Parmi les dix mille îles et îlots de Méditerranée, moins de trois cents seraient habités et seulement deux cents mesureraient plus de 5 km². Ces îles sont des entités géologiques et géographiques complexes où coexistent des formations de roches très anciennes et d'autres créées très récemment (îles volcaniques). À la fois ouvertes sur l'horizon et les côtes continentales voisines, elles restent, paradoxalement, relativement fermées de par leur isolement, créant ainsi des spécificités quant à leur biodiversité et leur colonisation par les sociétés humaines. Les îles de Méditerranée forment ainsi un objet d'étude privilégié pour la géoarchéologie. Cette dernière emprunte les concepts, les méthodes et les techniques de disciplines relevant des sciences humaines et environnementales (l'archéologie, l'épigraphie, la philologie, la géographie, la paléoécologie, la paléontologie…).

Cet ouvrage établit un premier état des connaissances dans le domaine de la géoarchéologie des îles de Méditerranée. L'éclatement géographique de ces dernières, ainsi qu'une histoire de l'occupation propre à chacune, démontrent toute la difficulté de globaliser ces espaces géographiques, progressivement transformés en territoires sous l'action répétée des sociétés humaines. Des spécialistes dressent ici les relations complexes entre les dynamiques et les processus paysagers et les logiques d'occupation humaine depuis la fin du Pléistocène.

Le présent ouvrage recueille vingt-quatre contributions regroupées dans cinq parties intitulées « Anthropisation et mutations paysagères à la transition Paléolithique/Néolithique » ; « Mobilité et reconstitution des anciens niveaux marins depuis la fin de la dernière grande glaciation quaternaire » ; « Adaptation aux mutations paysagères à l'échelle intra-site : la nécessaire prise en compte des paramètres environnementaux » ; « Deltas, lagunes et marais : des interfaces propices à l'implantation des sociétés humaines » et « Matières premières : exploitation et interactions ».

Cet ouvrage s'adresse principalement à des spécialistes de géographie, d'archéologie et de paléoécologie mais aussi à un public plus large : étudiants des niveaux L-M-D, enseignants et simples néophytes souhaitant s'initier aux concepts, méthodes et techniques de la géoarchéologie.

Matthieu Ghilardi est chargé de recherche du CNRS et affecté au laboratoire CEREGE (Aix-en-Provence) depuis 2009. Géographe de formation, spécialiste de géomorphologie et de géoarchéologie, il étudie plus particulièrement les îles de Méditerranée (Corse, Chypre, Eubée, Crète, Baléares, Thasos et Sardaigne). Ses recherches portent également sur la géoarchéologie des grands fleuves du pourtour méditerranéen.

Franck Leandri est conservateur Régional de l'archéologie de Corse, il est diplômé de l'Institut national du patrimoine et membre de l'UMR 5608 TRACES du CNRS. Il mène depuis 20 ans des recherches dans le domaine de la préhistoire méditerranéenne et notamment sur les monuments mégalithiques.

Jan Bloemendal est chercheur honoraire de l'Université de Liverpool (Royaume-Uni). Spécialiste de paléomagnétisme, il s'est consacré plus particulièrement à l'étude des dynamiques environnementales en Chine. Il a également collaboré à des programmes géoarchéologiques en Grèce.

Laurent Lespez est professeur de Géographie à l'Université de Paris-Est Créteil (UPEC) et exerce son activité de recherche au sein du Laboratoire de Géographie Physique de Meudon. Géoarchéologue et géomorphologue, il s'intéresse notamment au rôle des sociétés et du climat dans la transformation des systèmes fluviaux et dans la construction des paysages ruraux depuis le Néolithique.

Sylvian Fachard est collaborateur scientifique du Fond national suisse de la recherche scientifique à l'université de Genève. Spécialiste de l'étude des territoires et de l'économie rurale des cités grecques, il fut secrétaire scientifique de l'École suisse d'archéologie en Grèce de 2002 à 2011. Depuis, il dirige et collabore à plusieurs programmes géoarchéologiques en Grèce (Eubée et Attique).

€ prix valable en France
ISBN : 978-2-271-08915-1
www.cnrseditions.fr

Sous la direction de Matthieu Ghilardi
Avec la collaboration de Franck Leandri,
Jan Bloemendal, Laurent Lespez et Sylvian Fachard

Géoarchéologie des îles de Méditerranée
Geoarchaeology of the Mediterranean Islands

Sous la direction de Matthieu Ghilardi
Avec la collaboration de Franck Leandri,
Jan Bloemendal, Laurent Lespez et Sylvian Fachard

Géoarchéologie des îles de Méditerranée

Geoarchaeology of the Mediterranean Islands

CNRS EDITIONS

Géoarchéologie des îles de Méditerranée

Géoarchéologie des îles de Méditerranée

Geoarchaeology of the Mediterranean Islands

sous la direction de
Matthieu Ghilardi

Avec la collaboration de
Franck Leandri, Jan Bloemendal, Laurent Lespez et Sylvian Fachard

CNRS ÉDITIONS

ISBN : 978-2-271-08915-1

Sommaire

Reconstructing the coastal landscape of Selinus (Sicily, Italy) and Lipari Sotto Monastero (Lipari, Italy)

MAZZA Alba[1]

Abstract

This paper uses an interdisciplinary methodology to investigate the ancient paleolandscape of the ancient coastal settlements of Selinus in Sicily and Lipari Sotto Monastero (LSM) in Lipari Island (north of Sicily), and how these have changed over time. In order to reconstruct the landscape at the time when the cities were inhabited, we focused on the analysis of historical sources and archaeological evidence, which provide insights into the human components of a city. Data from previous geomorphological studies and from geophysical survey were analyzed in order to investigate the physical environment. Additionally, the study focuses on understanding the coastal landscape of these cities, as well as its diachronicity, from antiquity onwards (from the 7th century BC to the 4th century AD). The combination of traditional studies and modern forms of investigation provided remarkable results which enhance our understanding of the coastal landscape of ancient Selinus and LSM and how it has changed over time. In addition, the prediction of future coastal changes, based on this interdisciplinary methodology, offers useful insights into what we should expect in the future.

Introduction

Located in the centre of the Mediterranean Sea, Sicily functioned for millennia as a focal point for commercial activity and the exploitation of natural resources, as well as of human migration, interaction and the creation of new identities (Holloway, 2002). During Greek and Roman times the great majority of the coast was occupied by several cities and towns whose role was either economic or strategic (Columba, 1906; D'arrigo, 1965). Syracuse, Megara Hyblaea, Agrigento, Selinus, Palermo, Tindari, Lipari, Messina and Catania were some of the most significant (Figure 1). Despite the importance of such shoreline settlements, very little attention has been devoted investigating the relationship of ancient Sicilian coastal cities to their landscape. Antiquarian studies and later archaeological research undertaken in Sicily over the last two centuries have generally focused on the monumental aspect of the cities (De Miro and Lombardo, 1984; Tusa, 1984; Voza, 1999; Wilson and Leonard, 1980). Temples, public buildings and the land aspect of coastal archaeological sites were the most investigated aspect. In contrast, very little research has been undertaken in order to understand the coastal landscape, in particular the natural features of the shoreline and the aspect of the waterfront of important coastal settlements such as Selinus and Lipari (Figure 1). The appearance of structures at low tide, rather than a systematic study of the shore, flagged the presence of underwater urban-related structures. This was the case for the "Banchinamento Orsi" at Megara Hyblaea, north of Syracuse (Figure 1; Orsi, 1890; Vallet *et al.*, 1983) and the submerged remains of a Roman structure (dated 50 BC/50 AD) in the small island of Basiluzzo, north of Panarea, in the Aeolian Archipelago (Bernabò Brea, 1985; Figure 1). Studies of these structures had the

[1]The University of Sydney, Australia amaz6781@uni.sydney.edu.au / alba.mazza@gmail.com

