

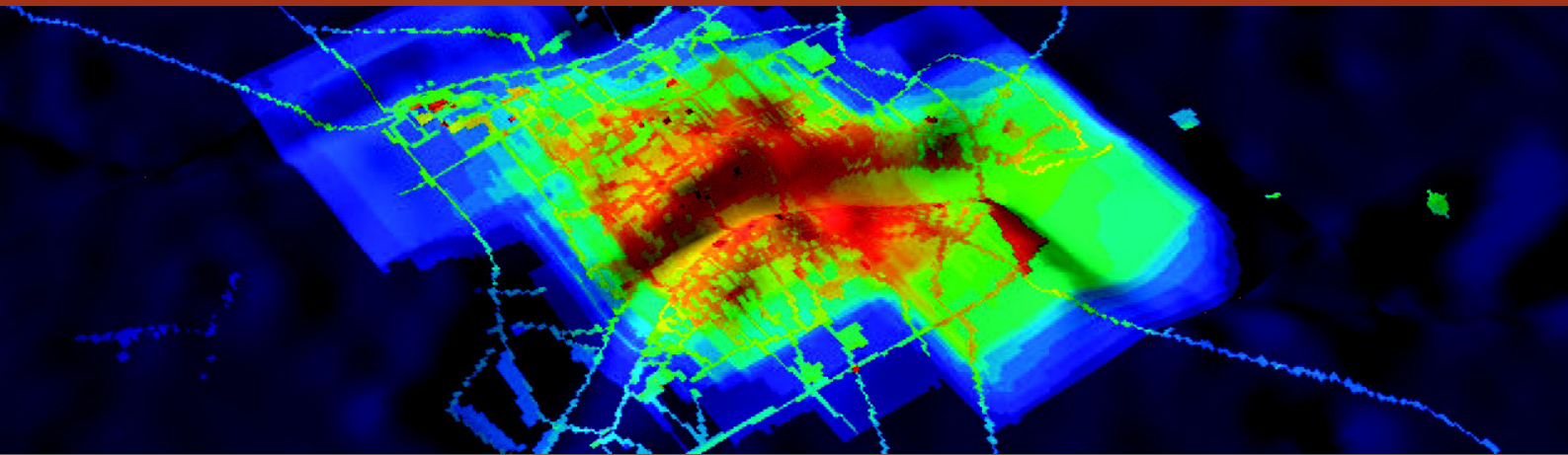


mappa

metodologie applicate alla predittività
del potenziale archeologico

Mappa

**Pisa in the Middle Ages: archaeology,
spatial analysis and predictive modeling**



UNIVERSITÀ DI PISA



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Regione Toscana



MAPPA

PISA IN THE MIDDLE AGES: ARCHAEOLOGY, SPATIAL ANALYSIS AND PREDICTIVE MODELING

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MAPPA PROJECT

Funding bodies:

Regione Toscana
Università di Pisa

Implementing body:

Università di Pisa

Partner:

Direzione Regionale per i Beni Culturali e Paesaggistici della Toscana
Soprintendenza per i Beni Archeologici della Toscana
Soprintendenza per i Beni Architettonici Paesaggistici Artistici Storici ed Etnoantropologici per le province di Pisa e Livorno
Comune di Pisa

Cooperation:

Aerofototeca Nazionale
Centro di documentazione aerofotografica "Marcello Cosci" - Università di Pisa
Consorzio LAMMA - Laboratorio di Monitoraggio e Modellistica Ambientale per lo sviluppo sostenibile - Regione Toscana e CNR
Istituto Nazionale di Geofisica e Vulcanologia
Laboratorio di cultura Digitale - CISIAU Centro Interdipartimentale di Servizi Informatici per l'Area Umanistica - Università di Pisa

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ISBN: 9788868120948

DOI: 10.4458/0948



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I. Introduction

This volume represents the third edition of a work cycle that started in 2006 for my PhD thesis. The thesis was presented in 2010 (first edition, GATTIGLIA 2010), partially published as a summary monograph in 2011 (second edition, GATTIGLIA 2011) or in articles (GATTIGLIA 2012, GATTIGLIA 2012a, GATTIGLIA 2011a), and now (third edition) takes the form of a more comprehensive publication in the light of new data. Over the past two years, the work study on Pisa, not only relating to the Middle Ages, continued within the MAPPA (Metodologie Applicate alla Predittività del Potenziale - Methodologies Applied to Archaeological Potential Predictivity)¹ project, allowing a widespread collection of data thanks to which it was possible to explain more fully the hydrogeological, geomorphological and topographic context and to check (and in many cases change) part of the assumptions made. Archaeology, albeit slowly, is moving towards *Big Data*, i.e. enormous amounts of machine readable data, continuously produced, which can modify theories, conclusions and assumptions at any time and develop new applications for archaeology. We no longer live in an age in which printed texts have a long life cycle before becoming outdated; new data are enough today to contradict or validate the assumptions made. Archaeology is closer and closer to science, not only because it uses scientific analysis methods but because it is based on falsifiable hypotheses, to put it as Popper would say. For this reason, the data analysed here are published as open data on the MOD (ANICHINI *et alii* 2013) (the open data ar-

chive of Italian archaeology www.mappaproject.org/mod) or as open access on MAPPA Web GIS (MAPPAGis www.mappaproject.org/webgis). As such, they can be reused, recycled, modified, transformed and implemented an endless number of times to reach interpretations, assumptions and original models that contradict what has been studied. Consequently, this volume will analyse data and interpret general trends; for details on the cases, reference can be made to the MOD data and MAPPAGis displays. The reader will not find “important” dates but analyses which, starting from archaeological data (whether material culture or topography), produce historical information and a new point of view to be associated with more traditional interpretations. Likewise, data from written sources will only be dealt with in specific cases, leaving this study to expert specialists. The title of my PhD thesis was “Pisa between the VII and XIV century. In the light of archaeology”, emphasising the key role played by archaeological sources. I am quite aware of the partial nature of this source, as also of written sources, but i am also well-aware of the great amount of data we produce, which may be read and re-interpreted by other researchers.

Over the last years, studies on medieval cities have increased in Italy, which have made wide use of GIS spatial analysis². I do not believe that these studies should be considered innovative or revolutionary, but simply contemporary to an everyday life made of tablets, IT applications and social networks. Equally, speaking of digital archae-

¹ All the publications may be downloaded at http://mappaproject.arch.unipi.it/?page_id=136 (last access 05/05/2013).

² See the second volume of *Postclassical Archaeology* and the recent volume *CITTE* 2012

ology or digital humanities is even more outdated when everything today is digital. If it is certain that we live in a digital world, we must be aware of the need to explain analysis procedures and make them transparent and reproducible, so that other researchers may retrace them, assess them, criticise them and find new, more effective paths³. I will take for granted, therefore, the knowledge of GIS applications and spatial analysis, while reference to recent publications (FABIANI, GATTIGLIA 2012, ANICHINI, GATTIGLIA 2012) can be made for the database structuring. Spatial analysis (now within reach of everyone) must not follow a totally uncritical or technocratic approach but must arise from evaluations: while spatial analysis methods were specifically created for geographical analyses and may, therefore, be easily used for archaeology (HODDER, ORTON 1976), geostatistic methods were not conceived for archaeology. On the one hand, therefore, it is necessary to proceed with great caution and attentively examine the pros and cons of their use, and, on the other, to create mathematical and statistical methods specifically created for archaeology (DUBBINI 2013). When speaking of an Archaeological Information System, we must not think of a GIS that elaborates archaeological data, but rather a software borrowed from the GIS which applies tools specifically conceived for archaeology.

From an interpretative viewpoint, this volume attempts to give an answer as to what the medieval city was and what the surrounding landscape represented. It was certainly not a container in which the city moved or a set, backdrop or stage where the city played a leading role. Rivers, marshes, mountains and man are only some of the agents that influenced the anthropic landscape. Of these, the city is the most archaeologically visible agent because it has left the most evident material trac-

es, yet it is not the result only of man's choices but also of the environment's influence which has shaped the city just as much as man. While one of these factors may have prevailed in certain periods, the ongoing correlation between them is evident. Only archaeology can narrate this story, made chiefly of material traces. It can do so by using contemporary digital tools which can broaden the scope of reasoning.

In this first introductory chapter, the history of urban archaeology in Pisa will be briefly presented. The second chapter will provide a broad outline of the territorial context and the landscape. The rivers and marshy areas will be analysed in order to understand how the environment influenced the development of the medieval city for better or for worse. Since man was not a passive responder to these events, the study of the port system and road networks will help understand which solutions were taken to draw the geographical benefits and generate economic and commercial profits.

The third and last chapter is divided into two parts. The first part will illustrate the great urban transformations throughout the period ranging from the end of the Roman Age (VI century) to the Florentine conquest (start of the XV century). Although it is still difficult to have a clear picture of the Roman and early-medieval urban fabric of Pisa, it is nevertheless possible to understand some of its nodal points, to interpret the city's development during the middle years of the Middle Ages and to analyse what happened during the transition that led to the modern city. The second part will deal with the material traces, i.e. the archaeological sources that allowed us to recover pieces of history and build the overall picture. Excavation data will provide information about the buildings, roads, workshops and craft labora-

³ Similarly to CITTER 2012, 2012a, who publishes the workflows of the ArcGIS model builder to make its process clear and accessible. Unlike him, I have decided to provide a more general and non-graphic description, in order to allow users of different GIS software to reproduce the analysis processes.

tories, waste disposal and water supply systems, and on the wealth and social status of the city's inhabitants.

1.1 Urban archaeology in Pisa

Topography, urban layout, architecture and (partly) the material culture of medieval Pisa were the subject of various studies at the start of the 1990s (GARZELLA 1990; REDI 1991; TOLAINI 1992; TOLAINI 1992a). At that time, however, only data from a few archaeological interventions and spits were available and the interpretative assumptions were essentially based on the interpretation of archival data, at times compared with the material evidence of the buildings or structures brought to light during excavations and restorations. From 1990, and especially over the past years, the number, quality and scope of archaeological interventions in the city have increased (ANICHINI *et alii* 2012). From the start of the nineties to 2013, 264 different archaeological interventions have been carried out, including watching brief, surveys archaeological excavations, building analysis and cores. Half of these interventions have regarded medieval stratifications and/or structures dating between the VI and XV century. The credit for the impetus given to urban archaeology in Pisa, especially during the last decade, belongs to the many professional archaeologists who have been involved in the city's development-led excavations. The first archaeological discoveries in the area of Pisa date back to the XVI century. The first acknowledged date is 1520 when a number of artefacts were brought to light at Porto alle Conche, interpreted as the remains of a Roman Imperial necropolis. Instead, the first intervention inside the city can be dated after about 40 years, when part of a necropolis was found at the Tax house in piazza del Duomo. The aim here, rather than go so far back in time or trace a fully-detailed history of urban archaeology in Pisa, is to highlight its distinguishing trends. Up to the first half of the twentieth century, archaeology in Pisa was related to occasional finds, except for the excavations at the

thermae of Porta a Lucca and at the Camposanto Monumentale. After the war, the approach to archaeological research started to change. Between the end of the 1940s and early 1950s, excavations were carried out at piazza del Duomo and interest began to be shown in the Middle Ages. The 1960s were dominated by occasional finds, especially pottery, which laid the foundations for the subsequent study on the Pisan and Mediterranean pottery that circulated in the city. This period marked a renewed interest in archaeology which was forced to chase urban works but was not able to control them. The 1970s were a turning point, also thanks to a nationwide ferment following the birth of medieval archaeology and its methodological background. 1977 was a black year for Pisa's urban archaeology, marked by a traumatic event: the works carried out at Torre della Fame and piazza dei Cavalieri, commissioned by the Scuola Superiore Normale – one of the leading cultural centres of the city – were appallingly executed, transforming a unique chance to gain historical knowledge into a huge loss of archaeological information. At the same time, however, this event inflamed the passions of many young archaeologists who we could define – given also the period – activists. During the eighties, extensive stratigraphic excavations marked the start of urban archaeology in Pisa as intended today. This period reached its peak in the excavation of piazza Dante and led to the publication of a series of volumes on the medieval city and its pottery. During these years, urban archaeology in Pisa was mainly (but not solely) medieval archaeology, due to the intrinsic methodological value of this discipline, as well as to the difficulty – for a city such as Pisa characterised by a high groundwater level – to reach the most ancient settlement phases, and to the strong link with medieval history developed by Pisa University researchers. During the 1990s, the tradition conceived during the 1980s was consolidated, forming not so much a “school” but rather a “training class” for Pisa archaeology. Over the last two decades, urban archaeology

has been accompanied by a high turnover rate among the archaeologists who have worked in the city (ANICHINI 2012). The Superintendency's great attention to preventive archaeology began to increase from the 1990s and further still at the start of the XXI century. This had led, over the past ten years, to a major surge in excavations and to increasing attention by the municipal administration to use public works as a chance to gain archaeological knowledge. In more simple terms, if the time and quality of the data produced were to be entered on a Cartesian graph, it would be possible to see how much the quantity and quality of the archaeological data collected have increased as time increases, being the increase in time expression of more effective excavation methods and greater attention to the collection of medieval and generically post-classic data. We must not be misled, therefore, by the quantity of data collected before checking their quality. The sample of data from Pisa confirms how the transition from rescue

and/or occasional activities to planned activities always and in any case leads to an increase in both the quantity and quality of data produced. The data collected clearly show how the attention to post-classic archaeology, ranging from the medieval to contemporary ages, was only recently developed, penalizing the knowledge of these periods. Numerically significant finds, related to medieval archaeological phases, can be seen from the 1970s onwards, clearly in line with the birth of this young (in Italy) discipline. On the one hand, this means that it is possible to have high quality archaeological data, since the start of this new discipline coincides with the introduction of more refined excavation methods and, on the other hand, indicates the total loss of all the data preceding this date. The development of this new attention over the past forty years has led to the collection of medieval archaeological data that represent little over a quarter of the total amount of data held.

2. The landscape: the anthropised environment

2.1 The city, man and the environment

This chapter will address the issue of the landscape surrounding the city, regarded as both a natural and anthropised environment. Whether natural or anthropised, the environment is not simply a container, but a key element in the development of human settlements. In this sense, the archaeological study of a city must be strictly related to the analysis of the environmental context surrounding it, which guides man's choices and contributes to determining economy as well as the social and political profile, namely, the history of a city. This awareness is not new¹: over the past years renewed interest has developed, focusing mainly on the development of new interpretative models based principally on spatial analysis² (CITTER 2012). An environment manipulated by man, therefore, must be analysed as a historical product allowing the social dimension to emerge (MILANESE 2004: 64) and in which "river banks, traces of cultivated fields, pastoral fences and traces of irrigation systems (buried or still on the surface) become recognisable archaeological traces which, as such, can be investigated" (STAGNO 2009: 22). In the case of Pisa, which is part of a geographical - environmental context characterised by a floodplain cut by the Serchio-*Auser* river basins to the north and by the Arno river basin to the south, forming wetlands and marshes over the past centuries, varying their course and modifying

the coastline, the influence of the environment is evident, even at first glance. Reconstructing the environmental context, therefore, reflects the desire to estimate its influence on urban development in its various facets. What has been the role played by environmental aspects in the development of Pisa? Were they decisive, definitive or concomitant with other factors? Attempting to understand where the rivers flowed and with which effects, how far the coast was from the city, and how vast were the marshes that surrounded it means trying to answer these questions. To do this, I used spatial analysis³ to provide a synchronic and comparative reading of data deriving from several sources (archaeological, geological, geomorphological and toponymic data, and data inferable from written sources) and located within a geographical area of around 350 km² comprising the area of *Portus Pisanus* to the south, the southern bank of Lake Massaciuccoli to the north, the Tyrrhenian Sea to the east, the first offshoots of the Monti Pisani (Pisan Mounts) to the north-west and the area of Navacchio to the west. The chronological period taken into consideration ranged from the Late Roman period to the start of the XV century (fig. 2.1). The chapter follows the analysis phases, which started by considering coastline variations and then moved on to studying the two river basins - *Auser* and Arno - and the presence of wetlands and marshes, as well as analysing the

¹ For Pisa see the work of F. Redi, especially REDI 1991.

² The attention to environmental themes in the studies of the Senese school, according to STAGNO 2009: 22 did not substantially modify a site-centred vision, as in the case of the studies carried out in the Padua-Venetian area, in Liguria and in northern Tuscany.

³ It should be recalled that "the main objective of spatial analysis is simply to identify, within a geographical - or spatial - distribution, of a stochastic nature, general non-evident trends concerning both ecological and cultural spheres" (MACCHI 2001:145).

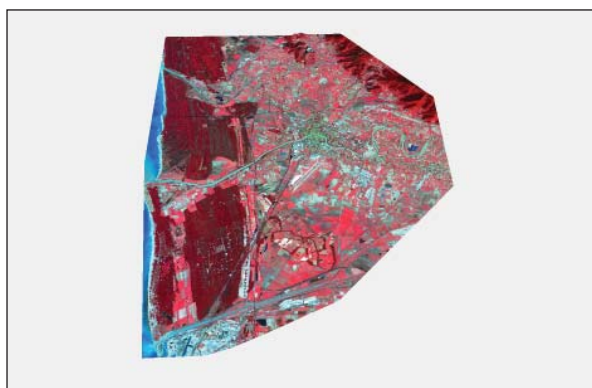


Fig. 2.1 3D satellite image of the area taken into consideration.

possible economic and agricultural uses of the landscape. Once the environmental framework was defined, terrestrial and fluvial mobility was analysed.

2.1.1 The geological context

The area under examination (fig. 2.2) can be divided into three components: Monti Pisani, the Pisa hills and the Pisa plain. The first is composed of an orogenic segment with Alpine strata, called *Toscanidi* and *Liguridi*, which is significantly raised compared to the surrounding landscape. Several springs may be found here, part of which feed highly uneven torrential watercourses⁴. The hilly area is quite homogeneous, with mainly sandy, conglomeratic and clayey surface deposits of neogenic and Quarternary formation, and well-differentiated heights compared to the plains. The largest hilly districts are separated by valleys cut by medium-sized watercourses which, flowing towards south or north, flow into the Serchio and Arno (BALDASSARRI 2008a: 98; MAZZANTI, RAÙ 1994). The Pisa plain, delimited by the Versilian coastal plain and the Monti Pisani to the north, and the

Hills of Pisa and Livorno to the south, forms the southern inshore portion of the wider basin of Viareggio. This sedimentary basin represents the fill of a half-graben system that evolved along the Tyrrhenian margin of the Apennine chain, starting from the upper Tortonian, in relation to the opening of the Tyrrhenian Sea and the concurrent counter-clockwise migration of the chain-foredeep-foreland system (SARTI *et alii* 2008; SARTI *et alii* 2010). From a physiographical viewpoint, it is divided in a coastal area, measuring 4-7 km, mainly composed of dune ridges alternating with inter-ridge deposits, that derives from the interaction between coastal, wind and fluvial dynamics, and in the floodplain featured by a thick layer of sediments deposited by the Arno and the Serchio rivers⁵, starting from the late Tertiary, within a tectonic depression. The Pisa plain subsurface may be divided into three parts: deep substratum, intermediate substratum and surface substratum. The first⁶ includes the lithoid formations of the Tuscan Series, the same that rise on the Monti Pisani (GHELARDONI *et alii* 1968) and the Ligurian allochthonous formations in the area to the west of Pisa. The intermediate substratum is composed of neoautochthonous sediments starting from the upper Miocene in the presence of a Tectonic subsidence. The succession starts in the lower most portion with sand and conglomerates, followed by lagoonal clay overlain by chalk separated by clay strata whose deposition coincides with the interruption of communication between the Mediterranean Sea and the Atlantic Ocean. Sand, clay and conglomerates may be found above the chalk, which represent the sedimentation of a basin with no communication with the open seas. These

⁴ The spring waters have limited flow, are highly variable during the year and have very low hardness, due to the nature of the rocks they cross. The presence of thermal waters is of interest, which are heated due to geothermal effects, and have been used since ancient times.

⁵ The first area preserves the original nature of the landscape quite well, making it easy to read the geomorphological evidences, whereas the second is difficult to read (BINI *et alii* 2012a: 139).

⁶ The depth of the top varies from a minimum of 500 m at the foot of the Monti Pisani to around 2000 m along the coast. In the Pisa area, the isobaths of the top of these lands are at a depth of around 1000 m.



Fig. 2.2 Mosaic of geological vector map (CAR.G.) overlapping the satellite images. The preponderance of alluvial deposits is evident (in blue).

are followed by the deposition of blue marine facies clay, blue clay and yellow sand, providing evidence of the alternation of more or less deep marine environments. Pleistocene sand and clay may be found above, followed by Nugola Vecchia sands which show low sea-level sedimentation and marine regression which took place at the end of the inferior Pleistocene. This stratification may be observed at surface level on the Pisa Hills where these lands form a monocline which sinks under the Pisa plain (FANCELLI *et alii* 1986). The upper substratum is formed of sediments subsequent to the inferior Pleistocene, deposited following variations in the sea level and in the structure of the rivers whose solid transport changed, due to climate changes, both in terms of amount and grain-size of the clasts. The formation of the conglomerates of the Arno and Serchio may be found in the upper substratum⁷, consisting of pebbles of the formations arising on the Monti Pisani, home to an important artesian aquifer which is highly exploited today. The coarser clasts of these conglomerates appear to be due to the Serchio, whereas the waters of the Arno produced finer clasts since provided with less energy. Subsurface fluvial-marshy silt may be found above, corresponding to a more limited phase of fluvial activity, confirmed by the drastically reduced size of the clasts (DELLA ROCCA *et alii* 1987). This reduction in transport is probably associated with the presence of an arid climate which, during the upper Pleistocene favoured the deposition of the sand dunes of Isola di Coltano above the subsurface fluvial-marshy silt. The presence of these sands indicates sea water ingress followed by a eustatic rise with the formation of wind dunes. These sands are followed by the deposition of fluvial-marshy silt

associated with the overbank of the Arno and with the variations in its course and are also affected by the presence of vast marshy areas. These are basically fluvial-marshy sediments located in the eastern part, separated from the open sea by transitional wind deposits of beaches and coastal dunes. The sediments of today's beaches are generally formed of fine sand⁸, whereas the sediments at the water's edge are slightly coarser (medium sand) and the sediments of coastal dunes (further away from the coastline) are wind-driven given their size and high sorting.

The sediments deposited by the current channels in the fluvial plain are associated with overbank and settling (FABIANI, GATTIGLIA 2012: 70-71). As regards the Arno, sediments of different grain sizes can be found ranging from clay-silty to sandy in correspondence of the energy of the waters that deposited them. The deposits belonging to this group are represented by very fine sediments and are generally located in areas that are more distant from the rivers and subject to overbank. In the more depressed areas, subject to the development of marshes, deposits of organic clay and peat⁹ may be seen. These deposits may be seen in areas that were permanently marshy in the past, but only occasionally so today in correspondence of serious weather conditions. These areas are located to the north of Coltano, in Stagno, in the area of Ballerina and of Gracitone and near Campaldo. The prevailing silty and sandy alluvial deposits have an averagely coarser grain size than those of the sediments described above. The repeated overbanks which involved the plain of Pisa in the past deposited the coarser silty fraction mainly in the areas located near the course of the Arno. In fact, silt can be found in the area of Barbaricina, Vettola, San Giovanni

⁷ At a depth of around 145 m in the area of Pisa and with thickness varying between 4 and 10 m.

⁸ The size of the clasts decrease to the south of the Arno mouth and increase to the north of it.

⁹ The deposition of peat is caused by an anaerobic degradation process involving hygrophilous vegetation which occurs because of the marshy conditions of the land; for "Marsh deposits" see FABIANI, GATTIGLIA 2012: 71.

al Gatano and in the southern area of Pisa, San Giusto, Sant'Ermete, Ospedaletto and in Le Rene, representing a river overbank sediment in these areas, which may have been deposited by an ancient channel of the now-abandoned river. The areas in which the substratum is composed of these sediments are slightly more elevated than the former marshy areas in which averagely finer sediments can be found. The prevailing sandy alluvial deposits are mainly composed of lower amounts of clayey and silty sands and can be seen in the first 5 metres of subsurface. These deposits are located in the area of Ospedaletto and in a number of sections adjacent to the current course of the Arno. They may be interpreted as sandy settlements which were formed in the inner part of meanders due to the slowing down of the current. The calcarenites and sands of Isola di Coltano are sandy sediments of prevailing quartz composition which rise in Coltano, in the area of Castagnolo and in a limited area near Montacchiello. The areas in which these soils are located have a higher morphology since they are wind-driven coastal dunes residues and reach maximum differences in elevation of 8-9 metres. These are deposits related to the upper Pleistocene deposited during the Wurm II (MENCHELLI 1984). The marshy areas are characterised by plastic and organic surface clay, at times with silty fractions, whereas the palaeochannel are generally characterised by sandy soils that show a lensing pattern separated by fine silty-clayey sediments, which may be associated with the presence of fine, at times organic, deposits due to the development of local marshes following the cutting of the meander.

It is possible to divide the soils of our area into:

filling soils, sands, fine silty sands, clay and silt, plastic blue-grey clay, and prevailing clayey soils. The filling soils, with thickness varying between 1.5 and 5-6 m, may mainly be found on the banks of the Arno¹⁰. Sands are present along the coastal strip in correspondence of the beaches and coastal dunes, in the areas of Coltano, Castagnolo and in a very limited area near Montacchiello. The sands are mainly composed of quartz, at times intercalated with silty sands, of a light-brown hazelnut colour in the more upper layers and grey in the lower layers. The fine silty sands that may be found along the coast, in inter-ridges deposits, and in certain sections along the course of the Arno and in the area of Ospedaletto, at times feature silty and clayey intercalations. Yellowish brown clay and silt emerge at Campaldo, Lenze, Cisanello, San Giusto in Cannicci, Campacci, Montacchiello and to the east of Ospedaletto. The plastic bluish grey clay may be found in the former marshy areas to the north of Coltano, in Stagno, in the area of Ballerina, Gracitone and close to Campaldo. This clay, which is highly plastic and naturally humid, contains sandy lenses with varying thickness and often peaty layers. The prevailing silty soils are located mainly in the vicinity of the current course of the Arno, for example in the area of Barbaricina, Vettola, San Giusto, Sant'Ermete, Ospedaletto and Le Rene. The ochre-hazelnut soils show clay and at times sandy intercalations, mainly deposited during overbanking processes also in recent times.

2.1.2 Palaeoenvironmental evolution

As confirmed by the data produced and analysed during the MAPPA Project (AMOROSI *et alii* 2012;

¹⁰ In the internal area of the meander of Cisanello, the thickness of the topsoil and filling soil may reach even 7 metres. They were deposited following the discharge and accumulation of excavated material during the construction of the banks and flood bed, whilst the fill material inside the flood bed of Cella is composed of an accumulation of inert materials formed of lithoid elements and bricks, as well as more or less fine material.

AMOROSI *et alii* 2012a), the palaeoenvironmental evolution of the Pisa plain, which started around 6000-5000 years B.C., was strongly influenced by a sharp deceleration in sea-level rise and by the increase in sediment supplied by the two fluvial systems: Arno and *Auser*-Serchio. The spatial distribution of 'pancone', in the lowermost portion of the mid-late Holocene succession, documents the development and persistence of a lagoonal basin at the turnaround from the maximum marine transgression (approximately 6000 years B.C.) to the subsequent highstand phase (AMOROSI *et alii* 2012a: 263), with sediment provenance from both fluvial systems. Lagoon siltation occurred around the middle of the III millennium B.C. and was completed, with the construction of the deltaic-coastal plain, around the end of the III millennium B.C.. During the Eneolithic Age (3000-2000 B.C.) the deltaic-coastal plain of Pisa was crossed by two fluvial systems: within a general Arno River provenance context, geochemical data reveal that the plain was also fed by the Serchio in correspondence of the modern Morto River course. This complex hydrogeological network marked by two river basins - Arno and *Auser* -Serchio - also characterises the phase of alluvial plain construction, which started approximately 1900 years B.C.. Between the Bronze Age and the Iron Age/Oriental Etruscan period (approximately 1900 years and 700 years B.C.), the swamplands progressively emerged and turned into poorly drained floodplain areas. The presence of at least three generations of channels and related levee and crevasse splay deposits document a highly dynamic protohistoric fluvial system, mainly fed by the Arno River. Geochemical data also provide evidence of a river branch fed by the Serchio in the Morto River area and another branch (*Auser*?) flowing from north-east towards the historical centre of Pisa. The formation of the alluvial plain dates back to the Etruscan-Roman Age and was preceded by the development of small

swamps, between the IX and V century B.C., in the historical centre of Pisa to the north of the Arno. These small transient marshes developed in morphologically low-lying zones close to one or more coeval or semi-coeval palaeochannels. Local palaeomorphologies, connected to fluvial dynamics, also determined the persistence of poorly drained conditions in the historical centre of Pisa, up to the marked diffusion of anthropic stratification starting from the Late Middle Ages.

2.2. The environmental conditions of the Pisa plain during the Middle Ages

2.2.1 The coastline

The Pisa coast is part of the physiographic unit extending from the mouth of the Magra River to the north and to the Livorno hills to the south. It features dune ridges formed after the supply of sediments from the Arno and *Auser*-Serchio River basins. The littoral drift at the mouth of the Arno River is divergent, flowing south on the left of the delta and north on the right, while it is convergent at Calambrone. The drift convergence could be correlated to the presence of dominating waves from south-southwest associated with strong south-westerly winds. The diffraction and refraction processes of the resulting incident wave generates two currents: a northern current that transports sediments from the Arno to Tirrenia and Livorno, and is partially responsible for the drift oriented towards south; a southern current generates the drift oriented towards north, which could be responsible for the sandy accumulation at Calambrone. According to SARTI *et alii* 2010 the Roman and medieval morphodynamic configuration does not seem to differ greatly from the current configuration in terms of littoral drift direction and sediment supply sources, since there appear to be no texture and compositional differences between more ancient (before the II-I century B.C.) and recent shorelines. The coastal morphology,

therefore, is similar to that found today except for the presence of the *Sinus Pisanus*¹¹, the large inlet on the southern part of the coast, which later changed into a wetland. Coastal progradation¹², in this part of the coast, which started around 7500 BP (AMOROSI *et alii* 2008), is related to the supply of sediments transported by the Arno and *Auser-Serchio* fluvial systems. It was conditioned by the climatic changes that affected the area and by man's impact on the territory, characterised by alternating periods of tree-planting and deforestation. The configuration of the Tyrrhenian deltas, including the Arno delta, is in fact characterised by a low platform – scarcely influenced by subsidence and by low tidal range – and is sensitive to environmental changes, less to anthropic action¹³ (BELLOTTI 2000). The sea level was lower than the current one: at the start of the I century A.D. it was around 0.9 m lower than today (PRANZINI 2007: 402).

A large number of studies¹⁴ have consistently dealt with the positioning of the coastline¹⁵ and its changes throughout history. The main difficulty lies in dating the subsequent phases of coastal advancement due to the scarce amount of archaeological data found and the lack of specifically targeted archaeological research. The most ancient coastline identified runs through

the western border of the *Cotone*¹⁶ *delle Cascine*, to the north of the Arno, and through the western border of the *Cotone San Guido - La Bigattiera*, to the south of the Arno, dating back to the VIII-V century B.C. according to some experts (CECCARELLI LEMUT *et alii* 1994), but to the II-I century B.C. according to the majority¹⁷ (MAZZANTI, PASQUINUCCI 1983; PASQUINUCCI 1988; DELLA ROCCA *et alii* 1987; DALL'ANTONIA, MAZZANTI 2001; PRANZINI 2007). The subsequent coastlines identified all date back to the Late Middle Ages. No study has localised the early-medieval coast. The most eastern runs roughly through the eastern border of the *Cotone delle Vacche* (PRANZINI 2007) and dates back to the XII century, followed by the coastline identified along the western border of the same *Cotone*, to the north of the Arno, and through the western border of the *Cotone del Mancino*, to the south of the Arno, dating back to both the XII (PASQUINUCCI 1988) and XIV centuries (DALL'ANTONIA, MAZZANTI 2001). A further west shore, running through the eastern border of the *Cotone Ferdinando*, to the north of the Arno, and along the eastern border of the *Cotone del Bassetto*, to the south, has been identified, dating back to before 1000 (CECCARELLI LEMUT *et alii* 1994), and also to the XII century (DELLA ROCCA *et alii* 1987). The coastline related to the XVI century, the last to be taken into consideration, is located

¹¹ The *Portus Pisanus* once rose in the southern portion of the bay (PASQUINUCCI 1988; BALDASSARRI, GATTIGLIA, 2009).

¹² Progradation continued up to 1830; after this date, the dredging of the Arno bed interrupted the supply of sediments and triggered coastal erosion (SARTI *et alii* 2010).

¹³ Against PRANZINI 2001; PRANZINI 2007.

¹⁴ MAZZANTI, PASQUINUCCI 1983; DELLA ROCCA *et alii* 1987; PASQUINUCCI 1988; CECCARELLI LEMUT *et alii* 1994; DALL'ANTONIA, MAZZANTI 2001, PRANZINI 2007 and *Cartografia Geologica Regionale (Regional Geological Mapping) -CAR.G.-* scale 1:10.000 edition 2005-2006. A number of mistakes were found in the latter (Table 2.1) and so was not considered in the general discussion.

¹⁵ The coastlines have been recognised in different coastal dunes, formed by the action of sea currents, which deposited the fluvial sediments and created submerged coastal ridges which, after emerging, were subject to the action of the wind, thus depositing further sediments and forming dune ridges parallel to the shore (BINI 2006: 25). PRANZINI 2007 in his study carried out with the creation of DEM from LIDAR pointed out how numerous convergent dune ridges are formed during rapid progradation, none of which reveal significant vertical growth; instead, when there is less supply, higher and parallel dunes are formed, since each ridge is more exposed to the action of the wind.

¹⁶ *Cotone* is a local term for beach ridge.

¹⁷ The position of this coastline is mainly based on the information provided by Strabo (V, 2, 5, C 222) who, although writing during the Augustan-Tiberian age refers to elements going further back in time. The archaeological finds in the area of San Piero a Grado (BRUNI 2001) provide evidence of settlement from the VII century B.C. and, therefore, of the existence during the Etruscan age of a coastline that was much nearer than the Republican age coastline.

to the west of the previous ones, but with some variations. In the stretch to the north of the Arno, it is situated along the western border of the *Cotone Ferdinando* (DALL'ANTONIA, MAZZANTI 2001; CECCARELLI LEMUT *et alii* 1994), or, further west, along the eastern border of the *Cotone dei Ginepri* (DELLA ROCCA *et alii* 1987; PRANZINI 2007) and, to the south of the river, along the western border of the *Cotone del Bassetto* (DALL'ANTONIA, MAZZANTI 2001; CECCARELLI LEMUT *et alii* 1994) or, further west, along the *Cotone* to the west of the *Lama Larga* (MAZZANTI, PASQUINUCCI 1983; DELLA ROCCA *et alii* 1987; PRANZINI 2007) (fig. 2.3).

All the data gathered were vectorised by creating a **linee_costa_biblio.shp**¹⁸ file, with the aim to analyse and check the published data and locate the probable early-medieval coastline starting from a series of considerations. Between the II century B.C. and the Late Roman period, coastline advancement was mainly caused by a series of alluvial events, as may be seen in the stratigraphic deposits of the Ancient Ships Archaeological

Site in San Rossore¹⁹ (CAMILLI 2004a: 59), in the gradual logging of hilly and mountain areas (CAMILLI 2004a: 56) and in the intricate network of trenches associated with centuriation. For the period ranging from the Late Roman Age to the Early Middle Ages, the data show that flooding increased²⁰, together with a growth in associated depositional phenomena²¹ and that, starting from the VI century A.D., the agricultural layout of centuriation areas was abandoned and the network of trenches was no longer used (ANICHINI 2004-2005; ANICHINI 2006; BONAMICI 1988; CAMILLI 2004a: 59). The data also show the gradual development of marshes in the Pisa plain²², a well-developed cusp of the Arno delta - denoting significant amounts of solids in the river²³ (BELLOTTI 2000) -, and a generally cold climate, thus identifying the VI century as a period with strong environmental difficulties²⁴. The chronological coincidence between the growth of the delta, increased floods and ascertained climatic variations²⁵ (BELLOTTI 2000) lead us to assume that the combination of these events, only partially mitigated by slow

¹⁸ Polyline file which reports all the various hypotheses on the progression of the coastlines from the VII century B.C. to XVI century A.D.; the shapefile attribute table has a reliability control field used to express values in a scale from 1 (min) to 3 (max).

¹⁹ SCIUTO C. 2012, *Intervention record no. 376* in MappaGIS, doi: 10.4456/MAPPA.2012.05, <http://mappaproject.org/webgis>, last access 03/05/2013 (henceforth abbreviated).

²⁰ The excavation at the Ancient Ships Archaeological Site reveals an increase in floods after V century A.D., following a period of attenuation between the II and V century A.D. (CAMILLI 2004a: 71); the excavation in via Marche shows evidence of late Roman flooding (PARIBENI *et alii* 2006:213), while the recent excavation in via Galluppi (ANICHINI, BERTELLI 2010) brought to light a necropolis used until the IV century A.D. and obstructed by a clayey level at the end of the IV century A.D.; given its proximity to the course of the *Auser*, it may have stopped being used following a flood (this cannot be documented due to subsequent post-medieval horizontal cuts). Lastly, the stratigraphic data from the Florentine excavation in via de' Castellani allowed to identify a flood during the late VI century A.D., which has been related (ARNOLDUS-HUYZENDVELD 2007:60) to the flood of 589 mentioned by Paolo Diacono (*Hist. Lang.*, III, 23, 24).

²¹ Documented for the valleys of central Italy, between 200 and 800 A.D. (BROWN 1997: 241).

²² See §2.2.3.

²³ Dating back generically to the post-Roman period.

²⁴ The phenomenon was observed in Modena (GELICHI 1989), Piacenza (CORRETTI 1999), Verona, Rome (GELICHI, BROGIOLO 1998:87) and, in Tuscany: in Florence (ARNOLDUS-HUYZENDVELD 2007:60), Lucca, Pistoia (CORRETTI 1999) and Grosseto (ARNOLDUS-HUYZENDVELD 2007a).

²⁵ I believe that environmental components, during strong hydro-geological difficulties, prevail over anthropic components, going against PRANZINI 2001, 2007 who considers the erosive phase of the Early Middle Ages caused by a drop in agricultural practices in the area and less fluvial supply after the fall of the Roman Empire due to demographic decline, and partially against ARNOLDUS-HUYZENDVELD 2007a:61, who believes that delta variations are also due to anthropic reasons, relating the cusps of the Ombrone delta to population growth and its erosive phases to depopulation.

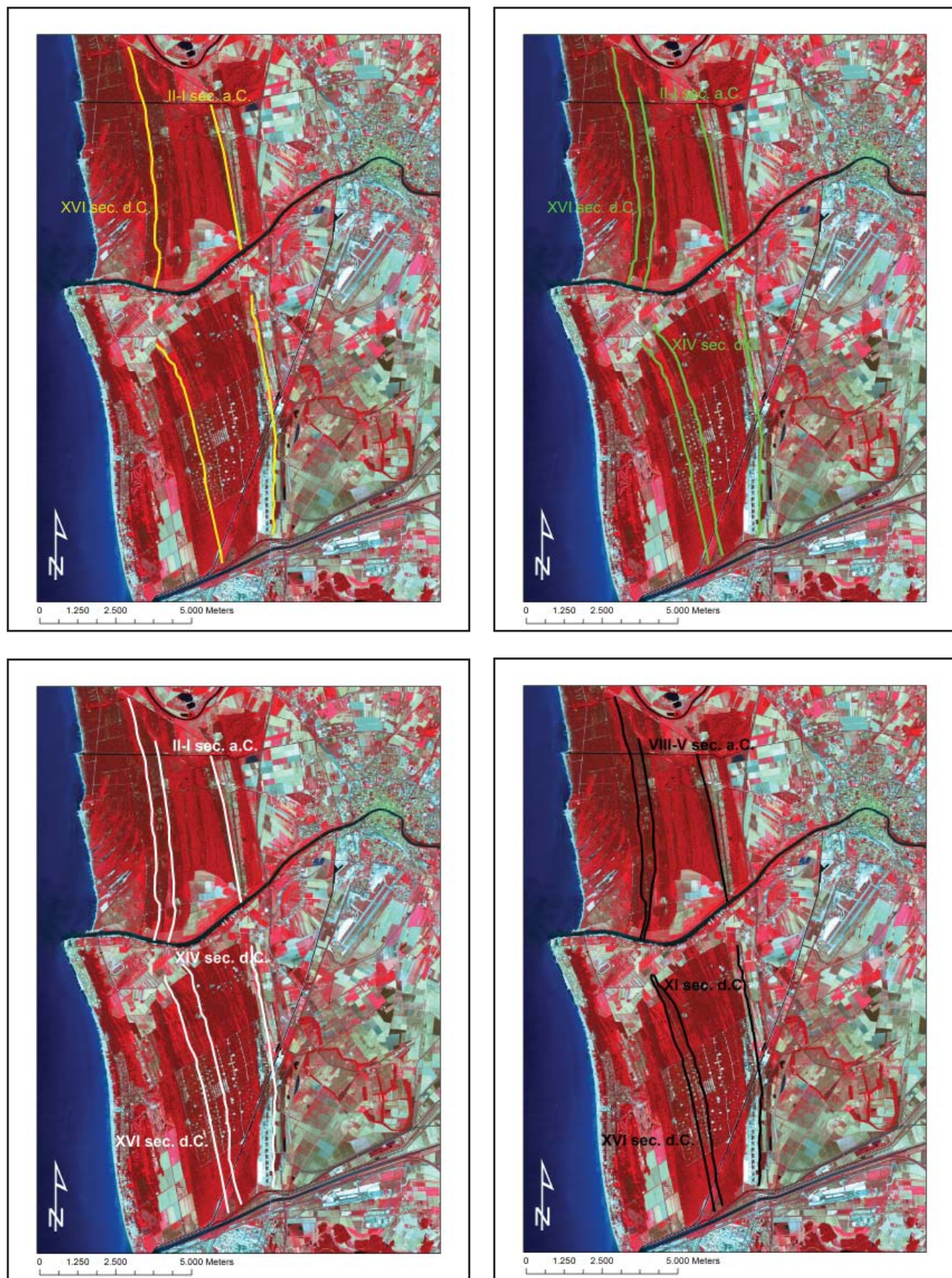


Fig. 2.3 From upper left in clockwise direction, the coastlines are visualised on the satellite image in false colour according to MAZZANTI, PASQUINUCCI 1983 (a); DELLA ROCCA et alii 1987 (b); CECCARELLI LEMUT et alii 1994 (c); DALL'ANTONIA, MAZZANTI 2001 (d)

natural afforestation, increased the level of coastal progradation²⁶. These data allow us to understand the general situation during the Early Middle Ages, but not to calculate the possible location of the early-medieval coast. For this reason, we analysed the percentage growth curve of the delta plain of the Arno (BELLOTTI 2000) over the long-term (200 B.C./1500 A.D.), noting a sufficiently constant percentage growth²⁷. Based upon this, we examined the location of the coastlines, observing almost total coincidence with the location of the II-I century B.C. coastline and a certain consistency in the position of the XVI century coastline. Given the constant percentage growth curve, substantially regular increase during the period prior to 200 B.C. was assumed, and the degree of average progradation in a period of 1700 years was calculated in three different points of the coast: at the mouth, where it is equal to 1.8 m/year, 3 km north, where it is equal to 1.41 m/year, and 3 km south, where it is 1.57 m/year. To obtain probable location of the early-medieval coast (800 A.D.), with respect to the coastline of 200 B.C., the level of average progradation acquired in the three different points was multiplied by 1000. The data calculated provide a homogeneous identification of the *Cotone* placed to the east of the *Cotone delle Vacche*, to the north of the Arno, and the western border of the *Cotone Grosso*, to the south (fig. 2.4), as possible early medieval coastline. If we compare this result with the altimetric variations of the coastal dunes (PRANZINI 2007: 404), the elevation of the ridges constantly drops in the stretch between 4.4 km and 3.5 km from the current coastline, where a sudden fall may be seen. This

drop coincides with the line calculated. Overall reading, therefore, confirms rapid advancement of the coastline between the Late Roman period and the first centuries of the Early Middle Ages (increasingly lower coastal dunes) with a standstill around the start of IX century, in agreement with climatic, environmental and demographic data. The XII century coastline, therefore, crosses the eastern border of the *Cotone delle Vacche* at around 3 km from the current coastline (PRANZINI 2007: 404), rather than the western border of the same *Cotone*, to the north of the Arno, and the western border of the *Cotone del Mancino*, to the south (PASQUINUCCI 1988); this latter line should be more correctly dated back to the XIV century (DALL'ANTONIA, MAZZANTI 2001; PRANZINI 2007). Between 800 A.D. and 1300 A.D, a progradation degree of around 1 m/year may be seen, which is in agreement with the retreat of the delta apex during the warm period between the start of the IX century and the half of the XII century (BELLOTTI 2000) and with a series of increasingly higher dune ridges (PRANZINI 2007: 404). The location of a coast generically dating back to before 1000 or to the XII Century along the eastern border of the *Cotone Ferdinando* and *Cotone Bassetto* (DELLA ROCCA *et alii* 1987; CECCARELLI LEMUT *et alii* 1994) appears to go against the above considerations (excessive coastline progradation) and must therefore be rejected. Over the following centuries, climatic variations and especially the cutting of the Vettola (1340) and San Rossore (1338) meanders increased the level of progradation²⁸, in this case also well evidenced by the reduced height of the coastal dunes. In this case, the XVI century line indicated

²⁶ This goes against PRANZINI 2001 and 2007, who associates delta progradation during historical ages mainly with anthropic causes and connects early-medieval depopulation not only to the reduced growth of the Arno delta, but also to possible erosion of the Roman Age cusp.

²⁷ The prerequisite of this reasoning is to identify the most reliable coastlines for II-I centuries B.C. and for the XVI century A.D., thus calculating a long-term average level of progradation on the basis of which the possible early-medieval coastline may be estimated and finally checking it with the altimetric data of the coastal dunes obtained using the LiDAR-derived DEM.

²⁸ Also influenced by the deforestation during the middle centuries of the Middle Ages (CECCARELLI LEMUT *et alii* 1994: 416).



Fig. 2.4 The assumed line (in blue) of the early medieval coast, which runs along the western border of the *Cotone* situated to the east of the *Cotone delle Vacche*, north of the *Arno*, and the western border of the *Cotone Grosso*, to the south, overlapping the satellite image in false colour.

Tab. 2.1 Comparative table of the location of the coastline between the VIII century B.C. and the XVI century A.D.

Location of the coastline	References	chronology
North of Serchio River		
Western border of the <i>Cotone</i> of the <i>Lama Larga</i>	CECCARELLI LEMUT <i>et alii</i> 1994	XVI century A.D.
Eastern border of the <i>Cotone</i> of the <i>Lama dei Ginepri</i>	CAR.G. 1:10.000 C.T.R. 272040	XIII century A.D.
	CAR.G. 1:10.000 C.T.R. 272080	
Eastern border of the <i>Cotone</i> of the <i>Lama Larga</i>	CAR.G. 1:10.000 C.T.R. 272040	XII century A.D.
Eastern border of the <i>Cotone delle Vacche</i>	CAR.G. 1:10.000 C.T.R. 272080	
Eastern border of the <i>Cotone</i> of the <i>Lama Larga</i>	CECCARELLI LEMUT <i>et alii</i> 1994	After the XI century A.D.
Western border of the <i>Cotone del Palazzo</i>	CECCARELLI LEMUT <i>et alii</i> 1994	VIII/V centuries B.C.
North of Arno River		
Western border of the <i>Cotone Ferdinando</i>	MAZZANTI, PASQUINUCCI 1983	XVI century A.D.
	DALL'ANTONIA, MAZZANTI 2001	
	CECCARELLI LEMUT <i>et alii</i> 1994 1994	
Eastern border of the <i>Cotone dei Ginepri</i>	DELLA ROCCA <i>et alii</i> 1987	XVI century A.D.
	PRANZINI 2007	
Eastern border of the <i>Cotone dei Ginepri</i>	CAR.G. 1:10.000 C.T.R. 272120	XV century A.D.
Western border of the <i>Cotone delle Vacche</i>	DALL'ANTONIA, MAZZANTI 2001	XIV century A.D.
	PRANZINI 2007	
Eastern border of the <i>Cotone Ferdinando</i>	DELLA ROCCA <i>et alii</i> 1987	XII century A.D.
	PASQUINUCCI 1988	
	CAR.G. 1:10.000 C.T.R. 272120	
Eastern border of the <i>Cotone delle</i>	PRANZINI 2007	

Vacche		
Eastern border of the <i>Cotone Ferdinando</i>	CECCARELLI LEMUT <i>et alii</i> 1994	After the XI century A.D.
Western border of the <i>Cotone delle Cascine</i>	MAZZANTI, PASQUINUCCI1983	II/I centuries B.C.
	DELLA ROCCA <i>et alii</i> 1987	
	PASQUINUCCI1988	
	DALL'ANTONIA, MAZZANTI 2001	
	PRANZINI 2007	
Western border of the <i>Cotone delle Cascine</i>	CECCARELLI LEMUT <i>et alii</i> 1994	VIII/V centuries B.C.
South of Arno River		
<i>Cotone</i> to the west of the <i>Lama Larga</i>	MAZZANTI, PASQUINUCCI1983	XVI century A.D.
	DELLA ROCCA <i>et alii</i> 1987	
	PRANZINI 2007	
Near the tower at the estuary (nowadays <i>Torretta</i>)	CECCARELLI LEMUT <i>et alii</i> 1994	
Western border of the <i>Cotone del Bassetto</i>	DALL'ANTONIA, MAZZANTI 2001	
Western border of the <i>Nuova (New) Lama Larga</i>	CAR.G. 1:10.000 C.T.R. 272120	XV century A.D.
Western border of the <i>Cotone del Mancino</i>	DALL'ANTONIA, MAZZANTI 2001	XIV century A.D.
Western border of the <i>Nuova (New) Lama Larga</i>	CAR.G. 1:10.000 C.T.R. 272160	
Eastern border of the <i>Cotone del Bassetto</i>	DELLA ROCCA <i>et alii</i> 1987	XII century A.D.
	PASQUINUCCI1988	
	CAR.G. 1:10.000 C.T.R. 272120	
	CAR.G. 1:10.000 C.T.R. 272160	
Eastern border of the <i>Cotone del Bassetto</i>	CECCARELLI LEMUT <i>et alii</i> 1994	After the XI century A.D.

Western border of the <i>Cotone San Guido - La Bigattiera</i>	MAZZANTI, PASQUINUCCI 1983	III/I centuries B.C.
	DELLA ROCCA <i>et alii</i> 1987	
	DALL'ANTONIA, MAZZANTI 2001	
	PASQUINUCCI 1988	
	PRANZINI 2007	
Western border of the <i>Cotone San Guido - La Bigattiera</i>	CECCARELLI LEMUT <i>et alii</i> 1994	VIII/V centuries B.C.

by DALL'ANTONIA, MAZZANTI 2001 does not coincide with their calculation, i.e., a progradation of 6 m/year totalling 1200 m. Maximum progradation that can be measured between the coastlines indicated by them for the XIV and XVI centuries is around 700 m equal to 3.5 m/year, which would represent, in any case, an increase in the level of progradation 3.5 times higher than the previous period; instead, if we consider the more western shorelines dating back to the XVI century (DELLA ROCCA *et alii* 1987), progradation would be approximately 900 m, equal to 4.5 m/year²⁹.

2.2.2 Rivers: fragments of a complex structure

The presence of a complex fluvial network conditioned the urban and economic development of Pisa. It is not surprising, therefore, that many experts have addressed issues regarding the network's courses over the historical ages³⁰, without being able, however, to reliably determine

them from both a spatial and chronological viewpoint³¹. Briefly, despite the undeniable quality of the work carried out, each study has gaps due to the sector-specific nature of the work: studies based on historical mapping have attempted to provide an overall view of the watercourses, without checking their actual presence; those based on subsurface data have allowed detailed identification of a number of palaeochannels, without fully reconstructing the entire palaeochannels network; those based on geomorphological data and photointerpretation have highlighted the visible traces, without being able to define their level of reliability. In the majority of cases, these are valid assumptions that must be checked using a multi-disciplinary approach, capable of giving an overall view of the data produced up to today and using aerial photointerpretation (BINI *et alii* 2012a), remote sensing (BINI *et alii* 2012), geophysical, geoelectrical and geomorphological investigations (BINI *et alii* 2012b), subsurface data (AMOROSI *et alii* 2012, 2012a),

²⁹ Again going against PRANZINI 2007, who does not consider the cutting of the Vettola and San Rossore meanders and suggests that progradation was interrupted from the mid-XIV century to the start of the XV century due to a decline in the population following the Black Death and frequent wars.

³⁰ Reference is made to the most comprehensive studies in both historical and spatial terms: PASQUINUCCI 1988, 2003 and REDI 1988 base their work mainly on historical mapping; ROSSI *et alii*, 2011 on subsurface data; FEDERICI 2005, DELLA ROCCA *et alii* 1987 on geomorphological data; COSCI 2005 only on photointerpretation; CECCARELLI LEMUT *et alii* 1994 on the integration between historical and geological data; GATTIGLIA 2010, 2011 on the integration between geological, archaeological and toponymic data.

³¹ Despite difficult comparison between the data produced, there is agreement with respect to certain reconstructions regarding parts of palaeo traces that are quite evident across the territory and well documented in written sources: for the Arno: the palaeo-meanders of San Rossore, La Vettola and Barbaricina (corrected, respectively, in 1338, in 1340 and in 1771-2) and of the mouth, deviated in 1606; for the Serchio: the palaeo-meander of Metato corrected in 1579 (BINI *et alii* 2012a: 139).

historical (GRAVA 2012) and archaeological data (ANICHINI *et alii* 2012), as in the case of the MAPPA Project, which (unfortunately) focuses only on an investigation area covering 26 km² around Pisa and with which it has been possible, also through C¹⁴ dating, to date various palaeochannels. 121 traces were identified, with a degree of reliability ranging between 1 and 8. They were compared with the subsurface database, checked (in many cases using geoelectric investigation) with historical and archaeological data, allowing the reconstruction of the most probable palaeo-traces for the various historical periods (BINI *et alii* 2013). Regarding the area between Lake Massaciuccoli and the Arno River, in addition to the above studies (checked with the data currently available in the subsurface database), we are also provided with an updated analysis of the aerial photographs and remote sensing data aimed at identifying traces attributable to palaeochannels preparatory to the MAPPA Project (BINI *et alii* 2012a: 140 ss), in relation to which aerial photographs taken between 1943 and 2010 were analysed, including the infrared photographs related to the night flight of 1983 and satellite data (BINI *et alii* 2012). This is a preliminary study from which assumptions may be made and checked using a detailed multi-disciplinary analysis. The traces identified were vectorised in GIS environment as a polygon file (**paleo_alvei.shp**). Every single item detected was digitised, following the palaeo-banks that identified their geometry, and was then hierarchised in order to separate the most reliable traces from the most insubstantial ones³². 287 fluvial traces were identified covering an overall surface of around 81 km² out of 350 km², corresponding to a 23% incidence. This datum shows the significant contribution of the fluvial network to the geomorphological evolution of the area. The largest traces characterise the area between the

Serchio River and the Arno River and the area to the south of the latter, while the smallest traces refer to the city centre of Pisa and the area to the south of Lake Massaciuccoli. The greatest concentration of traces may be seen near the modern courses of the Arno and the Serchio rivers, where they are highly reliable, probably due to the fact that they are more recent (and, therefore, more superficial) and also due to the presence of large overbanking deposits, i.e. easier to read compared to fine lithologies that are generally more characteristic of the closing facies of the palaeochannel. Sporadic concentrations of traces may be found in the areas immediately behind the more internal beach ridges (both north and south of the Arno River) and in the area around Coltano, probably due to the nature of the land (presence of marshy areas) or its use by man. Of interest is the fact that the area between Lake Massaciuccoli and the current course of the Serchio River, characterised by marshy deposits which make it difficult to read the fluvial palaeotraces, reveal the presence of narrow and elongated traces with north-south direction, some of which are highly reliable. They can be related to natural genesis on which man subsequently intervened by building artificial canals, at times navigable. The area between the current courses of the Serchio and Arno rivers features a large number of palaeochannels that cannot be definitely attributed to either of the two fluvial basins. The idea that the Arno River may have interested sectors located more to the north of its current course cannot be excluded, as suggested by the palaeochannels detected at the foot of the Monti Pisani, whose genesis is unlikely to be attributed to the Serchio River. The area south of the Arno River can be divided into two sectors: an eastern sector with a good number of traces, typical of the gradual migration of the Arno from south to north, and a western sector, close to the more

³² 31,5% of the traces detected have high reliability (level 8), whereas over 50% have a level of reliability between 1 and 2 (i.e. low) (BINI *et alii* 2012a).



Fig. 2.5 The traces (in black) of the paleo-river beds analysed during the MAPPA Project (from BINI et alii 2012a) overlapping the traces (in yellow) available during the previous study

internal beach ridges, where the traces become illegible as they approach Coltano. Overall, the study developed by BINI *et alii* 2012a identifies two series of traces belonging respectively to the fluvial basins of the Arno and the *Auser-Serchio* rivers, and a third series of uncertain attribution³³. The study shows how, geomorphologically, typological evolutions of the watercourses that constantly maintain a meandering pattern cannot be noted and underlines, once again, the extreme variability of the courses and the difficulty to define detailed chronologies. During my previous works on the matter (GATTIGLIA 2010, 2011), I addressed the issue by matching the toponymic data resulting from written sources with the data available until then on the palaeochannels, reaching various assumptions on possible fluvial palaeo-traces. The data review carried out for the MAPPA project provided quite a different picture (fig. 2.5). What to do? I decided to re-propose the previous method, well aware that only a multi-disciplinary approach, combining subsurface data and C¹⁴ analysis, is able to verify the assumptions on the medieval fluvial framework, and convinced

that toponymic tracking is able to provide an overall view of the courses. As data base, I took the existing studies that have addressed medieval palaeo-hydrographic issues including written sources³⁴, toponymy³⁵, the traces of palaeochannels³⁶ and historical mapping and I applied a basic, simple spatial analysis method³⁷ founded upon the identification of toponyms mentioned in medieval written sources still legible in existing toponymy and upon their spatial relation (*Select by Location*) with mapped palaeo-traces. Regarding the use of toponymic data, **Toponimi.shp** was created, containing all the toponyms included in the C.T.R. (Regional Technical Map). Georeferencing was carried out as a point shapefile with screen vectorisation 1:5000. The point was positioned at the centre of the toponymic name for toponyms indicating an area, in the middle of the settlement for populated areas, and in the middle of the building for all toponyms referring to a specific structure such as a house, villa, farm, etc. The second step consisted in creating Thiessen polygons³⁸ (**Thiessen_toponimi.shp**) from **Toponimi.shp**, based on cost

³³ The traces belonging to the third group need to be carefully checked by matching them with subsurface data.

³⁴ With regard to written sources, reference was made to key studies on this issue, especially to BERTI, RENZI RIZZO 2004; CECCARELLI LEMUT 2005; CECCARELLI LEMUT *et alii* 1994; REDI 1988; REDI 1990; REDI 1991.

³⁵ Taken from the C.T.R. map scale 1:10.000. The toponyms were also compared with the historical land registry maps of the Castore (historical land registers of Regione Toscana) website of Regione Toscana <http://web.rete.toscana.it/castoreapp/>.

³⁶ BINI *et alii* 2012, 2012a.

³⁷ Spatial analysis tools were used during an initial investigation phase to determine the medieval catch basins and rivers. The LiDAR-derived DEM was used considering a spatial extent contained within the XVI century coastline, but not its elevation points (given the absence of data); the current elevation points, therefore, were used (see § 2.2.3). The *Fill* command was applied to the DEM, in order to correct any DEM imperfections and values out of range (TARBOTON *et alii* 1991). The output file **fill_dem.grid** was obtained, to which the *FlowDirection* command was applied in order to process the flow direction map (based on elevation values of each pixel with the directly adjacent pixels) and the output raster **flow.grid** was obtained. Finally, the *FlowAccumulation* command was used to process the flow accumulation map (which highlights the preferential courses of water flows and not the actual water network, which depends not only on elevation values, DEM, but also on the type of soil and land management). Based upon the **flow.grid** input, the **flowacc.grid** was produced. The file obtained, once re-classified, was not very reliable due to the predominance of low-lying areas; for this reason, I preferred using more simple investigation methods which were more reliable.

³⁸ The Thiessen method consists in drawing a series of polygons with known value points in the middle, whose value is representative of the area of the entire polygon. The vertices of the polygons are built around intermediate points of the distances between two nearby points; each point interpolated inside a specific polygon assumes the value of the known value point nearest to it. These tessellations are used in archaeology to define areas influencing the sites and are successful when working with points of equivalent importance. For this reason I decided to use this system to estimate the areas of the single toponyms; indeed, it may be assumed as true that every

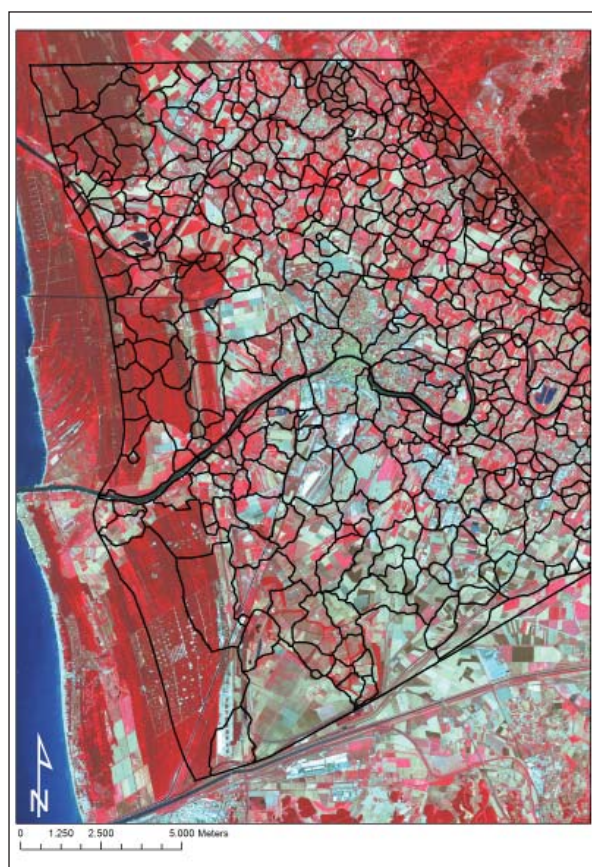


Fig. 2.6 The areas of the toponyms calibrated according to cost surface and hydrological data, and overlapping the satellite image in false colour.

surface and hydrological data (*Flow Direction e Basin*)³⁹ (fig. 2.6). The toponyms found in medieval written sources in relation to fluvial traces were extrapolated from **Thiessen_toponimi.shp**, and 4 specific polygon shapefiles were created (**toponimi_Tubra.shp**, **toponimi_Serchio.shp**, **toponimi_Auser.shp** and **toponimi_Arno.shp**, to which a numerical field was added regarding the

first attestation of the toponym in relation to the river in the written sources). These were related to the **paleo_alvei.shp** file on a case by case basis through *Selection by Location* which highlighted the palaeochannels located within 150 metres from the toponym's polygon. A 150 m distance was chosen due to the accuracy level of the toponymic areas obtained from the Thiessen polygons and from the georeferencing and vectorisation of the palaeo-traces using images with low-detail cartographic scale. The result obtained (and desired) shows a complex fluvial system not the reconstruction of a definite course, in view of the previously mentioned variability of the rivers and the difficulty to indicate a definite chronology. The medieval written sources show an extremely complex and hard-to-read hydrographic system (CECCARELLI LEMUT *et alii* 1994), in which the plain of Pisa was highly conditioned by a dense fluvial system featuring the *Auser* basin (consisting of *Auser*, *Auserclus/Serclus* -Serchio - and *Tubra* rivers) to the north, and the Arno basin to the south.

2.2.2.1 The *Tubra* River

The course of the *Tubra* River is the most difficult to determine, to such an extent that some experts doubt it was actually an independent river⁴⁰. The hydronym *Tubra* is attested in a series of documents written between the IX and XII century, the first mention dates back to 865, its last to 1156, when its

single toponym has the same importance, or weight, and that its area, therefore, is defined by the distance from other toponyms of equal importance. This principle was applied to define the areas of existing (**Thiessen_toponimi.shp**) and medieval (**Thiessen_topo_med.shp**) toponyms. This analysis, as may be seen in the following chapters, was particularly useful to locate data known only thanks to toponymy and to reconstruct the city's medieval fabric. In the case of medieval toponyms, the situation is more uncertain due to the difficult location and probably disappearance of certain toponyms.

³⁹ A similar procedure was adopted for the Thiessen polygons of the castles of the Florentine area in CITTER 2012: 74.

⁴⁰ According to REDI 1988: 160 "defining exactly whether the *Tubra* River had a well-defined and separate course with respect to the Serchio River or whether it was simply a swelling of the Serchio River in correspondence of islands and abandoned meanders, and also whether it was the ancient name of the *Auser's* deviation or the transitory phase of the development of the Serchio River" is a problematic issue.



Fig. 2.7 The traces of the possible paleochannels (from red to green based on the trace's level of reliability, from BINI *et alii* 2012a), associated with the toponyms that attest the passage of the *Tubra* River (in white) and of the *Auserclus* River (in black).

disappearance is attested. Written sources show the *Tubra* in Vecchiano⁴¹ from 940 (CECCARELLI LEMUT *et alii* 1994: 407-8), between Vecchiano and Carraia⁴², from 968 to 1023 (REDI 1988: 160), in Carraia in 1016, at *Ursi* port, in Arena where the cemetery stands today, in 865 and in 866, in Alzavola in 995 and in Pero in 1016⁴³ (CECCARELLI LEMUT *et alii* 1994: 407-8) and, finally at the mouth, in Sterpaia in 940 (REDI 1988: 160). The *Tubra* appears to have been considered as an independent river, differing from the nearby *Auserclus* (Serchio); in fact, a document dated 956 mentions them as two separate entities since a farmstead is located *prope [Tubra] ultra fluvio Auserclo* (CECCARELLI LEMUT *et*

alii 1994: 407). In practice, the *Tubra* River used to flow north of the Serchio River and then, due to the continuous transformation of its courses, merged into the *Auserclus* River, as attested by a judgment in 1156 which refers to a deed dating back three hundred years and regarding a land *ab hac Tubre parte que Serclus vocatur*. This indicates that certain stretches of the IX-century *Tubra* River partly coincided with the course of the Serchio River during the XII century (CECCARELLI LEMUT *et alii* 1994: 407-8). The search for the toponyms mentioned in the written medieval documents included in the **Thiessen_toponimi.shp** file led to the identification of Vecchiano, Arena, Carraia

⁴¹ The *Tubra* River crossed Vecchiano according to a written document of 1001 (CECCARELLI LEMUT *et alii* 1994: 407-8).

⁴² Carraia corresponds to Arena (REDI 1988; CECCARELLI LEMUT *et alii* 1994) on the basis of TONGIORGI, VIRGILI 1975 who demonstrated how the toponym Arena changed into Carraria at the end of the XVI century, when the baptismal font was moved from the abandoned *pieve* of Arena to the church of San Salvatore in Carraia.

⁴³ Toponym where the Serchio River also appears.

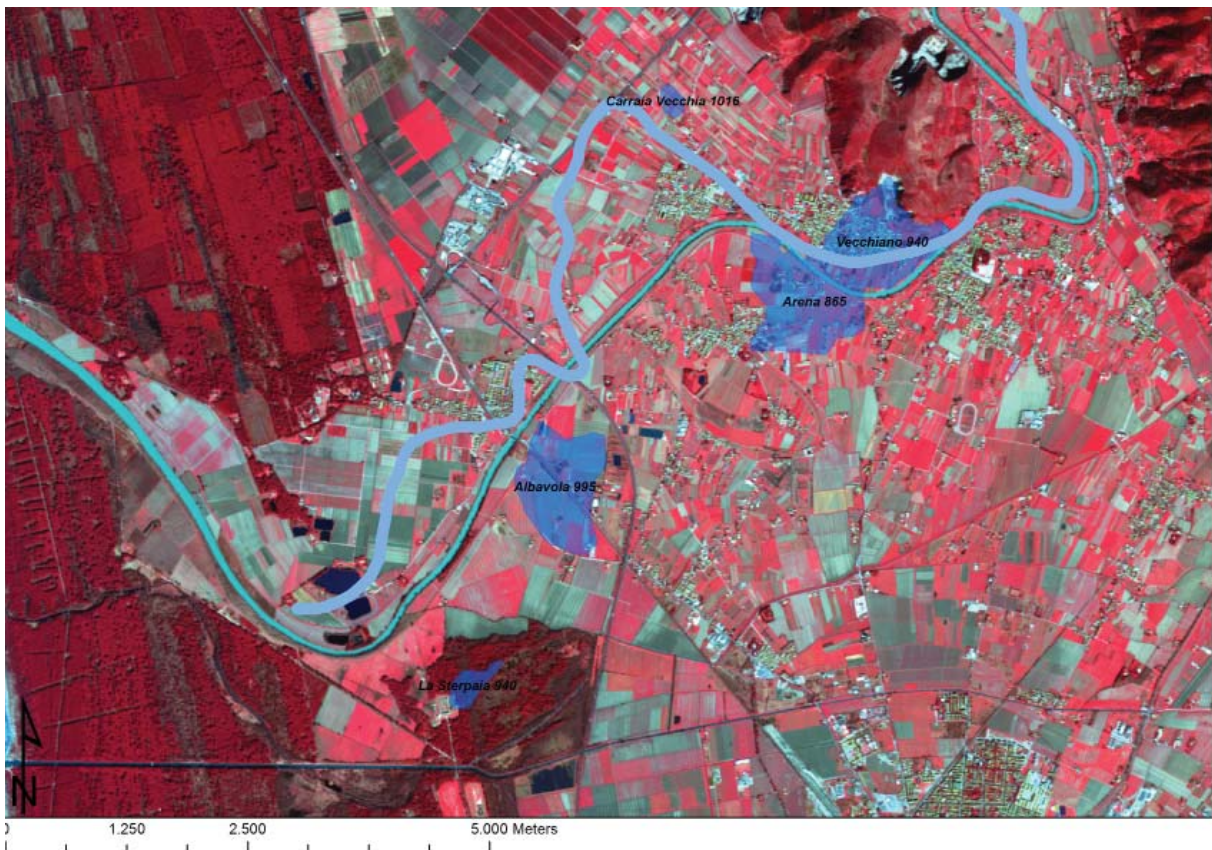


Fig. 2.8 Reconstruction of the possible course of the *Tubra* River.

Vecchia, Albavola (clearly referring to Alzavola) and La Sterpaia. *Selection by Location*, on the basis of the **toponimi_Tubra.shp** file (150 m search distance) and on the palaeochannel traces (**paleo_alvei.shp**), pointed out which traces may be attributable to the *Tubra* River. Two branches of southern palaeochannels were eliminated from the selection, probably pertaining to the *Auser* River (§ 2.2.2.3), as well as the most northern fluvial branches. Overall, the course of the *Tubra* River does not appear to be very different from the course of the *Auserclus* (Serchio) River (fig. 2.7), with which it partially merged later on, but it may have followed – at least during a certain period – a more northern course (the most ancient, as attested by a document of 956?). The *Tubra* River probably parted from the *Auser* River near Patrignone, formed a wide bend at Avane, following a course subsequently taken by the Serchio in the late-medieval ages, flowed to the south of Vecchiano,

then formed a bend to the north of Nodica immediately followed by a meander at Le Piagge and by another one at Migliarino-Pratavecchie, and then flowed into the sea towards north-west, north of Isola di Migliarino (fig. 2.8).

2.2.2.2 The *Auserclus* (Serchio) River

The *Auserclus* River was probably formed during the Roman Age or Late Roman period (DELLA ROCCA *et alii* 1987). It is mentioned in a large range of medieval written sources, starting from the IX century (866) when the river was mentioned as located in *Lintablo, prope ponte de Lignaria* to the north-west of Vecchiano (REDI 1988: 160). Mention is made of the river in relation to the towns, locations and territories of Colognole in 1046, Avane in 1110 and in 1202, 1205, 1232 in connection with the toponyms Riparia and Isola

(REDI 1988: 160), Pappiana in 1197, Limiti near the church of San Giovanni in 1198, Rasaiolo in 1175, Ponte a Serchio in 1191, Casale and Ramo, near Sant'Andrea in Pesciola in 1111, 1124 and 1163 (REDI 1988: 160), Vecchiano from 877, when the river divided Vecchiano from Vecchiano Minore, i.e. Vecchializia, today Pontasserchio, Carraia in 1078, Lama in 1183, Metato from 932, the *Ursi* port from 1067, Arena in 1198, Cafaggio Mori in 1095, Albavola in 1092, Cafaggio Regio in 1084, Albavola from 1078, Pero in 1226, Fiocina in 1186, Figuaia in 1171, Riglione from 1132, and Marmo and Isola in 1183. Metato, the *Ursi* port, Cafaggio Regio and Albavola were all located to the right of the river (CECCARELLI LEMUT *et alii* 1994: 408). The presence of toponyms such as Isola, Isoletta, Fiumaccio, Ugione, Isola del Serchio⁴⁴ in Patrignone and in Avane, Fiume Morto⁴⁵, again in Avane, in 1262, and in Pappiana and Limiti in 1179 and 1203, *Dirocta*⁴⁶, near the church of Santa Maria in Pappiana in 1065, Ramo and Lamo⁴⁷ in 1124, 1163, 1187 and 1223, the Canneto⁴⁸ Island formed by the Serchio River and its *ramisculo* (small branch) and recalled in 1182 at Marmo, Vecchio Serchio⁴⁹, at the northern boundary of the *silva Tumulus Pisanus* (the San Rossore woods) in 1155, *Flumine mortuo*⁵⁰ in Riglione in 1132, and finally indication of the mouth of the Vecchio Serchio again between San Rossore and Migliarino in 1084, 1110, 1147 and 1178 and at times, as in 1155, confused or assimilated to those of the *Auser* (REDI 1988: 161), allude to minor or more ancient

routes and to the extreme variability of the river's course. Written documents do not do not give a clear picture of the river's final stretch, which probably flowed close to the *Auser* River – given that the lands situated between Pero and Riglione between the XII and XIII centuries were crossed at one end by the Serchio River and at the other by the *Auser* River – and then flowed into a marshy area bordering the *silva Tumulus Pisanus* and the woods of Migliarino (CECCARELLI LEMUT *et alii* 1994: 408-9). Written sources speak of embankments only from the end of the XIII century, when the inventory of the prebendaries of the Cathedral of Pisa mentions them frequently along the two river banks, between Avane and Nodica (CECCARELLI LEMUT, *et alii* 1994: 410). Embankments were constructed when the course was stable and remained so up to the Modern Age⁵¹. GIS analysis of the toponyms mentioned in medieval written sources and which can still be recognised in current toponymy, led to extrapolating the **toponimi_Serchio.shp** from the **Thiessen_toponimi.shp** file, containing the toponyms Avane, Pappiana, Fossa Riparia, Pontasserchio, Sant'Andrea in Pesciola, Vecchiano, Arena, Legnaio (probable derivation from *Lignaria*?), Carraia Vecchia, Lamo Poggiale (connected to the medieval toponym Lama?), Metato, Cafaggiareggi (modification of Cafaggio Regio), Rigoli⁵², Albavola, Fiocina, Il Marmo and L'Isola (fig. 2.7). *Selection by Location*, based upon the **toponimi_Serchio.shp** file of the palaeochannels, identifies the possible palaeochannels ascribable

⁴⁴ Isola: Island; Isoletta: Little Island; Fiumaccio: Dangerous River, Ugione: Very Humid (from latin *udus*); Isola del Serchio: Island of Serchio.

⁴⁵ Dead River.

⁴⁶ (River flood). The variability and dangerousness of this stretch is confirmed by the XVI century flooding which submerged the church of Santa Maria in Pappiana (CECCARELLI LEMUT *et alii* 1994: 410).

⁴⁷ Branch.

⁴⁸ Groove of reeds.

⁴⁹ Old Serchio River.

⁵⁰ Dead River.

⁵¹ The works on the final section of the Serchio River and the straightening of its mouth took place before 1560, whilst the cutting of the bend of Metato dates back to 1579 (CECCARELLI LEMUT *et alii* 1994: 411).

⁵² Where the church of San Giovanni di Limiti rose (REPETTI 1833: II, 698).

