33}*S^{-0.167} \quad \text{Eq. (9)}$$

This equation is plotted for a series of fixed values of S to create the nomograph of Figure 16: navigation is permitted only in the area above the thick S = 20m/km line, as calculated in Section *2.1.3a* above. Fig. 17 presents the same data on Log-Log paper, on which it plots as a series of straight lines. This graph also shows Luna Leopold's (1994) lines relating mean annual discharge to width and bankfull discharge to width. Any stream that plots blow a horizontal line shown on the left side of Fig. 17 is, by this paper's definition, to be considered navigable.

In Figure 18 I show an example of the data on which Leopold based his curves.

2.1.4d: Calculation of Minimum Channel Width consistent with navigable water velocities:

For any slope and flow volume there is theoretically a channel width below which the flow velocity will exceed 2.5 ms^{-1}, thus making navigation impossible.

From Q = A*V (Eq.4) and A = W*Đ, where the average depth, Đ ~ 0.1*W for lowland streams (from Table 1), we have

$Q = 0.1*W^2V$, where we have fixed maximum V as 2.5 ms^{-1}

Thus, $Q < 0.25*W^2$ for the current to exceed 2.5 ms^{-1} …………………………… Eq. (10)

This quantity is calculated for a series of values of the width, W, from 1 to 10 m, at which point the quantity of water required to exceed the maximum permissible velocity for navigation becomes greater than would have been available in any of these rivers. The curve, the bottom curve, shown as a heavy black line on the nomograph (Fig.16), is of the same shape as the curves of constant S, because we have fixed all the terms in Equation (5) except S, and Q varies as the square root of S. However, the curve falls in a region of the graph that is already forbidden because S is greater than the 20 m/km we calculated as its limit, and therefore may be ignored.

2.2: Estimation of Inputs to Manning's Equation:

2.2.1. Stream Morphology: Roughness, Cross-Section Shape and Hydraulic Radius, n, W, Đ, and R

H.H. Barnes (1967) of the United States Geological Survey measured all of these quantities for 50 representative stream reaches from all over the continental United States. These streams ranged from tiny headwaters brooks in the coastal plains of the S.E. USA (#1173 in the table below, shown in Fig. 19) to torrents in the Rocky Mountains (#1198 and Fig. 20) to the Columbia River, but most were much larger

Col.1	*Column #2*	*Column #3*	*Col. 4*	*Col. 5*	*Col. 6*	*#7*	*#8*	*Col.9*	*Col.10*	*#11*
USGS#	Name	Location	n	Width m	Av.Dep. m	R m	R2/3	W/Đ	R2/3/W	Note
329	Indian Fork	Cumberl'd, OH	0.026	15.75	1.647	1.48	1.30	9.568	0.0250	Clay
512	Champlin Ck	Colo. City TX	0.027	23.77	1.382	1.28	1.18	17.20	0.0147	Rox
224	Salt Creek	Roca, NE	0.030	22.78	2.030	2.04	1.61	10.95	0.0223	Clay
1173	Tobesofkee Ck	Macon, GA	0.041	24.99	2.749	2.29	1.74	9.091	0.0223	Veg
962	Beaver Ck	Newcastle, WY	0.043	14.92	2.637	2.12	1.65	5.658	0.0330	Veg
769	Provo River	Hailstone, UT	0.045	15.48	1.061	1.02	1.01	14.59	0.0203	Mtn
1198	Clear Creek	Golden, CO	0.050	15.30	1.164	1.06	1.04	13.14	0.0208	Rox
1184	Mission Creek	Cashmere, WA	0.057	6.55	0.441	0.43	0.57	14.85	0.0259	Rox
452	Pond Creek	Louisville, KY	0.075	35.05	2.347	2.21	1.70	15.77	0.0154	Veg
n/a	Galván #1	n/a. Crossing		23.8	3.8			*6.26*		
n/a	Galván #2	n/a, Bend sectn.		21.1	3.8			*5.55*		
	MEANS	Lowland, #512, 224, 1173	0.032					9.87	0.022	
		Rocky, #769, 1198,1184,452	0.057					14.59		
	Standard Deviation							n/a	0.0053	

Table 1: Stream Channel Parameters for Selected Streams similar to those of Sicily (Barnes, 1967)

than the rivers of Sicily, and so could not be used for this study. I selected the 9 streams from Barnes that were most similar in size to, and that flowed through similar terrain as do, the four streams I am examining in NW Sicily. Table 1 gives for these nine streams the measurements from Barnes (1967) that are relevant to this study, along with partial information from Marcus Galvan (Pers. Communication, 2016) on two other channels. Pictures and cross-sections of four of these streams are given in Figs. 19 & 20.

The values of the Manning roughness coefficient, n, measured by Barnes for this sub-set of streams fall into two fairly well-defined groups. Three streams (#512, 224 and 1173) flow on clay beds through vegetated terrains and have similar, low, roughness coefficients, with values of 0.027 (+/- 25%). They also have similar W/Đ ratios, 9.57 – 10.95. Four streams flow on rocky beds in mountainous areas, and have mean n of 0.057 (+/- 25%). They also have similar W/Đ ratios: 13.1-15.8. Of the remaining two examples in Table 1, Beaver Creek in Wyoming (#962) appears to flow through a highland area consisting of soft rocks like those of Sicily, but the reach has a very low gradient (much lower than any in Sicily), the banks have a dense vegetation cover and its W/Đ is only 5.6. It has therefore been omitted from our group of exemplars. Champlin Creek in Texas (#512) could also be included in our group on the basis of roughness, but it has a very large W/Đ ratio and appears to be very much affected by human disturbance.

Since, in a given environment, stream channels have a limited range of shapes, we may calculate a dimensionless quantity W/Đ, where Đ is the average depth of the stream (Table 1, column 9). It is clear that the values of W/Đ also fall into two main groups: those for streams flowing slowly in clay- and vegetation-lined channels, with a roughness coefficient around 0.03, are generally deeper, with W/Đ close to 10 (Fig. 19, and #329 and #1173 in Table1) , and those flowing swiftly in rocky beds, with roughness coefficient around 0.06, are broader and shallower, with W/ Đ near 14.5 (Fig. 20 and #769, 1198 in Table 1). Channels that are choked by vegetation are outliers on either side of these groups. For this work I have accepted the value of W/Đ as 10 (and roughness coefficient 0.032), as the rocky headwater streams in Sicily are unlikely to be navigable, and Sicilian streams reach alluvial valleys while still quite small.

Fig.15 shows that the hydraulic radius is relatively insensitive to the shapes of a series of arbitrary channels, but that it does vary directly as the width of the stream channel for any given shape. This fact suggested that another dimensionless quantity, the ratio of the Hydraulic Radius to the width (R/W) might be fairly constant over a wide range of stream shapes. However, R is raised to the power 2/3 in Manning's equation, and the use of this makes for easier calculation later, so $R^{2/3}/W$ is tabulated in Column 10 of Table 1. The values of $R^{2/3}/W$ calculated by Barnes for this group of nine stream reaches are unimodal and fairly tightly grouped, with a mean of 0.022 and standard deviation 0.0053, or 24% of the mean (lower part of Column 10 in Table 1).

Thus, for a given type of stream, in this case a smallish stream flowing in a somewhat alluviated valley, both R and A in Manning's equation can be approximated by constants times W, the width of the stream. This enables us to calculate the stream width (and hence also the depth if our assumptions are correct) the two factors that mainly govern navigability, knowing only the slope, derived from the stream profile (Section 2.2.1b) and the flow volume (Section 2.2.3).

2.2.2. Stream Channel Gradient or Slope, S:

2.2.2a: Stream Profiles

Longitudinal profiles of the Modione, Délia/Grande, Mazaro, Cúddia, and Freddo/Caldo Rivers were plotted, with 100X vertical exaggeration (Figs.21-25). The extreme vertical exaggeration was required to make visible the details of stream channels, such as knickpoints, and to enable plotting of terraces above stream channels. The elevations of the channels were measured on Google Earth at 1.0km intervals upstream from the mouth to the summit, or as near as possible to the summit, of Monte Polizzo.

There are several limitations to this method:

(1) The arbitrary interval of 1.0 km is too large to capture the smallest details of the profiles, especially near knickpoints.

(2) Many stream reaches are overgrown by vegetation, and this may increase the apparent elevation on Google Earth, which uses SRTM ((Space) Shuttle Radar Topographic Mapper) as its elevation data source, by up to 2m. This was partially overcome at each data point by searching for the lowest elevation in the neighborhood of the point and interpolating. These lowest elevations were generally patches of exposed gravels in the channel.

(3) The pixel size of SRTM is 90x90m (almost the size of a football field) or, in certain areas, 30x30m, which is the area of three tennis courts. This resolution is far too low to measure details such as the depth of narrow channels accurately.

(4) In some parts of the world the registration between the SRTM elevation data and the satellite imagery in Google Earth is less than perfect. In this area it appears to be quite good most of the time.

(5) The SAR (Synthetic Aperture Radar) used by SRTM is C-band, with a wavelength of 5.5 cm. It is scattered by any feature, including water waves, larger than about 3 cm. This is why it gives too-high readings in vegetated areas if the stems of plants are >3cm in diameter. It also gives high readings (about 2m) in the sea off river mouths, as the signal is dominated by the foam on wave-crests. It will also give high readings over the water in streams if the water is flowing strongly or is ruffled by wind. Typically in this area, the apparent elevation of the water in a river channel was often about 1 m higher than that of an adjacent exposed gravel bar.

(6) There are also some apparent systematic biases: along the south coast of Sicily the water level near river mouths was shown as +2m, whereas on the north coast it was recorded as -2m.

As channel elevations were measured, notes were also made on the elevations of remnants of fluvial terraces and the elevations of surfaces into which the rivers are incised. In many cases the terrace was shown to be continuous with the stream profile above an upstream knickpoint: they therefore represent surfaces of alluvial erosion. Many of these stream terraces can also be correlated with the marine terraces and other evidence of raised sea levels described in the literature. For example, according to Liguori & Porcaro (2010), the acropolis at Selinunte sits on a Quaternary terrace at +50m m.s.l.: this correlates with fluvial Terrace #2 (Fig.21) of the nearby Modione R. or fluvial Terrace #3 of the Délia (Fig.22), Mazaro (Fig.23), Cúddia (Fig.24) and Caldo (Fig.25). However, I have not made a special effort to correlate the marine and fluvial terraces of the region, because they are all, even the lowest one, far older than the period of interest here.

2.2.2b: Canalization and Estimation of Straightening

The middle courses of the rivers, which in some areas were strongly meandering in the past, have been canalized and straightened, increasing their gradients and reducing the width and depth of the channels. Both things reduce navigability. This process may have started in Roman times, but is likely to have been mainly accomplished during the 15th to 19th centuries, as it was in the Valdichiana in Tuscany. I have not however, been able to find any reports discussing the drainage and canalization of these rivers.

Often the canalized reaches are raised above the surrounding flood plain by 1 to 3 meters, strongly suggesting that the area had been a marsh or shallow lake before canalization (Fig.14). An effort was made to estimate the degree to which the course of each river had been shortened in the canalized reaches, since this directly affects the gradient. This was done by trying to identify abandoned courses by means of crop marks, aligned wet areas, or curvilinear boundaries between differing patterns of land subdivision

(Fig.14). Thus, if a meandering reach was 1.5 times as long as its modern, straightened, version (i.e., the sinuosity was 1.5), then the gradient before straightening was only 2/3rds (=1.0/1.5) its present value.

The extreme degree of shortening in part of the Cúddia valley, as well as the outlining of old meanders by land-use boundaries, can be seen on Fig. 14.

The gradients of the previously meandering, marshy segments of Sicilian rivers appear to me to be extremely steep (in the range of 3m/km) to sustain a meandering mode: it appears that the fine grain-size of the available sediment and the dense growth of riparian vegetation are controlling factors in maintenance of the meandering mode (Braudrick, et al., 2009).

River Name	Canalized reach		Degree of Shortening	Present Gradient	Pre-canal Gradient	Figure No.
	Lower Limit	Upper Limit				
Modione1						
Arena/Delia	1.2 km	15.0 km	10%	2.9 m/km	2.6 m/km	Fig.22
Mazaro1	14.0 km	20.0km	20%	5.0 m/km	4.2 m/km	Fig.23
Mazaro2	20.0 km	23.0km	20%	15.0 m/km	12.5 m/km	Fig.23
Cuddia1	0.0 km	10.0km	10%	3.0 m/km	2.7 m/km	Fig.24
Cuddia2	10.0 km	14.0km	50%	3.5 m/km	1.8 m/km	Fig.24
Cuddia3	14.0 km	17.0km	25%	4.3 m/km	3.4 m/km	Fig.24
Freddo-Caldo	(0.0 km)	(5.0 km)	None	(4.5 m/km)		Fig.25

Table 2: Canalized and Straightened Reaches of the Modione, Délia, Mazaro, Cúddia and Caldo Rivers, with degree of shortening and original average gradient before canalization.

2.2.3. Stream Flow, Q

Water flow in a stream is directly proportional to the area of the watershed above the point of measurement. It is a complex function of the amount and distribution of rainfall, the absorptive capacity of the ground, and the combined rates of evaporation and transpiration, generally represented as

$Q = P – ET – D - \Delta S$, where
Q = Streamflow, measured as mm/km^2……..Eq. (11)
P = Precipitation (rainfall) (mm)
ET = Evapotranspiration (mm)
D = Groundwater recharge (mm/km^2)
ΔS = Change in amount of water stored in the basin.

where each quantity is integrated over the whole drainage basin.

The change in the amount of water storage in the basin, ΔS, can often be ignored when considering annual rainfall, but in a climate with pronounced seasonality in rainfall it becomes the dominant term for periods on the order of a month, because the soil dries out in summer and is saturated during the rainy season.

Moreover, since the distribution of all these quantities in both time and space is highly variable, it is very hard to make an estimate of stream flow, and especially of the variation of stream flow through time, in an uninstrumented basin. Instrumental records of the four basins under consideration may exist, but they are at present unavailable to me. However, in the absence of actual measurements of the water flow, it is possible to make estimates based on measurements in similar nearby watersheds, adjusting them where necessary for conditions in the watershed under study. In this region there are instrumented watersheds fairly close to our area of interest, including the Freddo basin, and these have been documented (see below, Results). There is also calibrated data for the Cúddia and the upper part of the Délia watersheds (Puma, Viola, and Nota, 2016).

I have made for each river basin a “crude” estimate of run-off by multiplying the area of each major component watershed (Fig.1) by the monthly mean rainfall for Oct, Nov, and Dec, correcting these numbers for 1 mm/day of evapotranspiration, and summing them over the entire drainage of each major river to yield a run-off curve for the whole river basin. I have then compared these results with those obtained by using the regression method given in Puma, Viola, and Nota (2016), using the Freddo Basin as a control.

The terms D (Groundwater recharge) and ET (Evapotranspiration) are linked and governed by geology as well as biology, as they involve the infiltration capacity of the surficial material and subsurface movement of water. Streams flowing over limestone or evaporitic rocks may lose flow to underground channels. In lower reaches they may also gain flow from these underground channels. Subsurface catchments often do not mimic surface catchments – streams may lose water underground to nearby streams, or vice versa. In this area these considerations are especially important for the Mazaro watershed and the region near Vita. I have constructed several geological cross-sections to evaluate the possibility of subterranean hydrologic transfers (Figures 12 and 26, see also location diagram for these cross-sections, Figure 27). In all of what follows I have had to assume that the area as a whole (the Velia, Cuddia and Mazaro basins) is a closed system as far as groundwater recharge is concerned: that infiltration in the headwaters area travels through the rocks and re-enters the channel further downstream. I have corrected at the end for losses from the Mazaro Basin to the Cuddia Basin.