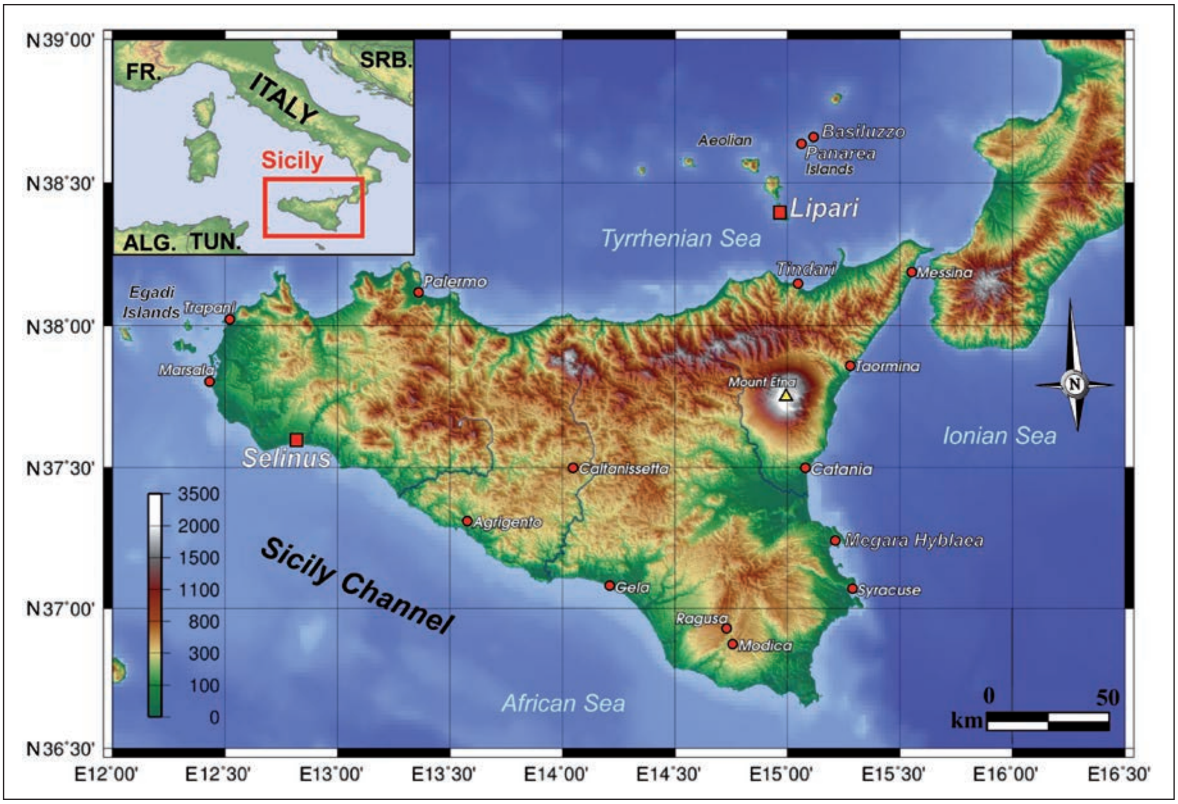

Figure 1: Location map of study sites in the Sicily-Lipari islands.

outcome of drawing attention to below the sea surface; moreover, they also they raised awareness of the existence of underwater archaeological evidence other than shipwrecks connected to a land site. However, methodological, qualitative and quantitative gaps in the archaeological approach to the study of the coast have left significant deficiencies in our knowledge of harbor-side infrastructure and waterfront architecture of almost all of the Greek and Roman coastal settlements of Sicily. The maritime aspect of Sicilian Greek and Roman coastal settlements, which includes both social and physical elements, needs hence to be investigated in order to obtain a full understanding of those coastal cities (Hesnard *et al.*, 2011; Marriner and Morhange, 2007). Our research focuses on the study of the ancient coastal landscape of the two key cities of Selinus and Lipari Sotto Monastero (LSM), to which an interdisciplinary methodology has been applied within the scope of the author's PhD thesis. These coastal cities are ideal case studies for investigating the relationship between humans and the coastal landscape. Each site possesses unique circumstances which should be further researched in order to enhance our knowledge of Sicily and its palaeolandscape. Moreover, by studying these cities it has been possible to highlight changes in the coastal environment, which may enable an improved understanding of current environmental hazards and the prediction of possible future coastal changes.

Geological background

Sicily, which covers an area of 25 711 km^2 is the largest Mediterranean island (Figure 1). From a geological perspective, it is a critical component of the Mediterranean belt (Caire, 1970; Catalano *et al.*, 1995) since the island connects the North African Maghrebides, formed by the Tellian and Atlas systems, to the Italian Southern Apennines and the Calabrian Arc (Catalano *et al.*, 2013). According to Agnesi and Catalano (Agnesi, 2004; Catalano, 2004; Catalano *et al.*, 2013), the island can be divided into three geological sectors, corresponding to three main tectonic elements formed by the early Miocene collision of the African continental margin with the Sardinia Block and later movements of migration, duplexing and rotation (Catalano, 2004). The first element, the foreland (Catalano *et al.*, 2013) is mainly composed of carbonaceous rocks. It includes the Iblean Plateau and continues southwards offshore into the Sicily Channel-Malta area and the Western Sicily Channel. Second is the foredeep (Catalano, 2004) that extends from the Iblean Platform to offshore southern Sicily and occupies almost the entire mid-southern area of the island. This area originated from the Late Pliocene onwards and is filled by Plio-Pleistocene pelagic marly limestones and sandy clays overlying the Messinian evaporites. The third element is the orogenic wedge (Agnesi, 2004; Catalano *et al.*, 2013). Sicily is surrounded by three seas, the Ionian Sea to the East, the Tyrrhenian Sea to the north and the African Sea to the southwest (Figure 1). The Ionian Sea is an oceanic basin of the Eastern Mediterranean basin formed during the early Mesozoic (Catalano *et al.*, 2001) or earlier separation of the Adriatic block from Africa (Catalano *et al.*, 2013). The Tyrrhenian Sea (Figure 1), which bounds Sicily to the north, is a mid-late Neogene partially-oceanic sub-basin of the Western Mediterranean basin (Carminati and Doglioni, 2012). The African Sea (Figure 1), also called the Sicilian Sea, separates the Western Mediterranean basin from the Eastern Mediterranean basin. Two straits separate Sicily from the mainland. The first, the Messina Strait in Eastern Sicily (Figure 1), is a 3.1-km-wide passage between the eastern tip of Sicily and the western angle of Calabria, in mainland Italy; and the second, the Sicily Channel or Sicilian Strait, is a much wider passage, *ca.* 145 km between Sicily and Tunisa which divides the Tyrrhenian Sea and the Western Mediterranean Sea from the Eastern Mediterranean Sea (Figure 1).

Archaeological context of Selinus and Lipari

Selinus

The ancient coastal landscape of Selinus, located on the southwestern coast of Sicily (Figures 1 and 2), has never been investigated systematically (Purpura, 1991; Tusa, 2010b). The present landscape provides few indications of the appearance of the ancient city's waterfront. Selinus, founded by the Greeks from Megara Hyblaea and from Megara Nisea (De Angelis, 2004), was one of the most important of the Greek colonies in Sicily and the one with the largest *chora* (Di Vita, 1996). The date of its foundation cannot be precisely determined and historical evidence ranges from 650 BC, as indicated by Diodorus, to 628 BC indicated by Thucydides. The city functioned as a Greek outpost in the Carthaginian West and was economically rich with high defensive walls, monumental temples, sacral areas, extensive necropolises, and direct contact with the fertile hinterland as result of navigable river systems (Cerchiai *et al.*, 2004; Crouch, 2004; Di Vita, 1996). Previous excavations indicate the presence of a port infrastructure in relation to the Modione and the Cottone Rivers (Lentini, 2011; Purpura, 1991; Figure 2), located respectively east and west of the acropolis (Figures 2 and 3). However, they have not been verified by extensive and systematic research (Purpura, 1991; Tusa, 2010b). Despite the current absence of evidence for the existence of port infrastructure in the Modione River dating to the Greek period, it is probable that the Greek settlers used naturally sheltered areas at the mouth of the river (Morton, 2001). In Greek times the river was considered navigable as far inland as the Gaggera Spring (Tusa, 1986; Tusa *et al.*, 1984). Its navigation would have accomplished two main interrelated tasks. First, was the provision of fresh potable water from the spring (Crouch, 1993); and second, a stopping place at the sanctuary precinct of the Malophoros, on the Western edges of the Modione River. However, the only known evidence of port infrastructure on the Modione River is dated to the Later Roman period (Lentini, 2010b; Figure 3, Nr. 3). To date, there is an absence of comparable evidence dating to Greek times from the Modione River mouth. Unlike in the case of the Modione River, in the Cottone River (Figures 2 and 3) port facilities pertaining to the Greek period were visible to travelers and explorers of the town in the late 1800s (Cavallari, 1872; Salinas, 1886), since they were occasionally exposed during winter and spring storms. Limited research by Salinas in 1886, 1888, 1902 and 1904, Bovio Marconi in 1950-51 and by the German Institute of Archaeology in 1995, has been undertaken on the remains of these mooring facilities on the Cottone River (Tusa, 2010b). These archaeological remains, consisting of docks and mooring facilities (Figure 3, No. 5; Figure 4) have been mapped by 16th to early 20th Cent. travellers. These travellers also documented geographical features such as ponds and marshes. Indeed, since the middle 16th century (Fazello and Nannini, 2012), and for the last 500 years, the area has been described as a marshy, unhealthy environment which was a source of malaria. Selinus, abandoned around the 250 BC, was sparsely populated in the Late Roman period and Byzantine times (Lentini, 2010a; Lentini, 2010b) and was not permanently inhabited up to the present. The ancient city of Selinus is currently an archaeological park which is the largest in Europe (www.selinunte.net). Surprisingly, despite the importance of Selinus in the history of Sicily, no research has been undertaken to understand its waterfront. As a result, many aspects of the topography and the social sphere of the city are unclear, such as the appearance of the waterfront and the related areas of commercial and social interaction.