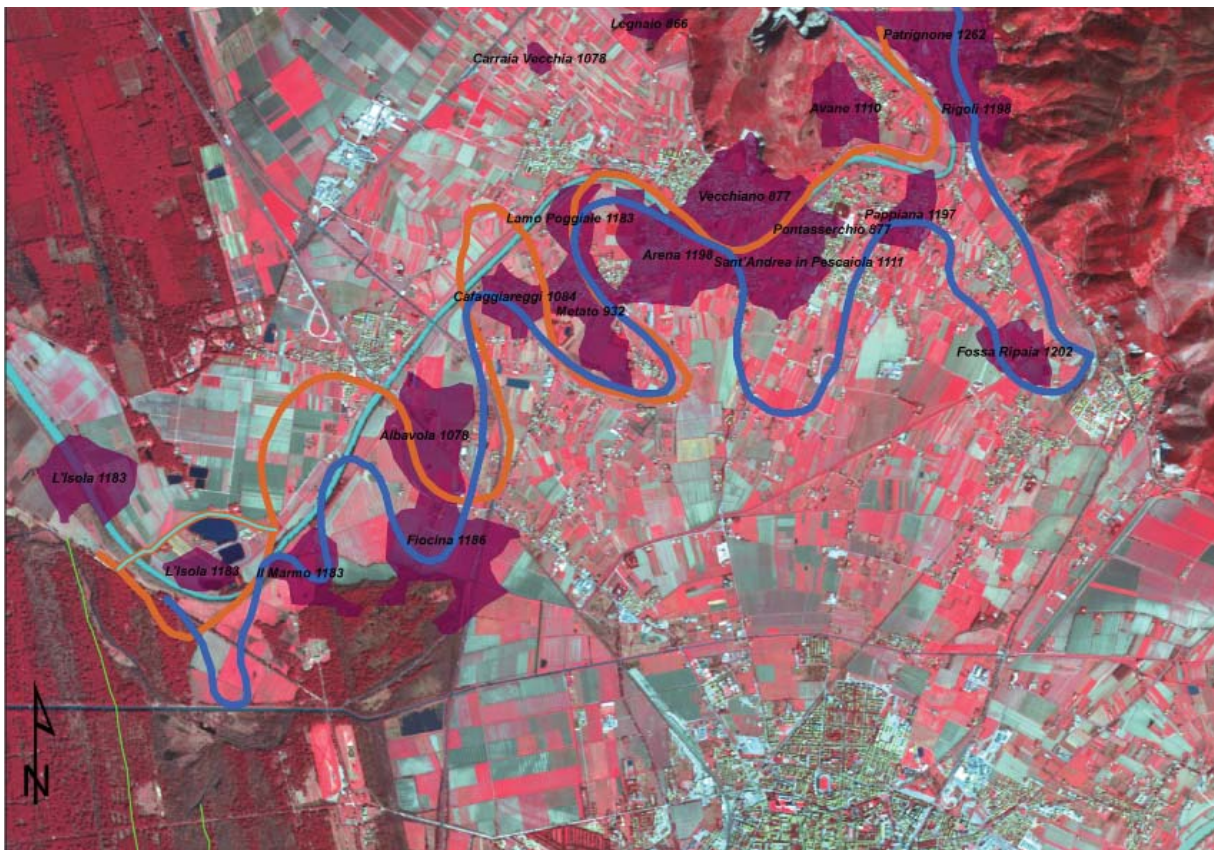


Fig. 2.9 Reconstruction of how the course of the *Auserclus* River may have changed: the probable course prior to the XII century is indicated in dark blue, the probable course after this date in orange. The areas of the toponyms with the date of their first attestation are indicated in purple.

to the *Auserclus* (Serchio) River. Some corrections were made on the selection obtained, excluding the most northern stretch in the Carraia Vecchia and Legnaio areas whose direction seems to come from the north, and the stretches of the Fossa Riparia area moving south-west. Lastly, the stretches previously attributed to the *Tubra* River were cancelled. The traces obtained show a course that partly coincides with the southern stretch of the *Tubra* River, thus strengthening the previous interpretations on the latter's course. Of particular interest is the initial stretch of the Serchio River, divided into a southern course at Fossa Riparia, which parts from the *Auser* to the east of Caldaccoli and then moves up towards Pappiana, and a northern course that passes through Avane, and retraces the initial course of the *Tubra* River. The southern course supports the idea of REDI 1988: 160 according to whom this toponym is probably the

remains of a branch that turned into a trench and suggests that the river bed gradually moved north until merging with the *Tubra*. The section between Pontasserchio, Vecchiano and Sant'Andrea in Pesciola appears to be particularly complex, with interlacing meanders (some very southern), such as those of Fabbriano. From Arena onwards, its course bends towards Lamo Poggiale, then makes a deep bend at Metato, with many variations, a further bend at Albavola, a northern bend at Pratevecchie, Starrigiana, maybe coinciding with that of the *Tubra* River, and after bending at Isola, it moves upstream to the north where it flows into the sea. The analysis confirms its position to the right of the toponyms Metato, Cafaggio Regio and Albavola. It also confirms how the Serchio and the *Auser* rivers could have flowed close to one another at the mouth, with a minimum distance between the river beds of around 650

m, which would attest the presence of lands delimited by two rivers. The identification of two different principal courses, not only highlights the continuous variations of the river's course, but also allows general chronological considerations to be made if compared with the *Tubra* River. The southern course, due to its complementarity with the *Tubra's* course, could be coeval and so anterior to the mid-XII century. The northern course, which partially coincides with the course of the *Tubra*, is instead posterior to the mid-XII century, when the written sources report the merging of the two rivers. The first parted from the *Auser* River at Fossa Ripaia and reached Orzignano and Pappiana, then continued first west, then southwest, with a series of meanders bending at Fabbriano, Sant'Andrea in Pescaiola, Piaggia, Migliarino⁵³, Albavola and Sterpaia where it flowed into the sea. The second was positioned more to the north than the first and partially coincided with the course of the *Tubra*. It parted from the *Auser* River near Patrignone, bending first southeast of Avane, passing through Pontasserchio and Vecchiano, and then continuing southwest along the bends of Nodica, Arena/Metato, Il Feo⁵⁴, Albavola, Migliarino and finally Sterpaia where it flowed into the sea (fig. 2.9).

2.2.2.3 The *Auser* River

The course of the *Auser* River is one of the most debated subjects in Pisa's topography. The river flowed from the plain of Lucca, splitting into two branches: one flowed to the north of the Monti Pisani and merged into Lake Sesto (no

longer existing) and then into the Arno River at the height of Vicopisano; the other branch, after passing the strait of Ripafratta, generated the *Tubra* and the *Auserclus* rivers and flowed into the plain of Pisa, giving it the name of *Vallis Auseris* or *Valdozzeri* (*Auser* Valley). The course of the Pisan branch is uncertain; medieval written sources speak of the *Auser* River in Patrignone, where it formed a whirlpool, from 1016 (REDI 1988: 160), in Orzignano in 1033, near Bagno del Monte Pisano⁵⁵ in 1287, in Gello and in Campolungo at the start of the XIV century, at the Manno hospital in 1287, in Macadio⁵⁶ from 1097, in Cafaggio in 1295, in Rete in 1174, in Pisa, where it brushed the northern walls, in Pero from 1110, in Fiocina from 1186, in Riglione from 1206 (CECCARELLI LEMUT *et alii* 1994: 409), and lastly in La Sterpaia in 1163, not far from the Serchio River, where it flowed into the sea (REDI 1988: 160). Reference to the atrophy of the most ancient fluvial branches included in written sources and toponymy, shows a landscape deeply marked by fluvial instability, as confirmed by the *fiumicello* (small river) between Capelle and Caldaccoli in 1098, the toponym Fiume Morto⁵⁷ located between Cornazzano, Pappiana and Orzignano in 1180, mention of an *Auser vetus*⁵⁸ in Cafaggio in 1264, in Gello at the end of the XIII century and in Campolungo at the start of the XIV, in Sossanto (or Sotto il Santo)⁵⁹, along the final stretch of the river, at the start of the XIV century, where an *Auser novus*⁶⁰ also appears, (CECCARELLI LEMUT *et alii* 1994: 410) and in locations quite difficult to identify - Lama, Aliscla, Mulina, Inchiuserle and Campo Martiuolo (REDI 1988: 161). At the end of the XIII century, the *Auser*,

⁵³ Still legible both on the C.T.R. map and the Leopoldino land register from the road network pattern.

⁵⁴ Coincides with the toponym Fiume Morto (Dead River) included in the Leopoldino land register.

⁵⁵ Today, San Giuliano Terme.

⁵⁶ Macadio is located between Rete and Gello (REPETTI 1833-46, III: 5); it appears that the hospital of Manno was also located in Macadio (CECCARELLI LEMUT 2005: 377).

⁵⁷ Dead River.

⁵⁸ Old *Auser* River.

⁵⁹ Below the Saint.

⁶⁰ New *Auser* River.

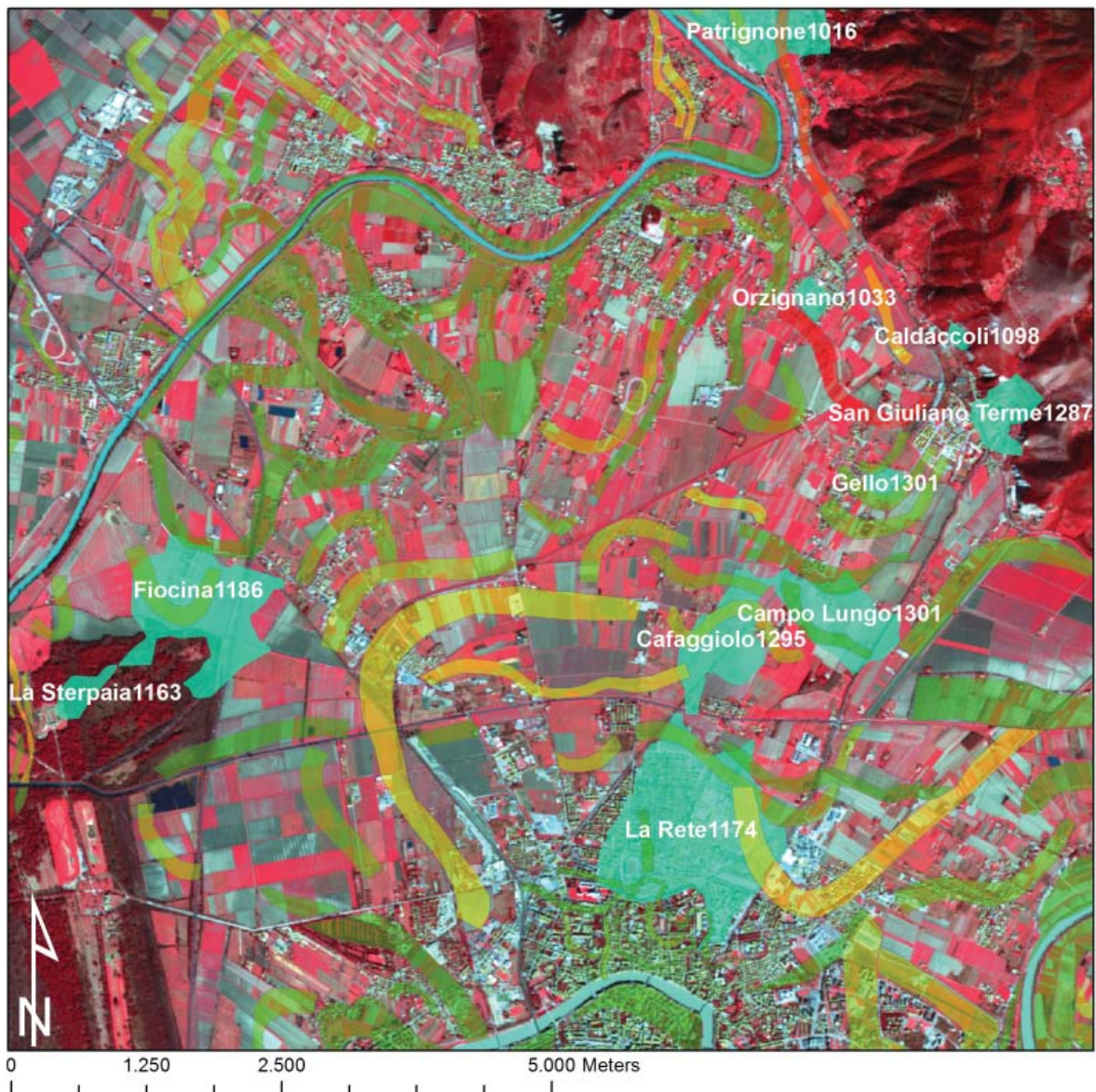


Fig. 2.10 The traces of the possible paleochannels (from red to green according to the trace's level of reliability, from Bini *et alii* 2012a), associated with the toponyms where the Auser River is attested.

by then embanked, had become a secondary watercourse⁶¹: in the *Breve Pisani Communis* of 1287 provisions were made to make it freely flow into the sea, according to the *Breve* of 1302 its waters were able to flow into the trench of Maltraverso,

whilst a subsequent agenda provided for the mouth to be corrected, embanked and merged into the Serchio River, works that do not appear to have been ever carried out (CECCARELLI LEMUT *et alii* 1994: 409-10). GIS spatial analysis of the

⁶¹ These interventions that led to the disappearance of the Auser were carried out during Modern Ages: the navigable canal of Ripafratta was built between 1564 and 1566, which used only part of the ancient course, making the old river useless. Its end part formed the Fiume Morto (Dead River) flowing, firstly – around 1560 – into the Serchio, then, in 1587, into the sea, and in 1612 again into the Serchio, and finally, in 1623, into the sea (CECCARELLI LEMUT *et alii* 1994: 411-12).

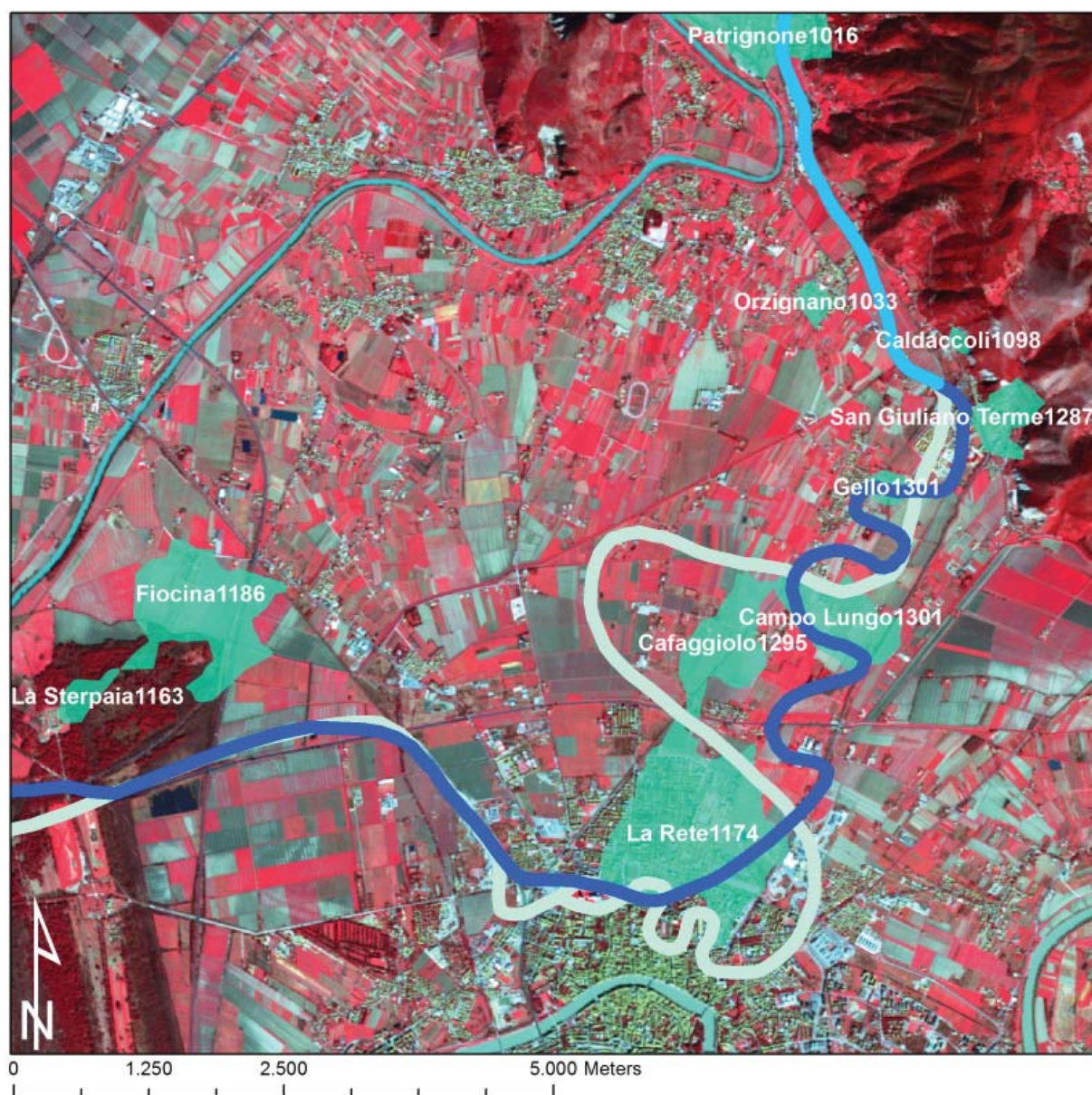


Fig. 2.11 Reconstruction of the possible early-medieval (light blue) and late-medieval (dark blue) courses of the *Auser* River. The initial stretch (blue) appears to have remained substantially the same throughout the Middle Ages. The areas of the toponyms with the date of the first attestation of passage of the *Auser* River are in turquoise.

toponyms mentioned in the medieval written sources and still recognisable in toponymy today, led to the creation of the **toponimi_Auser.shp** file, containing the toponyms of Patrignone, Orzignano, Caldaccoli, San Giuliano Terme, Gello, Campolungo, Cafaggio, La Rete, Pisa, Fiocina and La Sterpaia (fig. 2.10). *Selection by Location*, based upon the **toponimi_Auser.shp** file, made it possible to identify the palaeochannels ascribable to the *Auser*. Corrections were made on

the selection obtained, excluding the most north-western stretches near La Sterpaia and Fiocina, the north-eastern stretches at Orzignano, attributed to the *Auserclus* River, and the middle stretches due to their east/west orientation. The courses demonstrate that the *Auser* River flowed into the plain of Pisa at Patrignone, then ran straight along the foot of the Monti Pisani and moved away at Caldaccoli, meandering to the southwest towards Pisa. Its course was instable, characterised during



Fig. 2.12 The traces of the possible paleochannels (from red to green according to the trace's level of reliability, from BINI *et alii* 2012a), associated with the toponyms where the Arno is attested.

the Late Middle Ages by a series of sharp bends at Bottano, San Zeno, Casale, Cafaggio and La Cala, moving north of the city walls and, once it had passed them, bending to the north towards Madonna dell'Acqua and then west until reaching the sea. The course imagined for the early-medieval *Auser* was similar to that of the Roman Age⁶². After Puntata, it bent at Pratale, east of the imagined Roman bend, and then merged into the city course formed by the meanders of San Zeno, piazza Martiri della Libertà and Arena Garibaldi⁶³;

after reaching piazza del Duomo, it formed an island (BINI *et alii* 2013) and then left the city by bending at San Rossore and flowing north-west to Madonna dell'Acqua. Here, it bended west and flowed into the area of La Sterpaia, with a route similar to that of the Fiume Morto (fig. 2.11).

2.2.2.4 The Arno River

Only the final part of the Arno River, positioned between Navacchio and the sea, will be taken into consideration, since a broader study lies

⁶² The course of the *Auser* during the Roman age cannot be univocally determined: see CAMILLI 2004a and BENVENUTI *et alii* 2006, with related cartography, who agree on the eastern part of the course, up to the wide bend at Puntata, yet identify completely different courses for the urban and final part of the river. The study of the palaeo-river beds carried out for the MAPPa Project (BINI *et alii* 2013) permitted us to rebuild the urban part of the course. Therefore, we decided to connect the stretches already known with a hypothetical bend at Legnaia, and imagined the final course similar to the medieval one

⁶³ See § 3.1.



Fig. 2.13 Reconstruction of the possible courses of the Arno River during the Early Middle Ages (green) and Late Middle Ages before (yellow) and after the cut of the meanders of La Vettola and San Rossore (dark blue). The areas of the toponyms with the date of the first attestation of passage of the Auser River are in brown.

outside the subject of this study⁶⁴. Written sources mention the Arno River in Navacchio, Zambra⁶⁵, Arquata and Rivolta, in the area of Casciavola, from 1054 and from 1170 respectively, near Naviccio⁶⁶, in the area of San Prospero in via Cava in 1172, San Lorenzo alle Corti, Titignano⁶⁷, Montioni⁶⁸, Musigliano in 1195⁶⁹, the churches of San Vittore di Campo in 986 and San Giovanni di Mezzana in 1080, Colignola in 1041, Ripoli in 1074⁷⁰, Ghezzano in 1054, Cisanello in 1134, Barbaricina in 1031, and La Vettola from 1153

(CECCARELLI LEMUT, *et alii* 1994: 412-3). Compared to the other rivers, there is little information about abandoned courses, indicating the river's greater stability, except for two interventions carried out in 1338/40 to cut the meanders of La Vettola and San Rossore⁷² (CECCARELLI LEMUT *et alii* 1994: 413). The archaeological data⁷³, all located in the area of Barbaricina, have highlighted the presence of sandy-silty deposits of fluvial origins referable to a river bed. GIS analysis was carried out as in the previous cases by creating – on the basis of the **Thiessen_toponimi.shp** file, the **Toponimi_Arno**.

⁶⁴ For details on the course to the east of Calcinaia please see CECCARELLI LEMUT *et alii* 1994: 412.

⁶⁵ On the right bank (CECCARELLI LEMUT 2005: 383).

⁶⁶ Toponym referring to a boat passage (CECCARELLI LEMUT *et alii* 1994: 412).

⁶⁷ *Arginalto* (High Embankment) (1144) and the presence of a *Canneto* (Groove of reeds) (1154), which could indicate the presence of a marshy area along the river, are mentioned at Titignano (CECCARELLI LEMUT 2005: 383).

⁶⁸ A place called *La Lentia* rose here in 1082 (CECCARELLI LEMUT 2005: 383). This toponym (*Lentia*, *Lentha*, *Lenthe*) is linked to the presence of long and narrow shaped fields, typical of reclamation areas (Garzella 1990: 143).

⁶⁹ The presence of banks along the Arno is attested, contained in an embankment (CECCARELLI LEMUT 2005: 382).

⁷⁰ Where *Plaia* and *Plage* (i.e. Beaches) appear (CECCARELLI LEMUT 2005: 382).

⁷¹ Where the toponym *in lentha* appears in 1134 (CECCARELLI LEMUT 2005: 382).

⁷² The most significant modifications were carried out in any case during the Modern Ages: in 1606 the mouth of the river was corrected and oriented towards west instead of towards south-west, and in 1771 the bend of Barbaricina was cut (CECCARELLI LEMUT *et alii* 1994: 414).

⁷³ SCIUTO C. 2012, *Intervention records no. 353, 354, 365* in MappaGIS.

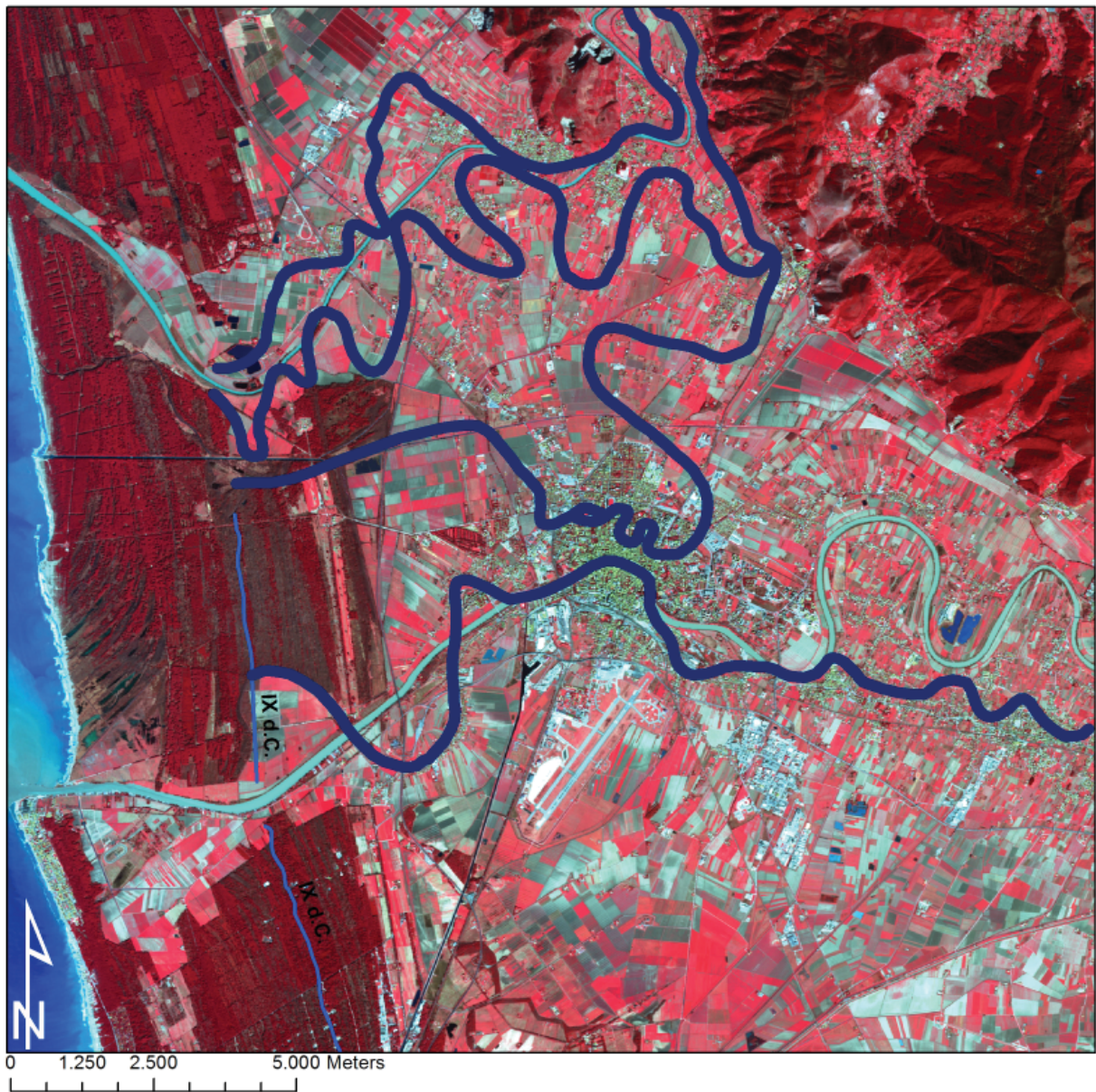


Fig. 2.14 Reconstruction of the possible hydrographic situation of the plain of Pisa during the Early Middle Ages.

shp polygon file which includes the toponyms Navacchio Casciavola, Zambra, San Prospero, Arquata, San Lorenzo alle Corti, Titignano, Montone⁷⁴, Musigliano, Campo, Colignola, Ghezzano, Riglione, Cisanello, Putignano, Barbaricina and La Vettola (fig. 2.12). *Selection by Location* of the palaeochannels identified the

possible palaeochannels ascribable to the Arno River. The selection suggests the presence of both a southern course, passing through Montone, Titignano and the monastery of San Savino where a landing place arose, and a northern course, which bent through Musigliano and formed another meander near Colignola. A series palaeochannels

⁷⁴ Previously *Montioni*.

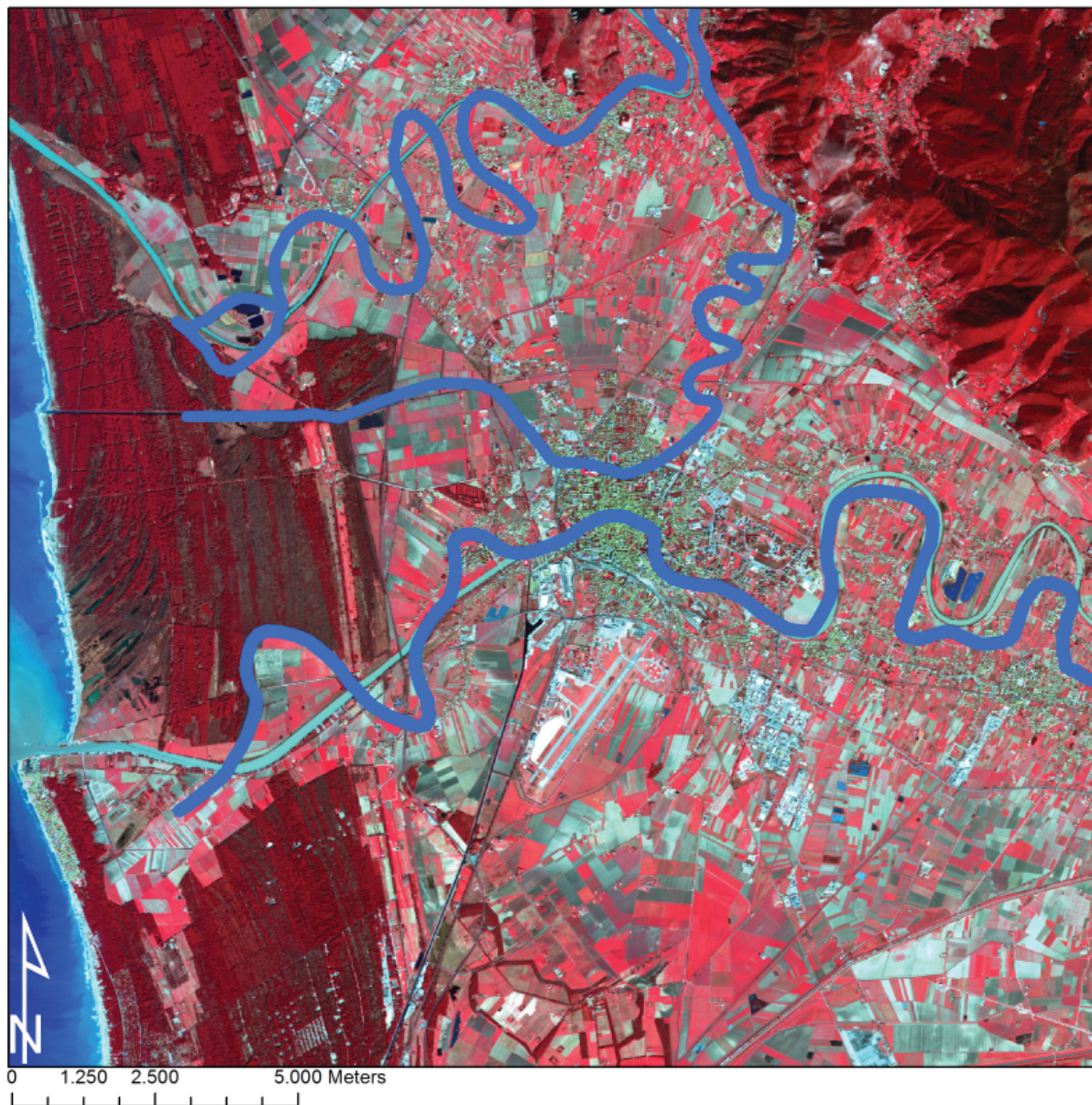


Fig. 2.15 Reconstruction of the possible hydrographic situation of the plain of Pisa during the Late Middle Ages, before the XIV century cuts of the La Vettola and San Rossore meanders.

are visible here, located more northwards. Although the absence of chronological indications prevents us from providing a clear evaluation, I am led to consider them prior to the Middle Ages, based on the interpretation of written sources and toponymy. Even the sector immediately to the east of the city is characterised by a large number of buried river beds and a course crossing Cisanello. After flowing through the city (§ 3.1.2; 3.1.3), the river bended north in the area of Barbaricina, and

then south at La Vettola; here, during the Middle Ages, the Arno changed its course compared to the Roman Age, keeping the area of San Piero a Grado to the left. Lastly, it formed a meander towards north at San Rossore, gradually moving its mouth increasingly towards south west. Considering the route of the *strata Vallis Arni* (§ 2.3.1.5), which retraces the Roman road network along Valdarno towards Florence, it is possible to imagine an earlier date for the most southern of

the two courses identified, between the Roman Age and the XII century, when the Arno was still mentioned at Titignano (fig. 2.13).

2.2.3 Wetlands: marshes and swamps

Throughout the Middle Ages, the plain of Pisa was characterised by marshy areas, wetlands and large submerged areas which had both a negative and positive impact on the city. Getting an idea of the size of these areas allows us to assess their impact on the development of Pisa. As in the case of the analysis of the rivers, I studied the presence of marshy areas in medieval written sources⁷⁵. They describe a large number of areas (called marshy) of different size and often of a seasonal nature. The following are mentioned between the Serchio River and Lake Massaciuccoli: the Vecchiano marsh to the east, ranging from *colle Greguli*⁷⁶ to Lake Massaciuccoli according to a 1159 deed, and from Monte Legnaio to Navariccia; the Viticeto marsh to the north, recorded in Nodica in 1047 and indicated in 1262 between Magna trench and the lake; to the west, the Malaventure marsh mentioned from 1262 (CECCARELLI LEMUT *et alii* 1994: 416-7). On the left bank of the Serchio, near Arena, written documents indicate the existence of a marshy area attested in 730 and in 1074. Marshy areas are described in the area of the mouth of

the Serchio, at Il Marmo, where in 1183 a marshy area is mentioned during winter, but dry during summer, and at the mouth of the *Auser* River where a 1175 document mentions the presence of a *terra da Sigalare* which over thirty years before had been a marshy land (CECCARELLI LEMUT *et alii* 1994: 409). A large swamp is described from this area, running southwest, down to Pisa and the Arno, called *pisana* in the 1139 diploma of Emperor Corrado III, but already existing with the name of *Authioli*, in 964, or *Osule*, in 1086, or *palus Auseris* (*Auser* marsh), in the XII century, and mentioned at Leona from 1067, Ponticello in 1064, Grumolo in 1062 and in the area of Scorno⁷⁷, near the Church of San Bartolomeo⁷⁸ in 1181 (CECCARELLI LEMUT *et alii* 1994: 417-8). Another marshy area, called *Silva Tumulus*⁷⁹ or *Sanageto*, is also mentioned in a 1291 document (BERTI, RENZI RIZZO 2004: 41), which spread from the left bank of the Serchio Morto⁸⁰, to the right bank of the Arno River and around the church of San Rossore⁸¹. Other marshy areas are mentioned along the foothills and in Valdozzeri at Capelle in 1098, in Caldacoli at the start of XIV century, in the area of Tabbiano at the end of the XIII century, in Macadio⁸² in 1105, in Cafaggio in 1227, and between Valdozzeri and the right bank of the Arno River in Ghezzano from 1020, in Colignola from 1076, in Campo from 1023 and,

⁷⁵ Data published in BERTI, RENZI RIZZO 2004, CECCARELLI LEMUT, *et alii* 1994, REDI 1988, REDI 1990, REDI 1991 were especially considered.

⁷⁶ Today, Le Grepole.

⁷⁷ Possibly identifiable with the existing toponym La Sterpaia (REDI 1979:10).

⁷⁸ The Church of San Bartolomeo was recalled for the first time in 1093 in *Servo Dei* or *Servodio* or *Servadio* (REDI 1979:7). It is difficult to locate it. According to REDI 1979:10, it was located to the north of Cascine Vecchie at La Sterpaia. The Leopoldino land register maps report the toponym Church of San Bartolomeo at Cascine Nuove, around 1 km northeast.

⁷⁹ The term *Tumulus* referred to areas alternating low-lying and wetland areas with drier hillocks and dunes. This marsh reached the church of San Rossore which rose at Cascine Nuove. The marshy area still existed at the end of the XIII century, until archbishop Federico Visconti annexed the church to the city convent church of San Torpè due to the difficult environmental conditions (BERTI, RENZI RIZZO 2004:38 ss).

⁸⁰ Identifiable with the Salaria trench or Old Serchio, or Dead River of the Serchio.

⁸¹ According to a document of 1084, the church of San Rossore devoted to San Lussorio and its monastery annex were positioned *prope litora maris, iuxta flumen Arni* in the middle of the *de Tumulo Marchionis* woods. The position was identified at Cascine Nuove, where many skeleton remains and a well were found in March 1907, ascribable to the presence of a cemetery and the cloister of a monastery (REDI 1979:7).

⁸² Macadio can be positioned between Rete and Gello (REPETTI 1833-46, III: 5); the hospital of Manno can also be located in Macadio (CECCARELLI LEMUT 2005: 377).

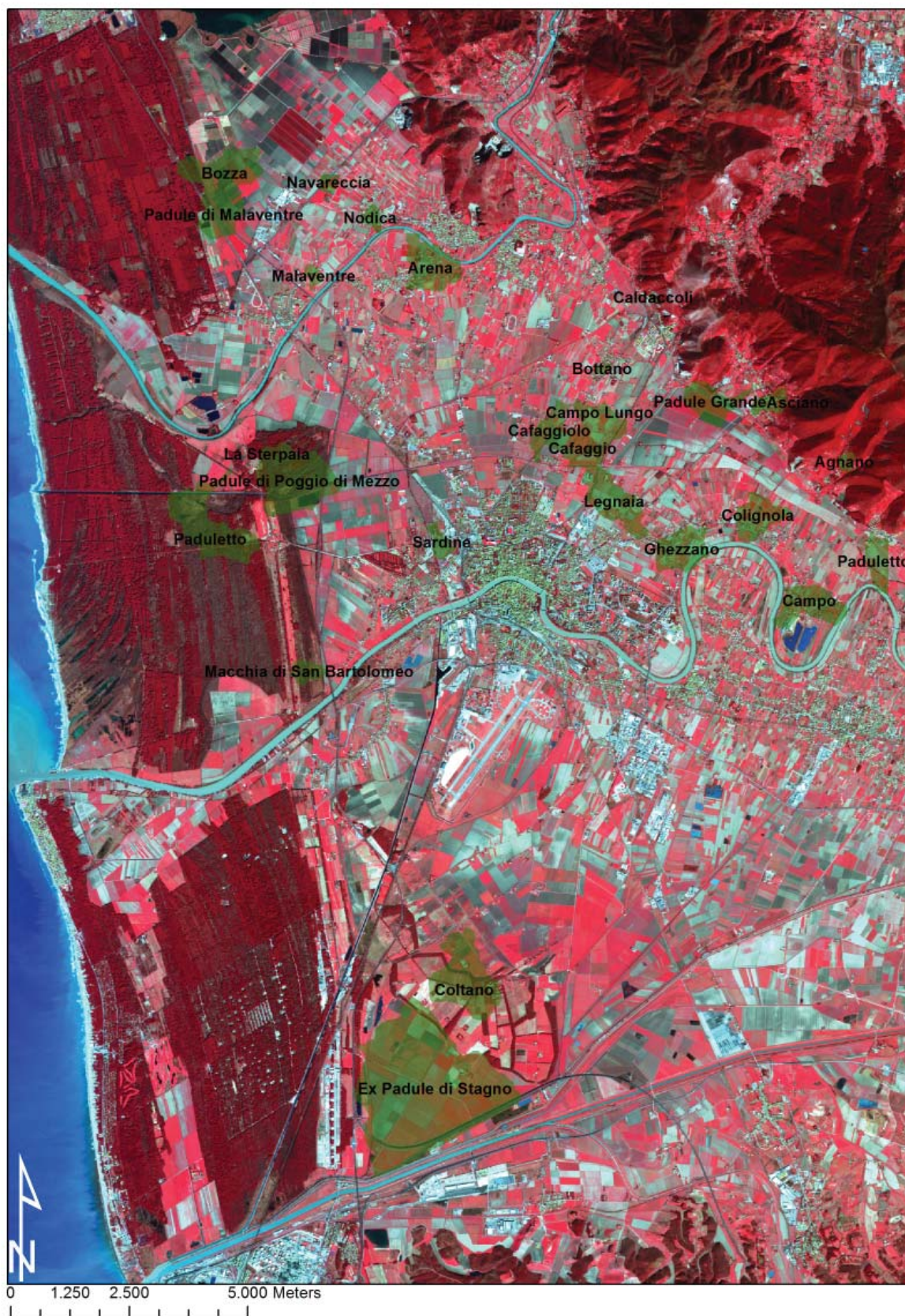


Fig. 2.16 The areas of the toponyms attributable to the presence of marshy areas.

finally, in Agnano and Asciano where a large swamp is recorded already at the half of the XI century, whose waters intended to be merged into the *Auser* in 1162 (CECCARELLI LEMUT, *et alii* 1994: 418-9). South of the Arno, written documents report the presence of a large marshy area, called *Tumulus* (BERTI, RENZI RIZZO 2004: 38) which spread from the sea to the mouth of Stagno (Pond), whose eastern border was located in the area of the church of San Piero a Grado during the XIII century and in the area of the Ognissanti monastery, behind Pisa's city walls near *tegularia*⁸³, during the XIV century (BERTI, RENZI RIZZO 2004: 41). Marshes are mentioned close to the city at Chinzica in 1067 and Orticaria from 1134, but it was mainly the lower lands south of the city, spreading to the foot of the first hills, and Livorno to be occupied by the vast marshy areas of Mortaiolo and Coltano (CECCARELLI LEMUT *et alii* 1994: 419-20) (fig. 2.16).

Recognising the marshy areas was more complicated than studying the rivers. First, a model of the areas that could have been potentially flooded was built⁸⁴ (GATTIGLIA 2012), then the model was checked in a sample area⁸⁵ through checks with palaeogeographical maps, historical DEM and archaeological data, until reaching a historical-archaeological interpretation of the data obtained. The model of the areas potentially subject to floods was created using GIS analysis which took into consideration the large amount of data of different provenance. First of all, geographic data: terrain elevation, based on the premise that

the areas located at lower heights, in our case close to or below sea level, are more easily subject to flooding; slope, considering flat terrains as those more easily subject to flooding; submerged or internal drainage areas. Geopedological data use land maps⁸⁶ and geological maps (CAR.G), and consider lacustrine, marshy and reclaimed lands as the most suitable for marshy areas. Finally, toponymic data identify toponyms referring to the presence of marshy areas and toponyms available in written medieval sources, in order to include a distinguishing chronological element. Spatial analysis of reclassified and processed data using the raster calculator function, allowed to create a map of the potential areas subject to flooding during the medieval period. A fundamental part of this work phase consisted in reclassifying (*Reclassify* tool), i.e. attributing parametric values to the data obtained; the final results depend on the new values assigned, therefore, in order to evaluate their validity, the steps taken will be reported in detail. The first stage regarded geographic data. A DEM of the area examined was created, generically referable to the Middle Ages, in respect of which I decided to use the XVI century coastline as a coastline that could take into account the advancement of the coast during the entire medieval period, and to exclude all the elevation points positioned to the west of this line. Since it was not possible to create a medieval DEM for such a large area, given the lack of sufficient elevation data referable to the Middle Ages, I

⁸³ The Monastery of Ognissanti is documented from 1227 close to the extra-urban church of San Giovanni al Gatano, on the left bank of the Arno to the south-west of Pisa; in 1406 it was transferred to the other bank of the Arno (inside the walls) at the church of Santi Vito e Ranieri, where it remained until 1551; then it was transferred to the no longer existing church of San Lorenzo alla Rivolta up to the suppression of ecclesiastic institutions in 1786. The monastery was built on a land bought in 1212 at the *carràia* (carriage road) *Lungaresca*, near the area mentioned in documents as *Tegularia, ut ecclesiam et hospitale vel alterum eorum in eo facere possitis ad vostram voluntatem* (PECORINI CIGNONI 1998).

⁸⁴ The procedure carried out was inspired by MACCHI 2001 and by CITTER, ARNOLDUS-HUYZENDVELD 2007.

⁸⁵ Corresponding to an area measuring 26 km² surrounding Pisa and investigated during the MAPPA Project.

⁸⁶ Regarding the use of the land map and of *Potential Land Evaluation* in the archaeological field, see ARNOLDUS-HUYZENDVELD 2007, VOLPE, ARNOLDUS-HUYZENDVELD 2005, CITTER 2012.

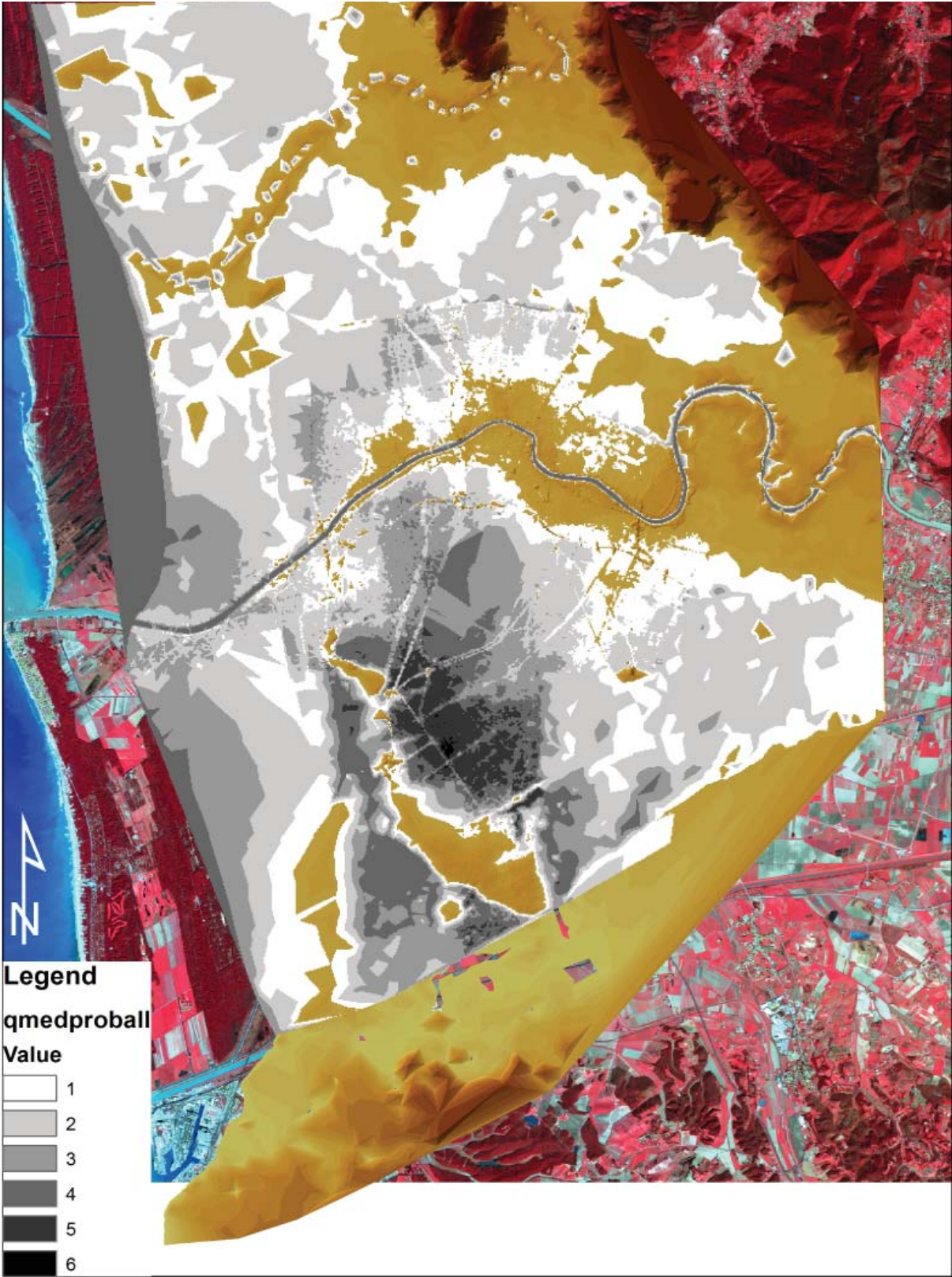


Fig. 2.17 The **qmedproball.grid** file overlapping the DEM of the area under examination limited to the late-medieval coastline.

decided to process the data on existing elevation points⁸⁷. A DEM raster file was created from the LiDAR with 25 m cell resolution⁸⁸. The latter was reclassified on the basis of elevation values (*Spatial analyst* → *Reclassify*) with a scale from 1 to 6, attributing a greater value to the lower areas, i.e. those which are more likely to be flooded (**qmedproball.grid** file). The DEM was also subject to the *slope* function, which identifies slopes expressed in percentage of inclination (*percent*), thus obtaining the **slope_med.grid** file, which was in turn reclassified (**slopmdproball.grid**), compressing the values on a scale of 1 to 5 so as to assign the greater values to the areas with a lower percentage of inclination, i.e. the areas more likely to flood. The last geographic data were related to submerged areas: the DEM was subject to the *sink* function so as to highlight the submerged areas (**sink.grid**), reclassified from 1 to 5 (**sink_probball.grid**), in which the greater values indicate the areas more subject to being submerged. The second stage considered the pedological and geological data. The former were inferred from the land map⁸⁹. Lacustrine, fluvial-lacustrine and peaty soils were selected from the vectorial format using *Selection by Attributes*. The selection file was rasterised (*Spatial Analyst* → *Convert* → *Features to Raster*) and reclassified assigning values 10, 8, 4 and 0, respectively to the unit of Stagno-Coltano⁹⁰, Malaventre⁹¹, Grecciano-Ponsacco⁹² and

⁸⁷ Regarding use of a similar method, only partially regressive and therefore not reconstructive, see CELUZZA *et alii* 2007:221 ss. Although provided with sample data in the neighbouring area of Pisa which was investigated by the MAPPA Project, we decided not to use them for the creation of a DEM for such an extensive area, given their low representativeness in an area of 350 km².

⁸⁸ The decision to work with 25 m cells is related to the level of accuracy desired for an area of 350 km² and to the need to use the land use map with 1:250.000 scale. The choice of the scale (one of the crucial phases of any scientific process) was based on the fact that a scale that is too thick does not necessarily ensure accuracy (MACCHI 2001). Furthermore, the purpose of our work is to evaluate the 'probable', not the 'real' influence of marshy areas throughout the landscape of Pisa.

⁸⁹ The land map of Regione Toscana (scale 1:250.000) may be downloaded from <http://sit.lamma.rete.toscana.it/websuoli> (last access 03/05/2013).

⁹⁰ The Stagno-Coltano unit is lithologically characterised by lacustrine clays including peat, whilst morphologically it is a reclaimed, coastal plain of fluvial-lacustrine origin with depressed surfaces. "The Stagno soils (STG1) (Halic Endoaquerts very fine, mixed, termic), which are moderately deep, with Ap-AC-Cg profile, non-gravelly, clayey, from poorly to moderately calcareous, from poorly to moderately alkaline, from very salty to extremely salty with salinity, very evident pressure and slip surfaces, and poorly drained, are situated on level surfaces with high risk of flooding and are very frequent. They are generally cultivated for sowing, when permitted by the salinity. The Coltano soils (CLT1) (Typic Sulfaquepts clayey over fine-silty, mixed, termic), which are moderately deep, with Ap-Bj profile, non-gravelly, clayey loam to clayey texture in the topsoil and from silty loam to silty-clayey loam in the subsoil, non-calcareous, from subacid to peracid, with exceptionally high salinity, already below Ap and above 5% of organic substances, poorly drained, with common concentrations of jarosite from varying depth and occasional presence of pressure and slip surfaces, are situated on sunken surfaces where peat covers the fluvial deposits by tens of centimeters, and are frequent. They are generally cultivated for sowing, when permitted by the acidity and salinity." (<http://sit.lamma.rete.toscana.it/websuoli/> last access 05/05/2013).

⁹¹ The Malaventre-Gambini unit is lithologically characterised by a peaty soil and morphologically by a fluvial-lacustrine plain. Our analysis only took into consideration the "Malaventre soils (MAL1) (Halic Haplosaprists), which are deep, with Op-Oe-2Cg profile, non-gravelly, non-calcareous, with reactivity ranging from poorly to moderately acid, with very high base saturation, very saline, moderately well-drained, situated in the reclaimed plain and very frequent." Generally cultivated for sowing (<http://sit.lamma.rete.toscana.it/websuoli/> last access 05/05/2013).

⁹² The Grecciano-Ponsacco unit has a main lithology characterized by recent fluvial-lacustrine flooding of the Arno (Holocene deposits) and an interfluvial plain morphology (backswamp). Our analysis took into consideration the Grecciano soils and the secondary soils of Arena. "The Grecciano soils (GRE1), (Typic Haplusterts fine, mixed, termic), which are deep, with Ap-Bss-Cgss profile, non-gravelly, with clayey-silty texture, from poorly to moderately calcareous, from poorly to moderately alkaline, from moderately well-drained to rather poorly drained, are situated on level or slightly sunken surfaces, in a distal position compared to the courses of the Arno and Arnaccio rivers, and are very frequent. They are generally cultivated for sowing (wheat and beet)". The "Arena secondary

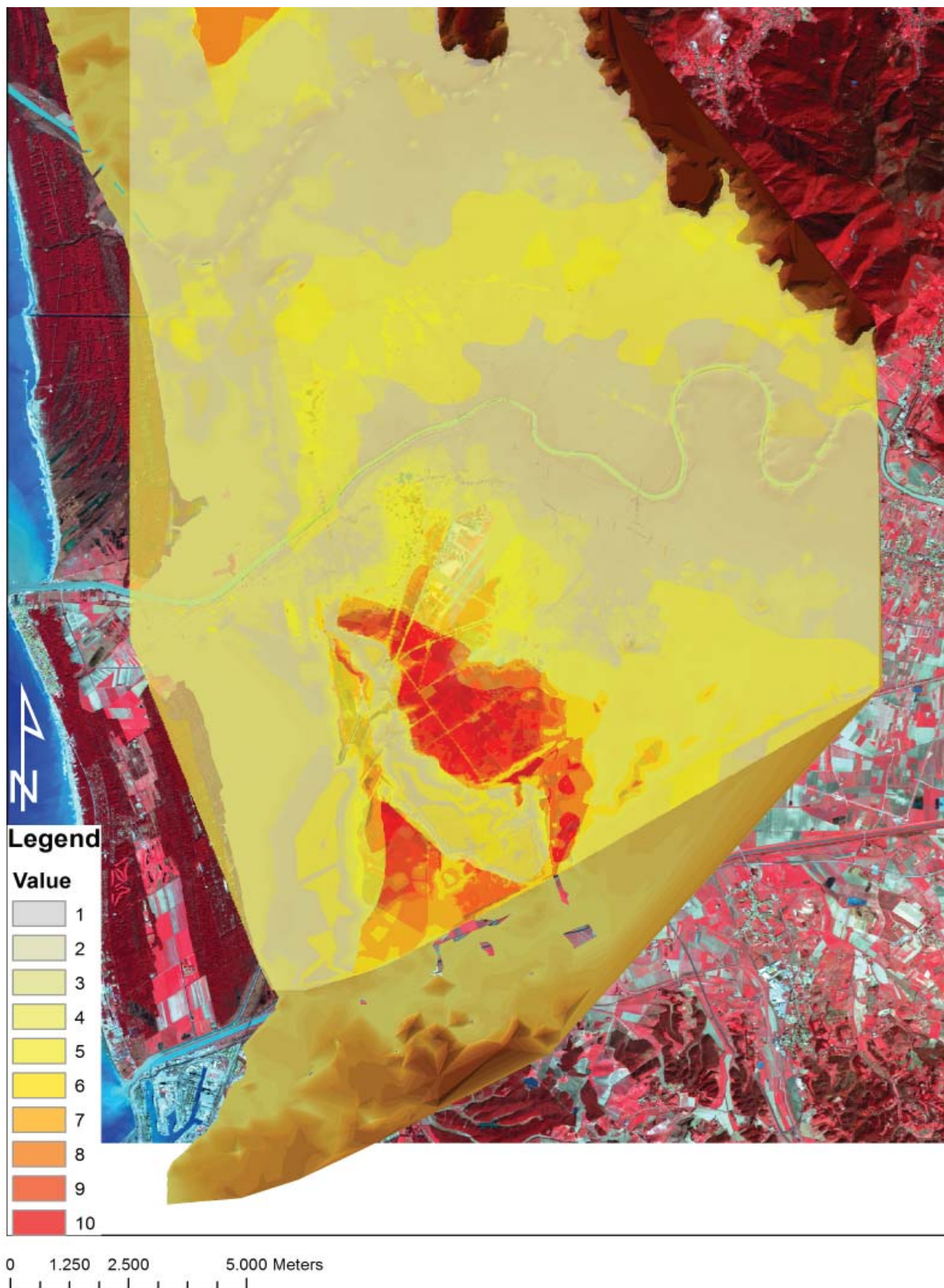


Fig. 2.18 Map (**proball_calc5.grid**) of the areas potentially subject to floods in three different shades of colour: red for areas with high flooding potential, orange for areas with medium flooding potential and grey for areas with low flooding potential.

NoData⁹³ (**suoli_probball.grid**). The geological data were obtained from the CAR.G. geological polygon shapefile, through *Selection by Attributes*, and marshy deposits were identified as well as areas related to reclaimed lands (**depositi_palustri.shp**), then reclassified in the **ricdepopalu2.grid** file with assignment of the following parameters: 5 to the marshy areas, 3 to landfill and reclaimed lands, 0 to all other soils. The third stage consisted in the creation of the polygon shapefile regarding the toponyms, which, as in the case of the study of the rivers, was obtained through *Selection by Attributes* from the **Thiessen_toponimi.shp** file, searching for the presence of toponyms mentioned in the medieval written sources and of existing toponyms connected to the marshes. The selection led to the creation of the **Toponimi_paludi.shp**⁹⁴ polygon file which was rasterised (**topo_palud3.grid**) and then reclassified (**rictopopalu3.grid**) assigning the value 3 to all toponyms indiscriminately and 0 to NoData. Spatial analysis was carried out during the final phase of the work (*map algebra*⁹⁵): the raster calculator (*Spatial Analyst* → *Raster Calculator*) was used to sum the values assigned and reclassify them on a scale of 1 to 10 (**proball_calc5.grid**), regarded as increasing flooding potential values. Overall, the geographic data influence the estimate of the potential of areas subject to flooding by 47%, geopedological data by 44% and toponymic data by 9%. The minor influence of the toponymic data is due to their minor accuracy.

The map obtained regarding areas potentially subject to flooding was divided into three scales of colour:

- Areas with high flooding potential: in shades of red, including to the north, the marshy area of Malaventre, i.e. the extreme offshoots of Lake Massaciuccoli, and to the south, Coltano and Stagno marshes;
- Areas with medium flooding potential: in shades of orange, including to the north, an area subject to flooding at Malaventre and two small areas close to the coast, in the area where the Marmo marsh was once situated; in the middle, a large section surrounding the city centre of Pisa moving from west to east and comprising the area of the *Palude Pisana* (Pisan Marsh), and to the east, the Asciano marsh area. By overlapping the urbanised areas, for which geological data are missing, it is evident how the data of this middle section may appear to be slightly underestimated given the absence of records. In fact, if we do not consider the geological data overall, owing to the influence of the urbanised areas, and if we calculate (*Raster Calculator*) the new raster **proball_nogeo.grid**, we note a significant coincidence with the data of the areas with high potential, but an increase in the areas with medium potential compared to those with low potential, with areas of medium potential within this area and at the foot of Monte Bruceto, near Arena, Nodica,

soils (ARE1) (Fluventic Haploxerepts coarse loamy, mixed, termic), which are very deep, with Ap-Bw-C profile, non-gravelly, with texture from loam to silty loam, from scarcely to moderately calcareous, with moderately alkaline reactivity, with very high base saturation and well-drained, are situated on the existing deposits and in the Serchio river bed" (<http://sit.lamma.rete.toscana.it/websuoli/> last access 05/05/2012) .

⁹³ It is necessary to attribute the value 0 to the NoData, otherwise these areas are not calculated by the raster calculator.

⁹⁴ Containing the following toponyms: Bozza, Padule di Malaventre, Navareccia (for Navariccia), Legnaio, Paduleto, Nodica, Malaventre, Arena, Caldaccoli, Bottano, Cafaggio, Cafaggiolo, Campolungo, Padule Grande, La Sterpaia, Padule di Poggio di Mezzo, Sardine (this toponym could be associated with the term 'sardigna' used in Florence for unhealthy places, see PIANIGIANI 1907, v. Sardigna), Asciano, Agnano, Colignola, Ghezzano, Campo, Macchia di San Bartolomeo, Ex-Padule di Stagno and Coltano.

⁹⁵ TOMLIN 1990.

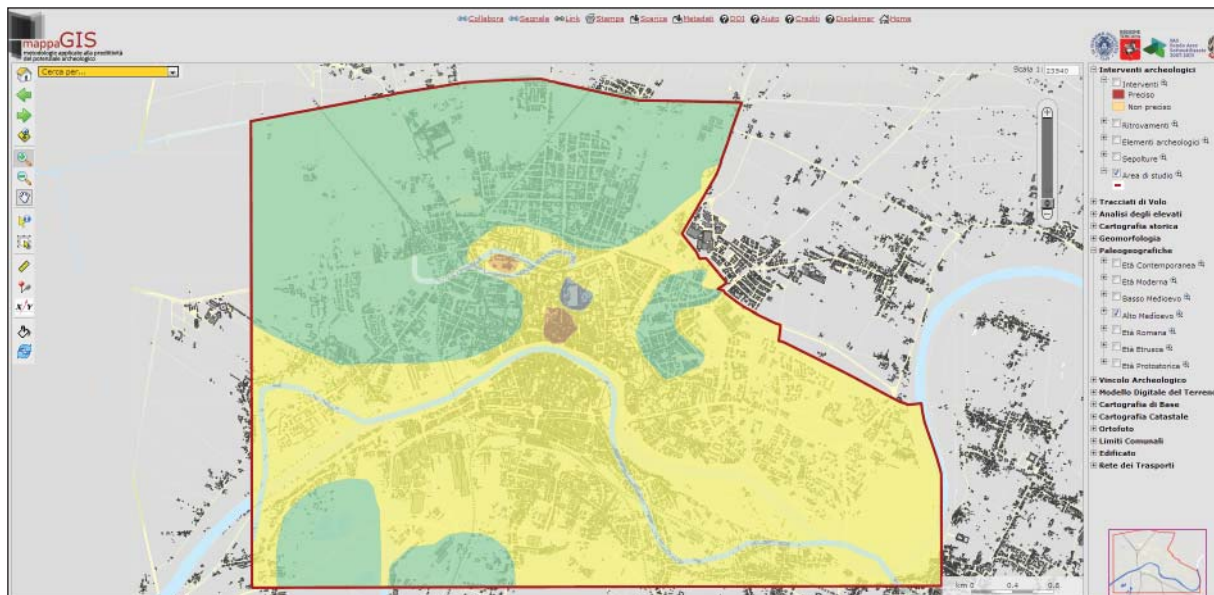


Fig. 2.19 Early-medieval paleogeographical map published on the MAPPAGis (www.mappaproject.org/webgis). Wetlands/marshy areas are indicated in green, areas subject to flooding in blue, plains in yellow and morphological highs in brown.

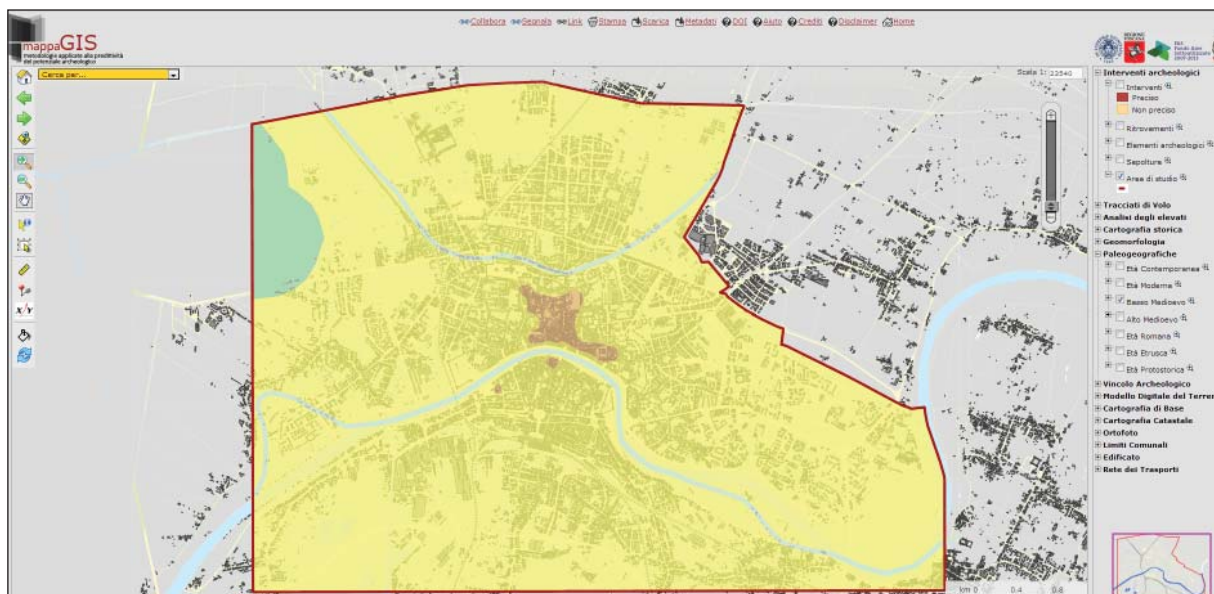


Fig. 2.20 Late-medieval paleogeographic map published on the MAPPAGis (www.mappaproject.org/webgis). Wetlands/marshy areas are indicated in green, plains in yellow and morphological highs in brown.

at Caldacoli and along the meanders of the Arno River to the east of Pisa. To the south of Pisa, medium probability involves the sections subject to flooding around the areas of Stagno and Coltano, identifying areas that could be possibly subject to flooding all the way to San Piero a Grado and to the southern

area of Pisa. Even in this case, the data may appear to be distorted due to the presence of large urbanised areas.

- Areas with low flooding potential: in shades of grey, basically corresponding to the coastal areas and those connected to the passage of the Arno and Serchio.

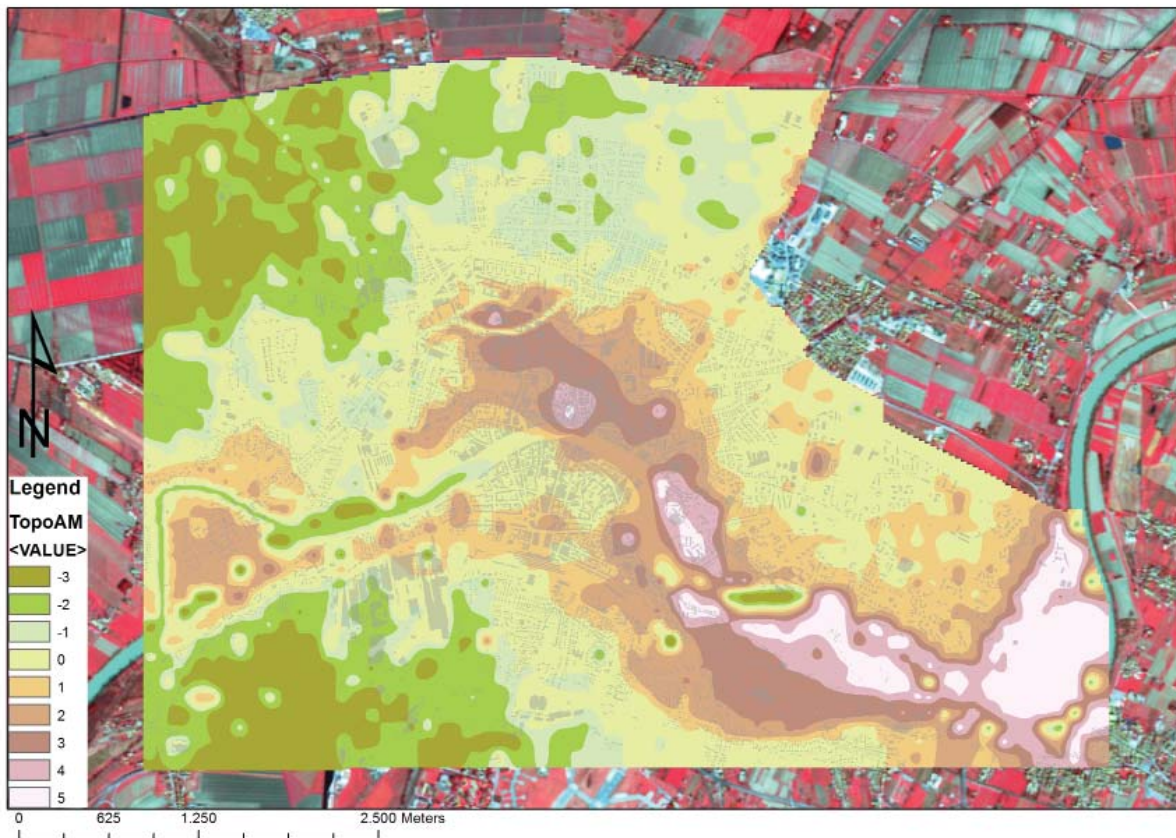


Fig. 2.21 Early-medieval DEM. Elevation is expressed at current sea level.

The next step was to make chronological assumptions related to these scales of values: attribution to areas that are still sunken, or were so until recently, was quite simple for the areas with high flooding potential; instead, for areas with medium flooding potential we assumed that they could represent maximum expansion of the marshes during the Early Middle Ages (limit of the area coinciding with value 4) and maximum contraction during the Late Middle Ages (limit of value 5 areas). This model was compared in the MAPPA project sample area⁹⁶ with the palaeogeographical period maps related to the Early and Late Middle Ages (BINI *et alii* 2013) and with historical DEM. The marshy area identified

in the palaeogeographical map referring to the Early Middle Ages almost perfectly coincides with the maximum limit of the area with medium flooding potential both to the north and south-west, while a depression is excluded in the eastern sector (at Pratale)⁹⁷ located on the basis of the MAPPA 4 and 5 cores. The former of these resulted in vegetal remains dated (C^{14}) between the IV and VI century (ALLEVATO *et alii* 2013) (fig. 2.19). Late-medieval palaeogeographical map identified a marshy area in the north-western sector, whose traces partly coincide with the largest value-5 depressions of the model (fig. 2.20). The second check was carried out using the historical early- and late-medieval DEM (figs.

⁹⁶ 26 km² area around Pisa.

⁹⁷ The model returns few, small areas with value 3 and a large area with value 2 (very low).

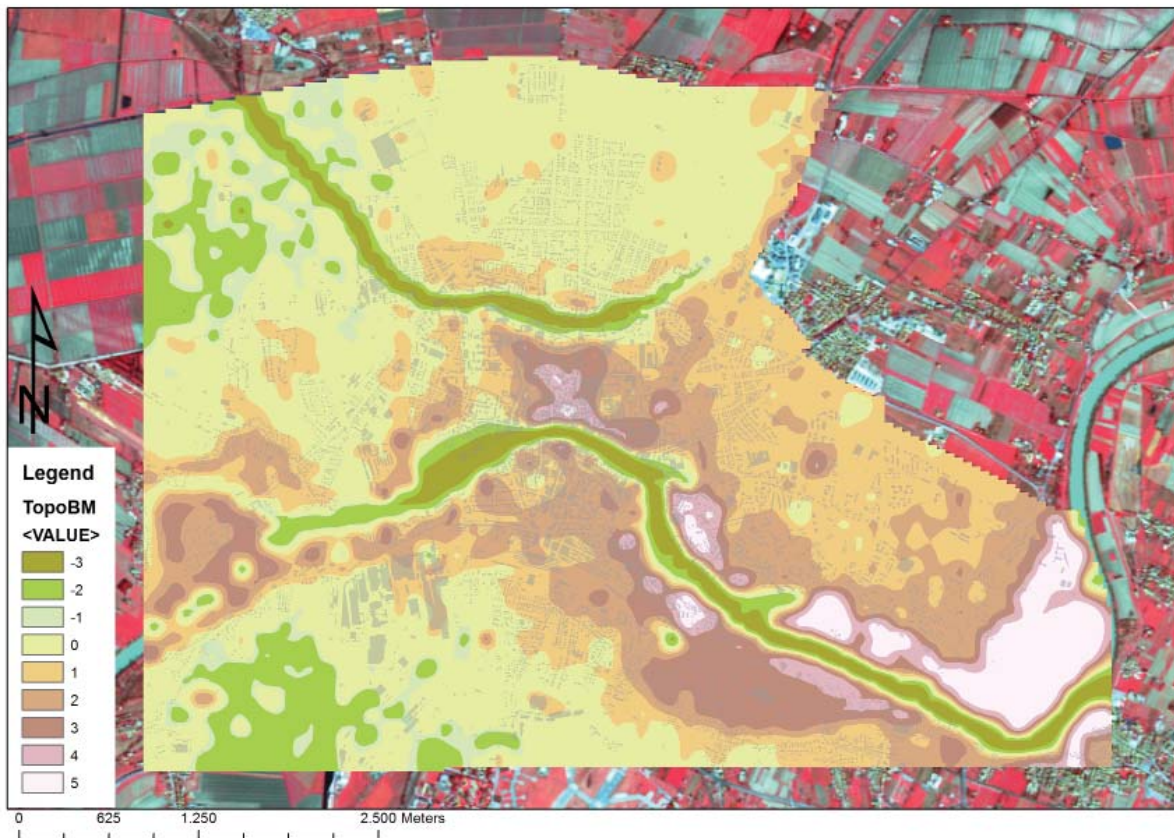


Fig. 2.22 Late-medieval. Elevation is expressed at current sea level.

2.21 and 2.22). They were created with a double reliability scale for urban⁹⁸ and extra-urban areas. The urban area DEM was created using the elevation points available from archaeological investigations⁹⁹, whereas the extra-urban area DEM was developed in a regressive manner, given the small number of elevation points available. First I checked whether it was possible to apply an

average yearly growth rate of 2 mm as found in other floodplain areas (CITER 2012: 71), however, the extra-urban archaeological data did not permit a similar growth rate to be assumed. I decided, therefore, to analyse the average values of the elevation points inside and outside the urban walled area from the excavation data¹⁰⁰ and to compare them with current elevation points,

⁹⁸ For the procedure see (BINI *et alii* 2013). An “urban” area means the area for which sufficient elevation points were available from the archaeological data and coincides with the city inside the walls only for periods after the Late Middle Ages. They were processed using the ANUDEM (Australian National University Digital Elevation Model) algorithm created for the development of hydrogeologically correct DEM (HUTCHINSON 1988, 1989, 1996; HUTCHINSON DOWLING 1991), selected following quantitative comparisons with other algorithms of the *algorithms general purpose* type (for example, Spline, IDW), in order to obtain the greatest elevation accuracy. The algorithms were compared using reiterative cross-validation techniques, which consist of creating a new DEM and omitting certain points of the original dataset and subsequently testing the elevation of these points with their original one.

⁹⁹ Both from subsurface data and data inferable from building analysis. The urban area DEMs were created with 20 m cells.

¹⁰⁰ This procedure was carried out for all historical periods.

inside and outside the walls, taken from the LiDAR, thus emphasising the growth rate of the deposits: in the area outside the walled centre, the elevation points grew averagely, from the Early and Late Middle Ages to today by 1.90 m and 1.57 m. The LiDAR, therefore, was rasterised in 100 m cells and these were transformed into elevation points; the difference between the average of the current elevation points and the average of the early- and late-medieval elevation points was subtracted from every rasterised LiDAR elevation points, then the cells containing excavation data were checked, finding an average error of 10%. Regarding the area inside the city, the elevation points were taken from the archaeological investigations. The data were analysed using *TopotoRaster* interpolation, to which the data of the city palaeochannels rebuilt for the palaeogeographical maps were added as stream. The result is a DEM of the periurban area of Pisa with two different reliability scales: high for the urban area and low for the extra-urban area. In order to compare previously processed data, elevation was classified into nine classes through *Natural break*¹⁰¹, and using manual correction to highlight the areas under sea level. Comparison with the previous data reveals basic uniformity between the maximum limit of the area with medium probability and with the limit of the marshy area identified by palaeogeographical maps. The interpolation using *TopotoRaster* produces a spot effect and, probably, better describes an environment made of wetlands, dry areas during arid months and marshes during rainy months. Even the *TopotoRaster* interpolation does not highlight the area identified by the geomorphological analysis, at Pratale. Regarding the areas identified with value 5, there is general coincidence between the *TopotoRaster* interpolation and the map of areas potentially subject to flooding, with a substantial coincidence with the palaeogeographical maps in the north-western sector, but not in the south-western sector. The last phase checked the actual presence of marshy areas in the areas identified through comparison with archaeological data¹⁰². Using a search (Level III¹⁰³ = Marsh, with chronology between Late Roman period and Late Middle Ages)¹⁰⁴ 29 different archaeological interventions were selected, in addition to one MAPPA core¹⁰⁵, all located to the north of the urban area, which reported the presence of clayey and/or sandy-clayey layers ascribable to marshy areas and dating often determined in a relative manner on the basis of the stratigraphic sequence, given that in the majority of cases these sediments cover Roman agricultural areas and are covered by post-medieval layers. In the sector to the north-east of the city, the excavation in La Figuretta¹⁰⁶ revealed the presence of a thick layer of light brown clayey soil containing 2 potsherds and 6 brick sherds, dating back to the I-II century A.D. which was related to the hydrogeological changes of the area during the Early and Late Middle Ages, given that the layer covered a well dating back to the I-II century A.D.. Similarly, the

¹⁰¹ By viewing the Natural Breaks, the data are grouped in classes on the basis of similar values in order to maximise the differences between the classes themselves.

¹⁰² During the MAPPA project work, the archaeological data related to marshy areas were reviewed together with geologists and geomorphologists; this led to generally redefining the contexts considered marshy by the archaeologists, highlighting (once again) the need for a more accurate geoarchaeological analysis of archaeological contexts. In GATTIGLIA 2010, 2011 the indications provided by the archaeological data were acritically examined.

¹⁰³ See ANICHINI *et alii* 2012: Appendix.

¹⁰⁴ This search may be carried out on the MAPPAgis www.mappaproject.org/webgis, where the data may be consulted, searched for and downloaded (ANICHINI, GATTIGLIA 2012a).

¹⁰⁵ MAPPA 4 (AMOROSI *et alii* 2012), with C¹⁴ dating between IV and VI century A.D. (ALLEVATO *et alii* 2013).

¹⁰⁶ GATTIGLIA G. 2012, *Intervention record no. 261*, in MappaGIS.

archaeological excavation¹⁰⁷ in via Consani identified the presence of an alluvial event, underneath the modern and contemporary agricultural phases, which cancelled an Imperial agricultural phase, thus dating from the Late Roman period along through the Middle Ages. Generic marshy areas, underlying post-medieval agricultural soils, were also identified at I Passi¹⁰⁸. Further south, in viale G. Pisano 29¹⁰⁹, a brownish gray plastic clayey layer was identified with a thickness measuring between 0.80 and 1.50 m, containing many remains of freshwater molluscs¹¹⁰, which cancelled a trench inside which flowed material was found dating back to the I century B.C. and I century A.D.. This was interpreted as an accumulation of marshy deposits which were probably formed “starting from the Early Middle Ages”, as a consequence of the abandonment of the countryside. In the northwest sector of the city, under a contemporary fill soil, the excavation in via Bragazzi¹¹¹ brought to light a rather consistent layer (around 1.60 m) of yellowish brown compact clayey soil, in which materials were found, overlapped by a reddish sandy and friable deposit lacking anthropic presence. Regarding the sector to the west of the city, traces of a marshy area underneath a generic postmedieval settlement may be seen in via Pietrasantina at Madonna dell’Acqua¹¹². All the area including via Andrea Pisano, via delle Cascine and via Aurelia Nord, subject to interventions carried out in the area of

the former Cristallerie Genoali¹¹³ and the former Scheibler area¹¹⁴, brought to light the presence of marshy soils, both clayey and sandy-clayey, with a grey, greenish grey or at times yellow, dark grey or bluish grey colour often containing vegetal fragments, or greenish grey lenses originating from the decomposition of vegetal elements and colonies of gastropods. These layers appear to have formed due to slow accumulation in marshy environments following cancellation of the early Imperial Age channelling works and, therefore, may be related to the development of marshes following the lack of maintenance of the Roman channelling system and possibly associated with the Late Roman /early-medieval period. The only two exceptions are the presence of an early-medieval necropolis composed of 30 burials highly damaged by ploughing¹¹⁵, whose superficiality may be evidence of a slight elevation, levelled following intense post-medieval agricultural use, and of an agricultural soil dating back (C¹⁴) to the VII century, slightly to the north, between via di Bagnile and via Mafalda di Savoia¹¹⁶. 25 finds out of 30 (83%) are included in the area with medium flooding potential and in the area indicated as marshy from the geomorphological analysis. The only exceptions are the MAPPA 4 core which identified a marshy area to the northeast of the city dating back to at least the IV-VI century (ALLEVATO *et alii* 2013) and finds referring to the cores at San Michele in Borgo¹¹⁷, Santa Cecilia¹¹⁸,

¹⁰⁷ ANICHINI 2006, CAMPUS A. 2012, *Intervention record no. 490*, in MappaGIS.

¹⁰⁸ SCIUTO C. 2012, *Intervention record nos. 696, 697, 699, 804*, in MappaGIS.

¹⁰⁹ Stratigraphic analysis of an exposed section following non-supervised earthworks and of a shovel test TARANTINO G. 2012, *Intervention record no. 240*, in MappaGIS.