2.2.3a: Measurement of Watershed area:

Main Drainage	**Sub-drainage**		**Area**	**Cumul-ative**	**Rainfall, Oct-Dec (from Table 4)**		**Cumulative Eq. Run-off (Streamflow)**		**E-T adjusted flow ***
	No.	Measured at Point:	km^2	Totals	Precip'n. mm/3mos	Mean Vol. m^3 /sec	Aver. Q m^3s^{-1} over 3 mos.		Av. Q m^3s^{-1}
Délia-Grande	3	Km31	16.4	16.4	245	0.505	0.505		0.327
	1	K31	13.8						
	2	Km 30.5	20.0	50.2	245	1.042	1.547		1.000
	3a	Km 27.0	17.9	68.1	245	0.552	2.100		1.336
	4	Km 23.0	66.1	134.2	237	1.971	4.071		2.603
	5	Km 15.6	63.5	197.7	231	1.845	5.916		3.757
	6	Km 4.0	118.0	315.7	225	3.340	9.256		5.803
		Total	**316**				**9.256**		**5.803**
Mazaro	1	Km34 #2a	5.7	5.7	245	0.176	0.176		0.110
	2	Km23.6	11.4	17.1	238	0.341	0.517		0.330
	3	Km14.5, #5	76.1	93.2	232	2.221	2.738		1.706
	4	Km 0.0	23.2	116.4	225	0.657	3.395		2.113
		Total	**116**				**3.395**		**2.113**

Cúddia	1	Km 31.5	18.1	18.1	245	0.558	0.558		0.360
	2	Km 27.0	61.4	179.5	240	1.854	2.412		1.537
	3	Km 17.0	24.4	203.9	235	0.721	3.133		1.987
	4	Km 12.0	115.7	319.6	230	3.348	6.481		4.036
	5	Km 0.0	132.3	451.9	225	3.751	10.232		6.336
		Total	**452**				**10.232**		**6.336**
Caldo	All	Km 8.0	104.0	710	272	3.559	**3.559**		**2.381**
Freddo	All	Km 8.0	307.5	710	272	10.522	**10.522**		**7.196**

Table 3: Watershed areas, cumulative areas, rainfall volume and "equivalent run-off" and stream flow adjusted for winter-time Evapotranspiration. *The E-T adjusted flow is what I have called the "Crude" estimate in my output curves.

The area of each of the major watersheds was mapped and measured in ArcGIS Explorer, and is shown in Fig.1. Each watershed was divided up into its major sub-drainages, and the areas of these were measured (Figs.28-31). The measured areas, rainfall and equivalent run-off are shown in Table 3. "Equivalent run-off "is what the stream flow, Q m^3s^{-1}, would be where the stream exits the watershed if 100% of the rainfall falling on the watershed between October and December and not used by plants left the watershed as stream flow during the three months (i.e., if ΔS were zero). Therefore, in Table 3 the "equivalent run-off" is corrected for losses due to evapotranspiration, but not for groundwater recharge and changes in water storage within the basin, see Sections 2.2.3c through 2.2.3e.

2.2.3b: Rainfall, P

City	**Mazara del Vallo**	**Salemi**	**Palermo**		**Castelvetrano**		**Castelvetrano**	
Date Range	1931-1940	1931-1940	undated		1965-1994		2000-2012	
Month	Rain	Rain	Rain		Rain	Mean	Rain	
	mm	mm	mm	Days	mm	Tmin°	mm	Days
Jan			72.0	10	74.0	6.7	55.9	13
Feb			65.0	10	62.0	6.8	37.7	11
Mar			60.0	9	48.0	8.1	33.7	10
April			44.0	7	42.0	10.2	67.7	11
May			26.0	4	20.0	14	25.9	6
June			12.0	2	3.0	16.7	4.5	3
July			5.0	1	3.0	20.2	3.4	2
Aug			2.0	2	7.0	20.7	32.2	3
Sept			42.0	5	39.0	17.9	49.9	9
Oct			98.0	9	79.0	14.6	108.3	10
Nov			94.0	10	66.0	10.8	81	13
Dec			80.0	11	80.0	8	98.2	18
Oct-Dec		**245***	**272**		**225**		**287.5**	
Annual	486	809	611		748		885.9	+
		*Estimate based on ratio of annual Salemi rainfall to Castelvetrano 1965-1984.						

Table 4: Precipitation and its distribution through the year, for stations in western Sicily.

Unfortunately I have not been able to find long records of monthly rainfall for anywhere other than Palermo. In this area, Mazara del Vallo, on the coast, during the period 1931-1940 (which is all that I have found for this station) received 20% less rain than Palermo's long-term average, whereas Castelvetrano, a few kilometers inland, received 22% more rain, but for the period 1965-1994 (Table 4 and Figure 32). Since rainfall at Castelvetrano continued to increase, by about another 18% for 2000-2012 over 1965-1994, it may be that the difference between the coast and Castelvetrano is not as great as these figures make it appear. Moreover, in the same 1931-1940 period that Mazaro del Valle received 486mm per annum, Salemi, only 2.5 km from Monte Polizzo, received 809 mm, or 66% more than the coastal city: if rainfall at Salemi has increased as much as it has at Castelvetrano, Salemi may be receiving almost a meter of rain every year now.

During June and August only a few millimeters (1 – 7 mm) of rain falls in this area: average rainfall then rapidly increases in September to peak in October at about 100 mm, after which it slowly tails off again to June (Figures 32 and 33). On average, 30% to 45% of the rainfall in the area falls in the last quarter of the year, and so this is the period I focus upon in assessing navigability. In detail, however (Fig. 33), there is a vast variation from year to year: some years having some rain every month, and one in three years having dry months within the rainy season. The wettest month in most years in the Freddo valley has between 100-150 mm rainfall, but in November of one year in this series there was 300 mm of rain, probably resulting in significant flooding along the Freddo River (Fig.33).

To summarize: rainfall in this area is highly irregular from year-to-year, and even medium-term (10-30 years) averages have varied quite markedly in just the last hundred years; rainfall is lowest at the coast and nearly doubles as one moves inland to the vicinity of Monte Polizzo, and more than a third of the rain falls in the 90 days from October first to December 31st. In my calculations of "equivalent run-off" (Table

3) I use as a base the rainfall at Castelvetrano in 1965-1994, as being the longest and most conservative data set, and I accept the higher value for Salemi. For areas between these two places, I have used a simple linear interpolation.

2.2.3c: Evapotranspiration, ET

Crops grown in western Sicily					
Trapani Province (Giambrone & Foderà, 2006)			**Délia Valley above Trinitá (Amore et al., 2004)**		
Crop	**Percent of Area**	**Crop Water Need (mm/growth period)**	**Crop**	**Percent of Area**	**Crop Water Need (mm/growth period)**
Grapes	52.2	(200-300 est.)	Grapes	47%	
Cereals	24.9	450-650	Wheat	29%	450-650
Olives	14.8	500 approx.			
Table vegetables	4.3	400-800			
Pulses	2.0	300-500			
Citrus	1.3	900-1200			
Potatoes	0.3	500-700	Meadow	21%	
Fresh fruit	0.2		Forest	3%	500

Table 5: Crops grown in western Sicily (Data on Crop Water Need from FAO, Undated).

Currently this part of Sicily is intensively farmed for grapes, citrus and other tree fruits, olives and cereals ((Giambrone & Foderà, 2006; Amore et al.,2004) and see Table 5), all of which require a great deal of water, and most of which are cultivated in such a way that there is a large amount of bare ground between the trees and vines (Figure 13, which shows orchards on the right side, and Fig. 14). Citrus is the most water-demanding crop, needing as much as twice the annual rainfall (Table 5), and at noon on 16th May, 2005, when evapotranspiration was measured by three different methods (designated by their initials as SWAP, SEBAL, and SWEP!) (Minacapelli, et al., 2009) (Fig. 34) at a research station 6.5 km SE of Castelvetrano (on the divide between the Belice and Modione rivers), citrus was using 1.5 -3 mm/day, whereas olives were transpiring 0.75 mm/day and vines less than 0.5 mm/day.

I have not been able to find good measurements of winter-time evapotranspiration (either of crops or forests) in the literature available to me. However, a compilation of partial sources and reports on transpiration of Mediterranean savannah woodlands suggests 1 mm/day or 30 mm/month as a conservative value (therefore see, for example, Baldocchi and Ryu, 2011), although Paço et al. (2009) measured a value of 0.50 mm/day in Holm Oak savannah in Portugal, with 2-3 mm/day in the summer months (Fig. 35). According to Paço et al., *Quercus ilex* in their Portuguese area used 75% of the rain that fell in abundant years, but almost 100% in drought years. Evapotranspiration from evergreen and deciduous oak woodlands in Mediterranean climates is limited to about 500 mm per year (Baldocchi & Ryu, 2011, citing Baldocchi et al., 2010) as it is suppressed by the lack of water during the summer drought, and only reaches a maximum in the fall, just as available sunshine is beginning to decrease. The last column of Table 2 therefore represents run-off corrected for winter-time evapotranspiration of 1 mm/day, or 90 mm over the three months.

2.2.3d: Groundwater recharge and recharge of the soil profile, D

These considerations suggest that the total growing season water deficit over farmed lands in the Castelvetrano area may be as much as 375 mm, whereas the surplus in the winter is only about 190 mm. Since irrigation must keep the upper soil damper than the wilt point, this means that pumping may be supplying as much as 300 mm of water per year from the shallow aquifers (Anonymous, undated, a & b), causing an annual deficit of 2.7×10^6 m^3 and lowering the piezometric surface by as much as 1 m per year (Aureli et al., 2007), and causing sea water incursion into the coastal parts of the aquifers (Anon, undated; Aureli et al., 2007) and Figure 35).

The surface soil (10 cm depth) dries from 30% saturation to 7% in about 20 days without rain. At 30 cm the soil dries from 30% to 12% moisture in the same period (water saturation numbers are taken from Longobardi and Khaertdinova, 2015, and were derived for a test plot in Salerno in which the soil is developed on alluvium and is probably similar to the soils in the valleys of our area of interest.). Since the soil is rarely saturated, therefore, run-off is only really possible in these irrigated areas for a few days after large rainfall events, and that is exactly what we see for the Freddo drainage on Figure 33 (Pumo, Vila and Noto, 2016). After any other than the wettest months discharge via the R. Freddo drops nearly to zero within a month (or less, we have no finer resolution stream flow data available). In other words, there is no winter-time base-flow. Even worse, since the water-table is below the level of the streambeds, the streams, when they do flow, will lose water to the ground water. An extreme case of this is the Mazaro: Fig. 36 shows severe depression of the groundwater table (Areas A, B1 and B2) around clusters of wells between the Mazaro and the Marsala Rivers. The arrows show groundwater flow into these 'Cones of Depression, including one centered right next to the Mazaro. Another map (not shown), shows that the water levels in Lago Prióla and Gorgo Basso have been lowered so much that sea water is being drawn in from the coast (Anonymous, undated, a). There are no maps (that I am aware of) of the situation in the inland areas, but intensive irrigation is obviously in use there, too. This intensive use of groundwater is exacerbating the drying-up of the local rivers, and making it even more difficult to ascertain their probable condition in the Iron Age.

However, at the beginning of the Iron Age forest clearance had barely begun, and the area would have been covered with a broad-leaved evergreen oak (*Quercus ilex)* forest, with more deciduous oaks at the higher elevations. During the latest Iron Age and the period of Greek Colonization (2600-2200 BP, but Heinzel and Kolb (2011) put this coastal deforestation at 850-650 BC), forests along the coast (for example at Lago Prióla and Gorgo Basso near Mazara del Vallo) declined and the shade-intolerant shrub *Pistacia* (pistachio) became common, to be replaced later by cereals (Caló et al, 2012). There would thus have been, in the area of Mt. Polizzo and at the beginning of its occupation, a canopy of vegetation and a substantial litter layer, both good water reservoirs, sitting on a thick and well-watered soil (see section *2.2.3e* below). If the area were under forest canopy today there would be a growth season deficit of only about 242 mm, almost in balance with a rainy season surplus of 190 mm. At the end of the dry season a layer extending from the surface to approximately the growth season deficit divided by the difference in water content between saturation and wilt point = 24.2/0.23 = 105 cm depth would be depleted to the wilt point (based on the Salerno measurements). If all the winter rainfall surplus soaked into the ground it could re-saturate 19.0/0.23 = 82.6 cm of this soil whose wilting point is 12% water content and saturation level is 35% water content. In practice both the summer desiccated layer and the winter re-saturated layer would have gradational boundaries, so there would be water throughout the profile, but even at the end of winter part of the profile would be unsaturated: there would always be a vadose zone (Fig. 37).

The soil would have a water deficit but, in the absence of irrigation pumping it would mainly be confined to the root zone, and groundwater in the phreatic zone would be free to move to the streams, providing base flow, especially in the winter. A less than 10% increase in the rainfall, relative to the present day (i.e., an increase of 60 mm on the present total of 600mm/yr.), would also have shifted the annual water balance for the area into positive territory. This is especially true for the higher elevations, which have higher rainfall and lower evapotranspiration.

We can therefore assume that, in the Iron Age, especially if rainfall were a little higher than today, the river channels intersected the ground water table during a large part of the year, so that water flowed from the ground into the rivers, providing a steady base flow between rainfall events. It is this reliable base flow that makes rivers navigable.

The thickness and degree of compaction of the soil cover is extremely important in providing base flow: generally speaking, soil will hold more water per cubic meter than will many rocks due to its generally high porosity. Rock porosity rarely exceeds 30%, and is mostly around 10%, whereas soil porosity is usually on the order of 50%-60% (Manger, 1963). In addition, most mature soils are finer-grained than are those rocks capable of transmitting water, and so they retain water longer and release it more slowly: both aspects of soils are important in maintaining base flow.

During the Iron Age, before the forests had been cleared and the soils plowed, the organic-rich surface layer would have been much thicker and would have acted to prevent compaction of the surface of the underlying clay-rich *terra rossa*, thereby allowing greater infiltration. The soil itself would have been thicker (see below, section *2.2.3e*), and thicker soils, in addition to holding much more water, take much longer to transmit it to the permanent groundwater table: thus the delay between the beginning of the wet season and the renewal of flow in the streams would have been longer. The thick soil profile would have held much more water and released it over a longer period of time, so that stream base flow would have been much higher and more constant in volume (J.L. Berry, personal experience, and see below).

A key concept for this part of Sicily is expressed very clearly by Verheye and de la Rosa (2005):

> "A soft limestone and marl behave completely differently in terms of permeability and water in filtration from a fractured hard limestone. The former is rapidly saturated after the first winter rains and remains almost impermeable for the rest of the season. Vertical water percolation and leaching in these soils is therefore seriously restricted, and enhances lateral runoff and surface erosion"

Possibly as much as 80% of this area is underlain by soft marl, gypsum and limestones, and is therefore, especially under present conditions of exposure of bare, eroded soil and subsoil, incapable of absorbing heavy rain and therefore subject to flooding, severe erosion and subsequent desiccation. This is reflected in Figure 31, which shows that the month in which 300 mm of rain fell experienced 265 mm of runoff (indicated by the blue dot just beneath the dark blue bars denoting the rainfall, month 59): only 35 mm or 12% was absorbed. Fig. 38 (from numbers on Fig 33) suggests that an average of 100 mm of rain over 1.5 months is required for the Freddo River to develop significant flow at the gauge station at Alcamo Scalo (see Fig.1 for location). Note that this is a factor of three greater than the amount absorbed (35mm) in the month with 300 mm of rain, suggesting that that rain fell in a single catastrophic event, which illustrates the vulnerability of this area to extremely erosive meteorological events.

Generally speaking, during the first month or more in which rainfall reaches significant amounts (usually late August or September, the amount of the rainfall consumed as evapotranspiration decreases rapidly from approximately 2.5 mm/day (75 mm/month) to 1 mm/day (30 mm/month) as the days shorten (Paço, et al., 2009). Rainfall replenishes the soil moisture until a threshold quantity of rain over a limited time is reached: Figure 38 is a plot of the rainfall leading up to each measurable flow of the Freddo River shown on Fig.33. It shows that the threshold is approximately 100 mm of rain over two months, with the month of actual flow (the "zeroth month" weighted 100%, and the month before that, the "minus-first-month" weighted 50%. Although the data are sparse, Figure 38 also seems to show that there is a systematic decline in the amount of rain required to start flow in the river from 120 mm in October through 110 mm in December and 100 mm in January to a minimum of about 60 mm in February after which it returns to 90 mm in March. Thus, in the Freddo catchment, which is the only one for which I have semi-detailed data, streamflow reaches a maximum in most years in February (Fig.33). An important point to note is that, although Puma, Viola and Noto (2016) have a term in their mathematical modeling of the relationship between run-off and rainfall in Sicily to account for a one month delay between rainfall and increased river flow, Fig. 38 demonstrates that any actual delay is less than this.

To summarize, there is a threshold amount of rain over a roughly 45-day period (to account for the 50% weighting in “month-minus-one” required to establish flow in the Freddo River. This flow decreases to almost zero (i.e., not measurable at the scale of Fig.33) within the same month unless rainfall once again exceeds the threshold. The threshold level of rainfall required to initiate river flow decreases from 120 mm in October to a minimum of 50 mm in February, and then increases towards 100 mm before the end of the season, based on very space data. This is consistent with the presence of a new, nearly saturated zone descending through the soil profile towards the water table as the rainy season goes on.

I have discussed the Freddo basin in detail because Pumo and Noto. (2016) present models for estimating monthly run-off series for Sicilian streams, and used that basin as a calibration case. The basin is 270.6 km^2 and receives 623 mm precipitation per year, the length of the stream above the measuring weir being 32.3 km. The Freddo drainage basin is almost entirely intensively cultivated, being largely under vines, with some fruit trees, including citrus. Much of this land is presumably irrigated, as I discussed for the Mazaro, Delia and Cuddia above, and may require the same 300 mm of irrigation water a year in this area. It is thus very comparable in size, climate and land use to the basins of principle concern.