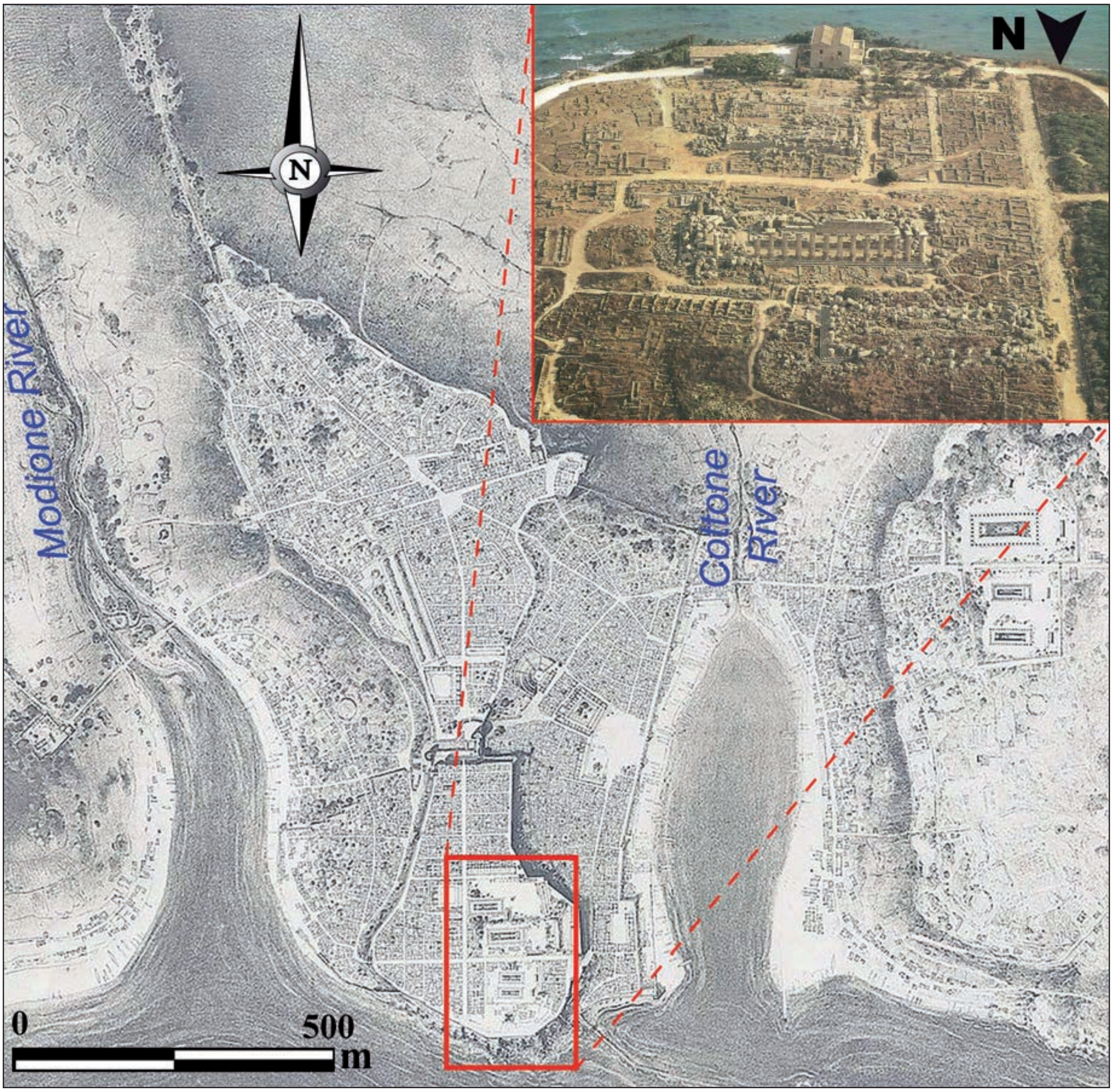

Figure 2: The ancient city of Selinus (West Sicily, See Figure 1 for location), as imagined by Hulot and Fougères (1910). Red box represents an aerial photo of the acropolis of Selinus.

Lipari

Lipari is the main island of the Aeolian volcanic archipelago in northeastern Sicily. Since prehistory, and in Greek, Roman and Medieval times, the island has played a crucial role in the Mediterranean as an important node in the network of trade and commerce (Bernabò Brea *et al.*, 1998; Cavalier and Bernabò Brea, 1991). This is well attested by the massive stratification on the Acropolis rock (Bernabò Brea and Cavalier, 1980) which has been inhabited continuously since 4000 BC (Bernabò Brea, 1957; Cavalier and Bernabò Brea, 1991). Unlike Selinus, Lipari has been inhabited continuously up to the present and therefore the ancient waterfront of the city has also been investigated by considering the urban development the island has undergone. The present coastal landscape of Lipari has left no visible traces of what the ancient waterfront would have looked like. Knowledge of the ancient harbor of Lipari is poor since historical sources do not mention any port-related infrastructure; however, archaeological remains suggest the existence of a possible monumental port (Bernabò Brea, 1985). Recently-discovered underwater archaeological remains in what is the present tourist and commercial port of the island, known as Lipari Sotto Monastero (LSM; Figure 5), finally shed light on the island's coastal landscape.

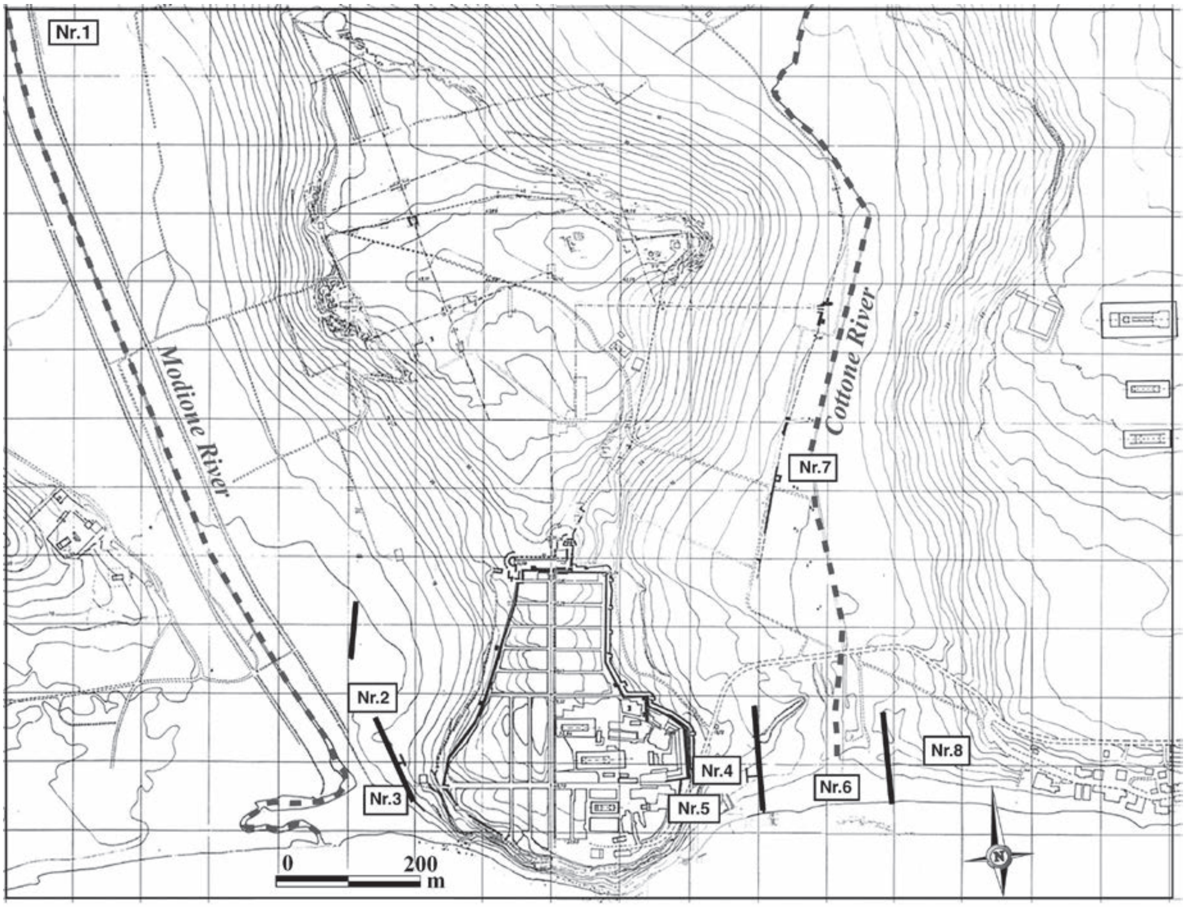

Figure 3: Map of Selinus with the harbor-related infrastructure after Hermanns (2014). N° 1: Structures discovered in *ca.* 1980; N° 2: Harbor structures discovered by Cavallari and observed by Hulot and Fougeres; N° 3: Late Roman dock; N°s 4 and 6: Elongated structures identified by Jean-Pierre Houel in 1772 and located in a map by William Harris in 1826; N° 5: Docking structures excavated by Bovio Maroni; N° 7: Part of the defensive structures of the eastern wall; N° 8: Core samples of the Rabbel *et al.* (2014) geophysical investigation.

Figure 4: Mooring remains of the Greek port infrastructure at the Cottone River mouth excavated by Marconi in 1950-51 (From Tusa, 2010).