¹¹⁰ Cleaning of the sections identified some *Sgraffito* ware sherds, which were considered in a wrong stratigraphical position (TARANTINO G. 2012, *Intervention record no. 7*, in MappaGIS).

¹¹¹ CAMPUS A. 2012, *Intervention record no. 141*, in MappaGIS.

¹¹² TARANTINO G. 2012, *Intervention record no. 802*, in MappaGIS.

¹¹³ CAMPUS A. 2012, *Intervention record no. 451*, in MappaGIS.

¹¹⁴ LA ROSA L. 2012, *Intervention record nos. 50, 51, 189, 192, 193, 194, 262* in MappaGIS.

¹¹⁵ The necropolis was identified at a height of -0.70 m from the current campaign level, LA ROSA L. 2012, *Intervention record no. 196*, in MappaGIS.

¹¹⁶ LA ROSA L. 2012, *Intervention record no. 889*, in MappaGIS; AMOROSI *et alii* 2012:192.

¹¹⁷ CAMPUS A. 2012, *Intervention record no. 828*, in MappaGIS.

¹¹⁸ TARANTINO G.. 2012, *Intervention record nos. 512, 513*, in MappaGIS.

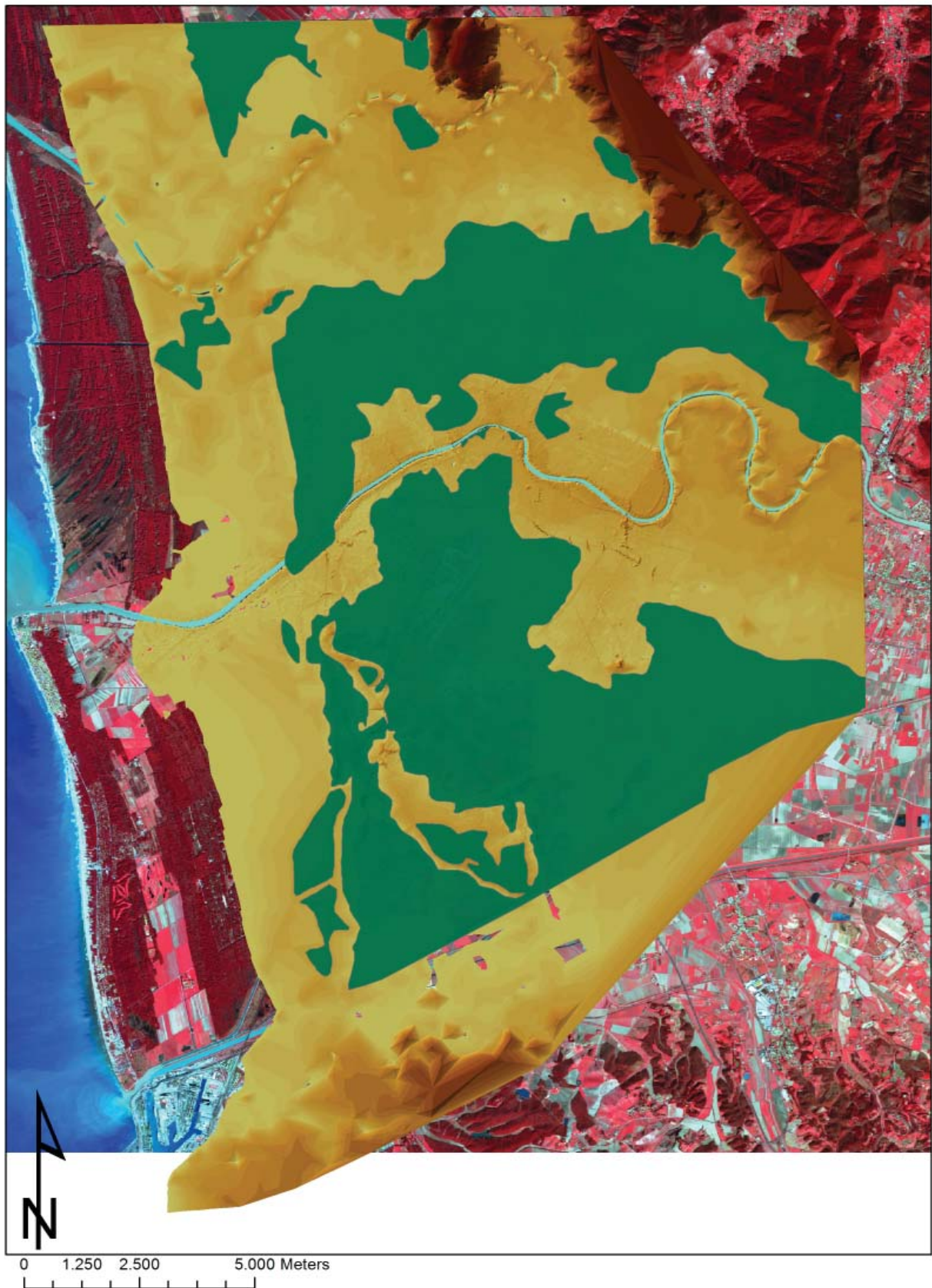


Fig. 2.23 Probable extent of marshy areas during the Early Middle Ages, as resulting from the predictive models.



Fig. 2.24 Probable extent of marshy areas during the Late Middle Ages, as resulting from the predictive models.

and the excavation at the former Marzotto textile factory¹¹⁹, probably related to the fluvial dynamics of the urban area (see § 3.1), demonstrating the significant validity of the model of flooding areas obtained and of palaeogeographical map; 22 finds out of 29 (75%) fall within the depressed areas of the ANUDEM algorithm (*TopotoRaster*) interpolation, although 3 are at a distance ranging between 30 and 50 metres from the depressed areas, which can be easily explained by the difficulties related to exact georeferencing of the interventions. Comparison of all the data shown appears to confirm the starting assumption: areas with medium flooding potential immediately north of Pisa city centre were actually marshy during the Middle Ages; it is legitimate to suppose, therefore, save for any further checks, that the areas identified as having high and medium flooding potential were indeed marshy during the Early Middle Ages. The procedure used to highlight the areas potentially subject to flooding is extremely effective on a large scale, when the need for in-depth details is not so strong. The model created with the *TopotoRaster* identifies the depressed areas, but does not take into consideration geomorphology, subsurface data and toponymy, although providing evidence – at least at macroscopic level – of the evolution between Early and Late Middle Ages, with the shrinking of the marshy areas, and in my opinion, provides a good idea of the seasonal development of wetlands that characterised the plain. A digital elevation model, therefore, is not sufficient on its own to understand the phenomenon and cannot be applied on a large scale.

After highlighting the substantial validity of the predictive model and the need to operate with

different analysis steps in an integrated manner, a historical reading will now be provided. Overall (figs. 2.23 and 2.24), the comparative analysis of archaeological and geomorphological data and of predictive model reveals, starting from the VI century A.D., on the one hand an increase in alluvial events (CAMILLI 2004a: 71; PARIBENI *et alii* 2006:213; ARNOLDUS-HUYZENDVELD 2007:60) and, on the other, the abandonment of centuriation agricultural patterns and so the lack of maintenance on channelling works (ANICHINI 2004-2005; ANICHINI 2006; BONAMICI 1988; CAMILLI 2004a: 59). These events led to the development of marshes in large areas previously drained by widespread Roman works, as apparently suggested by the increase in hydro-hygrophilous species (Acquatics) found between the IV and VI century in the pollen analysis of the MAPPA 4 core (ALLEVATO *et alii* 2013). The extension of these wetlands, whose surface changed over time, reached its peak during the Early Middle Ages and then decreased during the middle centuries of the Middle Ages, when part of these areas were reclaimed. It is yet to be confirmed whether the trend was reversed during the XV century due to hydrogeological instability, connected to the deforestation of the middle centuries of the Middle Ages and to the abandonment (following the Florentine conquest of 1406) of the maintenance of the many channelling works that the *Comune* had greatly attended to, as suggested by CECCARELLI LEMUT *et alii* 1994: 416. The wetlands that influenced the city more directly were the *Palude Pisana* (Pisan marsh), also known as the *Paludozzeri* (*Auser* marsh), which also involved the urban area¹²⁰, and the neighbouring area of *Silva Tumulus* to the west, where the waters from the *Auser/Serchio* basin were not able to flow towards the sea due to the hanging river bed of the Arno River at Barbaricina, and to the

¹¹⁹ CAMPUS A. 2012, *Intervention record no. 224*, in MappaGIS.

¹²⁰ See § 3.1.

Marsh of Asciano/Agnano to the east, which all together formed a semi-circle to the north of the city, also including, in my opinion, the area of Pratale, not identified in the GIS analysis, but evidenced by geomorphological analysis¹²¹ (BINI *et alii* 2013). Some wetland areas are to be related to the fluvial courses, such as the Caldaccoli wetland, to the northeast, along the foot of the Monti Pisani, connected to the course of the *Auser*, the Arena¹²² wetland close to the *Auserclus* and the *Tubra* rivers, and to the northwest, the Marmo wetland at the mouth of the *Auser* and the *Auserclus* rivers. Large marshy areas, in the northern section of the area taken into consideration, represented the most southern offshoots of Lake Massaciuccoli. The area to the south of the city, instead, was characterised by the marshes of Stagno and Coltano, which although further from the city centre, must have often reached the city borders as attested by XIV century documents¹²³. The extremely variable size of these areas is connected, in addition to anthropic interventions, to seasonality, influenced by the little difference in height of the lowlands which favoured the formation of wetland areas related to greater rainfall, to the rise of the water table and to fluvial flooding, as already highlighted in the already mentioned 1183 document which describes a wetland at Il Marmo as a marshy area during winter, yet dry during summer. Basically, starting from the VI century and throughout the Early Middle Ages,

there is great difference between the northern sector – associated with the less stable basin of the *Auser*/Serchio and subject to large wetlands caused by an inefficient natural drainage system due to both natural and anthropic reasons – and the southern sector subject to naturally well-channelled flows and associated with the Arno River (BINI *et alii* 2013). The presence of wetlands and stagnant water probably led to critical health situations, although the archaeological sources do not report data related to the presence of malaria¹²⁴; the demonstration of frequent cases of fever, mentioned in hagiographic sources could be related to a potentially malarial environment (FORNACIARI, SORIANI INNOCENTI 2011).

Extensive reclamation was mainly dictated by the need to manage the landscape related with the occupation of urban development areas and agricultural¹²⁵ or pasture lands, and the maintenance of waterways. If, on the one hand, rivers were embanked and meanders were cut, on the other, the main reclamation works developed a complex network of trenches and canals which, starting from XI century, involved the main marshy areas neighbouring the city. To the north of the Serchio, the Vecchiano and Malaventre area was influenced by the canal of Navariccia, the Magna (Great) trench, the trench of Montione and the Nuova (New) trench¹²⁶, whereas further west ran the Barra di Vecchiano (Canal of Vecchiano) which drained the water of Vecchiano into Lake

¹²¹ And also highlighted in COSCI 2005 photointerpretation.

¹²² Identified by GIS analysis as an area with low flooding potential. The second also coincides with the toponym Salceta present in XIX century land registers.

¹²³ A core carried out at San Giusto in Cannicci (SCIUTO C. 2012, *Intervention record no. 669*, in MappaGIS) showed the presence of a marshy area generically previous to the contemporary age. For this reason it was not considered in the previous considerations.

¹²⁴ There are no certain data on malaria in the Pisa plain during the Middle Ages; COLUCCI 1976: 106 excludes the presence of mosquitoes “belonging to the anopheles and antropophile species” given that the area of Pisa and Lucca is the area “where anophelism without malaria was discovered”.

¹²⁵ As occurred at the end of the XII century for the wetlands at Il Marmo and the mouth of the *Auser* River, which – once reclaimed – were used for the cultivation of cereal crops and called *terra da Sigalare* (CECCARELLI LEMUT *et alii* 1994: 409).

¹²⁶ CECCARELLI LEMUT *et alii* 1994: 416-7.

Massaciuccoli and the Bovario (Ox) trench¹²⁷. The area of the *Palude pisana* (Pisa marsh) was drained by the Cuccia trench¹²⁸, *Caballaria* (Horsey) trench¹²⁹ and Salaria (Salt) trench¹³⁰, which flowed towards east-west between the Arno and the Serchio, dividing the *Tumulus Pisanus* into two, by the Nuova trench which ran from the *Auser* River towards Sterpaia¹³¹, by the trench of Barbaricina¹³², by the *Docaria* trench, also called *Cula*¹³³, which flowed to the northwest of the city, and by the urban trenches such as the *de Flumine* (of river) trench¹³⁴. Trenches and canals also crossed Valdozzerri: the trench of San Jacopo drained the waters of the area south of the Serchio, and maybe the *Riparia*¹³⁵ trench was connected to it, which probably drained the marshy area of Caldaccoli, roughly following the course of today's Doppio (Double) trench, the *Angullaria*¹³⁶ trench, the *de flumine* trench or *de fluminis Auseris*¹³⁷ canal and the *Iuliana*¹³⁸ trench, whilst in 1156 the canals between Monti Pisani and San Zeno were developed for transporting materials needed to build the city walls¹³⁹. The sector to the east of the city, between the *Auser* and Arno rivers, was reclaimed by building the Vicinaia trench, which drained the marsh of Asciano flowing into the *Auser*¹⁴⁰ River and the trench of Maltraverso, which united the extremities of the bend drawn by the *Auser* to reach the walls of Pisa¹⁴¹. The area to the south of the Arno was crossed by a series of trenches which roughly extended towards the northeast/southwest, such as the Caligi¹⁴² or Fasciano trench, mentioned from 1162, which connected the Arno River to Stagno, the Noverchia¹⁴³ trench known

¹²⁷ In 1136, Magna trench, trench of Montione, Nuova trench and the sea delimited the area of Selva Palatina belonging to the church of San Niccolò di Palatino; the Bovario trench is mentioned in the territory of Malaventre from 1190 and a Bovario Vecchio trench (ancient defunctionalised course?) is mentioned in 1244 (CECCARELLI LEMUT *et alii* 1994: 416-7; REDI 1988: 166). The courses of these trenches may be seen in the traces of the north-south oriented palaeo traces to the south of Lake Massaciuccoli (Bini *et alii* 2012a: 146).

¹²⁸ Known since 1031 (CECCARELLI LEMUT *et alii* 1994: 417-8); its course, partially corrected, can still be seen in the modern Cuccia trench.

¹²⁹ Known since 1147 (CECCARELLI LEMUT *et alii* 1994: 417-8), legible today in the Cavalle trench which cuts in an east/west direction the area of Campaldo to the northwest of the city; the trench, however is identified as Dritta trench in the Leopoldino land register.

¹³⁰ Known since 1084 (CECCARELLI LEMUT *et alii* 1994: 417-8), maybe legible in the course of the current Grande trench.

¹³¹ Known since 1156 (CECCARELLI LEMUT *et alii* 1994: 417-8); maybe legible in the final section of today's Fiumicello trench, identified in the Lepoldino land registers as Fimmenello trench.

¹³² Known since 1129 (CECCARELLI LEMUT *et alii* 1994: 417-8); maybe identifiable in the final section of the del Tedaldo trench and in the Scolo del Tedaldo present in XIX century land registries.

¹³³ Known since 1139 (CECCARELLI LEMUT *et alii* 1994: 417-8).

¹³⁴ See § 3.1.

¹³⁵ The *Riparia* trench is mentioned in the XIV century to the south of Caldaccoli (CECCARELLI LEMUT *et alii* 1994: 418-9). The toponym Riparia trench can still be seen on maps today to the southwest of Caldaccoli and is crossed by Doppio trench, which also runs near the toponym San Jacopo and flows into Fiumicello trench.

¹³⁶ Mentioned at the start of the XIV century at Gello (CECCARELLI LEMUT *et alii* 1994: 418-9). Fosso dell' Anguillara is located today between the Palazzetto and La Sterpaia.

¹³⁷ Mentioned in Gello since 1080-1, in Bottano since 1136 and in Campolungo since 1190 (CECCARELLI LEMUT *et alii* 1994: 418-9).

¹³⁸ Mentioned in Macadio since 1140 (CECCARELLI LEMUT *et alii* 1994: 418-9).

¹³⁹ The *Breve* of 1287 also envisaged the excavation of a trench along the *Auser* River from Manno hospital (at Macadio?) to the *tegrarie* situated to the northeast of the city (CECCARELLI LEMUT *et alii* 1994: 418-9).

¹⁴⁰ The Vicinaia trench was extended or corrected at the start of the XIII century. Its course is still partially legible in current Vicinaia trench and was modified during the XVI century when, following the excavation of the Ripafretta canal (current Canale Demaniale), the Vicinaia trench passed under the canal, together with the Maltraverso trench, for which a new bed was excavated up to via delle Prata, running to the sea through the trench of Scorno and the Morto River (CECCARELLI LEMUT *et alii* 1994: 419).

¹⁴¹ Identifiable in the trench of Maltraversino.

¹⁴² Still partially legible in current trench of Caligi.

¹⁴³ Probably identifiable in current trench of Oratorio (REDI 1986: 200).

since 1191, the Torale¹⁴⁴ trench reported since 1158, the Docaja¹⁴⁵ trench, the Nugolaio¹⁴⁶ trench, the Solaiola trench and the Nuova¹⁴⁷ trench and by the Rinonico trench perpendicular to the previous which ran between Rinonico and Ospedaletto¹⁴⁸.

2.3. Moving people, moving goods

The landscape we have described – characterised by a complex and shifting fluvial system and by a large amount of depressed areas subject to becoming marshy – conditioned the movement of people and goods during the entire medieval period, both by road and water. Viability and especially mobility are issues that Italian medieval archaeology is starting to address very late (CITTER 2012: 79) and which it should deal with through national or Mediterranean projects, such as those developed for the Roman Ages¹⁴⁹. In the case of Pisa, we shall only address issues regarding mobility in the area between Livorno and Lake Massaciuccoli, leaving a wide-scale investigation to other occasions.

2.3.1. Road networks

Only the main road networks were taken into consideration, according to the definition of Tiziano Mannoni as “roads of transit uniting two important centres, one of which, or both, are included in the territory itself” (MANNONI 1983), and therefore: the *strata de Arbaula*, the *podium Vallis Serchii*, the *strata Vallis Ausuris* to the north of Pisa, the *via silice Portus Pisani* and the *strata Vallis Arni* to the south of the city. Minor or secondary road networks were not analysed¹⁵⁰. The data available derive mainly from studies on archive sources and toponymy, consisting mainly of documents subsequent to the XII century¹⁵¹. An overall archaeological study is instead missing on the medieval road network in the Pisa area. For this reason, I decided to verify the data using cost surface analysis¹⁵². This type of analysis allows us to calculate the cost of energy needed for an individual to move between two points and, therefore, not only to “evaluate the

¹⁴⁴ Present in the Leopoldino land register maps and identifiable in current trench of Zambriggiana.

¹⁴⁵ Present in the Leopoldino land register maps and partially identifiable in current trench of San Lorenzo.

¹⁴⁶ Still partially recognisable in current Nugolaio trench.

¹⁴⁷ REDI 1986: 201.

¹⁴⁸ Its course is still partially legible in the course of the current Vecchio (Old) trench. According to CECCARELLI LEMUT *et alii* 1994: 421 the Rinonico trench should be identified with the Guerra (War) trench built to defend Pisa during the war with the Lega Guelfa in 1275-76; on the contrary, according to REDI 1986 the two trenches do not coincide and the Guerra trench’s course is similar to the current course of the spillway channel. Again REDI 1986: 201 identifies in today’s Titignano and Ceria trenches the traces of the *Nugolarie* or *Nucularie* trenches and suggests a coincidence between current Sant’Ermete trench and the trench mentioned during the XIV century between Orticia and La Vettola.

¹⁴⁹ <http://orbis.stanford.edu/>

¹⁵⁰ A secondary road network, according to Mannoni’s classification, includes “roads connecting minor centres inside the territory or between them and main ways of transit” and “service roads that unite the major or minor centres with scattered settlements, or agricultural lands” (MANNONI 1983).

¹⁵¹ The already scarce early-medieval written sources provide very little information about road networks, apart from reference to a *de Lignaria* bridge over the Serchio in *Lintablo*, probably to the northeast of Vecchiano (DADA 2006: 73; REDI 1990: 298-300) and the toponym *Via Pisana*, at Pappiana mentioned in 975 (CECCARELLI LEMUT 2005: 386). Experts point out how the terms *strata* and *silice*, both related to the presence of stone paving, *podium*, indicating a raised path and *via antiqua* are attributed during the Middle Ages to Roman roads, whilst the term *carraricia* appears to be ambiguously used and *via vecchia* simply identifies an old trail (CECCARELLI LEMUT 2005: 375; GARZELLA 1990: 3 ss; FABIANI 2006: 63); the survival of paths during the Late Middle Ages which date back to the classical age leads us to assume a certain continuity of use of these paths during the Early Middle Ages.

¹⁵² For a general analysis on the problems regarding the use of cost surface analysis, see WHEATLEY, GILLINGS 2002: 151 ss; FORTE 2002: 108 ss. It is worth remembering that this is not an accurate system but a predictive model. For this reason, the path does not necessarily run in the point indicated by the GIS, but rather that the results obtained may lead to new elements allowing considerations on this issue. This analysis method has been used with interesting results in north-western France (VERMEULEN *et alii* 2001), more recently in the area of Grosseto, in relation to the Roman road network (CIANCURLO, GHERDEVICH 2007), in the area of Fiuli with a multi-period application field (GHERDEVICH 2008) and in certain areas of medieval Tuscany (CITTER 2012).

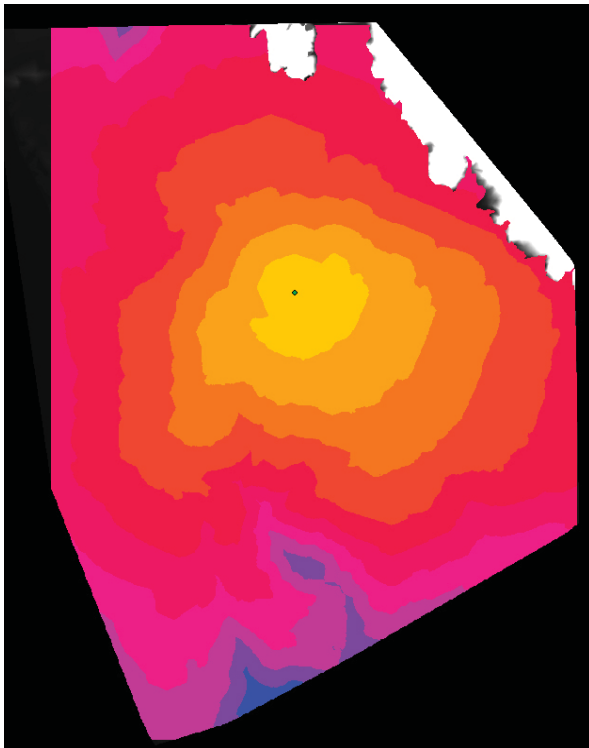


Fig. 2.25 The buffer zones indicating the different path costs from Pisa (central point) towards the surrounding territory. Costs increase as the distance increases.

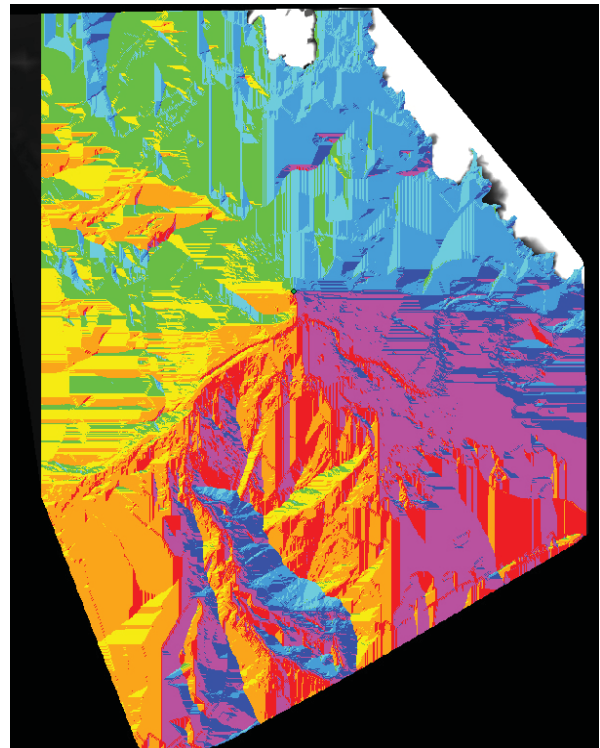


Fig. 2.26 Cost direction calculated from Pisa towards the surrounding territory.

journey but to rebuild the roads and routes of a landscape" (FORTE 2002: 109). The evaluations I propose were carried out from the DEM of the medieval landscape with an accuracy of 10 metres, from which three variables were extracted which may have influenced the creation of the road network. Slope: the excessive increase in slope makes the construction of a route less desirable, making it better to choose flatter land. Elevation: in general, excessive elevation influences the cost of a journey; furthermore, travelling at lower altitudes guarantees better climatic conditions especially during certain periods of the year. Areas potentially subject to flooding: these areas can pose challenging obstacles, also in economic terms. Rivers (and consequently bridges)

were not taken into consideration, due to their extremely variable courses and, as already seen, to the difficulty in providing chronological details¹⁵³, although we are aware of how much they affected travelling conditions¹⁵⁴. Slope was obtained by applying the *Slope function* (*Spatial Analyst*→*Surface Analysis*→*Slope*) with an output measurement in degrees and then reclassified (*Spatial Analyst*→*Reclassify*) into 120 classes. An influence equal to half of the slope was assigned to elevation: in this case the DEM was reclassified by dividing it into 60 classes, assigning a higher value (and so a higher cost) to the higher elevations. The same value was assigned to areas potentially subject to flooding obtained by reclassifying the **proball_calc5.grid**¹⁵⁵ file into 60 classes and

¹⁵³ Except for the last section of the Arno between Pisa and the sea which can be well reconstructed and is essential to understand the road to Porto Pisano.

¹⁵⁴ For the analysis of the costs of the fluvial courses and of the value attributable to bridges, see CIANCURLO, GHERDEVICH 2007: 226.

assigning a higher value to the areas with greater probability of flooding. Thus, the lower areas, therefore more subject to flooding, balance the value of the higher areas. These variables were summed using the *Raster Calculator (Spatial Analyst→ Raster Calculator)*, thus obtaining the cost model that was used when analysing the routes. On the basis of the point shapefile of the place of departure for every single road path, the weighted cost (*Spatial Analyst→Distance→Weighted Cost*) was calculated on a case-by-case basis, including cost direction, which indicates the costs as a consequence of direction. The buffer zones (fig. 2.25) indicate the different path costs from the point of departure towards the surrounding territory. Finally, on the basis of the weighted cost and cost direction (fig.2.26) the shortest path (*Spatial Analyst→Distance→Shortest Path*) was calculated with the point of arrival. Data processing produces a polyline shapefile which shows (based on the data entered) where the algorithm indicates that the costs for crossing the area or building a road are lower. It is evident, therefore, how this kind of analysis is well connected to the concepts of mobility, rather than road networks.

2.3.1.1 The *strata de Arbaula*

This route, named so in the *Breve* of 1302, is only found in late written documentation. According to CECCARELLI LEMUT 2005: 375 it departed from the Leone gate, continued along the route of today's via Pietrasantina and headed towards Viareggio, crossing the Serchio River at the Albavola bridge, where in the XIII century a hospital was situated; then it continued along a route that coincided more or less with today's via Aurelia, passing through the church of San Niccolò di Palatino, already known in the XI century (RENZI RIZZO *et*

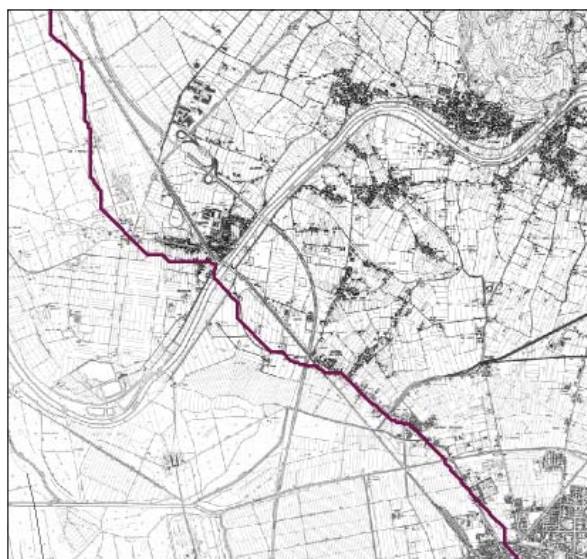


Fig. 2.27 The probable route of the *strata de Arbaula* calculated using the shortest path and shown on current maps.

alii 1988). It is not clear which period this route belongs to. According to DADA 2006: 78 it could date back to the XII century, when the *Comune* of Pisa newly built (or most probably repaired) a road that at least partially retraced the route of the ancient *Aurelia/Aemilia Scauri* connecting to the port of Motrone, which it had owned since 1170. The route identified through spatial analysis¹⁵⁶ (fig. 2.27) retraces the route of today's via Pietrasantina up to La Bucaccia, then it deviates to the west with a curvilinear pattern, along the Strada Maestra of Pietrasanta described in the Leopoldino land register, running along the left bank of the palaeo-trace of the bend of Albavola and then reaching the centre of Migliarino. It is in this area that the path passed over Albavola bridge (attested in 1230) to the right bank of the Serchio River (CECCARELLI LEMUT *et alii* 1994: 411). The bridge probably rose slightly to the west of the current bridge of Migliarino. Today, the area is still called La Barca (The Boat)¹⁵⁷, indicating

¹⁵⁵ See § 2.2.3.

¹⁵⁶ Spatial analysis was carried out in two phases: firstly by calculating the overall route between the Leone gate and San Niccolò di Palatino, and then – based on the reading of this route – by entering the point where the Serchio River probably crossed and by recalculating the overall route along these two paths.



Fig. 2.28 Modification of the route of the *strata de Arbaula* during the Late Middle Ages (in brown), due to the variation of the course of the *Auserclus* River. The possible early-medieval river courses are indicated in dark blue, the late-medieval courses in blue. The two shades of green refer to the probable size of the marshy areas during the Early (lighter) and Late (darker) Middle Ages.

a landing place or more generically a crossing. In fact, if we position an intermediate point of arrival in this area and recalculate the route from this point to the final point, it is possible to see how the path passed through Migliarino roughly following the XIX century route of the Strada Maestra of Pietrasanta, more to the west than the current SP10 Vecchianese road, and then deviated straight to the north towards the church of San Niccolò di Palatino, running along the Malaventre marsh and aiming at the castle of Viareggio, with a more eastern route compared to the current route of the SS 1 Aurelia road. If we overlap the cost surface analysis data with the hypothetical fluvial courses (fig. 2.28) it is possible to assume that the route was changed during the middle centuries of the Middle Ages (in brown), which ran to the west of the bend of Albavola¹⁵⁸, with respect to a more ancient and linear route (in grey), probably modified due to the environmental changes that occurred during the Early Middle Ages, thus confirming the assumption that a pre-existing, but partially abandoned coastal route, was repaired.

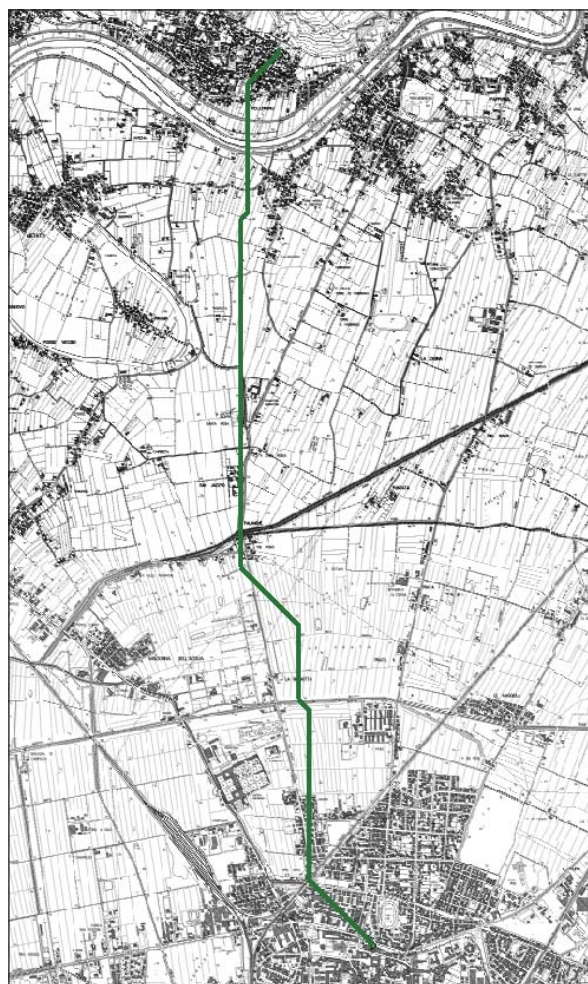


Fig. 2.29 The probable route of the early-medieval *Podium Vallis Serchi* calculated using the shortest path and shown on current maps.

2.3.1.2 The *podium Vallis Serchii*

The road that connected Pisa to Massaciuccoli, Massarosa, Pietrasanta e then Luni is indicated in the consular *brevia* of 1162 and 1164 with the name of *podium Vallis Serchii*. According to the majority of experts¹⁵⁹, this road coincided with *via Aemilia Scauri*, the path running at the foot of the hills between Pisa and Luni; the term *podium* would confirm this idea. Medieval documentation (CECCARELLI LEMUT *et alii* 1994: 411; CECCARELLI LEMUT 2005: 376) shows, from the XII century, the presence along this road of the monastery of San Jacopo, called *de Podio* and built around

1188, of a *podium Pisanum*, in *Sanguineto* near Arena, in 1190, of a bridge over the Serchio River in *Rosaiolo*, located in the area of the church of San Michele of Vecchializia, subsequently Pontasserchio, in 1168¹⁶⁰, and of a *via pubblica de podio* in *Ramo* (Vecchiano) in 1187. To this later route CECCARELLI LEMUT 2005: 389 opposes, on toponymic grounds, a more ancient path, more clearly north-south oriented which crossed the Serchio River near Carraia, where the toponym

¹⁵⁷ Existing on I.G.M. 1:25.000 mapping.

¹⁵⁸ According to a road path that can be found in XIX century land registry maps and still legible in the C.T.R.

¹⁵⁹ For a detailed analysis of the extensive bibliography, see FABIANI 2006: 63.

¹⁶⁰ The first attestation of the bridge associated with the toponym *Rosaiolo* dates back to 1183 (CECCARELLI LEMUT 2005: 376).

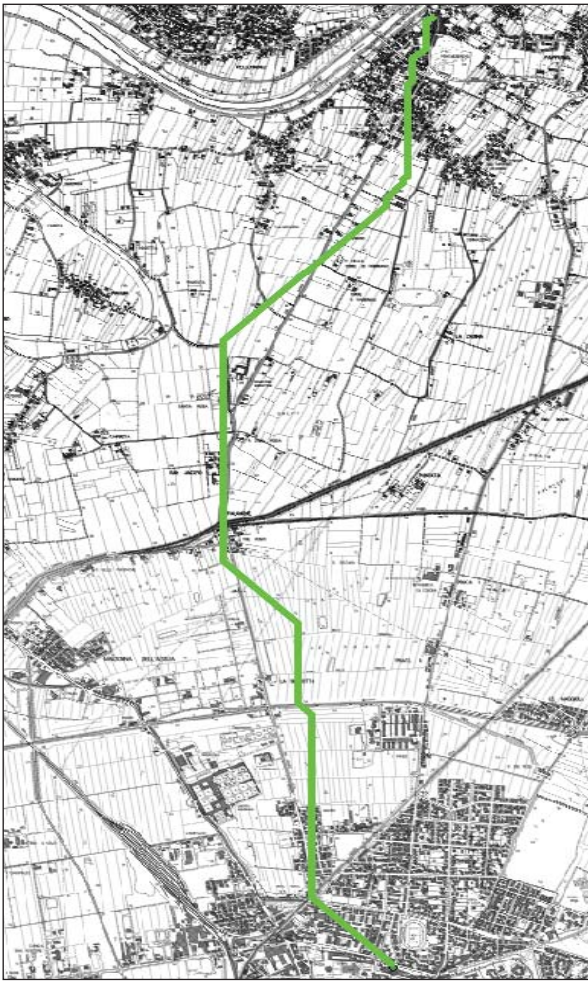


Fig. 2.30 The probable route of the late medieval *Podium Vallis Serchi* calculated using the shortest path and shown on current maps.

clearly indicates a cartroad. Spatial analysis was carried out taking into consideration both routes: the end point of the most ancient was Vecchiano, the most recent Pontasserchio. The gate of Santo Stefano was taken as point of departure for both courses. The processed routes show (figs. 2.29 and 2.30) that they initially coincided with *via di San Jacopo*, that is, a linear route with north-south orientation passing through the Monastery of San Jacopo. In the first

case, the route continues north towards Vecchiano in a linear direction, passing close to Arena, the ancient *Carraia*; in the second case, instead, it bends northwest, roughly following the route of the current SP9 provincial road of San Jacopo, and continues towards Pontasserchio where it crosses the river running more to the south than today. In the light of archaeological data, the first section of the route appears to be extremely interesting. It is oriented towards southeast/northwest until joining the route of current *via di San Jacopo* and almost perfectly coincides with the road network section identified during the excavation in *via Galluppi*¹⁶¹ and dated between the end of the II and mid-III century A.D.. It is also probable that the initial section of the medieval route was different: a path leading north and leaving the Leone gate probably replaced it or ran alongside it. The use of cost surface analysis overlapped on assumed fluvial courses seems to confirm the hypothesis of two different routes (fig. 2.31). The first (in grey), which crosses the river in *Carraia*¹⁶², could relate to the Roman Age, subsequently deviated (in brown) following the transformation of the landscape between the Late Roman period and the Early Middle Ages.

2.3.1.3 The *strata Vallis Auseris*

With the term *strata Vallis Auseris*, the *Breve* of 1287¹⁶³ defined the Pisan stretch of the route to Lucca, which left the Parlascio gate and entered the *Auser* valley. Written sources (CECCARELLI LEMUT *et alii* 1994: 411; CECCARELLI LEMUT 2005: 385) mention a *strada* at the Manno Hospital in 1160 and in the area of Macadio¹⁶⁴ in 1163, a *via Pisana* at Borgonuovo¹⁶⁵ in 1258, a bridge in Bottano in

¹⁶¹ TARANTINO G. 2012, *Intervention record no. 724*, in MappaGIS.

¹⁶² Positioned on the left of the course of the bend of Fabbriano and passing through modern Palazzaccio.

¹⁶³ Mentioned as *podium* in the *Breve* of 1302 (CECCARELLI LEMUT 2005: 385).

¹⁶⁴ "The name of a district in the northern suburb of Pisa between the trench of Maltraverso and the left bank of the Serchio" (REPETTI 1833-46: III, 5).

¹⁶⁵ Borgonuovo corresponds to current Cascine di Gello (REDI 1984: 373).



Fig. 2.31 Modification of the route of the *podium Vallis Serchi* during the Late Middle Ages (in brown) due to the variation of the course of the *Auserclus* River. The early-medieval river courses are shown in dark blue, the late-medieval courses in blue. The two shades of green refer to the probable size of the marshy areas during the Early (lighter) and Late (darker) Middle Ages.

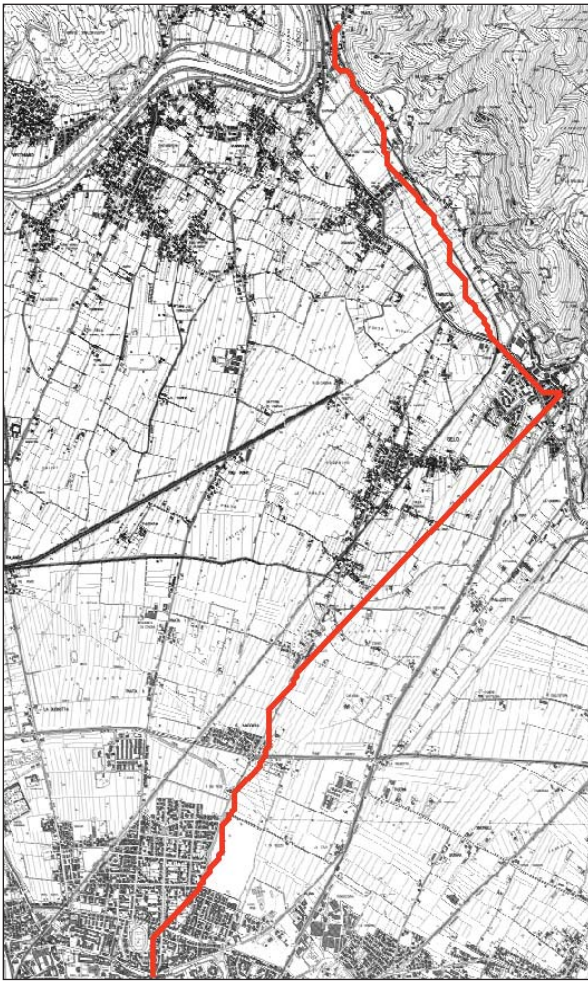


Fig. 2.32 The probable route of the *strata Vallis Auseris* calculated using the shortest path and shown on current maps.

1302 and one in San Giuliano in 1287. According to CECCARELLI LEMUT 2005: 385 at the *Balneum s. Iuliani*, modern San Giuliano Terme, the *strata Vallis Auseris*, encountered the *strata de Musileis* of eastern provenance along the foot of the hills, since a deed of 1070 locates *Musilei* at Asciano and mentions a *loco Monte Pisano qui vocatur Valle prope Mosileo*. TOLAINI 1992: 48, REDI 1990: 295 and DADA 2006: 79 are of a different opinion since they

identify this *strata* with the *strata Vallis Auseris*, concluding that the term *Musilei* derives from the ruins of the Caldacoli aqueduct. Although it may seem difficult to attribute this road toponym to a road at the foot of the hills at Asciano, this is less so for the existence of the road itself which is highly probable. After reaching San Giuliano, the path continued towards Lucca passing through Rigoli where it is mentioned in 1233, through *Lupino*, near Quosa, in 1194 and in the area of Pappiana already in 975. Spatial analysis was carried out by dividing the path into two parts: a first stretch between the Parlascio gate and San Giuliano Terme, and a second section between the latter location and Rigoli¹⁶⁶. The route suggested by GIS processing (fig. 2.32) almost perfectly coincides, especially when leaving Pisa, with current via di Gello, then it crosses the area of Cascine di Gello and continues in a straight line towards San Giuliano, to the right of the Auser River. The presence of a bridge at Bottano must refer to a bridge over the Maltraverso trench; attestation of the bridge dates back to the start of the XIV century, when the trench already existed. Furthermore, the toponym Bottano is indicated in the Leopoldino land register to the east of the current toponym Le Maggiola, in correspondence of the Maltraverso trench, today Morto River¹⁶⁷. Before the *Auser's* transformation into a secondary watercourse which occurred during the XIII century, therefore, the *strata Vallis Auseris* ran along the *Auser* River, to the right, crossing it only near San Giuliano. Then it continued along the foot of the hills to the left of the *Auser* River until reaching Rigoli, roughly coinciding with the current SS 12 road of the Abetone and Brennero, the former Strada Regia Lucchese¹⁶⁸, and after passing the strait of

¹⁶⁶ Similar processing was carried out in CITIER 2012:87 between Pisa and Avane. It shows a similar route that, however, does not cross San Giuliano.

¹⁶⁷ ASP, Land Registry of the Community of the Bagni di San Giuliano, Map 3, section B, San Jacopo <http://web.rete.toscana.it/castoreapp/>

¹⁶⁸ ASP, Land Registry of the Community of the Bagni di San Giuliano, Map 3, section H, Molina, Rigoli and Corliano <http://web.rete.toscana.it/castoreapp/> .



Fig. 2.33 Modification of the route of the *strata Vallis Auseris* during the Late Middle Ages (in brown) due to the variation of the course of the *Auser* River. The probable early-medieval river courses are shown in dark blue, the late-medieval courses in blue. The two shades of green refer to the probable size of the marshy areas during the Early (lighter) and Late (darker) Middle Ages.

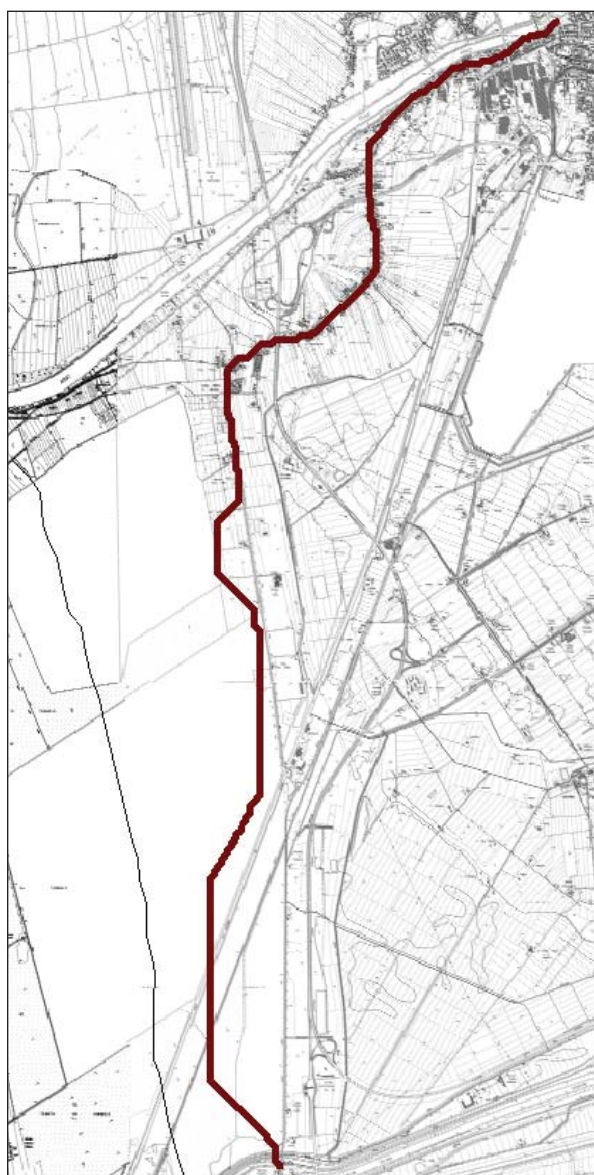


Fig. 2.34 The probable route of the *via Portus Pisani* calculated using the shortest path and shown on current maps

Ripafratta, continued towards Lucca (fig. 2.33). If we compare the cost surface analysis data with the processing carried out on the *Auser* courses during the Early Middle Ages and the middle centuries of the Middle Ages, we can assume, in this case also,

that the road networks changed, moving towards northwest of the medieval road (in brown), compared to the Roman one (in grey).

2.3.1.4 The *via Portus Pisani*

The road that joined Pisa to *Portus Pisanus* is called *strata* or *silice Portus Pisani* in the *Breve Pisani Communis* of 1287; it left Pisa through the Ripa d'Arno gate, reached the church of San Giovanni al Gatano, and continued towards San Piero a Grado, Stagno, Santo Stefano ai Lupi (where it is attested in 1116 as a *Carraia*) and Livorno (CECCARELLI LEMUT 2005: 371). A bridge rose at Stagno¹⁶⁹ along its route and one over the Ugione¹⁷⁰ river. Written sources report continuous paving, gravelling and banking works ordered by the *Comune* and necessary for the maintenance of this fundamental road axis, especially in the stretch between *Portus Pisanus* and San Piero a Grado, which was also protected by a number of soldiers varying from 4 to 8 (DEL CHIARO 1986:210). Spatial analysis was carried out by dividing the route into two: a first stretch from Ripa d'Arno gate to San Piero a Grado and a second stretch between San Piero a Grado and Stagno. The road network proposed by GIS analysis (fig. 2.34) shows a route that roughly coincides with that of *via Livornese*, which flanks the left bank of the Arno and the bend of La Vettola until reaching San Piero a Grado. In the stretch to Stagno the route runs close to the SP 22 del Mare road, the former *Strada Regia Livornese*¹⁷¹, moving away from it in two sections and running more to the west (fig. 2.35).

¹⁶⁹ According to CECCARELLI LEMUT 2005: 371 it was built between 1154 and 1167 since it is not mentioned in the deed of establishment of the San Leonardo Hospital, but was destroyed by a flood in 1167 and rebuilt by 1174 when newly mentioned. It is mentioned once again in the *Brevia* of 1287 and 1302.

¹⁷⁰ Attested from 1154 to the *Breve* of 1287 (CECCARELLI LEMUT 2005: 371).

¹⁷¹ ASP, Land Register of the Community of Pisa, Map 2, section N, San Piero a Grado <http://web.rete.toscana.it/castoreapp/>



Fig. 2.35 The substantial continuity of the probable route of the *via Portus Pisani* between Early and Late Middle Ages. The probable early-medieval river courses are shown in dark blue, the late medieval courses in blue. The two shades of green refer to the probable size of the marshy areas during the Early (lighter) and Late (darker) Middle Ages.

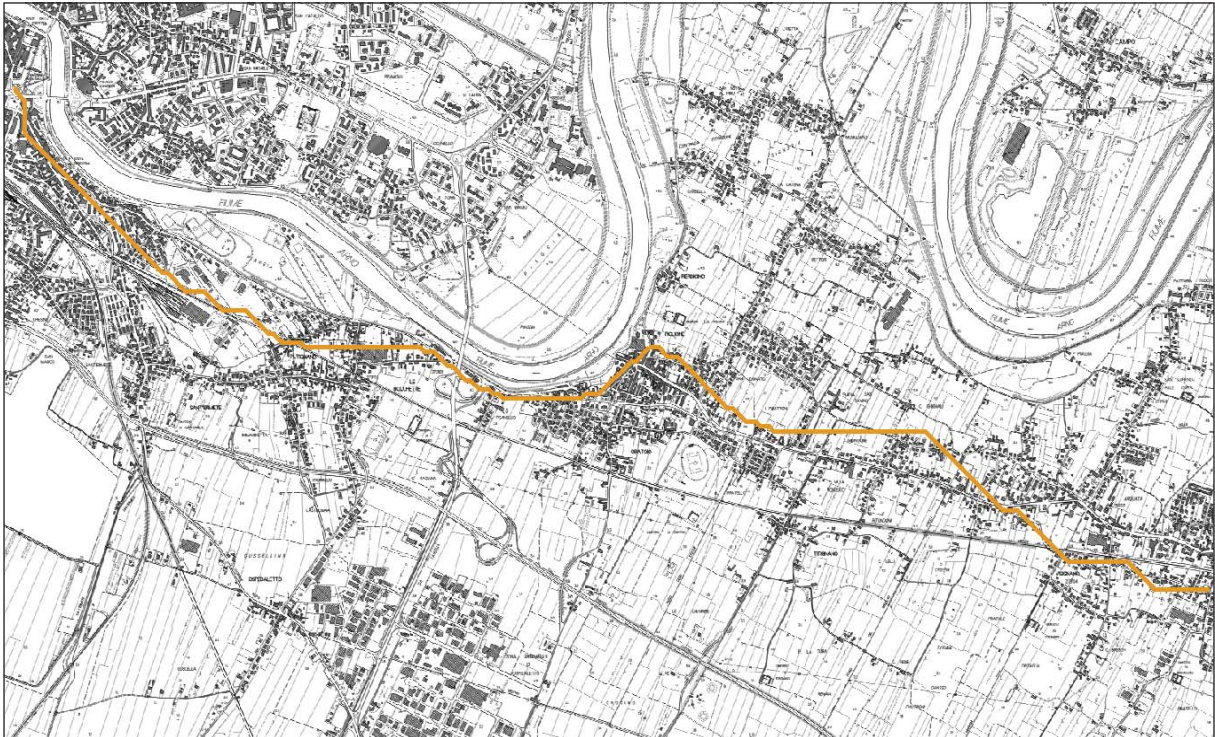


Fig. 2.36 The probable route of the *strata Vallis Arni* calculated using the shortest path and shown on current maps.

2.3.1.5 The *strata Vallis Arni*

The main road connection throughout the Arno valley was guaranteed by the *strata Vallis Arnis*¹⁷². XI-XIII century written sources and the *Brevia* of 1287 and of 1302 allow us to identify the route (CECCARELLI LEMUT 2005: 377; CECCARELLI LEMUT *et alii* 1994: 413): a *via Pisana* is mentioned in 1054 in *Orticaia*; both toponyms *Ad Stradam* in 1186, and the same road in 1169 and in 1186 appear in *Fasciano*¹⁷³; the *strada* is attested in 1137, in *Planicio* (Riglione), the *via publica strada* is mentioned in 1169 at the church of Sant'Ippolito, in *Termine* and *Debbia*; the *strada* is mentioned in 1137 at *Montioni*; the *strada* is mentioned in 1160 in *Montione* and *Petricio* and the *strada publica* between 1171 and 1182; the *silice pisana* or *strada publica communis* is mentioned at San Lorenzo

alle Corti in 1287 and at *Ponte* in 1199, the *strada publica* is mentioned at *Visignano* and presence of *Quarto*, connected to the ancient route¹⁷⁴; a *via antica* is attested at San Pietro a Pagnatico in 1181; the church of San Prospero is located *Ad Stradam* in documents dating back to the end of the XII century and the toponyms *Quinto e Ad Stradam* are mentioned in a 1202 deed at the church of San Michele di Casciavola. The route analysed through cost surface analysis lies between Pisa and the church of San Prospero (fig. 2.36). The route was divided into two segments: the first between San Marco gate and Riglione, the second between Riglione and San Prospero. GIS analysis highlighted a path leaving Pisa and following a route similar to current *via Cattaneo*, running however more to the south of the SS 67 Tosco

¹⁷² Also called *silice* and *via publica* (CECCARELLI LEMUT 2005: 377).

¹⁷³ According to CECCARELLI LEMUT 2005: 377 *Fasciano* was located between *Putignano* and *Riglione*, further attested by the toponym *via Fagiana*.

¹⁷⁴ *Quarto* is mentioned from 1018 and located between *Visignano* and *San Lorenzo a Pagnatico* (GARZELLA 1986:98e110).

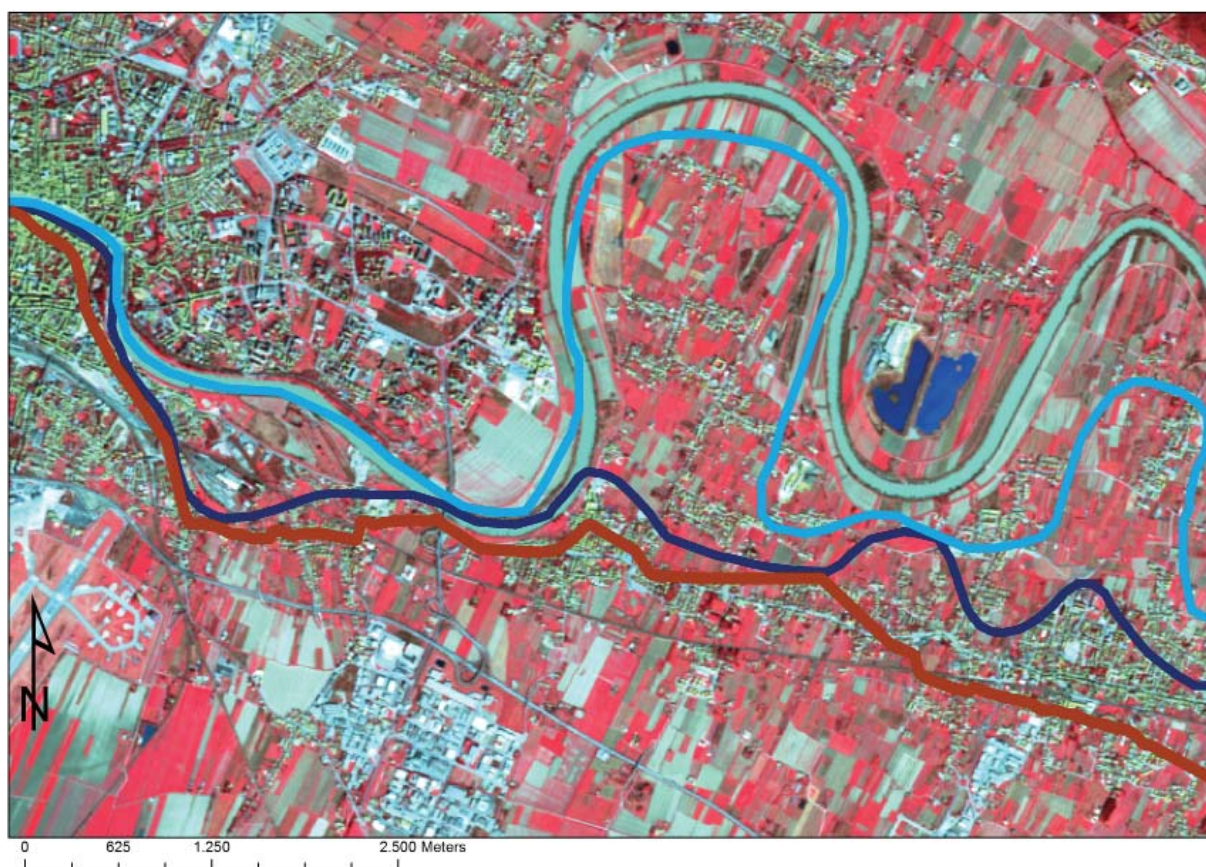


Fig. 2.37 The probable route of the *strata Vallis Arni* (in brown) and the variations of the course of the Arno River. The probable early-medieval river courses are shown in dark blue, the late-medieval courses in blue. The two shades of green refer to the probable size of the marshy areas during the Early (lighter) and Late (darker) Middle Ages.

Romagnola road, as suggested by CECCARELLI LEMUT 2005: 377, touching Putignano, then moving upwards towards *Fasciano*, probably in the current area between Le Bocchette and Pisanello, and running along the left bank of the Arno up to the church of Sant'Ippolito in Riglione. From this point onwards, the route runs alongside the left bank of the bend of San Savino and then continues towards east-west, more to the north of the SS 67 road, crossing the area of Montione and then bending towards south-east, towards Visignano and San Prospero following a path similar to current via Sirio Moggi. This non-linear route appears to be determined by the Arno: the accumulation of fluvial deposits guarantees the necessary stability and raising of

the road. The river and the road are mentioned in the same areas, so we can imagine that these two communication routes ran parallel to connect the inland with the sea (fig. 2.37).

2.3.2 Waterways: ports and landing places

The main mobility system, especially for goods, was guaranteed by waterways, i.e. an infrastructural network with a main hub represented by the *Portus Pisanus* connected to a series of nodes (small ports and fluvial landing places) which guaranteed the management of goods between the hinterland and the sea. This is how Pisa, despite not being a sea city, became a maritime commercial power during the Middle Ages. How did it reach this



Fig. 2.38 The early-medieval coastline, the possible river courses and the location of the early-medieval landing places known are reported on the medieval DEM.

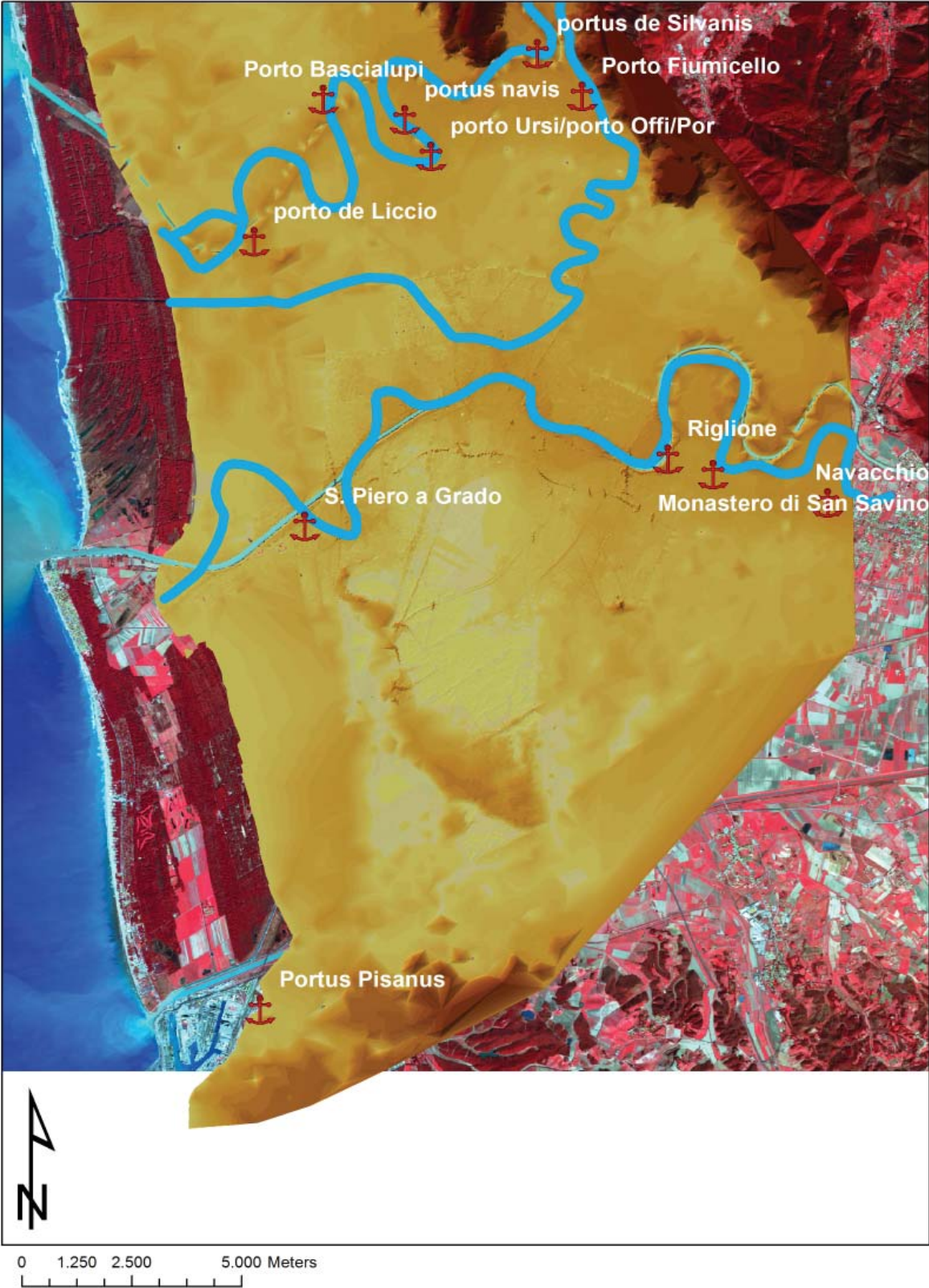


Fig. 2.39 The possible river courses and the location of the late-medieval landing places known are reported on the medieval DEM with the late-medieval coastline.

status? There does not appear to have been a plan, rather a series of responses to environmental and historical modifications which produced, at least during the first centuries of the Late Middle Ages, an extremely stable and efficient system. What was kept of this Late Roman port system? During the Late Roman period (fig. 2.38), the system depended on two main ports: *Portus Pisanus*/Santo Stefano ai Lupi, inside the *Sinus Pisanus*, between Calambrone and Livorno, and San Piero a Grado, along the final stretch of the Arno River. The two ports¹⁷⁵ are mentioned by Rutilius Namatianus in the V century A.D. and by the *Itinerarium maritimum*, at the start of the VI century A.D.¹⁷⁶ (BALDASSARRI, GATTIGLIA 2009), but only the former is attested archaeologically (BALDASSARRI 2010) and geologically (SARTI *et alii* 2010). Other minor landing places are archaeologically attested: Isola di Migliarino, located north of Pisa, between the courses of the *Tubra* and the *Auserclus* rivers, today lying at 3.7 km from the coast, to the right of the Serchio River, used between the middle/late Republican Age and the V-VI century A.D. (PASQUINUCCI 2003a, 2003b; CAMILLI, GAMBOGI 2005), and the nearby Poggio al Marmo and Porto alle Conche (PASQUINUCCI 1988; BRUNI 2003; PASQUINUCCI 2003a; CAMILLI, GAMBOGI 2005). A special case is the archaeological area of San Rossore¹⁷⁷: archaeological data do not indicate the presence of port infrastructures of Roman and/or Late Roman Ages and highlight continuous navigation along this stretch of the *Auser* River after the V century A.D. (wreck D) (BRUNI 2000: 21ss; BRUNI 2003; CAMILLI 2004a,b). For this reason, it is reasonable to assume, based on recent geomorphological studies and on an overall analysis of Roman Pisa archaeological data (BINI *et alii*, 2013; FABIANI *et*

alii 2013a), that there was a landing place, if not a real urban port, close to piazza del Duomo. Based on toponymy, it is assumed that there was another port near Livorno. Although the toponym is attested in written sources from the IX century, it can be traced back to the presence of a landing place for Byzantine *liburnas*, dating back to the end of the VI century A.D. (UGGERI 1998).

This system was not able to withstand the passage from the Late Roman period to the Early Middle Ages. Archaeological research has shown that these areas were practically abandoned after the VI-VII century, often after these landing places were buried due to the climatic variations already described and which may be compared to other sites of the Tuscan coast (BALDASSARRI, GATTIGLIA 2009; BALDASSARRI 2010). What happened, therefore, from the VII century? Written sources show an interruption between the start of the VII century and the last quarter of the VIII century, and even archaeological investigations do not indicate¹⁷⁸ use of Pisa port structures between the end of the VII/start of the VIII century and the IX century (BALDASSARRI, GATTIGLIA 2009). Similarly, in Valdarno stratigraphic contexts (CANTINI 2007, 2011), the absence of material coming from maritime commercial traffic during the same period may be noted. Otherwise, the persistence of sea routes and of activity in the upper Tyrrhenian ports and in Pisa between the VII and VIII centuries can be inferred from the presence of Lombard artefacts and tremisses in a number of Sardinian tombs (ARSLAN 2005; McCORMICK 2007), from Pisan archaeological contexts (§ 3.2.5.1) that imply trade with Campania, and from urban iron works which were never interrupted¹⁷⁹,

¹⁷⁵ Sources indicate a distance between the two sites equal to 9 miles (13.3 km), whereas the real distance is 11.4 km.

¹⁷⁶ *Itinerarium Maritimum* 501, Rutilio Namaziano, *De reditu suo* 1 527-540; 2, 11-12.

¹⁷⁷ Ancient Ships Archaeological Site; SCIUTO C. 2012, *Intervention record no. 376* in MappaGIS.

¹⁷⁸ It should be recalled that the port structures were mainly made of wood, therefore, their remains may not have been preserved or not have been identified, and that medieval wrecks are less visible than ancient and modern ones.

¹⁷⁹ As the excavation data collected in the former Scheibler area maybe demonstrates.

thus attesting continuous import of ore from the Colline Metallifere, Elba and Sardinia (BRUNI *et alii* 2000). The assumption, already developed by BALDASSARRI 2008, 2010 and BALDASSARRI, GATTIGLIA 2009 is, therefore, that Pisa inherited the ports of *Portus Pisanus* and San Piero a Grado from the Late Roman period, the only attested during the Middle Ages, and, in view of the abundance of areas suitable as landing places close to the river mouths and of wood for building vessels¹⁸⁰, continued to remain connected to the sea even during the Early Middle Ages. Being provided with ports between the VIII and X century A.D., as demonstrated also by the presence of the fluvial landing places *Ursi* or *Offi*, between Metato and Arena, and of *Fiumicello*, at Orzignano¹⁸¹, unlike other areas of the Tuscan coast, allowed Pisa to maintain its navigation techniques and establish itself as a naval power between the X and XII century. The advancement of the coastline between the Late Roman period and the Middle Ages (SARTI *et alii* 2010) produced consequences for the two main ports: the port of San Piero a Grado became a secondary port, only small draught boats passed there, making the traffic flow in the area of *Portus Pisanus*, which, due to the development of marshes, was moved towards west. Here, during the XII century, the new port was built (for the most part artificial) in the area where the industrial site of Livorno currently rises (fig. 2.39). The main structures for mooring, for maritime traffic control, for the unloading of goods and for the sailors' lodgings were built during the third

quarter of the XII century, whereas – starting from the XIII century – public documentation depicts a port that is well-structured and equipped for the needs of mercantile traffic which experienced continuous growth until the mid-XIV century. In addition to extraordinary interventions, such as the reconstructions required following the war with the Genoese between 1284 and 1290, in order to maintain the complex artificial port system, the *Comune* of Pisa had to carry out radical reconstruction of the palisade and piers around every twenty years, as attested in 1358, 1372 and 1392¹⁸² (ROSSETTI 1988; CECCARELLI LEMUT 1994, 2003; VACCARI 2003; BALDASSARRI 2008, 2010; BALDASSARRI, GATTIGLIA 2009). An integrated connection system rose behind *Portus Pisanus*, composed of minor landing places on rivers, canals, and lagoonal-marshy areas and of cartroads¹⁸³. Although it is not easy to have complete details, the general organisation of the transport of goods unloaded from the boats towards the city and/or Tuscan hinterland provides us with indications on this system. The Serchio and *Auser*¹⁸⁴ rivers were navigable (at least up to the XIII century), as also the Arno through which it was possible to reach Florence¹⁸⁵. As regards the Serchio River, a *portus de Silvanis* was situated in Pappiana, at the end of the XIII century, a *portus navis* in Carraia in 1263, and a *Ursi* or *Offi* port, between Metato and Arena, already around 1000, whilst a *Fiumicello* port, at Orzignano, is attested in 975 on the *Auser* and a *de Liccio* port, along the final section of the river in 1175 (CECCARELLI LEMUT *et alii* 1994, 2002; PASQUINUCCI,

¹⁸⁰ See § 2.5.

¹⁸¹ Mentioned respectively in 987 and 975 (CECCARELLI LEMUT *et alii* 1994: 411).

¹⁸² These works were not able to avoid the progressive siltation of *Portus Pisanus*, to such an extent that during the XIV century it was abandoned in favour of the moorings in the deep basins opposite Livorno. Only from the XVI century onwards, after the stalemate of the XV century, Medicean interventions turned Livorno into the new international port.

¹⁸³ For ground transport, see § 2.3.1.

¹⁸⁴ In Ripafratta, along the Serchio, first the local lords and then the *Comune* of Pisa charged duty on the goods being transited, whilst the *Auser* was used to transport construction material coming from the Monti Pisani and people travelling to the Bagno del Monte Pisano (CECCARELLI LEMUT *et alii* 1994: 410-11).

¹⁸⁵ Tolls were charged in Ricavo and Bientina to cross the river and the marsh (CECCARELLI LEMUT *et alii* 1994: 412-414).

2003). The Arno River is described by written sources as studded with many ports and landing places in addition to the already mentioned San Piero a Grado and urban landing places in Pisa: a boat crossing may be seen in Naviccio, dated 1172, at the Monastery of San Savino where a pier rose, destroyed at the start of the XII century by a river flood, in Navacchio, which probably took its name from a landing place, and in Riglione, where a port is mentioned from 1176. Connections were also guaranteed towards north and Versilia, through the trench of Navariccia, to the east of the Malaventre marsh, which was still navigable at the start of the XIV century when described as *fossa per quam itur cum navibus* (CECCARELLI LEMUT *et alii* 1994; ANICHINI, GATTIGLIA 2009). The impact of this infrastructural system on the economy is evident in the volume of traffic and – albeit partially – in the material found in the stratigraphic contexts of Pisa. The archaeological deposits ranging from the end of the X/start of the XI century and the first half of the XIII century show how a constant flux of vessels which carried loads from various parts of the Mediterranean Sea had been established, to such an extent that even good amounts of subsidiary goods such as pottery were shipped and widely distributed among the medium and high classes of society, as well as in important settlements (MILANESE, VANNINI 1998; CANTINI 2008, 2011; BALDASSARRI, BERTI 2009). On the other hand, the diffusion of Pisa archaic majolica (Maiolica Arcaica) throughout the entire upper-Tyrrhenian Sea, starting from the XIII century (BERTI 1997, 1997a; GIORGIO 2009), underlines the significant amount of outgoing goods and the seaports that were reached. Monetary finds, starting from the mid-XII century, provide details on regional, national and Mediterranean traffic: Pisa coins have been found in the area of Pistoia, in Valdarno as far as western Umbria, along the Tuscan coast

and minor islands to Rome, in Liguria, Corse, Sardinia, Sicily and Libya, whilst gold Byzantine and Norman-Swabian coins have been found in Pisa (BALDASSARRI 2000, 2003a, 2009, 2010a, 2012; BALDASSARRI, GATTIGLIA 2009). Starting from the XIV and XV centuries, the export of Pisa majolica continued as also the arrival of Mediterranean pottery, especially of Catalan and (in rare cases) far-Eastern origin, whereas the hundreds of trade coins show a lively trading of goods on city markets (BALDASSARRI 2003b, 2003c). However, the vessels transiting in the port during this period are largely foreign, the trade coins mainly belong to Florentine traders and local majolica are influenced by the success of contemporary Catalan products and of the goods produced by Valdarno craftsmen: all elements that can be read as signals of the city's crisis (BALDASSARRI, GATTIGLIA 2009).

2.4 Land use

Finally, I would like to understand the pressure generated by man throughout the landscape in terms of land use. The data, albeit preliminary, of the palaeo-vegetation analyses on the MAPPAs cores and spatial analysis will be used. The former (ALLEVATO *et alii* 2013) show first a sharp drop in anthropic pressure starting from the Late Roman period/Early Middle Ages¹⁸⁶ and then a period of recovery during the medieval/late-medieval period. From a vegetation viewpoint, instead, an increase in shrub and tree vegetation *taxa* may be seen with a consequent decrease in herbaceous *taxa* starting from the Late Roman period and a trend reversal during the Middle Ages. Starting from the Late Roman Ages, silver firs (*Abies alba*) and pine trees (*Pinus*) also increased compared to the Roman Ages, which is probably related to the natural reforestation due to lower anthropic pressure.

¹⁸⁶ Calculated by considering the presence of carbon, an indicator of human activity deriving from craft and/or domestic hearths and from forest fires provoked to create pasture or cultivation areas, and the presence of *Cichorioideae t. Minor* considered an indicator of cultivation activities (AROBBA, CARAMIELLO 2009: 122).

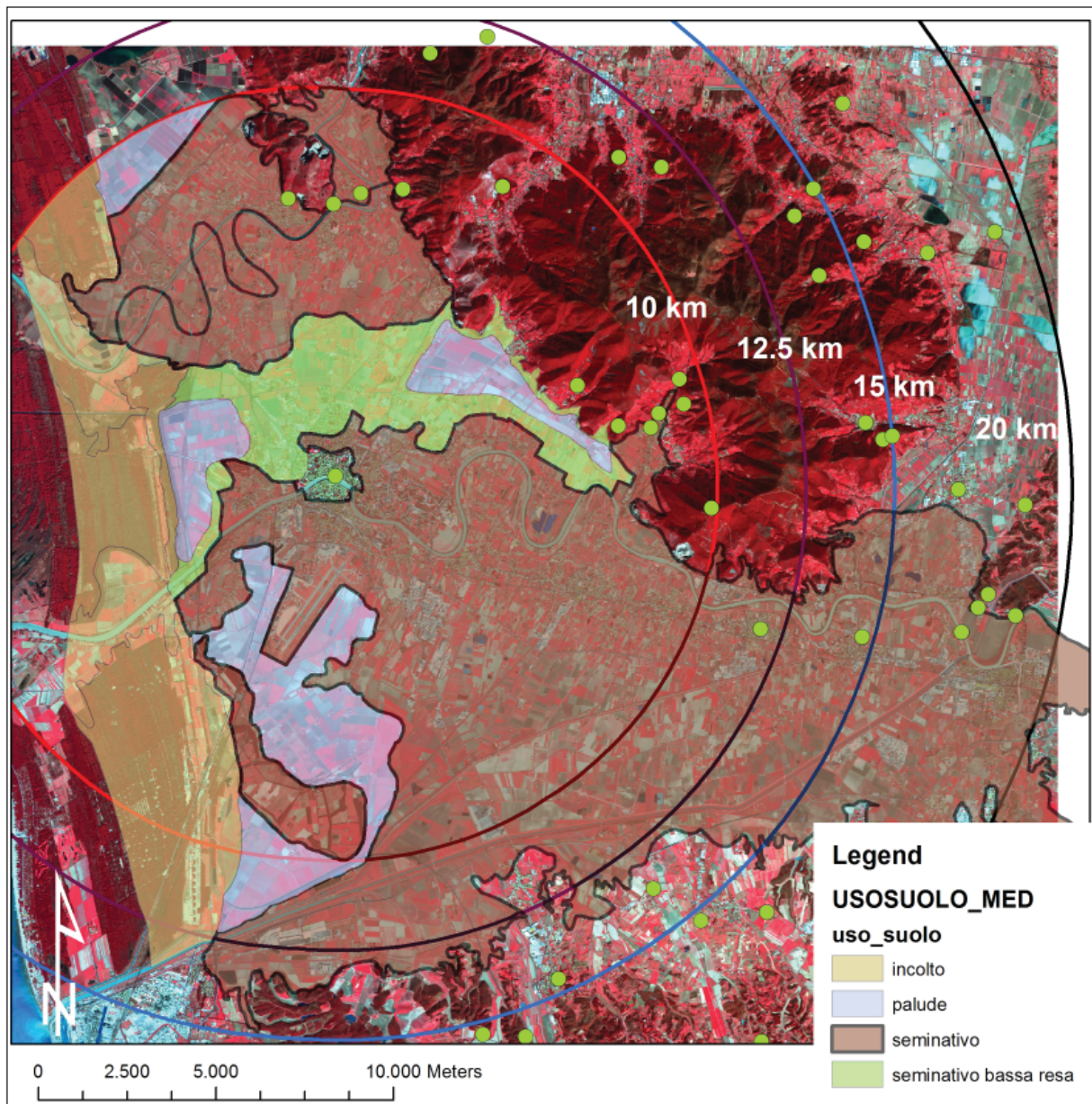


Fig. 2.40 Study of the landscape available to the city and possible land use considered to estimate the agricultural production needed by the city. Possible 'competitor' sites are indicated in green.

Subsequently (Middle Ages/Late Middle Ages), there was an evident decrease in firs, probably related to climatic variation (temperature increase) and a less marked decrease in pine trees, connected to the fact that they started to be cut down again due both to human population increase and to medieval shipbuilding and construction needs. A reversely proportional situation may be seen in mixed oaks, which increased during the Middle Ages, whereas chestnut trees (*Castanea*) constantly

increased from the Etruscan period to the Middle Ages and walnut trees (*Juglans*) are sporadically attested. The number of vines (*Vitis*) and olive trees (*Olea*) also fell starting from the Late Roman period, and re-appeared during the Middle Ages. Conversely, during the Middle Ages, the decrease in hydro-hygrophite plants typical of marshy areas may be related to the increase in cereals, to such an extent that the pollen peak of *Chicorioideae t. minor*, could signal the increase in agricultural

practices in the area, attested by the presence of oats. The medieval increase in *Chenopodiaceae* could be associated with both the presence of vegetables (beets) and forage, and may be related, therefore, to breeding areas which were located at the margins of the northern and southern areas of the city¹⁸⁷, where uncultivated publicly owned lands (called *guariganghi*) were situated for pasture, and between the mouth of the Arno River and the woods of Stagno, where privately owned lands were rented out to *tavernai* (butchers) to make herds pasture¹⁸⁸. The presence of marshy vegetation such as *Cyperaceae* which sedges belong to, could be related to the *palea* used by *barattolai* (jar makers) for their pottery furnaces, collected in lands located in the two areas called *Tumulo*¹⁸⁹ and in the marshes near Marmo, before they were reclaimed during the second half of the XII century. Even the presence of *Ericaceae* is mentioned in written sources: late XIII century Statutes, in fact, refer to *stipa* used both as fuel, and as a hiding place for wrongdoers (BERTI, RENZI RIZZO 2004:40). We can imagine, therefore, the late-medieval plain of Pisa as characterised by wetlands with both arboreal vegetation, composed of elms, alders, hornbeams and ashes, and herbaceous vegetation, composed of cespitose plants (reeds, hottonia, and sedges), graminaceous plants and beds of reeds, and by drier areas where Mediterranean maquis grew, but also included arable land, pastures and woods.