2.2.3e: Change in Basin Storage, ΔS

<u>2.2.3e(1) Soil erosion</u>

The time-lags discussed above would have had much different values in the Iron Age. Soil formation begins relatively rapidly at the surface, and the beginnings of a soil profile may be discernible after as little as a 1000 years (Ortolani et al., undated) but the process slows down as weathering proceeds more deeply into the bedrock, so that the formation of a mature soil profile some tens of meters deep requires on the order of a million years. Many mass-balance studies on small watersheds have shown that the rate of surface lowering by chemical weathering in many climates is between 3 m/Ma (3 meters per million years) (Berry, 1977) and 40 m per million years (Velbel, 1985) at equilibrium. Many authors (cited in Verheye and de la Rosa, 2005) believe that Mediterranean soils began forming under moist tropical conditions in the Pliocene, as long as 5 Ma (5 million years) ago: others are not so sure. Recent work by Banerjee and Merino (2011) reaffirms the slow rate of chemical weathering in the Mediterranean environment, and therefore that any thick soil profile (over ~1 - 2 m) began developing more than a million years ago. Soil formation is a balance between erosion and weathering, and soils on slopes form slowly and erode relatively rapidly, so never become thick. The soils on the marls in the valleys of the Délia and the Cúddia form relatively quickly and are eroded away quickly by sheet wash, gullying and the sideways movements of the rivers. The soils of much of the Mazaro catchment, developed on a relatively hard limestone, may be the oldest in the area.

Unfortunately, there is no cheap way to measure soil age: the standard among geologists would be ^{10}Be and ^{26}Al analysis. The ratio of the concentrations of these two nuclides can be used to determine the date at which the sample was last buried past the nuclide production depth (typically 2–10 meters). Another method is to study the history of deposition in local stream beds. This has been done for the Cúddia by

Heinzel and Kolb (2011), who have shown that there was extreme erosion by gullying in the uplands and filling of the Cúddia River channel by clay-rich quartzite conglomerate derived from Monte Polizzo between 600 and 380 BC.

The soils developed on Pliocene and older rocks in this area have had up to about half a million years to develop, based on the idea that the calcarenites of the Marsala Synthem covered most of the area, as witnessed by outcrops in the Salemi area (Fig.9), and were deposited beginning about 1.5 m.y. ago in inland areas, and ending 0.8 to 0.5 m.y. ago near the present coastline (Basilone, 2018, p.233). Beginning during deposition the inland areas were uplifted and the Marsala cover progressively stripped off by erosion, exposing the older rocks, particularly the Pliocene marls and shales, to erosion and soil formation. Therefore soils are older (perhaps somewhat more than 1 m.y.) in inland areas near the headwaters of the rivers, and younger, beginning to form even today where the Marsala cuesta is retreating, towards the coast. Heinzel and Kolb (2011) mention the widespread presence of a mature Armata Paleosol in the area, but they give no details of its thickness or distribution.

The processes of soil development and their chemistry may have slowed down during the glacial intervals, but did not cease. Full-glacial climate seems, based on mammalian fossils, to have been relatively dry with some open landscapes. But in very late glacial times there was an aridity crisis which led to the loss of many mammalian species (such as elephants and bison) and the spread of xerophytic vegetation assemblages. In early post-glacial times this was replaced by a wetter climate with widespread forest and the occurrence of red deer and the common dormouse (Bonfiglio, Marra and Masini, 2000).

The initial progress of chemical weathering is relatively fast, but it slows down as the thickness of the profile increases and, at equilibrium, weathering advances slowly as a front into the bedrock, lowering the surface by approximately 3 – 5 m/Ma (meters per million years) (Banerjee and Merino, 2011; Berry, 1972, although Priori et al., 2008 use an estimate of 20-40 m/Ma to yield about 1 m of soil in a million years). The material is dissolved and removed in groundwater. If erosion, the process of physically removing material from the soil surface, proceeds more slowly than this, the soil profile will increase in thickness: if erosion is faster than this the soil profile becomes thinner. Thus in glacial times erosion is favored over chemical weathering and soil formation.

On forested slopes the ground becomes covered by a thick litter of leaves and twigs, and this protects the underlying soil from compaction by the passage of people and animals and the impact of raindrops. In addition, the litter acts as a sponge, and is able to hold large amounts of water. Both of these factors increase the acidity of, and amount of, water that can soak into the ground – i.e., they increase the rate of infiltration, and act to radically slow down erosion on gentle slopes. This accounts for the common observation that erosion rates are faster in semi-arid climates than in humid ones, but that chemical weathering is faster in the more humid climates.

Since erosion is a surface process, the fertile, organic-rich topsoil is removed first, and then the relatively uncompacted, permeable ‘A’ Horizon, and finally the compact, relatively impermeable ‘B’ horizon, which accumulates clay and secondary carbonate cements, and so absorbs water poorly, leading to rapid runoff and further erosion. The ‘B’ Horizon is also a relatively poor storage medium for water because of the deposition in its pore spaces of clay and carbonate minerals, and it is relatively infertile. In this area *terra rossa* and related brown soils are very common (Fig. 1), and since they are clay-rich they exacerbate these problems.

If we assume an average rate of movement of the weathering front into solid limestone of 10 m/Ma, and that the average limestone in the area has 10% insoluble residue, then the rate of residual soil formation is 1 m per million years. Since this area has been exposed to weathering for up to that length of time, one would expect weathering to have removed 0-10 meters of rock, and to have formed 0-1 m of mature soil**,** with soil thickness and maturity increasing from the coast towards the lowlands immediately surrounding M. Polizzo**.** The rate of weathering would be faster, and the production of soil much faster, in soft marls (i.e., very impure limestones) and in secondary deposits such as the alluvial fans described by Heinzel and Kolb (2011). A 2m thick layer of 50% porosity soil could hold a column of 1 m of water or more than a years' worth of rainfall. It takes water about two months, in my experience, to drain through a 5 m thick layer of residual soil, but this figure is highly dependent on the permeability of the soil, and I have no exact figures to quote.

Conceptually-speaking, during the dry summer months, with a 242mm water deficit due to evapotranspiration by and under a forest canopy, the top meter of soil would dry from a saturated water content of 35% to one of 10% (using the Salerno data as above). The following winter, with, in this area, a rainfall surplus of 190 mm would re-saturate the top 75 cm of soil. The bottom of the newly-saturated layer moves slowly downward until it reaches the previous year's saturated layer, bringing the water table up to 25 cm (these are arbitrary depths chosen for illustration – see Fig. 39). The following year would start with the top 25cm of the soil unsaturated, and this zone would increase in thickness 25 cm each year. However, soon the vegetation would be unable to access enough water, and E-T would slow down, so that, overtime, the dry-season and wet-season water tables would stabilize, and there would always be a saturated zone in the lower part of a mature soil profile to provide base flow to the streams during the dry season (Berry, personal experience). Incidentally, the hard pan (calcrete or caliche) in these soils forms at the uppermost level reached by the capillary zone (Fig. 39): it might be very instructive to search for surviving examples of this hardpan, because they might enable a quantitative understanding of the hydrologic regime at the time they formed.

According to Costantini et al. (2013), the permeability (by which he means the hydraulic conductivity) of the clay-rich soils found in Sicily is about 20.10^{-6} ms^{-1}, which works out to about 51 meters per month. and Costantini et al.'s figure is three orders of magnitude too high in my own personal experience, so I think that he meant nanometers instead of micrometers ($\mu msec^{-1}$) per second. Zhang (2010) and several other sources give values in the range of 6 m/yr. ($0.20,10^{-6}$ ms^{-1}) for clay loams. Using Zhang's value, it would take from four months to a year for water to move through 2 – 5 m of soil. The other property of water in soils that is important is the <u>matric (or matrix) potential</u>**.** This arises because water is attracted to most surfaces, including those of the minerals that surround the pores and the <u>pore throats</u> connecting the pores. Since the pores and the pore throats are all different sizes and shapes, there is a huge variation in the ease with which, and therefore in the time frame in which, they yield up their water content: some water drains very quickly through the soil, and some drains very slowly. Since the water potential (of which, in the case of soils, the matric potential is the largest component) varies through a range of three orders of magnitude over the normal range of soil water contents, the time needed to release all the water from a thick soil ranges over the same sort of interval.

However, if soil erosion removes enough of the soil profile, the entire thickness can then dry out, allowing the streams to dry up quickly. This happens because unconfined rock aquifers, especially hard limestones, generally hold much less water and transmit it much more quickly than do soils.

Fortunately, the soil loss in the upper Délia watershed has been studied by Amore, et al. (2004), using the volume of sediment, measured in 1981 by Tamburino (Tamburino, et al., 1990) that has accumulated behind the Trinitá dam since its completion in 1959. The delta formed in the Trinitá reservoir contains 6.11 Mm^3 with a dry density of 1440 kg/m^3. The area of the watershed above the reservoir is 185 km^2, and the dry density of the original soil in place was probably about 1300 kg/m^3. My own measurements of dry bulk density of forested soils in a humid temperature gave results for the A and C horizons of about 1.2 (tons/m^3). Zou, et al. (2014) and Pirastru et al. (2013), however, found values averaging 1.3 for the upper parts of profiles in China and in Italy, respectively, and so I have used these published numbers.

Therefore, during this 22-year interval, the thickness, T, of soil removed annually from the ground in the upper Délia valley is:

$$T = \left(\frac{6.11 * 10E6m3}{185 * 10E6m2}\right) * \left(\frac{1.441}{1.3}\right) * \text{(100cm/22yrs) = 0.1663 cm/yr.}$$

This is equivalent to 1663 m/Ma, up to 1663 times as fast as the soil forms. If an area was deforested in 650 BC, and has remained under agriculture, it will have, on average, have lost 4.4m of its cover of soil and weathered rock: on steep slopes or over soft rocks, more – over flat areas and hard rocks, less. During the period of occupation of Monte Polizzo, deforested areas would have lost an average of 17 cm of soil, and this would have included all the surficial, water-retentive, organic humus.

Thus, on average, since the Iron Age, the area has lost at least as much soil as has formed in the past half-million years, or as much as eight times as much, depending on the lithology of the bedrock. This has almost eliminated water storage in the soil and thus the lag between rainfall and streamflow. It has therefore, almost eliminated base flow in the rivers.

2.2.3e(2): Effect of geological structure & stratigraphy: karst topography and the Mazaro River

It is clear from a cursory examination of the watershed map (Fig. 40) that the Mazaro drainage is anomalous: it is much narrower that the others, particularly in the northeasternmost (headwaters) third of its length. In this section, too, the river itself flows within 200 m of the northern edge of its drainage, and within 500 m of the southern edge of its drainage. These are signs of a river whose drainage is being "stolen" by its neighbors. One reason is clear from the stream profiles in Fig.4: the course of the Mazaro is consistently at a higher elevation than that of its neighbors. The main reason that this happens is that the stream flows over harder bedrock than its neighbors. But once a river finds itself flowing at a higher level than its neighbors, it becomes subject to "stream capture": the tributaries of neighboring streams have steeper gradients, and can therefore erode more quickly headwards than those of the elevated river, gradually stealing its tributaries from the latter. This process benefits from forward feedback: the faster it happens, the faster it will happen, until the "victim" stream also begins to lose water underground to the "aggressor" streams. Figures 12 and 24 show why this is happening to the Mazaro: it is flowing along the axis of a syncline that is floored by a relatively hard rock – limestone. The harder limestone resists erosion and stands up as a ridge, whereas the soft rocks below it are eroded away, leaving the Mazaro "high and dry". Fig. 41 is an oblique Google Earth view up the Mazaro showing a point of imminent stream capture just above Km. 32: here the divide between the Mazaro and a headwater of the Ricalcata (which eventually joins the Cúddia) is only 10 m above and 135 m horizontally from the Mazaro, whereas it is 30m above the Ricalcata. At Kilometer 29.5 the divide is 150m north of the Mazara and 10 m above, whereas the Ricalcata is 70 m lower at the foot of a steep slope that shows signs of instability due to water, such as debris flows and gullies ending in springs just below the level at which the Mazara flows (poorly visible on Fig.41, unfortunately).

Since the Mazaro valley is floored by limestone (and, in a critical reach, gypsum), which is soluble, underground seepage can lead its waters to the surrounding valleys, further robbing the Mazaro. Possible sinkholes can be seen at several places along the Mazaro, for example on the right-hand side of Fig. 10 (but the similar feature to the left looks man-made). Unfortunately, it was often impossible, because the low resolution of SRTM data made it hard to determine the depth of a feature, to decide unequivocally whether it was a sink or a much eroded old borrow-pit. However, it was clear for a few features along the Mazaro that water flowed into them, but never flowed out. In summertime the Mazaro is dry below the possible sinkhole at Km. 26.2 (Fig.10).

The measurements of actual stream flow and of the channel cross-section collected by Anders Blomqvist and provided to me by Ms. Sandström enabled me to calculate approximately the water losses along this stretch of the Mazaro (Figs.40 (location) and 42)) during both bankfull conditions and the conditions at the time Mr. Blomqvist was in the field. One is tempted to attribute the loss of 26 m^3s^{-1} of bankfull flow (about half of the expected flow) between Kms. 34.0 (Location 2a) and 32.5 (Location 2b) to measurement error, except that it is exactly replicated in the measured actual stream flow and occurs just above the point of imminent stream capture (Km 32).

Between Km.32 (Location 2b) and Km. 30.7 (Location 2c) the stream gains flow at a slightly greater than expected rate, but it then loses 70 m^3s^{-1}, or 4/5ths of its potential bankfull flow, between Km.30.7 (Station 2c) and Km 21.7 (Station 3). The actual flow, however, peaked one station lower, at Km. 28.4 (Station 2d) and then disappeared altogether by Km. 21.7 (Station 3). These results are very consistent with each other and suggest that 80% of the potential flow of the Mazaro is being diverted underground, probably to the Ricalcata, which becomes the Agézio and eventually joins the Cúddia at Km.12.

Bankfull flow in rivers usually represents approximately the level of the “1.5-year flood” – i.e., a flow that occurs sufficiently often to stop perennial vegetation encroaching on the channel (Leopold, 1984).
At Station 2a this bankfull flow rate, calculated from the area of the watershed upstream of the station, is equivalent to a rainfall rate of 9.2 mm/hour. One might expect only about half of the rain actually falling to enter the stream immediately, so this is very roughly equivalent to a brief storm yielding 2.0 cm of rain across the entire watershed, which seems a very reasonable amount for a once-a-year event in this area. At Station 5 equivalent reasoning yields a bankfull stage also equivalent to 2.0 cm of rain falling on the entire watershed of 93.2 km^2 if losses of 80% to the subsurface are accounted for.

North and east of the town of Vita there is a small but spectacular area of karst topography (Fig. 43)**.** Here there are about eleven closed depressions, the largest of which have streams within them that usually end at a grove of trees. All rain that falls onto this area sinks into the ground and travels several kilometers to issue at a large spring. Unfortunately it is impossible to tell, with the data at hand, which stream or streams benefit from this extra water. However, there are large hot springs on the Caldo river below Segesta: very deep circulation of groundwater could explain the heating (Fig.44). Also, the ground level and the streams slope more steeply north from Vita than they do to the south (see profile of Caldo River on Fig.4), and it is clear from the number of quarries that this is limestone country, suggesting that the groundwater from Vita most likely travels north.

2.2.3e(3) Pumping

It is apparent that irrigation with pumped groundwater has become important during the twentieth century. This lowers the ground water table below the stream-beds and leads directly to loss of water through the stream bed, and hence of base flow, severely restricting navigation potential, and invalidates any attempt to directly relate present conditions to those of the Iron Age. See Figure 34 and Section 2.2.3d for more discussion.

2.3: Adjustment of Present Stream Flow to Iron Age Conditions:

It remains to adjust the flows of the rivers for Iron Age climatic and vegetation conditions. This is an inherently very approximate exercise.

2.3.1: Rainfall

Martin Finné (2014), using a rather convoluted technique to smooth out the variation in results between a large number of studies in the Eastern Mediterranean (including Sicily), presents a graph showing the area to be generally drier than average from 3600 – 1800 BP but with a short wet spell at 3200-3000BP and a slightly longer one close to today's average from 2800-2400 BP. Finné's compilation probably conceals a lot of local variation, as the results he used come from regions as disparate as Etruria and Oman. His own work, however, on the $\delta^{18}O$ of speleothems from the Kapsia Cave in the central Pelopponese, shows that the area was wetter than today in 2900 BP, but became progressively more arid until 2400 BP, when humid conditions suddenly returned. His $\delta^{13}C$ results show increasing biological activity from 2800 BP to 2300 BP, followed by a drop-off in biological activity extending to the present.