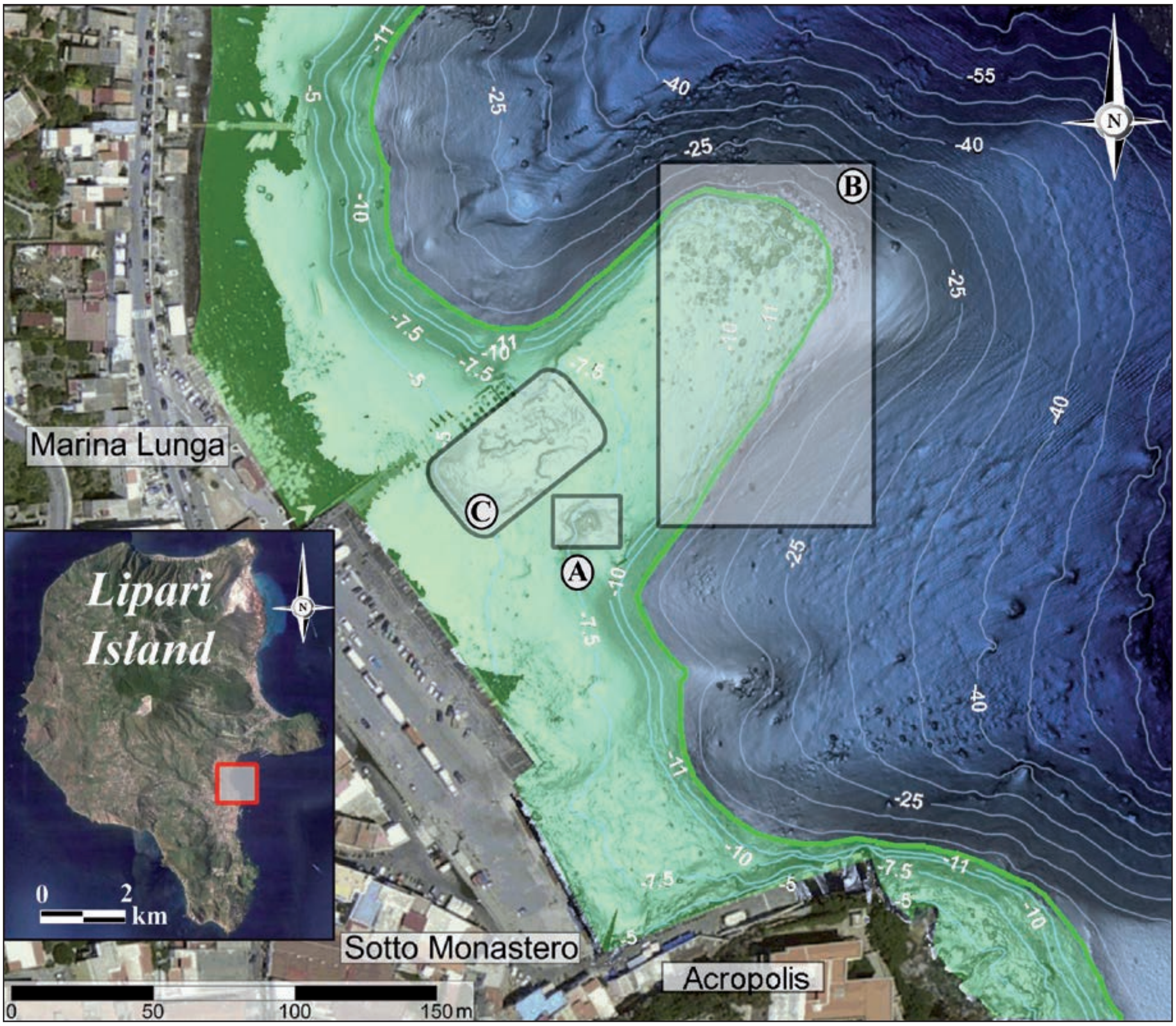

Figure 5: Map of Marina Lunga Bay and the LSM site. (North of Sicily. See Figure 1 for location) Red box shows the location of the LSM site within the island of Lipari. The area A shows the structure with molded blocks. The area B shows the outer end of the pier where it has been suggested the lighthouse was located. The area C shows the grooves caused by the propellers of hydro jet catamaran. Map edited by the author and by Chris Aguirre II, after Anzidei *et al.* (in press).

A combination of traditional methods and modern techniques for reconstructing the past archaeological landscape

Scrutiny of written sources

The interdisciplinary approach employed in the present research consists of a combination of traditional methods and modern techniques (Keay *et al.*, 2009; Marriner *et al.*, 2010; Morhange *et al.*, 2013; Rogers, 2013a). Historical written sources, archaeological evidence, and geomorphological and geophysical survey data have been analyzed in order to reconstruct the ancient coastal landscape of Selinus and LSM. Ancient written evidence from sources ranging from the 7th century BC to the 7th century AD, which mention the coast of Sicily and landscape features of the shore, has been investigated. The works of ancient authors, such as Thucydides (Smith, 1920), Diodorus (Oldfather, 1933) and Polybius (Walbank *et al.*, 2010), have been critically analyzed. However, due to their literary nature, this type of source is limited in terms of accuracy and therefore other forms of evidence have also been investigated. Published and unpublished archaeological evidence from previous excavations and fieldwork activity in Selinus (Purpura, 1986; Tusa, 2010b) and LSM (Tusa, 2010a) provide evidence of coastal-related infrastructure. Elements of archaeological interest, such as submerged building remains, on-land port-related infrastructure and archaeological materials related to the waterfront, have been analyzed. This important evidence has been combined with other data sources in order to gain a better understanding of the geological context in which these cities developed.

Study of ancient maps, travellers' description and photographs

In order to assess coastal landscape changes in later periods, the investigation also included the study of 12th-17th century maps, 17th-20th century travelers' descriptions, and photographic evidence of the last 150 years. Cartographic and graphic documentation of the coastal landscape in historical times was analyzed in order to identify important elements such as the topographic position of visible port-related archaeological markers in relation to coastal geographical features (shoreline position, river flow, extent of the coastal embayment). Therefore, a systematic study of available itineraries, portolani, maps and charts of cartographers from the 12th to the 17th Centuries AD, and diaries of travelers and explorers of the 18th and 19th century AD, was undertaken (Cluverius, 1619; Harris and Angell, 1826; Hittorff and Zanth, 1827; Houel, 1782; Hulot and Fougères, 1910; Koldewey and Puchstein, 1899; Lo Faso Pietrasanta Duca di Serradifalco, 1834; Reinganum, 1827; Salinas, 1886; Salinas and Patricolo, 1888). In addition, pictures of the past 150 years from online databases and private collections were also used to investigate more recent times.

Geomorphological, geophysical and bathymetric surveys

A crucial component of the investigation has been the researching of the geological framework for each site (Marriner and Morhange, 2007; Marriner *et al.,* 2010; Morhange *et al.,* 2013). Thus, existing literature based on field survey employing geophysical methods, Sub bottom profiler, multi beam bathymetric survey and sediment coring has been explored in order to establish the main components of the geological framework. For the site of Selinus data relating to the seabed have been collected from the geophysical survey of Brizzolari *et al.,* (1994) which employed sub bottom profiler operating between 2 and 7 kHz frequency. The geological framework of the land sector of the site of Selinus has been researched in the work of Barreca *et al.* (2014), Bottari *et al.* (2009), Brizzolari *et al.* (1992), and Crouch (2004). Specific data on the Cottone and Modione Rivers have been obtained from the seismic survey employing shear waves calibrated by coring performed by Rabbel *et al.* (2014) For the site of LSM the bathymetry data have been gathered thanks to the recent work of Anzidei *et al.* (in press) who adopted an ultra-high resolution multibeam system operating at 400 kHz frequency, emitting up to 512 beams across a 140°/165° wide swath. The volcano-tectonic setting of LSM has been researched in the map published by Tranne *et al.* (2002) and Calanchi *et al.* (2002). An important aspect of the study was the identification of features related to past of catastrophic events, such as flooding, tsunami, earthquakes and eruptions, which left an imprint on both the geological matrices and the archaeological record.