How large could the areas devoted to cultivation (especially cereals) be to sustain the population of Pisa? And how many inhabitants needed to be fed? To answer these questions, I borrowed and simplified the method used by CITTER 2012¹⁹⁰, which I explicitly refer to in order to obtain comparable data. The first step was to define the available space in the city during the XII century, when the city had already erected its widest walls; in other words, how large was the territory that could meet the population's food needs and at the same time effectively control the territory, bearing in mind that beyond a certain distance (not so much in spatial but in temporal terms), it was not convenient to directly cultivate, but rather to interweave commercial relations. In the case of Pisa, in contrast to CITTER 2012: 61, it must be recalled that a part (unfortunately not quantifiable) of food provisions arrived by sea¹⁹¹. Given that the main competitors of agricultural production were the hinterland castles, it can be easily noted that there were no castles within a 5 km radius around Pisa. If we broaden the radius to 10 km, we find 18 castles, 3 of which directly controlled by the *Comune* of Pisa and a monastery, all located to the east of the city near the Monti Pisani and the strait of Ripafratta; in the further 5 km radius, the number doubles (20 further castles), but what is most evident is that the plain of Pisa, as far as the Serchio to the north and the foot of the Monti Pisani and hills of Livorno to the east and to the south, is the real vital space of the city (fig. 2.40). The position of *Portus Pisanus*, around

¹⁸⁷ To the north located between Sterpaia, Cuccia trench and Pero (1119), to the south between modern Le Rene, Arnaccio and Guasticcie (1185) (CECCARELLI LEMUT *et alii* 1994: 416).

¹⁸⁸ During 1262-7, the area between the mouth of the Arno River and the woods of Stagno was the object of many rent agreements with *tavernai* (butchers) for the pasturing of their herds (BERTI, RENZI RIZZO 2004:40).

¹⁸⁹ Written sources, mainly dating back to the XIII century, which recorded the leases to the jar makers, define them as *palus de Tumulo/palus de S. Ruxore, pratum, plagia, palliaretum*, precisely indicating the sandy nature of the land, its significant humidity and probable vegetal associations (BERTI, RENZI RIZZO 2004: 39).

¹⁹⁰ According to CITTER 2012: 66 the estimates obtained are quite reliable for low-lying lands also in the presence of less detailed land use analysis, as in my case.

¹⁹¹ According to TANGHERONI 2002: 111, during the XIV century, there was a 1000-ton surplus production of cereals in Sardinia.

14 km to the southwest of the city, strengthens this interpretation: the area identified is consistent with the area needed to control the port and the final stretch of the Arno valley, i.e. the source of the city's economic wealth, which extended towards southwest rather than north. The development towards south represented, therefore, a need which increased during the Early Middle Ages due to the marshy area that surrounded the city to the north, as demonstrated by CITTER 2012: 87. It is plausible, therefore, to assume that the lands cultivated to the south of Pisa possibly reached a distance of 12.5 km, i.e. extending to the foot of the Livorno hills. Since a land use map as the one used for Grosseto was not available, I used the Land Map of Regione Toscana¹⁹² correcting it with the data of the late-medieval marshy areas. 4 different categories of lands were used: dunal sandy lands along the coast, mainly uncultivated and wooded lands, not suitable for agricultural productions; marshy lands, not suitable for agricultural productions, but rather for breeding purposes; partially cultivated lands, with low potential yield (125 kg), because partly used for breeding (area to the north of Pisa); cultivated lands with high potential yield (250 kg/ha). Lands situated between the Serchio (considering its late-medieval course) and Lake Massaciuccoli, whose production was probably connected to the dwellings and castles to the north of the Serchio River, were not taken into consideration. Work was conducted on two areas: the first within a 10 km boundary and the second within 12.5 km, leading to a cultivated surface with high potential yield varying between 15,700 and 19,000 ha¹⁹³, to which a surface of 2,600 ha with low potential yield must be added. Using the tables proposed by CITTER 2012: 62 (yield totalling 250 kg/ha for lands with high potential yield) together with my estimation equal to half of the previous one for lands with low

potential yield (125kg/ha), a hypothetical annual production is obtained fluctuating between 4315 and 5140 tons. Considering, therefore, average annual consumption per capita of 250 kg, a population varying between 17,260 and 20,560 inhabitants could theoretically be fed; to this amount, an unspecified supply of products by sea must be added, which in my opinion could not have sustained more than a quarter of the population, amounting to between 21,635 and 25,700 inhabitants. This amount is quite similar to that proposed for the start of the XIII century by SALVATORI 1994: 121, equal to around 22,000 inhabitants.

2.5 Conclusions

In this chapter, I believe to have demonstrated that studying an urban landscape does not mean studying the landscape as a simple container in which the city and its inhabitants live and work, but rather as a distinguishing element of history which, especially during the past, man has had to address, in some cases defying it and in others yielding to it. The environmental context greatly influenced the development and the choices made by the city, without taking a prevailing or definite role. Some environmental aspects certainly played a negative role, especially between the Late Roman period and the Early Middle Ages (fig. 2.41): climatic variations with repeated floods and the associated decline of the economic, social, political and demographic system – which guaranteed maintenance of the infrastructural network and, in turn, made agricultural use of the Pisa plain possible through an attentive regimentation of the waters – basically caused a widespread development of marshes in the low-lying areas around the city and along the rivers,

¹⁹² The Land Map of Regione Toscana (scale 1:250.000) can be downloaded at <http://sit.lamma.rete.toscana.it/websuoli> (last access 05/05/2013).

¹⁹³ Data are rounded down.

leading to the formation of wetlands. This led to urban settlement in the higher areas, located mainly to the north of the Arno River¹⁹⁴, and to territorial expansion towards south, rather than towards north, probably changing the area of influence of the Roman *municipium*. There were harsh repercussions on the port system of Pisa: archaeological data show the disappearance between the V - VI and VII century A.D. of two fluvial landing places - Isola di Migliarino and nearby San Rossore; however, it is possible to assume that, although not fully operating, the two seaports of greater importance - San Piero a Grado and *Portus Pisanus* - withstood. The latter started to move towards south due to the silting up of the area in order to build mooring necessary for the *liburne*. Traffic did not appear to cease completely, even if VII and VIII century archaeological data and written sources, reveal that it was reduced to minimum terms. A slow but constant recovery may be seen in the VIII century to such an extent that the first fluvial landing places mentioned in written sources date back to the second half of the X century. Even transport connections were interrupted. They are more legible along the northern and north-western routes, especially due to the fact that subsequent routes, dating back to the start of the XII century are different compared to those of the Late Roman period. In this case, environmental changes and (especially) the river courses must have interrupted or jeopardized communication especially near fords. This is the case of the coastal route (*strata de Arbaula*) and of the *podium Vallis Serchi*. Conversely, the progressive siltation of its main port between

the late XII and end of the XIV century, does not seem to be a determining factor for Pisa's crisis, which has more systemic and deep reasons. The anchoring basins opposite Livorno, where the modern port structures were built during the Modern Age, were already used by Pisa and could have been used to solve the problem, if only this were the crucial point. There are environmental aspects that, instead, positively influenced the development of Pisa after the XI century when the regimentation of the waters and territorial expansion were combined to wisely exploit the water network. Thus, during Pisa's maximum building expansion, the Monti Pisani supplied wood and building stones, whereas during the XII-XIV century, rivers and marshes were exploited to receive supplies of material for clay production (bricks and pottery) and represented an effective communication system, equalled only by modern road networks. Furthermore, this particular geomorphological situation helped improve the supply of water, since it was easier to reach groundwater¹⁹⁵. Lastly, the network of rivers and navigable canals made it possible to be provided with more landing places which were used alternatively during the Early Middle Ages, thus facilitating Pisa's early recovery and economic growth between 1000 and the XIII century, unlike other towns along the Tuscan coast. The history of Pisa during this period, therefore, is connected to a complex port system, with *Portus Pisanus* as its cornerstone and strong point thanks to its strategic position in the middle of a network of rivers and navigable canals related to the two basins of the Serchio-*Auser* and Arno rivers (fig. 2.42).

¹⁹⁴ See § 3.1.

¹⁹⁵ See § 3.1.3.2.

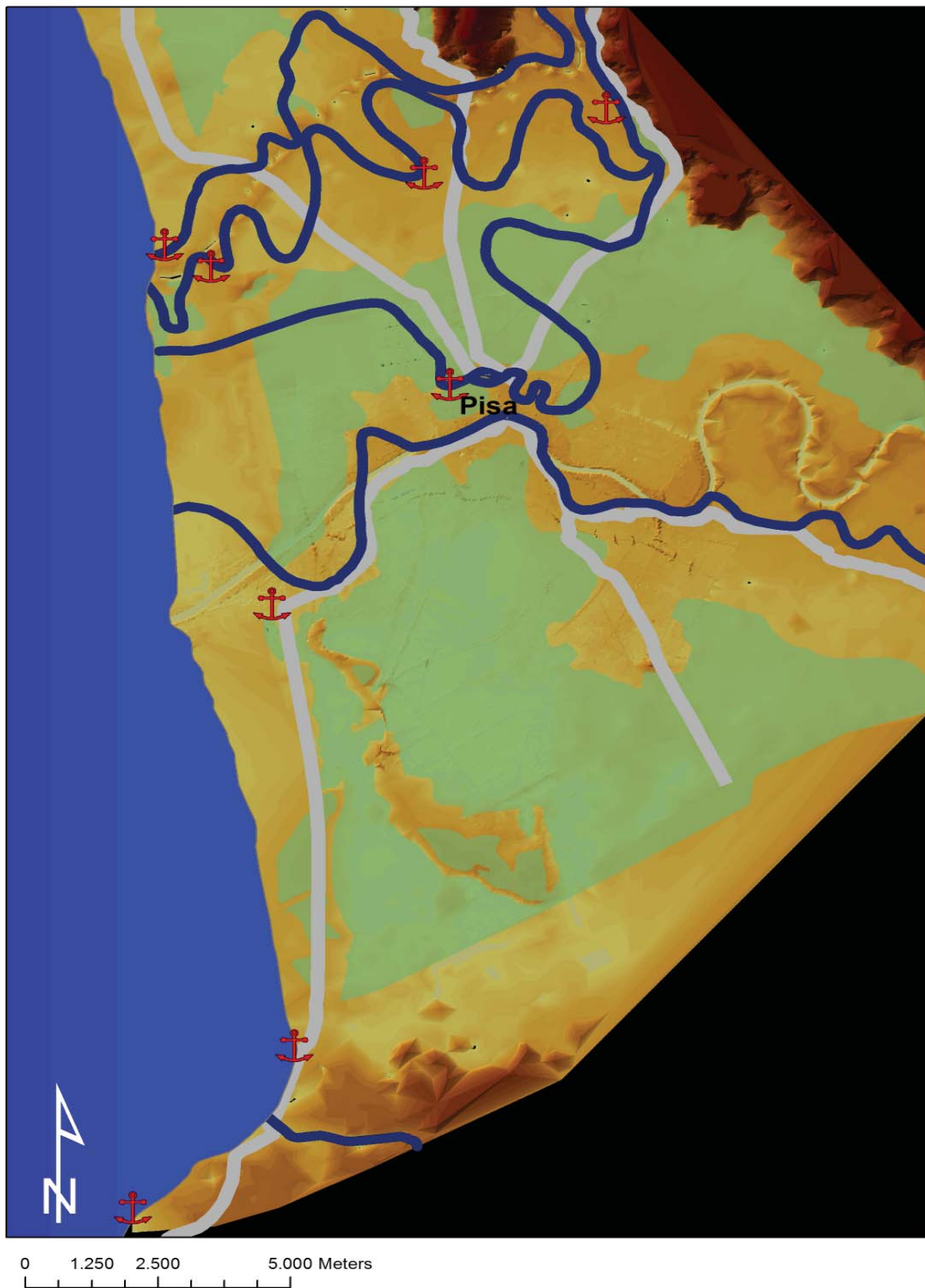


Fig. 2.41 Hypothetical reconstruction of the early-medieval landscape in the area around Pisa, between Malaventre and *Portus Pisanus*. In addition to roads and river courses, the landing places known and the possible extent of the marshy areas are highlighted.

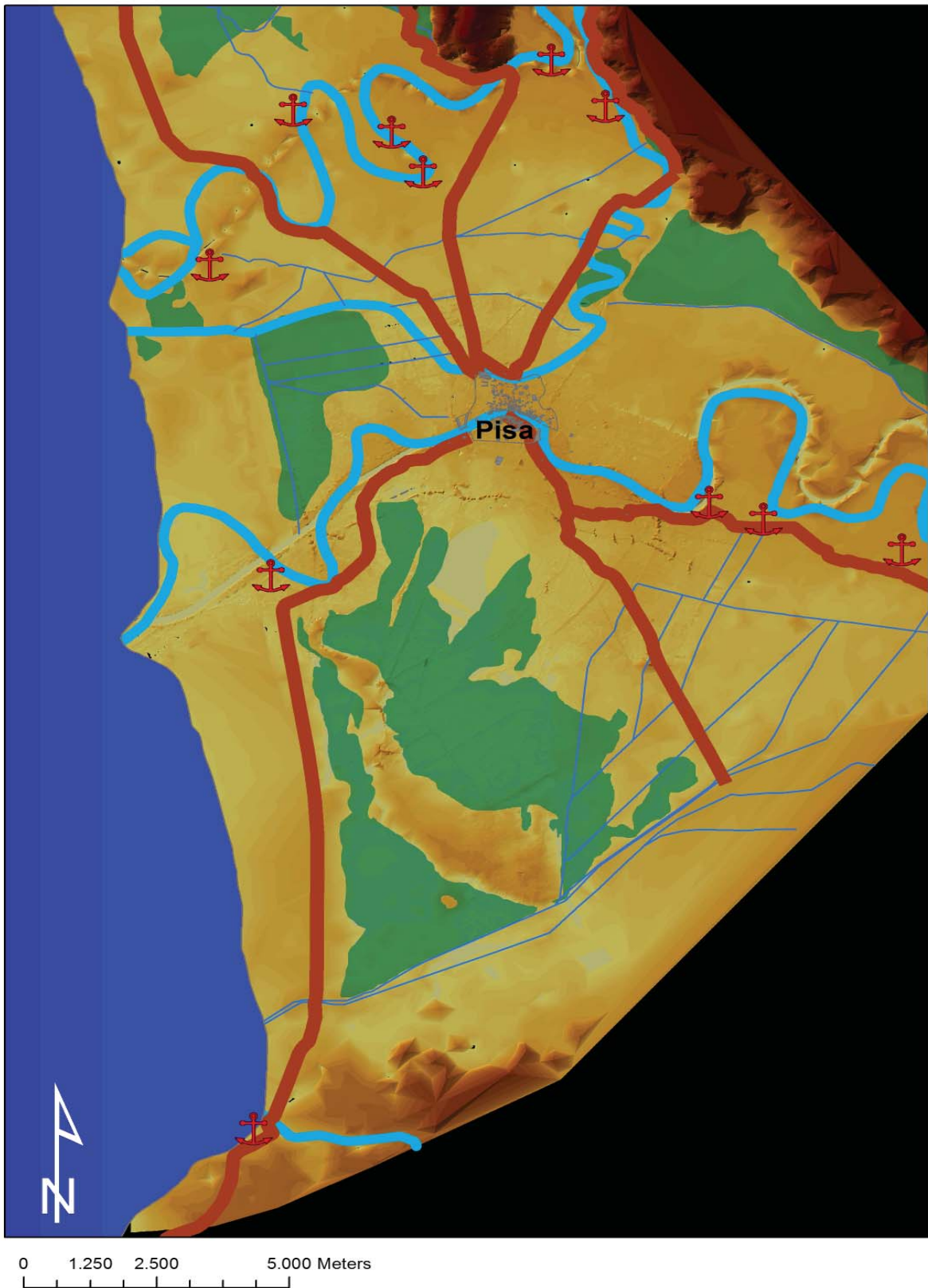
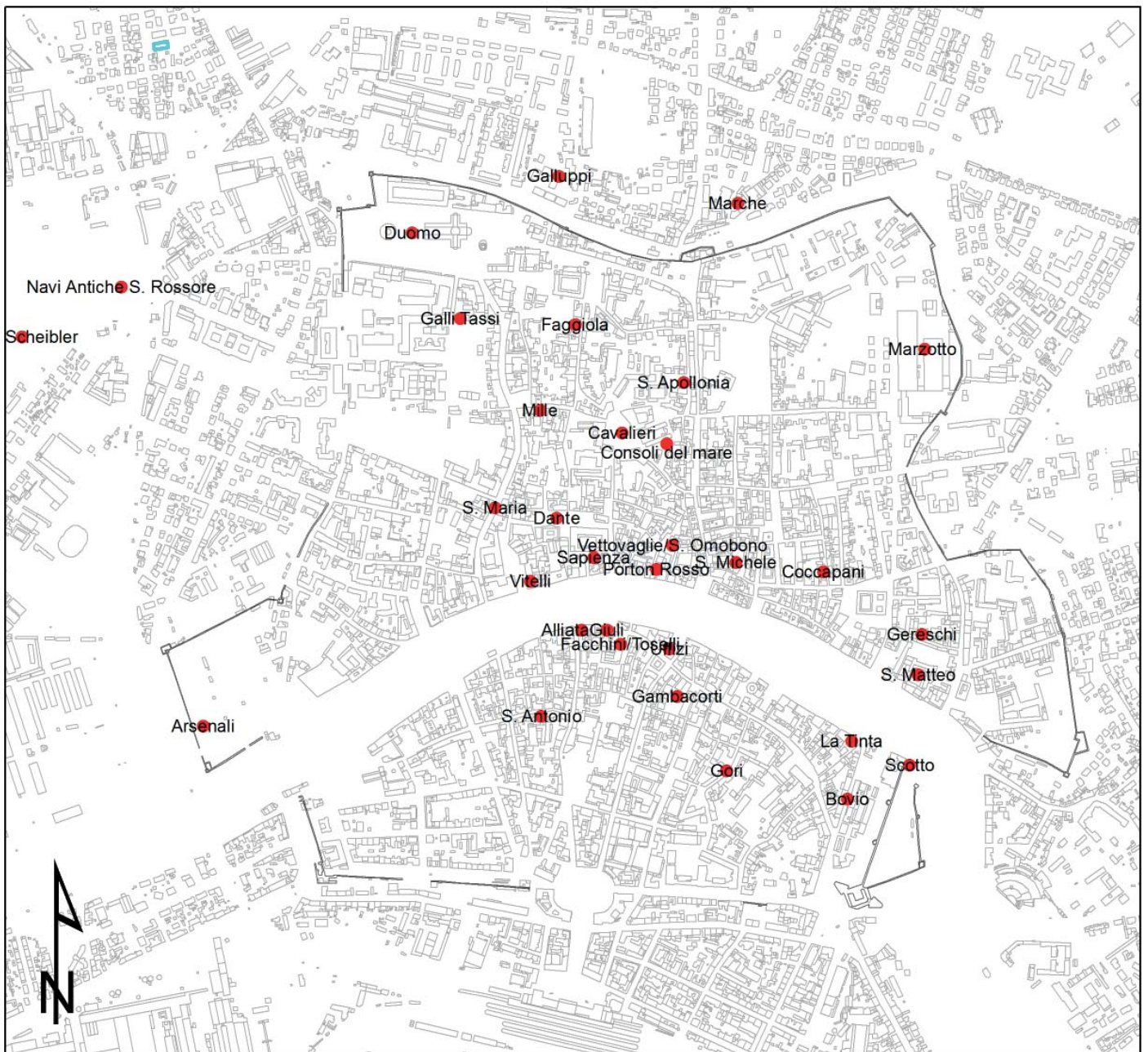


Fig. 2.42 Hypothetical reconstruction of the late-medieval landscape in the area around Pisa, between Malaventre and *Portus Pisanus*. In addition to roads and river courses, the landing places known, the trenches and the possible extent of the marshy areas are highlighted.



Tav.A. Location of main archaeological interventions mentioned in the chapter 3.

3. The city

In this chapter, I consider the city as the result of the choices made by an organised urban community, that is, of the natural and anthropic actions and of the archaeological traces that may be read and interpreted in the stratigraphic deposits. Following the path taken in the previous chapter, our urban analysis will span from topographic conformation and urban development through to details of the material traces found. Then, as in the previous case, spatial analysis and archaeological contexts will be dialectically related. Finally we will consider man as the actor of history and narrate how he lived and worked in medieval Pisa.

3.1 Snapshots of the city from the Late Roman period to Modern Age.

3.1.1 A question of method

Just three years ago (GATTIGLIA 2010), I used a traditional method to understand the urban physiognomy of Pisa during the Early Middle Ages, mainly based on the indications provided in GELICHI 1999:134, and I analysed spatial organisation in the city according to five orders of evidence: evidence of agglomerations of people and their topographic distribution in the settlement fabric; the organisation or maintenance of material structures for collective use, such as the arrangement and maintenance of aqueducts, walls, road systems and sewage channels; the presence of public structures with central administrative functions, such as places and buildings of public relevance, either political or religious; production and/or distribution functions with respect to a territory: i.e., evidence of production structures and demonstration of market areas; relations with external space, especially with transport routes and with the landscape and its transformation.

After three years, I decided to consider the issue from a different point of view and start from archaeological data, using a quite different quantitative approach.

Archaeological research must continuously deal with two main categories of variables: those linked to sampling and those to complexity. Sampling is connected to the fact that it is not possible to collect every single trace of the past, both due to the nature of the archaeological record and to the casual nature of its conservation and finding. Archaeological data are part of a whole which we will never be able to know in its entirety but which we can try to understand in its general sense. Complexity is related to the origin of the archaeological source and the method used to collect and file the archaeological record. The latter is influenced by the way the discipline has developed over the years and also by the lack of standardisation, as well as by the increase in the overall production of archaeological data and the number of operators producing the data (ANICHINI 2012). The unifying element of archaeological data is the spatial component: archaeological data have a clear and univocal spatial position. Archaeology, therefore, must address a huge amount of spatial, complex, heterogeneous and casual data, and must understand how to automatically process them to produce new knowledge: archaeology also has the opportunity to address Big Data. Archaeologists must no longer simply select the most useful statistic and/or mathematical models among those available, but must integrate them with new models conceived by and for archaeology. It is with this view that I followed the route presented over the next pages; a route that uses proven spatial analysis methods and proposes new tools. Reviewed and categorised raw

archaeological data (FABIANI, GATTIGLIA 2012), which may be viewed on the MAPPAGis (www.mappaproject.org/webgis), and geomorphological data (BINI *et alii* 2013) have always been the starting point, with the aim to provide an overall view of urban transformation bearing in mind urban palaeogeography. The data were analysed with three different kinds of spatial analysis methods: the first two available in the majority of GIS software (kernel density estimation and kriging) and the third specifically developed during the MAPPA project and based on a predictive mathematical model (DUBBINI 2013). In the first case, kernel density estimation (KDE) is a non-parametric technique to estimate the density of a random variable and belongs to the point pattern analysis family (HODDER, ORTON 1976: 30), i.e., spatial analysis tools developed from data points. It is a model in which a two-dimensional probability density function (kernel) acts among observed values to create a smooth approximation of its distribution from the centre outwards, weighing the events depending on their distance from the point where their intensity is estimated. When processing the data, it is possible to decide the kernel's shape¹ and bandwidth (or radius). The function is directly influenced by the radius within which the density of the point is calculated: the greater it is, the closer the result is, until coinciding with a continuous surface; the smaller it is, the more the result will capture single starting events only. The density value of each cell is calculated by summing the distribution density values that overlap in that cell, producing a continuous surface that can be more easily interpreted than that obtained with simple density and in which clusters are more evident. In our case, the greater the number of archaeological finds falling within

the radius, the greater the density will be in that area. The radius, therefore, must be assessed on the basis of the occurrence and determined, if necessary, by subsequent adjustments (CONOLLY, LAKE 2006: 186; BEARDAH, BAXTER 1996). Since it is not possible to weigh the single data, the result obtained is an approximate idea of the data's spatial structure (CITTER 2012), which in our case means the varying of the presence of finds and the greater or lesser concentration. Their representativeness is greater in areas where many archaeological interventions have been carried out, also in the absence of data regarding that chronological period. The analyses lean towards understanding Pisa's urban development during different historical periods². For this reason, I only took into account types of finds referring to the urbanised areas and excluded those related to *agricultural/vegetable gardening areas* or *natural contexts*. I chose a circular-shaped kernel, with a radius of 150m, a distance within which it is logical to suppose continuity of the urban settlement, and an output with 20 m resolution cells. As seen, a deterministic model does not allow spatial variation to be described and values to be estimated or predicted in areas for which we have no data. For this reason, a probabilistic approach must be used which considers the values to be calculated as a result of a random process and manages the uncertainty caused by the lack of knowledge. Using a probabilistic model does not mean that believing that spatial data to be analysed vary randomly in reality, but means rather admitting our ignorance (ISAACS, SRIVASTAVA 1989). Geostatistics allows us to describe spatial variation as the product of a deterministic and a stochastic component, according to the *regionalized variable theory* (MATHERON 1971). The deterministic

¹ Not in all GIS software

² Kernel density estimation was developed for the following chronological periods:

- VI-VII century;
- VIII- X century;
- XI-XV century.

component is a trend, whilst the stochastic component is composed of two parts: a random component correlated to a global pattern and a highly-localized casual random noise caused by a measurement error or by small-scale processes (CONOLLY, LAKE 2006: 97; LLOYD, ATKINSON 2004). Geostatistics is also based on the principle of spatial autocorrelation (HODDER, ORTON 1976: 174), i.e., on the fact that the values observed are related to each other. This means that values tend to be similar when they are spatially close to each other and to have different behaviours, or at least to differ from average values, when they are distant and, beyond a certain extent, to no longer be related. The correlation between the variable's values tends to decrease as distance increases. Although archaeology is a discipline that is strictly related to spatial aspects, it has not used geostatistical methods to a large extent as would be expected³, although a certain propensity to use kriging interpolations by Italian archaeologists has been noticed over the past years⁴. Kriging is a geostatistical weighted interpolation based on autocorrelation and is applied in cases in which both the distribution and density of the points are irregular. The weight given to the values depends on the spatial structure and on the degree of spatial autocorrelation of the distribution. For this reason, a semivariogram is used (LLOYD, ATKINSON 2004: 153), i.e. a plot that qualitatively and quantitatively evidences the spatial dependence degree (that is, the autocorrelation) and that, by relating the distance between two points (the lag) to the semivariance value between the measures carried out in these two points, interpolates the variance of the values observed in groups of pairs of points at set distances. The semivariogram has 3 main parameters: range, the maximum distance within which autocorrelation is displayed; sill, the maximum value reached by the semivariance; nugget, non-explicable part of the semivariance, which is attributable to measurement errors, instrumental errors and spatial variability at distances lower than the minimum sampling distance. In order to obtain a continuous function, the semivariogram must be associated with a mathematical model necessary to describe the general trend of spatial variation. The most frequent models used are circular, spherical and exponential. The first two show a decrease in autocorrelation, until becoming 0 at a specific distance (range). Exponential models are applied when spatial autocorrelation decreases exponentially with increasing distance and then disappears at an infinite distance. It is difficult to understand which mathematical model to choose, since every model produces different values for the range and nugget, and so influences the interpolation phase in a different manner. The kriging is able to define the main orientations of diffusion of the values – in this case we speak of anisotropic kriging – or not to define them – in this case we speak of isotropic kriging. Anisotropy is the property by which a defined set of data has features that depend on the directions along which they are considered, for example, the direction of prevalent winds or, in archaeology, the position along a road network axis. Before applying the interpolation, the data available must be analysed in order to check that they can be applied to the kriging: the main prerequisites are that the circumstance to be studied must be in some way continuous (this model does not appreciate sharp interruptions), that the data must be numerically and topographically relevant, that they are distributed according to a Gaussian curve (otherwise the method is not applicable) and that there is no longer correlation from a certain spatial distance onwards, or that the semivariogram curve flattens out beyond a certain threshold, i.e.

³ See LLOYD, ATKINSON 2004, for a brief study; there have been further examples over the past years.

⁴ PECCI 2009, for phosphates, CITTER 2012, for urban analysis, GATTIGLIA 2012 for the construction of historical DEM.

when it reaches the sill. At the end of the procedure, the kriging produces a standard error map which can be used to identify the areas where the interpolation is less accurate. Is there any sense in applying this type of analysis to archaeological data and, in our specific case, to urban data? In other words, can we assume, for example, that next to an urban archaeological find, such as a tower house, there could be another urban element? The answer is probably yes. However, cities do not always develop as a *continuum*; there can be sharp interruptions, such as the presence of city walls or of a geographical barrier. In order to solve the former problem, all the data were weighed using different values, whilst the latter was addressed by combining the archaeological dataset(s) with the geomorphological dataset, using co-kriging. Co-kriging – also defined as stratified kriging – allows us to combine further spatial information which improves interpolation; in practice, it uses both the autocorrelation of the variable at issue and the correlation between the variable and one (or more) quantitative variables to better estimate the weighted value used in the interpolation. Data weighting was carried out by attributing an urban development value from 1 to 4. The higher the value, the more it is the expression of the urban fabric; for example, a Late Middle Age tower house has coefficient 4, whereas an agricultural land has coefficient 1, a vegetable garden 2 and a church 3. This is the same for geomorphological aspects, where rivers have coefficient 1 and morphological highs have coefficient 3 or 4 depending on the periods⁵. A final warning is not to use the kriging tool available in GIS software with default settings: the risk in using next-next-finish mode is very high and the results, however pleasing they may appear, provide little or even misleading information. It is necessary, therefore, to have as much control over

the procedures as possible⁶. As observed by CITTER 2012: 50, archaeological data differ from geological or toxicological data, because they may have a high degree of causality or be highly random. For this reason, archaeologists need to conceive solutions more suitable to their datasets. The model developed during the MAPPA project (DUBBINI 2013) is a mathematical model conceived for the predictive calculation of the archaeological potential of an urban area and directly created by and for archaeologists. It was extremely useful as a Research tool for its ability to predict urban space. The difference between a statistical model and a mathematical model is that the former assesses the probable distribution of an event, whereas the latter recreates the basic rules that govern a certain event. Our model refers to the latter and is based on a modification to the PageRank algorithm. It starts from the assumption that the criteria used to attribute archaeological potential are very similar to those used by search engines for assigning importance to web pages, since both founded on reciprocal relations. For the algorithm to work, the archaeological data are categorised and a numeric value is assigned to them on the basis of their archaeological information potential, with a more sophisticated calculation grid than the previous one; in this case also, greater values correspond to greater urban importance. Furthermore, to allow the mathematical model to process the data and so recreate the urban environment, an algorithmic calculation of the functional areas, that is, of the base levels of the city's spatial and functional organisation (urban area, suburban area and agricultural area), was processed on the basis of the type of archaeological data. Thus, the archaeological data were all related to the functional area in which they are located and diffuse their information potential according to the assumption that archaeological data in a certain

⁵ The datasets with weighted values are available on the MOD.

⁶ I would like to thank Nevio Dubbini, the mathematician who has worked on the MAPPA Project over the past two years and who explained to me in simple words what the many kriging formulas meant.

functional area have similar data around them, not in a uniform manner but weighted according to the geomorphological data, since these data represent a sort of “basic condition” for development. The following paragraphs will provide an overview and analyse the historical variations of urban development, as it progressed from the Late Roman period to the Late Middle Ages.

3.1.2 The Late Roman and early medieval city

Pisa’s Roman topography was recently re-analysed by FABIANI *et alii* 2013a, in the light of the complete re-organisation of the archaeological data already known, of the acquisition of new data (especially geo-environmental data) and of the spatial analysis developed throughout the MAPPA project, and to which reference is made to provide a brief overview of the Roman city. Pisa was characterised by a road network⁷ composed of three main arterial roads: two running from north to south, the *Aurelia* and the *Aemilia Scauri*, and one running from east to west, which followed the left bank of the Arno River. The *Aurelia* reached Pisa from the south along a coastal route, passing through *Portus Pisanus*, then through the port of San Piero a Grado, and running along the left bank of the Arno River. It entered the city from the south-west, flanked by necropolis the remains of which have been found at San Giovanni al Gatano and Porta a Mare⁸. The *Aemilia Scauri* arrived from the south with a more inner route. It merged with the road arriving from Florence in Putignano and probably followed the route of current via San Martino/via Toselli. Then it merged with the *Aurelia* and crossed the Arno River, over a bridge where the church of Santa Cristina currently rises. To the north of Pisa, the *Aurelia* and the *Aemilia* ran towards Luni, the former with a coastal route, after passing the necropolis of via Pietrasantina⁹,

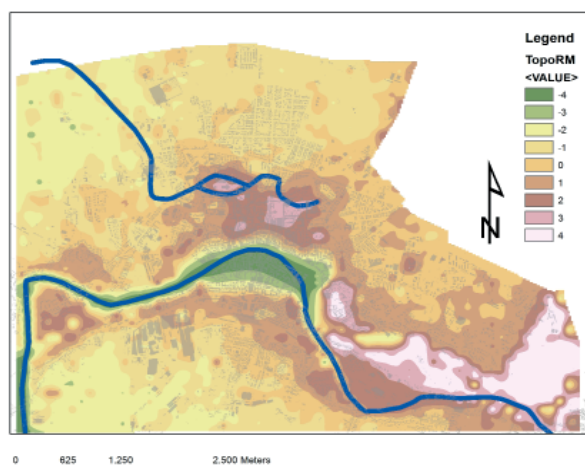


Fig. 3.1 The Roman Age DEM created using the elevation points resulting from archaeological investigations, for the urban areas, and in a regressive manner based upon the period palaeogeographical map, for the extra-urban area (see § 2.2.3), associated with the partial reconstruction of the hydrographic network (BINI *et alii* 2013). The heights are expressed at current sea level.

the latter following the route of the subsequent *podium Vallis Serchii*¹⁰. A third road, for Lucca, left the north-east sector of the city towards San Giuliano Terme and then flanked the foot of Monti Pisani. Next to the road network, the fluvial basins of the Arno and *Auser* rivers, featuring a thick network of landing places enabled navigation to the city. The discovery of many shipwrecks near San Rossore railway station attests the intense traffic, whereas the remains of a probable pier¹¹ seem to indicate a possible mooring point at the gates of the city. The reconstruction of Roman palaeogeography (BINI *et alii* 2013) reveals the presence of morphological high north of the Arno River, showing a significantly marked morphological high which coincides perfectly with the area of piazza del Duomo, and a further high at piazza Martiri della Libertà; to the west, instead, the palaeotopography appears to significantly decrease (fig.3.1). The hydrogeological network

⁷ See § 2.3.1

⁸ LA ROSA L. 2012, *Intervention record no. 288, 289*, in MappaGIS.

⁹ SCIUTO C. 2012, *Intervention record no. 165*, in MappaGIS.

¹⁰ See § 2.3.1.2

¹¹ La Rosa 2012, *Intervention record no. 418*, in MappaGIS; BRUNI 2003c: 95.



Fig. 3.2 Kernel Density Estimation (in green) of Roman Age finds (I century B.C./IV century A.D.) with a 150 m radius, overlapping the Roman Age DEM and the current urban grid.

may only be partially reconstructed. The Arno and the *Auser* rivers both flowed from west to east, to the south and north of the city respectively. The course of the Arno River was similar to the course we see today, although the eastern course of the current area of Chinzica followed a more southern course, close to current via San Martino, and formed a wider bend in the area of Barbaricina. The urban course of the *Auser* River is more difficult to identify. It seems to have had a more meandering course, bending to the south of San Zeno and again in the area of the Arena Garibaldi, then moving south again. From this point onwards, two branches of the *Auser* River may be identified, which flanked piazza Duomo, and although we are not certain that they were active at the same time, a fluvial island supposedly rose here. The branches then merged and continued towards San Rossore. An issue that has yet to be solved regards a branch of the *Auser* which flowed into the Arno, as described by sources up to the V century A.D. (Strabo, 5.2.5; Pliny, *N.H.* 3.5.50; *Scolio* at Ptolemy, 3.1.4; Rutilius Namatianus, 1.566) and identified by BRUNI, COSCI

2003 based on aerial photointerpretation, featuring a diagonal course in the western sector of Pisa in the area between the current Botanical Gardens and the Arsenali. The geophysical and geoelectrical investigations and the cores carried out during the MAPPa project do not seem to confirm this assumed course, whereas weak evidence¹² makes us believe that a fluvial course could have existed nearby. The limited extension of the find does not allow us to establish whether it was located to the east – not far from the supposed course in the Botanical Gardens – or to the west, in the area of via Santa Maria, where a *carbonaia*¹³ dating back to the second half of the X century is attested, possibly coinciding with *Fossa Flumine* recalled in XI and XII century documents, which may have been the remains of the *Auser*'s ancient branch flowing into the Arno River. Reconstructing the development of the Roman city through traditional study of the archaeological finds is highly complex because although the amount of finds is very high (208 finds, corresponding to around 10% of the finds of all ages), their georeferencing is difficult (out of 164 excavations, the single finds can be accurately georeferenced in 16% of cases only and the area of excavation can be accurately georeferenced in 39% of cases only). Furthermore, they often refer to out of context recoveries and do not clearly attest the presence of public and worship areas allowing a clearer definition of the urban fabric. Spatial analysis (Kernel density estimation, co-kriging) and the mathematical model (figs. 3.2, 3.3 and 3.4), instead, allowed us to evaluate the spatial distribution of the finds, thus revealing an urban area located in the north-western sector of Pisa's current historical city centre, in the area between Porta a Lucca and piazza del Duomo, to the north, via Santa Maria to the west, piazza Dante to the south and the axis comprising via

¹² SCIUTO C. 2012, *Intervention record no. 947*, in MappaGIS.

¹³ With this term, medieval written sources mean a ditch.

della Faggiola/piazza dei Cavalieri to the east, gravitating, therefore, towards the *Auser* River, which marks the northern boundary, rather towards the Arno River. The urban area was surrounded by a suburban strip, particularly consistent to the north and east of the *Auser* River, characterised by a large number of workshops, but less dense to the south, where it probably took on a more rural aspect, and, probably, featured a port area to the west. In detail, if epigraphic sources (the two *decreta pisana*¹⁴, approved in 2 and 4 A.D. respectively) mention the presence of the *Augusteum*, of temples, public baths, shops, buildings for entertainment and of a commemorative arch under construction, none of the buildings recalled is archaeologically attested¹⁵. The presence or less of Hellenistic and Roman period walls is yet to be demonstrated, and Rutilius Namatianus (1,567) does not recall the presence of city walls: it is probable, therefore, that city walls may have been erected immediately after Rutilius Namatianus' visit, maybe still during the V century A.D.. A public area, which FABIANI *et alii* 2013a do not go as far as defining *forum*¹⁶ could have risen in the area of piazza Duomo, to the east of the Camposanto Monumentale, where two quite large masonry structures have been interpreted as the central part of two large bases, originally covered in marble slabs or other stone material, which were probably used to accommodate honorary statues¹⁷. The public area would be located on a fluvial island, on the left bank of the *Auser* River, near a northwest-southeast oriented road which



Fig. 3.3 Co-kriging interpolation showing the probable size of the urban area during the Roman Age (I century B.C./IV century A.D.). The more urbanized areas are highlighted in red.



Fig. 3.4 The functional areas (the urban area is in red, the suburban area in dark brown and the rural area in white) algorithmically created by the MAPPA algorithm (FABIANI *et alii* 2013 e 2013a).

ran south of the current Camposanto Monumentale, along the route of via Cardinale Maffi, and reached the *thermae*¹⁸ of Porta a Lucca, built in the second half of the I century A.D. and restructured during the II century A.D.. The

¹⁴ CIL, XI. 1420, 1421; *Inscr. It.*, VII 1, *Pisae*, 6, 7; SEGNI 2011.

¹⁵ A temple dating back to the Etruscan Classical Age, restored at the start of the II century B.C., may have risen on the banks of the Arno River. The assumption is based upon the residual material of the excavations in piazza Dante: BRUNI 1998: 225, 240-241.

¹⁶ Again at the start of the V century A.D., Rutilius Namatianus (1,575 sgg.) describes the presence of a monumental forum. The location of the forum has been the subject of many assumptions: there is no objective evidence that it was located in the area of piazza dei Cavalieri or in piazza dell'Arcivescovado (SCIUTO C.2013, *Intervention record no. 948*, in MappaGIS; PASQUINUCCI 1993: 95-96; BRUNI 2001b).

¹⁷ TARANTINO G. 2012, *Intervention record no. 374*, in MappaGIS.

¹⁸ CAMPUS A. 2012, *Intervention records nos. 312, 313, 315, 316, 317, 318*, in MappaGIS; LA ROSA L.2012, *Intervention record no. 404*, in MappaGIS; TARANTINO G. 2012, *Intervention record no. 9*, in MappaGIS; LA ROSA L. 2012, *Intervention records nos. 276, 403*, in MappaGIS; CAMPUS A. 2012, *Intervention record no. 314*, in MappaGIS.

building rose close to the course of the *Auser* River and was connected to a branch of the aqueduct that from the end of the I century A.D. had supplied the city from Monti Pisani (PASQUINUCCI, MENCHELI 1989; PASQUINUCCI 2003c). A second branch probably flowed towards the area between the churches of San Matteo and San Francesco. Here, the two medieval toponyms, (*supra*) *castello* and (*suptus*) *muro vetere*, read together (GELICHI 1998:81), i.e. as a *castellum* associated with the nearby *murum*, would indicate the presence of an ancient monument whose distinctive feature is its length and, therefore, would indicate a portion of the ancient aqueduct. The term *castellum* would refer to the presence of a *castellum aquae*, the point of arrival of the aqueduct, to which the remains found in the area of the Palace of Justice may probably be attributed and whose arches would be the *murus vetus*, with a plan that could coincide with the via Buonarroti, via De Simone, via di Santa Bibbiana axis. The function of this aqueduct branch in an area that appears to be rather peripheral still needs to be understood: it may have been used for public buildings that needed a large amount of water, for example a bath complex located in this part of the suburban area. The Arno River bend, which shifted north during the Early Middle Ages, and the construction of the Lungarni may have cancelled any possible evidence of buildings in this area. The only evidence is an *opus signinum* paving found at Palazzo Scotto¹⁹, generically dating back to the Imperial Age, around 60 cm thick and probably related to a not better identified building of notable importance. The city's residential areas were spread out in the area of piazza del Duomo to the south of the mentioned route, where many portions of *domus* have been

found with an occupation span from the Republican to the Late Roman period²⁰, whereas in the rest of the city, traces certainly ascribable to houses are rather scarce and discontinuous. Structures referring to *domus*, again related to occupation phases spanning from the Late Republican to the Late Roman period were found in the gardens of the Archbishop's Palace²¹, and to the south-east, in via Sant'Apollonia, where the structures date back from the Augustan Age to the II century A.D.²². We are not certain whether the area of piazza dei Cavalieri also had a residential purpose (CORETTI, VAGGIOLI 2003; PASQUINUCCI 2003c), whereas the remains of the walls found in piazza Dante, dating back to the Augustan Age, have been attributed to a *domus*²³. The distance of these finds from the others could suggest that the area, albeit of an urban nature, was rather peripheral compared to the actual city centre. The suburb started to the north of the *Auser* River and included the amphitheatre and craftwork area. The remains of the structures²⁴, discovered in 1908 at the Physiology Institute in via San Zeno indeed are attributable to an amphitheatre (FABIANI *et alii* 2013a), situated on the river bank, immediately outside the urban area of the city and perfectly oriented with the centuriation axes. The presence of a building for spectacles in this area is suggested by medieval toponomy: by the toponym *Parlascio*, of Germanic origin, used to designate a place where bear fighting took place, and by the neighbouring toponyms *a le grotte* and *petricio* which could refer to the ruins of an imposing building, such as a theatre or amphitheatre, still rising and probably used as a stone quarry (GARZELLA 1990: 3ss). The craft districts devoted to pottery manufacturing flourished in this area, attested by the discovery

¹⁹ GATTIGLIA G. 2012, *Intervention record no. 367*, in MappaGIS ; GATTIGLIA 2006: 127.

²⁰ GATTIGLIA G. 2012, *Intervention record no. 363,367,608*, in MappaGIS; PARIBENI 2011.

²¹ LA ROSA L. 2012, *Intervention record no. 308*, in MappaGIS; PASQUINUCCI, STORTI 1989.

²² SCIUTO C. 2012, *Intervention records nos. 94, 95*, in MappaGIS; CORETTI, VAGGIOLI 2003.

²³ GRASSINI F. 2012, *Intervention record no. 325*, in MappaGIS.

²⁴ LA ROSA L. 2012, *Intervention record no. 278*, in MappaGIS; BANTI 1943.

of dumps containing pottery waste in the area of San Zeno. Furnaces dating back to the Republican Age and terra sigillata furnaces dating back to the I-II century A.D. rose further west in via Santo Stefano, at the Arena Garibaldi (MENCHELLI 2003). Workshops were usually located on the outskirts of inhabited areas in Roman cities due to smoke, risks of fire, manufacturing waste and proximity to points of supply or arrival of raw material. In the case of Pisa, the *Auser* River was most certainly the point of attraction. It provided the water necessary for the production processes and was also the preferential route for the provision of raw material and for the transport and trade of finished products (FABIANI *et alii* 2013a). A number of *villae* were located in the outer suburb, which combined both residential and productions functions, such as the one documented at the Arena Garibaldi²⁵, dating back to between the Republican and Late Roman periods, and possibly the one suggested by a number of structures found in via San Zeno²⁶, dating back to between the II century B.C. and II century A.D., and also by some mobile artefacts found in via Garofani²⁷, south of the Arno River, of uncertain date. In order to describe the main development lines of the urban area during the Early Middle Ages, all the finds recorded in the MappaGIS were considered and analysed through spatial analysis. The archaeological finds referring to the period between the VI and X centuries amount to 147, equal to 6.8% of all recorded finds. From a topographical viewpoint, they are located in the middle-northern sector of the urban and suburban area of Pisa and are mainly concentrated in the current city centre, especially in the area of piazza del Duomo, in the central portion of the walled city north of the Arno River and (outside the city

centre) at the former Scheibler area. Regarding the type of finds, the most attested categories are related to areas defined as *Non-place*²⁸, corresponding to contexts related to cancelling, abandonment and destruction, reaching 21%, *Natural contexts* amounting to 17%, mainly related to *Marsh*; then *Areas for private use*, related almost totally to *Housing units*, and *Funerary areas*, both totalling 14%, and generic *Frequentation* (*mobile artefacts, traces of use and indefinite finds*) reaching 13%. Lower percentages are related to *Infrastructures* (5%), *Areas for public use* (4%), *Agricultural/vegetable gardening areas* and *Production areas*, entirely represented by *Metal manufacturing* structures, amounting to 3%. In order to provide a thorough overview of the variations in the urban fabric, the finds were further divided into those dated between the VI and VII century (83) and between the VIII and X century (69). They were individually analysed using kernel density. Conversely, co-kriging interpolation and the mathematical model were applied to the entire data in order to elaborate a numerically and topographically significant sample. The development of settlements during the Late Roman period may be inferred from the kernel density results²⁹, based on the archaeological finds dated between the VI and VII century (fig. 3.5). Compared to the Imperial period city, the suburban areas were smaller, due to a general concentration of the urban area towards west: the eastern portions previously included in the suburb were excluded from the city fabric that took root especially in the areas corresponding to current piazza dei Cavalieri and piazza del Duomo. The south-eastern sector of the city appears to have been continuously frequented, as also the area of current Santa Cristina, at the point of crossing of the Arno River. A large number of finds are also

²⁵ SCIUTO C. 2012, *Intervention records nos. 322, 432, 841*, in MappaGIS.

²⁶ FABIANI F. 2013, *Intervention record no. 145*, in MappaGIS.

²⁷ SCIUTO C. 2012, *Intervention records nos. 918 and 413*, in MappaGIS; PASQUINUCCI 2003c.

²⁸ All the terms in italic refer to the categorisation of archaeological data applied in the MAPPA Project (FABIANI, GATTIGLIA 2012: 64).

²⁹ Derived from the point file **VI_VII3liv.shp** with 150 m radius and 20 m cell size.

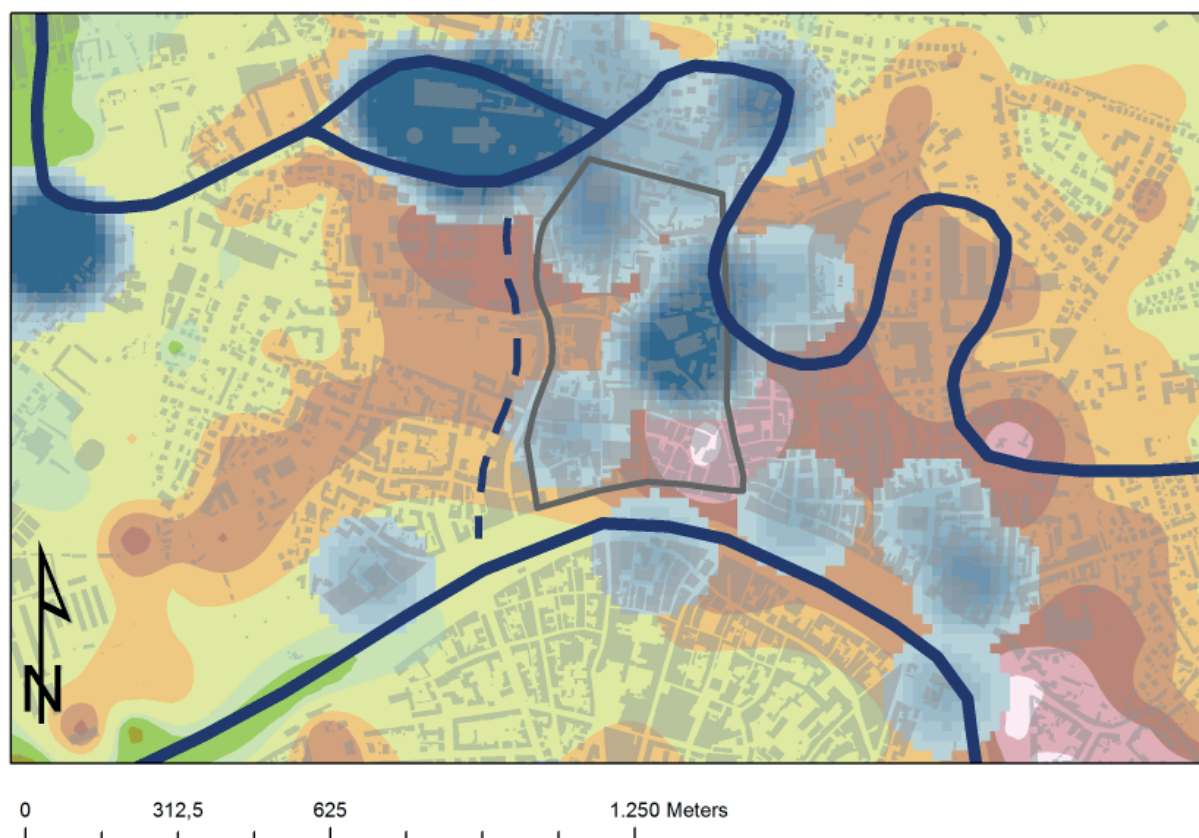


Fig. 3.5 Kernel Density Estimation (KDE) of the archaeological finds dating back to the VI-VII century A.D., visualized as 1/4 Standard Deviation, overlapping the early medieval DEM. Possible river courses are indicated in dark blue. The dotted line indicates the presumed course connecting the *Auser* River and the *Arno* River described in ancient written sources but not evidenced by geomorphological analyses. The possible length of the Late Roman city walls is shown in grey.

attested between the former Scheibler area and San Rossore, to the west of the city. If we consider the archaeological data from a qualitative viewpoint, it is extremely interesting to notice how – already at the end of the III-IV century – the production areas beyond the *Auser* River of via Santo Stefano³⁰ and via Galluppi³¹ were abandoned, defunctionalised and occupied by large necropolis. The vast cemetery area is proof of how the intended use of the northern suburban area changed over time. Used from the III to V century and partially re-used over the VIII century, the cemetery area was

discovered close to via Marche³². Less detailed information regarding burials (probably dating back to the Late Roman period), to the north-east of the area of the Arena Garibaldi³³ and in via San Zeno³⁴, probably refers to dilapidated villas and buildings, subject to more or less ephemeral occupation (FABIANI *et alii* 2013a), whereas we can only assume that the burial ground found at the former Scheibler area was used during the Late Roman period and subsequently re-occupied during VII century³⁵. The general trend that may be seen, however, is that suburban necropolis

³⁰ TARANTINO G. 2012, *Intervention record no. 15*, in MappaGIS.

³¹ TARANTINO G. 2012, *Intervention record no. 724*, in MappaGIS; ANICHINI, BERTELLI 2012.

³² LA ROSA L. 2012, *Intervention records no. 421 e 474*, in MappaGIS; COSTANTINI 2007-2008.

³³ SCIUTO C. 2012, *Intervention record no. 84*, in MappaGIS.

³⁴ FABIANI F. 2012, *Intervention record no. 145*, in MappaGIS.

³⁵ See § 3.2.1

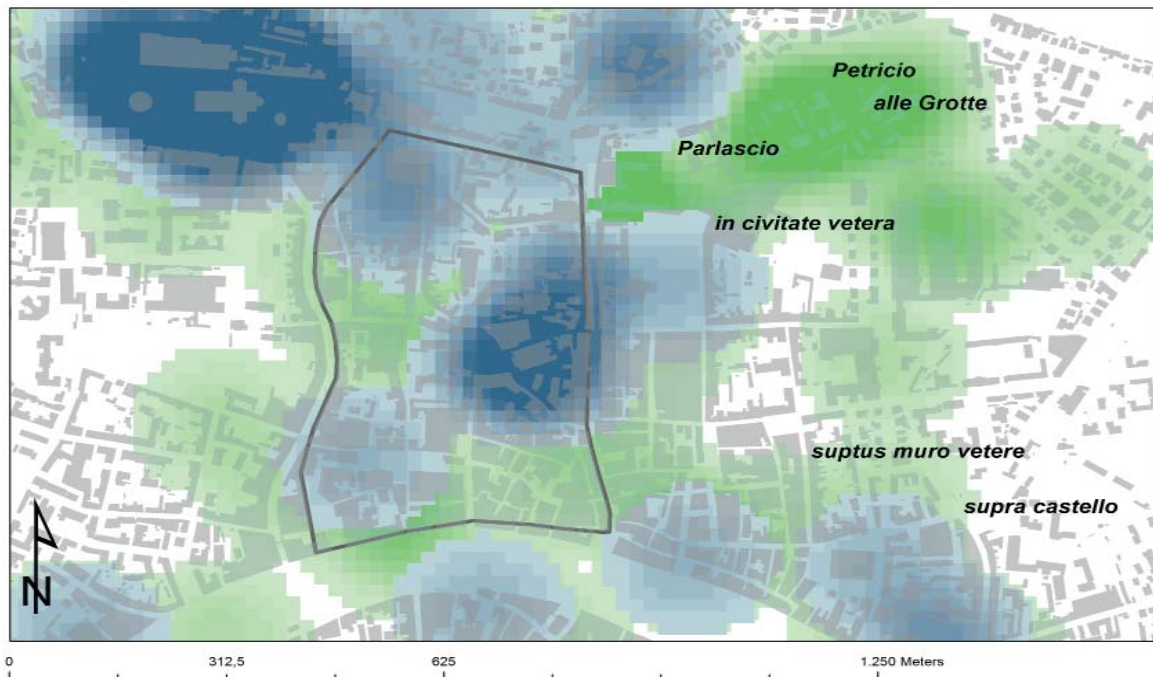


Fig. 3.6 Overlapping between the KDE of the finds dated between the I century B.C. and V century A.D. (in green) and the KDE of the finds dated between the VI and VII century A.D. (in dark blue), shows how the areas in which toponymic indications related to the Roman city are preserved (from GARZELLA 1990: 1-12 and REDDI 1991: tav. 6), do not represent the real city centre but rather an area where the emerging ruins were preserved for a longer time due to contraction of the inhabited zones.

slowly stopped being used at the same time in which the cemetery in piazza del Duomo was built around the primitive cathedral (ALBERTI *et alii* 2011). Here, from the end of V century, the space of the *domus* was occupied by structures in perishable material. Huts which partly used the decaying structures of the Imperial period, interrupted by vegetable gardens and waste pits, coexisted with a large burial area, used from the second half of the VII century to bury the Germanic elite. This area, therefore, acquired prevailing cult rather than residential patterns. The abandonment of the eastern production sectors must not be interpreted as evidence of the termination of production activities since the city continued to be productively lively, as witnessed for example by the Empoli wine amphorae. Produced in the Pisa *ager* and in the valley of the Arno River and attested in Rome and in many western Mediterranean sites, they also attest the production and trade of a conspicuous surplus in

agricultural production (MENCHELLI 2003: 102). We must assume, therefore, that different peripheral areas or areas with a previous urban connotation were reconverted or underwent functional transformation in a period in which the separation between urban and suburban settlements was less clear.

If we observe the subsequent development of the early medieval city towards the Arno River and the diffusion of workshops (such as metallurgic workshops) in current piazza dei Cavalieri, albeit the absence of archaeological data, it is possible to assume that this phenomenon began during the Late Roman period, confirmed by the fact that not only the nucleus of settlement shifted towards this area but various craft-trade activities also (FABIANI *et alii* 2013a). In the light of this, the north-eastern sector, i.e. the portion of the city in which Roman toponymic indications, such as *civitate vetera*, *le grotte*, *petricio* (GARZELLA 1990: 1-12) were preserved

for a longer time, did not represent the actual city centre but rather an area that, following the contraction of the inhabited area between the Late Roman period and Early Middle Ages, became marginal and uninhabited. This was also due to the expansion of marshy areas, where the emerging ruins, preserved for a longer time due to these conditions (fig. 3.6), could have belonged to urban buildings and to suburban complexes, perceived as part of the ancient city. Similar cases³⁶ may be seen for example in Bologna, where, between the V and VII century, the walls enclosed the main monuments of the ancient city, leaving neighbourhoods outside scattered with ruins and still defined during the XI century as *civica antiqua desrupta* (BROGIOLO 2011: 103). To better understand how these inhabited areas changed, the issue regarding the city walls must be addressed. Whilst there are no doubts about the presence of the city walls, witnessed by written sources through direct quotations, such as those referring to a *murus civitatis*, and indirect quotations, such as those pertaining to the city gates³⁷, an issue that has long been debated is when they were built, their supposed route and whether there were two circle of walls – one belonging to the Late Roman period and another to the Early Middle Ages (GARZELLA 1990; REDI 1991) – or just one Late Roman circle of walls (GELICHI 1998). The absence of accurate archaeological data makes it necessary to work circumstantially and provide as credible an assumption as possible, updated with the archaeological and historical data already known.

Let us start from the consideration that in Italy walls were not usually built during the Early Middle Ages to defend the city since the scarce archaeological and written sources we have refer to maintenance works (BROGIOLO 2011: 99) and the cases known to us regard the construction of castles in the city, usually to protect Episcopal areas³⁸. The construction or reconstruction of defensive walls is rather a phenomenon of the Late Roman (BROGIOLO, 2011: 90ss) or medieval municipal period. The construction of Pisa's city walls during the Early Middle Ages, therefore, would be strange, not only for the time of construction but also for the fact that the Episcopal area was left outside, not inside. This means that the Episcopal area, since located outside the walls, must have been built after their construction³⁹. If we take into consideration the testimony of Rutilius Namatianus (1.565-568), who does not refer to the presence of city walls in Pisa at the start of the V century, mentioned instead, in the cases of Cosa and Luni, we can assume that the walls were built after his visit and before the proposed date of the Episcopal area between the end of the V and VI century (§ 3.2.1). If we consider that the VI century was a period of great geomorphological and political turmoil, together with the general conditions of buildings in Pisa during this period (§ 3.2.2), we can assume that the city walls were built during the V century, when the defences of the western portion of the Empire were generally increased (BROGIOLO 2011:92). Lastly, the 1081 diploma of Henry IV⁴⁰ mentions

³⁶ See GELICHI 1998:83 and the many cases provided.

³⁷ See the detailed examination in GARZELLA 1990:26ss.

³⁸ As affirmed by GELICHI 1998:84, the few building activities related to the construction of fortified walls regard the Bishop's residence and the protection of the Episcopal area; these were often fortifications inside urban areas (for a general overview see BROGIOLO, GELICHI 1998:67-76). These cases include the Leonine walls of Rome, the walls of Bishop Leodoino in Modena and those in Reggio Emilia. In the case of Pisa, as confirmed by written sources (RONZANI 1993), the Episcopal residence was not only outside the inhabited area but was also outside the walls as described in XI century sources. Regarding the construction of city castles, see the construction of the Late-Carolingian *castrum aureum* in Rome (MANACORDA, MARAZZI, ZANINI 1994).

³⁹ The more isolated position of the cathedral area has been related to Christianisation and to evangelisation via sea (GARZELLA 2003).

⁴⁰ Mentioned in GARZELLA 1990:37; REDI 1991: 46; GELICHI 1998:85.

the presence of a defunctionalised section of walls⁴¹ along the Arno River, revealing their old age⁴². Although it is not possible to exclude partial reconstruction and maintenance during the Early Middle Ages, it is very likely that Pisa was provided with walls during the Late Roman period and that they partially survived, with a gradual defunctionalisation due to urban expansion, at least up to the construction of the XII century walls. The walls⁴³ (fig. 3.7) surrounded a quadrangular area, elongated upon the north-south side and with a more irregular western side, maybe because it was flanked by a *carbonaia* (a ditch), the possible relict of a stretch of the *Auser* River. To the east, the walls roughly followed the route of Borgo Stretto and via Sant'Apollonia, where at least two gates were situated: the *Samuel* gate located near San Michele in Borgo (GARZELLA 1990: 30), which gave access to the city from the east and became the city's main gate - the *Foriporta* (out of the gate) district rose outside this gate during the middle centuries of the Middle Ages - and the postern of the *Vicedominus* near the church of San Felice (GARZELLA 1990:31). This portion of the walls could hypothetically refer to a stretch of walls found near San Michele in Borgo⁴⁴ and generically dated to before the XII century. The southern stretch ran along the bend of the Arno River, where at least two gates opened: gate of San

Martino (GARZELLA 1990:39), positioned along the axis of vicolo de Porton Rosso⁴⁵, and *Porta Aurea*. This was located along the axis of via Curtatone e Montanara. This stretch of walls could refer to a stretch of double stone with core masonry⁴⁶, parallel to the Arno River, around 7 m long and 1.90 m wide with a face of limestone blocks and panchina stone laid in regular courses, found in 1969. The little information and non-stratigraphic methods of the intervention do not allow us to clearly understand the structure (city walls? The embankment already mentioned at the end of XI century?), to the point that at a distance of around 40 m to the north, other two parallel masonry stretches were found, typologically described as being the same as the structure closer to the Arno River⁴⁷. The interpretation of the toponym given by GARZELLA 1990:41 is more convincing, i.e. a corruption of the term Aurelia, identifying the entrance of the via *Aurelia* and *Aemilia Scauri* into the city through this gate. The western stretch is the easiest to identify: its route retraces that of current via Santa Maria, along which a ditch once ran (GARZELLA 1990:46) and then a road. *Porta Maris* (GARZELLA 1990:52), was located in this area, near the church of San Donato. The *Porta Archiepiscopi*, with a neighbouring postern, once located along the western stretch of the walls (GARZELLA 1990:53), can probably be placed along the northern stretch, along the axis of the medieval

⁴¹ The use of the plural (*muros*), instead of the singular (*murus*), as attested for certain stretches provides evidence of the non-continuous nature of the structure, rather than the presence of several urban walls (GELICHI 1998:85).

⁴² In my opinion, it is difficult to believe that they were built between the X and XI century. REDI 1991:99, for example, sustains that they were already in such condition at the end of the XI century.

⁴³ Without dwelling upon the written sources which allow us to identify the layout of the *murus civitatis*, a brief description of the route will be given, mainly using the data published in GARZELLA 1990:29-58 and partly in REDI 1991: 97-107, rejecting, however, the latter's assumptions regarding the presence of further gates (to be proved) and especially the presence of a fortification in the eastern area of the city, in the area called *Castellum*, for which, as already seen, we believe the interpretation of GELICHI 1998 to be correct.

⁴⁴ LA ROSA L. 2012, *Intervention record no. 68*, in MappaGIS; MILANESE 2004a.

⁴⁵ Although there is no certain proof, the presence of this route from the IX century may be assumed upon the orientation of the buildings found in the excavation of vicolo del Porton Rosso (TARANTINO G. 2012, *Intervention record no. 611*, in MappaGIS; GATTIGLIA G. 2012, *Intervention record no. 611*, in MappaGIS; FEBBRARO, MEO 2009).

⁴⁶ LA ROSA L. 2012, *Intervention record no. 68*, in MappaGIS; BORGHI 1974.

⁴⁷ These structures have been interpreted as evidence of a possible double circle of walls: a Late Roman circle positioned further back and an early medieval circle closer to the river (GARZELLA 1990:44).

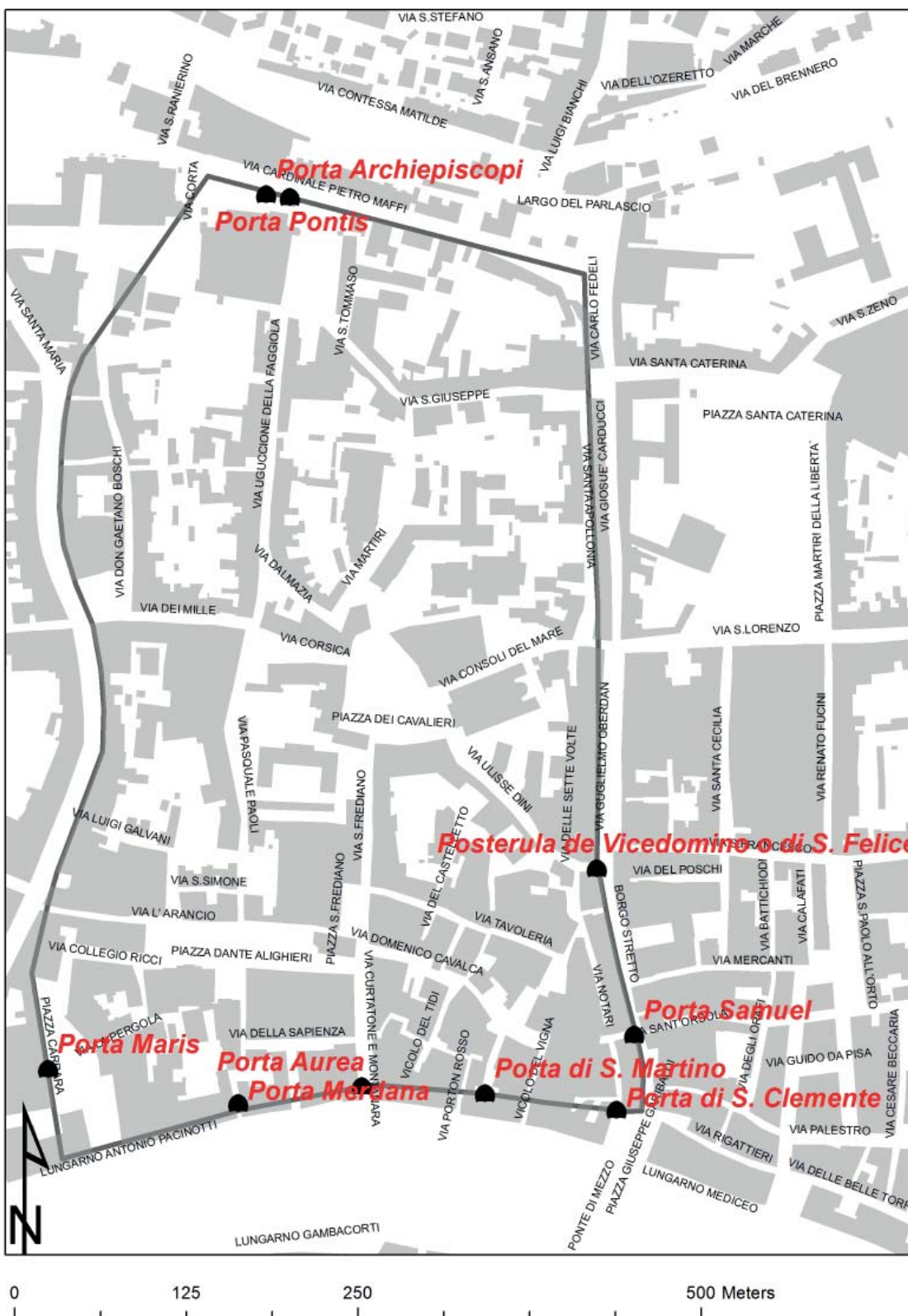


Fig. 3.7 The possible route of the Late Roman walls with location of the gates (from GARZELLA 1990: 32 ss, REDI 1991: tav. 13, GATTIGLIA 2011 with modifications) as known from late-medieval written documentation, overlapping the present-day city fabric.

via publica que dicitur Archiepiscopi which led to the *insula episcopalis*, and which probably joined the coastal route to the north of *via Aurelia*, in what became the medieval *strata de Arbaula* (§2.3.1.1). The presence of a postern suggests that there was at least a tower in this point to defend the gate. The northern stretch poses more problems given the difficulty to recognise the trace, but, at least, has one more gate: *Porta Pontis* (GARZELLA 1990:55). The toponym *ponte* (bridge) gave the name to the entire area as attested by the many churches *de ponte*: Sant’Alessandro, San Cristoforo, San Bartolomeo, San Tommaso, San Biagio and San Salvatore⁴⁸ (fig. 3.8). Since the toponym *ponte* was used to describe all the area to the north of what should have been the Late Roman walled city, and given that based upon the courses of the *Auser* River, the bridge should have been at *Porta Archiepiscopi*, mentioned in just one document written in 1136 (GARZELLA 1990:53), it is possible that these two gates actually coincided. The northern route should hypothetically be parallel to the road that joined the area of piazza del Duomo to the area of the *thermae*, that is, with a route similar to *via Cardinale Maffi* and an orientation similar to that of the *thermae* of *Porta a Lucca*. It is possible that the *Porta Archiepiscopi* opened onto this road and was close to a bridge used to reach the fluvial island corresponding to piazza del Duomo. The absence of gates in certain stretches, as revealed from XI century written sources, could result from the long time span between the construction of the walls (V century) and the written sources that refer to them (XI century). Indeed, when the written documents mention the urban gates, the walls (as seen in the case of Henry IV’s diploma) are partly defunctionalised. It is probable, therefore, that

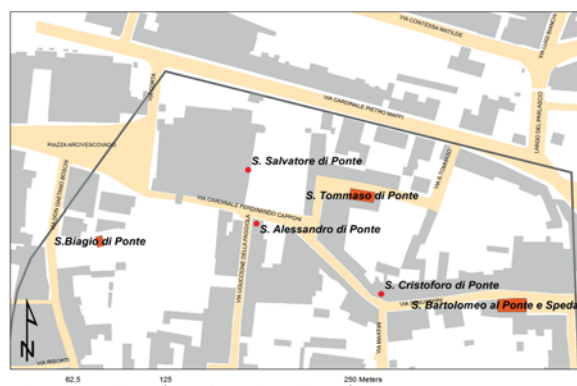


Fig. 3.8 The northern sector of the Late Roman walls (dark grey) showing the many churches *de Ponte* (of Bridge) and the diffusion of the toponym. The point graph regards buildings with uncertain location.

part of the walls were no longer visible and also that some gates had gone missing. This may have happened in the Early Middle Ages, thus leaving no traces in microtoponymy. Finally, since it is difficult to exclude the presence of accesses along the north-eastern stretch, close to the *thermae* and amphitheatre, the absence of gates in medieval written documentation could be the result of the loss of this stretch of walls owing to variations in the *Auser*'s course, which may have been responsible for its partial collapse. Overall, we can say that if previous urban areas became peripheral, conversely, areas that were once peripheral were now enclosed by the walls, such as the area close to the Arno River where settlements evidently developed during the Late Roman period. It is from this period onwards that the city, previously gravitating around the *Auser* River, appears to slowly shift towards the Arno River, in a relationship that becomes increasingly stronger during the Middle Ages. Indeed, to the south of the Arno River, outside the city walls, structures and residual materials⁴⁹ seem to suggest the

⁴⁸ The location of these buildings is certain, with the exception of the church of San Salvatore located near the current Bishop's residence along the continuation of *via della Faggiola* (GARZELLA 1990:55) or more to the north-west, on the corner between *via Corta* and *via Cardinal Maffi* (REDI 1991:126). I believe the assumption proposed by GARZELLA 1990:55 to be more convincing, especially for its position within the Late Roman walls.

⁴⁹ LA ROSA L. 2012, *Intervention record no. 61*, in *MappaGIS*; GATTIGLIA G. 2012, *Intervention record no. 589*, *MappaGIS*; MILANESE, BALDASSARRI 2004; DUCCI *et alii* 2008.

presence of a settlement area which is difficult to identify yet meaningfully linked to the road network and to the support offered to travellers, already from the late Republican Age (FABIANI *et alii* 2013a), yet still existing in the V/VI century A.D., and maybe at the basis of the nucleus from which the *villa* of Chinzica was developed after the construction of the church of Santa Cristina in the VIII century.

Starting from VI-VII century, archaeological and geomorphological data reveal drastic environmental and settlement changes. As seen in Chapter 2, the passage from the Late Roman period to the Early Middle Ages, especially the VI century, witnesses an incredible hydrogeological transformation, as evidenced by the archaeological data of the urban area. The stratigraphic sequence of the archaeological site of the San Rossore⁵⁰, not only documents the difficulty of an area subject to periodical floods, but particularly shows how the last of these floods – which caused ship “D” to sink and this fluvial branch to be no longer used – may be dated to a period subsequent to the V century A.D.. Ship “D” settled on a layer of V century materials⁵¹ and its characteristics suggest “at least an early medieval” dating (CAMILLI 2004a: 71). Another breaking point is witnessed by the stratification of the excavation in via Marche; here, the filling of the canals caused the rapid cancellation of the Late Roman necropolis⁵² and abandonment of the area, upon which only a number of burials dating back to the second half of the VII century may be seen. Even the excavation in via Galluppi⁵³

reveals a similar situation: at the end of the IV century A.D., a vast area of the necropolis was covered by a sandy-clayey layer. In this case, we do not know if this was a conclusive event since the subsequent post-medieval cut – which removed part of the stratifications – do not allow us to be sure. In the same area, the core of via San Zeno⁵⁴ identified a crevasse splay level generically dating back to between the I century A.D. and the Middle Ages, whilst at the former Marzotto textile factory⁵⁵ a structure dating back to the early Imperial Age was cancelled by floods dating back to the Late Roman period and Early Middle Ages. In the western sector, between 1.30 m and 3.70 m, the cores carried out in the area of Santa Chiara Hospital⁵⁶ evidenced coherent levels of yellowish brown clayey silt mixed with millimetre fragments of bricks and mortar, interpreted as marshy deposit. These levels rest upon layers of Etruscan (VIII-V century B.C.) or Early Imperial Age material and are covered by post-medieval layers, suggesting the presence of a wetland during the entire Medieval Ages. Regarding the city centre, the cores carried out near San Michele in Borgo⁵⁷ indicate the presence of early medieval marshy deposits and two carried out near the church of Santa Cecilia⁵⁸ indicate the presence of unspecified “alluvial levels” with thickness varying between 4 cm and 1.5 m for which neither their stratigraphic position nor chronology is identified. With regard to the area to the south of the Arno River⁵⁹ we are provided with data regarding a core carried out in via della Nunziatina which revealed a crevasse

⁵⁰ SCIUTO C. 2012, *Intervention record no. 376*, in MappaGIS; CAMILLI 2004a.

⁵¹ A *spatheion* and a fragment of African red slip (Hayes 60), which mark a *terminus post quem* at the V century (CAMILLI 2004a: 71).

⁵² Unit D composed of “grey, massive, non-pedogenic medium to coarse sand around 80 cm thick” (PARIBENI *et alii* 2006:213).

⁵³ TARANTINO G. 2012, *Intervention record no. 724*, in MappaGIS; ANICHINI, BERTELLI 2012.

⁵⁴ LA ROSA L. 2012, *Intervention record no. 887*, in MappaGIS; AMOROSI *et alii* 2012.

⁵⁵ CAMPUS A. 2012, *Intervention record no. 224*, in MappaGIS.

⁵⁶ TARANTINO G. 2012, *Intervention records nos. 592, 593, 594, 595, 596, 597, 598, 599, 600, 601*, in MappaGIS; ANICHINI *et alii* 2007.

⁵⁷ CAMPUS A. 2012, *Intervention record no. 828*, in MappaGIS; REDÌ *et alii* 1987.

⁵⁸ TARANTINO G. 2012, *Intervention record nos. 512, 513*, in MappaGIS.

⁵⁹ LA ROSA L. 2012, *Intervention record no. 894*, in MappaGIS; AMOROSI *et alii* 2012.

splay area previous to the XI century. Although the archaeological sequences provide a series of point data, in order to obtain an overall picture, it is necessary to analyse the palaeogeographical reconstruction of the period (BINI *et alii* 2013) together with toponymic data. Late Roman and early medieval urban palaeogeography⁶⁰ appears to be characterised by a detailed micro-elevation, with a strong alternation between higher and lower areas reaching the urban fabric, with two main higher areas at piazza del Duomo and between piazza delle Vettovaglie/piazza Sant'Omobono and Castelletto, a low wetland in correspondence of current piazza Martiri della Libertà and a large marshy area which extended to the west of via Santa Maria and to the north of the city (fig. 3.9). The hydrographic network pertaining to the *Auser* River seems to maintain characteristics similar to those of the previous period – a bend running south of the Arena Garibaldi and two branches, which delimit current piazza del Duomo and the watercourse originating from their confluence – and runs along current via Giunta Pisano, keeping a winding route in correspondence of the area to the west of San Rossore station. Its eastern course is less clear and the presence of a wetland depression could possibly mean that the course wedged towards southwest with a large bend. The course of the Arno River seems to be similar to the Roman one. The most eastern stretch, above the city, had a less winding course compared to today and a southeast to northwest orientation. The wide bend that started from the current district of Porta Fiorentina was narrower, leaving sections of plain to the right of the river which are currently on the left (in correspondence of the current

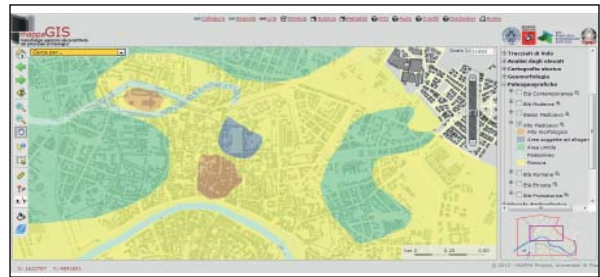


Fig. 3.9 Detail of the early-medieval palaeogeographical map from BINI *et alii* 2013, published on the MAPPAGis (www.mappaproject.org/webgis).