This is in general agreement with climatic inferences from Lake Preola (a karstic lake 5 km SE of downtown Mazara del Vallo, and spelled L. Prióla on p.30 of "Atlante stradale d'Italia Sud 1:200,000"). At Preola water levels were somewhat higher during the Iron Age than they are today, suggesting slightly wetter or cooler conditions (Magny et al., 2011). The pervasiveness of the forest cover at L. Preola prior to Greek colonization) suggests that the summer drought may not have been quite as pronounced as it is now (Caló et al., 2012). Results of analysis of plant remains at M. Polizzo (Stika et al., 2008) also suggest, to me, slightly wetter and cooler conditions. This includes the dominance of Phalaris (Canary grass) and Lolium (Ryegrass) temulentum among the grasses. Both are weeds that infest winter crops and prefer cool (5-20˚C) and damp conditions. Among other plants Chrysanthemum coronarium (chop-suey greens) and C, segetum (corn marigold) both require shade and dampness, as do the goosefoot Chenopodium album and the plantain (Plantago) genus, and also many members of the Liliaceae.

I will assume rainfall 10% higher than today's, but with most of the increase in the summer, so only 5% more in the winter.

2.3.2: Temperature and Evapotranspiration

Sea-levels, which are correlated with the average temperature of the earth's surface, were about a meter lower than at present (Lodolo et al., 2020, and see Fig. 6) at the beginning of the Iron Age (1,000 BC or 3,000 BP) and rose gradually to near present levels by the beginning of the Common Era. Behre (2003, cited in Wanner et al, 2008) shows a much more detailed sea-level curve for the southern North Sea area, with a pronounced period of lower sea level (about 3 m below that of recent times) from 3100 – 2300 BP, and shorter drawdowns of about a meter at 2000 BP, 1000 BP, and 1600 BP. World-wide compilations of data and model simulations by Wanner et al. (2008) show a wet period in Israel, based on $\delta^{18}O$ measurements at Soreq Cave, extending from 3200-2400BP, a cold period in Fennoscandia from

3000-2400BP based on lake temperature at Tsuolbmajarvi, and a cold period in the N. Atlantic region from 3400 to 2700 BP (Bond et al., 2001). In the north Atlantic there was a brief warm spike, and in Finland a very brief cold spike, at 2950 BP.

Sea-levels thus suggest that the world was a little cooler in the Iron Age than it is now but evidence for any substantial change in Sicily is lacking. The plant evidence from Monte Polizzo (Stika et al., 2008) cited just above suggests, as noted, slightly cooler conditions there than at present. One gets the same impression from the human diet inferred by Stika et al: barley and fava beans are both crops tolerant of cool, wet conditions, and high consumption of animal fats rather than olive oil suggests a need to keep warm. If wheat was grown for export to Selinunte, as suggested by Stika, et al., it may have been grown on the *terra rossas* developed on limy rocks at lower elevations.

Evapotranspiration would have been lower in the lowland areas than it is now because the evergreen forest has less demand for water. However, the presence of the forest and its leaf litter, plus 2m to 5m of soil that does not exist today, would have greatly smoothed out the river flows, helping to create a steady base flow.

Based on the discussion in Section 2.2.3c above, I will assume 1 mm/day winter transpiration in order to be conservative.

2.3.3: Basin Storage

Since there was no pumping of groundwater during the Iron Age (although, after colonization, there may have been extensive irrigation by means of water transfers using aqueducts), one can assume that, other than by direct groundwater flow into the Mediterranean (see Fig.37) the only systematic losses are from the Mazaro River basin, dominantly as a subsurface transfer to the Cuddia. These losses represent as much as 80% of the Mazaro's flow below about Km.25. They are predominantly from the channel and so will have been reduced, if anything, by channel siltation consequent on post-Iron Age soil erosion.

If I am correct in calculating that the average loss of soil cover has been about 4.4m of an original 5 m thickness, then there would have been sufficient water storage in the soil, and sufficiently slow and long drawn-out drainage through the soil to maintain a nearly uniform base-flow in the streams throughout the rainy season and for some time into the dry season (see discussion under *2.2.3e(1)*). We may therefore use the mean run-off for each winter month as a good guide to Iron Age base flow. The Armata Palaeosol (Heinzel and Kolb 2011) may represent a surviving remnant of this regional soil cover.

2.3.4: Navigability before canalization and drainage:

In the reaches that have been straightened currents would have been slower, and the channel cross-section deeper and narrower (i.e., more suitable for navigation) than it is now. In upstream, rapidly flowing low-sinuosity reaches this will have been of little significance.

2.3.5: Combined effect of all changes on streamflow

The net effect of these changes is that one can say, with some assurance, that in an average year the navigation season (for very small boats or for logs) on the rivers of western Sicily would have been approximately 3 months, roughly from late November to late February, because in those months they would have had sufficiently large and stable base flow. It is therefore reasonable to use the calculated mean monthly run-off, assuming no change in basin storage (except in the case of the Mazaro) as a basis for estimation. I will not use the very complicated regression formula of Puma, Viola and Noto (2016) as it takes into account the present-day intensive cropping (hence increased E-T and pumping of groundwater. In any case it does not seem to change the estimated total quantity of water available: it merely shifts it to later in the year.

Because rainfall may have been a little higher and temperature a little lower, I will add 10% to the estimated current stream flows. I will use 1 mm per day as a conservative (i.e., on the high side, so unfavorable for navigability) estimate of Iron Age winter-time E-T.

Tinner et al (2016) show, using pollen records from Gorgo Tondo (close to Lago Preola), Gorgo Lungo (North coast, near Cefalu) and three other sites whose exact locations I could not ascertain, that land clearing and fire activity increased at the beginning of the Bronze Age (4500 BP) and the beginning of the Iron Age (2800 BP, 800 BCE). Under natural conditions, most of the Sicilian mountains below 700m were covered by deciduous forests dominated by Quercus (oak and live oak) species, Fraxinus (ash), elm and ivy.

Therefore, as the Iron Age went on, and especially after Greek colonization of the coast, forest-clearing operations in the uplands and the spread of agriculture in the lowlands would have destabilized the landscape, leading to rapid erosion, silting up of the channels, and increasing loss of base flow and occurrence of flash floods, thereby destroying navigability

3. NAVIGABILITY OF THE RIVER, OR OF THE ESTUARY?

This study was originally focused on the navigability of the rivers. But I wondered why there was no published evidence in English for deep incision of their lower reaches during the lowered sea levels of the glacial periods. These low stands reached, in the Mediterranean, 110-115 m below present m.s.l. (Lambeck and Bard, 2000), and more specifically, in this area -125m (Lodolo et al., 2020) (see Figs. 4 & 45). This lack of evidence is presumably because of a lack of published deep boreholes along the river courses. It also seemed clear that the reason that the Mazaro today provides a much better harbor than do any of the bigger streams along the coast, was that it carries much less sediment (due to its smaller catchment), and therefore has not succeed yet in filling up its glacial valley all the way to the coast. A glance at an old map suggested that both the Mazaro and the Arena had substantial estuaries as late as the early sixteenth century A.D., whereas both harbors of Selinunte were at the mouths of very minor streams, as was that of Agrigento (Fig. 46).

I hypothesized that the smaller streams had good harbors in the Greek period and in some cases for long afterwards, whereas the larger streams had filled in their valleys to the coastline long before the Phoenicians and the Greeks got to Sicily. I further hypothesized that the Greeks, where possible, founded their cities on a harbor that had access to a much larger river that could serve as a route inland. The Mazaro is a special case because of its long gorge extending into the hinterland: this was potentially a strength because it saved 10 km of overland transport, but a weakness in that it provided many strong locations for even a weak enemy to interdict trade on the river. If these hypotheses are correct, the importance of the

Mazaro may not have lain in its ability to serve as an easy trade route, but in the excellent port at its mouth, or in some optimal combination of the two.

3.1: Evidence from Old Maps:

I have compiled as many old maps of Sicily as I conveniently can: most maps from the sixteenth century are not helpful, as they seem either to derive from Pomponius Mela, or to be very confused about the geography of Sicily, so that it is not possible to be sure of the location of Mazara on the map. However, Matthias Quad (of Cologne)'s map of 1594 (Fig.47), though with some issues such as the large island directly off Marsala, the islands along the coast between Marsala and Cap Foetas (Feto) and the location of Moharta south-east of the Salemi (Grande) River, clearly shows Mazara between two river systems, one of which is the Arena, whose course is rather accurately represented. The other, much smaller river has two tributaries, like the Mazara, the eastern one sourced at Rapicalidus fons and the western at Sanagia fons: unfortunately neither of these two places can be identified on today's maps. At Selinunte there is some confusion about the relative sizes of the Cottone and the Modione ("Madinus fl.").

The important thing about this map is that it shows "lakes" associated with the Mazara (a widening of the river behind the coast), the Arena (which has a very wide mouth and a lake off its west bank, and the Modione, whose source is a large lake inland. The map shows no such features elsewhere in Sicily, so I think they were real, and I think (though it would be hard to prove) that they are shown, and shown connected to the sea, because they were in some sense navigable. Maps from 1635 (William Bleau) and 1692 (In Coronelli's Atlante Veneto, v.2) both show the same features, perhaps copied from Matthias. Ortellius (1624) shows no inland bodies of water, but then neither does he show the Belice R. In 1700 Mortier shows no lake on the Mazara but a big one near the mouth of the Belice. After that all signs of harbors disappear, except that the 1870 British Admiralty chart shows the Mazara and Modione as larger rivers (they are given a width rather than just a line: I think that probably means that someone took a ship's boat up them) than the Arena and the Belice.

3.2: The South Coast of Sicily since the last Glacial Maximum:

At Glacial Maximum there were two large areas of dry land, one south of the coast between Marsala and the mouth of the Belice (the Adventure Plateau), and the other connecting the southern corner of Sicily to Malta (Fig.45). Only between the Belice and Gela was there any "south coast" of Sicily. When it reached the sea the Belice probably turned east towards Gela (Fig.45) and the Arena and Mazara turned west towards Marsala (Fig.45). The Marcanzotta turned north and drained directly to the Tyrrhenian.

However (Fig.48) the slope of the land down to the Glacial Maximum shoreline was basically the same as that of the exposed Pleistocene Marsala calcarenites, much steeper than the usual lower courses of rivers. Thus, the rivers began to cut down to the new base level: a detailed map of the sea floor off northern Malta shows canyons cutting the lower slope but, contrary to my expectations, they do not seem to be very deep. Similarly, buried valleys mapped on the New Jersey continental shelf (Norfjord et al., 2005) are only 10 m deep, but here the continental shelf and upper slope have very gentle gradients. The deep glacial valleys that one hears about in northern Europe are apparently all carved beneath ice sheets, and so are not to be expected off Sicily. However, very deeply incised non-glacial Pleistocene valleys are known: those of Cornwall and Brittany and the Rias of NW Spain are famous. This is a key question, and I am still searching for work that has been done in Italy, and especially, Sicily.

In the absence of hard data, I have extended the profiles of the Arena, Mazaro, and Marcanzotta to the seafloor at 125m depth (Figs. 49, 50, 51), and tried to plot the geology on the profiles – always a risky thing when one only has a regional map to work from.

The results are as follows:

1. The Arena/Délia Drainage:

   The Arena seems to have been graded to the Late Glacial sea-level, and to have built a delta out as sea-level rose. However, post-glacial erosion (using the numbers derived from sedimentation in Lago Trinitá in Section 2.2.3e(1) above, p.21) can only account for 40% of the volume of sediment in the delta, 50% if the contribution of the Mazaro is taken into account. Therefore it is likely that a major part of this delta was built in a previous interglacial (the Eutyrrhenian interglacial stage). However, there are features on the seafloor (including a large area of closed drainage), that appear to be related to the present of the Marsala calcarenite at depth.

   At best in the Archaic era, only the lowest 2.7 km of the river would have been estuarine, and this would have provided little shelter from the wind. There may have been extensive lagoonal areas behind the river's bar, which may account for the "lake" shown on 16th Century maps, as perhaps the lowest 0.5 km would then have still been estuarine.

2. The Mazaro River:

   Since the Mazaro and Arena rivers join about 5 km offshore, the submarine profile of the Mazaro has to match that of the Arena, which is much better constrained. This means (Fig. 55) that the Mazaro flows on the Marsala limestone for almost its entire length, and has been able to break through it for only a very short length onshore and again for a short length offshore, which gives its onshore profile the distinctive downward "kink" at the 20 km mark.

   The Mazaro estuary was therefore no longer in the Archaic era than it is now, having been only about 3.5 km ever. It provides a sheltered harbor now for a distance of about 1.7 km inland, but is at the mercy of the "Mad Sea" phenomenon, which also probably helps keep it flushed of sediment.

3: The Marcanzotta/Cúddia Drainage:

   The submarine channel of the Marcanzotta ends in a "cliff" over a hundred meters high. This is probably upheld by the Marsala limestone. On the shallow shelf above this the Marcanzotta has built out a delta whose volume is 60% percent of the potential sediment supply, suggesting that much of the latter has ended up filling the southern part of the lagoon, due to longshore drift.

   At 2600 BC the estuary would have extended to the foot of the topographic slope (3.8 km inland), where further progress may have been impeded by rapids where the river crossed the Marsala limestone outcrop.

3.3: Comparanda:

3.3.1: Agrigento (Fig. 40):

Agrigento sits behind the Hypsas/Drago and Akragas/S. Biaggio rivers, and is 3 km from the sea at S. Leone as the crow flies. The mouth of the merged rivers is protected by hills up to 40m high, behind which there was an Emporium in antiquity. The Temple of Aesculapius is 1600 m from the Valley of the Temples and may have been reachable by river in antiquity: it is 3.4 km from San Leone by river. However it is more likely that the head of navigation was where the two rivers join, 1.7 km from the sea and only 7 m above sea level now. The plain on which the rivers flow, and which is directly overlooked by the ancient city, is clearly an old alluvial fan whose apex was at about 50m above sea-level, and which has been incised 20 m by the two rivers, probably in the late Pleistocene. The lower valley of the two rivers appears to be an active alluvial plain graded to an elevation present m.s.l., with reclaimed land extending about 750 m inland from the present beach. The present estuary appears to extend to the second weir, 600 m by river or 300m as the crow flies from the beach, so my guess is that the river was navigable by small craft in Antiquity as far as the junction of the two rivers, 3.4 river km from the sea.

Both of the small rivers provide valleys suitable for travel into the near interior, perhaps 10 km upstream from Agrigento, but this would have been mostly overland, so Agrigento's main role was probably as a harbor and transshipment point for trade to the interior.

3.3.2: Eraclea Minoa:

This is the least clear-cut situation, because the Antique city sits high up on a bluff that is somewhat closer to the mouth of the Plátani (700m) than it is to the insignificant little stream whose mouth abuts the southern side of the modern village (1100m). Both potential harbors are protected from southerly storm winds, but only the one south of the village is protected from northers. As far as I know there are no surviving remains of a harbor at either place. The 'insignificant stream' would have carried little sediment, but also would have had no place to store it before filling up its mouth. The estuary of the Plátani currently extends inland for 2.7 km, or 4.3 km by river, but is hemmed in closely by reclaimed lands. Very high sinuosity meander scars are visible in these reclaimed lands, and "modern-style" land-subdivisions extend 7 km inland.

Eraclea Minoa was sited to control this route inland, but its harbors seem to have been deficient. Also, even today there are no large towns in this hinterland, so perhaps little trade with Eraclea was possible. It is also possible that Agrigento "controlled the territory".

3.3.3: Selinunte:

Selinunte is situated on a high, cliffed, bluff at the seacoast, giving it security, but perhaps not as much as had Agrigento, which was hidden behind coastal hills. Selinunte also has two small rivers, the Cottone to the east and the Modione to the west, each with a harbor, though the harbors are poorly documented. The harbors are actually adjacent to Selinunte. There are nineteenth century photographs that show water in the Modione extending up to the Temple of Jupiter, so it was perhaps only straightening and embanking of the river that eliminated its potential for a harbor (Fig.52).

Selinunte also had easy access to the Belice River, the largest along this coast, and the one that provides easiest access overland to the north coat, a route that was apparently well-guarded by the Elymians

The settlement was definitely established to support trade up the Belice River.

3.3.4: Motya/Marsala.:

These two places appear to be completely different from the Greek cities, but the underlying realities are the same. The Antique city is on the defensible island in the lagoon, whereas the Greek cities are on defensible hills near the coast. The fact that the Phoenicians chose an island with no hills suggests that they actually beached their ships during storms. The lagoon is partly related to an ancient delta of the Marcanzotta River, but is also related to longshore currents created by the presence of Isola Fanignana offshore. The fact that it is a lagoon behind a barrier island suggests that sea level has risen slightly since the original delta formed, perhaps 6,000 years ago. There is a much larger older (Tyrrhenian, or pre-last glaciation) delta at Salinagrande, related to a very small river that seems to have had the major part of its drainage captured by the Marcanzotta in fairly recent times (the divide between the two is less than 10 m above the current level of the Marcanzotta). Before the land on which the airport sits was drained, the Marcanzotta may have drained into an extension of the lagoon, providing the Phoenicians with an easy and easily controlled route inland.