Results and discussion

Selinus

The analysis of ancient written sources is of significant value for informing us about the landscape of ancient Selinus, and about human interactions with the coast. Diogenes Laertius in his *Life of eminent and opinion of philosophers* (Hicks, 1925) describes an important historical event that helps us investigate a specific element of the city's landscape and the engagement of the inhabitants with it. The ancient historian states that Empedocles reclaimed the area of Selinus from a very unhealthy marshy environment that was responsible for malaria and other diseases. The passage has been a source of speculation for many scholars and we are far from achieving a complete understanding of it (Rambaldi, 2010). However, whether Empedocles' action was an engineering masterwork such as the deviation of nearby streams into a bigger river, or the creation of an aqueduct connected to the "vasca selinuntina" of Torre Bigini (a massive cylindrical tank of 15 m diameter and 4 m depth linked to a 14 km channel system connecting to Selinus; Formount, 2012). It may have been a combination of engineering and pharmaceutical/chemical/medical actions (as personally suggested by Prof. Fernando Santoro of the Universidade Federal do Rio de Janeiro, who has published extensively on Empedocles) his achievement represents an important example of human intervention in the landscape. Despite the importance of those port infrastructures on the Cottone River mouth for the understanding of the Selinus waterfront during Greek times, no effort has been devoted to framing it in the broader context of harbor-related infrastructure. The reason that such an important part of the city has been neglected, in comparison with the broader study of Selinus, may be related to the unhealthy and unappealing long-lasting environmental features of the landscape at the Cottone River which has been attested to on the basis of literary evidence and recently by geophysical investigation. This port infrastructure (Figure 3, N° 5) has been continuously covered and uncovered by sediments during the last three centuries (Purpura, 1975). Recent palaeoenvironmental and geophysical investigations, including seismic profiling, a magnetic survey and sediment coring on both the Cottone and the Modione Rivers by the Institute of Geosciences of the University of Kiel (Rabbel *et al.,* 2014), have revealed evidence of the existence of two palaeo-rivers which have undergone progressive sedimentation. As a consequence of sedimentation, as well as harbour siltation, the port at the Cottone river mouth was probably abandoned at around 200 BC (Crouch, 2004). Those processes created a marsh and lagoonal environment. An important element identified thanks to geophysical survey in both riverbeds is banking which underlies the Greek urban area and terminates at the city wall (Rabbel *et al.*, 2014). Whether this banking is artificial, and possible related to possible measures to reclaim the land in order to improve the channeling of the river water and to prevent the formation of swamps and the occurrence of malaria, cannot be confirmed without further investigation. Indeed, it cannot be completely excluded that the banking is of natural origin. For example, it may represent a layer of limestone debris from the city hill that was intermittently deposited onto the lagoon sediments by landslides before the streets and houses were constructed. However, shells (*Cerastoderma* sp.) and pottery fragments found during sediment coring have not been yet analyzed, and therefore the age of the deposit, which is an important element for investigating the time span of the stratigraphic formation of the banking and the other layers, cannot be established. Knowledge of Selinus' landscape has also benefited from recent investigation of tectonic movements in the area. The identification of active tectonics in southwestern Sicily (Barreca *et al.*, 2014; Bottari, 1973; Bottari *et al.*, 2009; Monaco *et al.*, 1996) could shed light on the many earthquakes in the history of ancient Selinus. Indeed, earthquakes documented by the collapse of Greek temples in Selinus, occurred between 370 and 300 BC and between 300 and 600 AD (Bottari *et al.*, 2009; Guidoboni *et al.*, 2002). These earthquakes (Table 1) had a dramatic impact on the population, influencing building techniques, urban development and possibly also leading to the abandonment of the city (Crouch, 2004).

Thanks to maps and charts of Sicily dating from the 12th to the 17th century, and since the beginning of exploration of the ancient city of Selinus by 18th and 19th century travelers, details of the paleogeography of the city, especially its hydrology, have been analyzed. Results of the diachronic investigation of these maps demonstrate that both the Modione and the Cottone Rivers (known in Roman times as ancient Apiario or Lanario, respectively) underwent a progressive sedimentation process that resulted in deltaic progradation (Figures 2 and 3). In addition, modern cartographers and Grand Tour travelers have provided evidence of changes the Modione River changes in later times. Indeed, the geographer Ptolemy, in the 2nd century CE, suggested that the river had two mouths (Lentini, 2010b). Despite the fact that the two mouths of the Modione River may have been continuously migrating over the following century, this hydrological feature has been prevalent in the last 200 years. This is demonstrated by maps from 1782 to 1910 (Figures 2 and 3; Cavallari, 1872; Houel, 1782; Hulot and Fougères, 1910; Lo Faso Pietrasanta Duca di Serradifalco, 1834; Reinganum, 1827) which also document the river's meandering, as well as swamps.

Literary sources, archaeological data, the results of geophysical surveys and sediment coring, as well as the modern cartographic evidence presented here, demonstrate that a marshy, brackish environment existed in Greek times and may have been a persistent feature of the coastal environment up to modern times. It can be hypothesized that when the city was inhabited the necessity of maintaining an efficient navigable river system and functional harbors demanded constant maintenance by the inhabitants in order to avoid diseases such as malaria. After the abandonment of the city, possibly caused by sediment accretion which prevented a safe landing, and/or by the frequent earthquakes, both the Modione and the Cottone river bed underwent progressive sedimentation. This process was still *in fieri* during the 17th to the beginning of the 20th century. Mid-20th century channeling work on both the Modione and Cottone Rivers dramatically changed the flow of both rivers, and today they consist of small confined streams.

Lipari

In 2008 an underwater structure was discovered 9 m below present-day sea-level (Figures 5 and 6). Preliminary results suggest the existence of a pier of Roman age dating to between the 1st century BC and the 1st century AD. Since the excavation is still ongoing, other dates are also under discussion: 3rd century – 2nd century BC (Tisseyre, in press) or the 2nd century AD (Tusa, 2013). However, pottery fragments from the 3rd century BC to medieval glazed ceramics have been collected. The structure consists of a curved artificial terrace (Figure 6A) on two steps, composed of squared lava blocks of local origin, and imported white marble blocks whose provenance is still under investigation. On top of this

Date	Location and possible damage
550-490 BC	Selinus, many old buildings destroyed
426 BC	Selinus, probable minor damage
390-300 BC	Selinus, the Triolo N temple is destroyed
370-200 BC	Selinus, the temple M is destroyed
17 AD	Major event in eastern Sicily and Calabria, possibly also affecting unpopulated Selinus(?)
361-365 AD	Severe earthquake in Belice valley, West of Selinus
After 330 before 500 AD	Selinus, the Temple C is destroyed
6th century AD	Major damage to the temples, possibly caused by an earthquake nearby Selinus
8th and 9th century AD series of earthquakes—the worst in 852—	Near Castelvetrano, NW of Selinus
12th century AD	Selinus, two temples damaged
1968 AD	Major earthquake in Belice valley, west of Selinus

Table 1: List of historical earthquakes in Selinus (after Crouch, 2004 and Bottari *et al.*, 2009).

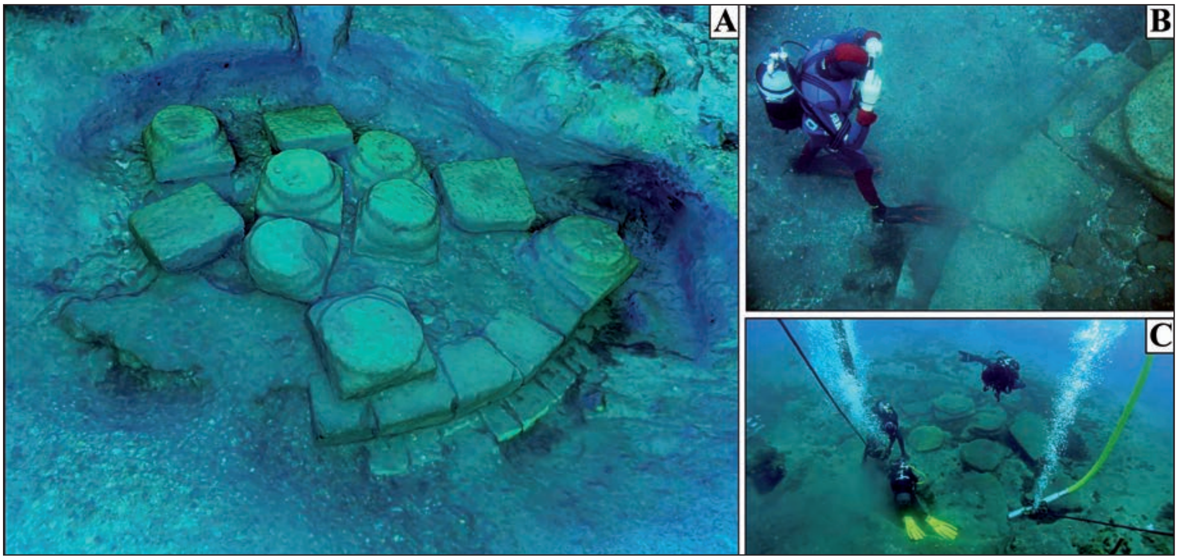

Figure 6: The LSM site. Figure 6A: 3D representation of the submerged archaeological site, courtesy of the Soprintendenza del Mare - edited by Massimiliano Secci - Sassari University; Figure 6B: Detail of the platform on which the blocks are placed, by Salvo Emma - courtesy of the Soprintendenza del Mare; Figure 6C: The site during the 2014 excavation (photo: Salvo Emma, courtesy of the Soprintendenza del Mare).