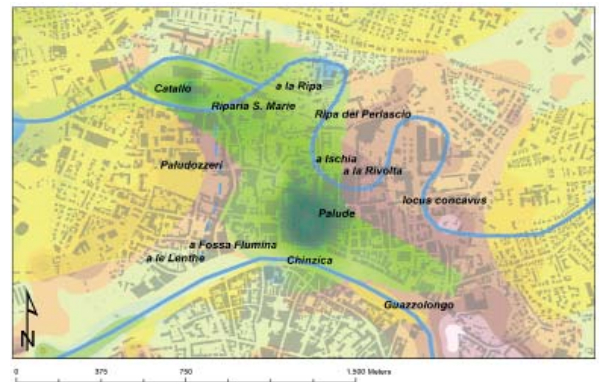


Fig. 3.10 The medieval toponyms known for the city area and attributable to hydrological aspects associated with the early medieval DEM (the centre, in shades of green, is the most reliable) and the probable size of the marshy areas (in yellow).

suburban route of the Tosco-romagnola road), but which proves that the eastern urban stretch (area of San Martino in Chinzica) moved towards north. If we consider the many medieval toponyms (fig. 3.10) known for the city area and attributable to hydrological aspects, it is possible to have a clearer picture. In the eastern area of the city, the toponyms *a la Rivolta*, *a Ischia* and *in Palude* are known. The first indicates the presence of a fluvial bend and can be located near current piazza Martiri della Libertà⁶¹, in correspondence of the wetland

⁶⁰ The Late Roman and early medieval urban DEM was implemented on the basis of the elevation points available from archaeological finds dated between the VI and VIII century, however, due to their scarce numerical consistency, is less reliable in its reconstruction (BINI *et alii* 2013), furthermore just limited to the urban area north of the Arno River.

⁶¹ The toponym *a la Rivolta* is mentioned *prope ecclesiam sancti Simeoni* in 1039, i.e. the church of San Simone al Parlascio located to the north of the church of San Giuseppe. It is associated with the church of San Lorenzo in 1095, whilst in 1116 it is connected to the church of San Pietro, then to *Ischia*, (GARZELLA 1990:4) and seems to extend to a large territorial area which is well suited with the bend of this course.

depression mentioned above. The second refers to an island and is attested in association with the church of San Pietro, current Santa Apollonia⁶². The third is related to the church of San Pietro, subsequently Sant'Omobono, in the square bearing the same name, and could be connected to the presence of wetlands in the depressed zone, also referred to as *locus concavus*⁶³, which spanned from east to the church of Santa Cecilia to San Francesco. Two brooklets, attested in 1120 and 1193 respectively, between San Lorenzo alla Rivolta and San Pietro a Ischia and between San Michele in Borgo and the depression to the east of San Paolo all'Orto are interpreted by REDI 1991: 12-13 as possible drainage works or rests of the cutting of a fluvial meander. In the northern portion, the toponym *a la Ripa* or *ripa de Perlascio* may be seen, mentioned at the church of Santi Simone e Giuda in 1119 – 1122 (GARZELLA 1990: 35). Given the vicinity of the late medieval course of the *Auser* River, it is difficult to establish whether the toponym refers to a situation running parallel or prior to its attestation, although the positioning of the amphitheatre, right on the bank of the *Auser* River, makes the second assumption highly suggestive. To the west, the following toponyms may be found: *Catallo*, *Padule Authiuli* or *Paludozzeri* and *a le Lenthe*. *Catallo*, known since 937, *prope domus sancte Marie*, i.e. the then cathedral of Santa Maria, is related to the presence of a trench (GARZELLA 1990: 22), which may be identified in the remains of the southern branch of the *Auser* River at piazza del Duomo. The toponym *Paludozzeri*, which coincides with a strip of the wide *Padule Authiuli*, defined as *non longe a*

civitate Pisae, bordering with the *via publica recto fluvio Arno* and attested as *locus*⁶⁴ from 964 (REDI 1991:14), was situated in the area west of via Santa Maria. The toponym *a le Lenthe*, attested in 1106 and located close to San Vito, was linked to the presence of long and narrow shaped fields, typical of reclamation areas (GARZELLA 1990: 143), but also of places located along river bends or courses, as may still be seen in current toponymy to the west of the bend of Barbaricina and between the Serchio River and the Canale Demaniale. Further information about this city section comes from the existence of the *Fossa Flumine*⁶⁵, which according to archive documents had one end in *Catallo* and the other in the Arno River between 1064 and 1112 (Redi 1991: 15), and of the *Riparia S. Marie*, which could be the river bank close to the cathedral of Santa Maria⁶⁶. Based on all these data, it may be reasonably assumed that the urban course of the *Auser* River bent northwest below San Zeno, then deeply curved southwest at Sant'Apollonia. This shift, with respect to the Roman Age, caused the formation of a wetland. From here, the riverbed followed the Roman Age course, bending once again to the south of the Arena Garibaldi, and then divided into two branches around piazza del Duomo which subsequently joined together and continued towards San Rossore. The toponym *Ischia*, therefore, is not related to a large island that was formed following the forking of the *Auser* along its eastern stretch, as sustained in GATTIGLIA 2011, but rather to the fact that it rose on higher ground and was surrounded by a depressed humid area. The connection to the Arno River, in the area of

⁶² Ischia comes from *insula* and is considered by GARZELLA 1991: 192 as the continuation of a more ancient toponym with respect to the first attestation dated shortly after 1160.

⁶³ *Locus concavus* attested around 1193 in the area east of San Paolo all'Orto (BRESCHI 1966-7:8).

⁶⁴ According to REDI 1991:14, the attestation as *locus* could refer to a portion of the marsh already reclaimed.

⁶⁵ According to REDI 1991:15-16 the river from which it took its name was the *Auser*, of which it was only a drainage, representing the remains of its final course. Again according to Redi, the course of the trench, subsequently filled and turned into a road, coincides with current via Roma. The latest data could suggest that the trench was used to drain the urban stretch of *Paludozzeri* and the southern branch of the *Auser* River at piazza del Duomo.

⁶⁶ GARZELLA 1990: 147, as Du Cange, also interprets it as a riverbank, unlike REDI 1991: 17 who relates it to the supposed presence of a trench parallel to *Fossa Flumine*.

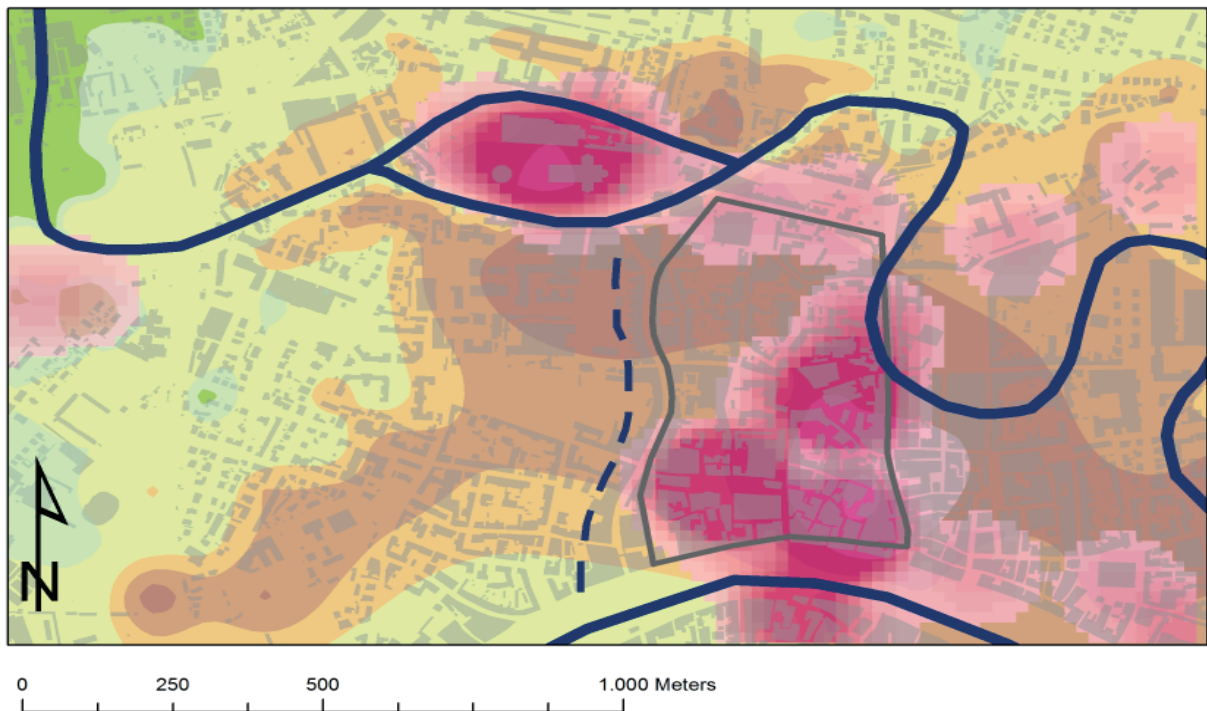


Fig. 3.11 Kernel Density Estimation (KDE) of the finds dated between the VIII and X century, visualized as 1/4 Standard Deviation, overlapping the early medieval DEM. The possible river courses are indicated in dark blue. The dotted portion indicates the presumed course connecting the Auser River and the Arno River described in ancient written sources but not evidenced by geomorphological analyses. The possible length of the Late Roman city walls is shown in grey.

the Arsenali, as previously seen, can only be assumed; instead, the presence of a trench, maybe the *carbonaia* mentioned by sources or the *Fossa Flumine*, is confirmed by a core carried out for the MAPPA project in the southern part of via Santa Maria⁶⁷ which reveal crevasse splay deposits characterised by a low-traction channel. What deeply changed in the environmental conditions was the formation of vast marshy areas: one rose in the eastern depression in the area of the *locus concavus* and of the marsh which the toponym associated with the church of San Pietro refers to, which was probably formed following the flooding of the wide bend of the *Rivolta*, the other

in the western sector, which was invaded by the Paludozzeri. A lower amount of archaeological and toponymic data is available for the southern area of the city. The area to the south of the Arno River is defined by the Germanic toponym, *Chinzica*⁶⁸, attested from 1006, which appears to designate stretches of the palaeochannel of the Arno River, still visible upon the arrival of the Lombards (GARZELLA 2004: 31), and by the toponym *Guassolongo*⁶⁹, attested for the first time in 1067 (GARZELLA 2006: 16) and indicating a long strip of marshy land, which occupied the stretch of riverside between the churches of Sant'Andrea and of San Sepolcro in *Chinzica* (REDI 1991:19).

⁶⁷ SCIUTO C. 2012, *Intervention record no. 895*, in MappaGIS; AMOROSI *et alii* 2012. The stratigraphic, albeit synthetic, section of an intervention, carried out in via Santa Maria in 1956, shows interesting analogies with the stratification found in MAPPA core 9.

⁶⁸ *Chinzica* is to be related to the Germanic *Kinz* and *Kinzig* in its general meaning of crevasse, ravine or steep place caused by water (ARCAMONE 1978). According to GARZELLA 2004:31 it was used to designate a stretch of the palaeochannel of the Arno River still visible upon the arrival of Lombards in the form of a cutting or large trench.

⁶⁹ The toponym firstly appeared as *Vuattio Lumgo*. According to GARZELLA 2006:16 *Vuattio* is to be interpreted as puddle and the adjective *Lumgo* indicates its shape and size with the overall meaning of a long strip of marshy land, marked by mud puddles.

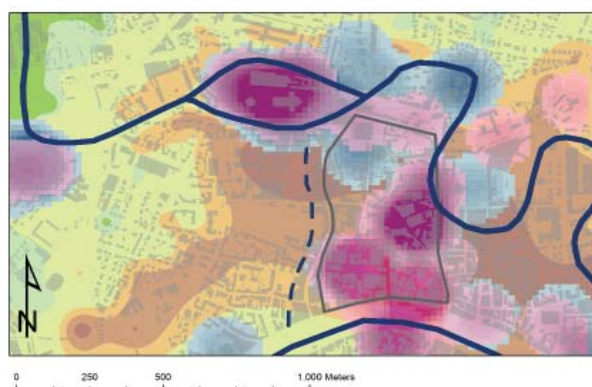


Fig. 3.12 Overlapping between the KDE of the finds dated between the VI and VII century (in dark blue) and finds dated between the VIII and X century (in fuchsia) shows the trend of settlement variations.

The two toponyms seem to indicate the presence of a depression determined by the remains of a Roman riverbed, which as we have seen ran alongside via San Martino. Even during the Early Middle Ages, therefore, the Arno River had a less stable course characterised by vast flooding areas when encountering depressed areas along its path, for example, in the area of the *Piagge*⁷⁰, of *Guassolongo*, and maybe those identified in the sandy deposits identified at the tower of San Giorgio⁷¹.

The modified environmental picture and the political and economic transformations consequently produced the destructuring of the urban area, the signs of which are marked by the end of the *domus*, quite evident in the area of piazza del Duomo (ALBERTI *et alii* 2011c), and by the creation of new Christian topography. The kernel density of the archaeological finds dated between the VIII and X century⁷², although over the long term, reveal how the city shifted towards south and the Arno River; the kriging and the

mathematical model (despite being carried out with data dating back to between the VI and X century) show the same trend (figs. 3.11, 3.12, 3.13, 3.14 and 3.15). If we overlap spatial analysis with the palaeogeographical map, it is possible to see how settlements tended to gather on the highest portions of the city. This is a sign of the difficult hydrogeological situation that surrounded it: the vast eastern deviation of the *Auser* River (the dark earth soils of via San Apollonia are tangible evidence of this) and large marshy areas that flanked it to the west and distinguished both its inner and eastern areas, making the majority of the abandoned classical structures quite inhospitable. Although data are missing, the absence of maintenance works and the great hydrogeological disruptions which we have described, led to the collapse of the water supplies between the VI and VII century A.D. (BALDASSARRI 2008a: 99). The urban area shifted towards the Arno River, mainly concentrated in the central-southern area of the Late-Roman walled city, whereas more suburban areas (small settlements) were located in the area of piazza del Duomo to the northwest, of San Zeno and Fuoriporta to the east and Santa Cristina to the south. If we overlap the spatial analysis results with the location of the churches attested by the VIII century – Santa Maria Vergine, Santa Cristina, San Pietro ai Sette Pini, Santa Margherita, Sant’Eufrasia (GARZELLA 1990: 14ss) and the Episcopal area – we can see a basic correspondence between their position and the areas of greater urban concentration⁷³: religious buildings tend to be at the centre of settlements. The nucleus of the city developed around the city churches of Santa Maria Vergine, Santa Margherita and

⁷⁰ The toponym, attested since 1078 on the right of the river between the churches of San Iacopo and San Michele in Orticaria, refers (REDI 1991:19) to the sandy intake, deposited on the concave side of a meander by the centrifugal action of the current and periodically submerged by the river in flood.

⁷¹ LA ROSA 2012, *Intervention records nos. 36,37*, in MappaGIS. The anomalous tilting of the tower suggests that it was built on a palaeochannel bank (PEDRESCHI 1951: 116ss).

⁷² Derived from the point file **VIII_X3liv.shp** with radius of 150 m and 20 m cell size.

⁷³ The result obtained is particularly significant, because no archaeological data exist for the churches attested in the VIII century. The only exceptions are the indirect archaeological data regarding the Episcopal area.

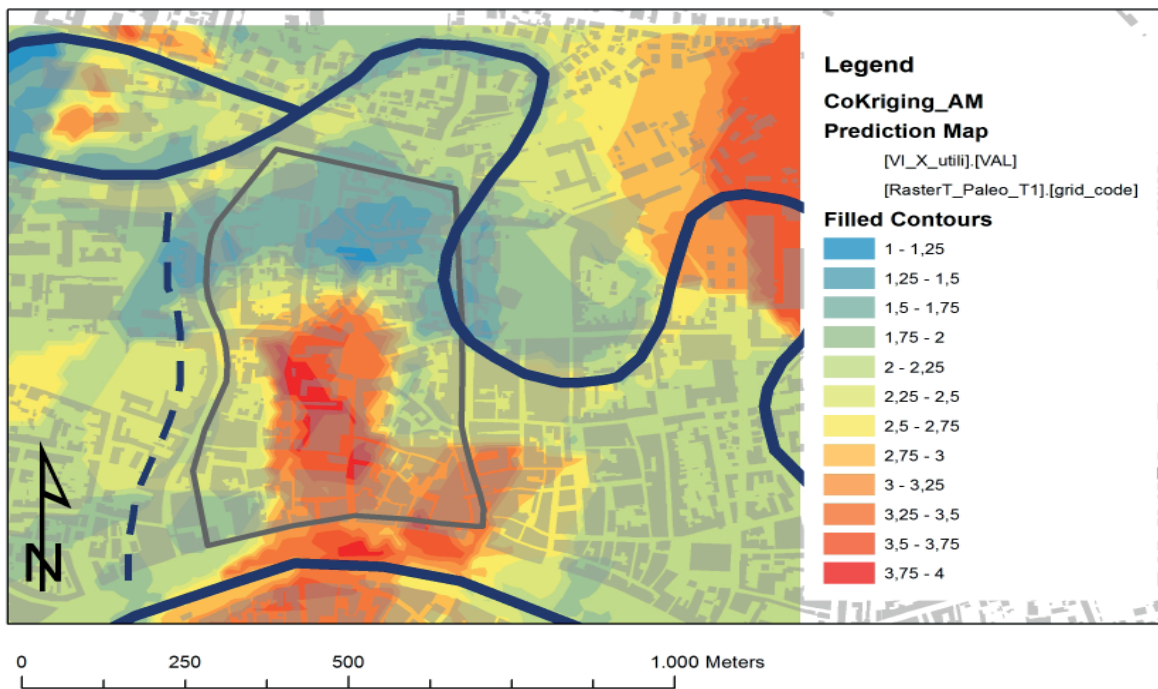


Fig. 3.13 Co-kriging interpolation showing the possible size of the early-medieval urban area (values between 2.75 and 4) over the long period spanning from the VI to the X century.

Sant'Eufrasia, and over the next centuries became the place around which political power revolved; here, in fact, in addition to the late attestation of the toponym *Cortevecthia*⁷⁴ (indicating the existence of the Lombard administrative centre), the presence of a vast ironmaking area, which was already active from the VII-VIII century and spread between piazza dei Cavalieri and via Sant'Apollonia⁷⁵, indicates the neighbouring presence of the centre of political power, given the control exercised by the latter over manufacturing. The northern portion of the walled area was scarcely inhabited and probably took on the aspect of a highly rural suburb, as appears from the few data regarding the intervention in via della Faggiola⁷⁶. The area of piazza del Duomo outside the walls and home to the *insula episcopalis* represented the centre of religious power and, starting from the VIII century,

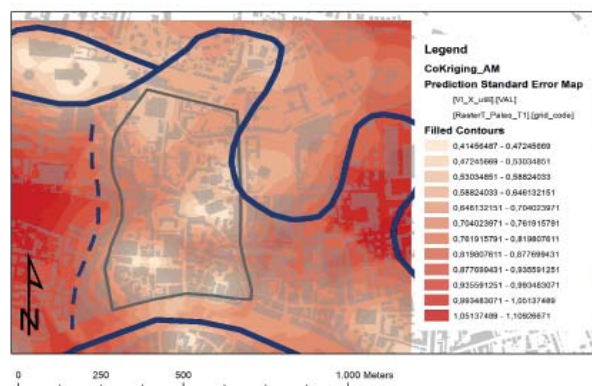


Fig. 3.14 The co-kriging validation map of the early medieval urban area: the lowest values (in white) refer to areas where prediction is most reliable.

became more a worship area and less a residential area, taking on suburban features which it kept throughout the Middle Ages. Indeed, from the VIII century, the material interests of the church

⁷⁴ Located in the area of current piazza dei Cavalieri (REDI 1991: 81). The toponym attested since XI century is related to the presence of the *curtis* of the Lombard gastald (GARZELLA 1990:60).

⁷⁵ SCIUTO C. 2012, *Intervention records nos. 94,95*, in MappaGIS; CORRETTI, VAGGIOLI 2003. This was probably close to the bend of the *Auser* and subjected to its overbanks.

⁷⁶ LA ROSA 2012, *Intervention record no. 4*, in MappaGIS.

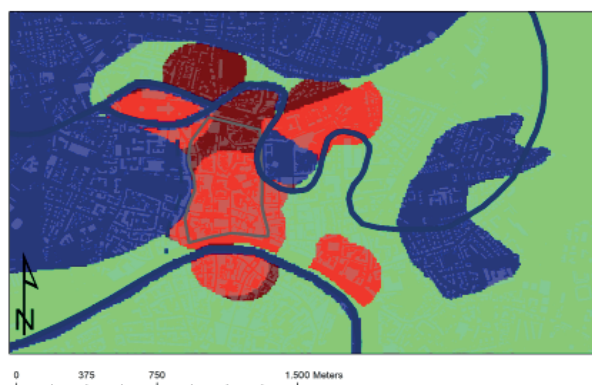


Fig. 3.15 The functional areas, related to the long period spanning from the VI to the X century, algorithmically created using the MAPPA algorithm: the urban area is indicated in orange, the suburban area in brown, the rural area in green, and the marshy areas and rivers in dark blue.

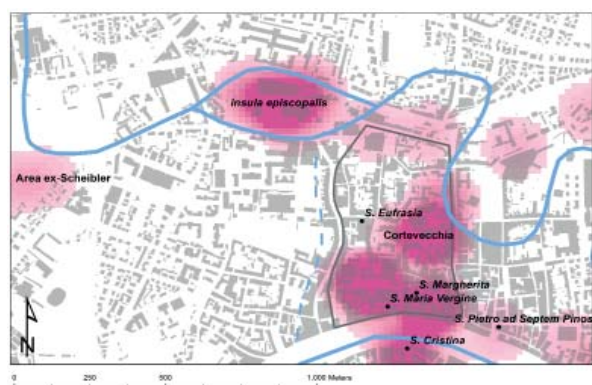


Fig. 3.16 Overlapping between the churches attested during the VIII century and Kernel Density Estimation.

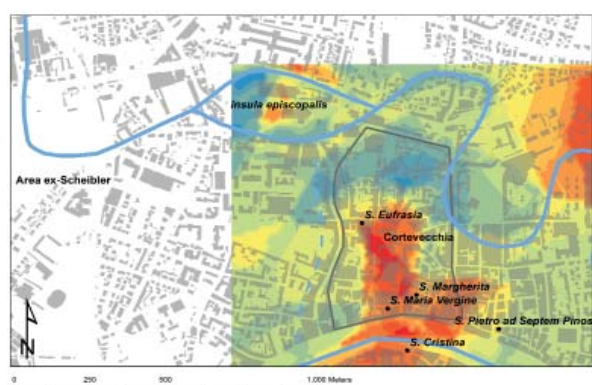


Fig. 3.17 Overlapping between the churches attested in the VIII century and the co-kriging interpolation.

of Pisa were carried on at the Episcopal church of Santa Maria (i.e. the cathedral) (GARZELLA 1990:20). To the east of the *civitas*, along the initial stretch of via Calcesana, a small settlement probably revolved around the church of San Pietro ai Sette Pini. To the south of the city, on the left of the Arno River, a settlement arose in the strategic crossing point of the Arno, where continuity between the V-VI centuries may only be presumed, attested by residual ceramic materials⁷⁷ and by the presence of the church of Santa Cristina in the VIII century. Finally, uncertain data allow us to conjecture the presence, at least until the VII-VIII (?) century, of a small settlement to the west of the city at the former Scheibler area⁷⁸, along the left bank⁷⁹ of the western branch of the *Auser* River, where iron works were probably carried out and abandoned due to the change in the hydrogeological conditions which produced the vast marsh of Pisa. If we observe the position of the iron manufacturing areas, with respect to the river courses, it is possible to imagine a course that once took the raw material needed for manufacturing the iron along the river both to the settlement at the former Scheibler area and inside the city. While it is chronologically probable that the situation described started from the second half of the VII century when Pisa, as attested by the trade exchange documented in the excavations in piazza del Duomo (COSTANTINI 2011) moved away from the Byzantine into the Lombard sphere, from a topographical viewpoint, these nuclei reveal the city's polycentric dimension in which the concept of centre and suburb merge, qualifying different spaces in spite of the walls, and coincide with the topographical division perceived at the time: *civitas*, the area surrounded by the walls, and the places outside them, *Foriporta*, *Borgo* and *villa di Chinzica*. The latter, possibly due to its physical separation from the rest of the city, was considered

⁷⁷ GATTIGLIA G. 2012, *Intervention record no. 589*, in MappaGIS; DUCCI *et alii* 2008a.

⁷⁸ LA ROSA L. 2012, *Intervention record no. 196*, in MappaGIS.

⁷⁹ In GATTIGLIA 2011 I had assumed that the settlement was on the right of the *Auser*. Thanks to recent geomorphological studies, I have been able to better define the course of this river and the position of the settlement.

a real open village, outside the city itself⁸⁰.

The city's residential buildings (§ 3.2.2) between the VI and VIII centuries were made of perishable material (wood or other material), with a masonry socle made with material recovered from buildings of the ancient city, bonded simply with earth, without mortar. The city road network is difficult to understand. *Selection by location* of possible medieval paths with kernel density pattern shows preferential road routes, with continuation of the Roman road network south towards Santa Cristina, the presence of a route that will later be called via Maggiore, archaeologically attested in the excavation of piazza Dante⁸¹, which reached the area of the *insula episcopalis* to the north, and a route to the north of the Arno River which, from the east, continued north along the old and partially inaccessible arteries of the Roman road network. The route of greatest interest is current via Ulisse Dini, which as well as supposedly being *via de fabricis* (ANICHINI, GATTIGLIA 2008), appears to follow the orientation of the new bend of the *Auser* River, making it possible to suppose that the route was actually built during the Early Middle Ages⁸². Technically, the roads (at least with regard to most ancient evidence⁸³) were built with paving stones, maybe partly taken from previous ancient paths. Examples such as piazza Dante, where the VIII-X century road network was built on the levelling of the Roman *domus*, show how the urban fabric changed; indeed, continuation of the road axes did not imply their maintenance in an urban environment where the buildings overlooking them are highly ruralised (BROGIOLO 2011).

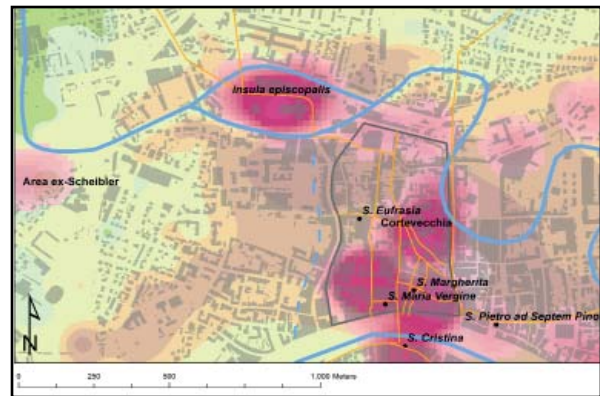


Fig. 3.18 Early-medieval preferential roads identified using 'selection by location' (in orange) among the possible medieval routes and kernel density.

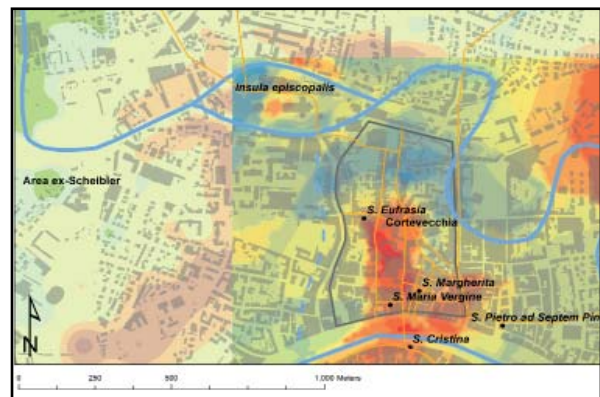


Fig. 3.19 Early-medieval preferential roads (in orange) overlapping the co-kriging interpolation.



Fig. 3.20 Early-medieval preferential roads (in orange) overlapping the functional areas calculated algorithmically.

⁸⁰ This sharp distinction between open village and fortified area created by the physical separation due to the Arno River could also be evidence of the loss of the bridge that connected the two riversides. Communication by boat between the two river banks could have strengthened the perception of separation between the two entities: the real city and the village.

⁸¹ GRASSINI F. 2012, *Intervention record no. 325*, in MappaGIS; BRUNI, MENCHELLI 1993.

⁸² As already perceived by REDI 1991:89.

⁸³ Piazza Dante (BRUNI, MENCHELLI 1993), piazza dei Cavalieri (ABELA, BRUNI 2000).

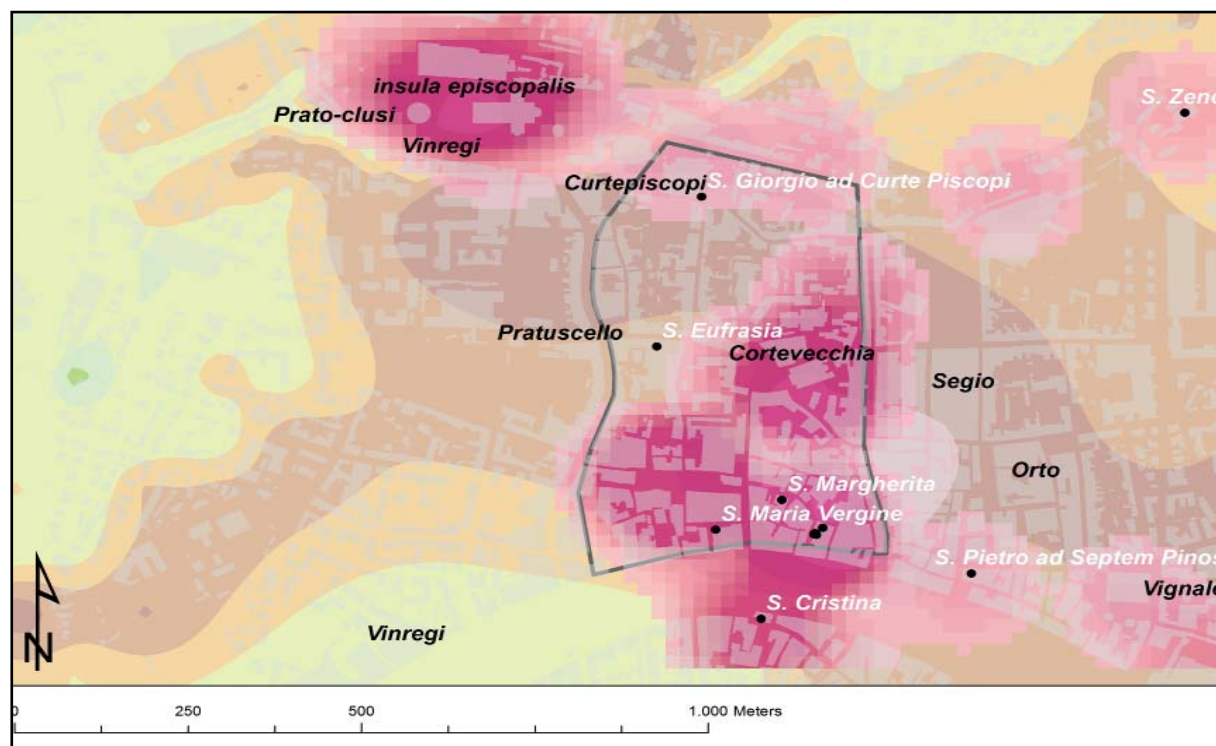


Fig. 3.21 The expansion of the urban area, from the IX century, associated with the presence of toponyms (in black) that seem to indicate improved environmental conditions. In white the churches attested in this period.

Between the IX and X century, Pisa (fig. 3.21) started its expansion influenced by the increase of its inhabitants and the improvement of the surrounding environmental conditions. In this period, religious buildings flourished and built small cemeteries close by: the church of Sant'Isidoro, in the city centre, the church of San Zeno⁸⁴, in the north-eastern portion of the settlement which was once the suburb of the Roman city⁸⁵, and probably a chapel near *Borgo* which developed during the second half/end of the X century outside the south-eastern corner of the walls⁸⁶. Overlapping, based on kernel density, of the churches attested in this period reveals a slowly evolving situation⁸⁷. The first novelty is the construction of the church

of San Zeno between the VIII and IX century. Its position, further away from the central settlement area, is related to the presence of a new and quite large agglomeration of people and to the improved environmental conditions. Written sources record the almost complete disappearance of other toponyms referring to this area, from the XI century, revealing the topographical importance of San Zeno in this area of Pisa. The second change regards the urbanisation – probably from the start of the X century – of the north-western part of the *civitas* determined by the presence of the church of San Giorgio *ad Curte Piscopi*⁸⁸, and especially of the *curtis dominicata*, the centre of the Episcopal land administration, which moved from the previous

⁸⁴ The Church already existed in the VIII-IX century (FEBBRARO 2011), the monastery is attested in written sources since 1029 (GARZELLA 1990:69).

⁸⁵ In 1029 it was reported to rise in *loco et finibus ubi dicitur Civitatae Vetera* (GARZELLA 1990:69).

⁸⁶ I am referring to a chapel that existed before the monastery of San Michele in *Borgo* (GARZELLA 1990:68).

⁸⁷ A written document dated between the end of the X and very beginning of the XI century shows that the church of San Pietro had lost its religious function in these years and was simply a *casalino* (hut) (GARZELLA 1990:17). This must not lead us to believe that the population surrounding this building decreased, since the church of San Pietro in Vincoli, which replaced the previous church of San Pietro ai Sette Pini, is mentioned a few years later, from 1018.

⁸⁸ Attested in written sources from 934 (GARZELLA 1990:20).

premises at the Episcopal church of Santa Maria to this area⁸⁹ during the first decades of the X century, (GARZELLA 1990:20). We do not know to which point these two facts were related together, but archaeological sources, exactly between the second half of the X and start of the XI century, refer to the construction of the new cathedral with three naves (ALBERTI *et alii* 2011a). It is difficult to understand the amount of these agglomerations, however, material sources reveal that changes took place, leading to an increase in the population and greater economic and social differentiation.

Indeed, alongside structures partly built with perishable material (a sign of the continuation of the building practices of previous centuries), with earth and/or wood elevations resting on a stone socle and a roof made of schist slabs, the first residential buildings (§ 3.3.2) completely made of masonry started to rise. These were not particularly tall buildings and besides showing a greater diffusion of construction techniques previously used only for public and/or religious buildings and now affordable to private citizens, they underlined the shaping of a larger power elite. From an environmental viewpoint, the marshy areas began to retreat thanks to anthropic interventions, trenches and drainage systems, such as the *carbonaie* positioned along the western and eastern sides of the city. Mid-X century toponymy shows that marshy areas were no longer present in the western sector where the marsh of Pisa or *Paludozzeri* partly retreated, as attested by the toponym *Pratuscello* from 964, indicating the retreat of waters towards west perhaps also thanks to the *carbonaia* of via Santa

Maria attested from 978 (GARZELLA 1990:50), into which the southern branch of *Auser*⁹⁰ was probably deviated. It is therefore possible that the area of piazza Duomo ceased to be an island during this period. These lands were cultivated as vineyards during the second half of the X century, confirmed not only by the toponym *Vinregi*⁹¹, but also by a written document dated 978 (GARZELLA 1990:24) which confirms the presence of vineyards also in *Pratuscello*, thus attesting the definite conversion of marshy areas into agricultural lands. In the eastern sector, the construction of the church of San Zeno must have been connected to the improved environmental situation, which could be confirmed by both the toponym *Segio*, indicating building lands, i.e. reclaimed from the marshy areas – which, however, appears only in 1027 – (GARZELLA 1990:71), and the eastern *carbonaia*, it too mentioned later⁹² and probably used to convey the city deviation of the *Auser* to the Arno. Finally, it is possible to assume that the shifting towards north of the course of the *Auser* began exactly in this period making the river flow to the north of the San Zeno complex, as suggested by palaeogeographical data (BINI *et alii* 2013). The vicinity between the river and this religious building seems to be confirmed by the devotion to San Zeno, which from the VIII century appears to be associated with churches located close to watercourses, in remembrance of the episode which saw the basilica of San Zeno in Verona miraculously saved from a flood of the Adige (CECCARELLI LEMUT, SODI 1996:40). This new organisation of the territory led to the construction of the new road network connecting the area of San

⁸⁹ The area is still occupied today by the Bishop's residence, whereas the late medieval structures of the church of San Giorgio were identified by REDI 2001, in the southeastern corner of the Episcopal building.

⁹⁰ The toponym *Catallo* of Lombard origin, indicates the presence of a ditch, but could relate to the remains of a passage of the *Auser* at the foot of the cathedral area.

⁹¹ From *vinea regi*, attested from 964 (GARZELLA 1990:24).

⁹² The *carbonaia* to the east of the Late Roman walls is only mentioned from 1113 (REDI 1991:100; TOLAINI 1992:43). Given the presence of a *carbonaia* on the western side at least from the second half of X century, I think it right to assume that they were coeval and that the late attestation is only due to the casual nature of the written sources available to us.

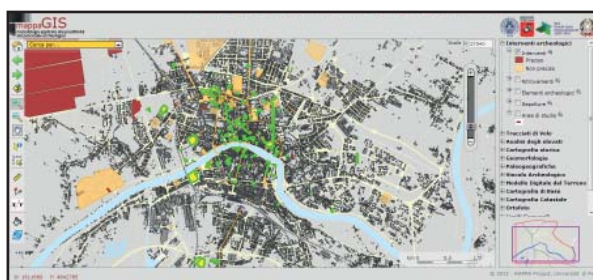


Fig. 3.22 The archaeological interventions which brought to light late medieval finds (in green), from the MAPPAGis (www.mappaproject.org/webgis).

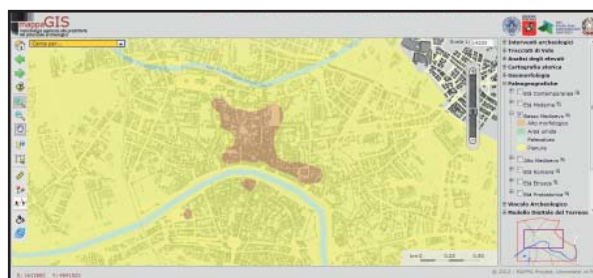


Fig. 3.23 Detail of the late medieval palaeogeographical map (from MAPPAGis www.mappaproject.org/webgis).

Zeno to the area of the new Episcopal *curtis*. From a material viewpoint, the excavations brought to light cobbled paving and/or paving stones. During the IX-X century, the city seemed to slowly expand and also lay the foundations for a new start. Ceramics show the presence of exchanges with the high-Tyrrhenian area and with the Campania-Lazio area; above all, however, the end of the X century saw the arrival of Mediterranean pottery.

3.1.3 The late medieval city

There are more data available to reconstruct the physiognomy of the city between the start of the XI and mid XIV century, compared to previous centuries, given that almost all the stratigraphic investigations reached deposits attributable to this period. The archaeological finds relating to the period recorded in the MappaGIS (fig. 3.22) are 519 overall, amounting to 24% of all finds

collected. Topographically, they are located in the northern-centre section of the area under study and are highly concentrated in the current city centre, where they are spread out quite evenly, with the exception of the western and south-eastern sector. With regard to the type of finds, the categories more greatly attested are *Areas for private use* (23%), attributed almost entirely to houses, for the majority tower houses, and to contexts which cannot be better interpreted, such as those relating to generic *Frequented areas* and to *Indefinite structures* which together amount to 21% of the total finds. *Infrastructures*, especially roads, squares and alleys, refer to 16% of finds; *Areas for public use*, almost entirely places of worship, to 10%; *Production areas*, represented for the most part by metal manufacturing, to 9%; *Natural contexts*, mainly marsh and overflow areas, to 7%; areas defined as *Non-places*, corresponding to contexts related to cancelling, abandonment and spoliation, to 5%. Smaller percentages of finds (4%) regard *Areas with military function*, mainly referred to the urban defensive system; *Agricultural/vegetable gardening areas*, corresponding mainly to vegetable gardens, and *Funerary areas* amounting to 2%. The late medieval palaeogeographical scenario (BINI *et alii* 2013) (fig. 3.23) was reconstructed in great detail, allowing us to highlight the palaeomorphology of the entire urban area. With general reference to the drained plain, higher and lower areas may be seen in the urban fabric. The more elevated area, which took shape during the previous period, developed in correspondence with the stretch where the two watercourses were the closest to one another. Subsurface data suggest that roughly along the current road network axis of via San Frediano, overbank deposits created a prominence transversal to the direction of flow; this elevation was certainly preserved and emphasized by the anthropic works connected to the development of the settlements from the Early Middle Ages. To the east and west, respectively, of this morphological high, two lows, in correspondence of the area west of via Santa Maria

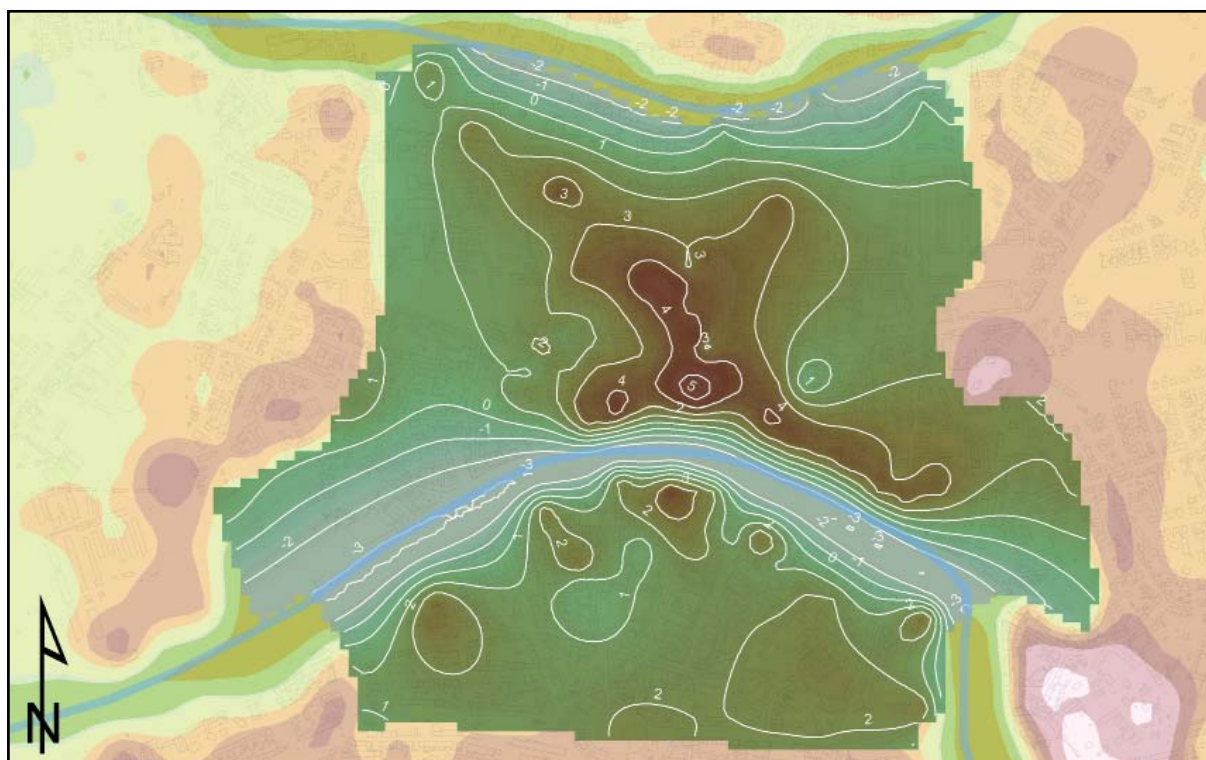


Fig. 3.24 The late medieval DEM of the urban area created using the ANUDEM algorithm; the centre, with the contour levels, is the most reliable area, created thanks to the elevation points collected during the archaeological investigations.

and east of the piazza Santa Caterina – via Fucini, via Verdi axis, represent the morphological trace of the two marshy areas described in the previous periods and well represented by the stratigraphic data. The reduction of the western wetland created a clearly marked stretch of the *Auser* riverbed along the current route of the Genoa-Pisa railway line, which favoured the channelling of flows to the north and west of the urban nucleus. Starting from the XI century, the urban course of the Arno River was the same as it is today, as confirmed by the excavation of Palazzo Scotti. Positive morphologies attributable to strips of intermeander bars may be seen behind the convex bank of the wide bend that the river makes in correspondence of the urban nucleus. The DEM (fig.3.24) relating to the urban area during the Late Middle Ages was completely changed compared to the previous one (GATTIGLIA 2012), thanks to a

greater number of elevations points and better references for the current ground surface defined from the LiDAR, using the ANUDEM⁹³ algorithm, instead of the kriging interpolation as previously done. The result provides a representation of a city that is clearly divided by the Arno River, with elevations included between current -1 m a.s.l. and + 5.6 m a.s.l. The northern part shows a central and irregular (elevation above + 3 m a.s.l.) relief, which stretches to the northeast until reaching the church of Santa Caterina, and to the northwest until reaching via Leopardi; to the southeast, after curving inwards as far as the church of San Frediano, it reaches the area of piazza San Giorgio, while to the southwest, after a wide bend, it arrives at the current area of via Gereschi/San Matteo. A slightly detached elevation above + 3 m a.s.l. is located at the Collegio Ferdinando. An elongated area (elevation above + 4 m a.s.l.) is visible in this

⁹³ Present in the ArcGIS software with the *TopoToRaster* tool.

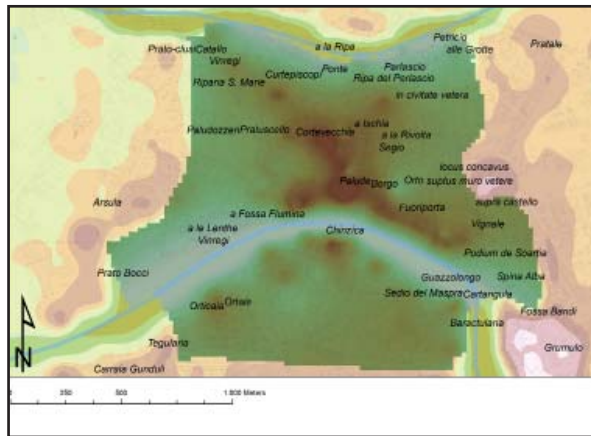


Fig. 3.25 The late-medieval DEM of the urban area with the main medieval toponyms (re-elaboration from GARZELLA 1990 and REDÌ 1991).

portion, oriented towards southeast/northwest which stretches from San Michele in Borgo to piazza dei Cavalieri and then descends with a bend down to via Cavalca. Two micro-elevations above 4 m a.s.l. are located in the area of the current Cassa di Risparmio bank in piazza Dante and the cloister of San Michele in Borgo. The highest part (height above + 5 m a.s.l.) is enclosed in a small area between piazza Sant'Omobono and the adjacent stretch of via Cavalca. Both the eastern and western areas are depressed areas: to the west, the depression gently descends until reaching + 1 m a.s.l., to the east, instead, a large inlet is formed between the church of Santa Caterina and via Gereschi, with the core situated at the church of San Paolo all'Orto. A depression can be seen here, reaching an elevation of + 1 m a.s.l.. It appears that during the Late Middle Ages the area of the Cathedral lost the topographical preeminence that had distinguished it during previous centuries (BINI *et alii* 2013). The southern area, south of the Arno River, is particularly characterised by depressed areas (minimum elevation 0 m a.s.l.; maximum elevation + 3.9 m a.s.l.), located immediately to the west of the church of Santa Cristina, where the 0

m a.s.l. contour line includes Lungarno Gambacorti entirely, and to the east of the church of San Sepolcro where the 0 m a.s.l. contour line includes Lungarno Galilei as far as Ponte della Fortezza. The highest areas (above + 2 a.s.l.) form a series of microelevations spread mainly along the bank of the Arno River. The main one, which reaches an elevation of + 3.90 m a.s.l., is situated around via Toselli, forming a triangle between the Logge di Banchi, to the east, via Mazzini, to the west, and piazza Gambacorti to the south east. Moving west, an elongated microelevation can be seen between via Sant'Antonio and via Mario, followed by another one at the church of San Paolo a Ripa d'Arno. To the west, a small elevation can be seen at Palazzo Scotto and a larger area between the church of San Martino, the Bastione Stellato of the Sangallo fortress and via Gori. An interesting depression, instead, lower than +1 m a.s.l. can be seen between via della Nunziatina, via Sant'Antonio and via Manzoni.

The course of the Arno River (fig. 3.25), therefore, was basically the same as today's with flooding in the depressed areas it encountered along its course, as in the area of the *Piagge*⁹⁴ and of *Guassolongo*, probably the trace of a Roman palaeochannel (BINI *et alii* 2013) that gave the name to the district itself. This environmental situation appears to have continued – albeit with some modifications – up to the period between the XI and first half of XII century, when the space of the *civitas*, by now too small for a settlement undergoing continuous economic expansion, required new building or cultivable lands. These were obtained by reclaiming previously inhospitable areas. In the eastern sector, the bend of the *Auser* River was cut by connecting San Zeno and Porta a Lucca⁹⁵; several drainage trenches were built between San Lorenzo alla Rivolta and San Pietro a Ischia and between San Michele in Borgo

⁹⁴ The toponym *Piagge* (shores), attested since 1078 on the right of the river between the churches of San Iacopo and San Michele in Ortocaria, refers (REDÌ 1991:19) to the sandy intake, deposited on the concave side of a meander by the centrifugal action of the current and periodically submerged by the river in flood.

⁹⁵ According to REDÌ 1991: 93, the *Auser* was corrected in the stretch to the north of the city by the end of the X century. In my opinion, the river was corrected before the construction of the walls.

and the depression to the east of San Paolo all'Orto and the *fossa bandi*⁹⁶, which drained the marshy area that had formed in the *locus concavus* area towards the Arno River. It is exactly in this area that the toponyms *Segio* and *Orto* appeared at the start of the XI century (GARZELLA 1990: 29). The former refers to the presence of building land (DU CANGE 1883-7: *sedes*) indicating that the area could be used as urban land. In the western sector, during the XI century, the *Fossa Flumine* was excavated, which from the *Auser* branch south of the Cathedral area, probably following the old course of its southern branch, drained into the Arno River. Its use ceased already at the start of the XII century⁹⁷, when the meander that brushed the Cathedral to the south, between Santo Stefano and Catallo, was most probably completely reduced, and when the cut to the north-west of the Cathedral, which reduced the course towards Madonna dell'Acqua, was carried out. The presence in this area of toponyms such as *a le Lenthe*, *Pratoclusi*, *Prato Bocci*, *Vinregi* and *Vinea Canti*, referable to an agricultural use of the area and also confirmed by the nearby excavation of via Galli Tassi⁹⁸, could be related to the presence of areas that had been gained but not yet perfectly suitable for building, as confirmed by the fact that the trench *Docaria*, also called *Cula*⁹⁹, which flowed to the northwest of the city, was active throughout the entire XII century. Cancelling of the *Fossa de flumine* (River trench) and the continuous use of the *Docaria* trench indicate continuation of the marshy area of *Paludozzeri* and at the same time its gradual departure from the city. Lastly, the *Breve* of 1287

reports the excavation of a trench from the *de Villani* bridge (over the *Auser* River to the northwest of the city) to the Arno River (CECCARELLI LEMUT, *et alii* 1994: 417-8). The wetlands of *Guassolongo* were gained along the left bank of the Arno River due to new urban needs, as attested by the embankment built at the end of the XII century on the western corner of Chinzica (GARZELLA 2006: 19; GATTIGLIA, MILANESE 2006), to which the toponym *Cartangula*¹⁰⁰ could be related. The existence of wetlands, up to the XI century and beyond, in the southern part of what will be the urban settlement of the Pisan *Comune* age is confirmed by the presence of wetlands in via Sant'Antonio, where the first settled areas are dated between the end of the XII and start of the XIII century. Overall, this hydrogeological situation, even after reclamation and river works, led to constant alluvial, groundwater rising and subsidence problems that can easily be seen in the archaeological stratifications. Although we do not have stratigraphic data about the 1117 flood of the Arno River, which devastated the first premises of the monastery of San Savino, not far from the church of San Giusto di Visignano (CECCARELLI LEMUT *et alii* 1994: 412-3), probably because its strength was lost in the countryside to the east of the city, the excavation at Palazzo Scotto¹⁰¹ (GATTIGLIA 2006: 130 ss) highlighted the presence of a consistent sandy level, characterised by ripple marks, which hit the entire area, forcing the elevation of the district to rise by 60/80 cm, dating back to the first half of XIV century and attributable to the 1333 flood¹⁰². Subsidence events are recorded for the

⁹⁶ The toponym *Fossabandi* is attested since 1034 (GARZELLA 1990: 6).

⁹⁷ The trench was probably cancelled by 1125 when a *via que dicitur Fossa de flumine* is mentioned (GARZELLA 1990: 147).

⁹⁸ LA ROSA L. 2012, *Intervention record no. 604*, in MappaGIS.

⁹⁹ Known from 1139 and still active in 1178 (CECCARELLI LEMUT *et alii* 1994: 417-8).

¹⁰⁰ Name of unclear origin which appeared at the end of the XI century and could be related to the physical conformation of the area, referring to the shape of the fluvial bend (almost an angle), in turn connected to the embankment found during the excavation at Palazzo Scotto and built at the same time as the church of Sant'Andrea in Chinzica as a safety measure for the new building so near to the river (GARZELLA 2006:19).

¹⁰¹ GATTIGLIA G. 2012, *Intervention record no. 367*, in MappaGIS; GATTIGLIA 2006.

¹⁰² In an attempt to avoid floods in the city, overflows were already provided during the 1300s that allowed the floods of the Arno to flow towards peripheral areas, however, it was only during the Medicean period that the overflow of Putignano (1558) and the overflow of Fornacette (1568) were built (CECCARELLI LEMUT *et alii* 1994: 414).

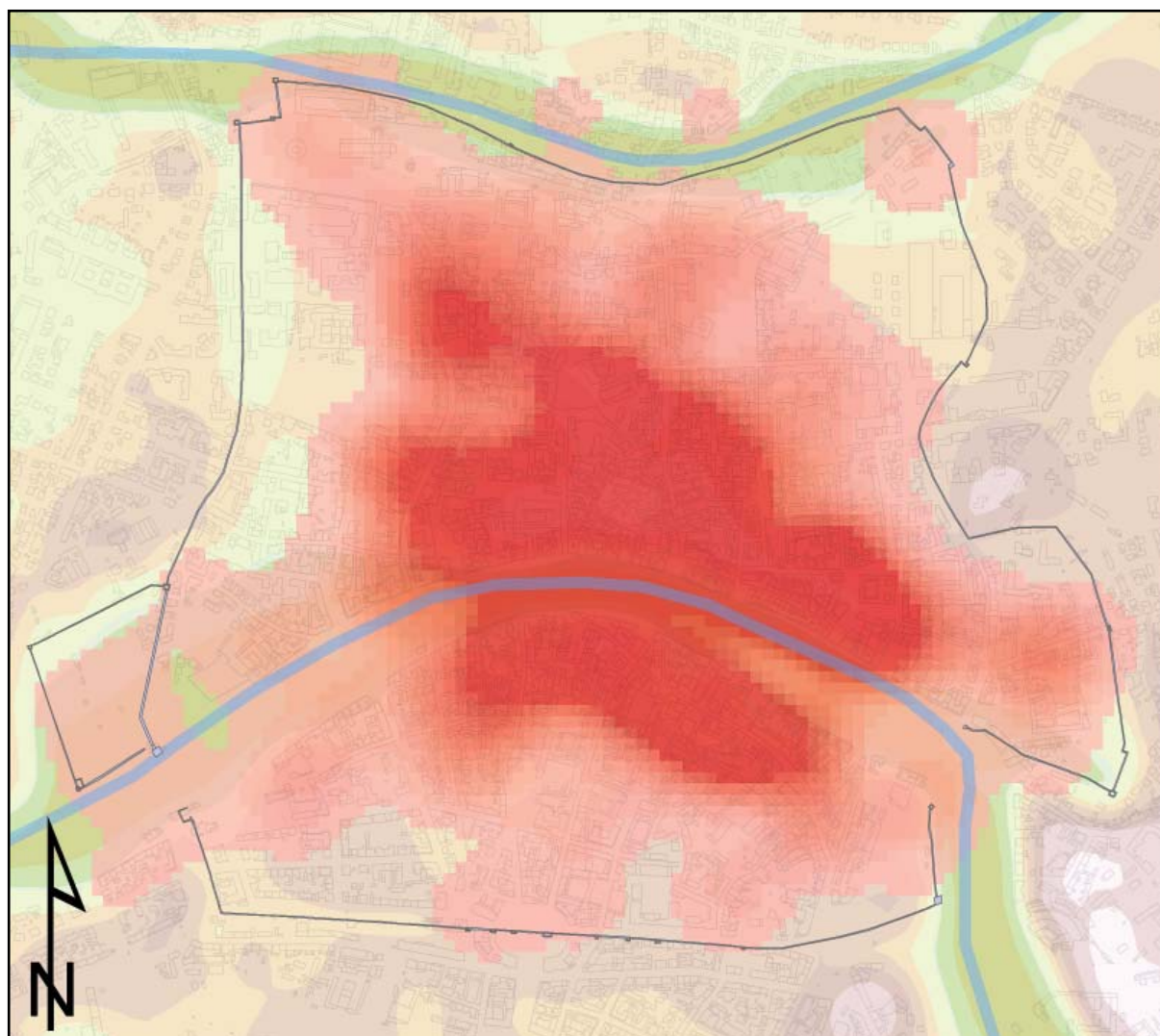


Fig. 3.26 KDE of the finds dated between the XI and XIV century, visualized as 1/4 Standard Deviation, overlapping the late medieval DEM.

same period in the church of San Lorenzo, where the flooring sank by 20-25 cm compared to the original plan and was raised by 50 cm to avoid groundwater rising (SANTUCCI 2005: 29). Extensive raising can also be seen in large construction works during the XI and XII century carried out mainly with draining materials as a response and/or prevention to these events (ALBERTI *et alii* 2006; ANICHINI, GATTIGLIA 2006; ANICHINI, GATTIGLIA 2008), as in the tower houses of via Toselli, for example (BALDASSARRI, MILANESE 2004).

Kernel density estimation (fig. 3.26) identified a greater density of finds in the central area to the north of the Arno River, in a triangle whose

vertices correspond to the area of San Matteo to the east, San Nicola to the west, and San Giovanni dei Tedeschi to the north. To the south, the area with the highest density is concentrated between the Arno to the north, the axis comprising via San Bernardo, via della Nunziatina and via Mario to the south, between via la Tinta to the east and via Sant'Antonio to the west. Density around these areas decreases until disappearing in several points close to the walls: this is due to the absence of finds in certain areas. The co-kriging geostatistical analysis (fig. 3.27), instead, allows us to interpolate the data also for places in which there are no finds. The scale assigned to the type of

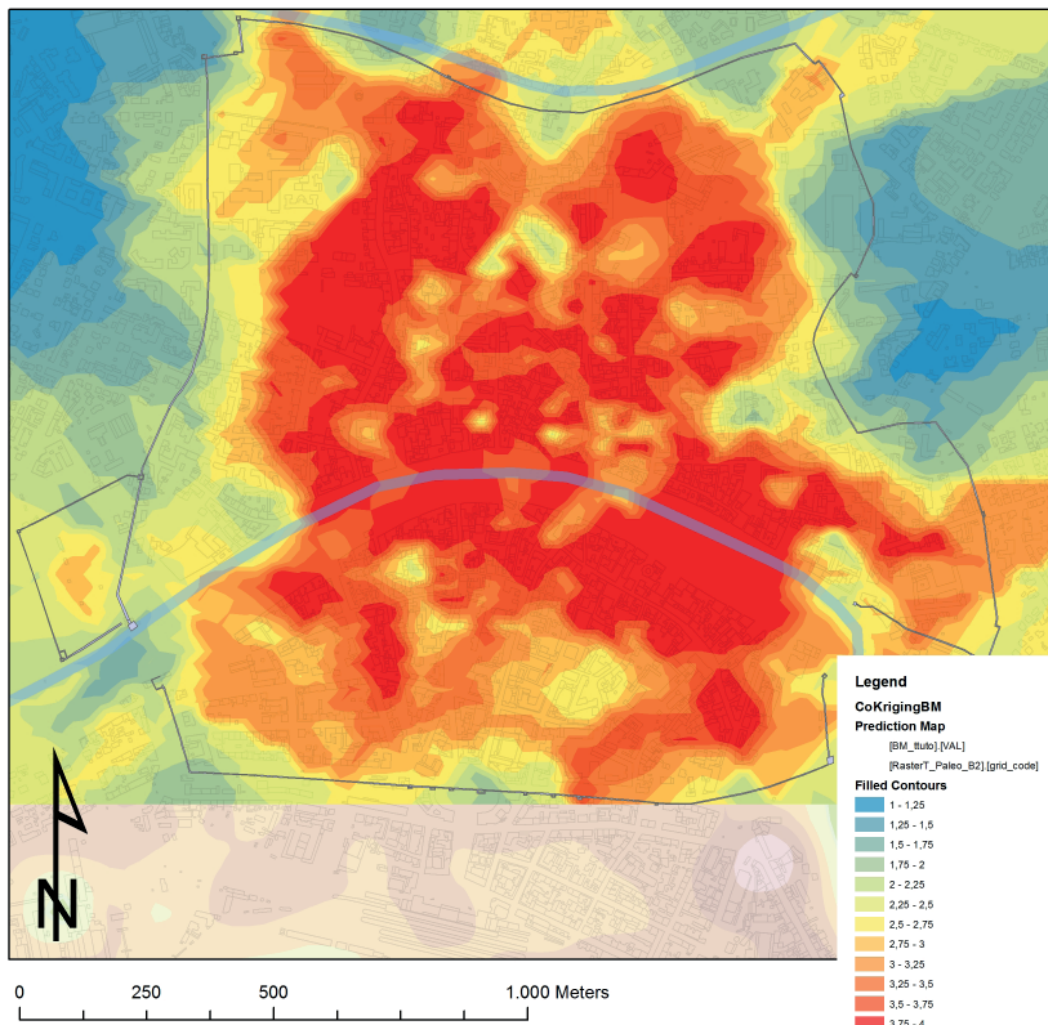


Fig. 3.27 The co-kriging interpolation showing the possible size of the following late medieval areas: urban (values between 3 and 4), suburban (values between 2 and 3) and rural (values below 2).

finds on the basis of the coefficient of their greater or lesser urban development value (§ 3.1.1) shows urban areas (red), suburban areas (yellow/orange) and extra-urban/agricultural areas (blue). The validation map (fig. 3.28) shows good prediction reliability in the area inside the walls and in certain extra-urban areas, especially western areas, but less reliability in the extreme eastern portion. The area to the north of the Arno River has a highly urban nature, as highlighted by the mathematical model too (fig. 3.29), surrounded by a suburban portion as far as the urban walls, where it takes on prevalent agricultural/vegetable gardening characteristics.

Even the area of piazza del Duomo has suburban characteristics given its specific cult nature and outer position, whilst the area of the Archbishop's residence has a more urban nature. The southwestern slope of the left bank of the Arno River – between San Vito and the Tersana (the dockyard) – is highly suburban, given its shipbuilding requisites, and situated outside the walls until the mid XIII century. Outside the walls, the initial stretch of the road network along via Calcesana, the area of Santo Stefano beyond the *Auser* River and the area of Fossabanda are suburban. The district of Chinzica, to the south of the Arno, reveals an urban strip along the river

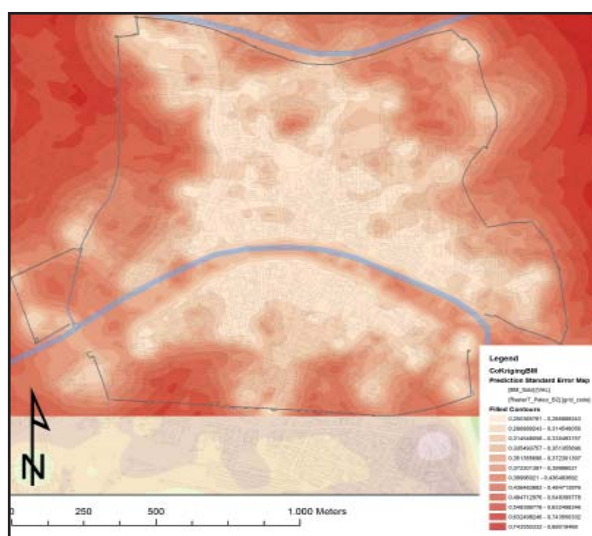


Fig. 3.28 The co-kriging validation map of the late medieval area: the lowest values (in white) refer to areas where prediction is most reliable.

over via San Martino/via Toselli, whilst the remaining part characterised by workshops, such as those of the area of Palazzo Scotto¹⁰³ and via Sant'Antonio¹⁰⁴, and by monastery structures, such as those of San Paolo a Ripa d'Arno, has a suburban nature. The extent of this strip confirms the lasting status of Chinzica as a *villa* and the late completion of the walls. The *extra moenia* areas, with the exception of the few suburban areas neighbouring the walls, have a clear agricultural character. The spatial analyses describe the conclusion of an ongoing expansion process, more linear compared to the Early Middle Ages, which commenced between the end of the X and start of the XI century. This expansion led to a gradual increase, between the XI and XII century, in religious buildings

(including the current cathedral) and to the construction of the city walls, which started on the northern side during the mid-XII century and was completed to the south and to the west during the XIII century. An outburst of city constructions may be seen in this period, which produced a greater concentration of residential space in the city centre and continued up to the XIV century until coming to an end during the next century. If we compare the IX-X century city with existing churches during the XI century, it is possible to notice how the urban area mainly expanded towards east, both to the north of the Arno River, filling up nearly all the spaces included within the Late Roman walls¹⁰⁵ - the *civitas* of the written sources - and expanding to the east of these, and towards south, in the *villa* of Chinzica, where the city developed, again eastwards, along the route of the *carraia maggiore* (current via San Martino). Eastern expansion to the north of the Arno River, particularly during the second half /end of the XI century, favoured by the gradual reclamation of the regained areas, was carried out at the expense of the lands abandoned during the Early Medieval Age. An inhabited area with typical urban features quickly rose in the portion closer to the *civitas*, which, starting from the start of the XI century was called *Borgo* (GARZELLA 1990:68). The foundation of Sant'Andrea in Chinzica in 1095¹⁰⁶ reveals how the entire left bank of the Arno River to the east of Santa Cristina was urbanised¹⁰⁷ at the end of the XI century and Chinzica was the city's second development area. The construction of buildings in the central area, in via Toselli¹⁰⁸/via dei

¹⁰³ GATTIGLIA G. 2012, *Intervention records nos. 264, 367*, in MappaGIS.

¹⁰⁴ CAMPUS A. 2012, *Intervention records nos. 744/783*, in MappaGIS.

¹⁰⁵ In chronological sequence, on the basis of their first attestation: San Pietro in Cortevicchia (1027), San Filippo dei Visconti (1030), San Simone al Parlascio (1039), San Martino alla Pietra del Pesce (1066), Santi Felice e Regolo (1070), Santi Giusto e Clemente al Parlascio (1071), San Sebastiano alle Fabbriche Maggiori (1074), San Bartolomeo degli Erizi (1079), San Clemente (1085) and San Sisto in Cortevicchia (1087) (GARZELLA 1990:59-68).

¹⁰⁶ GATTIGLIA G. 2012, *Intervention record no. 367*, in MappaGIS.

¹⁰⁷ Over the subsequent century, the churches of San Sebastiano (1111), San Lorenzo (1127), San Sepolcro (1138), and the hospitals of San Sepolcro, San Martino and Sant'Andrea were added (GARZELLA 1990:155ss).

¹⁰⁸ GATTIGLIA G. 2012, *Intervention record no. 589*, in MappaGIS.



Fig. 3.29 The functional areas, related to the period ranging between the XI and XIV century, algorithmically created using the MAPPA algorithm: the urban area is indicated in light red, the suburban area in dark red, the rural area in white, and the rivers in dark blue.

Facchini¹⁰⁹ and via degli Uffizi¹¹⁰, is the archaeological demonstration of this urbanisation process. The construction of the city walls marked the culmination of the concept of the city by the inhabitants of Pisa themselves. The expansion process of the city, with respect to the restricted and partly no longer visible boundaries of the Late Roman walled city, began and strengthened during the first half of the XI century, as attested by the treaty of friendship entered into with Amalfi in 1126, in which the three main urban nuclei were together called *populus Pisanus et Kinthicanus et Foriportensis et de burgi eorum* (GARZELLA 1990:152). The occupation of urban spaces was practically concluded during the first half of the XII century and, alongside creating a true community, the construction of the urban walls also arrested the city's expansion. The walls enclosed a space larger than that actually built.

They left room for possible expansion (which was never used) and also a sort of vital space with lands partly used for vegetable gardens and for the conservation of the XII century power elite. The walls were built between 1154 and 1161 in the northern part in seven subsequent lots (MARAGONE *Annales*; GARZELLA 1990:161-165; REDI 1991:140-147). The works started from the cathedral. Between April 1156 and 1 January 1157, the walls running from San Zeno to the Calcesana gate were built and at the same time navigable canals were excavated to allow easy transport of the *petras pro muris* from the quarries of San Giuliano to the area of San Zeno. The stretch of the *Parlasci* gate was built in 1157. By 1161, *tota civitas* was surrounded by walls, apart from Chinzica which was protected by the ditch and the wooden defences built in 1156 *turribus et castellis et britischis* (GARZELLA 1990:182-3). Whilst we have sufficient information about

¹⁰⁹ LA ROSA L. 2012, *Intervention record no. 61*, in MappaGIS.

¹¹⁰ CAMPUS A. 2012, *Intervention records no. 489, 602*, in MappaGIS.

the construction phases of the northern section, the walls of Chinzica are a more complicated issue. According to written sources (GARZELLA 1990:182-3), the works for the completion of the city walls were resumed in 1164, but were discontinuous: at the end of the XII century, the walls were apparently still missing in the San Martino area, in 1242 they reached Porta Sant'Egidio, in correspondence of the *carraia Pontis Veteres*, however, they were missing slightly to the west, in the Santi Cosimo e Damiano area; in 1288, according to the Statutes, the *muros civitatis ex parte Kinthice* [...] *jubi complendum restat* still had to be completed, although the exact part was not specified. Archaeological data give us a clearer idea, especially the intervention at Degazia Nuova¹¹¹ and at the Sant'Egidio gate¹¹². Archaeological and written sources seem to suggest that the walls started to be constructed (nothing is known about the exact time span) from the two opposite ends and that they were almost completed probably within the mid-XIII century, with the exception of the areas mentioned in the Statutes (the stretch of walls between Santi Cosimo e Damiano?), probably completed towards the end of the century. During the XIV century, in addition to maintenance works, construction was resumed and monumentalisation interventions were carried out, such as Porta Sant'Egidio. The walls enclosing the Terzana were also built during the second quarter of the XIII century. They were raised and strengthened between the end of the XIII century and mid-XIV century, when the Republican dockyards were also built¹¹³.

The co-kriging interpolation and the analysis carried out with the mathematical model clearly show the restricted space of the urban area compared to the space within the city walls: the urban area

(red) reveals an extremely dense urban settlement area, which can easily be seen in the urban and architectural transformation, with the occupation of new settlement areas, the construction of tower houses and the cramming of buildings in already occupied areas. Urban development in this period did not have rules, clear evidence of an economic resurgence and real building boom. From the end of the X century, the city rapidly and stunningly expanded, thanks to the city's economic/commercial importance, clearly shown in the city's port traffic, for which renovation works were carried out from the mid-XII century, necessary following the sharp increase in trade. Indeed, although Tunisian, Sicilian and Spanish/Moroccan – and to a lesser extent Egyptian/Middle East – pottery can already be found on the internal market between the end of the X century and the first half of the XI century, it is from the second half of the XI – start of the XII century that the amount of imported artefacts considerably increased. During the XII century, on the one hand, the privileged routes towards the western Mediterranean were maintained, with an increase in trade from the Spanish and north African areas, on the other, with the arrival of Byzantine products (although with lower traffic levels), the routes towards the eastern Mediterranean and the relations with southern Italy and the coasts of the southern Adriatic were intensified. The sign of a greater organisation, but also of the need for building products, can be noted in the type of construction materials used; although a large amount of reused materials were initially employed (FEBBRARO 2011), from the end of the XI century, the limestone quarries of the Monti Pisani, whose importance as supply source is witnessed by the construction of the navigable canal up to San Zeno during the mid-XII century, and the organogenic Livorno *panchina*

¹¹¹ CAMPUS A. 2012, *Intervention record no. 226*, in MappaGIS; MILANESE 2004a.

¹¹² SCIUTO C. 2012, *Intervention record no. 180*, in MappaGIS; ANDREAZZOLI, MEO 2006.

¹¹³ FEBBRARO M., SUSINI F. 2012, *CA/CF U1789CA1, CA/CF U1789CF3, CA/CF U1789CF4, and CA/CF U1789CF7 records* in MappaGIS.

stone, a highly desired material thanks to its light weight, supplied the city's construction sites. The demand for new constructions, proof of the sharp increase in the population (only autochthonous or also attracted by the economic opportunities of a fast expanding city?), led to an incoherent urban development. The northern part of the city was the first to move towards a more regular development. This is witnessed by the mid-XII century transformation in the central area at current piazza Sant'Omobono¹¹⁴, where a large intervention was carried out, destroying the buildings less in keeping with this urban phase and at piazza dei Cavalieri, where the iron works ceased production and moved to suburban areas, and less invasive bronze productions were confined to more hidden areas. This process arrived a little later in the area of Chinzica, but the transformation was greater: from *villa* to a place of *civitas*. A disordered sequence of constructions can be seen from the start of the XII century which increasingly reduced any pre-existing open places. Then, during the XIII century, the urbanisation of the villa, that was completed between the end of the century and the start of the subsequent one, commenced, according to a division into lots which appears to be pre-arranged or based on specific lines and planning rules. Lots were created with the most important buildings overlooking the main roads, interrupted by alleys and narrow streets. This also happened in the more peripheral area of via Sant'Antonio, which started its urbanisation process from the end of the XII-start of the XIII century (Ducci *et alii* 2010). It was during this period that bricks started to be used, initially for important constructions, then as a common building material, as witnessed by the buildings in via Toselli¹¹⁵, via dei Facchini¹¹⁶, via Sant'Apollonia¹¹⁷ and the construction of

seven tower houses during the second half of the XIII century in the area of Palazzo Giuli¹¹⁸. The use of construction elements that could easily be found and transported and that were statically lightweight, easy to lay and less expensive than stone which, together with wood, had been the main building material up to that time, responded to the increasing demand for buildings yet at the same time was the propelling force of demand itself.

The ordered development of Chinzica was undoubtedly favoured by the low urbanisation of the previous period; the abundance of free space allowed its planning and made the area more desirable to the aristocratic classes, a sort of highly valued residential area around the church of Santa Cristina. Here, ceramic contexts, especially those of via dei Facchini, reveal that the inhabitants enjoyed a better lifestyle than those of the city centre where the middle classes of the craftsmen and the middle/high classes of the entrepreneurs and merchants prevailed. The search for residential space in initially peripheral areas, yet in the end highly urban, is also visible in the eastern sector to the north of the Arno River, behind the monastery of San Matteo, in via Gereschi¹¹⁹. Here, during the XII century, clients were forced to build their houses on the space left from pre-existing buildings if they wished to have a house in an exclusive city area. At the end of the XII - start of the XIII century, the city, therefore, underwent a gentrification process. Workshops, especially the more invasive and polluting ones, such as the metallurgic and ceramic workshops, moved from the city centre to the suburban areas. The same attention to urban decor cannot be found in the city's waste management, which up to the

¹¹⁴ SCIUTO C. 2012, *Intervention record no. 488*, in MappaGIS.

¹¹⁵ GATTIGLIA G. 2012, *Intervention record no. 589*, in MappaGIS.

¹¹⁶ LA ROSA L. 2012, *Intervention record no. 61*, in MappaGIS.

¹¹⁷ SCIUTO C. 2012, *Intervention record no. 92*, in MappaGIS.

¹¹⁸ GATTIGLIA G. 2012, *Intervention record no. 843*, in MappaGIS.

¹¹⁹ TARANTINO G. 2012, *Intervention record n. 603*, in MappaGIS.

XV century is basically¹²⁰ left to private citizens, with extensive use of alleys as rubbish dumps, also in environments inhabited by the urban elite, such as the alley of via dei Facchini¹²¹. Although we do not know whether, together with more strictly practical reasons¹²², the need was felt for a greater attention to urban décor, from the XIII century, road paving started to be made of bricks, thus replacing the old stone paving, which continued to be used for covering squares. The main areas used for agriculture/vegetable gardening were moved towards the borders and the partly rural XI-century landscape was replaced by an increasingly urban landscape, which maintained small green areas and vegetable gardens behind the tower houses¹²³.

3.2 The urban fabric

3.2.1 Religious spaces: churches and cemeteries

The importance in analysing urban religious spaces is connected to a wide range of social, economic and topographic facets. Investigating Christian topography provides an important interpretative key to reconstruct the spatial characteristics and transformations that took place in the city from the Late Roman period to the Middle Ages. To achieve this, we used all available sources (archaeological sources and written sources) and subjected them to GIS spatial analysis, bearing in mind the limits of this process. Archaeological

data are quantitatively limited and are often not able to provide a general and non-point overview, whereas written sources rarely report the dates of foundation. The first attestation of a building must consequently be regarded as a *terminus post quem* and data analysis, in their entirety, as a chronological and topographical trend. Finally, it is important to understand that it is difficult to georeference buildings that they no longer exist.

Early medieval churches, included in a much less coded urban context, acted as centres of agglomeration for the population, thanks also to their location along the main internal and external road network axes. Up to the VIII century, written sources document the churches of Santa Maria¹²⁴, Santa Cristina¹²⁵, San Pietro ai Sette Pini¹²⁶, Santa Margherita¹²⁷, Sant'Eufrasia¹²⁸, and Santa Maria Vergine¹²⁹.