There is a major constriction on the Marcanzotta as it passes through the cuesta, 6.5 km from the sea, and my guess is that this was silted up or impeded by rapids several centuries before the Phoenicians arrived. The raison d'être of Motya would have been salt production and trade up the Marcanzotta/Cúddia, possibly for timber to build boats, if that was short on the North African side of the Straits of Sicily.

3.4: Conclusions:

This section demonstrates that it was more important to the Phoenicians and Greeks to have access to a secure port than it was to have immediate access to a navigable river, and that the small rivers of the coast, including the Mazaro, provided these small harbors because their sediment load could not keep pace with the post-glacial rise of sea-level.

Any inland riverine transport would have to have been on very small boats, and only in wintertime, and these could not get within about 15 kilometers of Mt. Polizzo. Summertime transportation would have to have been by porters, animals, or wheeled vehicles.

Swamps were probably as extensive in the Archaic period as they were in the early modern age, and so the use of the rivers in summertime would have been unwise on health grounds (malaria, etc.)

From the Elymians point of view, the Délia was the most useful river, and could be used for transporting heavy goods such as logs. The Cúddia would be the next most useful, and the Elymians would therefore have been able to play the Phoenicians off against the Greeks when it came to timber and firewood exports. It is hard (for me) to envisage struggling up any of these rivers against the flow and with no tow-path through the dense riverine vegetation.

These arguments lead to the conclusion that all trade during the eight or nine months that the rivers did not have sufficient flow would have been on tracks or paths, and therefore trade in perishables (the sheep and goats that the Elymians kept on the slopes of M. Polizzo), or valuables (the wine brought in amphorae to M. Polizzo). In that regard, there must have been waystations for the succor of the traders. It is a one-day unencumbered journey, or two days with pack animals or herds from M. Polizzo to any of the coastal settlements, and in dry weather the tracks would be easy – it is possible to pick routes that avoid most hills.

4: RESULTS & CONCLUSIONS

4.1: Total Stream Flow

3.3.1: Estimation of present water flow, Q:

I present tables and graphs of the flow of each river estimated at points just below the junction of each major tributary (Figs. 53-56). The curves for the Delia and Cuddia are stepwise: this is because there is a big jump at each tributary junction, and only slow increases between junctions. The Mazara has only one major tributary, and that is low down in its course, so I have presented its flow as a smooth curve.

These graphs are developed for October, November and December only – a “strategic decision” that turned out to be wrong because of the extra delays that thicker soils and a forest cover would introduce into the hydrologic system. I do not think they will make a huge difference to the conclusions.

Each graph shows the curves for all three months superimposed, and shows my “crude” estimate as a solid line in a specific color for each month. The estimates based on Puma, Valeria and Noto’s statistical model are presented as dashed lines in the color assigned to each month.

It is clear from these graphs that the model systematically shifts flow from the beginning of the rains (October – the dashed line is below the full line) to later in the rains: the December dashed curve is far above the continuous line for the month. The same phenomenon is perhaps even more clearly shown in Figure 57, which directly compares both methods. The total amount of flow predicted for the three-month interval does not seem to be much different: the area between the curves on the left side of the crossing point in each case being the same as, or only a little smaller than, the area between them to the right of where they cross.

4.2: Winter-time Base Flow

I have tried to demonstrate that there was sufficient time after the creation of the present topography of western Sicily to form a blanket of soil at least 2-5 m thick across the whole area (less on limestones, more on marls), and that this layer would have remained largely intact as long as the area remained forested. Records of sedimentation in the Trinitá Reservoir demonstrate that, at present rates of loss, about 4.5 m of soil have been removed from the area since the beginning of the Iron Age, leaving only rare pockets of anything but the most immature soils, as confirmed by the descriptions of Sicilian soils given by Venturella (2004) and Costantini et al. (2013).

The loss of soil has resulted in the loss of a steady base flow in the rivers, and their conversion into flashy torrents. The variability in pore size and shape in a soil lead to local variations in drainage rate (between adjacent pores) of as much as three orders of magnitude which, as the soil gets thicker, has the effect of greatly increasing the amount of time that it takes to release its water. Since a two-month moving average smooths out much of the irregularity in the rainfall curve (see Figure 33), once the soil is thick enough to retain substantial moisture for more than two months, base-flow throughout the winter is assured.

4.3: Adjustment to Iron Age Conditions.

The arguments in 3.4 allow us to consider Iron Age winter-time river flow as constant in a normal year, and thus we can use the mean monthly flow for all calculations. This constant base flow is essential for any regular navigation.

To allow for the evidence of slightly more rain and slightly cooler temperatures, I have re-run all calculations with 10% increased rainfall.

4.4: Creation of methodology of universal application:

3.4.1: Flowchart:

1. Measure stream profile

2. Calculate stream gradient.

3. Determine catchment areas of the mainstream and its important tributaries.

4. Use nomograph to determine discharge necessary for navigation at significant points along stream (tributary confluences, settlements, etc.)

5. Obtain long-term monthly rainfall data for the area

    5a. Obtain one or two years of daily rainfall records

6. Obtain daily hydrographs for the streams of interest

7. Calculate thresholds and response times of stream flow to rainfall (i.e., how much rain does it take to cause stream to flow, and how does flow vary with rainfall above that point?)

8. Determine the p=90 and p=75 recurrence intervals for above-threshold monthly rainfall.

9. Try to determine the ground cover at the time of interest (and before the time of interest if it is necessary to calculate the amount of erosion).

10. Try to determine what the changes in rainfall and temperature may have been in the area since the time of interest.

11. If it is not obvious, try to discover the agricultural history of the area, and its consequences for soil destruction.

12. Obtain as much information as possible about the soils of the area: maturity, thickness, permeability, hydraulic conductivity.

13. Determine the presence of any known mature paleosols in the area.

14. If possible, measure their thickness, porosity, hydraulic conductivity.

15. If no good paleosol information, determine the length of time that the area has been above sea-level and tectonically quiet, and calculate the depth of soil that could have formed since then, using rates of chemical weath ering published for similar environments.

16. Ascertain probable erosion rates through time (from reservoir siltation rates, delta build-out rates, etc., ^{10}Be dates, archaeological evidence, etc.

17. Try to estimate the probable thickness of the soil profile at the time of interest.

18. Determine the amount of water they could have released at the end of your p=90 threshold rainfall recurrence interval.

19. Would the soils still have been yielding enough water to maintain a navigable base-flow at the end of this interval?

20. Use the spread sheets provided to calculate the flow at each point along the stream. Determine the highest point of navigability.

21. Repeat for p=75 recurrence interval if necessary.

4.5: Tools provided:

Nomographs for Channel Width, Channel Slope and Stream Volume (on arithmetic [Fig.16] and log-log [Fig.17] graph paper.

Figs.16 & 17show the relationship between channel width (and hence channel cross-section), the stream volume, Q (in cubic meters per second) and channel slope (in meters of vertical fall per kilometer of channel length), calculated for stream velocity of 3 ms-1, and channel widths greater than 1.5 m, our arbitrary cut-off for navigability. Fig. 17 shows the same data, plus two lines from Luna Leopold's (19940 publication, but plotted on log-log graph paper. This converts the curves to straight lines, making it much easier to read off values.

These charts are universally valid and can be used in any environment to assess a stream's potential navigability once the minimum channel size consistent with navigability has been chosen. They can be recalculated from Equation 2 for any maximum current speed that is selected. They are valid unless the stream bed is exceedingly rough (boulders) or exceedingly smooth (clay with no tree roots or pebbles), since the results are relatively insensitive to the value of k, the roughness, and to the channel shape in cross-section.

To use the charts it is first necessary to have settled on the criteria for navigability in terms of stream width and current speed, in our case 2m and 3 ms-1. Then select the point on the stream at which navigability is to be determined. First determine the average stream gradient in this reach, using a stream gradient profile that has been constructed as described above (Methodology/Stream gradient Profile), and then estimate the flow that would have been available in the past (see below) under various assumptions and conditions. Enter each flow volume on the X-axis and trace this value upwards to the proper stream gradient curve. Determine the value of this point on the Y-axis: this is the stream width for this flow volume and 3 m/s current. If your condition for navigation is a stream width greater than this, your stream is unnavigable with this gradient. It may be navigable if you can feed more water into (e.g., by using winter flow instead of year-round average), or if you can use a lower gradient. Both conditions can usually be met by making the measurement further downstream.

A lower bound to the graph is imposed by channels so narrow that the maximum water velocity for navigation is exceeded at a given slope and flow volume (Q). For a channel slope of greater than 15m/km there are virtually no combinations of channel width and flow volume for which the current velocity is less than 3 m/s. There is no upper bound: the lower the slope the wider and deeper the channel for any given flow rate: the graph could be extended upwards and to the right to calculate navigability for large ships on very large rivers with very low gradients.

5. RECOMMENDATIONS:

I have not found in the literature reference to any study that has attempted to systematically examine each aspect of the past hydrology of Italian rivers that would have affected their navigability in ancient times. Much of the information required to do this kind of study may only be available locally, as detailed below. Other information must be drawn from such a wide array of disciplines that it is very difficult for one person to access all the necessary information or skills: these disciplines include, from "heaven to earth", climate science, meteorology, agricultural science, geomorphology, hydrology, soil science, geohydrology and geology, as well as a passing familiarity with archaeology.

5.1: Records Searches:

This study could have been considerably improved (at considerable coast in time and resources, though) had I had access to much more detailed, lengthy and geographically denser meteorological records. These must be available in Sicily.

The study would have benefited even more from more detailed hydrological information: records and compilations from gauge stations in the area. These also must be available in Italy. The same is true of soil science and agricultural science: there are research stations in the area that must have a vast amount of information on evapotranspiration, irrigation practices, and so on that is directly relevant.

5.2: Field work:

The most urgent problem is to ascertain, not just in general, but in some detail, how much soil was present, and how much is left. It is clear from many sources that Sicilian farmers are essentially "ploughing bedrock", but much more detail on what that means is needed, in particular for areas where the bedrock is young and unconsolidated. Much more information is needed on possible paleosols and their characteristics.

It turned out very useful to have information on the channel of the Mazaro River. Channel size is determined by the "1.5-year flood", which in Sicily seems to be about 23 times the volume of the mean monthly flow. Since channel size is the most likely hydrological feature to be investigated archaeologically it may turn out to be one of the most important things to map systematically in the field.

6: CONCLUSIONS: NAVIGABILITY OF RIVERS

6.1: Delia:

The Delia was navigable up to a point 27 km from the sea – only 13 km from Monte Polizzo.

6.2: Mazaro:

The Mazaro was navigable only in months that were unusually wet. And only for the last few kilometers to the sea: essentially the estuary.

6.3: Cuddia:

According to the Nomogram of Fig 47, navigable for 17 km up from the mouth, or halfway to Monte Polizzo.

6.4: Caldo:

No detailed calculations made, but it is clearly navigable now to the hot springs near Segesta (see Figures 44 & 48).

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APPENDICES:

I: END NOTES ON GEOLOGY.

1. During the Messinian epoch at the end of the Miocene period, about 6 million years ago, the Mediterranean Sea dried up repeatedly, leading to the deposition of thousands of feet of salts such as Anhydrite, Halite, and Sylvite (KCl), which is mined in south-central Sicily. The surface rocks of Sicily have been pushed ("thrust"), as a result of the convergence of Europe and Africa, from the north across these evaporite deposits, severely deforming them. Where the evaporites are brought close enough to the surface to be exposed to rainwater they dissolve rapidly, forming underground channels and caves similar to those found in limestone terrains. When large caves collapse they form surface depressions known as sink holes or "dolines": there are at east eleven of these around Vita. All rainwater falling in such a "karst" area passes underground to large springs at lower elevations. The presence of large hot springs such as the ones at Terme Segestana on the F. Caldo suggests either very deep circulation of this groundwater, or the presence of hot rocks at shallow depth.

2 (Page 19): My interpretation of the capacity of a mature soil profile to hold water is based on 6 years of experience of logging 6-8 hand-dug prospecting pits in Zambia every day. The soils were not *Terra Rossas*, but they were residual soils (i.e., they were derived from the rocks immediately beneath them, not from sediments washed in from elsewhere). They were probably less clay-rich than Mediterranean *Terra Rossas*, as they were derived from more sand-rich rocks. The "A" Soil Horizon was on average about 3 m thick, and was underlain by a lateritic rubble zone of varying thickness, below which was the "B" Horizon of about 5 m thickness. This graded down into weathered bedrock (the "C" Horizon). At the end of the dry season, the water table would be a meter or two below the top of the "C" Horizon, say at 10 m depth. When the rains began, a new saturated zone would form at the surface and gradually move downwards, joining with the old water table about two months after the beginning of the rains.

At this point the water table in the pits would suddenly rise approximately 5 m, and the seasonal watercourses would begin to flow freely. The shallow part of the soil profile at no point became so saturated that it "wept" into the pits; the soil near the downward-moving front was, however, saturated to the point of weeping.

II: KEY TO TERMINOLOGY

Bankfull (flow in a stream):

Base flow (of a stream): The portion of stream flow that is not runoff and results from seepage of water from the ground into a channel slowly over time. The primary source of running water in a stream during dry weather. In this report I will be focusing on the winter-time base flow, because in the Mediterranean climatic regime of hot, dry summers and cool, wet winters, there is often no base flow during the summer – the streams dry up. (https://www.oregon.gov/LCD/docs/publications/wqgbglossary.pdf)

Base level: the vertical datum to which a stream profile is graded, and below which therefore erosion cannot occur. Worldwide, mean sea-level is the ultimate base-level, but lakes commonly provide local base levels for the streams that feed them. Sills of very hard rock and junctions with tributaries can provide temporary and local base levels.

Borrow-pit: a small excavation from which soil or rock has been removed for local use as, for example, road-metal, foundation fill, or field dressing.

BP: Before the present. The usual geological approach to dating, especially radiometric dating, in which the year zero is roughly 1950 AD

Calcarenites: Carbonate rocks (i.e. rocks consisting of CaCO3 [limestone] or CaMgCO3 [dolomite]) whose individual grains are sand-sized (i.e. have diameters between 0.006mm and 2.00mm. They are formed on beaches.

Cuesta: The steep slope of a ridge underlain by gently dipping rocks. The gentle slope, which slopes in the same direction as do the underlying rocks, is called the "dip slope".

Divide: see watershed.

Doline: A sinkhole. The word is often used in technical literature and is a Slovene word from the Karst area. It often seems to imply a larger feature than does the term sinkhole.

Eustatic: Eustatic changes in sea level are world-wide and are those caused by changes in the volume of the ocean itself (e.g., by the melting of ice caps) or by changes in the depth of the ocean (e.g. by the consumption of deep ocean crust at subduction zones). They are independent of local tectonic movements, which must be added to eustatic changes to arrive at local changes of sea level.

Eutyrrhenian stage: roughly 120k.y. BP (120,000 years ago).

Evaporite: a rock composed of minerals that are precipitated as sea or lake-water evaporates. Usually the first such mineral deposited is dolomite, but it is not usually thought of as an evaporite, as it requires only 10% evaporation. Gypsum crystallizes at ~80% evaporation), and halite (salt) at (~90% evaporation). Sylvite (KCl), carnalite ($KMgCl_3.6H_2O$) and langbeinite ($K_2Ca_2Mg(SO_4).6H2O$), which require much more concentration of sea water, and are therefore known as "bitterns", are typical minor components of marine evaporites.

Evapotranspiration or **E-T:**_the total rate at which water is lost to the atmosphere both directly by evaporation from the soil surface and indirectly by transpiration from the pores (stomata) of plant leaves.

Flashiness (of a stream): tendency of the stream to flood violently after heavy rain but to have very low flow for long periods between rains.

Gradient (of a stream): the slope of its bed, measured in meters/km.

Graded Stream: one which is everywhere along its length is in equilibrium, tending neither to erode its channel downward nor to deposit material to raise its channel.

Groundwater terms:

Cone of Depression (or **withdrawal)**

Phreatic Zone: the water saturated soil and rock below the **Ground Water Table.**

Vadose Zone: the unsaturated soil above the water table. It absorbs moisture from precipitation: some of this is re-evaporated in dry weather, some is used by plants, and some moves downwards to the water table and eventually becomes available to streams.

Holocene: the last 11,000 years of the Earth's history, marked by the disappearance of the polar ice-caps and the rise of sea-level to close to present levels.