structure, which has been only partially excavated, 10 molded bases (or capitals) of columns have been found, positioned above a floor made of cemented lava beach stones (Figure 6B). These blocks, which are randomly positioned on the floor and without any visible architectonical connection, appear eroded. It has been argued that the blocks may be related to the abandonment of the harbor (Anzidei *et al.*, in press; Regione Siciliana, 2014) which is dated, on the basis of archaeological materials from the excavation, to the 4th century AD (Anzidei *et al.*, in press). Another archaeological area (Figure 6B) has been found less than 150 m northeast of the previous structure. It is located at a depth of -11.6 m and has been interpreted, due to its prominent geographical position toward the open sea, as a possible lighthouse in service at the same time as the pier (Anzidei *et al.*, in press). The submerged context of the pier-lighthouse is certainly located at a very deep level in comparison with other underwater archaeological sites of the low Tyrrhenian Sea (Anzidei *et al.*, 2014; Bernabò Brea, 1985; Evelpidou *et al.*, 2012; Lambeck *et al.*, 2004) and therefore local factors have been investigated. A recent Multibeam bathymetric survey, in conjunction with the preliminary results of an ongoing underwater archaeological excavation (Anzidei *et al.*, in press), sheds light on the geological context of the underwater sites. The study shows that the submergence of the pier and its outer part is related to land subsidence, which has been estimated to be 5.79 ± 0.01 mm y^{-1}. The submergence has been related to the combination of a regional glacio-hydro-isostatic signal estimated at 0.62 mm y^{-1} and a local volcanic-tectonic contribution of 5.17 ± 0.01 m y^{-1} for the last 2100 ± 100 years cal. BC (Anzidei *et al.*, in press). Together with these data, and with the functional height of the pier estimated as at least 2 m above sea level, the sea level at the time of usage of the port infrastructure (1st century BC-1st century AD) is estimated to be 12.3 ± 0.7 m (Figure 5, green line). As a result, during roman times a wider space was indeed available for the many port-related activities related to commercial and social life. Therefore, it is probable that facilities related to the maritime life of a roman harbour would have existed, such as mooring spots, areas dedicated to loading and unloading, storage rooms, warehouse quarters, shipsheds, porticoes and temples (Brandon, 2008; Keay and Millet, 2005; Rogers, 2013b) may now lie underwater. Consequently, the coastal palaeo-landscape of ancient Lipari in Roman times would have been completely different from today. Due to its geographical position at the time of its usage, the pier was a crucial element of the island waterfront. The scene at Lipari waterfront, for those who approached it by sea, was a monumental port entrance, safeguarded by the massive presence of the acropolis on the left, and by the jutting pier on the right. These elements contributed not only to the creation of a protected bay, but would also have shaped the monumental entrance to the city by sea. However, this image would not have lasted for very long. Land subsidence and sea level change (a relative sea level change at 12.3 ± 0.7 m with a subsidence rate at 5.79 ± 0.01 mm.yr^{-1} and a volcanic-tectonic contribution of 5.17 ± 0.01 m yr^{-1} for the last 2100 ± 100 yr BP has been estimated by according to Lambeck *et al.,* 2004). This would have led to the rapid submergence of the structure, which according to the date of the archaeological materials identified in the latest context was completely submerged around the 4th century AD (Anzidei *et al.*, in press). It is therefore possible to hypothesize that the 10 molded blocks were placed on the pier, which was already in disuse, in order to create a form of breakwater as protection and a defense from sinking (Regione Siciliana, 2013 and 2014). Subsidence and sea level changes also resulted in marine inundation and therefore had a dramatic impact on the coastal landscape during late roman times. Lipari's inhabitants probably wanted to protect their waterfront from a continuous and irreversible sinking process that created visible and damaging effects as the sea invaded houses and public buildings. Indeed, all of the sea-related construction along the waterfront, such as piers, docks, ship sheds, port infrastructure, storage rooms and harbor facilities, would have been the most damaged structures.

These coastal landscape structures finally disappeared from the visible landscape, together with the knowledge of an existing palaeo-waterfront. No medieval sources mention a harbor-related infrastructure, and only early cartographic evidence provides a limited basis for coastal landscape reconstruction during modern times (Caruso and Nobili, 2001; Gulletta, 2009). Campis (Iacolino, 1980) describes a sheltered and protected pebble beach at LSM, which persisted until 1894 (Salvator of Austria and Paino, 1989). From 1894 to the present day, the shore has undergone major changes due to development and the construction of a tourism infrastructure. The 20th century AD development of the coast, especially construction of residential buildings in the 1950s and 1960s, seems not to have considered the active subsidence which this section of the island is currently undergoing (Anzidei *et al.*, in press; De Guidi *et al.*, in press). As a result, subsidence is causing problems for the people who live at the present waterfront of Lipari. Buildings whose entrance was well above the sea level at the time of their construction are now encountering inundation by seawater. LSM represents an example of how people in antiquity faced the challenges of living in a subsiding environment, and the ways in which they coped with a changing landscape. A complete understanding of the ancient coastal landscape and its changes over time requires further investigation – such as a broader topographical investigation of the urban waterfront – especially in order to answer specific questions such as the initial phases of the structure and the topographic relationship of the submerged structures with the ancient urban plan.

Conclusions

Greek occupation of the island of Sicily has left archaeological imprints on the coastal landscape. It has been shown that an interdisciplinary investigation is the most successful strategy for studying ancient coastal landscapes. Results of the interdisciplinary investigation undertaken at two archaeological sites in Sicily, Selinus and LSM, have been presented and demonstrate that despite the differences in date, size and type (land *vs* underwater) this methodology has provided an improved understanding of the coastal landscape and its changes. As a result, the maritime and coastal landscape of these important archaeological sites can be pictured in a more realistic way. The investigation of Selinus and LSM has enhanced our understanding of the waterfront of these cities by presenting it within a more realistic environmental context. Indeed, the results of this study highlight archaeological features of the ancient landscape and the strategies adopted in antiquity to cope with environmental changes and natural hazards. At Selinus, for example, a marshy environment, frequent earthquakes and the progressive sedimentation of the rivers' harbours have been highlighted, together with the attempt by the selinuntines to reclaim the land and inhibit landslides. The evidence presented here documents new elements of the city of Selinus. The continuous maintenance of the urban landscape, the attempt to inhibit landslides possibly by creating an artificial barrier (Crouch, 2004) and to reclaim the river mouths to prevent harbour siltation – and the consequent creation of an unhealthy marsh environment – was often interrupted by catastrophes such as earthquakes and tsunamis (see list of earthquakes; Carrozzo *et al.,* 1992; Guidoboni *et al.,* 2002). Despite the occurrence of these high magnitude events of geological and natural origin, the inhabitants of Selinus cultivated one of the largest *chorai* of antiquity, maintained a peaceful commercial relationship with the indigenous people and with foreigners, and developed some of the most exceptional monumental architecture and artistic productions of the entire Hellenic world. Conversely, at Lipari, land subsidence challenged the local inhabitants who experienced marine inundation and consequently created sea barriers as a protection strategy. The inhabitants of Lipari also had to cope with the challenges of living in a changing coastal environment. The results reveal that the main coastal settlement of the island possessed a monumental waterfront during Roman times, which has been subject to an irreversible and continuous sinking of 12.3 m. An attempt to avoid marine inundation was probably attempted during late Roman times (4th century AD) in order to protect buildings and houses from the related effects and the changing landscape. Lipari, unlike Selinus, was not abandoned in medieval times and has been continuously inhabited up to the present day. As a result, the modern inhabitants of Lipari suffer from the same marine incursion problem experienced by their ancestors. Reconstruction of the ancient coastal landscape is an important element that should not be underestimated for palaeo-landscape reconstructions of ancient cities and for accurate investigation of the past (Westley and Dix, 2006). It helps us to better understand how people lived in the past and how they experienced the sea, and therefore also to better understand human-sea-landscape relationships in antiquity. It has been shown that Sicily provides an ideal context for studying changes in the coastal landscape, as well as how people living in past times faced the challenges of living in a changing landscape. Indeed by understanding the natural causes of coastal changes, and by reconstructing catastrophic events and the strategies that coastal inhabitants adopted to cope with those changes, it should also be possible to apply this knowledge to current coastal issues.

Acknowledgments

I would like to acknowledge Prof. Sebastiano Tusa and the Soprintendenza del Mare who allowed me to be part of the research team excavating LSM in 2013 and 2014. I also thank Soprintendenza del Mare archaeologists Roberto La Rocca, Philippe Tisseyre, Francesca Oliveri, the GIS specialist Claudio di Franco, and Prof. Marco Anzidei of the INGV. I am deeply grateful to Prof. Rabbel for his help with the interpretation of geoacoustic data, and for his extremely useful suggestions. I also thank Prof. Ted Robinson, Dott. Camilla Normann, Susan Wirgley, Prof. Piergiorgio Spanu and Massimiliano Secci of Sassari University, the director and the staff of the Regional Archaeological Museum of Lipari, and all the students and the volunteers involved in the excavation of LSM and the Coast Guard underwater unit. The research reported in this article has been supported by the Postgraduate Research Support Scheme funded by the University of Sydney, the International Postgraduate Research Scholarships funded by the Australian Government, the Australian Postgraduate Awards funded by the Commonwealth Government, the Carlyle Greenwell Research Fund (Archaeology) and the Hellenic Club Research Scholarship in Classical Archaeology. Finally, I am indebted to the anonymous reviewers for providing insightful comments and directions for additional work which has resulted in this paper.