Archaeological sources, at times quite difficult to interpret, document the construction of an unfinished cathedral¹³⁰ between the end of the X and start of the XI century, as well as the probable presence of an early-medieval baptistery (ALBERTI *et alii* 2011), VIII-IX century phases at San Zeno and an end-IX – X century phase for the church of Santa Cristina (FEBBRARO 2011). They also highlight a vast cemetery area in the area of piazza del Duomo, at the former Scheibler area, to the west of Pisa, in via Marche, and a more doubtful one in

¹²⁰ The city was provided with drainage and trenches that brought waste water outside the city, especially towards the rivers.

¹²¹ The most exclusive houses started to be provided with new comforts, such as cesspits, from the late XIV century, as attested at Palazzo Gambacorti (ANICHINI, GATTIGLIA 2008:140).

¹²² The XIII century marked the huge increase in the use of bricks in all building sectors, except for roofing. Excavation data show that residential buildings, such as the tower house of piazza Sant'Omobono (ANICHINI, GATTIGLIA 2006), and religious buildings, such as the church of Sant'Andrea in Chinzica (GATTIGLIA 2006) had a grey schist slab covering.

¹²³ The toponym *Orto* is symptomatic of this situation: in the XI century it was a vegetable garden area which became increasingly built up from the XII century onwards.

¹²⁴ The Episcopal Church was attested for the first time in 748 (GARZELLA 1990:14).

¹²⁵ Attested for the first time in 768 (GARZELLA 1990:14).

¹²⁶ Attested for the first time in 763 (GARZELLA 1990:15), for its location in the area upon which the church of San Pietro in Vinculis rose, see GARZELLA 1990:16ss.

¹²⁷ Attested for the first time in 765 (GARZELLA 1990:14).

¹²⁸ Attested for the first time in 780 (GARZELLA 1990:18).

¹²⁹ Attested for the first time in 780 (GARZELLA 1990:18).

¹³⁰ GATTIGLIA G. 2012, *Intervention records nos. 363, 608*, in MappaGIS.

the area of piazza Dante. By overlapping kriging and kernel density analyses referring to the Early Middle Ages and the location of the churches known in VIII century, it is possible to highlight their function as places of human agglomeration. If we overlap the position of the cemetery areas dated between the VI and VII century, we notice the presence of extra-urban funerary areas (former Scheibler area, via Marche), which were no longer used following VIII-century stabilisation of the urban area, when a marked north/south axis running from the church of Santa Cristina to the Episcopal area may be noticed. The transfer and migration of the cemetery areas clarifies the formation of a Christian topography, which is more clearly outlined from the VIII century (fig. 3.30). The area of piazza del Duomo started to take on the shape of a sepulchral area between the end of the V and start of the VI century (ALBERTI *et alii* 2011: 205), in conjunction with the termination of the necropolis in the north-eastern area (via Marche/via Galluppi). This concomitance of events could be related to the rising of a new worship-oriented topography associated with Christianity and especially with the creation of an important religious pole in the area of piazza del Duomo related to the *insula episcopalis*. The cemetery area coexisted with other housing structures and probably spread across the majority of the current square, enclosed by an earthen *temenos* identified close to Porta del Leone¹³¹. It was composed of a large strip with east-west orientation characterised by a

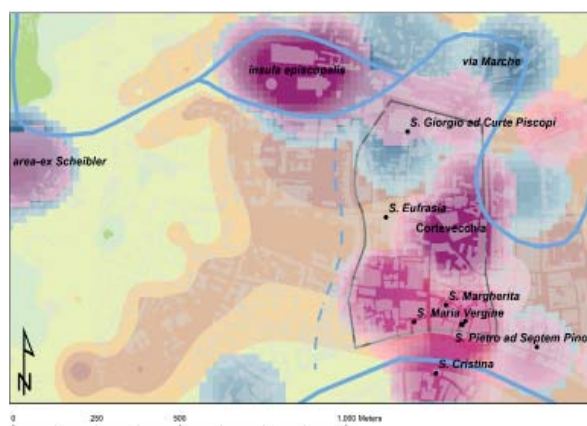


Fig. 3.30 KDE of VI-VII century (dark blue) and VIII-X century (fuchsia) finds. The two cemeteries of Via Marche and the former Scheibler area can be seen.

stratigraphic deposit consisting of a very high number of various sized tortoises¹³², edible animal bones (mainly sheep and pigs), sherds of unglazed cooking ware and some (not better specified) small coins (BRUNI 1995:172). Since more detailed study is missing on burials related to this cemetery phase, reference may be made to some of the burials found in the square: the burials at Porta del Leone where two earth-pit burials oriented towards east-west are documented as well as numerous highly devastated depositions regarding a series of burials included in a time span ranging from the Late Roman period to the end of the VII century¹³³. Some of these tombs used materials from the Roman city¹³⁴ and were probably covered by large tiles. The 'cappuccina'¹³⁵ burial, "formed of two 63x46 tiles with a double sloping roof, and two large bricks at the grave's head:

¹³¹ GATTIGLIA G. 2012, *Intervention record no. 357*, in MappaGIS.

¹³² The meaning of the presence of tortoises is to be sought in the funerary meaning of this animal both in the classical world, as demonstrated by the fact that the tortoise is associated with Hermes as a psychopomp animal connected to the afterworld, both in the Christian world, as attested for example by a number of Aquileian mosaics (BRUNI 1995:172-3).

¹³³ GATTIGLIA G. 2012, *Intervention record n. 357*, in MappaGIS. No further indications are provided as to their chronological attribution, which must therefore be considered with some caution.

¹³⁴ The burial ground was positioned above the falls of an Imperial building. Among the materials reused, a marble slab fragment with a Latin inscription dating back to the II century (according to the epigraphic characters) is worthy of note (SOPRINTENDENZA PER I BENI ARCHEOLOGICI DELLA TOSCANA, BRUNI 2013:6).

¹³⁵ 'Tomba a la cappuccina' is a tile-built tomb composed of a leaning tile roof covering the deceased who was laid on a tile floor.

evidently a child's grave attributable to the V-VI century [...]”¹³⁶, found to the south of the Camposanto Monumentale. Three earth-pit burials¹³⁷ found behind the cathedral apse with no grave goods, dating back to the V-VI century, which seem to coexist with the residential use of the area, whereas two earth-pit graves located in the southern portion of the piazza are also attributed to the VI century¹³⁸. The former is a simple earth-pit burial, the latter has a schist slab covering. This situation changed in the VII century with the arrival of the Germanic populations, when alongside the funerary area of piazza del Duomo, cemeteries in the area of via Marche and the former Scheibler area were also used. In via Marche¹³⁹, the cemetery (in use up to the V century) was partially reused between the VI and VII centuries (COSTANTINI 2007-2008: 160), when burials with grave goods attributable to Germanic populations may be seen. A necropolis is attested in the former Scheibler area¹⁴⁰, strongly damaged by ploughing and located in two sectors: north-eastern and north-western. It is composed of 30 earth-pit burial traces, the majority of which are simply traces of the graves characterised by a darker colour, and 5 stone-lined graves, one of which fully conserved. Almost all the earth-pit graves are oriented towards northwest-southwest, whilst the stone-lined graves have a northwest-southeast orientation, as well as at least two of the via Marche burials. The grave goods recovered are: fibula, bronze buckles and a bracelet belonging to the Lombard period. The only fully preserved grave has a rectangular structure made of sandstone and limestone blocks arranged in two rows, with squared inner sides, and the floor is made of brick fragments and small limestone blocks. The presence of mortar residue on the lithic

elements and bricks confirms that they were reused materials. This is the burial of a woman placed on her back with her arms along the body. The grave goods consist of a necklace made with pierced coins and glass paste beads. Another highly damaged stone-lined grave contained few grave goods consisting of a bronze needle and a bronze buckle with wool residues. The presence of Lombard grave goods suggests a VII century dating, whilst the different orientations of the burials, as already attested in the necropolis of via Marche, could refer to at least two phases of funerary depositions: a Late Roman phase, by similitude with the necropolis of via Marche, maybe connected to the earth-pit burials, and another phase linked to a partial reoccupation during the VII century and featuring stone-lined burials. These two necropolises outside the urban settlement could be explained by the existence of small inhabited areas, which did not survive the first phase of Lombard settlement. The former could be related to the road network exiting the city towards northeast, the latter with the presence of landing place along the *Auser* River connected to a possible productive area (see § 3.2.4.1). During the VII century, piazza del Duomo became increasingly used for cult and burial purposes in which stone-lined graves began to be used¹⁴¹, some of a privileged nature with grave goods ascribable to military figures. This use is associated (although it is difficult to say how sporadically) with the search for building materials, whilst the residential structures still existing during the previous phase disappeared. We can retrace this vast cemetery in several burials which came to light since the end of 1940s. Two stone-lined tombs¹⁴² were located immediately to the south of the Camposanto Monumentale, placed against the

¹³⁶ Firenze SBAT ref.pos9Pisan.274/42.

¹³⁷ TARANTINO G. 2012, *Intervention record no. 356*, in MappaGIS; ALBERTI, BALDASSARRI 1999.

¹³⁸ TARANTINO G. 2012, *Intervention records nos. 369, 371*, in MappaGIS.

¹³⁹ LA ROSA L. 2012, *Intervention records nos. 421, 474*, in MappaGIS.

¹⁴⁰ LA ROSA L. 2012, *Intervention record no. 196*, in MappaGIS.

¹⁴¹ The analytical study of 5 of these tombs is published in ALBERTI *et alii* 2011: 209ss. These are two burials found by Sanpaolesi and Tombs C, D, E found in 1998.

¹⁴² TARANTINO G. 2012, *Intervention record no. 28*, in MappaGIS.

masonry of a Roman building, with grave goods dating back to the VII century. The quality of the grave goods associated with the burials reveals a high social class. A Lombard burial was also found¹⁴³ in the area east of the left transept of the cathedral. The burial is partly devastated but still preserves the bronze parts of a belt (buckle and tip). However, it is the entire south-eastern area that includes a large amount of burials. Two stone-lined burials¹⁴⁴ with squared stone blocks dated between the beginning and end of VII century, were found behind the current apse of the cathedral. One of the burials (Tomb E, former burial 7), brought to light a Constantine IV half *folles*¹⁴⁵ in a circular cavity in the stone, which can be related to the Charon's obol custom, frequent in Imperial depositions and typical of Roman or Romanicised cultures, which could be related to the fact that the coin is a Byzantine nominal issued by the mint of Rome. The grave goods of the other graves refer to male burials, including Tomb C (former burial 4), which contained a bone comb, an apotropaic element typical of both male and female depositions, as also evidenced by the grave goods of the second burial in the area south of the Camposanto Monumentale. A monumental grave was found close to the current baptistery (ALBERTI *et alii* 2011: 221ss), including three depositions. The first related to a male of around 20 years of age with abundant grave goods composed of a golden cross and two silver buckles probably belonging to the city elite. In the area between the apse and the transept of the current cathedral,

further three stone-lined burials are attested¹⁴⁶ probably dating back to the VII century: the first is delimited by stones and covered by slabs placed adjacent to one another; the second is a sarcophagus burial, without cover; the third is covered by small overlapping slabs and a chest made of large slabs placed adjacent to one another. Lastly, in the southern part¹⁴⁷ of the current square, a stone-lined grave was identified dating back to the VII century. The graves with the wealthiest grave goods are located in the northern part of the square and this could depend on the position of the depositions with respect to the *ecclesia cathedralis*. The grave goods of the most distant burials, as also those found behind the current apse of the cathedral, only include a few personal items. Where were the church and the *insula episcopalis* located? Written sources attest the presence of the Episcopal church of Santa Maria from the mid-VIII century, whereas the first attestation of the baptistery dedicated to San Giovanni Battista¹⁴⁸ is most recent by two centuries. Although the data on the cemetery areas allow us to assume that the Episcopal area already existed in this sector at the end of the V-beginning of the VI century, it is much more difficult to understand if certain finds refer to the material traces of the buildings connected to it. Especially the building discovered during the excavations carried out during the mid-1930s (NICCOLAI *et alii* 1942), with octagonal layout and an apse on the east side, located inside the lawn of the Camposanto Monumentale¹⁴⁹ (fig. 3.31). These remains were attributed by SANPAOLESI

¹⁴³ TARANTINO G. 2012, *Intervention record no. 23*, in MappaGIS.

¹⁴⁴ ALBERTI, BALDASSARRI 1999; ALBERTI *et alii* 2011: 220.

¹⁴⁵ Imperial chronology allows dating to the last quarter of VII century.

¹⁴⁶ TARANTINO G. 2012, *Intervention record no. 28*, in MappaGIS; STIAFFINI 1985.

¹⁴⁷ TARANTINO G. 2012, *Intervention record no. 372*, in MappaGIS.

¹⁴⁸ The first attestation in written sources dates back to 953 (GARZELLA 1990: 19).

¹⁴⁹ The wall reveals a double face with core masonry with an external facing and corners, apart from the apse, in squared ashlars of white San Giuliano stone, Caprona conglomerate, travertine, tuff stone and other materials from the Monti Pisani, all worked with a *subbia* (pointed chisel), arranged along quite regular course and an internal brick face. The apse is made of brickwork and abuts on the octagonal structure; it was therefore built after the original octagonal layout. The foundations, instead, are made of irregular medium-sized quarry waste, mainly of white San Giuliano limestone, together with rare brick fragments, held together by mortar. The presence of heterogeneous lithotypes suggests the use of reworked elements.

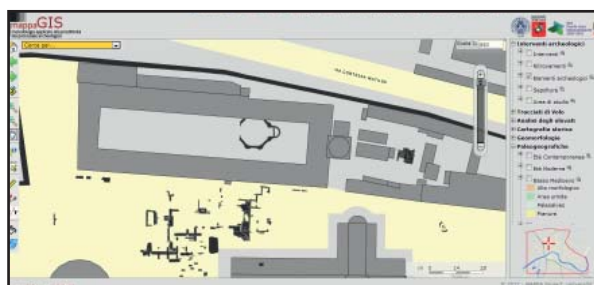


Fig. 3.3I The octagonal building found inside the *Camposanto Monumentale* (upper centre), in relation to all the other structures found in the northern area of piazza del Duomo (from MAPPAGis www.mappaproject.org/webgis).

1956-1957 to a baptistery and subsequently dated by PANI ERMINI 1985 to the V-VI century, whereas QUIROS CASTILLO 2005 believed the building to belong to the second half of the XIII century, attributing it to the funerary church of Santissima Trinità. ALBERTI *et alii* 2011, in the light of the reopening of the 1930s' excavation, proposed a new reading of the structures. They directly measured the thickness of the bricks and presented results (still to be published) on the thermoluminescence analysis carried out in 1998 on a brick that was produced within the X century. Brick productions prior to the XI century, however, give rise to many doubts. In GATTIGLIA 2011, I tended to attribute the structures to the baptistery, accepting the dating proposed by PANI ERMINI 1985 and still considered valid as generally related to the presence of an Episcopal area. In the current state of knowledge, however, I do not believe it entirely feasible to attribute the structures inside the Camposanto Monumentale to the Late Roman baptistery and, in general, to establish a definite attribution. Thermoluminescence analysis, the results of which are yet to be published, was carried out on a too narrow sample, consequently, the doubt that it may be a reused element still remains. Furthermore, dating within the X century presumes a very early production of bricks of which we have no information. The bricks used in the apse of Santa Cristina, which dates back to the

same period, are reused elements. X century dating is instead confirmed by the first mention of the baptistery of San Giovanni Battista dated 953 (GARZELLA 1990: 19). Even mensiochronological dating does not provide definite evidence, there are no curves relating to local or regional late Roman/early medieval bricks, and even the late medieval curves are not fully reliable. The building technique featuring a base in blocks and elevation in bricks may be compared to other mid-XIII century religious and civil constructions. Therefore, although these structures cannot be definitely attributed to one of the buildings of the late Roman/early medieval Episcopal area, archaeological data highlight a general "requalification" of the area aimed at cancelling the remains of the *domus* by the mid-VI century (ALBERTI *et alii* 2011:203). The location of the graves belonging to the city elite leads us to assume that the Episcopal church and the baptistery were located in the northern area of the square, to the north of the Roman road network. A public Roman area may have been located in this portion of the square (FABIANI *et alii* 2013a), possibly connected to an urban port, which could be confirmed by the evangelisation of the city via sea and, archaeologically, by the Bishop's palace which rose in the port sector of Luni. If we were to attribute the structures inside the Camposanto Monumentale to a late Roman/early medieval baptistery, the two buildings were probably on the same axis, according to a layout that continued over the next centuries and attested from the IV century in Florence, Novara, Aquileia, Torcello and Piacenza (PANI ERMINI 1985:18). The excavations of the last decade¹⁵⁰, which re-explored the 1940s trenches, exclude the presence of an ecclesiastic building dating back to the VI century in the area south of the Camposanto Monumentale, since during this period the area was occupied by houses in perishable material. The excavations

¹⁵⁰ GATTIGLIA G. 2012, *Intervention record no. 363*, in MappaGIS.

only identified the presence of an IX-X construction phase, connected to the construction of the pre-Buscheto cathedral.

Between the VIII and X century, the city flourished with religious buildings next to which cemeteries were built. Spatial analysis, with the overlapping of the churches attested in this period (fig. 3.24), shows a rather static situation compared to the previous. The only new element is the construction of the church of San Zeno¹⁵¹, in the north-eastern area of the settlement, once part of the Roman city's suburb. The first phase of the church is attributed to the VIII-IX century, based upon the building techniques, whereas the excavations carried out inside¹⁵² with non-stratigraphic methods do not provide a clear definition of the chronological span (FEBBRARO 2011) (fig. 3.32). Its more remote location, far from the main nucleus, can only be related to the presence of a small-sized agglomeration of people. Starting from the XI century, written sources record the almost complete disappearance of other toponyms that indicate this area, hence defining its topographic importance in this suburban portion of the settlement (GARZELLA 1990:10). In the central area of the city, a large burial ground characterised the area of current piazza Dante between the IX and X century¹⁵³, suggesting a rather sparse settlement. The cemetery must have been connected to a nearby religious building, maybe the church of Sant'Isidoro¹⁵⁴. The first building phase, consisting of split and roughly squared Verrucan stone wall, random coursed, bonded with mortar, was



Fig. 3.32 The structures found inside the church of San Zeno which can be georeferenced and the record with summary data on the main construction phases (from MAPPAGIS www.mappaproject.org/webgis).

attributed to the IX-X century¹⁵⁵ (REDI 1993:200). A large cemetery was positioned even around the Episcopal church, in piazza del Duomo, during the VIII and IX centuries, as documented by the earth-pit burials found behind the apse of the current cathedral¹⁵⁶. As proposed by FEBBRARO 2011, the construction of these religious buildings required the availability of skilled manpower, which operated, however, occasionally throughout the territory and was connected to the city elite and their need to represent themselves through these buildings. In terms of building techniques, the skilled workers employed reused building materials and/or gathered materials, as attested by the masonries of the church of San Zeno and its topographical location near the toponym *Petricio*. Construction activities flourished between the end of the IX and start of the X century. The most important building site was the construction of the new cathedral, previous to the one of Buscheto and positioned south of the current Camposanto Monumentale. Archaeological deposit¹⁵⁷ witnesses a building site project (ALBERTI *et alii* 2011a: 243),

¹⁵¹ The first attestation in written sources dates back to 1029 (GARZELLA 1990:10).

¹⁵² LA ROSA L. 2012, *Intervention record no. 69*, in MappaGIS; REDI 1991:77-80.

¹⁵³ GRASSINI F. 2012, *Intervention record no. 325*, in MappaGIS; TARANTINO G. 2012, *Intervention record no. 326*, in MappaGIS.

¹⁵⁴ The first attestation in written sources dates back to 1030 (REDI 1993); GRASSINI F. 2012, *Intervention record no. 325*, in MappaGIS.

¹⁵⁵ Bedding trenches were not excavated so dating is assumed on the basis of the presence of the nearby cemetery area (IX-X century) and of building techniques (BRUNI, MENCHELLI 1993:168-169). According to others, instead, it dates back to the X-XI century (FEBBRARO 2011: 553).

¹⁵⁶ TARANTINO G. 2012, *Intervention record no. 356*, in MappaGIS.

¹⁵⁷ GATTIGLIA G. 2012, *Intervention records no. 363, 608*, in MappaGIS; ALBERTI *et alii* 2011a.

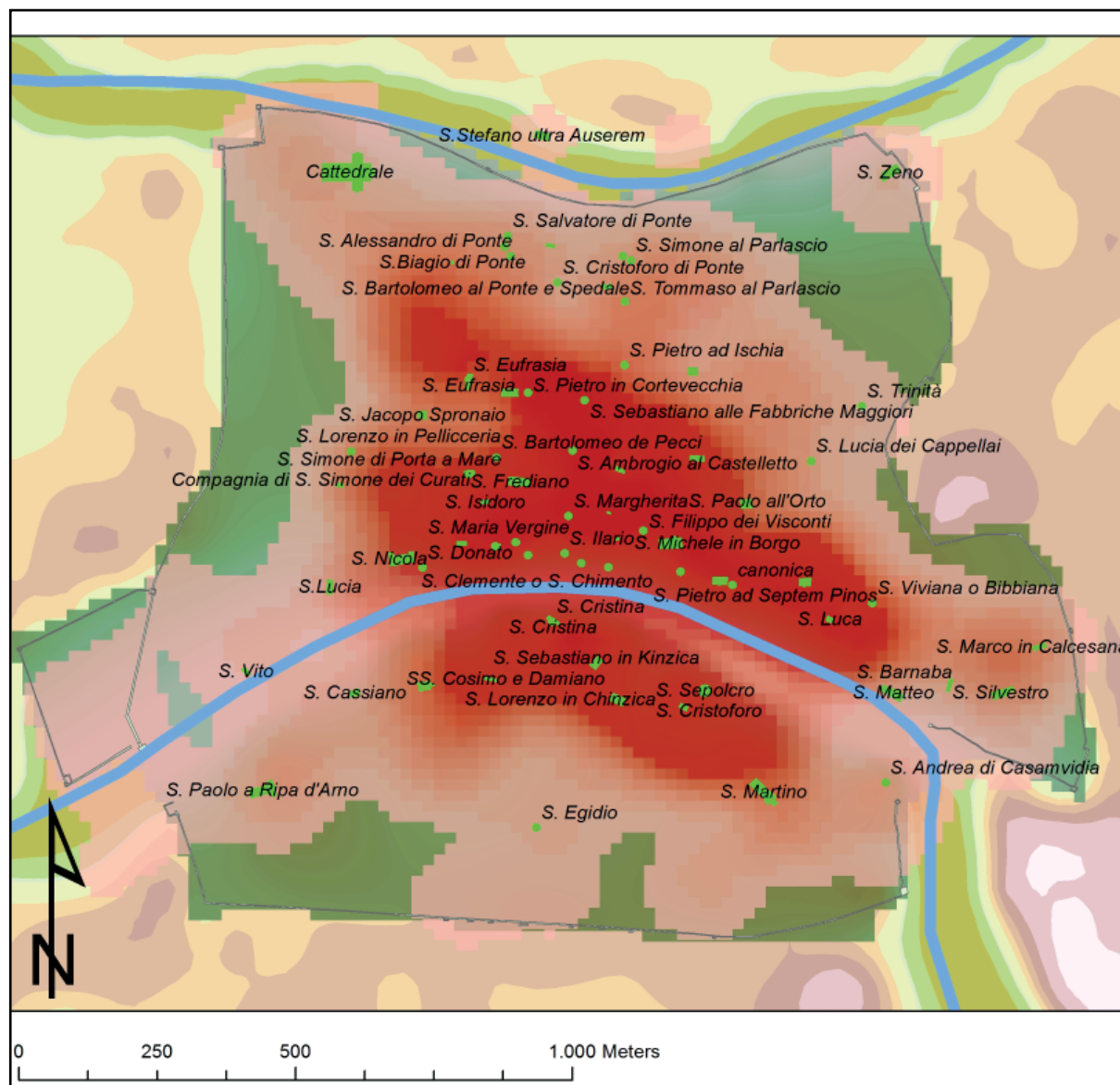


Fig. 3.33 The main religious buildings known and dated prior to the end of the XII century overlapping the late medieval KDE.

started between the end of the X - start of the XI century, yet never completed, regarding the construction of an east-west oriented building with three naves and measuring around 54x20 m, probably provided with a crypt. Of this structure, only traces of the building site and part of the walls remain, robbed during the XI century to build the current cathedral. The first construction of the church of San Matteo can also be dated back to this period, as well as the expansions of the churches of San Zeno and Santa Cristina (FEBBRARO 2011). During the X century, skilled

workers still used recovery materials (Verrucan and panchina stone), but associated with splitting techniques and arrangements in uneven courses, whilst between the end of the X and start of the XI century, reused materials simply consisted of bricks and marble. At the same time, quarrying activities were resumed (panchina stone, limestone and Verrucan stone), stone was rough-hewn and panchina stone, being softer, was squared. This strong commitment towards construction, well reflected in the building site for the new cathedral, is the expression of a

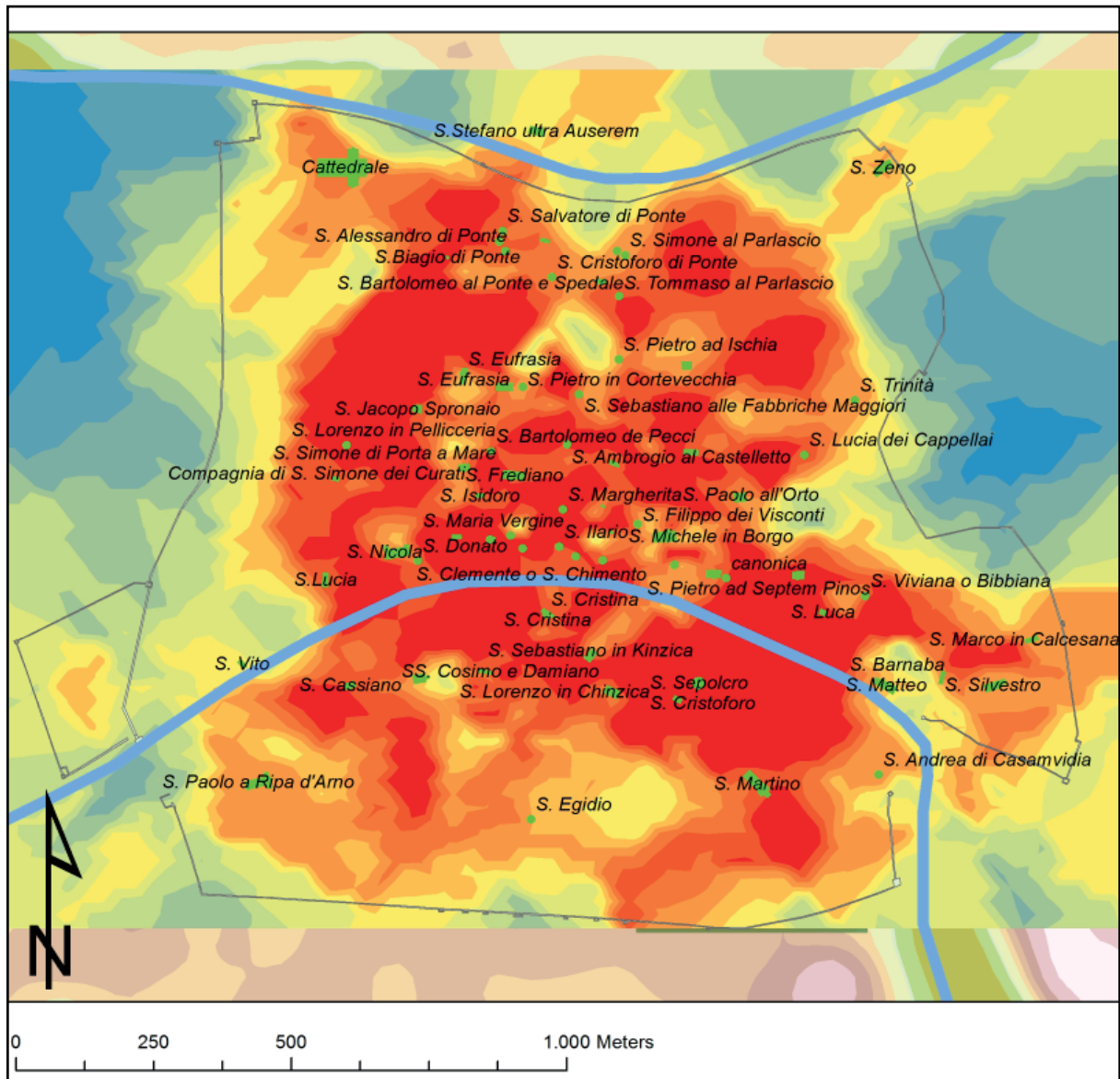


Fig. 3.34 The main religious buildings known and dated prior to the end of the XII century overlapping the late medieval co-kriging interpolation.

composite society, of clients' investment capacity and of the presence of skilled manpower, in a framework that reveals the city's early economic revival.

Between the end of the X/start of the XI century and the XII century, the city underwent a building boom leading to the construction of an extensive number of churches and a higher concentration of residential space to the north of the Arno River, which around the mid XII century was surrounded by walls. Spatial analysis with the overlapping of the churches attested in this

period (figs. 3.33, 3.34 and 3.35) reveals both an increase in population in the northern portion of the city, especially in the middle and along the Arno River, leaving large non-urbanised areas to the east and west, and the gradual development of the southern portion which up to the previous centuries had been basically concentrated around the church of Santa Cristina. Overall, we have 23 different archaeological finds related to religious buildings in this period and only 3 finds associated with cemeteries, two of which, better documented, in the area of piazza del Duomo.

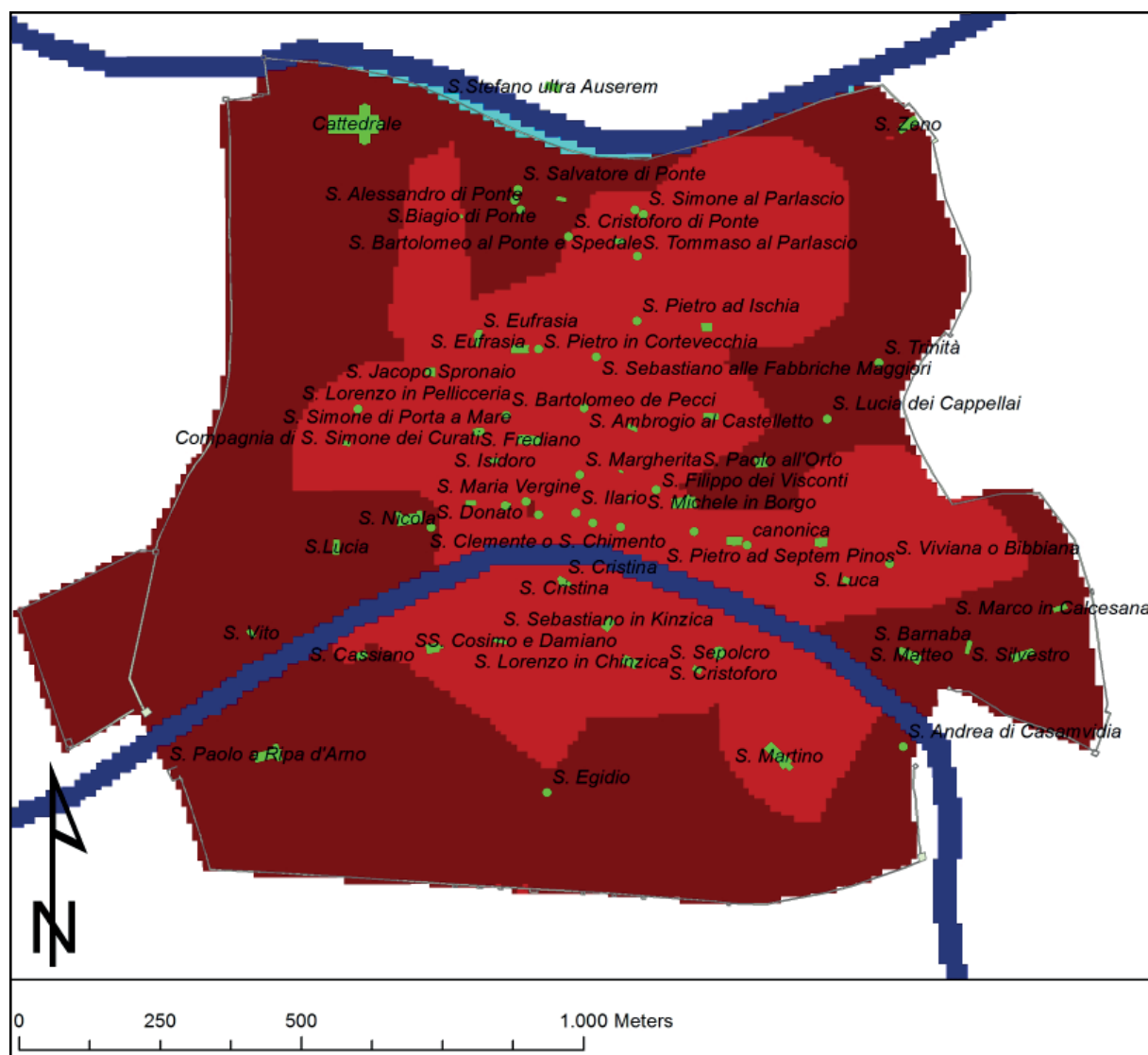


Fig. 3.35 The main religious buildings known and dated prior to the end of the XII century overlapping the functional areas created using the MAPPA algorithm.

The archaeological data¹⁵⁸ record this phenomenon, both in the new buildings and the restructuring of previous ones. The archaeological interventions of the last decade provide a particularly good view of this phenomenon. In the area of the cathedral, a 2004-5 excavation¹⁵⁹ revealed that the site of the previous X century cathedral was greatly robbed during Buschetto's construction of the cathedral,

evidenced by deep robber trenches, which in some parts reached the last foundation course, and by the complete removal of the internal floors. In other words, an intense gather activity and a huge amount of semi-processed and processed stone associated, most likely, with the building site of the Romanesque cathedral. The definite defunctionalisation of the area comprising the

¹⁵⁸ We will consider data from stratigraphic excavations, leaving aside or just briefly considering data from building archaeology, for which reference may be made to FEBBRARO, SUSINI 2012, *Building analysis*, in MappaGIS doi: 10.4456/MAPPA.2012.43, last access 03/05/2013.

¹⁵⁹ GATTIGLIA G. 2012, *Intervention records nos. 363, 608*, in MappaGIS; ALBERTI *et alii* 2011a.

early medieval worship building led to the conversion of this space into a cemetery. In fact, after the construction of the Buscheto cathedral¹⁶⁰ (XII century), the area in front of the new cathedral's façade was used as a cemetery, as documented by the presence of 29 burials, 2 of which are stone-lined and 27 earth-pit, dated between the XII and XIII century; 27 are adults and young people, whilst only two are children (ALBERTI *et alii* 2011b). All the individuals are west-east oriented and buried lying on their backs apart from one body that is lying to one side. None of the graves have grave goods with the exception of one case, where a bronze ring on the right annular was found, and of the assumed presence of a shroud in some burials. Lastly, four individuals in a monosome burial and three in a trisome burial have their upper arm (in some cases the right arm in others the left) completely bent over their shoulder. Eight stone-lined graves made of limestone and moulded panchina slabs, again dating back to the XII century after the construction of the new cathedral, were also found. They lacked grave goods, were arranged at the foot of the Duomo apse and cut into the ground surface upon which the foundations of the cathedral were constructed¹⁶¹. Archaeological data reveal how, in addition to the new buildings, a number of churches were also restructured: this is the case of the church of Sant'Isidoro¹⁶², where the IX-X century (?) structures are overlain by a XI-century renovation, characterised by a wall in small, rectangular Verrucan fair faced squared stone, arranged in regular course with rare vertical chinking and rather thin mortar bed joint (REDI 1993: 206), and of the church of San Zeno. Here,

although the situation is not as clear because stratigraphic data are not available, an early XI-century renovation and a subsequent expansion dating back to the first half of XII century may be seen (REDI 1991:77 ss). Little is known about San Biagio¹⁶³ alle Catene, around which a cemetery arose as attested by the discovery of a nearby burial. Even the excavation inside San Pietro in Vincoli was quite limited. Another interesting case is the church of San Sebastiano alle Fabbriche Maggiori (ANICHINI, GATTIGLIA 2008). The excavation of via Consoli del Mare (GATTIGLIA, GIORGIO 2007a; PARIBENI *et alii* 2012) did not reveal church structures, but overall analysis of the nearby data allows us to identify the location of the religious building with certain accuracy. The church, attested from 1074, was demolished (GARZELLA 2000) because it partially occupied the area chosen for the future church of Santo Stefano dei Cavalieri, as resulting in a 1569 document, which graphically reports the vegetable garden of Vincenzo Caprile overlapped by the new religious structure¹⁶⁴. The boundaries of Vincenzo Caprile's vegetable garden seem to trace chronologically previous orientations, as attested by the parallelism between the western side, the structures that arose in the excavation of piazza dei Cavalieri and the medieval buildings positioned on the west side of current via Dini, then absorbed into post-medieval buildings, between the eastern side of the structures pertaining to the north building of the excavation of via Consoli del Mare, and, lastly, between the northern and southern sides of Palazzo degli Anziani. On the basis of topographic and archaeological data, we can presume that the area occupied by Caprile's vegetable garden was previously occupied by abandoned buildings or

¹⁶⁰ FEBBRARO, SUSINI 2012, *Record CF U1204CF1*, in MappaGIS.

¹⁶¹ TARANTINO G. 2012, *Intervention record no. 356*, in MappaGIS.

¹⁶² GRASSINI F. 2012, *Intervention record no. 325*, in MappaGIS.

¹⁶³ GATTIGLIA G. 2012, *Intervention record no. 3*, in MappaGIS.

¹⁶⁴ This analysis was possible thanks to the georeferencing of this map (ASPi, OSS, f.455, tra cc. 638b and 638c, already published in KARWACKA – CODINI 1980: 235), of the structures identified in Saggio (test pit) I of the excavation of piazza dei Cavalieri (SCIUTO C. 2012, *Intervention record no. 130*, in MappaGIS) and in the excavation of via Consoli del Mare (TARANTINO G. 2012, *Intervention record no. 587, 588*, in MappaGIS).

buildings that had disappeared, as attested by the case of the north building (*sovita*) of the excavation in via Consoli del Mare. It is possible to assume, therefore, that – at least from the start of the XI century until the mid-XIV century, period in which the buildings of Saggio (test pit) I of piazza dei Cavalieri (ABELA, BRUNI 2000: 59) were demolished – the road route of current via Dini continued inside current piazza dei Cavalieri, towards what was then piazza delle Sette Vie, and that, also the east side, in the area included between the southern border of the small square with the statue of Ulisse Dini and the northwest corner of Caprile's vegetable garden, was occupied by buildings. Thus, the two buildings found in the excavation of via Consoli del Mare were behind the highly prestigious buildings along via Dini, which could also be identified with the *via de fabricis* mentioned in documents (GARZELLA 2000:42; ANICHINI, GATTIGLIA 2008); foremost, though, the church of San Sebastiano was located north of the vegetable garden, between the garden itself and Palazzo degli Anziani, probably further back than the façade of the Palazzo, as suggested by the clear east-west orientation of the eastern portion of the northern side of the vegetable garden (under the northern portion of the current church of Santo Stefano dei Cavalieri) (fig. 3.36). The remains found in the southeast corner of piazza delle Vettovaglie¹⁶⁵ could also belong to a religious building. The construction had an elongated shape built with limestone ashlars and the masonry suggests that it was a prestige building dating back to between the XII and XIII century. It could possibly be the church of San Bartolomeo degli Erizi, mentioned in written sources from 1079 (GARZELLA 1990:61) and demolished during the mid-XVI century to

construct piazza delle Vettovaglie. The district of Chinzica also underwent strong urban development from the XI century, witnessed by the rapid construction of religious buildings especially towards east: San Cristoforo attested from 1062, San Martino attested in 1067 and finally Sant'Andrea founded in 1095¹⁶⁶. The latter was archaeologically investigated during the excavation at Palazzo Scotto¹⁶⁷. The intervention brought to light the north-western portion of the church of Sant'Andrea in Chinzica (fig. 3.37), clarifying its precise topographical location. At the time of the foundation, the area granted for the construction was located on the left bank of the Arno River in an abandoned and probably wetland area upon which Roman remains still rose. The difficulty in building on this area must have been immediately evident to the constructors as also the need to defend the building, once complete, from the floods of the Arno River. For this reason, a large embankment was built together with the construction of the church foundations, which elevated the ground surface by around 2.50 m. By extending towards north and east it led to the creation of a new bank to protect the area¹⁶⁸. The bedding trench was directly made on the remains of the Roman structure; the foundations were made of rough hewn limestone and bonded with abundant mortar (fig. 3.38). Once completed, the building must have had a one-room appearance, with a peaked roof covered by schist stone and three entrances on the façade. The internal flooring was made of simple mortar around 6 cm thick and reinforced with small fluvial pebbles similar to those inside the church of San Lorenzo in current piazza Gambacorti (SANTUCCI 2005). The interior must have been fully plastered and

¹⁶⁵ SCIUTO C. 2012, *Intervention record no. 130*, in MappaGIS; ALBERTI, BALDASSARRI 2004.

¹⁶⁶ The church of Santi Andrea e Vincenzo was founded around 1095 in a place called *Cartangula* by two brothers, Signoretto and Bono, children of Moro and Bona, and for two centuries was a priory of the Benedictine monastery of San Vittore in Marseille. At the start of the XV century it passed on to the friars of the Order of Mary's Servants, which remained there up to its demolition probably shortly before 2 October 1465 (FEBBRARO *et alii* 2006:41).

¹⁶⁷ GATTIGLIA G. 2012, *Intervention record no. 367*, in MappaGIS; GATTIGLIA 2006.

¹⁶⁸ From this moment onwards the Arno River needed to sharply bend to access the urban part of its course.



Fig. 3.36 Possible reconstruction of the area of San Sebastiano alle Fabbriche Maggiori during the Late Middle Ages. Georeferencing of Caprile's vegetable garden allows us to understand the topographic pattern of the area, locating the church of San Sebastiano with sufficient accuracy and highlighting the route of *via de fabricis* (which coincides with current Via Ulisse Dini), upon which tower houses presumably rose and behind which the metallurgic workshops were located. The buildings that can be reconstructed on the basis of archaeological sources (excavations and building analysis) are indicated in white, the medieval road networks in red, and the current urban fabric in grey. Current road toponymy has been used.

probably painted as suggested by red decorations on the lower part of the walls. The external face is made of limestone ashlar blocks, accurately worked into elongated slabs. The internal wall, instead, was made of smaller-sized rough hewn material, and arranged in regular courses of low but constant

height, despite the uneven sizes of the material used. The excavation also confirmed that the square-based tower, included in the eastern curtain of the XV century fortress and subsequently known as the tower of Sant'Antonio was originally the bell tower¹⁶⁹ of the church of Sant'Andrea (fig. 3.39),

¹⁶⁹ FEBBRARO, SUSINI 2012, *Record CF U1788CF1*, in MappaGIS. This is a common structure in Pisa as in the case of the late XI century bell tower of San Zeno and the later one of San Matteo (REDI 1991: 378-380).



Fig. 3.37 Excavation of Palazzo Scotto. The church of Sant'Andrea (part of the façade and northern building wall) referred to the XIV century phase.



Fig. 3.38 Excavation of Palazzo Scotto. Foundations of the church of Sant'Andrea (end XI century).

as confirmed by the four, 1 m wide, corner parastades connected by a wall curtain, and continued at least up to the second floor. They were made of ashlar Verrucan stone and limestone, whereas the curtain facing was made of squared stone laid along regular courses. On the north side was a narrow single light window monophore, with Verrucan stone jambs, whereas on the west, a portal with approximately 1.40 metre opening, featuring a Verrucan stone round arch faced the church. The Church of San Lorenzo in Chinzica, instead, was built upon the initiative of a family of devoted laymen residing in the district of Chinzica, in San Martino¹⁷⁰. The archaeological remains¹⁷¹ referring to the first layout of the church, dating back to the XII century, comprise the southern building walls, made of limestone ashlars with panchina stone inserts along the lowest courses, in the squared bases of the stone pillars, which divide the interior into naves, and in structures parallel to the main building walls, which are difficult to understand. The building had three naves, with main access on the western façade comprising a large entrance flanked by two small entrances, and two side entrances along the southern building wall. The most ancient flooring (XIII century) was constructed with yellow mortar, probably made with a mixture of crushed panchina stone, brick fragments, gravel, sand and mortar positioned on a thick crawl space of stones. This technique was used due to the need to isolate the floor from possible groundwater rising, a widespread phenomenon in this part of Pisa already during the Medieval Age. Although this religious building belonged to private citizens, it does not have the aspect of a private chapel, both in terms of size (around 300 m²) and construction details. The building, straight from its first construction phases, must have been

¹⁷⁰ The first attestations of the existence of the church of San Lorenzo date back to the start of XII century, and are contained in a number of documents reporting the sale of lands by the building's owners.

¹⁷¹ LA ROSA L. 2012 *Intervention record no. 263*; MILANESE 2005.

connected to a cemetery. Documentary sources attest the presence of a cemetery next to the church, in the southern part of the current square which, however, has not been archaeologically investigated. The only information available comes from the interior, thanks to the excavation of a number of prestige burials. In fact, at flooring level, various rectangular and east-west oriented brick tombs were built, arranged three by three with a precise pattern – from north to south – and dating back to XII-XIII century.

A final development phase involving new religious buildings can be seen between the XIII and XIV century, representing a further moment of expansion which partially occupied space to the south, east and west that was still scarcely urbanised (fig. 3.40). Yet it is above all in this period that archaeological data report internal¹⁷² and external¹⁷³ renovations, whereas cemeteries relating to these centuries are archaeologically documented close to the area of piazza dei Miracoli¹⁷⁴ and at Sant'Andrea in Chinzica¹⁷⁵. This latter building underwent an interesting renovation during the XIII century: the building walls were newly covered with highly selected and evenly coloured and sized bricks. The reasons for the renovation were clearly cosmetic, carried out in a period in which the city visually changed, taking on a red hue due to the extensive use of bricks. A small cemetery was located outside the northern side of the church during the second half of the XIV century. Nine burials were identified, all in earth pit, only three of which excavated, partly positioned in highly organic soil and interrupted by trees, as revealed by the tree-removal pits. This may have been a vegetable garden area with fruit trees, related to the tradition of orchard-cemeteries in monasteries, in which



Fig. 3.39 The bell tower of the church of Sant'Andrea in Chinzica as seen today at the entrance of Giardino Scotto.

the burial area, according to the Christian view of death as rebirth, coincided with the orchard, and graves alternated with trees which symbolically represented regeneration. In the western portion, the graves not only are not in a vegetable garden area but the type of hasty burial (in one case a body was thrown in the pit where it remained face down) suggests emergency burials made during an epidemic event of the second half of the XIV century (fig. 3.41). In the church of San Lorenzo in Chinzica, the excavation¹⁷⁶ revealed a transformation at the end of XIV century, when a traumatic event hit the structure of the building

¹⁷² Church of San Lorenzo in Chinzica LA ROSA L. 2012 *Intervention record no. 263*; MILANESE 2005 .

¹⁷³ Church of Sant'Andrea in Chinzica GATTIGLIA G. 2012, *Intervention record no. 367*, in MappaGIS; GATTIGLIA 2006.

¹⁷⁴ In addition to construction of the Camposanto Monumentale at the end of the XIII century; GATTIGLIA G. 2012, *Intervention record no. 608*, in MappaGIS; ALBERTI, PARIBENI 2005; ALBERTI *et alii* 2011b).

¹⁷⁵ GATTIGLIA G. 2012, *Intervention record no. 367*, in MappaGIS; GATTIGLIA 2006.

¹⁷⁶ LA ROSA L. 2012 *Intervention record n. 263*; MILANESE 2005.

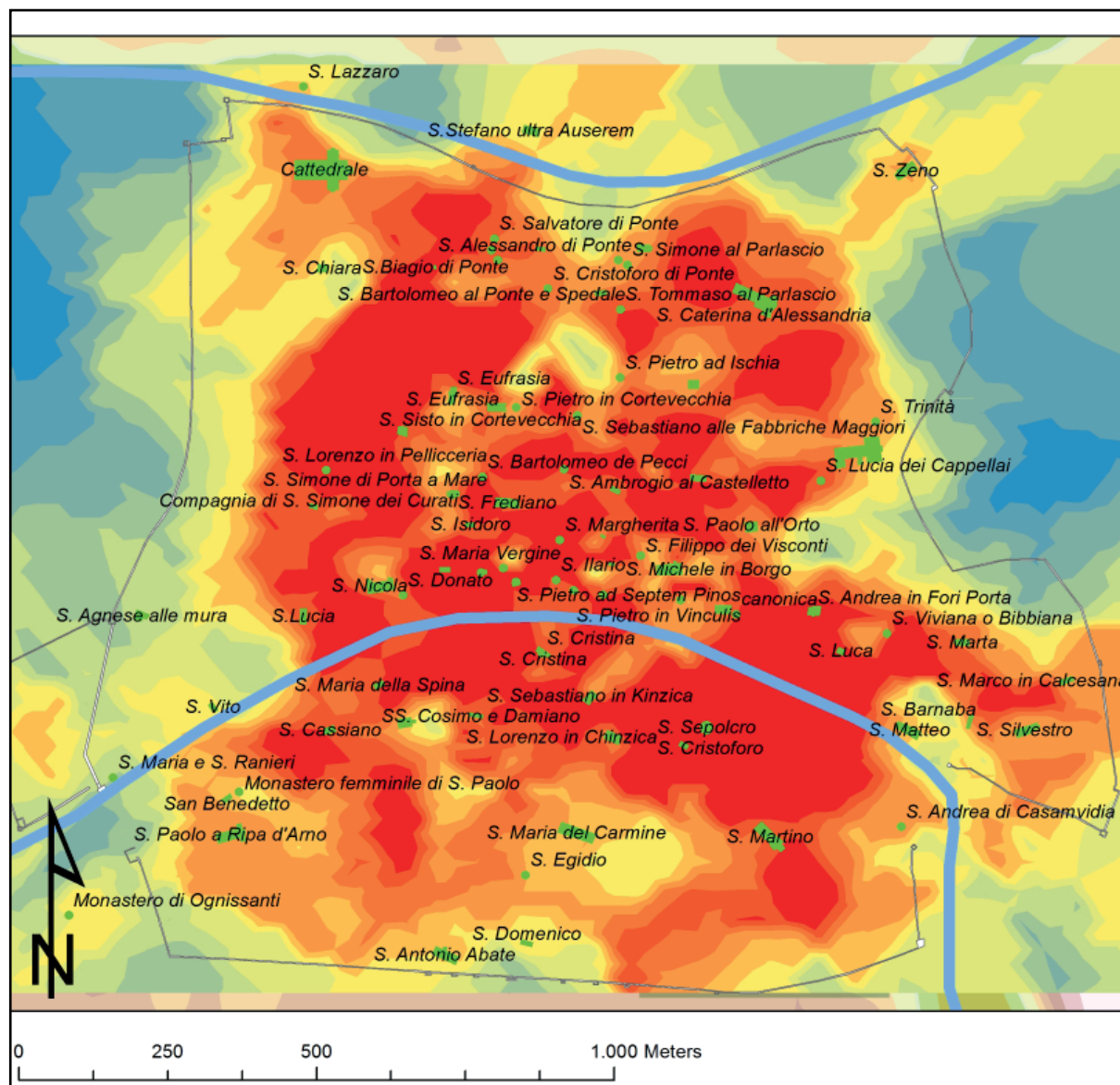


Fig. 3.40 The main religious buildings known and dated before the end of the XIV century overlapping the late medieval co-kriging.

to the point that the majority of the internal space had to be newly designed. A consistent deposit of rubble, charcoal and burn traces spread all over the area suggests that a fire may have destroyed the wooden parts of the building. From this moment onwards, a new flooring was built in bricks arranged in a herringbone pattern, 50 cm higher than the previous floor. The bases of the columns and the sepulchral structures were consequently raised, while in correspondence of the western border of the presbytery, a brick wall was erected delimiting this area from the rest of the church.

3.2.2 Building. Houses, construction sites and transformations

Analysing building and the issues connected to it (building techniques, clients, ways of living, just to mention a few) only through the study of the ground floors is difficult without doubt. Nevertheless, for some periods, foremost the Early Middle Ages, these are the only archaeological data available and, although scarce, are in any case able to provide a picture of the way buildings were constructed and people lived in certain

periods. The chronologies inferable from buried stratifications – i.e. 11 early medieval finds (fig. 3.42) referring to living environments of various nature, dated between the VI and IX century, situated in the city area to the north of the Arno River relating to the areas of piazza del Duomo, via Sant’Apollonia, piazza Dante, vicolo del Porton Rosso¹⁷⁷, and associated with the data of buildings archaeology¹⁷⁸ - allowed us to identify how construction materials varied over time and to draw a picture of early medieval house constructions¹⁷⁹. Structures erected in perishable material can mainly be seen, with rammed earth and timber walls, while structures completely made of masonry only appeared later (IX-X century).

The recent excavations of piazza del Duomo offer more interesting data for determining Late Roman/early medieval building techniques between the end of the V and VIII century. Late V-early VI century phases, identified in various areas of the square, reveal the existence of buildings in perishable material confirmed by postholes and by narrow dry stone walls probably used as socle for timber, wattle or rammed earth walls, as well as by hearths. An example is the excavation behind the apse of the current cathedral where, in the phase dated between the V and VI century, a rectangular structure was identified delimited by postholes, associated with fireplaces and remains of a meal¹⁸⁰. Makeshift constructions can also be seen, which partly reused the masonry



Fig. 3.41 Excavation of Palazzo Scotto. One of the ‘hurried’ burials, dating back to the second half of the XIV century. The lower left limb is missing due to a post-depositional removal.

of the *domus* as element of delimitation, as in the case of the large *domus*¹⁸¹ partially reoccupied, between the end of the V and first half of the VI century, which reduced the internal rooms and used beaten earth floors. Starting from the end of the VI-VII century, building techniques are similar to the previous period. Where the large Roman

¹⁷⁷ Certainly prior to the XI century is the 80 cm wide, east-west oriented structure, in the southern part of the excavation in via degli Uffizi (ANICHINI, GATTIGLIA 2008). The very small portion that can be analysed consists of two courses of the southern face made of large-sized cuneiform Verrucan stone slabs, laid on regular courses, bonded with abundant mortar. The core is made of similar materials. Since the excavation was interrupted due to groundwater rising, the sample was too small for a typological comparison allowing possible dating and identification of the function of the structure; information on the presence of a structure in the area is in any case provided, also in such early periods, subsequently cancelled by the mid-XI century construction of two tower houses overlying the levelling.

¹⁷⁸ Reference may be made to FEBBRARO M., SUSINI F. 2012, *Building analysis*, in MappaGIS and to FEBBRARO 2011.

¹⁷⁹ It is important to remember once again that the very few early medieval contexts investigated depend on the difficulty to reach certain depths due to the presence of groundwater; piazza del Duomo is the only area where early medieval phases are above today groundwater level.

¹⁸⁰ TARANTINO G. 2012, *Intervention record no. 356*, in MappaGIS; ALBERTI, BALDASSARRI 1999.

¹⁸¹ GATTIGLIA G., *Intervention records nos. 363, 608*, in MappaGIS; ALBERTI et alii 2011c.



Fig. 3.42 Location of the finds mentioned in the text within the current city. The KDE of the VIII-X century finds is indicated in fuchsia.

domus once arose, a rectangular structure partly uses the still emerging structures and overlooks an area to the south with burials and a large pit. The northern sector of the current square¹⁸², further away from the cemetery, is occupied by buildings made of perishable material, with a dry stone masonry socle, partially abutting on residual Roman structures, a timber covering, as confirmed by the postholes, associated with waste pits and hearths. This area may have been occupied by timber structures between the VII and VIII century. Apart from the waste pits, however, no

other traces remain. The scarce data inferred from the excavation of Sant' Apollonia¹⁸³ may also attest the presence of a not better identifiable building erected in perishable material. The association of *testelli* (shallow plates used for cooking flat bread), glass, Forum ware and a fragment of iron ore, could suggest a VII-VIII century frequentation coeval with the first metallurgic structures found in neighbouring piazza dei Cavalieri, and maybe connected to the ironworking structures. The only certain archaeological records relating to VII and VIII century civil constructions regards the production area of piazza dei Cavalieri¹⁸⁴, where a structure was found with a roughly worked socle in panchina stone blocks with chinking made of reused bricks, bonded with clay, featuring holes for the wooden poles of the elevation. Despite the very few sources, a 720 written source is available reporting the deed of sale of a building *cum gronda sua livera, tam solamentum quam lignamine fine grondas; ipsa medietatem de casas cum petras* placed *infra civitatem*, that is, a structure with a stone socle (*solamentum*) and timber elevations (*lignamine fine grondas*) (GARZELLA 1990:18). It is possible to assume, therefore, that a good part of city houses were made of perishable material, timber or other material, with a masonry socle made of reused materials, taken from the buildings of the ancient city and bonded with clay, not by mortar. As pointed out by BROGIOLO 2011:148, although written sources describe the existence of prestigious constructions within the early medieval city fabric, archaeological data show a sharp prevalence of huts and buildings of low quality. Pisa, with its still limited archaeological record, is no exception. If we consider architecture as an important indicator of economic development, it is obvious

¹⁸² TARANTINO G.2012, *Intervention record no. 374*, in MappaGIS; ALBERTI *et alii* 2011c: 178 ss.

¹⁸³ SCIUTO C.2012, *Intervention record no. 94*, in MappaGIS; CORRETTI, VAGGIOLI 2003, if my interpretation is correct regarding traces of fire activities (hearth of a hut?) and of sporadic frequentation evidenced by pottery artefacts, generically defined as early medieval.

¹⁸⁴ SCIUTO C.2012, *Intervention record no. 94*, in MappaGIS; ABELA, BRUNI 2000). The dating of the structure is rather vague since, according the authors, it is between the Late Roman period (although not investigated by the excavation) and the IX-X century layers (ABELA, BRUNI 2000:77).

that the shift from masonry to buildings made of perishable material indicates not only a cultural (and maybe ethnic) change but also less economic resources, in a period during which only the most powerful classes could afford stone constructions. Nonetheless, the building of timber houses implies skilled knowledge. Indeed, while on the one hand the simplification of the construction process is evident, on the other, different skills come into play, such as knowledge of wood, its seasoning, cutting, resistance and structural characteristics.

There is a greater availability of archaeological records from the IX century onwards. The excavation at vicolo del Porton Rosso¹⁸⁵ particularly identified a number of houses of different building-type and construction technique. The two most ancient houses (building I and II), belonging to the end of the IX – start of the X century, are made, respectively, of masonry held together with mortar and mixed masonry with a stone socle and clay walls. Building I presents a double stone with core masonry, around 40/45 cm thick, made of Verrucan stone elements and panchina stone, roughly hewn and random uncoursed, held together by a mortar also used as internal and (probably) external plaster. This type of masonry and its conservation for more than 2.5 m suggest that the building probably had two floors. Building II has a socle made of reused blocks, pebbles and cut stone (Verrucan and panchina stone) laid in a double stone with core masonry random coursed with the use of a clayey bonding material, from which a rammed earth wall rose, internal flooring in beaten earth and schist slab covering. This building probably had a rectangular, east/west oriented layout and overlooked the north/south road network axis corresponding to current vicolo del Porton Rosso (FEBBRARO, MEO

2009:188). This building-type was widely diffused throughout the city for a long time since similar structures were found both in the neighbouring excavation of piazza Sant’Omobono, and beyond the Arno River in the excavation of via Toselli, up to the XII century. This type of construction is worthy of attention; although plenty has been written on major constructions and on tower houses, much still remains to be said on ‘minor’ constructions, which excavations are bringing to light. A building was found during the excavation of piazza Sant’Omobono¹⁸⁶, built before the XII century, with a stone socle and clay walls, which collapsed before the mid-XII century. Its building walls were made of large-sized pebble socle¹⁸⁷ and it featured a probable schist slab covering and a beaten earth floor, raised several times. Excavation data reveal that the building was internally divided by a partition erected at the start of the XII century, featuring a stone socle made of sandstone elements, simply cut and held together by a clayey-silty sediment. The excavation of via Toselli¹⁸⁸, instead, identified a building dating back to the first half of XI century with a socle in Verrucan and panchina stone, barely rough hewn and held together by friable mortar (fig. 3.44). While the elevation was still partly in lythic elements held together by an earthen bonding material and partly in rammed earth, the covering was made of a timber supporting structure and schist slabs. The building was doubled in size, expanding westwards during the second half of the XI century. In this case also, a socle in rough hewn stone was used, but bonded only with clay, completed with an elevation in timber and clay, and covered by schist slabs. The building survived until the end of the XI – start of the XII century. Overall, it is difficult to determine the function of these structures. With

¹⁸⁵ TARANTINO G. 2012, *Intervention record no. 611*, in MappaGIS; GATTIGLIA G. 2012, *Intervention record no. 612*, in MappaGIS; FEBBRARO 2011.

¹⁸⁶ SCIUTO C. 2012, *Intervention record no. 488*, in MappaGIS; ANICHINI, GATTIGLIA 2006.

¹⁸⁷ To the south, the building probably abuted upon a structure with a stone wall, as a powerful collapse in the southern part of the building would seem to confirm.

¹⁸⁸ GATTIGLIA G. 2012, *Intervention record no.589*, in MappaGIS; DUCCI *et alii* 2008a.



Fig. 3.43 The building of piazza Sant'Omobono. The north-eastern building wall US 174 and the internal partition US 176 are visible.



Fig. 3.44 Excavation of via Toselli: in the foreground, the XI century building and the subsequent transformations that may be seen in the Area 6000.

regard to the most ancient attestations (IX-X century), they may be attributed to living contexts, as probably attested by building II of vicolo del Porton Rosso, which directly overlooked the road.

Regarding later attestations (XI-start XII century), these buildings could have been used as service structures, adjacent¹⁸⁹ to a stone building, in the case of piazza Sant'Omobono, or as a storage room for furs subsequently finished in the laboratory situated on the ground floor of the main building, in the case of via Toselli. With regard to X-century civil constructions, examples are taken from vicolo del Porton Rosso, piazza Dante, via della Sapienza and Palazzo Giuli. In vicolo del Porton Rosso¹⁹⁰, two buildings were erected during the X century. One has a double stone with core masonry, with a rough hewn, panchina stone face, random coursed bonded with mortar, suggesting that the building may have had two floors (FEBBRARO 2011: 556). The second is an ellipsoidal hut with a socle in reused blocks and pebbles (limestone, panchina stone and Verrucan stone) and an elevation in perishable material. These small-sized buildings had one floor and were made with perishable material, as attested by the continuous collapses and renovations over a short period of time. In piazza Dante (Saggio I)¹⁹¹, buildings I and II evidence a first IX-X century dating, with double stone with core masonry with a Verrucan stone face, cut or roughly squared, random coursed. In this case also, as for building I of the excavation in vicolo del Porton Rosso, external plastering may be seen. It may probably have had only a masonry socle and the remaining part in timber or other perishable material (REDI 1993:227). Nearby building IV dates back to the end of the X century and its masonry reveals a wall in cut or barely rough hewn Verrucan stone, random coursed with vertical chinking, held together by abundant and excess mortar, but without plastering on either the inner or exterior surfaces (REDI 1993:200). In

¹⁸⁹ This could be a building situated behind the stone building. Unfortunately we know little of the road network during this period to be certain. The only certain information is that mid-XII century interventions significantly changed the topography of the area.

¹⁹⁰ TARANTINO G. 2012, *Intervention record no. 611*, in MappaGIS; GATTIGLIA G. 2012, *Intervention record no. 612*, in MappaGIS; FEBBRARO 2011.

¹⁹¹ GRASSINI F. 2012, *Intervention record no. 325*, in MappaGIS; BRUNI, MENCHELLI 1993.

via della Sapienza¹⁹², a building with a stone socle and timber structures dates back to between the second half of the X century and first half of the XI century. Three stone tower houses in the area of Santa Cristina, at Palazzo Giuli (REDI 2009), were found dating back to the same period and featuring masonry with hewn stone arranged, in some cases, with a herringbone design¹⁹³ or vertically, as well as a tower house in via Toselli¹⁹⁴, directly overlooking the *carraia maggiore*, which show the early development of this area as a residential area for the elite. Although the number of cases available is rather limited, archaeological data show how, starting from the end of the IX – start of the X century, constructions in perishable material were erected together with stone buildings. A hierarchy may be seen (FEBBRARO 2011) between buildings constructed in masonry bonded with clay and those in masonry bonded with mortar. These different construction techniques, therefore, reflect the city's social patterns: the number of clients who could afford such property investments increased, meaning that a greater amount of the city elite had money to invest. Qualified labour was also available, bringing together workers of different skills: workers who knew how to erect buildings in perishable material and workers specialised in the reuse of construction materials and who knew how to make a good mortar. Civil constructions at the end of the X-start of the XI century, such as religious buildings, introduced squared and squared stone, while the re-opening

of quarries led to the creation of a new type of construction: tower houses, which symbolically and materially represented the economic and political power reached by the city elite. The introduction of this type of house coincided with the city's economic development and its diffusion over the following centuries, and is a sign of the city's growing economic wealth and the creation of a middle-high entrepreneurial class.

The great building transformations of the XI-XII century were built with lime and Verrucan stone from the Monti Pisani and with the organogenic panchina stone from the area of Livorno, a material highly desired for its light weight. The XI century was a period in which tower houses flourished¹⁹⁵, although, as already seen, structures in perishable material continued to be built next to stone buildings such as those in piazza Sant'Omobono and via Toselli. The urban fabric became thicker and the city definitely took on the aspect of a city of stone. This process is apparent both to the north of the Arno River in the middle of the city, and to the south, in Chinzica. To the north of the Arno River, building developed on a long-lasting urban fabric. Archaeological data of the area between piazza delle Vettovaglie, piazza Sant'Omobono and vicolo del Porton Rosso, allow us to follow this process¹⁹⁶. At the start of the XI century, two buildings were erected in vicolo del Porton Rosso. The first had large foundations made of

¹⁹² TARANTINO G. 2012, *Intervention record no. 718*, in MappaGIS.

¹⁹³ According to FEBBRARO 2011:568, the herringbone technique was introduced by skilled workers from Lucca and in its first attestations was associated with prestigious buildings, while its use in XII and XIII century buildings is related to buildings used by middle class craftsmen.

¹⁹⁴ GATTIGLIA G. 2012, *Intervention record no. 589*, in MappaGIS; DUCCI *et alii* 2008a.

¹⁹⁵ We especially make mention of the finds of the excavation in via dei Facchini (BALDASSARRI, MILANESE 2004), Palazzo Vitelli (GARZELLA, REDI 1980), San Michele in Borgo (REDI *et alii* 1987), piazza dei Cavalieri (ABELA, BRUNI 2000), piazza delle Vettovaglie (ALBERTI, BALDASSARRI 2004), piazza Dante (REDI 1993), via degli Uffizi (ANICHINI, GATTIGLIA 2008), Palazzo Giuli (REDI 2009), via Toselli (DUCCI *et alii* 2008), vicolo del Porton Rosso (FEBBRARO, MEO 2009).

¹⁹⁶ Indeed, here, between 2002 and 2008 a series of interventions were carried out in piazza delle Vettovaglie (SCIUTO C. 2012, *Intervention records nos. 212, 213, 214, 216, 217*, in MappaGIS), in piazza Sant'Omobono (SCIUTO C. 2012, *Intervention record no. 488*, in MappaGIS) and in vicolo del Porton Rosso (TARANTINO G. 2012, *Intervention record no. 611*, in MappaGIS; GATTIGLIA G. 2012, *Intervention record no. 612*, in MappaGIS), which not only have been carried out recently, but also have good excavation documentation and have all been published, at least on a preliminary basis.

rough hewn Verrucan stone or roughly trimmed on uneven courses, held together by abundant mortar, and Verrucan stone facing, arranged on uneven courses with string blocks interrupted by small-sized quadrangular elements, revealing an opening in the middle with jambs in squared panchina stone. Only the foundations remain of the second building, made with Verrucan stone waste and abundant mortar. A series of tower houses were built between the end of the XI and start of the XII century in the area of piazza delle Vettovaglie with walls characterised by irregularly squared blocks arranged on regular courses (fig. 3.45).

The greatest transformation, instead, took place during the first half of the XII century. A new north/south oriented building was erected in the area of vicolo del Porton Rosso and a building was constructed in the area of current piazza Sant'Omobono which occupied the area of the square, part of the neighbouring tower houses and the church of San Pietro in Palude, attested for the first time in 1153¹⁹⁷. All these transformations raised the flooring levels both at the excavation of Porton Rosso and piazza Sant'Omobono. The foundations of the building in vicolo del Porton Rosso were made with reused elements, such as squared or rough hewn Verrucan and panchina stone and with a facing made with fragments or small-sized blocks of Verrucan

stone with reused Roman bricks arranged in a herringbone pattern¹⁹⁸ and bonded with mortar. According to FEBBRARO, MEO 2009:188 buildings of this kind were the expression of middle class craftsmen and, given the building technique, were not particularly high. They were of lower quality and probably rose next to higher quality buildings or were positioned behind them, as in the case of the southern building in via Consoli del Mare¹⁹⁹. This building, probably built during the XII century, and evidenced by two parallel and northwest/southeast oriented masonry foundation fragments, built of a rubble masonry with limestone and Verrucan stone abundantly mortared, was a small building with two floors and was probably used as a *casa*²⁰⁰. The flooring on the ground floor reveals continuous remakes with both floor bricks laid in mortar or sand, and beaten earth. The inner rooms were divided by wooden partitions. The upper floor was built with floor bricks laid upon a wooden supporting structure and the roof was made of schist slabs. An even clearer situation may be seen in the construction of the two tower houses in via Gereschi²⁰¹, in the eastern portion of the city, which during the XII century were built resting upon each other. The client supposedly wished to own a house in an important area of the city and as a result built on spaces left empty by pre-existing buildings. The eastern building, with north/south orientation and the facade

¹⁹⁷ According to Redi (REDI 1991:123) the church was already built during the X century.

¹⁹⁸ This is not the only structure found in Pisa during this period with a herringbone design elevation: in the excavation at Sant'Apollonia a masonry fragment is documented with north/south layout and a facing made of bricks laid with an alternated herringbone pattern, above a base of square stones, which can be dated back to the second half of the XII century based upon the presence of Tunisian cobalt-manganese majolica in phase with the construction of the structure (CORRETTI, VAGGIOLI 2003:62). Herringbone-arranged lithic elements were also found in the intervention in via Gereschi (ANICHINI, FEBBRARO 2007) regarding a foundation fragment made of two large limestone steps, roughly levelled laid with herringbone design, dating back to before the XII century.

¹⁹⁹ TARANTINO G. 2012, *Intervention record no. 588*, in MappaGIS; GATTIGLIA, GIORGIO 2007.

²⁰⁰ For an overview of *casa* see REDI 1991:284.

²⁰¹ TARANTINO G. 2012, *Intervention record no. 588*, in MappaGIS; ANICHINI, FEBBRARO 2007. The intervention is situated behind the monastery of San Matteo and close to the church of San Luca, in an area defined by ancient toponyms as *Supracastello* and *Soarta* (GARZELLA 1990). Historical documentation provides us with a clearer view of this part of the city only from the XI century.



Fig. 3.45 Possible reconstruction of the area corresponding to current piazza delle Vettovaglie/piazza Sant'Omobono during the Late Middle Ages. The buildings reconstructed on the basis of archaeological sources (excavations and building analysis) are indicated in white, the medieval road networks in red, and the current urban fabric in grey. Current road toponymy has been used.

overlooking the road and the monastery of San Matteo, was the first to be built. The tower house had squared limestone masonry pillars. The western tower house next to it was built shortly after. The long sides of the building opened out along the southern side, taking the shape of a pillar, whilst the vertical structure featured Verrucan stone architraves on the first and second floors, with expanded internal space thanks to wooden overhangs, as highlighted by the Verrucan stone shelves and quadrangular openings for positioning the beams. Even in this

case, limestone is the predominant material used which in pillars is dressed in ashlar. Along the facing of the long side the lithotype is rough hewn and squared with dressed elongated elements arranged in uneven courses. Despite the need to fill up all empty spaces, great attention was given to secondary roads, as well shown in the examples of Chinzica: to the east of the first tower house, a trail perpendicular to the main road in front of the houses connected the main artery to the inner part of the urban fabric. The archaeological data of greatest interest for

the area of Chinzica come from the excavation of via degli Uffizi²⁰², via dei Facchini and via Toselli, since they evidence not only the building techniques (especially the former) but also urban transformations (especially the latter). In the area of via degli Uffizi²⁰³, a real property project appears to have been carried out between the end of the XI and the mid-XII century, with the construction of just one building site for two 'twin' tower houses rising one next to each other (tower house A and B)²⁰⁴, overlooking the *carraia maggiore* and separated by a small alley, followed by the construction of a third building (tower house C) in the northern part during the XII century (fig. 3.46). The buildings were erected on the levelling of a previous, non datable (but previous to XI century) structure in Verrucan stone, which for building technique and masonry thickness could be related to a not better specified building of a certain importance (FEBBRARO 2011:557). The first construction phase consisted of the stepped foundation of tower house A with limestone elements which, from down upwards, reveal an increasing level of workmanship, from quarry waste to rough hewn and then squared stone. The laying also improved and was reinforced in points requiring greater structural load with large-sized overlapping blocks. During the same construction phase, the foundation of building B was built, characterised by an executive change during the design phase necessary for its elongation. The two parts have

a different number of steps and whilst fragmentary bricks, maybe belonging to the Roman Age, were reused for the northern part, limestone and cut Panchina stone were used for the southern portion (fig. 3.47). The period of time lapsing between the two buildings appears to be very short and, technologically, the two foundations seem to have been built by the same workers. Based upon the data known, the use of Panchina stone elements and bricks does not seem to be attested in the houses of this period, whilst a comparison may be found in the nearby church of Santa Cristina²⁰⁵, whose apse, dating back to the end of the X – start of the XI century, is mainly built with similar reused elements (FEBBRARO 2011). The construction of the facings of both houses was carried out at the same time and featured a succession of four construction yard levels in the alley and inside house B, characterised by lithic material waste and mortar, transformed by treading activities and gradually increasing the elevation. The eastern face of tower house A²⁰⁶ is very high (at least four floors including the ground floor) and is about 7 metres long. Its facing is made mainly of limestone blocks, with rare elements in Verrucan stone, dressed and arranged in uneven courses, divided in correspondence of the quoins and jambs of the openings, made of ashlar. The façade had seven small-sized, architraved portals, arranged along four vertically aligned orders (fig. 3.48). Only a few courses of the

²⁰² The area is located in a crucial point of the city, between *carraia maggiore* and the Arno River within a sort of ideal triangle, whose sides are represented by the river to the north and by the *carraia maggiore* (i.e. the ancient road axis of *Aemilia Scauri*) to the south, converging into a vertex represented by a bridge that at least until the XII century (REDI 1991:111) was the only connection to the inhabited area north of the Arno River. This was one of the highly desired areas for families holding economic and political power who built their homes here from the XI century, i.e. tall tower houses whose main facade overlooked the above roads.

²⁰³ CAMPUS A. 2012, *Intervention records nos. 489, 602*, in MappaGIS; ANICHINI, GATTIGLIA 2008.

²⁰⁴ The two buildings were only partially analysed: only the eastern facade of the western building (tower house A), incorporated into Palazzo Gambacorti during XIV century, is legible; the western side and small portions of the northern and southern sides of the eastern building (tower house B), cancelled by a XVII century building, were examined.

²⁰⁵ Located a few tens of metres to the east.

²⁰⁶ FEBBRARO M., SUSINI F. 2012, *Record CF U2CF13*, in MappaGIS.

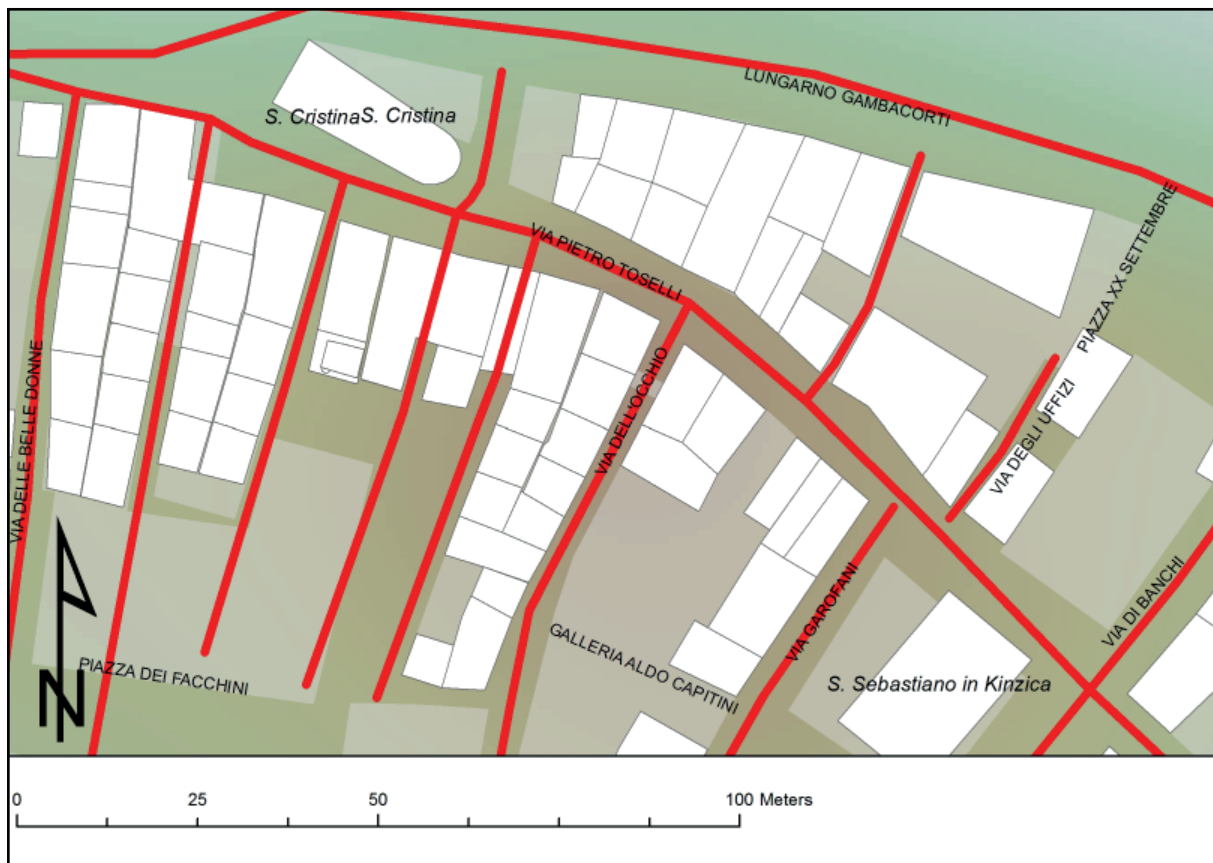


Fig. 3.46 Possible reconstruction of the area between Santa Cristina and San Sebastiano in Chinzica during the Late Middle Ages. The buildings reconstructed on the basis of archaeological sources (excavations and building analysis) are indicated in white, the medieval road networks in red, and the current urban fabric in grey. Current road toponymy has been used.

elevation of tower house B have been preserved. They are technically very similar to the previous building since wedges in grey, rough hewn and smoothed limestone were used for the external facing of the double stone with core masonry. They are arranged in almost regular courses, divided in correspondence of the quoins (the south of which has squared limestone elements). The small doors on the eastern façade of tower house A, overlooking the alley which separates

the two buildings probably connected the two structures via a wooden balcony and suggests that the clients were probably related to each other²⁰⁷. This solution is practically identical to that of the tower houses in the nearby excavation in via dei Facchini²⁰⁸, dating back to the end of the XI and start of the XII century (ANDREAZZOLI 2004). Both structures overlooked *carraia maggiore* and were situated in correspondence of a religious building: the church of San Sebastiano²⁰⁹ was

²⁰⁷ Although we cannot determine the owners with certainty, we can nonetheless describe the type of client who may have requested this property: a rich family, with neighbouring property, divided among members of the family. Still existing in the land registry of 1428, the small alley that separates the two tower houses is described as an alley between two houses belonging to different people but both from the Gambacorti family (ANICHINI, GATTIGLIA 2008:136).