Infiltration Capacity of a soil: maximum rate at which water can be absorbed by a soil per unit area.

ka: Geological notation for "thousand years".

Lacustrine: sediments laid down in lakes.

Knickpoint (of a stream): place on a river or channel where there is a sharp increase in channel slope. Lowering of sea level, or faulting, can cause the stream to start deepening its valley, initiating a knickpoint that then travels slowly upstream over time. However, knickpoints can also be due to change in rock type, change in the stream load, or the entrance of a tributary (ODES).

Ma or **m.y.**: geological notation for "Million years".

Matric (or matrix) potential: Soil matric potential (SMP) is a realistic criterion for measuring soil water availability to plants as it constitutes the force with which water is held by soil matrix (soil particles and pore space) and is measured by tensiometer (q.v.).

Manning's Equation: an empirical formula estimating the average velocity of a liquid flowing in a conduit that does not completely enclose the liquid, i.e., open channel flow. All flow in so-called open channels is driven by gravity. It was first presented by the French engineer Philippe Gauckler in 1867, and later re-developed by the Irish engineer Robert Manning in 1890.

Nomograph: A nomogram consists of a set of n scales, one for each variable in an equation. Knowing the values of n-1 variables, the value of the unknown variable can be found, or by fixing the values of some variables, the relationship between the unfixed ones can be studied. The result is obtained by laying a straightedge across the known values on the scales and reading the unknown value from where it crosses the scale for that variable. The virtual or drawn line created by the straightedge is called an *index line* or *isopleth*. (Wikipedia). Fig. 21 is a kind of pseudo nomograph very frequently used in Geology to solve equations in 3 variables.

Notation: I have used exponential notation for units. E.g. ms^{-1} = m/sec = meters per second.

Oxygen Isotope Stage 3: Roughly 57,000 yrs ago, or 60 k.y. B.P.

Paleosol: an ancient soil profile, now buried beneath younger deposits, usually because sea-level rose, but occasionally, as in SW Sicily, because a climate change led to the burial of the soil by sand dunes. The ancient soil profile is often incomplete, either because there was not sufficient time for it to fully develop, or because erosion accompanied burial, and removed the upper part of the profile.

Phreatic Zone: see **Groundwater Terms,** above.

Pore throats: the narrow spaces connecting two larger pores, or spaces between the grains, in a granular rock. The number, size, and distribution of the pore throats control many of the resistivity, flow and capillary-pressure characteristics of the rock.

Potentiometer: a probe with two exposed conductors which acts as a variable resistor whose resistance varies according to the water content in the soil. This resistance between the two conductors is inversely proportional to the soil moisture.

Reach of a stream): a length of stream with similar characteristics of gradient, velocity, etc.

Ria: a deep estuary formed by the drowning of the lower reaches of an incised stream valley by post-glacial sea-level rise. Rias are typical of the coasts of SW Britain, Brittany, and NW Spain: the word is of Spanish dialectical origin. They also occur in the US Pacific NW and in the Canadian Maritimes. Rias are not as deep as fjords and are not usually girt by such high and rugged mountains.

Roughness: in its technical sense a measure of the friction between the water in a channel and the material lining the channel. It is very difficult to measure in natural channels, but is related to the size of the gravel, etc., comprising the stream bed. The units of the roughness coefficient are length m).

Sheet-wash: A geomorphological process in which a thin, mobile sheet of water flows over the surface of a hillslope and may erode and transport the surface regolith. It is important in semi-arid regions, and may also be significant in temperate zones if the vegetation cover has been removed. Downslope the sheet of water often gathers into channels or gullies, and then becomes a damaging debris- or mudflow

Sink, or **Sinkhole:** a pit or gash in the bed of a stream down which water disappears to enter an underground cave system. They are characteristic of limestone and evaporite country, causing streams to normally be much smaller in these areas. However, when the sinks are overwhelmed by a flood, the water level downstream can rise very suddenly as a "flash flood". See *flashiness*.

Soil Nomenclature:

Lithosol: A thin soil consisting mainly of partially weathered rock fragments. The summit ridge of M.Polizzo is underlain by vertisol.

Regosol: A very weakly developed mineral soil in unconsolidated materials. Regosols are extensive in eroding lands, in particular in arid and semi-arid areas and in mountain regions. This is the soil left in Sicily after the extensive erosion that gives rise to the saying that the Sicilian farmers "plough the bedrock".

Vertisol: Has a high content of expansive clay minerals that form deep cracks in drier seasons or years. This alternate shrinking and swelling may cause *self-ploughing*, where the soil material consistently mixes itself, causing some Vertisols to have an extremely deep A horizon and no B horizon. (A soil with no B horizon is called an *A/C soil*). Vertisols typically form in climates that are seasonally humid or subject to erratic droughts and floods thatt impede drainage. Depending on the parent material and the climate, they can range from grey or red to the more familiar deep black. These soils are very common on the gypsiferous clay rocks of this part of Sicily, where they form very unstable slopes.

Soil Horizons (see Figure 39); there are various terminologies, but the one that I am familiar with, and I think the most used, is as follows:

'O' Horizon; the organic litter layer.

'A' Horizon: The zone from which clay particles are 'illuviated' downwards towards the 'B' Horizon. Thoroughly penetrated by roots and burrowed and mixed ("bioturbated") by organisms of all sizes. May be called the topsoil in temperate humid climates, but in warm and/or dry climates) it may be very thick and essentially inorganic in its lower parts.

'B' Horizon. The zone of accumulation. In all climates clay accumulates here, but in humid climates iron accumulates as a hard Laterite layer, termed the B_0 horizon. In dry climates quartz accumulates as silcrete, or calcite accumulates as 'caliche' or calcrete in the B_0 horizon. The B horizon marks the upper limit of capillary action in the dry season, and is formed by the collapse, illuviation and perhaps bioturbation of the 'C' horizon

'C' Horizon (or, in the SE USA, the Saprolite). This consists of weathered bedrock that still shows the original rock structure. However, all minerals except quartz have weathered to clay, and the material is very light (bulk dry density ~ 1.2). Its upper surface is very irregular, and it gradually becomes solid bedrock (sometimes termed the 'D' Soil horizon!) downwards.

Speleothem: a structure formed in a cave by the deposition of minerals from water, e.g., a stalactite or stalagmite. Because they are built up of annually deposited thin layers, each of which can be dated and analyzed chemically to yield information on climate (temperature and rainfall), they have become very important to geologists in the last few decades.

Stream: a general term in geology and hydrology for a natural river of any size, from brook to the Amazon

Synthem: a major stratigraphic unit that is unconformity-bounded. In Italy there seems to be a tendency to use this word to replace the old term "formation" See also "Unconformity"

Transpiration: the release to the atmosphere of water vapor by photosynthesizing plants.

Unconformity; a lithologic contact at which there is some interval which may be very short or very long, of missing time. They are recognized because the beds below the unconformity are truncated by the ones above (an angular unconformity caused by folding of the earlier rocks before the later ones were deposited, or strata known elsewhere to lie between the rocks above and below this contact are missing (a disconformity), or age dates above and below the surface may show a missing interval of time. In western Sicily due to ongoing tectonic movements, almost all major lithological contacts represent unconformities.

Vadose Zone: see **Groundwater Terms,** above

Watershed: used here in the American technical sense. The area drained by a stream and its tributaries. The boundary between two watersheds is a Divide (in the UK this is the Watershed, which separates two Catchments).

Wave notch: a notch cut into a cliff by breaking waves after a rise in sea-level. They are quite common in NW Sicily.

Xerophyte: a plant adapted to growing in dry or desert conditions.

III: LIST OF FIGURES WITH CAPTIONS AND ATTRIBUTIONS.

Fig.1: Watersheds of Western Sicily. Yellow = Mazara watershed; orange = Delia/Grande watershed; green = Cuddia watershed; red = Caldo watershed; blue = Freddo watershed. Streams whose profiles were measured are shown as thick colored lines. The purple area east of M. Polizzo is an area of internal drainage, or karst area. Base map courtesy of DeLorme through ArcGIS Explorer. **On p.2**

Figure 1: Soils Map of SW Sicily. Soils are in general controlled by geology. 1: Lithosols – Rock outcrop. 3. Regosols on gypsum (area around Vita). 4: Regosols on sandy and conglomeratic rocks (see south flank of M.Polizzo). 5. Regosols on clay rocks. 8: Vertisols. 9; Lithosols - Red Mediterranean soils. 10: Brown soils related to #9. 14: Brown regosols. 21: Alluvial (depositional) soils. For definitions of soil terms, see Appendix I: Key to Nomenclature. Map is from Ballatore and Ferrotti, 2011.**On Page 5.**

Figure 2: Various kinds of functions can provide a close fit to stream profiles: here exponential, power, and logarithmic functions are regressed against a typical data set. The fits are all close, but not exact (from Snow and Slingerland, 1987). **On Page 5**

Fig. 4: Comparison of Longitudinal profiles of the Mazara, Modione, Délia-Grande, Cúddia and Caldo Rivers in western Sicily. None of the rivers are perfectly graded, as shown by deviations of their profiles from an ideal curve. This is due to the youth of the Sicilian topography and ongoing tectonic activity. Note that the average gradient roughly corresponds to the area of the watershed (cf. Fig. 1). **On page 5.** ***(Redrafted, May 2021)***

Fig. 5: Craft capable of navigating a stream 2m wide and 90 cm deep.

Fig.5a: A small trading boat (a *Rabelo*) of perhaps 1.5m beam and 40 cm draft used for negotiating rapids on the upper Douro River, Portugal, with cargoes of wine bound from the vineyards upstream to Oporto. The long sweep at the stern is hand steered by three men at once to guide the boat through the many rocky rapids on the approximately 80-mile journey *(Photo courtesy Henry McCown,2016, photo #20160912_080230)*

Fig.5b: A Delaware Railbird Skiff, which is a double-ended punt 15.5ft x 4.5ft with 1 ft draft. (4.7m x 1.37 m, 30 cm draft) used in salt marshes to carry two people while hunting waterfowl. Downloaded on 2016/11/01.from http://traditionalsmallcraft.com/Railbird.html. **On page 5.**

Figure 6: Relative Sea-Level curve derived for the Adventure Plateau off the coast of SW Sicily. This curve is corrected for uplift in the area onshore and offshore between Mazara del Vallo and Sciacca. The vertical red line represents the period of occupation at M. Polizzo. Fig. 6 in Lodolo et al., 2020. **Referenced on Page 5.**

Figure 7: Climate zones in the circum-Mediterranean Area. 1= present day limit between humid and arid zones; 2= northwards limit shift during multicentennial warm periods (enhanced Greenhouse Effect); 3= southwards limit shift during multicentennial cold periods (Little Ice ages). (Fig.3 in Ortolani et al., undated). **Referenced on Page 6**

Figure 8: Evidence of climatic variation at Selinunte. Climate variation_at_Selinunte: the photograph shows a layer of windblown sand from the period 1100-1270AD covering an organic soil horizon from

400-1100AD, and refers to a similar underlying couplet with an organic soil developed be-tween 700BC and 150 AD buried by sand (which also buried the buildings) deposited 150-300AD. Fig.4 in Ortolani et al., undated. **Referenced on Page 6**

Figure 9: Lithologic Map of Western Sicily. The arrow with the notation “2.4” (referring to the legend below) points to the karst area at Vita. M. Grande (blue star) is shown as 2.1 (chalk) when it should be shown as 3.1 (hard limestone). From Fantappié et al., 2015, Fig.2. **Referenced on Page 6**

Figure 10: Possible sinkhole (indicated by arrow) on Mazara River at 26.3km. Google Earth Image of 2013-4-14. **Referenced on Page 6.**

Figure 11: View up the Mazara Valley showing old erosional surfaces. The oldest and highest, ‘A’, is indicated by white urban areas below the two ‘A’s on the right. The third ‘A’ sits on an extension of this surface. The intermediate surface ‘B’ is recognizable as an incised plain sloping towards the observer: this is cut into easily erodible shales and marls. ‘C’ is the current floodplain of the Mazara River, an extremely low relief alluvial terrain in the foreground. ‘D’ is the point at which a major tributary of the Mazara was recently captured by the Agézio, which flows into the Cúddia. Vertical exaggeration: 3X. Screen capture from Google Earth. **Referenced on Page 7.**

Figure 12: Geologic Cross-Section MAZ35. Shows upper reach of Mazara River (35 km from the mouth) flowing in syncline of limestone at a much higher level than the neighboring rivers, which can therefore extend their headwaters by erosion at the expense of the Mazaro’s catchment area. ***(Redrafted 2021/5/6)*** **Referenced on Page 7.**

Figure 13: Mazara River where it enters the gorge that it has cut into the mid-Pleistocene Marsala Syn-them (which I have called the Marsala limes=tone on most figures). Google Earth oblique view looking toward the coast. The calcarenites of the Marsala Synthem were deposited on the shoreline between 1.5 and 0.8 m.y. ago. Since then, they have been uplifted and tilted towards the sea: Outcrops near Salemi (erosion surface ‘A’ in Fig. 12) are 1500m above sea level but at the coastline the base of the formation is 100 m below sea level. Erosion surface ‘A’ in Fig.11 is an uplifted remnant of the surface shown in this figure. **Referenced on p.7**

Figure 14: The remains of an old meander (orange line) are visible in this 2015 Google Earth image on the Marcanzotto River at 37.8624 N, 12.5841 E. The straightened modern course is in cyan. The sequence of land reclamation is often shown by the field pattern: the smaller and less regularly laid out field pattern is old. Large regular fields with narrow strips are newer, and larger rectangular fields the newest (post WWII?). **Referenced on Page 7.**

Figure 15: Demonstration of insensitivity of hydraulic radius to channel shape. ***(Redrafted 2021/05/05)*** **Referenced on Page 8.**

Figure 16: Nomograph for Calculating Channel width from Stream Discharge, Q, and gradient, S. **Referenced on Page 10**

Figure 17: Log-Log Plot of Data in Nomograph of Fig.16, plus Luna Leopold’s compiled W vs D data. This may be used to read off the flow velocity of a stream given the width and discharge or width and gradient in the same way as the nomogram can be used.

Figure 18: Luna Leopold’s compilation of Log. Width vs Log Mean Annual Discharge (Leopold 1994).

Figure 32: Precipitation at Palermo and Castelvetrano, showing that the south coast is much dryer. **Referred to on Page 17**

Figure 33: Monthly rainfall (top) and run-off (Bottom) for the basin of the Freddo River. The correlation between wet months and enhanced stream flow is obvious, but so is the failure of stream flow to last much more than a month beyond a major rainfall event. Blue dots are individual flow readings, the dotted red curve is the best fit curve to those readings (from PUMO, Dario, Francesco VILA and Leonardo Valerio NOTO, 2016. **Referred to on Page 17**

Figure 34: Evapotranspiration by various crops in the Castelvetrano area in late Spring. Note the very high water demand by citrus orchards. From Minacapelli, et al., 2009. **Referred to on Page 18**

Figure 35: Long-term record of daily transpiration by Holm Oak in Portugal (grey data in top row) suggesting that a reasonable wintertime average is about 1 mm H_2O/day. This figure is based on data from 2001-2006, and part (A) shows daily tree transpiration of *Quercus ilex* (n=4) per unit of crown projected area (grey line), and solar radiation (black line). In part D the rainfall anomaly shows the departure each year from the long-term (1961-1990) mean of 669 mm/yr. From Paço et al., 2009. **Referred to on Page 18**

Figure 36: Groundwater drawdown in the Mazara-Marsala coastal area. In coastal areas over-pumping is leading to saltwater intrusion and is causing the streams to run dry. Darker shading indicates a greater degree of salinization, contours indicate drawdown of water table near groups of wells, with height of water table in meters above sea level, and arrows indicate direction of groundwater flow. (From Anonymous, undated, b). **Referred to on Page 19**

Figure 37: Sketch of idealized soil profile and movement of rainy season precipitation through soil: under present conditions the winter groundwater table does not, theoretically, get quite back to its position the previous year: there is a long-term hydrologic deficit. This could be reversed by increased rainfall, the presence of more and better soil, which would decrease run-off, or the presence of a vegetation canopy, which would have the same effect. **Referred to on Page 19**

Figure 38: Freddo River response to precipitation. Both axes are in mm rain per month integrated over the whole watershed. Dividing the numbers on the x-axis by 10 gives the flow in m^3/s^{-1}. **Referred to on Page 20**

Figure 39: Sketch of idealized soil profile, with horizon nomenclature given down right side. ***(Modified May 2021).*** **Referred to on Page 23**