References

AGNESI V., « Sicily in the last one million years », *Bocconea,* 2004, 17, p. 23-32.

ANZIDEI M., BOSMAN A., CASALBORE D., TUSA S., LA ROCCA R., « New insights on the subsidence of Lipari island (Aeolian islands, southern Italy) from the submerged Roman age pier at Marina Lunga », *Quaternary International,* in press, p. 1-12.

ANZIDEI M., ESPOSITO A., BENINI A., « Evidence of active subsidence at Basiluzzo island (Aeolian islands, southern Italy) inferred from a Roman age wharf ». *Quaternary International,* 332, 2014, p. 143-150.

BARRECA G., BRUNO V., COCORULLO C., CULTRERA F., FERRANTI L., GUGLIELMINO F., GUZZETTA L., MATTIA M., MONACO C., PEPE F.,

« Geodetic and geological evidence of active tectonics in south-western Sicily (Italy) », *Journal of Geodynamics,* 82, 2014, p. 138-149.

BERNABÒ BREA L., *Sicily before the Greeks,* London, Thames and Hudson, 1957, p. 140-141.

BERNABÒ BREA L., « Basiluzzo. Banchina di approdo sommersa in età romana », *Bollettino d'Arte del Ministero dei Beni Culturali ed Ambientali,* 29, supplemento, 1985, p. 77-79.

BERNABÒ BREA L., CAVALIER M., *Meligunis-Lipara IV. L'acropoli di Lipari nella preistoria,* Palermo, Flaccovio, 1980, p. 7-15.

BERNABÒ BREA L., CAVALIER M., VILLARD F., GIARDINA R., *Meligunis Lipara. IX. Topografia di Lipari in età greca e romana,* Palermo, Flaccovio, 1998, p. 35-72.

BOTTARI A., « Attività sismica e neotettonica della Valle del Belice », *Annali di Geofisica*, 26, 1973, p. 55-84.

BOTTARI C., STIROS S.C., TERAMO A., « Archaeological evidence for destructive earthquakes in Sicily between 400 B.C. and A.D. 600 », *Geoarchaeology,* 24, 2009, p. 147-175.

BRANDON C. J., « Roman structures in the sea: Sebastos, the Herodian harbor of Caesarea », *in* Hohlfelder R.L., *The Maritime World of Ancient Rome,* Roma, Supplements to the memoirs of the American Academy in Rome, 6, 2008, p. 145-254.

BRIZZOLARI E., PIRO S., VERSINO L., « Metodi geofisici ad alta risoluzione per lo studio dei fondali nell'area costiera selinuntina », *in* Brizzolari E., Piro S., Versino L., *Selinunte 2: intesa di programma CNR-MISM, Progetto strategico Tecnologie moderne per la conservazione dei beni culturali*. Roma, Bulzoni, 1994, p. 17-50.

BRIZZOLARI E., CARDARELLI E., FEROCI M, PIRO S., VERSINO L., « Monograph on the geophysical exploration of the Selinunte Archaeological Park », *Bollettino di Geofisica Teorica ed Applicata*, 34 (134-135), 1992, p. 1-232.

CAIRE A., « Sicily in its Mediterranean setting », Alvarez W., Gohrbandt K., *Geology and History of Sicily.* Castelfranco Veneto, Grafiche Trevisane, 1970, p. 145-170.

CALANCHI N., LUCCHI F., PIRAZZOLI P., ROMAGNOLI C., TRANNE C.A., RADTKE U., REYSS J.L., ROSSI P.L., « Late Quaternary relative sea-level changes and vertical movements at Lipari (Aeolian islands) », *Journal of Quaternary Science*, 17, 2002, p. 459-467.

CARMINATI E., DOGLIONI C., « Alps vs. Apennines: The paradigm of a tectonically asymmetric Earth », *Earth-Science Reviews,* 112, 2012, p. 67-96.

CARROZZO M.T., COLELLA P., DI FILIPPO M., QUARTA Y., TORRO B, « Detailed Gravity Prospecting and Geological-Structural Setting of the Selinunte Archaeological Site », *Bollettino di Geofisica Teorica ed Applicata,* 34, 1992, p. 101-108.

CARUSO E., NOBILI A., *Le mappe del Catasto Borbonico di Sicilia. Territori comunali e centri urbani nell'archivio cartografico Mortillaro di Villarena (1837-1853)*, Palermo, Arti Grafiche Siciliane, 2001, p. 1-45.

CATALANO, R., « Geology of Sicily: an introduction », *Bocconea,* 17, 2004, p. 33-46.

CATALANO R., AGATE M., ALBANESE C., AVELLONE G., BASILONE L., GASPARO MORTICELLI M., GUGLIOTTA C., SULLI A., VALENTI V., GIBILARO C., PIERINI S., « Walking along a crustal profile across the Sicily fold and thrust belt ». AAPG International Conference & Exhibition, 23-26 October 2011, Milan. Post Conference Field Trip 4, 27-29 October 2011, Palermo, *Geologica Field Trips,* 5, 2013, p. 1-213.

CATALANO R., DI STEFANO P., VITALE F.P., « Structural trends and palaeogeography of the central and western Sicily belt, new insights », *Terra Nova,* 7, 1995, p. 189-199.

CATALANO R., DOGLIONI C., MERLINI S., « On the Mesozoic Ionian Basin », *Geophysical Journal International,* 144, 2001, p. 49-74.

CAVALIER M., BERNABÒ BREA L., *Isole eolie: vulcanologia archeologia*, Napoli, Oreste Ragusi, 1991, p. 5-23.

CAVALLARI F.S., « Topografia di Selinunte e i suoi dintorni ». *Bullettino della commissione di antichità e belle arti in Sicilia,* V, 3, 1872, 3 p. and 1 tab.

CERCHIAI L., JANNELLI L., LONGO F., *The Greek cities of Magna Graecia and Sicily ,* Los Angeles, J. Paul Getty Museum Print, 2004, p. 5-67.

CLUVERIUS P., *Sicilia antiqua, cum minoribus insulis, ei adjacentibus. Item, Sardinia et Corsica. Opus post omnium curas elaboratissimum, tabulis geographicis, aere expressis, illustratum, Lugduni Batavorum,* Leiden, 1619, p. 1-425.

COLUMBA G. M., *I porti della Sicilia,* Roma, Officina Poligrafica Italiana, 1906, p. 7-27.

CROUCH D. P., *Water Management in Ancient Greek Cities,* New York, Oxford University Press, 1993, 35 p.

CROUCH D.P., *Geology and Settlement: Greco-Roman Patterns,* New York, Oxford University Press, USA, 2004, p. 76 and 87.

D'ARRIGO A., *I porti della Sicilia,* Palermo, Irfis, 1965, p. 9-36.

DE ANGELIS F., « The foundation of Selinous: overpopulation or opportunities? », Boardman J., Tsetskhladze G.R., De Angelis F., *The archaeology of Greek colonisation: essays dedicated to Sir John Boardman*, Oxford, Oxford University Committee for Archaeology, 2004, p. 87-110.

DE GUIDI G., SCUDERO S., TUSA S., TISSEYRE P., NICOTRA E., « First evidences of active submergence of the eastern coast of Lipari Island (South Tyrrhenian Sea, Italy) », *Quaternary International*, in press, p. 1-26.

DE MIRO E., LOMBARDO M., « Agrigento », Nenci G., Vallet G., *BTCGI,* 1984, p. 66-128.

DI VITA A., « Urban Planning in Ancient Sicily », Pugliese Carratelli G., *I Greci in Occidente,* Milano, Bompiani, 1996, p. 263-308.

EVELPIDOU N., PIRAZZOLI P., VASSILOPOULOS A., SPADA G., RUGGIERI G., TOMASIN A., « Late Holocene Sea Level Reconstructions Based on Observations of Roman Fish Tanks, Tyrrhenian Coast of Italy ». *Geoarchaeology,* 27, 2012, p. 259-277.

FAZELLO T., NANNINI R., *Le due deche dell' historia di Sicilia,* ebook, 2012, 211 p. Avaible:[http://www.liberliber.it/mediateca/libri/f/fazello/le_due_deche_dell_historia_di_sicilia/pdf/fazello_le_due_deche_dell_historia_di_sicilia.pdf, last access on 23/09/15

FORMOUNT M., « La vasca selinuntina di Torre Bigini fra archivistica e archeologia », *Sicilia archeologica*, 106, 2012, p. 108-135.

GUIDOBONI E., MUGGIA A., MARCONI C., BOSCH E, « A Case Study in Archaeoseismology. The Collapses of the Selinunte Temples (Southwestern Sicily): Two Earthquakes Identified », *Bulletin of the Seismological Society of America,* 92, 2002, p. 2961-2982.

GULLETTA M. I., « La Sicilia nelle immagini della cartografia storica (XV-XVIII) », Ampolo C., *Immagine e immagini della Sicilia e di altre isole del Mediterraneo antico.* Pisa, Edizioni della Normale, 2009, p. 157-194.