²⁰⁸ LA ROSA L. 2012, *Intervention record no. 61*, in MappaGIS; BALDASSARRI, MILANESE 2004.

²⁰⁹ The church of San Sebastiano, attested for the first time in 1111 (GARZELLA 1990:115), was situated at the start of Corso Italia, close to the start of current via Toselli, opposite Logge dei Banchi. It was partially destroyed by the Allied bombing of 1943-44 and subsequently demolished. Only the fresco of the portal lunette remains, now at the Museum of San Matteo.



Fig. 3.47 Excavation of via degli Uffizi. The foundations of tower houses A, on the left, and B, on the right.

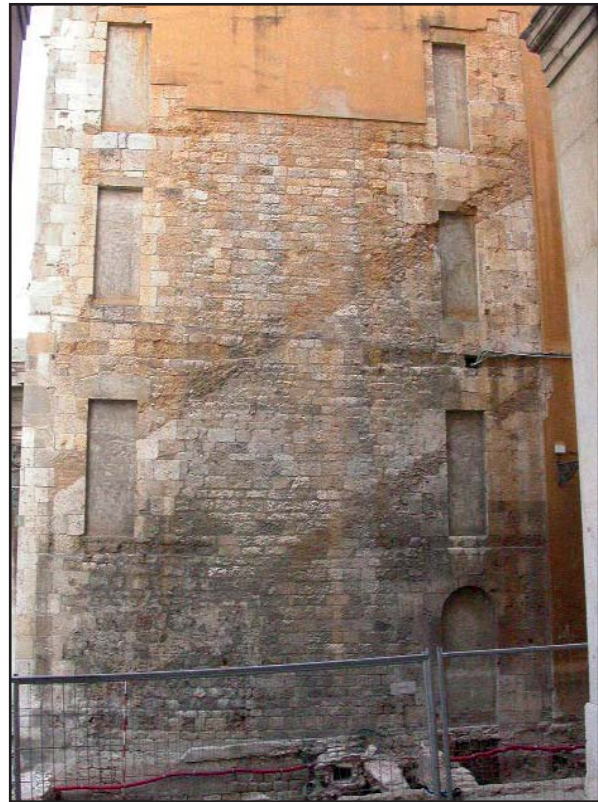


Fig. 3.48 Excavation of via degli Uffizi. Eastern elevation of tower house A.

immediately south of via degli Uffizi, and the church of Santa Cristina²¹⁰ was situated to the north of the buildings of via dei Facchini. These housing structures rose in scarcely built area subject, until then, to unregulated development. Indeed, the neighbouring excavations in via dei Facchini and via Toselli and Palazzo Giuli, show how the area of Santa Cristina underwent chaotic and unplanned development from the X century which gradually became more organised, evidencing the passage from *villa* to a place of *civitas*. The excavation in via Toselli²¹¹ revealed the presence of a first building, of which only a limited portion of the southern building wall was identified, parallel to via Toselli, directly overlooking the *carraia maggiore*, facing the church of Santa Cristina and dating back to the end of the X century. During the XI century, to the south

of the original building, a new 4.5 m-long building was added, made of small limestone blocks held together by mortar. These renovation works led to the demolition of the southern boundary wall and, therefore, to the creation of just one bigger building to which – between the end of the XI and start of the XII century – a further building was added facing south. It is during this period that the tower houses of via degli Uffizi via dei Facchini were built, as well as tower house E of the excavation in via dei Facchini, positioned further back from the front of the *carraia maggiore*, but along the same axis of the opposite tower house A (ANDREAZZOLI 2004). The fact that the fabric of the city became denser is also evidenced by the construction of tower house C in via degli Uffizi, again between the end of the XI and start of the XII century, situated north of the

²¹⁰ The church of Santa Cristina is attributable to the the VIII century (GARZELLA 1990:14 ss).

²¹¹ GATTIGLIA G. 2012, *Intervention record no. 589*, in MappaGIS; DUCCI *et alii* 2008a.

previous buildings and featuring a structure with pillars on various sides in squared limestone, which became rough hewn along the southern side, and by the construction of a tower house currently incorporated inside Palazzo Mosca (FEBBRARO 2005-6:§2.3.1). The disordered sequence of these constructions between the end of the X and start of the XII century clearly shows the reduction of open place in this area of Chinzica and that urbanisation of the *villa* only started subsequently, according to a pre-arranged division into lots or at any rate based upon specific planning rules. The creation of building lots with the most important buildings overlooking the *carraia maggiore*, interrupted by alleys and narrow streets was carried out during the XII century and was completed between the end of this century and the start of the next one. During this phase, the two east and west building walls of the expanded building of the excavation in via Toselli were built with a socle in squared limestone blocks and brick elevation (fig. 3.49) and with north/south orientation. This transformation led to the definition of a new open courtyard, an item often present in tower houses during this period, attached to the building's southern side, and paved with floor bricks with herringbone design, and also to the closing of the space to the east thus forming a narrow alley (*chiasso*)²¹². From the end of the XII century, more specifically at the start of the XIII century, the city truly "exploded": open and uncultivated areas were crammed with buildings and areas considered outside the *civitas*, such as Chinzica, flourished with new houses and streets connected to the main roads accessing the city centre. This is the case of the more peripheral area of via Mario/via Sant'Antonio, which started its urbanisation process from the end of the XII – start



Fig. 3.49 Excavation of via Toselli. Expansion of the tower house with base in limestone blocks and brick elevation.

of the XIII century (DUCCI *et alii* 2010). It is during this period that bricks started to be used, initially to build important constructions, such as the bell tower of San Sisto (ALBERTI *et alii* 2006), and then for the building walls and paved floors of the buildings belonging to the upper classes; lastly, it became a common building material, as witnessed by the impressive renovation of the building in via Toselli²¹³, by the partitions and floors of the buildings in via dei Facchini²¹⁴, by the *domus* in via Sant'Apollonia²¹⁵ and by the construction of seven tower houses during the second half of XIII century in the area of Palazzo Giuli, which were located along the secondary road network moving further away from the main roads. The use of construction elements that could be easily found and transported and that were lightweight, easy to lay and less expensive than stone²¹⁶ which, together with wood, had been the main building material up to that moment, responded to the increasing demand for buildings yet at the same time was the propelling force of demand itself. This new construction method led to the introduction of new construction

²¹² This closing led to intensive use of the alley as a place for disposing waste and building material debris, at least up to the XIV century.

²¹³ See above.

²¹⁴ LA ROSA L. 2012, *Intervention record no. 61*, in MappaGIS; BALDASSARRI 2004.

²¹⁵ SCIUTO C. 2012, *Intervention record no. 92*, in MappaGIS; ANDREAZZOLI *et alii* 2002.

²¹⁶ The use of this material led to the disappearance of panchina stone, whilst limestone continued to be used throughout the XV century as attested by the structures of the Florentine fortress.

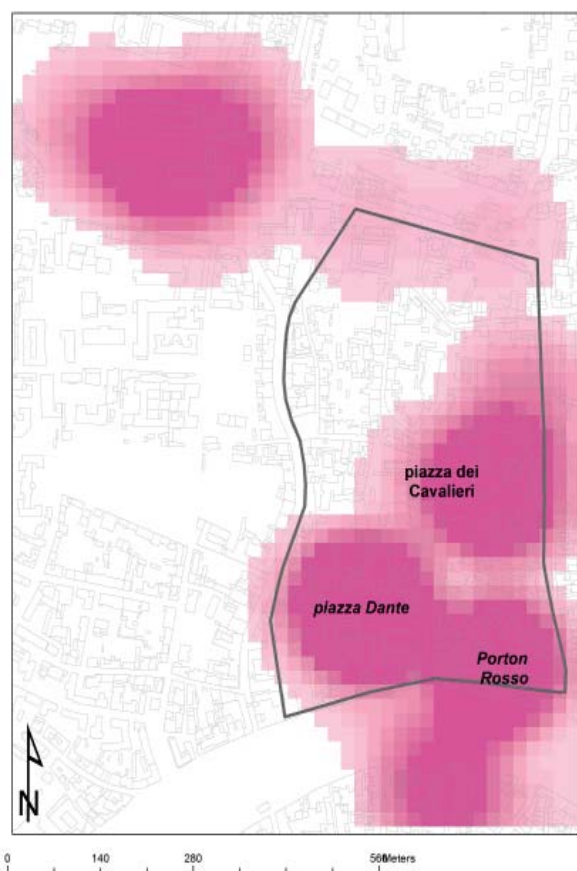


Fig. 3.50 Location of the finds mentioned in the text within the current city. The KDE of the VIII-X century finds is indicated in fuchsia.

techniques and skilled workforce, and highlights the economic and social development of the middle/upper classes, probably favoured by lower construction costs.

3.2.3 Urban infrastructures: road networks, water supply and waste management.

3.2.3.1. Roads, alleys and squares: chronology, techniques and hierarchy

Roads, alleys and squares are the framework upon which the urban fabric has grown and changed over the centuries. Archaeological sources provide 54 different finds connected to early and late medieval

road connections. The data available allow us to understand trails between XI and XV century, but we do not have a sufficiently clear picture of the road network between the Late Roman period and the Early Middle Ages. The only information about Late Roman road networks is related to suburban and extra-urban routes, as seen in the previous chapter, with the assumed coincidence between the final southern stretch of the *Aemilia Scauri* and the *carraria maggiore* (current via San Martino/via Toselli), which we may assume maintained its function as road axis during the Early Middle Ages. The excavation in via Galluppi²¹⁷ provides weak archaeological traces, where a route was cancelled at the start of the IV century following the construction of the necropolis. Further evidence may be obtained from toponyms which refer to the presence of the gates of the Late Roman city walls, which survived during the Early Middle Ages. In this latter case, these are city areas mentioned in documents dated between the end of the XII and start of the XIII century: *Porta Sancti Felici*, between Borgo Stretto and via Dini, *Porta Sancti Martini*, to the west of Borgo Stretto, *Porta Aurea*, to the right of the Arno at via Curtatone e Montanara, *Porta Maris*, between via Santa Maria and Lungarno²¹⁸, which could indicate continuation of the roads accessing and departing from the Late Roman/early medieval urban area. Even information about the Early Middle Ages is very little, limited only to the excavations of piazza Dante (providing the greatest amount of information), piazza dei Cavalieri and vicolo del Porton Rosso (fig. 3.50). To date, Saggio (test pit) I²¹⁹ in piazza Dante is the richest examples of early medieval road connections since it brought to light examples related to both the main and secondary road connections. The first attestations of a main road network date back to between the VIII and X century, and correspond

²¹⁷ TARANTINO G. 2012, *Intervention record no.724*, in MappaGIS; SCIUTO C 2012, *Intervention record no. 905*, in MappaGIS.

²¹⁸ The areas indicated are rather large and it is not easy to accurately identify a road that could cross these gates.

²¹⁹ GRASSINI F. 2012, *Intervention record no. 325*, in MappaGIS; BRUNI, MENCHELLI 1993.

to a north/south stretch resting on layers of fill or abandoned layers and on the levelling of walls relating to Roman *domus* (BRUNI, MENCHELLI 1993: 159). The road surface²²⁰ is composed of medium-sized pebbles (around 8x10 cm) held together by lime mortar. Between the X and start of the XI century, the paving was replaced with a new road surface made of large (around 18x30 cm) rounded paving stones bonded with clay mixed with crushed stone. The construction of the buildings overlooking the road during the X century, led to the creation of *chiassi* (alleys) between the buildings perpendicular to the main road²²¹. Saggio I²²² of piazza dei Cavalieri evidenced an alignment composed of just two large-sized rounded paving stones, which was interpreted (with some doubt) as a road surface (ABELA, BRUNI 2000: 75 and fig. 22) dating back to the VII-VIII century; the limited size of the excavation did not make it possible to fully comprehend if it rested on a previous route. Lastly, the excavation at Porton Rosso²²³ evidenced a paving²²⁴ in pebbles and medium and small-sized blocks embedded in a clayey-sandy sediment, located between buildings I and II, belonging to the mid-X century and north/south oriented as the adjacent route of vicolo del Porton Rosso upon which building II most probably overlooked (FEBBRARO, MEO 2009: 188)²²⁵. As previously seen, from a technological viewpoint, the main road connections during the Early Middle Ages were characterised by surfaces with medium and large sized stones laying either in a preparation of mortar or more generally in a earth preparation. It is even more difficult to identify secondary road connections, probably made of simple earth beaten surfaces. Given the few archaeological sources, we can only attempt to outline the internal and peri-urban road network on the basis of the locations of churches, documented from the VIII century and before the mid-XI century (figs. 3.18, 3.19 and 3.20): Sant'Isidoro and Sant'Eufrasia, but also Santa Maria Vergine, confirm the route identified in piazza Dante, establishing its range as far as the area of Cortevicchia, where it then continued and reached the Bishop's palace to the north. Santa Cristina was situated on the left bank of the Arno River at the entrance of the *carraia maggiore* of medieval documents (current via Toselli/via San Martino), whilst in the eastern peri-urban area, the church of San Piero in Vincoli traces the route of via Calcesana. It is difficult to understand, therefore, if and how Roman roads survived during the Early Middle Ages and what sort of impact they had on the urban fabric in general. The preservation of certain routes, especially those connected to the gates, only means that there was a public authority capable of contrasting occupation of the streets. The topographic continuity of routes must not be confused with continuity of the urban tissue, which is often characterised by the ruralisation of areas overlooking the routes²²⁶, as we assume happened in piazza del Duomo. The large *domus* overlooked a road which was probably preserved during the Late Medieval Age

²²⁰ Tower houses I and II were built on this road surface.

²²¹ The construction technology of these alleys is not described.

²²² SCIUTO C. 2012, *Intervention record no. 130*, in MappaGIS; ABELA, BRUNI 2000.

²²³ GATTIGLIA G. 2012, *Intervention record no. 61*, in MappaGIS; FEBBRARO, MEO 2009.

²²⁴ According to the authors, the small excavation does not make it possible to understand if it is a road or internal courtyard.

²²⁵ The excavation in the Area 4000 evidenced during the X-century phase, a paving in pebbles held together by mortar, upon which a new floor was added after a short period of time made of lithic scales, set in a sandy-silty sediment and held together by mortar, upon which, a hearth was found. These pavings are doubtedly attributed to a road surface, with east/west orientation and perpendicular to the north/south road network of Porton Rosso, rather than to an internal floor (FEBBRARO, MEO 2009:190). The presence of a hearth makes me inclined to interpret it as related to an internal space, maybe a courtyard connected to the building.

²²⁶ For details see BROGIOLO 2011: 35ss.

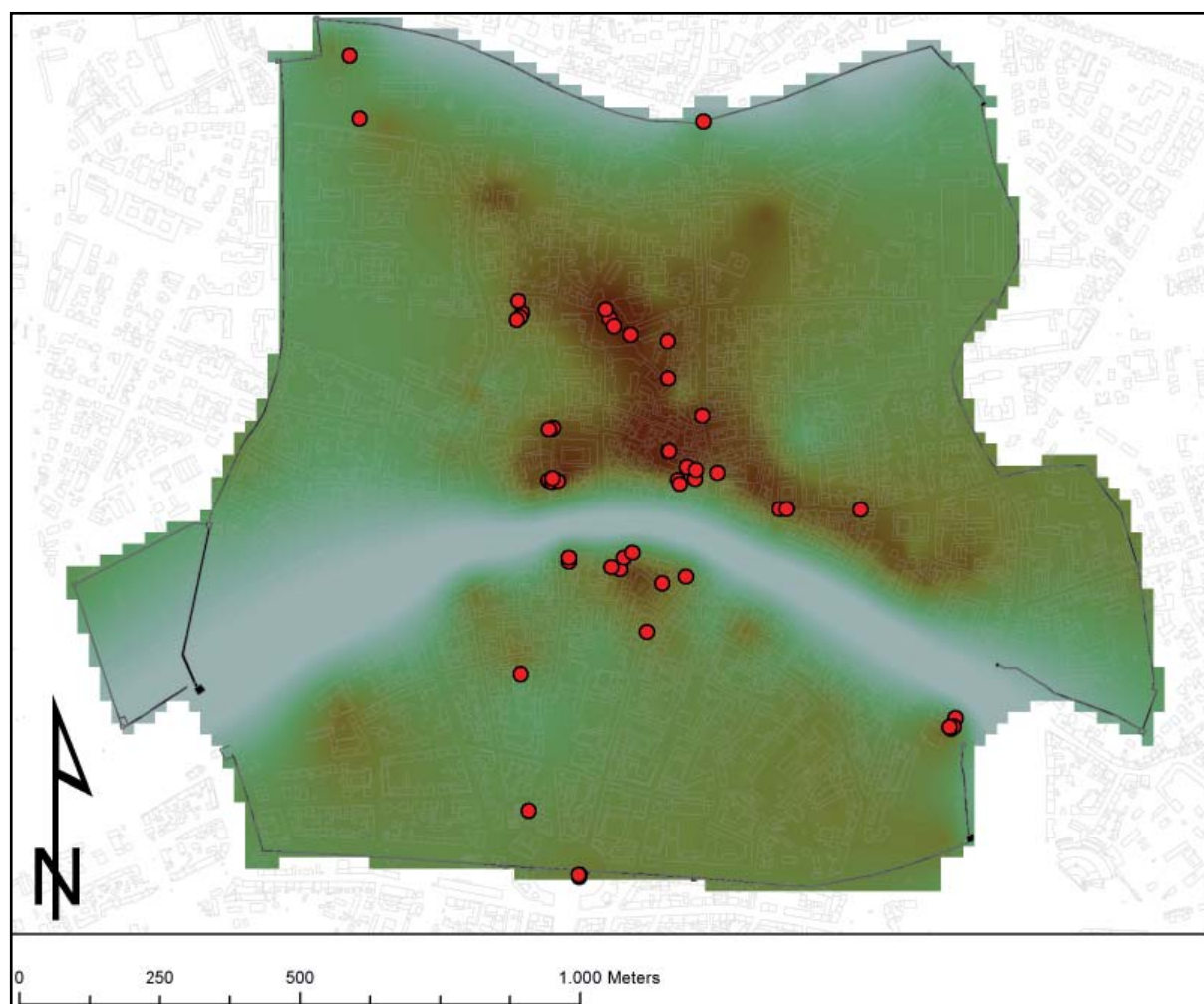


Fig. 3.51 All the late medieval finds relating to roads are reported on the late medieval DEM.

south of the Camposanto Monumentale²²⁷. The existence of the road, however, did not imply the preservation of the urban fabric which from the VI century was highly ruralised to such an extent that it underwent a transition from residential area to cemetery. Conversely, examples such as those of piazza Dante highlight the transformation of the urban tissue.

A greater number of stratigraphic evidences are available from the XI century, which allow us to provide a preliminary picture of the urban road

network, not so much at topographic level, but in terms of functional hierarchy and technological differences (fig. 3.51). *Porta Parlasci* and the road axis found in piazza Dante are among the most ancient road surfaces documented in excavations. With reference to the road surface documented under *Porta Parlasci*²²⁸, made while the gate was being built, in the stretch of city walls built between 1157 and 1158, the excavation documented a rather regular cobblestone paving, slightly hump-backed, resting upon the internal towers situated at the side of the gate, at a depth

²²⁷ TARANTINO G. 2012, *Intervention record no. 865*, in MappaGIS.

²²⁸ TARANTINO G. 2012, *Intervention record no. 47*, in MappaGIS; ALBERTI *et alii* 2007: 57.

of almost 2.50 m compared to the current level. The frequentation of the road may be documented through the numerous restorations of the road surfaces. In an over one metre thick deposit, at least four risings can be seen made of earth mixed with gravel and ceramic or of mortar, which each time cover an alluvial layer which covered the road surface due to flooding of the nearby Auser River. The excavation of piazza Dante brought to light an urban road context dating back to between the X and XII century, as identified by the chronological sequence. Saggio I²²⁹, which includes two opposite facades of tower houses crossed by the road which ran from Lungarno to the area of *Cortevicchia*, documented a sequence of five overlapping road trails, interrupted by level rises and preparations, ranging between the X and XIV century, and included in a stratigraphic deposit of around 1.50 m. The most recent road surface, belonging to the XIV century, was exclusively built in dry-laid pebbles, whilst the pavement seems to be composed of stones and broken bricks held together by mortar. The same exclusive use of stones is confirmed for all other documented road surfaces. The road surface dated between the end of the XII and start of the XIII century was made of large fluvial pebbles resting on a double preparation of sand and clay and of mortar and clay; it could belong to the same period of the road excavated under Porta del Parlascio and so be related to the reorganisation of the road surfaces following the construction of the municipal walls. The underlying road paving is probably related to a previous phase (XI-XII century). It is also made of large, dry-laid pebbles resting upon a sandy sediment (ALBERTI *et alii* 2007: 55). Stones are again exclusively used for the road surface dating back to the XI century found in via

dell'Ulivo²³⁰, which could belong to the same road axis found in piazza Dante and maybe to the *via maggiore* mentioned in written sources. A road route dates back instead to the end of the XII century, which is the southern continuation of vicolo delle Conce²³¹, and is provided with drainage on its sides for carrying away water. At the start of the XIII century, concurrently with an urban restructuring phase, a north-south oriented road was built with irregular brick fragments which encountered a second east/west road axis made of paving stones in a mortar preparation.

From the XIII century, archaeological data show the rapid diffusion of bricks used for road surfaces, laid edgeways and arranged in a herringbone pattern with a highly selected sandy sediment. From the excavations of piazza delle Vettovaglie²³², we know that there were differences during the XIII and XIV century between carriage ways and roads used mainly by pedestrians. The former were made of bricks laid edgeways and parallel to one another, but orthogonally with respect to the sense of direction, and had stone reinforcements where the road was subject to greater stress or wear by carriage wheels. The roads mainly used by pedestrians were made of bricks arranged in a herringbone pattern, with the tips oriented towards the sense of direction. In both cases the bricks and stones were blocked by highly selected river sand. Underneath the sand, at a height of around 15 cm, a thin layer of silt could be found, to make the road surface settle and make it waterproof with respect to the underlying ground. A similar technique was also found in the road fragments belonging to the same chronological period in Borgo Stretto²³³, via Ulisse Dini²³⁴, the church of Sant'Andrea in Pesciola²³⁵, Logge dei Banchi²³⁶, via Toselli²³⁷, via

²²⁹ GRASSINI F. 2012, *Intervention record no. 325*, in MappaGIS; BRUNI, MINETTI 1993.

²³⁰ GATTIGLIA G. 2012, *Intervention record no. 325*, in MappaGIS; GARZELLA, REDI 1980.

²³¹ GATTIGLIA G. 2012, *Intervention record no. 776*, in MappaGIS; DUCCI *et alii* 2010.

²³² SCIUTO C. 2012, *Intervention records nos. 212, 213, 214, 216, 217*, in MappaGIS; ALBERTI, BALDASSARRI 2004.

²³³ LA ROSA L. 2012, *Intervention records n. 267,268*, in MappaGIS; MILANESE 2004a.

²³⁴ TARANTINO G. 2012, *Intervention record no. 520*, in MappaGIS.



Fig. 3.52 Excavation of via degli Uffizi. The alley (chiasso) between tower houses A and B.

dei Facchini²³⁸, Palazzo Giuli²³⁹, and corso Italia²⁴⁰. In this overall picture, exceptions can be seen in the four earth-beaten roads dating back to the XIII and XV century in Lungarno Gambacorti²⁴¹ and the paving²⁴² built during the XIII century in pebbles embedded in a sandy preparation, among the buildings incorporated in Palazzo Giuli and

at the excavation in via Toselli. This route entered onto the road network of the *carrara maggiore*, at the church of Santa Cristina, which was made of bricks arranged in a herringbone pattern and embedded in a sandy sediment. The many investigations in the area of via Toselli/via dei Facchini/Palazzo Giuli emphasise how in this area of the city, and maybe more generally in Chinzica, the significant construction phase of the XIII century was also an urban planning operation. The road layouts fully confirm this. Of note is the modular layout of the north/south road network overlooking the *carrara maggiore*, with an alternation between secondary roads and alleys. Blocks of buildings are created, separated by secondary roads and composed of two parallel tower houses separated by an intermediate alley. Alongside the main road network, composed mainly of *carrarie*²⁴³, i.e. carriage ways, and of the greater *viae*, a secondary road network also existed, especially for pedestrians, as well as narrow *chiassi* and *chiassatelli* (alleys). The road axes found at via degli Uffizi²⁴⁴, via Consoli del Mare²⁴⁵, piazza dei Cavalieri²⁴⁶ and Palazzo Alliata²⁴⁷, as well as that already described at via Toselli, may be considered as different examples of a secondary road network. The former (fig. 3.52) was created during the XI century following the construction of the two tower houses A and B, and underwent four subsequent reconstructions between the XI and XIII century. It was around 1.40 m wide and

²³⁵ CAMPUS A. 2012, *Intervention record no. 229*, in MappaGIS.

²³⁶ LA ROSA L. 2012, *Intervention record no. 273*, in MappaGIS; BORGHI 1972.

²³⁷ LA ROSA L. 2012, *Intervention record no. 426*, in MappaGIS; TONGIORGI 1974.

²³⁸ LA ROSA L. 2012, *Intervention record no. 61*, in MappaGIS; BALDASSARRI, MILANESE 2004.

²³⁹ GATTIGLIA G. 2012, *Intervention record no. 590*, in MappaGIS; REDI, GUERRUCCI 2006, relating to a widening of the *carraria maggiore* at Santa Cristina, which may also be a square associated with the religious building.

²⁴⁰ TARANTINO G. 2012, *Intervention record no. 619*, in MappaGIS.

²⁴¹ SCIUTO C. 2012, *Intervention record no. 658*, in MappaGIS.

²⁴² GATTIGLIA G. 2012, *Intervention record no. 589*, in MappaGIS; DUCCI *et alii* 2008.

²⁴³ The axes of via Toselli (*carrara maggiore*), Borgo Stretto, Borgo Largo and piazza delle Vettovaglie may be related to this type of routes, for example.

²⁴⁴ CAMPUS A. 2012, *Intervention record no. 489*, in MappaGIS.

²⁴⁵ TARANTINO G. 2012, *Intervention record no. 588*, in MappaGIS; ANICHINI, GATTIGLIA 2008.

²⁴⁶ SCIUTO C. 2012, *Intervention record no. 125*, in MappaGIS.

²⁴⁷ LA ROSA L. 2012, *Intervention record no. 290*, in MappaGIS.

its paving was made of pebbles and reused brick fragments. It was reconstructed several times, in one case with the use of mortar as bonding material, until it was finally constructed with bricks held together by mortar, dating back to the XIII century. This route can clearly be considered a secondary road network, but was not a narrow alley since it was not used as a rubbish dump, and had construction characteristics similar to the alley identified in piazza dei Cavalieri whose surface is made of stones and pebbles embedded in a layer of mortar. The situation observed at the excavation in via Consoli del Mare is different. Here, a stretch of road was found, used between the XII and XV century, made with beaten earth, around 2.60 m wide and positioned between a *casa solariata* and a metallurgic workshop. In this case also, it is a secondary road axis and the simple technique with which it was built is closely related to the production activities of the area. Alleys, instead, were narrow spaces between two building walls, less than 1 metre wide, without specific paving, made of simple beaten earth without draining or waterproof materials. These spaces were generally used as rubbish dumps rather than areas of transit, as demonstrated by the alley situated between the two tower houses identified on the eastern side of current piazza delle Vettovaglie as well as the one between the tower houses of the excavations of via Toselli/via dei Fachini and the one between the tower houses of Palazzo Giuli.

Special routes were found in piazza del Duomo and dated between the second half of the XIV and XVI century. The technique used was of poor quality, typical of the PostMedieval Age when road construction techniques were highly simplified (ALBERTI *et alii* 2007). The first, ran from the southern sector of the square towards Porta del Leone and its surface was made of mortar,

limestone scales and brick fragments²⁴⁸; the second, into which the first one merged, ran south of the Camposanto Monumentale and was made of lithic elements and brick fragments set in a sandy-silty sediment and provided with a side kerb²⁴⁹.

Compared to the number of road routes found during the archaeological investigations, the examples attributable to open places, widenings and squares are fewer but not less important. More or less large squares are attested in the excavations of piazza Dante – Saggio II, piazza Sant’Omobono, piazza delle Vettovaglie, via degli Uffizi, Palazzo Scotto and via dei Mille. The paving made of bricks laid flat found in the excavation of piazza dei Cavalieri²⁵⁰ is of difficult interpretation, yet appears to pertain to an internal paving or courtyard, as also the paving arranged in a herringbone design which is perhaps related to one of the road axes before the square was built. Instead, the open place with the well found in the excavation of via Sant’Apollonia²⁵¹ is related to an internal courtyard. Squares consisted of open places, widenings between buildings and connections between road networks. They were the places where people met and carried on their social life, and were the point where water infrastructures, such as wells and washhouses, were situated. The construction technique used to pave these areas differs from roads, which, as already seen, used bricks almost exclusively. Stone, instead, continued to be used for paving open places, especially pebbles, which were often alternated with brick fragments, often reused. The decision to use a different construction technique could be related to a greater static function, i.e. the fact that people stopped in these areas rather than transiting through them. The most ancient examples of open places come from

²⁴⁸ GATTIGLIA G. 2012, *Intervention record no. 361*, in MappaGIS; ALBERTI *et alii* 2011d.

²⁴⁹ TARANTINO G. 2012, *Intervention record no. 865*, in MappaGIS; ALBERTI *et alii* 2011d.

²⁵⁰ SCIUTO C. 2012, *Intervention records nos. 129,130*, in MappaGIS; ABELA, BRUNI 2000.

²⁵¹ SCIUTO C. 2012, *Intervention record no. 94* in MappaGIS; CORRETTI, VAGGIOLI 2003.



Fig. 3.53 Excavation of piazza Sant'Omobono. Of note, the division of the square into private area (above) and public area (below).

the southern sector of Saggio II in piazza Dante²⁵², from the excavation of piazza Sant'Omobono²⁵³ and of via dei Mille²⁵⁴ where it is possible to identify squares belonging to the XII century. In piazza Dante, an area used as open place between the houses was firstly paved with a simple layer made of mortar with *opus signinum* and panchina stone, then, during the XII century, by a layer of crushed stone mixed with mortar and *opus signinum*, together with large rounded paving stones, which rises on an embankment made of panchina stone blocks held together by compact clayey sediment and large-sized stones. The paving layers found in the excavation of piazza Sant'Omobono regard an open place adjacent to the church of San Pietro in Palude, which rose to the north of the current square and whose remains are partially visible at number 6. The two subsequent XII-century pavings are similar to those of piazza Dante, in stone and pebbles, the

former very compact and held together by mortar, the latter characterised by a silty-clayey bonding material. The open place to the west of the church of Sant'Eufrasia identified in via dei Mille and dating back to the XII century also had a mortar paving. Unlike those found in piazza Dante, in the pavings of piazza Sant'Omobono, especially in the second, dating back to the second half of the XII century, reused brick fragments may be seen. Brick fragments and mortar also appear in a subsequent paving of Saggio II of piazza Dante, upon which an embankment rests of highly compact crushed stone and pebbles. The paving generically dates back to before the XIII century and this does not help us understand whether there was an early use of wasted and/or reused brick fragments for this type of paving. The use of panchina stone blocks is also attested in the paving of piazza Sant'Omobono. Unlike the excavation of Saggio II of piazza Dante, they are not used as embankment, but as a true paving, arranged only in the southern half of the square (fig. 3.53). In fact, during the XII century, spaces within the square were sharply separated, possibly coinciding with the separation between area belonging to the church and private property area (pertaining to the building demolished in the XVI century which rose in the current southern part of piazza Sant'Omobono). The decision to repave in panchina stone could have been made by the private owners, whereas the church continued to use the pebble paving which had previously covered the entire square. This separation continued until the XVI century. Between the end of the XII and start of the XIII century, the paving was raised even further. The new paving was made of pebbles and bricks laid edgewise, held together with mortar and laid on sand preparation layers. The south western corner of piazza delle Vettovaglie²⁵⁵ brought to a light a

²⁵² TARANTINO G. 2012, *Intervention record no. 326*, in MappaGIS; BRUNI, MINETTI 1993.

²⁵³ SCIUTO C. 2012, *Intervention record no. 488*, in MappaGIS; ANICHINI, GATTIGLIA 2006.

²⁵⁴ GHIZZANI MARCIA F. 2012, *Intervention record no. 884*, in MappaGIS.

bricked open place, dating back to the XIII – XIV century, connected to a brick well provided with a circular footboard and assumedly related to the piazza dei Porci (Pigs Square) mentioned in late medieval documents. This find opens an interesting debate on the type and size of open places and on their relationship with water supply points. Starting from the XIV century, in addition to the previous examples, evidence may also be seen in the excavation at Palazzo Scotto²⁵⁶, where a large square was found with a well adjacent to the church of Sant’Andrea in Chinzica, repaved during the second quarter of the XIV century after a strong flood which hit the entire district south of the Arno River in 1333. The XIV century paving was made of pebbles and bricks, divided into northwest/northeast oriented sectors and delimited by stone or brick kerbs. During the XIV century, a circular brick footboard was built around the well, sloping outwards from the well, which terminated with a conduit connected – through a square hole provided with an iron filter – to an underground channelling system linked to a tank used as washhouse/drinking trough. The tank was positioned in the middle of the square and covered by a long timber roof. The open place, in this case, was extremely large (around 40 m²) and developed around an important infrastructural element (the well provided with a washhouse covered by a roof²⁵⁷) (fig. 3.54). The search for an ornamental element is also evident in this paving: the kerb, which is partly found in paving at the end of the XIV – start of the XV century, of the excavation of piazza Sant’Omobono, made of pebbles, partly cut stones (sandstone and limestone), bricks, all laid edgeways, on a crawl space covered by sandy layers. The stones positioned along its southern edge – marking the

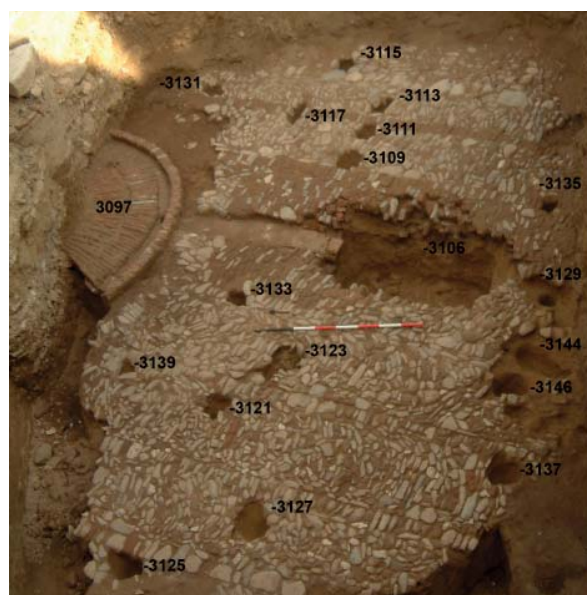


Fig. 3.54 Excavation of Palazzo Scotto. The square at the church of Sant’Andrea in Chinzica. Of note is the circular footboard of the well and the negative trace in the centre related to the removal of the drinking trough connected to the footboard via a conduit. The many postholes refer to a timber roof which covered the area.



Fig. 3.55 Excavation of piazza Sant’Omobono. The square dated between the end of the XIV and start of the XV century. It is interesting to notice how the separation between public and private space continued.

boundaries – were laid flat and of a larger size. The material was not positioned casually but followed a decorative intent (fig. 3.55). The mid XIV/XV century paving of Saggio II of piazza Dante, made of bricks and small and medium

²⁵⁵ SCIUTO C. 2012, *Intervention records nos. 216,217*, in MappaGIS; ALBERTI, BALDASSARRI 2004.

²⁵⁶ LA ROSA L. 2012, *Intervention record no. 53*, in MappaGIS; GATTIGLIA G. 2012, *Intervention record no. 367*, in MappaGIS; GATTIGLIA 2006.

²⁵⁷ We do not have comparisons for Pisa, but written sources report the construction of a well with a washhouse in Cecina during the second half of the XIV century (GATTIGLIA 2006).

sized stones held together by mortar and laid on a sandy preparation, had parts missing and did not allow us, therefore, to study the use of ornamental elements. A small open place that is difficult to understand also rose in the widening to the north of tower houses A and B and to the west of tower house C of via degli Uffizi²⁵⁸. The paving was built during the first half of the XIII century and rested upon brick conduits that carried away the rainwater. Despite the existence of analytical documentation, data have been only partially published which would have otherwise allowed us to have a more complex and thorough view: the excavation at San Michele in Borgo²⁵⁹ brought to light a late medieval paving in bricks laid on edge relating to a cylindrical well existing prior to the cloister, which cannot be defined as an internal courtyard or as an open public space; a square was also found at San Biagio alle Catene²⁶⁰, however, the scarce data published do not give us a better understanding, and a square with well was found at piazza San Giorgio, but in this case, none of the documentation has been published. Despite the lower number of cases, it is possible to suggest a hierarchy between open places, whether simple widenings such as piazza delle Vettovaglie, large “district” squares such as the square at Sant’Andrea in Chinzica, divided spaces such as piazza Sant’Omobono or open places between houses such as piazza Dante and via degli Uffizi. Instead, it is more difficult to understand the construction technique of these spaces and their link to the public water

infrastructures. Although the use of lithic material seems to be related to real squares, and bricks to widenings along the road and/or courtyards between the houses, it is difficult to make a clear distinction, provided that these sharp differences actually did exist. In a highly urbanised fabric such as the Middle Ages, it is probable that open places were generally small sized areas and, in this case, the large size of the square of piazza di Sant’Andrea di Chinzica was favoured by its marginal position compared to the actual city centre²⁶¹.

In a city crossed by two rivers, bridges were very important and the authorities devoted special attention to considering them important assets for the community, to such an extent that already at the end of the XI century it was forbidden to erect towers at the ends of the only bridge crossing the Arno (GARZELLA 1990: 104), while two centuries later, the 1287 *Breve Communis* prohibited executions and punishments to be carried out on or near them (GHIGNOLI 1998: 396). At the end of the Middle Ages, the Arno River was crossed by four bridges and the *Auser* River by three. The most ancient bridge that crossed the Arno connected Santa Cristina, on the south bank, to Porta Aurea (current via Curtatone e Montanara), on the north bank. It was positioned on the route of the Roman consular roads entering the city, although we do not know how it was built and if it survived the early medieval hydrogeological turmoil. Between the end of the XI – start of the XII century it was replaced by a new *ponte de Arno* situated in correspondence of

²⁵⁸ CAMPUS A. 2012, *Intervention record no. 602*, in MappaGIS; ANICHINI, GATTIGLIA 2008.

²⁵⁹ CAMPUS A. 2012, *Intervention record no. 104*, in MappaGIS; REDI *et alii* 1987.

²⁶⁰ GATTIGLIA G. 2012, *Intervention record no. 3*, in MappaGIS; REDI 1982.

²⁶¹ These considerations seem to be confirmed by the thinning works inside the historical centre carried out during the Modern Age, especially from the mid-XVI century. During this period, the city seems to lose its medieval aspect and embraces new urban concepts made of large open places, true squares suitable for different purposes as in the case of piazza del Grano or the thinning out of piazza Sant’Omobono, probably connected to the market, or for the new layout of piazza dei Cavalieri (ALBERTI *et alii* 2007:67).

the current Ponte di Mezzo, given that early XII century documents mention the church of San Sebastiano (to the south of the current Logge dei Banchi) and San Michele in Borgo (GARZELLA 1990: 118). The presence of a structure such as this was certainly tempting for traders, to such an extent that the authorities²⁶² often had to clear the bridge of all kinds of obstructions, assumedly haphazard wooden shops. Yet shops still rose on the bridge during the Late Middle Ages, to the point that when Pietro Gambacorti renovated it he boasted that he had had the shops removed (SUPINO 1904: 304). At the end of the XII century a new bridge (*Ponte Nuovo*) was built between via Sant'Antonio, on the south bank, and via Santa Maria, on the north bank, which transformed the previous one into Ponte Vecchio (Old Bridge). Finally, during the second half of the XIII century, the Arno River was crossed by further two bridges, first the *pons Spine* where the current Cittadella bridge rises, to the east, and then the Ponte a Mare at the Tersana, in the western part of the city (GARZELLA 1990: 248). Regarding the *Auser* River, apart from the problematic location of a *ponte Così* mentioned in 1072 (GARZELLA 1990: 45), the most ancient bridge connected the urban area to the female monastery of Santo Stefano *Oltre Auser*; however, already during the mid XII century, during the construction of the city walls, three bridges are mentioned: the bridge of Santa Maria, at the north western corner of the walls, a bridge at Porta Santo Stefano, the most ancient one, and a *pons in capitae viae burgi*, in correspondence of Porta al Parlascio (TOLAINI 1992: 326). From a material viewpoint, an anonymous manuscript belonging to the mid XV century describes the three bridges crossing the Arno River made of stone and decorated

bricks, and the Ponte Vecchio with three arches (SUPINO 1904: 304). The only archaeological source available, instead, refers to the XIV century bridge at the gate of Sant'Egidio²⁶³, which crossed the ditch that ran underneath the walls to the south of the city. The only remains of this bridge are two piers with rough hewn and squared limestone faces and the monumental entrance gate.

To conclude, it is possible to state that from a technological viewpoint, stones and pebbles were especially used for road networks from the X until the XII century, at times laid upon mortar, and were mainly replaced by bricks from the XIII century, following the booming production of bricks. Conversely, open places, of which we have fewer examples and only from the XII century, continued to use lithic materials. From the XIII century, the road surfaces of the main networks began to be made of bricks, arranged with a herringbone pattern in a highly selected sandy sediment, whereas for secondary roads, paved surfaces continued to be built. Mixed techniques can also be found, such as the carriageway of piazza delle Vettovaglie where two strips of cobblestone paving may be seen, in correspondence of areas where the friction with carriage wheels was greater. The urban road network that began to form from the Early Middle Ages reached its definite aspect with the construction of the city walls, which rigidified and restricted the urban fabric, influencing it during its future development.

The early medieval inhabited areas, positioned along the road axes accessing the city, began to be populated from the end of the X century, to the point that it became necessary to include them in the new XII century *civitas*: the main city access and exit road axes became urban routes, and

²⁶² As the consular oath in 1164 (GARZELLA 1990: 176).

²⁶³ SCIUTO C. 2012, *Intervention record no. 452*, in MappaGIS; ANDREAZZOLI, MEO 2006.



Fig. 3.56 The main late-medieval urban road connections (in grey), reconstructed on the basis of archaeological data, historical mapping and assumptions drawn from REDI 1991 and TOLAINI 1992, overlapping the late-medieval DEM.

therefore restored and adapted to the new walled *civitas* (fig. 3.56).

4.1.3.2 Water supply: wells and cisterns

As already seen, Roman-age Pisa was fed from an aqueduct arriving from the north-western strata of Monti Pisani which supplied water to the *thermae* at Porta a Lucca and probably an area to the south east of the city (which probably stopped working between the VI and VII century). The only certain data in our possession is that after the Roman Age, Pisa no longer had an aqueduct until the start of the XVII century. The characteristics of the geomorphological context of Pisa make it easy to

reach groundwater, often containing lime or brackish water, so we can assume that wells were excavated starting from the Early Middle Ages, probably in association with direct supply from river waters, although not archaeologically attested. We have knowledge that many wells were built from the mid XI century. Public wells were located in squares and widenings, private wells were positioned in the courtyards of tower houses and wells could also be found in connection to workshops, which needed abundant water. The most ancient documentation relates to a small well found in the excavation of piazza dei Cavalieri²⁶⁴ associated with a metallurgical phase dated between the mid-XI century and first half of the XII

²⁶⁴ SCIUTO C. 2012, *Intervention record no. 130*, in MappaGIS; ABELA, BRUNI 2000; CORRETTI 2000.

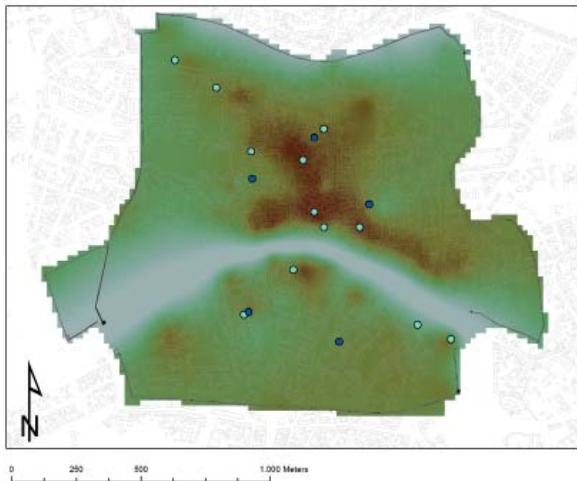


Fig. 3.57 Finds related to wells (in blue) and collection tanks (dark blue) are positioned on the late-medieval DEM.



Fig. 3.58 Excavation of Palazzo Scotto. The well in the XIV century square. Of note, the continuous rising that the well underwent until the XVIII century.

century. It would seem to be a small well directly dug into the ground and used, for a short period of time, to carry out metallurgical activities. A well, therefore, connected to a workshop, as may have been the case for early medieval wells. The remaining structures date back from the XIII century, both in the case of public wells, built where the network of houses and roads thinned out, for example piazza delle Vettovaglie²⁶⁵, via Cavalca²⁶⁶, Palazzo Scotto²⁶⁷, and of private wells, for example the wells of via Galli Tassi²⁶⁸, piazza Dante²⁶⁹, Palazzo Vitelli²⁷⁰, San Michele in Borgo²⁷¹, via Coccapani²⁷², via Toselli²⁷³, via La Tinta²⁷⁴, via Sant'Apollonia²⁷⁵ and piazza del Duomo²⁷⁶, as also wells related to workshops such as the well of via dei Mille²⁷⁷ and probably of via Sant'Antonio²⁷⁸ (fig.

3.57). The first, as already seen, were situated in public squares or widenings, whereas the second were generally located behind buildings, at times covered by roofs and paved with floor bricks, and the last were near or in the middle of workshops. Technologically, wells were cylindrical structures made of reused bricks held together with a firm (non hydraulic) mortar, until reaching deep groundwater. Since used continuously, they were often raised and the well curb had to be moved to adjust the entrance to the rising ground surfaces. They were often provided with one or more external footboards, which were round or concentric and made of bricks laid edgewise and arranged in a radiating pattern (fig. 3.58). The most complex case is the well found at Palazzo Scotto. It²⁷⁹ is part of a

²⁶⁵ SCIUTO C. 2012, *Intervention record no. 213*, in MappaGIS; ALBERTI, BALDASSARRI 2004.

²⁶⁶ SCIUTO C. 2012, *Intervention record no. 488*, in MappaGIS; ANICHINI, GATTIGLIA 2006.

²⁶⁷ GATTIGLIA G. 2012, *Intervention record no. 367*, in MappaGIS; GATTIGLIA 2006.

²⁶⁸ TARANTINO G. 2012, *Intervention record no. 516*, in MappaGIS.

²⁶⁹ TARANTINO G. 2012, *Intervention record no. 352*, in MappaGIS; BRUNI, MENCHELLI 1993.

²⁷⁰ LA ROSA L. 2012, *Intervention record no. 77*, in MappaGIS; GARZELLA, REDI 1980.

²⁷¹ CAMPUS A. 2012, *Intervention record no. 104*, in MappaGIS; REDI *et alii* 1987.

²⁷² TARANTINO G. 2012, *Intervention record no. 14*, in MappaGIS.

²⁷³ GATTIGLIA G.. 2012, *Intervention record no. 589*, in MappaGIS; DUCCI *et alii* 2008a.

²⁷⁴ LA ROSA L. 2012, *Intervention record no. 60*, in MappaGIS.

²⁷⁵ SCIUTO C. 2012, *Intervention record no. 94*, in MappaGIS; CORRETTI, VAGGIOLI 2003.

²⁷⁶ GATTIGLIA G. 2012, *Intervention record no. 927*, in MappaGIS; ALBERTI *et alii* 2011d.

²⁷⁷ GHIZZANI MARCIA F.. 2012, *Intervention record no. 881*, in MappaGIS. The well is situated in the middle of a fabric washing/dye workshop. According to the author of the excavation, a grinding wheel was placed on the bottom of the well used as filter to keep the water clean.

²⁷⁸ CAMPUS A. 2012, *Intervention record no. 613*, in MappaGIS.

composite system: around the mid-XIV century, a circular brick footboard was built around the well, made of bricks laid on edge with a radiating pattern, so as to slope towards the outside. Here, a small circular conduit was connected, through a square hole provided with an iron filter, to an underground channelling system linked to a tank used as washhouse/drinking trough. The tank was positioned in the middle of the square and covered by a long timber roof (fig. 3.54). In this case, it is evident that the water cycle was designed so as not to waste this important natural resource. The city laws that have reached us say nothing about the management of public wells and only seem to deal with the maintenance of the well curbs by users in order to avoid runoff water flowing along the roads (BALDASSARI 2008a: 100); this is probably why footboards and channelling systems for draining the water were built, as evidenced by archaeological records. Other structures also rose close to wells used for collecting rainwater: cisterns. In this case, archaeological records are less clear. The most ancient example is the underground compartment found inside building IV of Saggio I in piazza Dante²⁸⁰ built with a barrel vaulted roof of panchina stone (REDI 1993), called cistern, but also interpreted as a storage room, and belonging to the XI-XII century. A water reserve, maybe a cistern, generally defined as a late medieval cistern, was also found at Palazzo Venera²⁸¹. An underground structure made of reused bricks and river pebbles held together by mortar was found in the excavation behind Palazzo dei Cavalieri²⁸² and defined as a XIII - XIV cistern. This cistern is

not associated with buildings and its construction technique appears to belong, however, to the Post Medieval Age²⁸³. The structure found inside unit 2 of Palazzo Alliata²⁸⁴, and defined cistern, is small sized (1.60x1.40, x1.40 m), made of bricks, with a barrel vaulted roof and a drain for conveyance to the structure (REDI 1982a:67). Even its date is generic, since prior to the XVI-XVII century restructuring. It was most probably a cesspit rather than a small cistern, dating back to the XV-XVI century, rather than to the Late Medieval Age. A brick cistern connected to the Hospital of San Giovanni Gerosolomitano in via Gori²⁸⁵, was built in the XIII century and filled with Maiolica Arcaica (Archaic Majolica) waste between the last quarter of the XIII and start of the XIV century. Although the archaeological data regarding cisterns are not uniform, confirmation about their use may be found in the systems used to convey rainwater. Underground channelling systems, such as those found in via degli Uffizi²⁸⁶, made of bricks and dating back to the first half of the XIII century, were used to transfer water into the underground cisterns. Further confirmation of these systems is the archaeologically attested presence of earthenware pipes, representing the vertical element of this system. The use of various-sized earthenware pipes for constructions is well documented during the Roman Age, yet there are few studies on this product and on its medieval use (GATTIGLIA, GIORGIO 2010a). The excavations of via Consoli del Mare and via dei Facchini brought to light a good amount of artefacts of this kind, placing attention on their probable urban or suburban production. They were apparently

²⁷⁹ In addition to the complex water system, it must also be remembered that during the second half of the XIV century, the well was also situated in the middle of a metallurgic area and was important for the production operations.

²⁸⁰ GRASSINI F. 2012, *Intervention record no. 325*, in MappaGIS; BRUNI, MENCHELLI 1993.

²⁸¹ SCIUTO C. 2012, *Intervention record no. 377*, in MappaGIS.

²⁸² TARANTINO G. 2012, *Intervention record no. 16*, in MappaGIS.

²⁸³ The date seems to be attributed more on the basis of the cut layers than the layers related to its construction.

²⁸⁴ LA ROSA L. 2012, *Intervention record no. 290*, in MappaGIS; REDI 1982a.

²⁸⁵ GATTIGLIA G. 2012, *Intervention record no. 614*, in MappaGIS.

²⁸⁶ CAMPUS A. 2012, *Intervention record no. 602*, in MappaGIS; ANICHINI, GATTIGLIA 2008.

produced already from the end of the XII/first half of the XIII century and remained unvaried until the end of the XIX/start of the XX century. The excavation of via Consoli del Mare highlights the presence of earthenware pipes already from the second half of the XII century, immediately after the construction of the surrounding tower houses, and their interruption between the mid-XIII century and start of the XIV century, followed by a revival during the first half of the XV century. Since the data relating to the first half of the XV century regard the demolitions carried out in this period, the piping fragments found are residual and pertain to the building transformations of the XIV century. The contexts of via dei Facchini indicate a later presence, starting from the first half of the XV century, and a sudden increase in their use from the XVI century. The pipes were generally uncoated throughout the Middle Ages and were chased into the house walls. Observation of the internal walls reveals recurring lime incrustation, thus indicating that they were continuously used to drain water. During the Late Middle Ages, these pipes may already have been connected to underground brick channelling systems used to carry away waters from the tower houses, thus showing how earthenware pipes – at least in upper social contexts, such as via degli Uffizi – were most probably connected to a network of subservices. The presence of earthenware pipes from the second half of the XII century may be associated with the start of brick production in the city, thus emphasising the development of ancillary elements such as these. Their introduction not only shows a different way of building but also evidences the specialised production of construction materials. The autoptic analysis on the pastes evokes typical Pisa manufacture, given the similitude of both the ceramic body and surface finishing with locally

produced unglazed fine ware (GIORGIO, TROMBETTA 2008). Its find in different contexts suggests a varied and transversal use, whose nuances are currently not legible yet. Archaeological data, therefore, seem to highlight a widespread system for the collection of both public and private water. The majority of private examples attested in archaeological records suggest that private wells and/or cisterns were not a rarity, given the easy abstraction of underground water thanks to the presence of not excessively deep sub-surface layers. In my opinion, the picture seems to contradict certain statements made by historians according to whom drinking water was a problem, since wells and cisterns were a prerogative of the wealthier classes (HERLIHY 1990:77), to such an extent that wells continued to survive also during the Modern Age, when the city was provided with an aqueduct, as demonstrated by the continuous raising of the medieval wells²⁸⁷. Water was collected from wells and cisterns with wood or ceramic containers, especially jugs and small fine ware amphorae. Since the water had to be filtered before being used, in more privileged social environments, such as the excavation in via dei Facchini (BALDASSARRI 2008:107), filtering jugs of Islamic import were used. Regarding the need to boil water before using it both to remove lime and especially to make it safe, the jugs found in the excavations of via dei Facchini may have had this purpose (BALDASSARRI, MILANESE 2004a:139). This coarse cooking ware is apodal with a ribbon handle attached to the top of the rim and the inner surface covered with lime incrustation. It is not clear, however, whether it was simply used to heat water.

As already seen in the cases of piazza dei Cavalieri, Palazzo Scotto, via Sant'Antonio and via dei Mille, water supply was not only connected to domestic use but also to production purposes.

²⁸⁷ An extremely clear example of this continuous reuse is visible in the well found at the excavation of Palazzo Scotto, raised at the start of the XVI century to be used inside the fortress of Sangallo and at the end of the XVIII century with the creation of Palazzo Scotto, where it rose inside the garden.

Alongside metallurgic manufacturing, a large amount of water was necessary for tanning²⁸⁸, dyeing wool and silk, for butchering (GHIGNOLI 1998:289, 371) and for ceramic production. In the latter case, water was needed to work the clay and dilute the minerals of the coatings and coloured pigments. Part of the earthenware pipes found in the excavations of via Consoli del Mare may have been used for supplying and discharging the water required for metallurgic manufacturing. Finally, water was needed for the baths inside the city²⁸⁹, of which, however, we only have news from written sources but no archaeological data available.

To conclude, it is possible to say that we have a sufficiently clear picture of the late-medieval water supply systems – starting from the XII century, but especially from the XIII century – whilst we have only a sense of the supply systems during the previous centuries, given the very few data available. The Roman aqueduct, built during the last quarter of the I century A.D. ran from the area of San Giuliano at the foot of Monti Pisani and reached the city in the area between the churches of San Matteo and San Francesco (defined *supra Castello*) where, as suggested by the toponym, the *castellum aquae* probably rose, i.e., the final collection point (GELICHI 1998:81). It is difficult to say for how long this structure operated, but it appears that the lack of maintenance and the intense hydrogeological upheavals which we have described in the previous chapter, led to its definite collapse between the VI and VII century A.D. During this period, water supply needs were probably directly resolved by private citizens. From a technological viewpoint and building

on the most ancient evidence found in Pisa – the well in piazza dei Cavalieri –, the city probably used simple, small-sized and wood-lined artesian wells, directly excavated in the ground until reaching the most superficial groundwater levels.

3.2.3.3 Waste management

Another interesting aspect highlighted by recent excavations – so far not greatly studied on an archaeological basis for the area of Pisa – is waste disposal and sewage infrastructures. Material sources offer an interesting and tangible contribution to understanding the waste methods used and so to better outline certain aspects of daily life such nutrition, hygiene, quality of life, cultural changes and different technological solutions adopted. While the majority of data is attributable to the Late Middle Ages, an attentive analysis of the archaeological records gives a summary picture of the Early Medieval Age, although only relating to the area of piazza del Duomo. Here, during the ruralisation process of the urban fabric, which took place between the Late Roman period and the Early Middle Ages, so-called dark earth²⁹⁰ developed. Its origin may be related to waste disposal practices by a society which was not provided with draining or solid waste transport systems, so buried its waste underground or abandoned it in the numerous unused open areas inside the city. Deposits interpreted as dark earth may be seen in the layers of brown earth with early medieval materials, subsequent to the spoliation of the structures of an Roman Imperial house, found in the excavation at Porta del Leone²⁹¹, whereas waste dumps have been attested in various points

²⁸⁸ The wide variety of uses – both domestic and productive – of the well found in the excavation of via Toselli, close to the furrier's laboratory, is clear.

²⁸⁹ Mention is made of *balneum Baroncelli* or *Ricucchorum* at San Vito, the only one known in Pisa (we do not know if it was only private), during the XII century and still functioning at the start of the XIV; and a *stufa*, a public establishment, on the *carràia maggiore*, between the church of San Lorenzo and Ponte Vecchio, alongside which a further structure was built at the start of the XIV century (GARZELLA 1990:144).

²⁹⁰ Dark earth will be analysed in detail when taking into consideration the agricultural areas § 3.2.4.4.

²⁹¹ TARANTINO G. 2012, *Intervention record no. 358*, in MappaGIS.

of the square. In the southern portion²⁹², a large pit was found, partially filled with an organic deposit of charcoal and remains of fauna (maybe the rests of meals) rich in ceramic artefacts, mainly amphorae and fine tableware, dating back to the VI century. In the northern portion²⁹³, the waste pits are associated with the presence of huts dating back to between the VII and VIII century. Two of these pits have brought to light construction material, pottery and charcoal, as well as animal bones related both to carcass partitioning and to direct consumption. This provides an interesting qualitative picture²⁹⁴ of both food consumption and the presence of animals, an evident sign of the city's ruralisation. The attestation of goats and pigs, at least one case per species, is linked to nutrition: both animals were slaughtered when the quality and quantity of meat was at its highest; conversely, the slaughtering of old-aged cattle and donkeys indicates that these animals were used as beasts of burden. The presence of courtyard animals, such as cocks, completes the picture (ALBERTI *et alii* 2011c: 190).

Waste disposal was not governed by an organised and widespread system in the Late Middle Ages either. Alongside a system of draining canals and trenches, which carried waste water outside the city (especially towards rivers), waste dumps rose all over the city. The presence of a draining system is attested by archaeological sources such as the opening in the city walls at the tower of Santo Stefano, to the east of the adjacent gate and, in the eastern sector, between the church of San Francesco and the gate of Santa Marta. Late XIII century written sources also document a draining system to the west, at the hospital of Santa Chiara and at the *chiasso* (alley) of the hospital of

San Frediano, to the east, at the monastery of San Francesco, and in the western and southern part of Chinzica (REDI 1991:147). The trenches were used to dispose of urban waste, turning these trenches into real open-sky sewers. The custom to throw waste directly into the streets, especially in the narrow spaces between two neighbouring buildings was an extremely common practice, confirmed by both archaeological and written sources. Archaeological sources have greatly evidenced how the narrowest alleys were used as rubbish dumps. The alley-rubbish dump inside the excavation of via dei Facchini/via Toselli²⁹⁵, the one identified between the tower houses in piazza delle Vettovaglie²⁹⁶, and the one between the tower houses of Palazzo Giuli²⁹⁷ and, probably, the one near Torre Lanfreducci²⁹⁸ are tangible documents that portray the utter unplanned growth of the city, which was left to the free initiative of citizens, without any sort of municipal regulations until at least the end of the XIII century. It is only from the late XIII century that city Statutes started to include specific waste management regulations especially related to the care of public roads, in conformity with the development of a true waste management policy, which was also experimented by other cities in Tuscia during this period (ALBERTI *et alii* 2006). The hygiene problems caused by this type of waste disposal which attracted mice, carnivorous animals and reptiles is evident by the bone remains of the alley of via dei Facchini, which indicate the presence of rodents, carnivores and reptiles, as well as traces of the bites of rodents and carnivores on the bone remains, especially where rich in cartilage. Archaeological evidence, however, suggests that the regulations were followed rather late, given that the

²⁹² TARANTINO G. 2012, *Intervention record no. 369*, in MappaGIS.

²⁹³ TARANTINO G. 2012, *Intervention record no. 37*, in MappaGIS; ALBERTI *et alii* 2011c.

²⁹⁴ Unfortunately not quantitative given the very small sample.

²⁹⁵ LA ROSA L. 2012, *Intervention record no. 61*, in MappaGIS; BISIO 2004; GATTIGLIA G. 2012, *Intervention record no. 589*, in MappaGIS; DUCCI *et alii* 2008a.

²⁹⁶ SCIUTO C. 2012, *Intervention record no. 216*, in MappaGIS; ALBERTI BALDASSARRI 2004.

²⁹⁷ GATTIGLIA G. 2012, *Intervention record no. 843* in MappaGIS; REDI 2009.

²⁹⁸ GATTIGLIA G. 2012, *Intervention record n. 3*, in MappaGIS; REDI 1982. The narrow space to the north of the Torre Lanfreducci, between the tower itself and a building demolished at the end of the XIV century, filled with abundant ceramic material, mainly composed of Maiolica Arcaica and fine pottery dating back to the XIII-XIV century, has been interpreted as a conduit, but it may be a narrow alley (*chiasso*).

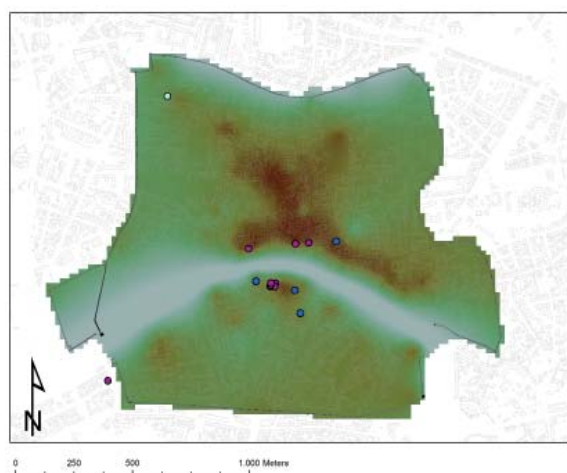


Fig. 3.59 The late medieval DEM shows the positioning of waste dumps (in purple), sewage systems – cesspits for example (dark blue) – and freshwater systems (blue).

construction of the first waste containment wall in via dei Facchini dates back to the XIV century. On the contrary, the continuous use of these spaces is attested by the deposits which, in the case of the alley of via dei Facchini, cover a chronological period ranging from the end of the XI to the end of the XIV century, and by the waste disposal practices implemented by removing and periodically cleaning these spaces. This is confirmed by the silty layers with a low presence of ceramic materials, and by the conformation of the layers moulded by the action of water running through the alley deposits, all prior to the construction of the wall closing the narrow alley. The alley of via dei Facchini provides good evidence of the type of waste disposed of: domestic waste related to the rests of meals, both of animal and vegetal origin, and to cooking ware no longer used, as well as fox fur manufacturing waste from the nearby furrier, and construction materials used for internal renovations. Even in this case, the study of the fauna gives us a detailed picture of the food eaten in a wealthy environment between the XII and XIV century. The inhabitants of the tower houses had the opportunity to follow a varied diet mainly composed of mutton and goat meat (the main source of animal proteins), with a prevailing consumption of mutton

over goat meat, but also of beef, pork, birds, poultry and fish. The fact that sheep, goats, cows and pigs were slaughtered at a generally young age, when the quantity/quality of their meat was at its highest, further underlines the social status and wealth of the environment. Birds and poultry include domestic species, such as geese and chicken, but also wild birds, such as buzzards, pheasants, coots and doves. The latter provide evidence of the hunting activities practiced, especially bird hunting, since the remains of other wild animals, such as roe deer and wild boars, are very few. The consumption of tortoises is slightly more frequent, whereas the hedgehog is rare (BISIO 2004). Fish was highly consumed, including rare species such as ray. A change is perceived only at the end of the late XIV²⁹⁹ century when new public and private infrastructures were built. A first (uncertain) example of sewer, dated around the mid XIV century, could be the small conduit found north of building I of Saggio I of piazza Dante³⁰⁰. This structure, over 4 m long, 40 cm wide and 90 cm deep, is made of brick masonry and covered with flooring made of aligned floor bricks (REDI 1993:220). It has been interpreted as being part of the drainage gutter mentioned in the 1286 Statutes, which was situated alongside the alley of the hospital of San Frediano and carried away the hospital waters towards *Paludozzeri* (REDI 1991:147). Archaeological data report the presence of private structures for waste disposal around the last quarter of the XIV century related to the construction of Palazzo Gambacorti, where two barrel vaulted cesspits (*bottini*) made of bricks were constructed outside the building along the eastern alley (ANICHINI, GATTIGLIA 2008:140). This is a particular case, probably dictated by the wish of a wealthy family to adjust to the highest comfort standards of the age. Standards which became of common usage only between the XV and XVI century (fig. 3.59).

²⁹⁹ The most evident phase of this change dates back to the XV-XVI century, coinciding with inclusion in the Florentine state (ALBERTI *et alii* 2006).

³⁰⁰ GRASSINI F. 2012, *Intervention record no. 325*, in MappaGIS; REDI 1993.

3.2.3.4. Hydrogeological phenomena

The development of medieval Pisa is also linked to hydrogeological problems (flooding, subsidence and groundwater rising) connected to the presence of the Arno and the *Auser* rivers, as indicated by the toponyms *Paludozzeri*, *Palude*, *Chinzica* and *Guazzolongo*. These phenomena may be seen directly and indirectly in the archaeological stratifications. Stratifications referable to flooding, in addition to those already analysed in the periurban area of Pisa for the Early Medieval Age, are documented at Porta al Parlascio³⁰¹. Here, raised road levels are alternated with layers attributed to flooding of the *Auser* River, at San Giorgio Tower³⁰², where an approximately 80 cm layer of sand has been interpreted as resulting from flooding, and at Palazzo Scotto³⁰³. The stratification investigated in this area attests very strong flooding during the first half of the XIV century, witnessed by a series of sandy levels, practically lacking materials, interrupted by irregular silty fractions which invested the entire area and raised the level of the district by 60/80 cm. According to Tronci's Annals, Chinzica was completely flooded by the Arno River at the start of November in 1333³⁰⁴. The extensive raising of levels during the XI-XII century urban transformation phase³⁰⁵ (in certain cases associated with levelling which cancelled the early medieval phases), was chiefly the result of large construction projects, but it cannot be

excluded that they were an answer and/or acted as a prevention to groundwater rising³⁰⁶ or floods. This could be the reason for the construction of the large terrace at the end of the XI century – built to obtain an area for building the district of Sant'Andrea di Chinzica³⁰⁷. Stratigraphic evidence directly related to these phenomena is also available. During the XIV century, a subsidence phenomenon inside the church of San Lorenzo³⁰⁸ caused the flooring to sink by 20-25 cm. The problem was addressed by raising the floor by 50 cm when the church was restructured, in order to avoid groundwater rising. The very thick crawl space filled with stone underneath the XIII flooring can be explained by the need to insulate the floor from possible groundwater rising, an evidently diffused phenomenon in this part of Pisa already during the XIII century. If we add the data of via dei Facchini³⁰⁹, it is evident how the area of Chinzica was hit by a number of hydrogeological problems during the XIV century. In the excavations to the north of the Arno River, these aspects are less evident: the presence of green clayey layers in piazza dei Cavalieri interpreted – although with some hesitation – as alluvial (ABELA, BRUNI 2000: 72), shows how difficult it is to read natural actions within urban stratifications. Subsidence phenomena that are difficult to date may also be seen in the excavation of piazza Sant'Omobono where part of the stratification has sunken.

³⁰¹ TARANTINO G. 2012, *Intervention record no. 47*, in MappaGIS; GELICHI 1996.

³⁰² LA ROSA L. 2012, *Intervention records nos. 36, 37*, in MappaGIS.

³⁰³ GATTIGLIA G. 2012, *Intervention record no. 367*, in MappaGIS; GATTIGLIA 2006.

³⁰⁴ Paolo Tronci, *Annali Pisani*, 2, Livorno 1682, erw. Ausg. Pisa 1871² (Reprint Bologna 1975).

³⁰⁵ Reference is made, for example, to the cases already mentioned and found in the excavation of piazza Sant'Omobono (ANICHINI, GATTIGLIA 2008), vicolo del Porton Rosso (FEBBRARO, MEO 2009), via dei Facchini (BALDASSARRI 2004) and via Toselli (DUCCI *et alii* 2008a).

³⁰⁶ From the late XV/XVI century many internal floors were raised with engobed ware and sgraffito ware wastes, which started to be greatly produced during the XVI century. The thick deposits of ceramic wastes found underneath the paving in Lungarno Simonelli, Sant'Apollonia and the Benedictine convent, and also underneath piazza Solferino (BERTI 2005: 5-8) and via dei Facchini (BALDASSARRI, MILANESE 2004), refer to this chronological period. It is interesting to note that the use of ceramic wastes started when the laws prohibited to dig up sand from the rivers, while it is unknown in the Middle Ages.

³⁰⁷ GATTIGLIA G. 2012, *Intervention record no. 367*, in MappaGIS; GATTIGLIA 2006.

³⁰⁸ LA ROSA L. 2012, *Intervention record no. 263*, in MappaGIS; SANTUCCI 2005.

³⁰⁹ LA ROSA L. 2012, *Intervention record no. 61*, in MappaGIS; BALDASSARRI 2004: 48.

3.2.4 Production areas

Starting from the Early Middle Ages, as a consequence of the destructuring of the Roman city, the presence of large empty spaces and the different social organisation of productions, workshops, craft activities and production areas were established in the urban fabric, to the point that it was no longer possible to distinguish between centre and suburb. This process clearly carried on throughout the entire Medieval Age and it was only during the Late Middle Ages that the production activities started to stretch out towards the suburban areas. The presence of craft/production activities inside the city not only transformed urban organisation and topography, but above all is indication of a social and technological transformation: the gap between the elite and the lower productive classes narrowed, as also that between noble arts and production, leading to a technological development unknown during the Roman age. The topographic location of early medieval production structures was based on a topography of power and set within a framework of public control of the main production activities (BROGIOLO: 2011: 181). As a result, the metallurgic district of piazza dei Cavalieri rose next to the *Cortevecchia* area where the Lombard administrator resided, whereas the suburban workshops of the former Scheibler area could have risen close to the *Auser* River, near the mooring point inherited from the port close to San Rossore. Workshops were located inside the city centre also during the Late Medieval Age, when production structures and houses coexisted. Craftsmen's laboratories, which directly overlooked the street, were often located on the lower floors of houses, although there was not always a clear (even social) separation between shop/laboratory and

above living areas. Similarly, a sharp distinction cannot be seen between the various production activities, as well documented by archaeological records. Production processes were dynamic, interconnected and smooth-running also in spatial terms: metallurgic productions, for example, were connected to clothes manufacturing and tanning (as demonstrated by the excavations in via Sant'Antonio and via Toselli), but also to naval and construction works, and bell founders advertised their names on pottery ware. It was only at the end of the Late Medieval Age that a part of the productive areas started to move away from the city centre towards the suburban areas, leading to a gentrification of the urban area. Overall, archaeology allows us to have quite an accurate picture of metallurgic and food production (the latter related to the city's vegetable gardening activities), to outline more specific practices such as shipbuilding works, leather manufacturing and bread baking, and to understand where they were carried out. Unfortunately, archaeology only makes it possible to indirectly understand the problems connected to ceramic and brick production, of which the former was an important economic factor for the city.

3.2.4.1 Metallurgic processing

Metal manufacturing played an important role in Pisa's medieval history. The practices connected to iron manufacturing are indeed the only production activities archaeologically attested from the Early Middle Ages (BRUNI *et alii* 2000), and the archaeological finds relating to metallurgic activities are by far the greatest in terms of quantity and quality of the material sources, allowing us to identify the even production structures. Overall³¹⁰ (fig. 3.60), three main areas, in terms of size, may be identified:

³¹⁰ Identification was carried out adopting kernel density estimation analysis with a 75 radius to the file of periodised finds (**ritrovamenti.shp**) after carrying out a query on Level II 'Metal manufacturing' with a chronological period ranging between the VII and XV century. A multi-period selection was used which takes into account the entire medieval chronological range. Consequently, the image photographs a topographic not a chronological situation, since it represents areas that are not contemporaneous.

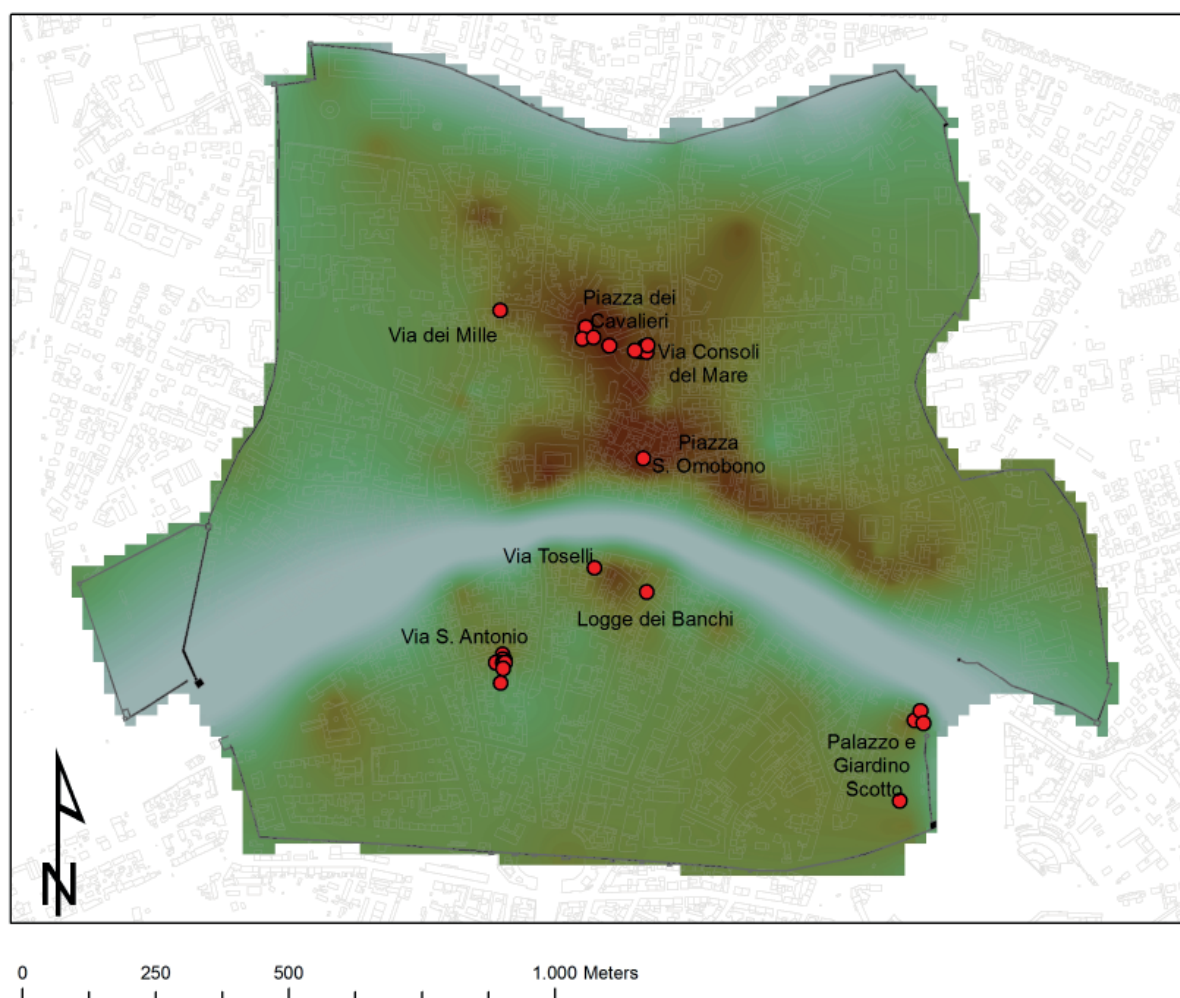


Fig. 3.60 The metallurgical areas identified inside the urban centre of Pisa. The finds are positioned on the late medieval DEM.

one in the central area of the city at San Sebastiano alle Fabbriche Maggiori (current piazza dei Cavalieri), another located in the far eastern area of Chinzica, at the church of Sant'Andrea in Chinzica (current area of Palazzo and Giardino Scotto) and yet another one in via Sant'Antonio. Secondary areas, again based on size, were situated in current piazza Sant'Omobono³¹¹ and in via Toselli, and an extra-urban area was

probably situated in the former Scheibler area. Even written sources, especially the 1305 *Breve dell'Arte dei Fabbri* (GARZELLA 2000), and to a lesser extent the 1228 oath³¹² (SALVATORI 1994), help us understand the topographic position of the metallurgic workshops: at San Sebastiano, San Lorenzo alla Rivolta, Santa Cecilia, Porta Buoza, the Cathedral and Fuoriporta, north of the Arno River, and at the *carraia Pontis Veteris* (Corso

³¹¹ This is a waste containing charcoal and slags from copper alloy manufacturing, which is only supposedly related to a late medieval metallurgic workshop, located on the ground floor of the building (ANICHINI, GATTIGLIA 2008a: 133).