Figure 40: The Mazaro R. drainage, showing how the narrow upper part is about to be captured by a gully (too small to show) draining into the Ricalcata at 'A', and by a small tributary of the same stream (here called the Agézio) at 'B'. At 'C' a small tributary of the Marcanzotto, having already robbed the Marsala R. of its headwaters at 'D', robbed the Mazara od one-third of its drainage area to form the upper Agézio/Ricalcata drainage (outlined by double dashed brown line). **Referred to on Page 24**

Figure 41: Oblique view showing incipient stream capture at 'A' (the same location as in Fig.40). At 'B' stream capture seems less imminent, but there are several signs of slope instability, perhaps due to groundwater seepage, below and to the left of the letter 'B'. **Referred to on Page 24**

Figure 42: Bank full flow and actual flow data for the Mazaro River, Oct. 2015. Note the losses in actual flow below km 34 and km 32 and between km 28.4 and km 20.7. Measurement of the channel cross-section, which represent bank full stage, corroborate these observations, but suggest that losses also

occur between km 30.7 and km. 28. The curve based on predictions from rainfall and size of watershed increases continuously downstream. **Referred to on Page 25**

Figure 43: Karst collapse (‘doline’) at Vita. The water drains through the white area to the right of ‘A’, and above ‘A’ there is a cliff of gypsiferous rock. The town of Vita can be seen on the other side of the doline. **Referred to on Page 25**

Figure 44: Warm water flowing over the weir at Acque Calde, near Segesta (by Giustina Aresu). This order of streamflow easily meets the criteria for navigability. **Referred to on Page 25**

Figure 45; Water depths in the Sicily Channel. All areas in shades of green and yellow were dry land during the last glaciation maximum. The Mazaro and Arena/Délia rivers drained to the north of the Adventure Plateau, (labeled) and the Belice to the south. The Marcanzotta drained directly to the Tyrrhenian Sea. From Ph.D. thesis by Spatola. **Referred to on Page 28**

Fig. 46: Old Map of Agrigento, showing its situation on the Drago and Akragas, rather small rivers that provide limited access to the hinterland. However, they provided a good harbor, now silted in, secure behind the cliffs along the coastline (drawn by Robert Koldewey (1855–1925), from Wikipedia). **Referred to on Page 28**

Fig. 47: The Matthias Quad map of 1594. The islands shown along the coast may have been real sand bars, now attached to the mainland by reclamation of the coastal marshes. Mazara is shown between the Mazara (not separately labeled) and Arena rivers: the former has a widening of its estuary shown and the latter a large body of water behind the coast (again, possibly unreclaimed marshland). Both rivers at Selinunte, the “Madinus” and the (unlabeled) Cottone are shown, the former with a large harbor inland. **Referred to on Page 29**

Fig. 48: The late glacial, now submerged, courses of the lower Marcanzotto, Arena and Mazaro rivers. The Mazaro joins the Arena 4 km offshore. Salmon-colored contours inland at 10m intervals show that offshore slopes are roughly the same steepness as onshore, although there is a “flat’ area between 10-20m above sea level. The area of complex bottom relief enclosed by a yellow line was at first thought to be an eroded delta, but it is now thought to be of structural origin, due to the presence of folded and faulted Marsala limestone. Heavy white dashed lines are the shoreline at Full Glacial according to Spatola (2016), The yellow polygon at the mouth of the Marcanzotto is my interpretation of the extent of its Holocene delta, which overlies an older, larger delta. ***(Redrafted, May 2021).*** **Referred to on Page 29**

Figure 49: Inferred Full-Glacial (20,000 yrs BP) profile of Arena-Délia-Grande river. The interpretation of this profile is complex because of the complex topography of the seafloor, which could be the result of either partial filling of a submarine valley (indicated by profiles “1” and “2”) by marine deposition, or the outcropping of folded Marsala limestone on the sea floor. “1” indicates the upstream Arena profile extended smoothly to the Full-Glacial shoreline. “2” suggests that the lower course of the Arena is flowing on thick alluvium that extends out below the sea as a delta. The small size of the Marcanzotto Holocene delta suggests that “2” is probably not correct. The heavy dashed black lines outline the Marsala limestone, whose folding onshore is consistent with it being responsible for the sea floor topography (heavy solid line). Boxes indicate the timing of the filling of the estuary by alluvium. ***(Redrafted, May 2021).*** **Referred to on Page 29 and 30**

Figure 50; Inferred Full-Glacial (20,000 yrs BP) profile of the Mazaro River. Note that the lower (left side of the figure) is the same as the previous figure because the Arena and Mazaro join 4 km offshore. Explanation same as previous Figure, except that “3” now represents the shape of the actual sea floor. Note that the estuary was largely silted up after 3000 BCE and before 600 BC, when it was the same as today, though wider and not so well blocked by a sand bar. This figure is key to understanding the Mazaro's history, as it shows that its course is mainly on (relatively) hard limestone, but that in its middle course it broke through the limestone about 8,000 years ago. ***(Redrafted, May 2021).*** **Referred to on pp. 29 and 30**

Figure 51: Inferred Full-Glacial (20,000 yrs BP) profile of the Marcanzotto/Cúddia/Collura river. The submerged Marcanzotto is impeded by a sill of hard rock (inferred here to be the Marsala lst.) about 15 km offshore. It then plunges very steeply to the full-glacial sea-level. "1" is an idealized profile to the sill. "2" is the river's actual profile above and below sea level and shows that it probably flows on a thick pile of deltaic material. However, only the uppermost part of this pile is related to the current interglacial: beyond 4 km inland it is uplifted and dissected by the present river, and therefore older. ***(Redrafted, May 2021).*** **Referred to on pp. 29 and 30**

Figure 52. Selinunte, Temple of Demeter Malophoros. This photograph shows the temple flooded by the Modione River, suggesting that it may have fronted onto the estuary itself before the nineteenth and twentieth century reclamation works. Photo by Cosimo Ronzi. **Referred to on p. 31**

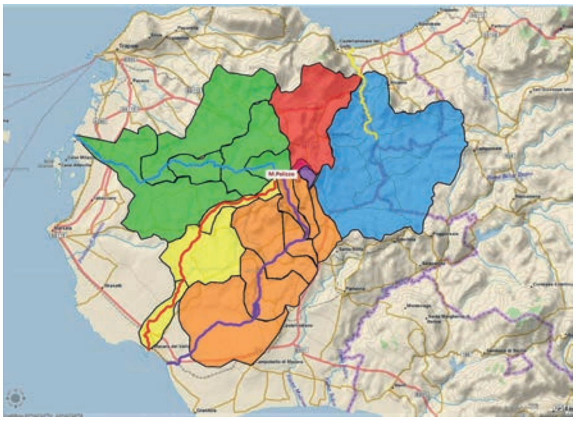
Figure 53: Predicted Iron Age Mean Flow of Cuddia River for October-December. **Referred to on p. 33**

Figure 54: Predicted Iron Age Mean Flow of Delia River for October-December. **Referred to on p. 33**

Figure 55: Predicted Iron Age Mean Flow of Mazaro River for October-December. **Referred to on p. 33**

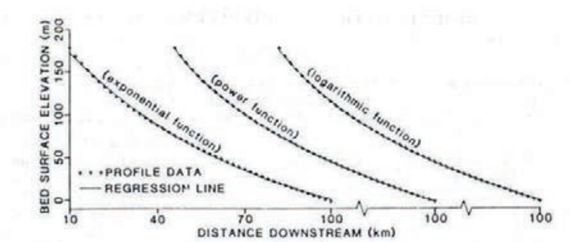
Figure 56: Completed nomogram for Délia, Cúddia and Mazaro. **Referred to on p. 33**

Figure 57: Comparison between Puma et al.'s model for the Freddo calibration basin and my estimate. My inputs (using the Palermo rainfall averages and a slightly higher average elevation for the basin, gives results that are a factor of two higher than those from using Puma et al's model, but that converge towards the end of the year for my method of calculating run-off. The results for my method and the model are almost identical in November, but the Puma model shifts the basin run-off towards the end of the year. **Referred to on p. 33**



Figur 1

Figur 2



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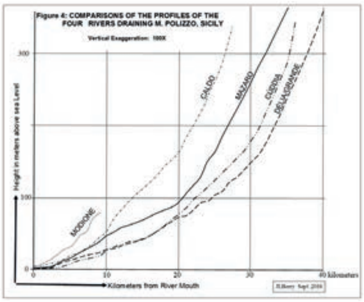
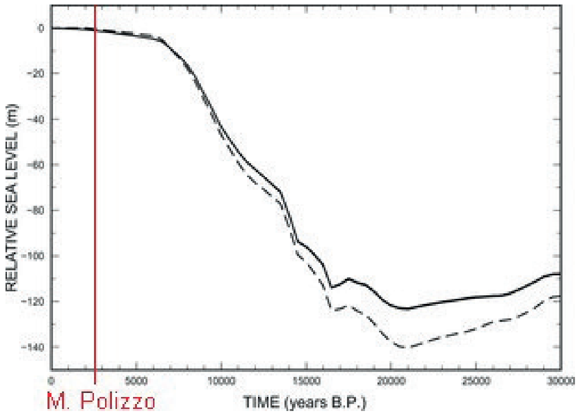


Figur 4

Figur 5a

Figur 5b



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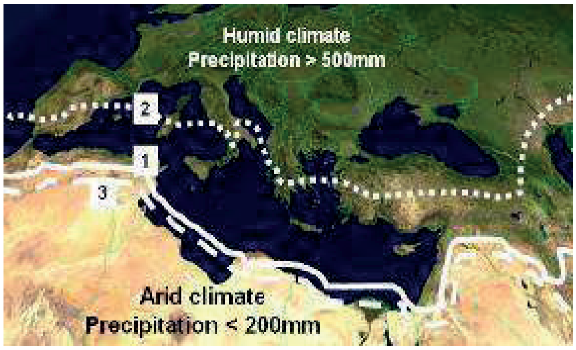

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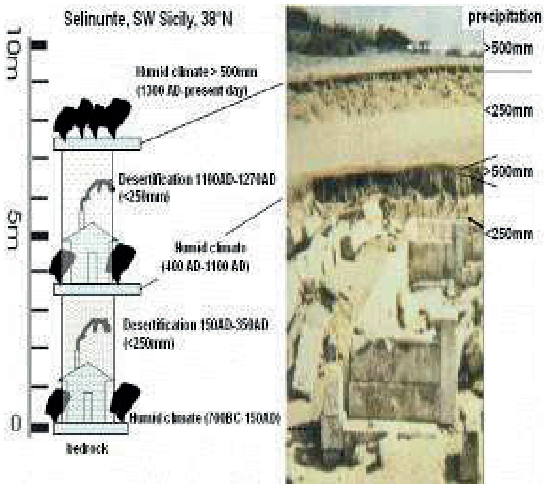

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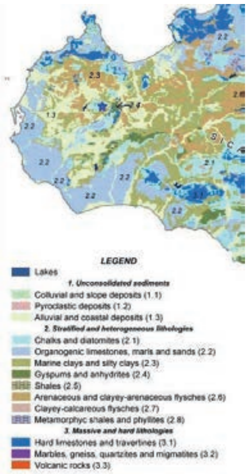

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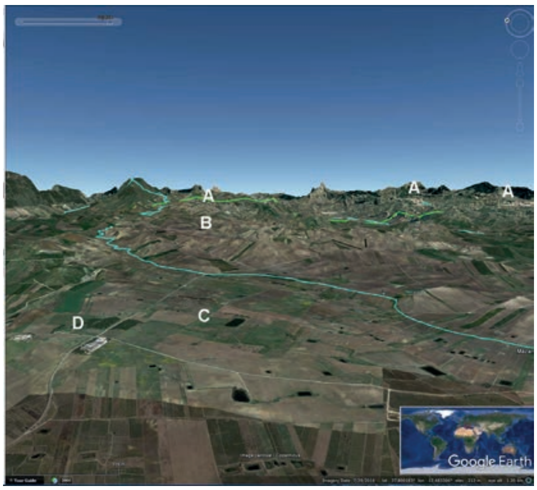

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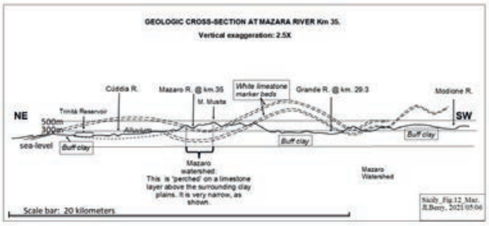

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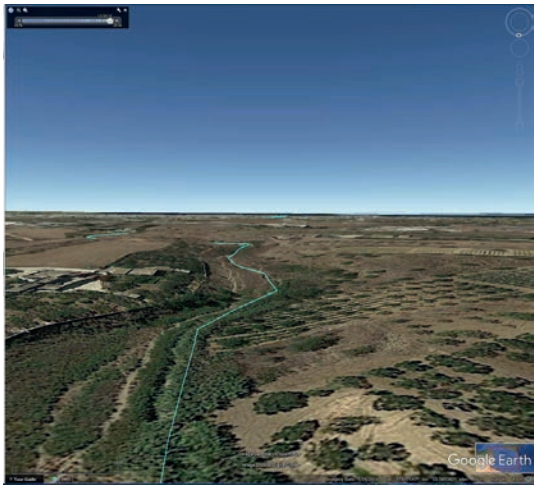

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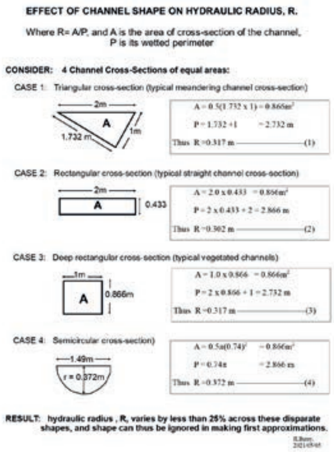
Figur 14



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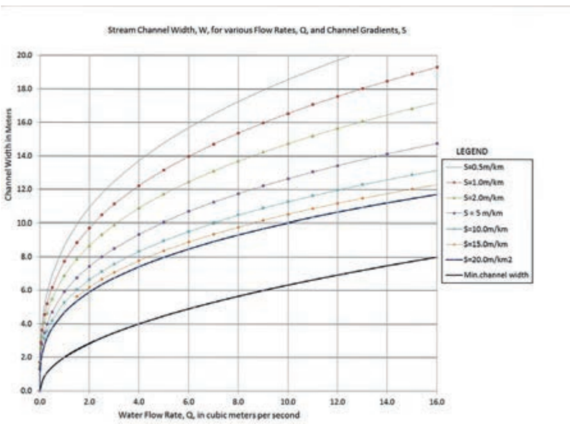

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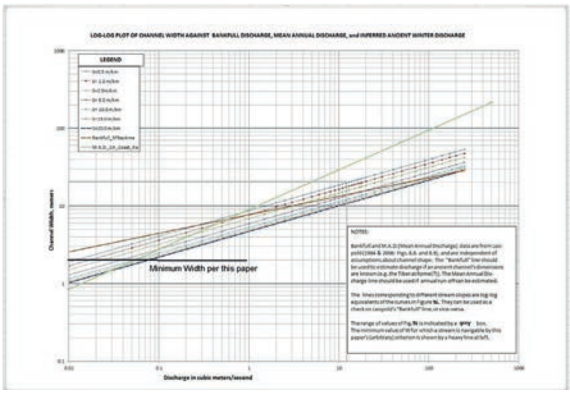

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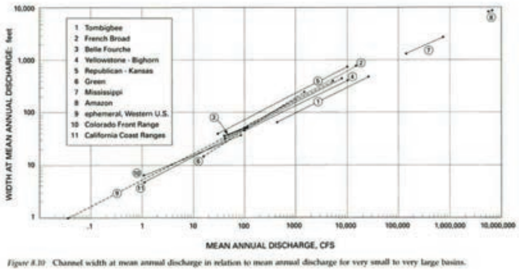

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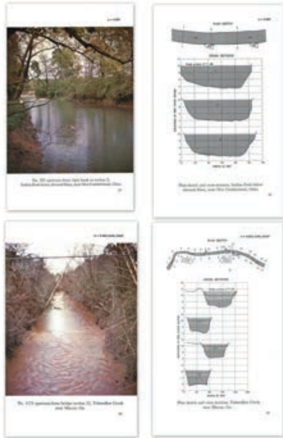

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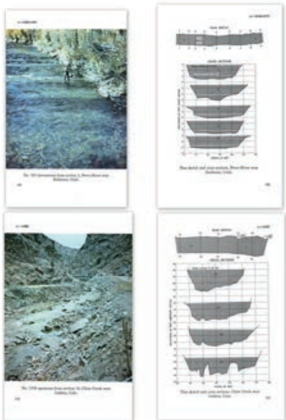