HARRIS W.V., ANGELL S. *Sculptured Metopes discovered amongst the ruins of the temples of the ancient city of Selinus in Sicily,* London, Priestley and Weale, 1826, p. 27-35

HESNARD A., MARRINER N., MORHANGE C. « ArchéoMed PaléoMed. Géoarchéologie en Méditerranée ». Aix-en-Provence, Publications de l'Université de Provence, *Méditerranée*, 117, 2011, p. 11-13.

HICKS R.D., *Diogenes Laertius: Lives of eminent and opinion of philosophers*, Loeb classical library v. 1, Cambridge, Harvard University Press, Loeb Classical Library, 184, 1925.

HITTORFF J.I., ZANTH L., *Architecture antique de la Sicile; ou, recueil des plus intéressans monumens d'architecture des villes et des lieux les plus remarquables de la Sicile ancienne,* Paris, Renouard, 1827, p. 1-6.

HOLLOWAY R. R., *The archaeology of ancient Sicily,* London - New York, Routledge, 2002, p. 49-54.

HOUEL J., *Voyage pittoresque dans les isles de Sicile, de Malte et de Lipari,* Paris, 25, 1782, p. 3-138

HULOT J.P., FOUGÈRES G., *Sélinonte, colonie dorienne en Sicilie: la ville, l'acropole et les temples, relevés et resaurations,* Paris, Ch. Massin, 1910, p. 1-37, 134-311.

KEAY S., EARL G., HAY S., KAY S., OGDEN J., STRUTT K.D., « The role of integrated geophysical survey methods in the assessment of archaeological landscapes: the case of Portus », *Archaeological Prospection,* 16, 2009, p. 154-166.

KEAY S., MILLET M., « Portus in context », Keay S., Millet M., Paroli L., Strutt K., *Portus: an Archaeological Survey of the Port of Imperial Rome,* London, The British School at Rome, 2005, p. 297-314.

KOLDEWEY R., PUCHSTEIN O., *Die griechischen Tempel in Unteritalien und Sicilien,* Berlin, Asher, 1899, vol. 2, p. 77-81.

LAMBECK C., ANZIDEI M., ANTONIOLI F., BENINI A., ESPOSITO A., « Sea level in Roman time in the Central Mediterranean and implications for recent change », *Earth and Planetary Science Letters,* 224, 2004, p. 563-575.

LENTINI F., « Il territorio di Selinunte in età imperiale », *in* Tusa S., *Selinunte,* Roma, L'Erma di Bretshneider, 2010a, p. 205-218.

LENTINI F., « L'insediamento tardoantico alla foce del fiume Modione », Tusa S., *Selinunte,* Roma, L'Erma di Bretsheneider, 2010b, p. 191-203.

LENTINI F., « L'insediamento tardoantico alla foce del fiume Modione », Pandolfi P., *Selinunte tra terra e mare. Atti delle giornate di studi, Castelvetrano, CAM*, 2011, p. 21-32.

LO FASO PIETRASANTA DUCA DI SERRADIFALCO, *Antichità della Sicilia esposte ed illustrate*, vol. 2, Palermo, *Tipografia del Giornale Letterario*, 1834, p. 12-30.

MARRINER N., MORHANGE C., « Geoscience of ancient Mediterranean harbours », *Earth-Science Reviews,* 80, 2007, p. 137-194.

MARRINER N., MORHANGE C., GOIRAN J.P., « Coastal and ancient harbour geoarchaeology », *Geology Today,* 26, 2010, p. 21-27.

MONACO C., MAZZOLI S., TORTORICI L., « Active thrust tectonics in western Sicily (southern Italy): the 1968 Belice earthquakes sequence », *Terra Nova,* 8, 1996, p. 372-381.

MORHANGE C., MARRINER N., BONY G., « Coastal geo-archaeology in the Mediterranean: A French perspective », Keay, S., *Rome, Portus and the Mediterranean.* British School at Rome, 2013, p. 403-409.

MORTON J.U., *The Role of the Physical Environment in Ancient Greek Seafaring,* Leiden - Boston, Brill, 2001, p. 114-115

OLDFATHER C.H., *Diodorus Siculus: Library of History*, Cambridge, Harvard University Press, Loeb Classical Library, 279, 1933.

ORSI P., « Megara Hyblaea », *Monumenti Antichi dei Lincei*, 1890, p. 757-761.

PURPURA G., « Alcuni rinvenimenti sottomarini lungo le coste della Sicilia Nord Occidentale », *Sicilia archeologica,* 28-29, 1975, p. 57-84.

PURPURA G., « Rinvenimenti sottomarini nella Sicilia Occidentale », *Bollettino d'Arte,* Supplement, 37-38, 1986, p. 139-160.

PURPURA G., « Il porto sotto la sabbia », *Kalos,* 70, 1991, p. 20-23.

RABBEL W., HOFFMANN WIECK G., JAKOBSEN O., ÖZKAP K., STÜMPEL H., SUHR W., SZALAIOVA E., WÖLZ S., « Seismische Vermessung der verlandeten Buchten des Medione und Gorgo Cotone. Hinweise zur

Lage des Hafens der antiken Stadt Selinunt », *R*ömische Abteilung (Römische *Mitteilungen),* 120, 2014, p. 135-150.

RAMBALDI S., « Empedocle e la bonifica di Selinunte: un breve riesame », Onlus F.K., *Selinunte si racconta. CAM 5 maggio 2010. Atti della giornata di studi,* Castelvetrano, CAM Campus Archeologico Museale, 2010, p. 12-17.

REGIONE SICILIANA, 2013, *Archeolie 2013* [Online]. Available: [http://www.regione.sicilia.it/beniculturali/archeologiasottomarina/sez_eventi/archeolie_2013.htm] *(*Accessed 23/12/2014).

REGIONE SICILIANA, 2014, *Archeolie 2014* [Online]. Available: [http://www.regione.sicilia.it/beniculturali/archeologiasottomarina/sez_eventi/archeolie_2014.htm] (Accessed 23/12/14).

REINGANUM H., *Selinus und sein Gebiet,* Leipzig, 1827, p. 59-88.

ROGERS A., « Social Archaeological Approaches in Port and Harbour Studies », *Journal of Maritime Archaeology,* 8, 2013a, p. 181-196.

ROGERS A., *Water and Roman Urbanism: Towns, Waterscapes, Land Transformation and Experience in Roman Britain,* Leiden-Boston, Brill, 2013b, p. 17-23.

SALINAS A., *Selinunte*, NScA, 1886, p. 104

SALINAS A., PATRICOLO G., *Selinunte*, NScA, 1888, p. 595

SALVATOR OF AUSTRIA L., PAINO P., « *Le Isole Lipari, terzo volume Lipari. Riproduzione litografica dall'originale con traduzione in italiano* », Edinixe, 1989, p. 129-135.

SMITH C.F., *Thucydides: History of the Peloponesian war, Volume 2, books 3-4*, Loeb Classical Library, 1920.

TISSEYRE P., « Lipari, il porto di Meligunis Lipara, III-II sec. a.C. I sondaggi recenti », *Vincenzo Tusa e il mare. Giornata di Studio in memoria di vincenzo Tusa per l'Istituzione dell'Ossercatorio Mediterraneo sui Beni Culturali Sommersi*, 6 Giugno 2009, Ustica, in press, p. 1-2.

Tranne C.A., Lucchi F., Calanchi N., Lanzafame G., Rossi P.L., *Geological Map of theIsland of Lipari (Aeolian Islands),* University of Bologna and INGV, L.A.C., Firenze, 2002.

TUSA S., « Selinunte-Malophoros. Rapporto preliminare sulla II campagna di scavi », *Sicilia archeologica,* 60-61, 1986, p. 13-22.

TUSA S., *Arte e storia nei mari di Sicilia,* Vicenza, Magnus, 2010a, p. 181.

TUSA S., « Selinunte e il mare », Tusa S., *Selinunte,* Roma, L'Erma di Bretschneider, 2010b, p. 219-231.

TUSA S., DE WAILLY M., GREGORI B., PARISI PRESICCE C., RIOTTO M., DEHL C., DI SALVO R., BELLOTTI P., « Selinunte-Malophoros: rapporto preliminare sulla prima campagna di scavi – 1982 », *Sicilia archeologica,* 54-55, 1984, p. 17-58.

TUSA V., *La scultura in pietra di Selinunte,* Palermo, Sellerio, 1984, p. 199.

VALLET G., VILLARD F., AUBERSON P., ROME E.F.D., « *Megara Hyblaea. 3, Guida agli scavi: introduzione alla storia di una città coloniale d'occidente* »*,* Roma, École Française de Rome, 1983, p. 23-34.

VOZA G., *Nel segno dell'antico: archeologia nel territorio di Siracusa,* Palermo, Lombardi, 1999, p. 67-79.

WALBANK F.W., HABICHT C., PATON W.R., *Polibius: the Histories*, vol. 1-2, Cambridge, Harvard University Press, Loeb Classical Library, 137, 2010.

WESTLEY K., DIX J., « Coastal environments and their role in prehistoric migrations », *Journal of Maritime Archaeology,* 1, 2006, p. 9-28.

WILSON R. J. A., LEONARD A., « Field Survey at Heraclea Minoa (Agrigento), Sicily », *Journal of Field Archaeology,* 7, 1980, p. 219-239.