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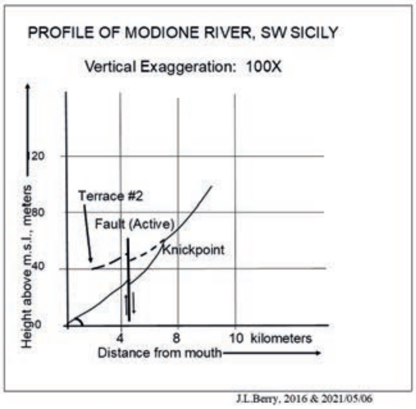

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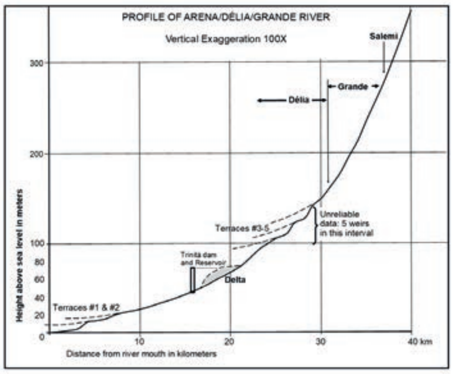

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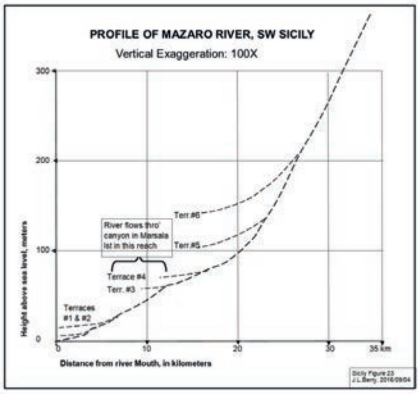

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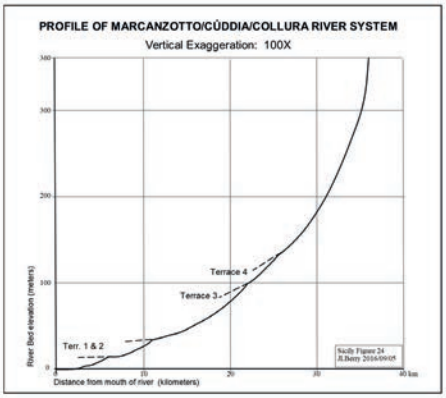

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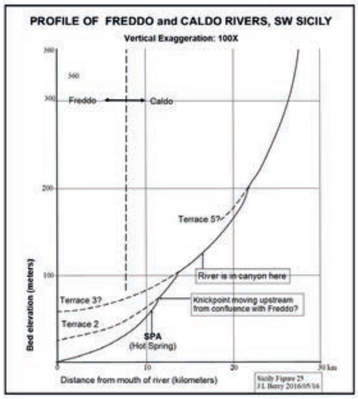

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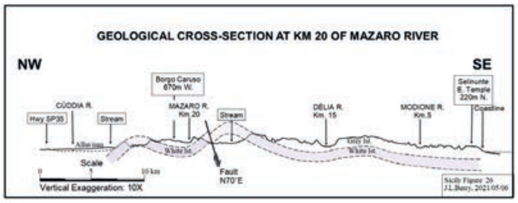

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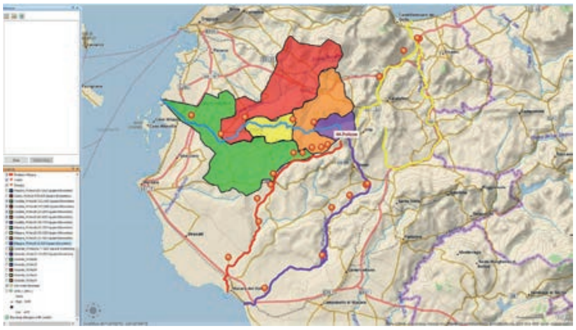

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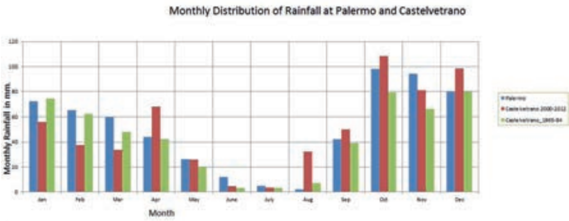

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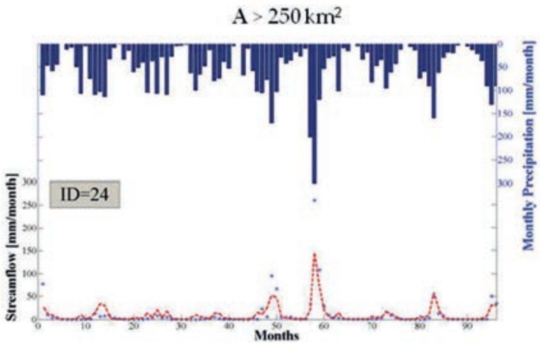

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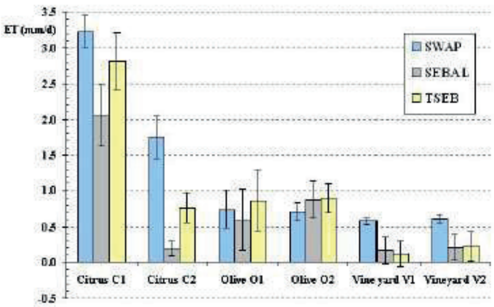

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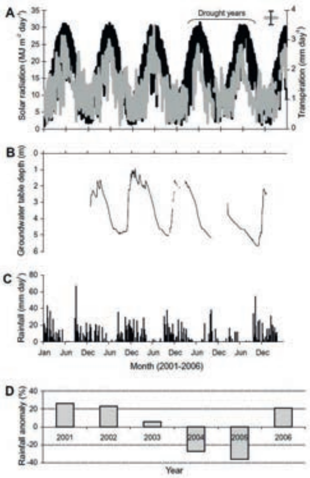

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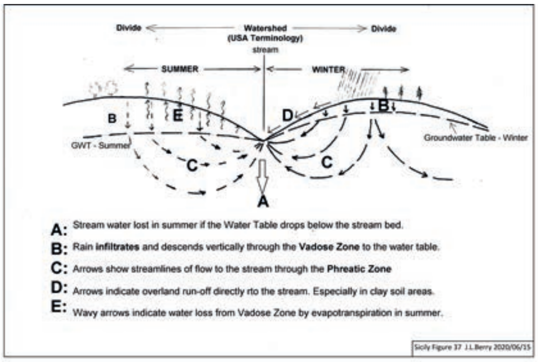

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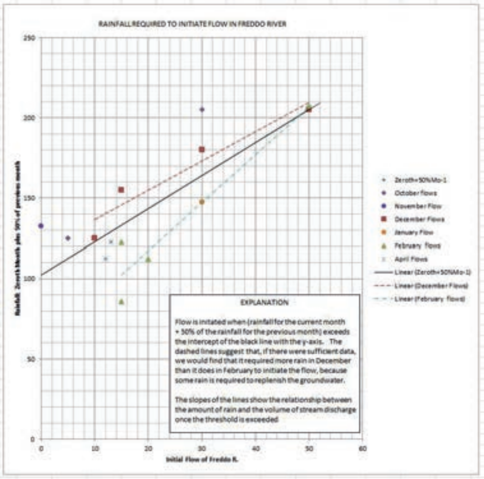

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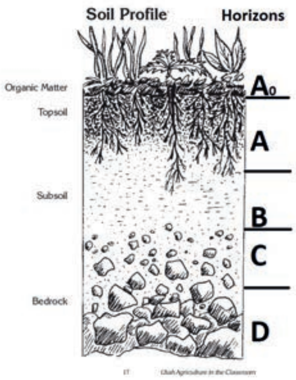

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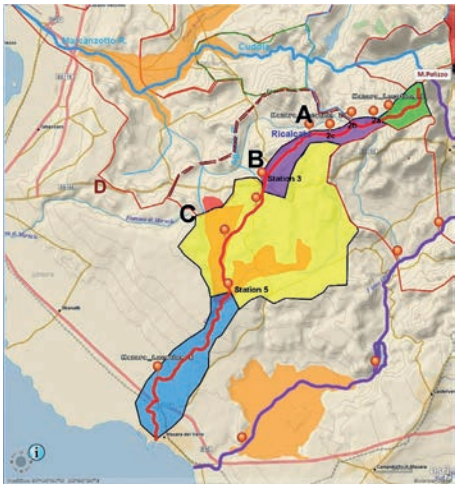

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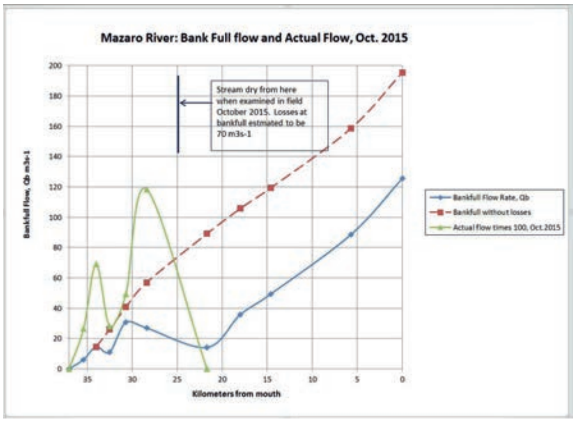

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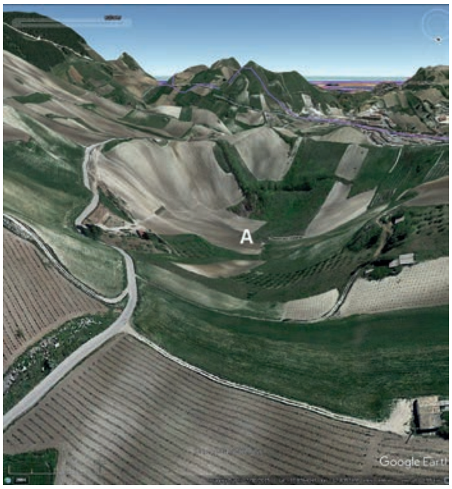

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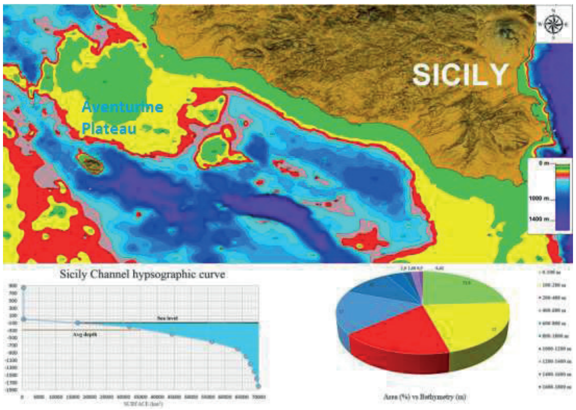

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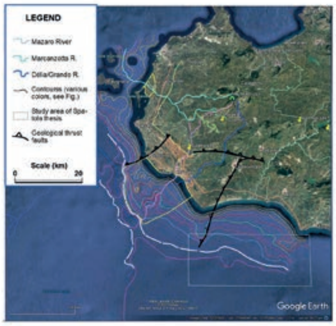

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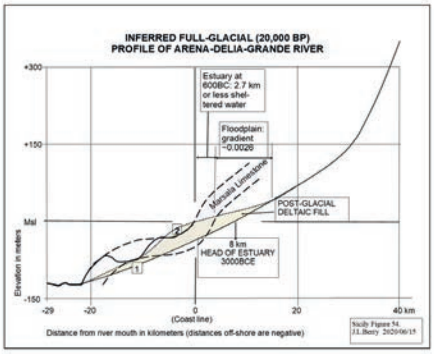

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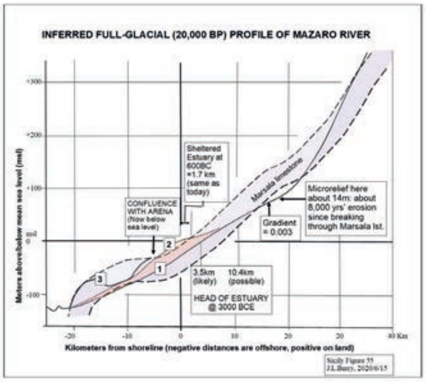

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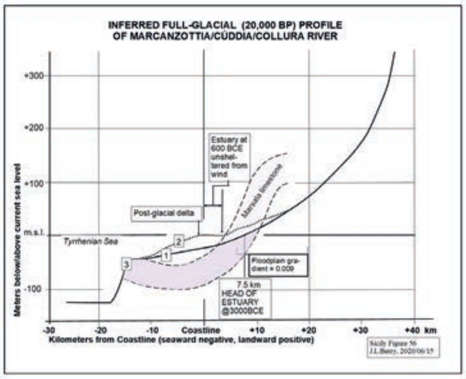
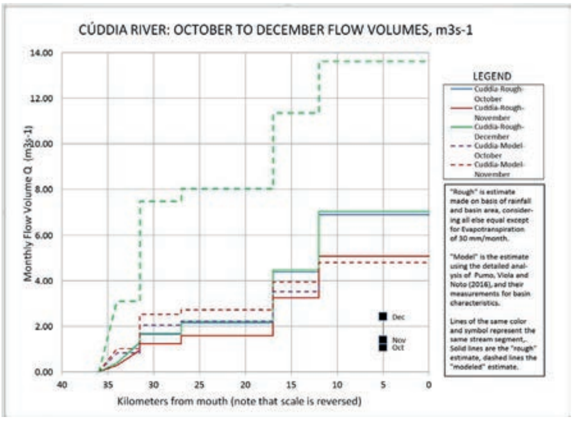


Figur 51

Figur 52



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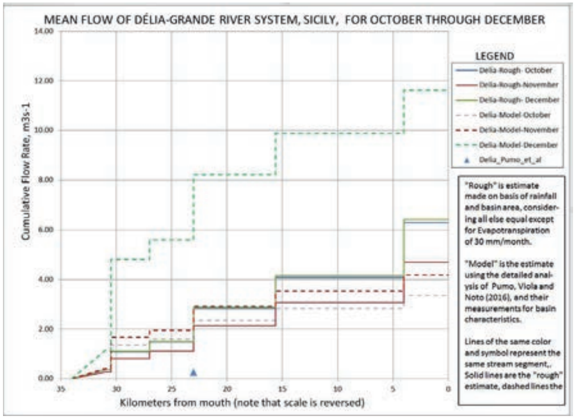

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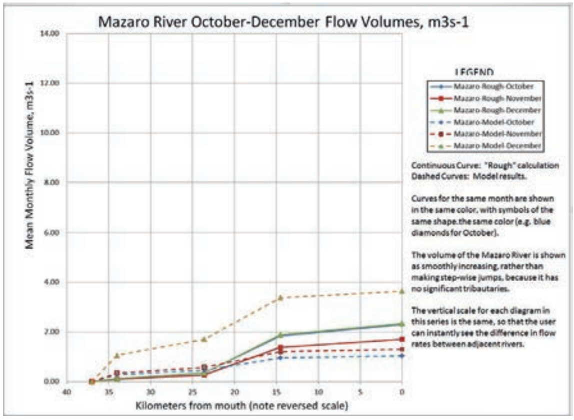

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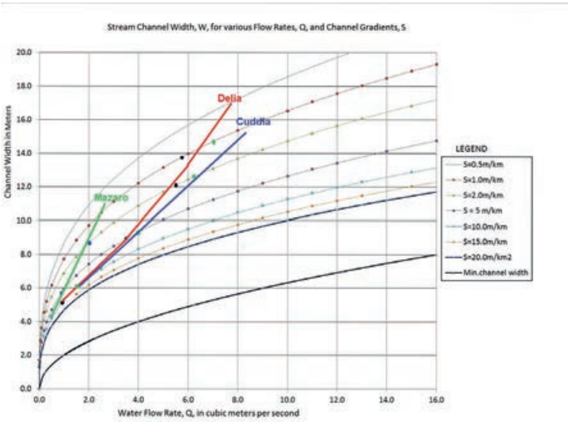

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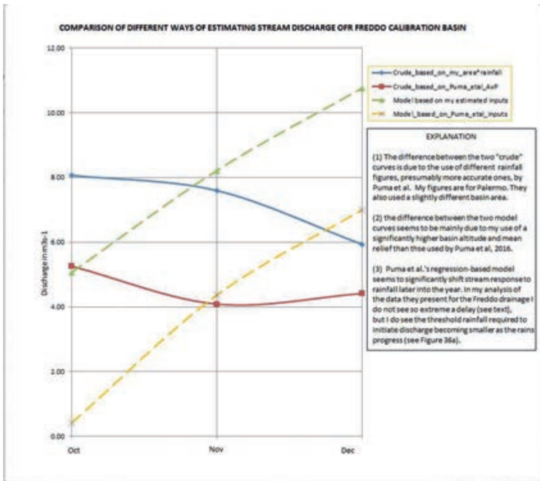

Figur 57

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