³¹² The document reporting the names of 4300 Pisa citizens, i.e. the total adult male population, called to take oath to seal the alliance with Siena, Pistoia and Poggibonsi against Florence, listed by parish with the specific profession carried out, indicates the place of residence of Pisa citizens, not their workplace.

Italia), *carrara Pontis Novis* (via Sant'Antonio), the neighbouring *campo Canapaio*, and the eastern area of Chinzica south of the river. The latter is not mentioned in the *Breve*, but a good number of metal manufacturers resided here. The importance of blacksmiths as an economic category was due to connections with the construction sector, the shipbuilding sector, military supplies and the production of objects of daily use. The work of the *fabri*³¹³ had patterns of seasonal mobility, since the blacksmiths moved to metal mining areas, especially in the area of Elba Island, from autumn to late spring (CORRETTI 1991:16). During the XIII century, blacksmiths were the first labour force in the city, whereas the category of metal workers was the third occupational sector and one of the major drivers of local economy (SALVATORI 1994: 162). The location of the *fabbricae* confirms their importance. Until the end of the XIII century, they were located in the political-administrative centre of the city and mostly concentrated between San Sebastiano, indeed called 'alle Fabbriche maggiori' referring to the greatest iron manufacturing district in Pisa, and San Pietro in Cortevicchia. The importance of this area is strictly connected to chronological (metallurgic activities continued incessantly from the VII-VIII until the second half of the XII century) and typological factors, since a first long iron manufacturing phase (VIII - end XII century) was followed by a short copper alloy manufacturing phase (XIII century), as evidenced by the excavations of piazza dei Cavalieri³¹⁴ (BRUNI *et alii* 2000) and via Consoli del Mare³¹⁵ (GATTIGLIA, GIORGIO 2007; ANICHINI, GATTIGLIA 2008; ANICHINI,

GATTIGLIA 2008a). During the Early Medieval Age, metallurgic activities were also carried out outside the medieval city centre, as confirmed in the excavation at the former Scheibler area³¹⁶, where four hearths were found together with a stone structure, associated with a Lombard necropolis³¹⁷. The hearths have similar features and are described of circular shape with vertical walls, flat or slightly concave base. One of the hearths, was filled with sandstone, limestone and travertine blocks highly combusted, carbonised logs and ashes, while the underlying earth was burnt. The complete lack of pottery or other datable elements in the hearth fills, as well as the sole presence of brick fragments, does not allow us to assume its date. The structure was characterised by an accumulation of stones, disorderly overlapped, mixed with pottery sherds, bricks, iron slags and hematite ore. Under this accumulation, three stone circles contained hematite ore, two sherds of *terra sigillata* and a soapstone fragment³¹⁸. The description of the archaeological record is comparable to the structures of the forges and iron bloom found in piazza dei Cavalieri (CORRETTI 2000), while the presence of iron slags and hematite ore strengthens this interpretation. The chronological framework, based on the data available, is not very clear, but the association with the early medieval necropolis and the presence of soapstone vessels³¹⁹ could suggest a VI-VII century dating. The area was situated close to the *Auser* River, was probably still navigable and not far from a landing place. This would explain the presence of a small settlement where iron manufacturing activities were carried out, favoured by the supply of raw materials. If this interpretation were to be verified by further data,

³¹³ The term *fabri* in written sources refers to both small craftsmen and entrepreneurs.

³¹⁴ SCIUTO C. 2012, *Intervention record no.130*, in MappaGIS.

³¹⁵ TARANTINO G. 2012, *Intervention record no.587*, in MappaGIS.

³¹⁶ LA ROSA L. 2012, *Intervention record no. 196*, in MappaGIS.

³¹⁷ See § 3.2.1.

³¹⁸ LA ROSA L. 2012, *Intervention record no. 196*, in MappaGIS.

³¹⁹ The presence of soapstone vessels on its own, without being able to check its provenance, does not guarantee the early medieval origin of the context, yet in any case justifies, while pending for certain data, its assumption (see ALBERTI 2009 e § 3.2.5.1).

this would confirm the assumption that the supply of iron was never interrupted during the passage between the Late Roman period and the Early Middle Ages³²⁰. The excavation of piazza dei Cavalieri not only attested, for the first time and coherently, the iron production phases but above all it demonstrated the start of this production from the Early Middle Ages, in a central area of the city close to the *curtis*, home to the Lombard gastald. The authors identified iron slags and *tuyeres* fragments, belonging to a period ranging between the Late Roman period and the IX-X century, and suggested to be between the VII and VIII century (ABELA, BRUNI 2000:77). The better documented structures are dated between the IX-X and first half of the XI century, with a scarcely legible structure dated between the XI and first half of the XII century (CORRETTI 2000). In this area, the production activities ceased between the end of the XII and first half of the XIII century (ABELA, BRUNI 2000: 62). The adjacent excavation in via Consoli del Mare did not investigate the most ancient phases, partially identifiable only in the reading of some cores³²¹ (ANICHINI, GATTIGLIA 2008a), but allowed us to effectively understand the end of the iron manufacturing activities, identified in the last phases of a furnace, and the transformation in the area connected to the casting of copper alloys. This transformation took place between the end of the XII and start of the XIII century, when iron manufacturing activities ceased and new structures were opened which operated until the end of the XIII/start of the XIV century. These new highly articulated production structures were used to cast small and medium sized copper alloy objects by means of crucibles³²² (fig. 3.61) and small casting pits (ANICHINI, GATTIGLIA 2008: 123-124). It was only



Fig. 3.61 A number of crucible fragments from the XIII century production structure found in the excavation of via Consoli del Mare.

at the start of the XIV century (MALFATTI *et alii* 2011) that these production activities ended, probably transferred to suburban areas. The iron manufacturing structures³²³ found (CORRETTI 2000) are mainly forges and/or bloomery, often abutting on masonry structures, without an identifiable elevated structure, apart from the structure found in via Consoli del Mare (ANICHINI, GATTIGLIA 2008) where the dismantled walls of bricks held together by mortar can be seen. Air was blasted into these structures with bellows, as demonstrated by the many fragments of *tuyeres* that protected the bellow nozzle from the exposure to heat, secured to the ground with wooden structures, of which the postholes remain. As clearly shown from the restored *tuyeres* and from the degree of firing of the furnace bottoms, these structures had a rather long lifecycle, and in the case of the masonry structure in via Consoli del Mare, probably a very long one. The abundant manufacturing slags, whether casting slags or furnace blooms, witness the continuous use over time of these iron manufacturing structures³²⁴. Copper alloy manufacturing structures are well documented above all in the excavation of via

³²⁰ Thus confirming the retention of navigation skills.

³²¹ TARANTINO G. 2012, *Intervention records nos. 621, 622*, in MappaGIS.

³²² The recent hypothesis that this plant was also used for glassworking is not, in my view, sufficiently demonstrated.

³²³ The iron manufacturing structures are mainly documented in the excavation of piazza dei Cavalieri (CORRETTI 2000) and to a lesser extent in the excavation of via Consoli del Mare (ANICHINI, GATTIGLIA 2008).

³²⁴ The excavation of via Consoli del Mare brought to light 20 boxes of iron slags.



Fig. 3.62 The production structure of via Consoli del Mare at the end of the XIII century: the masonry casting pit may be seen below, the base of the crucible furnace, covered with mortar, on the right. A cut next to the furnace can be seen for small cylindrical bellows used for blasting air. The two small postholes close to the pit have been interpreted as a timber structure, possibly a small wrench, while the four, large-sized circular postholes contained the poles that supported the schist roof that shaded the area.

Consoli del Mare³²⁵, especially during the last production phase, when the area covered by a timber roof was divided into two different production areas – southern and northern – which operated at the same time and were subject to ongoing adjustments and renovations. The southern area, which provided the clearest and most complete traces of the metallurgical process, during its final phase, dating back to the second half of the XIII century, is composed of a crucible furnace, a casting pit and a small wooden winch (fig. 3.62). The furnace has a circular concave mortar structure, its diameter is 30 cm and it is 3 cm thick and 12 cm deep. A circular cut can be seen immediately next to it (diameter 22 cm and depth 3 cm), used to rest a cylindrical bellow. The casting

pit is an elliptical-shaped structure excavated in the ground³²⁶, made of bricks bonded together with mortar. The absence of charcoal or burning traces suggests that moulds were not fired inside it, while the size of the pit suggests that it was used for casting small-sized objects. Crucibles of various sizes were used for casting³²⁷. Structures for casting bronze objects are attested in the centre of the city, also in via dei Mille between the mid-XII and mid-XIII century³²⁸. From the XIII century, the metallurgic activities gradually shifted towards the outer areas of the inhabited city centre, for example, the production structures of via Sant'Antonio³²⁹ (DUCCI *et alii* 2010). Here, close to a previous glassworking workshop³³⁰, a laboratory for casting copper alloy clothing accessories and a blacksmith were established from the first two decades of the XIII century. The laboratory had a production area with at least two crucible furnaces blasted by bellows (as attested by the many fragments of *tuyeres*) for the production of buckles and rings – cast using crucibles inside composite moulds –, and also directly sold its goods. Of particular interest is the presence of a dumping pit full of goat horns cut at the base and tip, and interpreted as possible bellow nozzles. This interpretation is not fully convincing since bellow nozzles were usually made of metal (CUCINI 1990) as confirmed by the traces on the *tuyeres* of piazza dei Cavalieri (CORRETTI 2000) and via Consoli del Mare; furthermore, they do not seem to present traces of wear. Another interpretation could come from the attested presence of a goat hide tanner (*cordovaniere*)³³¹, in the same parish of Santi Cosma e Damiano (SALVATORI 1994: 301), thus referring to

³²⁵ Certain crucible fragments with copper and lead incrustations can also be seen in the excavation of piazza dei Cavalieri (CORRETTI 2000:93).

³²⁶ Only half of the structure width was found measuring 1x0.47m, and 0.5 m deep.

³²⁷ The excavation also brought to light crucible fragments with a diameter of a few centimeters.

³²⁸ GHIZZANI MARCIA F. 2012, *Intervention record* no.884, in MappaGIS.

³²⁹ CAMPUS A. 2012, *Intervention records nos. 754, 756, 759, 760, 761*, in MappaGIS.

³³⁰ § 3.2.2.4.

³³¹ Traces of leather manufacturing activities were found in neighbouring areas GATTIGLIA G. 2012, *Intervention record no. 777*, in MappaGIS.

the waste produced when making the bellows for which leather was essential (CUCINI 1990). What is certain is that an iron manufacturing workshop, dated between the start of the XIII century and the second half of the XIV century, rose next to the copper alloy laboratory. Here, hematite ore was directly reduced. Iron, therefore, not only arrived in the city as a semi-processed material, but also as ore (hematite ore elements – from Elba? – are also attested in the excavation of via Consoli del Mare and at the former Scheibler area). The presence of a forge and a hammering area complete the laboratory (DUCCI *et alii* 2010). Further finds between via Toselli and corso Italia show how other metallurgic workshops rose in the area of Chinzica, although production structures have not been discovered. The first is dated between the end of the XI and mid-XII century, and it refers to a floor layer rich in charcoal and slags, containing abundant fragments of crucibles, placed inside one of the buildings that rose close to the church of Santa Cristina³³². The limited portion investigated makes us assume that the excavation area was close to a copper alloy casting structure, as attested by the crucibles and slags. The second refers to an

occasional find (BORGHI 1972), at the Logge di Banchi, regarding a layer composed exclusively of iron slags. Although of difficult interpretation³³³, the presence of abundant iron slags in this area would assume a nearby iron manufacturing workshop. It may have been one of the workshops situated in *carraia Pontis Veteris* where charcoal was transported, as attested in the 1305 *Breve*.

A very specific production was instead carried out in the area of Palazzo Scotto/Giardino Scotto during the second half of the XIV century³³⁴, although 36 blacksmiths already resided in this area at the start of the XIII century (SALVATORI 1994: 313). A large stable foundry³³⁵ rose here for founding bells³³⁶ (GATTIGLIA, MILANESE 2006a), an activity in which, especially between the XIII and XIV century, the skilled and mainly itinerant craftsmen of Pisa had reached a notable technical ability (LERA, LERA 1998: 59 ss). The archaeological traces reveal how the structure was built after the alluvial event of the 1330s (GATTIGLIA 2006:130), on an area previously used most probably for ceramic not metallurgic production³³⁷. From an architectural viewpoint, it was formed of units arranged in rows, measuring around 30 m², made

³³² GATTIGLIA G. 2012, *Intervention record* no.589, in MappaGIS; only partially published DUCCI *et alii* 2008; DUCCI *et alii* 2008a.

³³³ The layer was interpreted as related to the late medieval road network (BORGHI 1972); LA ROSA L. 2012, *Intervention record* no. 274, in MappaGIS.

³³⁴ GATTIGLIA G. 2012, *Intervention records nos.* 264, 367, in MappaGIS; LA ROSA L. 2012, *Intervention record no.* 53, in MappaGIS.

³³⁵ Archaeological documentation relating to the stable foundry of one or more *campanari* is quite exceptional; usually, the remains of metallurgic activity are found in the building for which a specific bell was founded. This provides us with greater details on the residential nature of certain workmanship and on the activities of these skilled workers (GATTIGLIA, MILANESE 2006a). This also seems to confirm that in certain port cities, stable foundries were set up, as supposed by NERI 2006:8.

³³⁶ In the 1228 oath of Pisa, which sealed the alliance with Siena, Pistoia and Poggibonsi, the district of Chinzica and its eastern sector had a large number of metallurgic workers (general blacksmiths and other specialised workers). However, only one craftsman among the 251 workers related in some ways to metal (among the 4300 names listed) is defined as a *campanarius*: Buonagionta, *campanarius* for the chapel *de Sancto Laurentio in Guinzica* (SALVATORI 1994:162 ss, 230 ss). At the start of the 1300s, *Andreas magister campanarius* lived in Chinzica and in 1333 he founded the bell of San Martino (*in Guazo Longo*), chapel of Chinzica already comprising 36 blacksmiths in 1228 (some of whom may have occasionally been bell founders) and probable place of residence of Andrea, *campanarius*, mentioned in a deed of sale regarding a piece of land with a house situated in the chapel of San Martino, dated 28 June 1325 (FANUCCI LOVITICH 1986: 301). Andrea founded the bell of San Martino with Gherardo, whose sons Bencivenni and Nanni were well known for their bell founding activities in Lucca, Pisa, Florence and Viterbo: in particular, Nanni was bell founder of the chapel of Sant'Andrea in Chinzica, highlighting how this trade was well rooted in this urban area.

³³⁷ See § 3.2.4.2.



Fig. 3.63 The most well-preserved casting pit found at the excavation of Palazzo Scotto. Of note are the *prae-furnium* and the elliptic firing chamber with two sections upon which the mould base of the last bell cast is visible. A blackened circular ring can be seen inside the mould, caused by the combustion needed to melt the wax of the false bell and harden the mould.

of brick masonry and definitely covered³³⁸. Each unit had a furnace and a casting pit which was often repositioned in the same place (probably to use the part already excavated). Temporary structures probably rose next to them, probably

with timber coverings, as confirmed by a casting pit and postholes³³⁹ outside the units, in the southern part of a wide square. The long duration³⁴⁰ and size³⁴¹ of the foundry is also confirmed by the many charcoal layers with bronze slags and burnt clay lumps across the entire square, as far as the well, which further encouraged the construction of the production structure. The only probable traces attributable to a crucible furnace were documented inside one of the units³⁴², comprising a number of postholes and a nearby and larger-sized pit. The former are apparently attributable to a wooden supporting structure for the bellows to blast air when founding the metal in the crucible, whilst the latter may have supported the crucible (in iron?)³⁴³ (NERI 2006: 52). Other postholes may be connected to wooden structures used to make the moulds or to raise the mould from the casting pit. The casting pits are cut in the layers underlying the groundfloor and are completely lined with bricks (mainly reused bricks) held together by a clayey sediment. They have a long duct terminating in an elliptic casting chamber with two semi-elliptic brick supporting sections. The pit (fig. 3.63) in a better state of conservation is a duct 2.40 m long and a casting chamber (1.10x0.85 m) with two semi-elliptic brick supporting sections, 57 cm high, upon which the blackened trace of the mould (external diameter measuring 75 cm and internal diameter 44 cm) can be seen. The bottom

³³⁸ The presence of covered structures is related to the need for casters to work in environments not directly illuminated by the sun so as to check the melting temperature based on the colour of the metals.

³³⁹ LA ROSA L. 2012, *Intervention record no. 53*, in MappaGIS.

³⁴⁰ Overall at least 10 different casting processes can be seen. The reuse of these production structures is evident in the casting pit found in unit 6. In addition to showing its complete renovation, it also revealed that the firing chamber was narrowed twice. This renovation is probably related to technical expedients aimed at improving the production process, maybe in relation to smaller sized bells. The solidity of the structures suggests that the pits were used on a long-lasting basis. The pits were cleaned thanks to the wide duct of the combustion chamber in which a person could easily work (GATTIGLIA, MILANESE 2006a: 543).

³⁴¹ The overall area, presumable from the structures used for the bellfounding activities and from the dispersion of slags, occupies a surface of around 750 m² against an approximately 1000 m² excavation area (GATTIGLIA, MILANESE 2006a: 542).

³⁴² Unit 5.

³⁴³ Fragments related to ceramic crucibles were not found.

of the duct shows clear burning traces due to the action of the heat and was filled by a layer of ashes and charcoal relating to the last use of the pit, whereas the soot traces visible on the end wall of the casting chamber in correspondence of the duct evidence the vertical draught for the discharge of smoke. The inner surface of the mould has a blackened circular ring caused by the combustion needed to melt the wax of the false bell and harden the mould. Furthermore, it is possible that certain soot traces visible between the outside of the mould and the brick wall of the casting chamber refer to the firing of the mould (NERI 2006: 48-50), whereas the previously mentioned circular fragment of the bottom of the mould may have been caused by adhesion, due to the casting weight of the metal, and subsequent pulling away during the raising operations after cooling. The discovery of a fine ware potsherd with a bell bearing the name *Benciveni* incised directly on the biscuit (fig. 3.64), allows us to attribute the structure to the *taglia* of Gherardo³⁴⁴, of whom we have knowledge through written sources and the signatures on the bells, especially thanks to the work of his two sons Bencivenni e Nanni³⁴⁵. Written sources reveal how – starting from the fourth decade of the XIV century up to the start of the XV century³⁴⁶ – the members of the *taglia* of Gherardo were closely related to Chinzica and how, surely from the second half of the XIV century they resided in the parish of Sant'Andrea. The morphology of the structures and the traces of the different production phases recall the Germanic technology, described by Theofilus at the start of the XII century (NERI 2006: 29), with some variations. The archaeological data are confirmed in a contract entered into on 15 April 1383 between the *Comune* of Lucca and Bencivenni and his sons Iacopo and Bartolomeo,



Fig. 3.64 Fine ware potsherd with a bell bearing the name *Benciveni* incised directly on the biscuit.

to whom the right was granted to recover the wax used for founding a number of bells in the city (CORSI 1973: 66). The XIV century chronology (subsequent to 1330) of the structures show that they are the latest attestations of this technology in Tuscany, leading us to suggest that the technology described by Theofilus prevailed throughout the XIV century in an important bell founding area such as Pisa. These data, as also suggested by the recent finds in Imola, where a late XIV – early XV century structure still used Theofilus' technique, which in this case apparently precedes a casting with Biringuccio's technology (MICHELINI 2005: 102; GATTIGLIA, MILANESE 2006a: 544), allowed us to understand how the technology described by Theofilus or Biringuccio was distributed among the production centres, and lead us to reconsider the statements of a prevailing of the latter method over the former during the XIV century (NERI 2006: 209 e tav. XV).

³⁴⁴ Bell founders were divided into *taglie*, family-based structures, with a rather limited number of members, under the control of the *magister*, the head, who was the holder of the secrets and directed the founding operations.

³⁴⁵ GATTIGLIA, MILANESE 2006a and related bibliography.

³⁴⁶ GATTIGLIA, MILANESE 2006a and related bibliography.

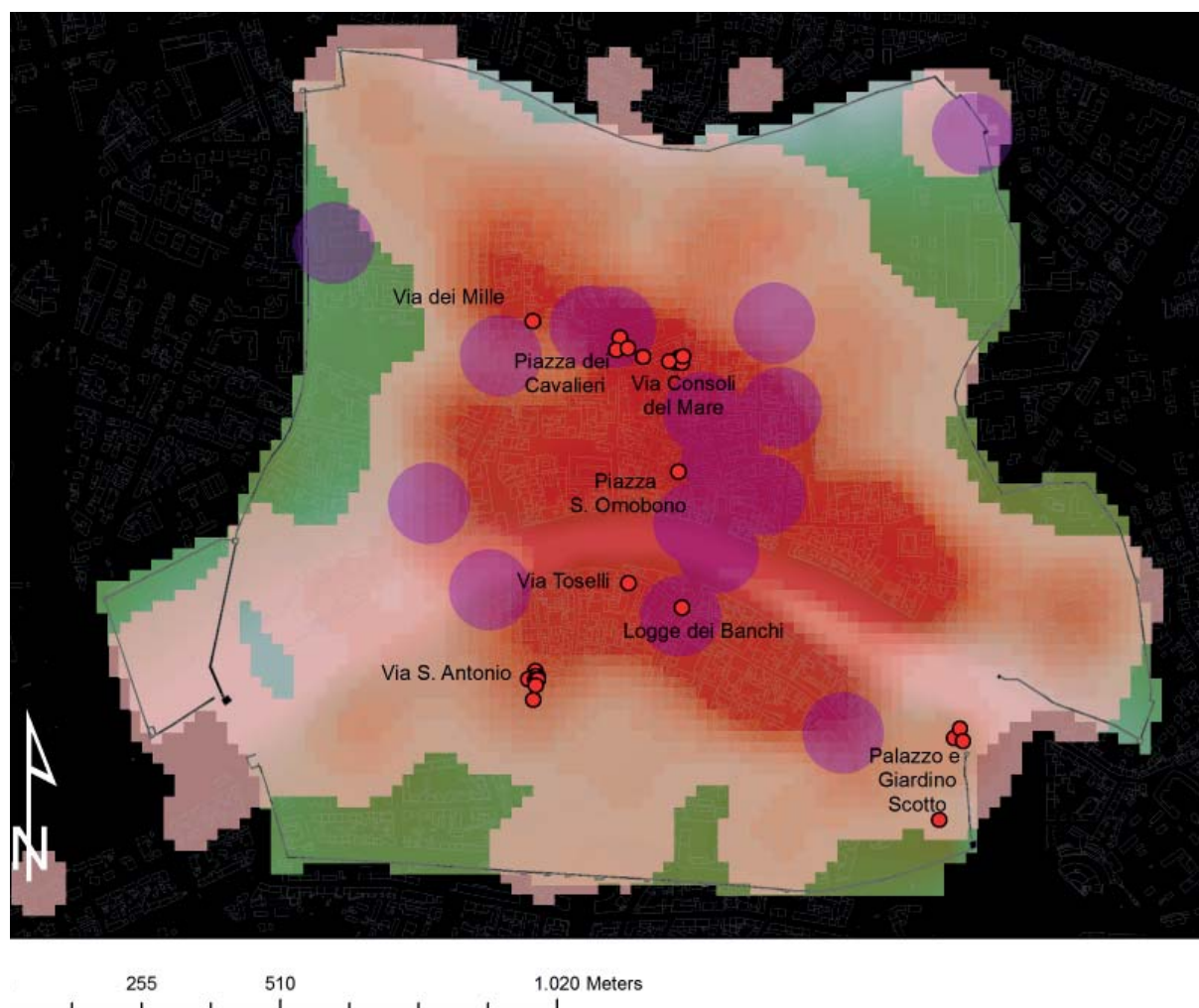


Fig. 3.65 Location of the metallurgical workshops within the urban centre of Pisa during the Late Middle Ages, revealing their high number. The metallurgical areas evidenced by archaeological sources are indicated in red, while the buffer areas in violet (75 m radius) are obtained on the basis of the metallurgic production activities identified through written sources (from GARZELLA 2000 and REDDI 1991: tav. 25) and available in the `elementi_urbani_ipotesi.shp` file. Overlapping with the KDE of late medieval finds shows that that these workshops were concentrated in the urban area.

Pisa had its own mint, which definitely operated from the XII century, whilst the presence of a mint during the Lombard age is still a matter of debate. Mint buildings, which have not been archaeologically attested, were located by BALDASSARRI 2010: 158 ss, through the study of written sources. They probably rose in the southern part of the chapel of Santa Margherita, between current via del Castelletto, vicolo Santa Margherita and via San Frediano, where they remained, used only for striking the coins, even at the start of the XIV century when the metal casting furnaces for the coins were transferred outside the walls, near

San Zeno, thus shifting to more suburban area as in the case of other metallurgic production activities. Archaeological sources have not made it possible to identify part of the workshops inferable from written sources, that is, those situated between Santa Cecilia and San Lorenzo, in the north-western area, and Fuoriporta, but provide a very detailed view of the city's metallurgic workshops, allowing us to make both accurate and hypothetical considerations (fig. 3.65). First of all, it is clear that early medieval iron workshops were related to public control associated with both the city's political centre – the area of *Cortevicchia* – and hypothetically with

the probable presence of port structures. These workshops, unlike the later centuries, were only specialised in ironworking, since copper alloy manufacturing has never been attested. Is this random, due to the involuntary sampling of archaeological sources? Or is it possible to read evidence of the basic disappearance of metallurgic knowledge? Although I personally tend to opt for the second assumption, the data available are still too scarce to state so with reasonable certainty.

The end of the XII century underwent an urban renovation process, leading to the termination of the ironworking activities in the area of San Sebastiano and their general shifting towards suburban areas, such as the area of via Sant'Antonio. Several metallurgic workshops continued their activity at San Sebastiano for around 100 years, transformed into less invasive activities, such as those related to copper alloy casting. In the light of the transfer of iron production from the central areas, I believe it is possible to reconsider the differences in the prices of coal reported in the 1305 *Breve*, whose cost of transport³⁴⁷ was considered (GARZELLA 2000: 45) inversely proportional to the number of blacksmiths in the area, as connected to a chronological element or of loyalty, in which areas with lower transport costs indicated areas in which metallurgic production was active for a longer time, in other words, the fossilisation of consolidated, privileged relationships. The workshops were transferred to areas previously used for production activities, yet replaced the earlier different productions, as in via Antonio, where they replaced the previous glassworking activities, and in the area of Palazzo Scotto, where they replaced the previous ceramic production activities. This could suggest the presence of an urban topography in which certain areas had a specific function, acquired and consolidated

through time. The gentrification process of the city centre was concluded at the start of the XIV century, when the majority of these polluting activities were transferred towards the suburb, including part of the metal coining activities, and only part of the small workshops, such as the one in piazza Sant'Omobono remained in the city. The end of the ironworking activities is attested during the second half of the XIV century. In this period, production activities at the workshop in via Sant'Antonio ended, in line with the situation that took place on Elba Island and in Versilia. On the island, following the intense deforestation during the first half of the XIV century and the effects of the plague, which forced blacksmiths to write a plea begging the *Anziani* (Elders) to accept that they could not keep faith with the agreements taken, mining activities declined until ceasing (CORRETTI 1999). In Versilia, at the same time, the number of workshops decreased, perhaps due both to quarrying difficulties and the low quality of certain veins (ANICHINI, GATTIGLIA 2009). The metallurgic activities definitely ceased, however, with the first Florentine conquest, as unmistakably attested in the excavation of Palazzo Scotto (GATTIGLIA, MILANESE 2006) and, to a lesser extent, of via Sant'Antonio (DUCCI *et alii* 2010). Evidently, the Florentines decided to eliminate the competing productions, in order to economically break the conquered city.

From a material viewpoint, apart from the workshops situated on the ground floors of the tower houses, such as those of via Sant'Antonio, the buildings used for metallurgic processes were characterised by structures with just one floor, often covered with timber roofs with openings to carry away the smoke, but not too wide so as not to let the sun directly shine through, since this would have made the metallurgic process more difficult. These kinds of buildings were already

³⁴⁷ The area with a greater concentration was San Sebastiano where the tariff was 3 *denari* for *quartum medii de quartuccio*, followed by the areas of San Lorenzo alla Rivolta and Santa Cecilia, of Porta Buoza, of the *carraia Pontis Veteris* (corso Italia), of the *carraia Pontis Novis* (via Sant'Antonio) and the neighbouring *campo Canapaio* where the cost was 4 *denari*, and lastly the areas of the Cathedral and Fuoriporta (GARZELLA 2000).

used during the VII-VIII century as indicated by the portion of masonry found in Saggio I of piazza dei Cavalieri (ABELA, BRUNI: 2000:72ss) made with a socle of roughly squared panchina stone blocks and brick chinkings, featuring quadrangular holes on the socle top for the wooden poles of the elevation. Later examples may also be found in via Consoli del Mare (XII-XIII century), in stone, and Palazzo Scotto (second half of the XIV century) in bricks.

Finally, from an economic-social viewpoint, the data collected on the bell founders reveal a wealthy entrepreneurial class, which could afford to advertise its name on pottery (albeit of low quality) and probably owned the foundry. Their family-run businesses organised in *taglie* also employed a certain number of specialised craftsmen. Can this pre-capitalistic entrepreneurial model be extended to other metallurgic entrepreneurs? The study of the archaeological context of via Consoli del Mare suggests (GATTIGLIA, GIORGIO 2010) that there was proximity between workshops and homes and to reconsider the fact that in some cases there was a distinction between home and workplace³⁴⁸ for people working in metallurgic workshops but not for the entrepreneurs who owned them. The ceramic contexts show on the one hand how the many objects offered on the ceramic market could easily be found and, therefore, the good economic level achieved, on the other hand the predominance of medium quality pottery indicate, instead, lower standards compared to the finds documented in the aristocratic tower houses (BALDASSARRI, MILANESE 2004; ANICHINI, GATTIGLIA 2008: 144). Pottery in itself does not indicate high social standing (MOLINARI 2003),

but in this case well describes the entrepreneurial character of Pisan blacksmiths, belonging to a rising 'middle class'. If this assumption were to be confirmed, it could be possible to state that from the end of the XII/start of the XIII century and throughout the entire XIV century, a 'pre-capitalist' and entrepreneurial class started to establish itself, which owned both production tools and workplaces (close to their houses) and employed skilled workmanship. The few ceramic and numismatic data available (BALDASSARRI 2012:747) relating to via Sant'Antonio seem to confirm this interpretation, but the complete publication of the excavation will allow us to confirm or refute this assumption.

3.2.4.2 Ceramic productions

The importance of Pisa as a centre of ceramic production³⁴⁹ is well known, however, although production already started between the end of the X and XI century (GIORGIO 2012: 590) it is nonetheless difficult to exactly locate the furnaces³⁵⁰. Despite the many excavations carried out, there are no finds relating to medieval ceramic production structures. Finds attributable to production waste, often considered as good indicators of the vicinity of production plants, on their own, are not considered a reliable attestation. This is due to the custom to use these materials, which could probably be found at very low cost, as isolating material and drainage for both house floorings and road paving. The data, therefore, need to be analysed in greater detail, taking into account both archaeological evidence and data taken from written sources and toponymy. Many written sources speak of *tegularii* (tile makers)³⁵¹, *baractularii*, *vasellarii*, *scudellarii*,

³⁴⁸ "(...) both because the shops located on the ground floor of the buildings were separated from the above houses and because the position of some of them, underneath *domus*, leads us to exclude that craftsmen could live in such luxurious buildings" (BERTI, RENZI RIZZO 2004: 57).

³⁴⁹ This paragraph only refers to the possible location of the production areas, the ceramic products are analysed in §3.2.5.1.

³⁵⁰ A production structure, active during the XIII century, rather doubtfully interpreted as a brick furnace is attested in the excavation of via dei Mille (GHIZZANI MARCIA F. 2012, *Intervention record no. 882*, in MappaGIS).

³⁵¹ The presence of just one tile maker, residing in the parish of San Silvestro, in the 1228 oath, is rather anomalous (SALVATORI 1994: 313).

but also of *coppai*, *broccai*, or *orciolai*³⁵² (BERTI, RENZI RIZZO 2004: 30ss). The reconstruction carried out by REDI 1991: tav.25 regarding the location of pottery and tile workshops, shows a widespread diffusion of the productions especially towards the city's boundaries, both along the Arno and the *Auser* rivers³⁵³, with evident preference for the suburban areas³⁵⁴. Toponymy indicates two toponyms of reference for ceramic production: *Baractularia* and *Tegularia*, respectively located in the eastern and western parts of Chinzica. The former appears in written sources from 1246-48, in the area of Sant'Andrea in Chinzica; it was initially used alongside (and then replaced) the previous name *Casainvilia* until disappearing at the end of the XIII century. The attestation of a *baractulario*, however, appeared 10 years earlier (GARZELLA 2006: 21; BERTI, RENZI RIZZO 2004:56), which makes us assume that the area had this name at least from the XIII century. The presence of jar makers is still attested during the XIV century but slowly give way to *vasellai* and *scudellari*, i.e. producers and sellers of fine ceramics (FIORI, MILANESE 2006: 160). The second toponym, evidently resulting from the presence of *tegolai* can be found in the furthest western area of Chinzica at least from the start of the XIII century since the first attestation dates back to 1204. In this case also, the toponym loses importance during the XIII century to the point that the last written source is dated 1287. Considering that REDI 1986a discovered the formation of micro-toponyms related to urban activities, from the second half of the XII century, which reveal the prevalence of certain production activities over others, it is probable that XIII century furnaces were most greatly concentrated in the areas of *Tegularia* and *Baractularia*. If we highlight the urban finds related to production indicators,

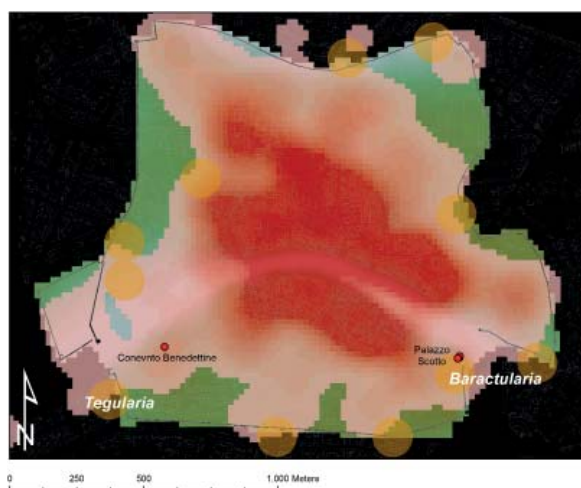


Fig. 3.66 The KDE of late medieval finds shows buffer areas (75 m radius, in yellow) containing the location of the ceramic and tile workshops inferable from written sources (elaboration from REDI 1991: tav. 25), of the toponyms *Tegularia* and *Baractularia*, and of the finds that can be more explicitly attributable to the presence of production areas, revealing the suburban nature of these workshops.

using GIS selection by attributes (Level II = 'clay manufacturing'), their number is 4, concentrated in the south of the Arno River in the western and eastern portions of Chinzica, practically in the areas of *Tegularia* and *Baractularia* (fig. 3.66). If we add other finds attributable to production waste, these amount to 7 overall, all concentrated in the same areas.

In the eastern part, of note is the recovery of Maiolica Arcaica³⁵⁵ waste in the area of Porta a Mare in 1962 and in 1970, dating back respectively to the second half of the XIV and first half of the XV century³⁵⁶ (BERTI 1997: 51); two finds at the Benedectine convent, in 1975³⁵⁷, brought to light wastes from the firing of XV-century Maiolica Arcaica and XVI century sgraffito ware, associated with pottery spacers, burned bricks (the rests of

³⁵² Different names connected to potters that can be found in the written sources.

³⁵³ The 1287 *Breve*, for example, also included the excavation of a trench along the *Auser* River from the Manno hospital (at Macadio?) to the *teglarie* located to the north-east of the city (CECCARELLI LEMUT *et alii* 1994: 418-9). The close connection between production plants and rivers is again quite evident.

³⁵⁴ In addition to the presence of a *scodellaio* in the area of San Lorenzo in *Pelliparia*, the 1287 *Breve* seems to refer to the presence of furnaces in the area of Santa Lucia dei Cappellari (BERTI, RENZI RIZZO 2004: 59).

³⁵⁵ CAMPUS A. 2012, *Intervention record no.111*, in MappaGIS.

³⁵⁶ TARANTINO G. 2012, *Intervention record no.341*, in MappaGIS.

³⁵⁷ CAMPUS A. 2012, *Intervention record no.112*, in MappaGIS.

a furnace?) and ash waste, interpreted in primary context, and, in 1976, material in secondary context, interpreted as a fill taken from nearby furnace waste, comprising Maiolica Arcaica, glazed and slipped ware and other non-specified pottery³⁵⁸. In the eastern portion of Chinzica, of note are the find in via Bovio³⁵⁹, at the start of the 1960s, and in Palazzo Scotto³⁶⁰. In the first case, the find consists of unglazed ware sherds, which were initially attributed to furnace waste, but after an attentive reading, since the sherds did not have defects sufficient to definitely regard them as production waste, they were attributed to living (storage? cellar?) or selling contexts (BERTI, GELICHI 1995: 193). In the excavation of Palazzo Scotto, furnace wastes were found in primary context composed of XIII-century biscuit firing ceramic waste and, in secondary context, a large number of pottery spacers (GATTIGLIA 2006: 130); instead, in the overbank sands prior to the construction of the metallurgic workshop, dating back to the 1333 flood, a small earthenware mould was found used for branding unglazed pitchers (FIORI, MILANESE 2006: 160). Lastly, the sherd of a pitcher was found among the demolitions of the bell founding workshop with a bell bearing the name of the bell founder - *Benciveni* incised directly on the biscuit (fig. 3.66). This seems to attest proximity between ceramic and metallurgical workshops, revealing that this isolated area of Chinzica, close to the Arno River, took the shape of a real "industrial" pole, whose ceramic productions lasted at least until the mid XIV century.

To complete the overall picture, considerations may be provided on the raw materials used for producing pottery. Regarding the clay used, archaeometric data on X-XI century pottery reveal that the body was made with the metamorphic rocks of Monte Serra (PALLECCHI 1993: 768) whilst, starting from the XI century, subsequent ceramic production - fine ware from via Bovio and Maiolica Arcaica - used clay from the alluvial deposits of the terminal valley of the Arno (BERTI, GELICHI, 1995: 196, PICON, DEMIANS D'ARCHIMBAUD 1978). Clay was recovered by using settling and filtering tanks³⁶¹, which allowed purified clay to be collected, along the rivers east of the city, allowing its easy transport by river³⁶². Regarding the materials required to produce fine ware (Maiolica Arcaica and green lead-glazed ware), i.e. tin oxide, lead oxide, copper and manganese, some recent assumptions (GIORGIO 2009: 130 ss) have opened interesting perspectives, especially, on the possible area of supply, identified in the area of the mines of Monte Valerio and Monte Rombolo near Campiglia Marittima. These mines, which produced cassiterite but also lead and copper, were under the control of Pisa at the end of the XII century and were intensely exploited already in the XI century with the establishment of fortified settlements connected to the mining economy. The coexistence of these three minerals allowed the city to be supplied from just one place. The idea that there was a connection between blacksmiths and the supply of tin could be a very interesting and meaningful research line, but unfortunately is not yet sufficiently evidenced.

³⁵⁸ A further find (TARANTINO G. 2012, *Intervention record no.35*, in MappaGIS) of sgraffito furnace waste, dating back to the last quarter of the XV century, was found in the area between via Crispi, via San Paolo and via Carabot-taia. This could suggest a certain continuity of production activities in this area until the end of the XV century. Although this assumption is not improbable, given the association with waste found in previous finds, we must not forget that this waste was also used to raise ground surfaces.

³⁵⁹ TARANTINO G. 2012, *Intervention record no.5*, in MappaGIS.

³⁶⁰ GATTIGLIA G. 2012, *Intervention record no.367*, in MappaGIS.

³⁶¹ The system used in Valdarno just up to a few decades ago consisted in digging basins on the river bank. During winter floods they filled up with a fine sediment which fell to the bottom after a first settling phase. During summer, the deposited clay was collected after withdrawal of the river and underwent a further settling phase (BALDASSARRI 2008a:104).

³⁶² To this regard, a landing place rose on the Arno River in via Bovio during the Post Medieval Age (perhaps previously).

If we gather all collected data, we may attempt to reconstruct an overall picture. Archaeometric analysis seems to suggest that the supply zones of clay changed from the XI century. This period marks the start of Pisa's urban development, which culminated during the XII and XIII century. We may assume that during this first phase, since the city centre was particularly located to the north of the Arno River, ceramic furnaces were more highly concentrated in the northern sector of the city³⁶³, with clay supply from the *Auser* River. It was only from the XI century, also in the light of the gradual conquest of the southern city areas (*Chinzica*), that clay started to be supplied from the terminal valley of the Arno River. This change is probably connected to the greater stability of the course of the Arno River, although we have information about a number of *tegularie* (tile maker workshops), in the north-eastern sector of the city at the end of the XIII century, and to the greater space available in the southern sector of the city which was more suitable for hosting production activities thanks to its lower urbanisation and better connection to river and sea transport routes. The toponyms *Tegularia* and *Baractularia* seem to indicate, therefore, that the XIII century inhabitants of Pisa perceived them as being the areas of greater ceramic specialisation. Archaeological records not only confirm this idea but strengthen it extending the period of activity until the XIV and XV century. Nonetheless, ceramic production areas were also located north of the Arno River, not far from the rivers; unfortunately the lack of archaeological finds directly ascribable to the production structures and the limited number of archaeometric analyses make it difficult to fully understand both the location of the furnaces and

the production processes.

3.2.4.3 Other production activities: leather and glass manufacturing, shipbuilding and bread baking.

Written sources depict a city fabric with an extremely high amount of workshops: in addition to metallurgic and ceramic manufacturers, the city was also populated by coopers, canvassers, hat makers, cobblers, wax-chandlers, leatherworkers, tanners, mortar bakers, bread bakers, wool makers, furriers, and silk makers. Archaeological sources have been able to describe the wide variety of professions only up to a minimum extent (fig. 3.67, see pg. 174). From a chronological viewpoint, all the archaeological data refer to the Late Middle Ages, whilst in typological terms they refer to leather and fabric manufacturing, glass manufacturing, shipbuilding and bread baking. Regrettably, they consist of partial finds, which do not allow us to fully reconstruct the manufacturing process, or of interventions for which complete publication of the excavation data is missing.

Leather manufacturing was the second production sector by number of workers in the city at the start of the XIII century (SALVATORI 1994: 146). The workshops were located³⁶⁴ in suburban areas, since they were highly polluting and malodorous, and along the Arno River given the need to use large amounts of water during the manufacturing process (HERLIHY 1990: 175), to easily dispose of waste and to transport products. Not by chance, therefore, they rose near San Nicola, where the toponym *Pellaria* (Leather workshop) is attested (HERLIHY 1990: 172). Furthermore, the toponym *Conce* (Tanneries) on the opposite riverside can still be seen in 1700³⁶⁵ and 1800³⁶⁶ maps. A large number

³⁶³ The ceramic furnaces dated prior to the Roman Imperial Age (MENCHELLI 1995a) are all located in the north-eastern part of the current city. Archaeological sources, although lacking structures, reveal a good amount of furnace waste which seems to exclude that this production area continued to be used during the Early Medieval Age.

³⁶⁴ See especially REDI 1995: tav. 25

³⁶⁵ GRAVA M. 2012, *Historical mapping (Da Morrone)*, in MappaGIS doi: 10.4456/MAPPA.2012.39, www.mappaproject.org/webgis last access 03/05/2013.

³⁶⁶ GRAVA M. 2012, *Historical mapping (Leopoldino Land Register)*, in MappaGIS doi: 10.4456/MAPPA.2012.40, www.mappaproject.org/webgis last access 03/05/2013.

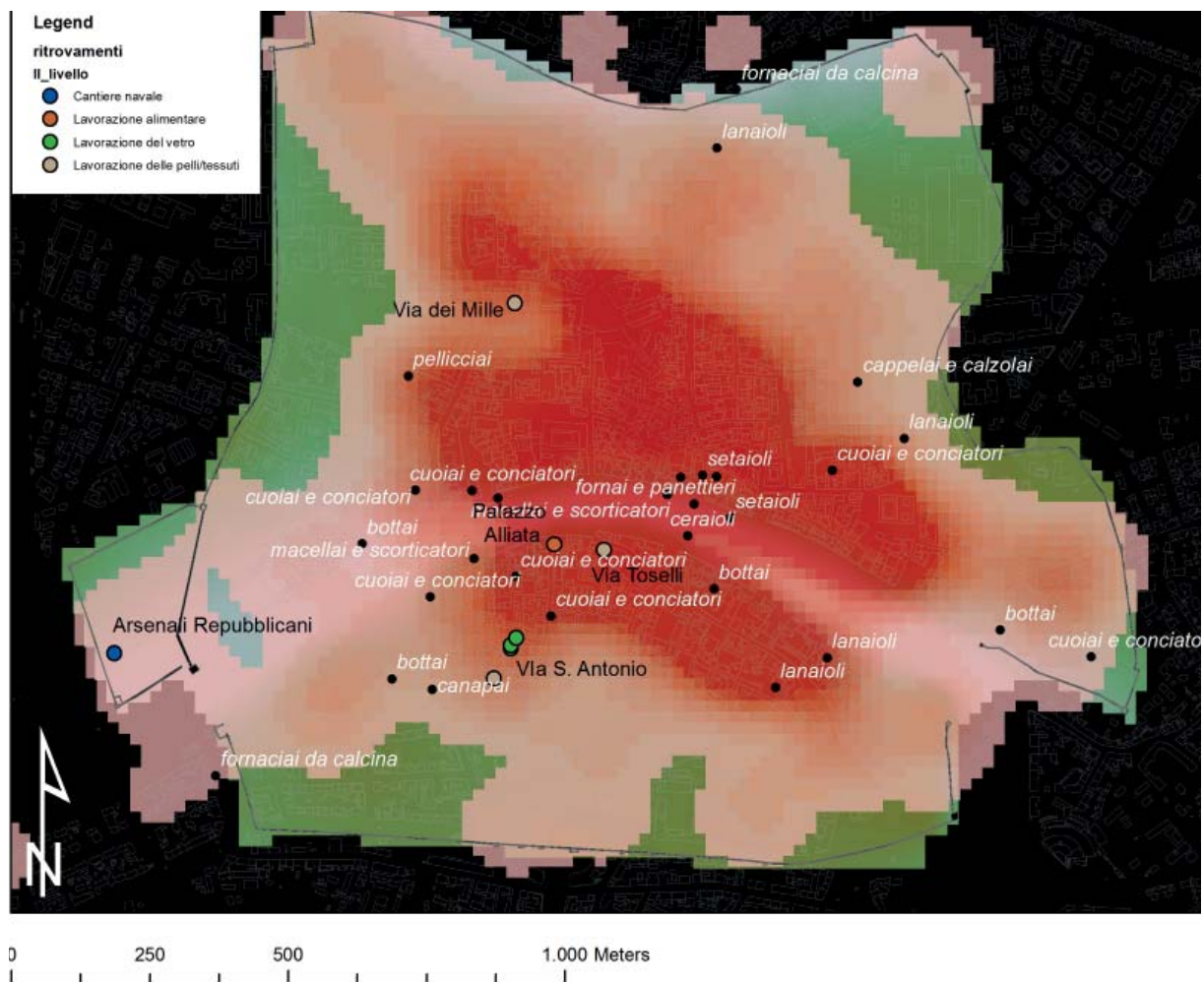


Fig. 3.67 Location of late medieval finds on the KDE relating to production activities (with the exclusion of ceramic, tile and metallurgic workshops) on the basis of written sources (re-elaboration from REDI 1991) in white, and of the archaeological data relating to the presence of leather/fabric (light brown) and glass manufacturing (green), food processing (orange) and shipbuilding activities (dark blue).

of workshops were probably concentrated in *Pelleria*, as already seen for the toponyms indicating ceramic and brick production areas. Sadly, the lack of archaeological data does not allow us to confirm this or understand its size. Leather manufacturing indicators are attested in via Sant'Antonio and via Toselli based upon manufacturing wastes. In the former case, they are probably related to nearby laboratories where copper alloy objects were cast. They consist of goat and sheep horns³⁶⁷, in one case

found in a dumping pit, which may be related to the presence of a cordwainer (see § 3.2.4.1), therefore to the final manufacturing phases (the Statutes did not allow cordwainers and goat and sheep skin manufacturers to tan hides), and to the tanners of the area, whose presence is attested by toponymy. The fact that no structures have been found does not allow us to fully comprehend how the production process was carried out³⁶⁸. The second case refers to a furrier. Furriers were an important sub-group of

³⁶⁷ GATTIGLIA G. 2012, *Intervention record no. 777*, in MappaGIS.

³⁶⁸ See HERLIHY 1990: 170ss for a detailed study of the leather manufacturing cycle and the hot and cold tanning techniques.

the wider leather manufacturing sector, to the point that the Art of furriers is already mentioned in 1235. At the start of the XIII century it employed around 20% of workers of the entire sector (SALVATORI 1994: 155). Archaeological records allow us to backdate evidence of this manufacturing process to between the XI and first half of the XII century³⁶⁹, when in the area of via Toselli³⁷⁰, an internal ground floor room began to be used as a furrier laboratory. The small excavated portion brought to light several layers characterised by an organic sediment and by a large number of fox paws and (rarer) tails (fig. 3.68), which were interpreted as relating to fur production waste materials. A hut situated further back with a stonesocle and rammed earth walls was probably used as a warehouse. Unlike tanneries, these workshops were less polluting and were positioned in areas which were becoming increasingly urbanised.

Likewise, textile production was connected to the manufacturing and colouring of clothes, wool fabric and or fabric made of vegetable fibres such as linen and canvas. Even in this case, the structures were located inside the urban area, as apparently confirmed by the presence of a workshop in via dei Mille³⁷¹, between the churches of San Sisto and Sant'Eufrasia. The production structure, dated between the XIII and XIV century and used for washing/dyeing fabrics, has an open paved courtyard, containing three circular brick tanks and a central well, in which a wooden beating tool was found. The presence of many postholes on the ground surface is related, instead, to the use of working machines or hangers. The presence of a well indicates that a good deal of water was also needed for this production process. Finally, its central position, given the cooperation that must have existed between clothes manufacturers and producers of copper alloy objects positioned close



Fig. 3.68 Bones of a fox tail and two paws found during the 2008-9 excavation in via Toselli.

to Sant'Eufrasia and in the neighbouring area of San Sebastiano is not surprising, to the point that at the start of the XIII century, a cloth maker, a weaver and two dyers resided in the parish of San Sisto (SALVATORI 1994: 303).

Archaeological records help us further understand the production activities in Pisa, since the excavation in via Sant'Antonio³⁷² brought to light a glass furnace, dated between the mid and end of the XII century. Its functioning seems to have ended more or less with the installation of nearby metallurgic workshops. This find, for which the publication of the excavation data is pending, would attest the presence of glass production workshops already during the XII century, whereas written sources of the early XIII century do not seem to mention any glass manufacturers residing in Pisa, with the exception of *mogliolari*, a term which could indicate manufacturers of glass containers (SALVATORI 1994: 174).

Shipbuilding was a vital activity for a city that based great part of its power on maritime trade and on its fleet. Many professions were connected

³⁶⁹ In 1228, a furrier still resided in the parish of Santa Cristina (SALVATORI 1994: 302).

³⁷⁰ CAMPUS A. 2012, *Intervention record no. 589*, in MappaGIS; DUCCI *et alii* 2008, 2008a.

³⁷¹ GHIZZANI MARCÌA F. 2012, *Intervention record no. 881*, in MappaGIS.

³⁷² CAMPUS A. 2012, *Intervention record no. 762*, in MappaGIS.

to shipbuilding and subject to the Ordine del Mare (Order of the Sea), ranging from shipwrights to caulkers, etc. (SALVATORI 1994: 174). Regrettably, archaeological sources are limited³⁷³ to the very scarce information retrieved from the excavation carried out at the Republican Dockyards, related to the phases of use of the ship building site. The finds consist of a large amount of nails used for repairing ships³⁷⁴, which attest how the area, immediately attached to the first western stretch of the walls, was already used as a ship building site before the construction of the dockyards during the mid-XIII century.

Lastly, food processing activities are taken into account, which are little attested in archaeological sources but represented the first occupational sector by number of workers in the city (SALVATORI 1994: 148). The weak traces or the difficulty to correctly interpret them do not provide us with an overall picture of food production, with the exception of bread baking³⁷⁵, confirmed by a bakery found in Palazzo Alliata³⁷⁶, on the ground floor of building 8, which brought to light two brick bread-baking ovens (REDI 1982a: 68), dating back to the XIII-XIV century, with a diameter of 1.60 and 1.40, respectively. Even the bread-baking ovens were situated in a little building that did not directly overlook the street, probably a *casalino* (hut) during its first construction phase. As already seen for the metallurgic workshops, laboratories were mainly located behind buildings which did not directly overlook the street, especially during the middle centuries of the Middle Ages. It is probable, therefore, that ground floors used as laboratories had an area strictly used for production, a back area, used as a *casalino*, and

perhaps a front area open to the public. Smaller buildings rose next to these laboratories, as in the case of the *casa solarziata*³⁷⁷ of via Consoli del Mare (ANICHINI, GATTIGLIA 2008), which were the houses used by small craftsmen or workers.

3.2.4.4 Agricultural-vegetable gardening areas

Describing medieval agricultural-vegetable garden areas means taking into account 'dark earth', which up to now had not yet been seen in the stratifications of Pisa. In my opinion, it is possible to suggest the presence of dark earth in certain points of the city, based on interpreted and/or partial archaeological records. These deposits do not have a univocal meaning, which is rather the result of several factors and/or formation processes which may have acted individually or together. Dark earth deposits have a strong organic component; they characterised a good part of urban stratifications between the Late Roman period and the Early Middle Ages and are related to short term rather than long term events. Dark earth may be the product of the waste disposed by a society that no longer had functioning draining systems or organised suburban/extra-urban systems for the transport of solid waste, also favoured by the large amount of unused open urban spaces which were at times located close to houses. It is possible, therefore, that its organic component and easy access made it immediately available as fertiliser. For this reason, these deposits could indicate cultivated, vegetable gardening areas. Another hypothesis tends to interpret dark earth as the product of collapsed buildings or structures made of earth

³⁷³ Publication of the data of the 2011 excavation are still pending; SCIUTO C. 2012, *Intervention record no. 862*, in MappaGIS.

³⁷⁴ LA ROSA L. 2012, *Intervention record no. 86*, in MappaGIS.

³⁷⁵ Perhaps due to the large number: 114 *forarii* (bakers) residing in Pisa are attested in 1228, 31% of all workers in the sector (SALVATORI 1994: 148).

³⁷⁶ LA ROSA L. 2012, *Intervention record no. 290*, in MappaGIS.

³⁷⁷ TARANTINO G. 2012, *Intervention record no. 588*, in MappaGIS.

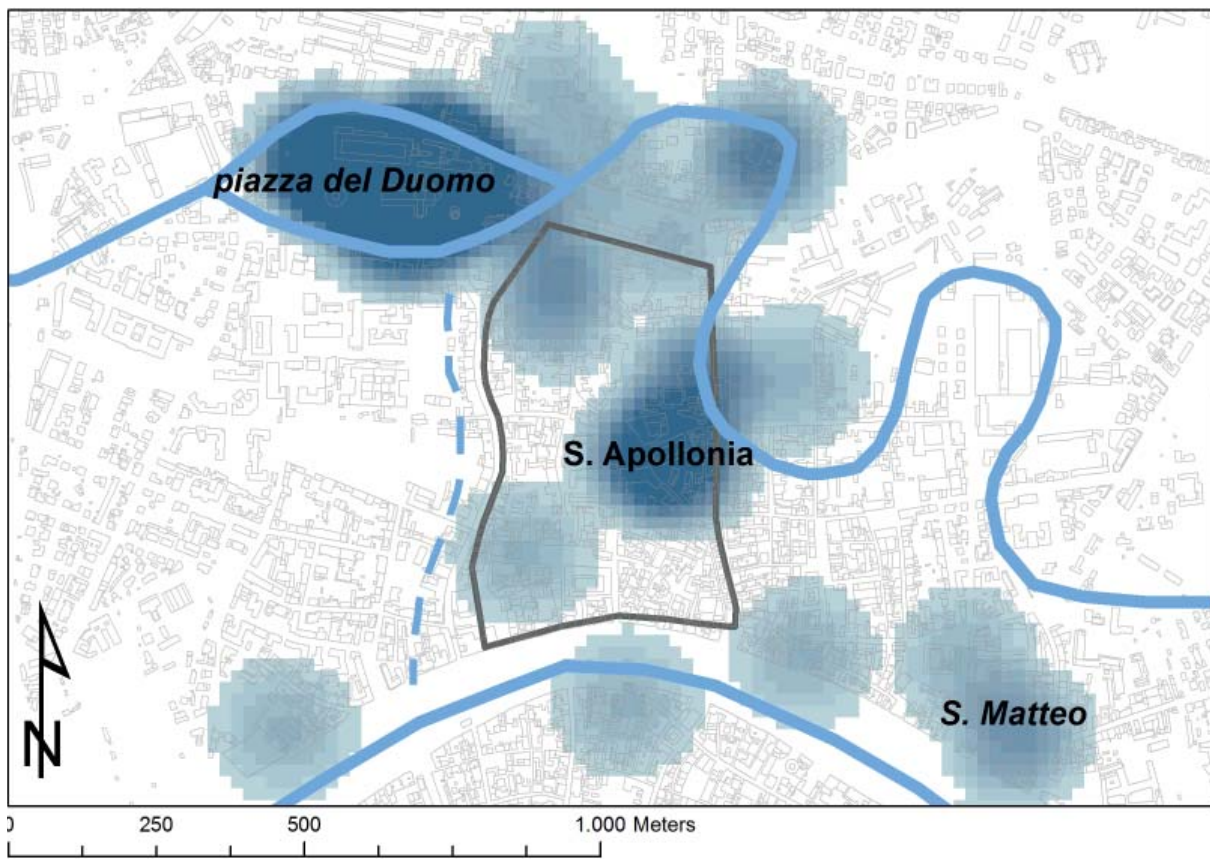


Fig. 3.69 Location of points where deposits interpreted as dark earth have been found, overlapping the KDE of the VI-VII century finds. The probable courses of the Auser River (to the north) and of the Arno River (to the south) are indicated in blue. The dotted line is the presumed branch that connected the two river basins.

and wood. This interpretation, however, is less suitable for Pisa, that appears characterised by rammed earth wall buildings during the Late Roman period and the Early Middle Ages. A recent geo-archaeological interpretation, based on the analysis of dark earth in Ferrara, tends (at least in this case) to attribute its origin to flooding events (NICOSIA 2010), an assumption that cannot be entirely overlooked in our case, given the VI century water collapse discussed in the previous chapter. If the problem is difficult to solve in the presence of definite archaeological data, caution is even further necessary in the case of Pisa, where a new way of using space was established, in part related to de-urbanisation processes, but above all to a new concept of urban economy based on

agricultural practices rather than on production-craftsmanship (BROGIOLO 2011: 133). Overall, 5 different finds of deposits attributable to dark earth were found, concentrated in three main areas of the city to the north of the Arno River: the north-western area of piazza del Duomo, the middle area of Sant'Apollonia and the eastern area of San Matteo (fig. 3.69). In the area of piazza del Duomo³⁷⁸ deposits defined as dark earth may be seen in layers of dark brown earth with early medieval materials, subsequent to the robbing of an Imperial-age house, found in the excavation at Porta del Leone. If we relate these deposits to the presence of houses in perishable material existing between the VI and VII century in the square, they may credibly be interpreted as

³⁷⁸ TARANTINO G. 2012, *Intervention record no. 358*, in MappaGIS.

pertaining to waste disposal areas, situated in a slightly peripheral area with respect to the early medieval settlement. In the central area of the city, the two excavation areas at Sant'Apollonia³⁷⁹ revealed consistent layers of dark earth, above the last frequentations dating back to the start of the III century, interpreted as an abandoned place, interspersed by limited frequentations and interrupted by the VII-VIII century hearth/hut. These deposits are ascribable to dark earth, but their attribution is more difficult in this case. This is due both to the scarce documentation available and, especially, to the presence of one of the *Auser's* palaeo-riverbeds in this area, indicating that the layers may be the result of flooding³⁸⁰. In the excavation samples carried out in the northern courtyard of the monastery of San Matteo³⁸¹, plastic and blackish, rather organic, silty-clayey soil levels were documented, identified as similar to dark earth and related to more ancient phases, although not dated. In this case, correct attribution appears to be even more complicated. We have no traces of early medieval settlements in this area and our knowledge of this portion of the Roman city is extremely hypothetical, since connected to the possible presence of the *castellum aquae* of the aqueduct from which the medieval toponym *supra castello* derives (GELICHI 1998: 81). The silty-clayey sediment of the deposits and proximity of the traces of the early-medieval Arno and *Auser* palaeo-riverbeds cannot exclude the presence of partially marshy overbank environments. During the Late Medieval Ages, vegetable gardens were mainly located, in terms of number and size, in the suburban area, at times associated

with monastic buildings, and, to a lesser extent, inside the city centre often situated between buildings on the rear, where they were often small gardens with orchards. Archaeological data are quite consistent given that 12 areas³⁸² connected to vegetable garden cultivations were identified³⁸³. The most marginal areas belong to the category of suburban vegetable gardens, such as those along the wall at the former Marzotto textile factory area³⁸⁴, where agricultural/vegetable garden layers were found continuously ploughed from the Late Middle Ages to the XIX century, but also more central areas, such as those found in the excavation of via Galli Tassi³⁸⁵. Here, an interesting XIII/XIV-century stratigraphic sequence was brought to light, consisting on an alluvial layer, only partially investigated, which could be attributed to the early medieval Pisa marsh. A phase related to construction site activities may be seen, attributable to the construction of nearby buildings, followed by a second phase characterised by organic clayey/silty sediments with traces of vegetable decomposition, and by two holes. One of these – given its size and type of organic fill – was interpreted as a tree-removal hole. The interpretation of the archaeological records suggests that this area included an open, vegetable garden area, with vegetation (fruit trees?) and that it was subject to sedimentation phenomena.

A number of vegetable garden lands linked to religious institutions were situated in suburban areas: those found in the internal courtyard of the Opera Primaziale del Duomo, dating back to the XIV - XV century³⁸⁶; those connected to

³⁷⁹ SCIUTO C. 2012, *Intervention records nos. 94, 95*, in MappaGIS.

³⁸⁰ See the already mentioned case of Ferrara (NICOSIA 2010).

³⁸¹ SCIUTO C. 2012, *Intervention records nis. 609, 610*, in MappaGIS; BALDASSARRI 2006.

³⁸² The excavation at Ancient Ships Archaeological Site in San Rossore, which identified layers subject to agricultural cultivations generically dating back to the Late Medieval Age, is not taken into account, given its position outside the city (SCIUTO C. 2012, *Intervention record no. 376*, in MappaGIS).

³⁸³ Level II search layer finds = Vegetable garden with late medieval chronology in MappaGIS.

³⁸⁴ CAMPUS A. 2012, *Intervention record no. 224*, in MappaGIS.

³⁸⁵ LA ROSA L. 2012, *Intervention record no. 604*, in MappaGIS.

³⁸⁶ TARANTINO G. 2012, *Intervention record no. 374*, in MappaGIS.

the house of the Undertaker adjacent to the Camposanto Monumentale³⁸⁷, those inside the northern courtyard of the monastery of San Matteo³⁸⁸, dated between the end of the XIII and beginning of the XIV century; and those at the church of Sant'Andrea in Chinzica³⁸⁹, where, during the second half of the XIV century, a small vegetable garden area was situated on the northern side of the church, which then became an orchard-cemetery between the end of the XIV and start of the XV century. A vegetable garden was situated immediately adjacent to the church, which shows holes related to the removal of poles and two (fruit?) trees, filled with organic soil. Following their removal, the area was cultivated as evidenced by a dark-coloured silty-sandy sediment with organic elements, the removal of which showed parallel cuts in the underlying interface – a clear proof of vegetable garden cultivations (fig. 3.70). Other vegetable gardens were located in via della Faggiola³⁹⁰, Palazzo Giuli³⁹¹, in the southern sector of the city, where between the XIII and XIV century a large amount of space left empty from previous structures was delimited by brick and/or stone walls and subsequently used as vegetable gardens, and via Sant'Antonio, where vegetable gardens were related to buildings overlooking the street³⁹².

If we combine archaeological analysis with toponymic studies (fig. 3.71), it is possible to see how toponyms connected to vegetable garden cultivations and to vineyards were located in suburban areas within the late medieval city walls, apart from the toponym *Orto* (Vegetable garden)³⁹³ of which we have knowledge from the start of the XI century and probably related to lands initially positioned close to the *Auser* River, therefore, more fertile. Toponyms



Fig. 3.70 Excavation of Palazzo Scotto. The image shows a portion of the vegetable garden area that rose to the north of the church of S. Andrea in Chinzica. Two large holes may be seen related to the presence of two small-sized trees as well as smaller holes connected to the presence of a small vegetable garden. The presence of an earth-pit burial made it possible to retrace this area to the orchard cemetery tradition.

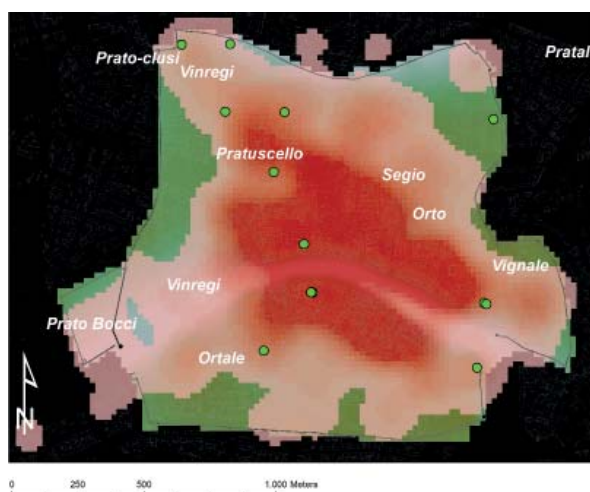


Fig. 3.71 Location of the late medieval finds and main toponyms (re-elaboration from GARZELLA 1990 and RED I 1991) on the KDE relating to vegetable garden areas; a higher number of vegetable garden areas may be seen in the suburban section together with a lower number of gardens/vegetable gardens in the urban area. The use of KDE in this case is preferable because the co-kriging interpolation is directly influenced by this kind of finds; the algorithmically elaborated model provides a result similar to KDE.

specifically related to grasslands (*Prato -clusi*, *Prato Bocci*, *Pratale*, *Pratuscello*), most probably used for breeding and/or sheep farming, were all

³⁸⁷ GATTIGLIA G. 2012, *Intervention record no. 357*, in MappaGIS.

³⁸⁸ SCIUTO C. 2012, *Intervention records nos. 364, 609*, in MappaGIS.

³⁸⁹ GATTIGLIA G. 2012, *Intervention record no. 367*, in MappaGIS; GATTIGLIA 2006: 134.

³⁹⁰ LA ROSA L. 2012, *Intervention record no. 4*, in MappaGIS.

³⁹¹ GATTIGLIA G. 2012, *Intervention record no. 843*, in MappaGIS; RED I, GUERRUCCI 2006.

³⁹² GATTIGLIA G. 2012, *Intervention record no. 777*, in MappaGIS.

³⁹³ GARZELLA 1990: 6.

positioned outside the XII century city walls, apart from *Pratuscello*³⁹⁴. This toponym, known since 964 and connected to the gradual reconversion of the Pisa marsh, indicated one of the boundaries of the early medieval city. The overall presence of vegetable garden areas inside the walled city continued up to modern and contemporary ages as confirmed by both the large amount of XVII and XVIII maps and land views, and the Leopoldino land register³⁹⁵, which depict a city with countless vegetable gardens behind its houses and wide open cultivable spaces in the suburban strip behind the city walls. The data available, therefore, allow us to perceive the widespread nature and location of these cultivation practices within the walls. Regrettably, the lack of archaeobotanical studies on the many samples of sediment collected does not allow us to understand the exact species cultivated.

3.2.5 Economy, trade, social status

3.2.5.1 Ceramic contexts

The analysis of ceramic contexts is frequently used³⁹⁶ to understand both the size of trade between the city and the Mediterranean area and internal economic circulation, hence providing evidence of the economic/social status of the

inhabitants of a city. Based upon the excavation data that can be analysed, it is difficult to study early medieval contexts from this viewpoint. Based on the foregoing, the only stratifications that can be dated between the VI and VIII century derive from the excavations of piazza del Duomo³⁹⁷, whereas reference can be made to the excavations of piazza dei Cavalieri and piazza Dante for the VIII and IX centuries. Starting from the X century, contexts from urban excavations mainly pertaining to the last decade are available³⁹⁸. The most quantitatively significant data start from the period overlapping the end of the X and start of the XI century: foremost all the material of the excavation in piazza Dante, which however reveal associations characterised by a chronological range that is too wide to be of any use for defining index fossils for the period. The contexts of piazza dei Cavalieri are undoubtedly better in terms of depositional dynamics, although they are quantitatively limited given the small surface of the areas investigated; the materials of via dei Facchini³⁹⁹ are a valid sample starting from the end of XI century, the contexts of via Consoli del Mare⁴⁰⁰, although deriving from a production area, are extremely interesting, while important elements may also be seen in the recent excavations of vicolo del Porton Rosso⁴⁰¹, piazza delle Vettovaglie⁴⁰², piazza Sant'Omobono⁴⁰³ and

³⁹⁴ GARZELLA 1990: 24.

³⁹⁵ GRAVA M. 2012, *Historical mapping (Leopoldino land register)*, in MappaGIS.

³⁹⁶ I am aware that ceramics are only a part of the products used and certainly not the most suitable to definitely determine the social standing of their owners or the volume of trade. However, as often underlined by experts, they are the most quantitatively represented artefacts and above all the only that can be compared with significant percentages. For this reason, although I am aware of the limits of this analysis, I believe it capable of providing a sufficiently indicative picture of both trade and social status.

³⁹⁷ The publication of the contexts of vicolo del Porton Rosso excavation is pending.

³⁹⁸ This type of comparative analysis (BALDASSARRI, BERTI 2009; BALDASSARRI, GIORGIO 2010; GATTIGLIA 2010; GIORGIO 2012) is based on the comparison of different contexts by type, size and position of intervention, as considered throughout the course of this research. Specifically, it should be pointed out that, together with these general problems, the lack of closed contexts, the little attention paid to residual elements, the lack of archaeometric analyses and the different state of conservation between ceramic classes, which can make the recognition and attribution of a specific production area very difficult, need to be added.

³⁹⁹ BALDASSARRI, MILANESE 2004a; BALDASSARRI, GIORGIO 2010.

⁴⁰⁰ GATTIGLIA, GIORGIO 2007; BALDASSARRI, GIORGIO 2010; GATTIGLIA, GIORGIO 2010.

⁴⁰¹ FEBBRARO, MEO 2009.

⁴⁰² ALBERTI, BALDASSARRI 2004; BALDASSARRI, BERTI 2009.

⁴⁰³ ANICHINI, GATTIGLIA 2006; BALDASSARRI, BERTI 2009.

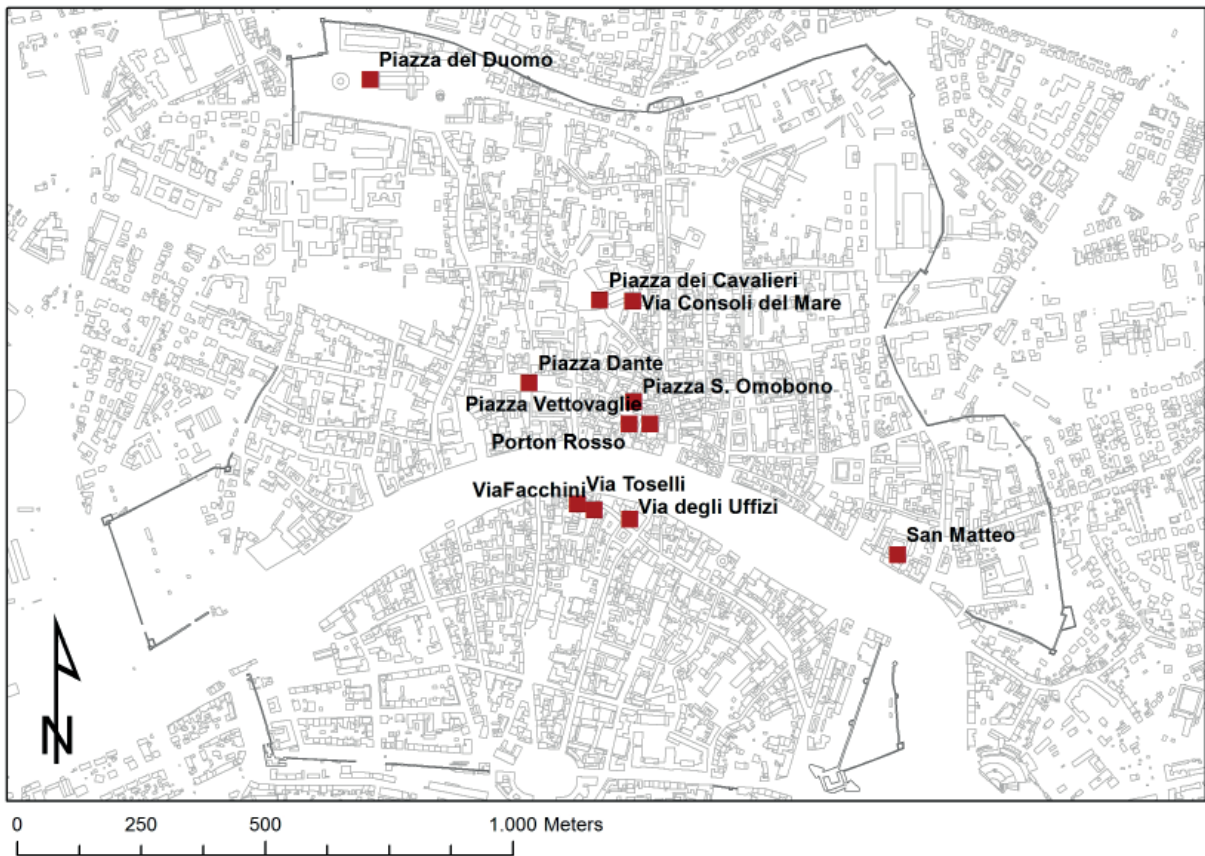


Fig. 3.72 Location of the main archaeological interventions mentioned in the text.

via degli Uffizi⁴⁰⁴, where the quality of the ware overcomes, at least partly, its small amount (fig. 3.72). The chronological range proposed contains elements of arbitrariness, due to changes in the ceramic associations identified in the stratigraphic contexts. The chronological range must not be considered as a sharp interruption of the passage of time, but rather as a simple way to highlight certain events.

3.2.5.1.1 VI-IX century

As previously mentioned, we have few data regarding early medieval contexts. Nonetheless, the excavations in piazza del Duomo (ALBERTI, PARIBENI 2011) provide a first understanding of the ceramic contexts of Pisa especially during the passage from the Late Roman period to the Early

Middle Ages, between the VI and VIII century. The first element that must be taken into account is that the economic and commercial liveliness of the city and local areas appears to continue until the first decades of the VII century, given their inclusion in the Byzantine world. Trade exchanges were dictated by political and strategic reasons which allowed goods to arrive from the African coasts and eastern Mediterranean areas but also from the nearby Ligurian ports under Imperial control, as in the areas belonging to the Tuscan coast, Tuscan archipelago and Liguria. Traffic and routes began to change already during the second half of the VII century, when considerable pressure by the Lombards managed to weaken a commercial system essentially based on intervention by the Byzantine state, and forced it

⁴⁰⁴ ANICHINI, GATTIGLIA 2008; BALDASSARRI, GIORGIO 2010.

to definitely abandon the Upper Tyrrhenian area. As a result, the VIII century scenario drastically changed: the market of reference narrowed and imports arrived only from the western Mediterranean, although the city continued to be engaged in sea activities, as seen in chapter 2.

Between the VI and the start of the VII century, tableware seems to comprise two types of ware: common ware flanged bowls, which reproduce the Hayes 91 shape in African Red Slip (ARS) ware, and pitchers with flared rim and ribbon handle attached to the top of the rim⁴⁰⁵, widely attested in coastal and internal Tuscia, here also associated with common ware pitchers with cylindrical necks and ribbing. These are African productions with good technical quality (RIZZITELLI 2011). Alongside these undecorated vessels, ARS could also be found: brimmed bowls and flanged bowls (open forms) and jugs, pitchers and bottles (closed forms). These were African imports produced between the IV and VII century. In addition to import products, local and sub-regional products also appeared such as broad-line painted ware and red-brown decorated pottery, mainly closed forms. This production was at its most developed between the VI and VIII century and may be related⁴⁰⁶ to Valdarno production centres, such as the one in San Genesio (Valdarno Pisano), operating between the VI-VII century. Closed forms were mainly produced, together with flanged bowls. Alongside these, other closed forms appeared during the VII century, such as bottles or flasks with wavy incised patterns, in some cases accompanied by broad lines (ALBERTI 2011). Tableware also included ARS, which cannot be seen in the contexts of the nearby excavation at the Garden of the Archbishop's

residence and scarcely attested in the excavation of piazza Dante. This type of ware, attested by forms Hayes 80B/99, by *Atlante* XLVI, 7 and Hayes 104A brimmed bowls, by Hayes 91 flanged bowls, with B and C variations, by Hayes 94 and 98 goblets, and by Hayes 64, Lamboglia 60 and Hayes 104B brimmed bowls, showed a decline already from the VI century. The decline is even more evident for vessels dated between the second half of the VI century and the first half of the VII century, when the Hayes 104 brimmed bowl and the Hayes 91 flanged bowl are attested. The variety of forms, in any case, reveals moderate functional diversification for both individual and collective tableware (MILETI, RIZZITELLI 2011: 372-374). Cooking ware is attested in VI-VII century contexts, consisting of olla, lids, basins, pots, mortars and *testelli* (also attested in the VI-VII century contexts of piazza dei Cavalieri and in the VIII-X century contexts of piazza Dante) (ALBERTI 2011a). Food was also cooked in green soapstone pots with unrestricted frustum (made with chlorite-schist from the north-western Alps), especially in VI century contexts related to the Late Roman burial ground⁴⁰⁷, in V-VI century contexts related to the abandonment and robbery of Roman *domus*⁴⁰⁸ and in mid-VII century Lombard contexts⁴⁰⁹ (ALBERTI 2009, 2011b). Even the amount of transport containers shows a strong decline from the VI century, with prevailing African production (Keay55, 62 and 62Q), totalling 60% of incoming products, compared to Eastern ware (LRA2) amounting to 30%. Eastern amphorae are also attested in the excavation of via Toselli⁴¹⁰, where residual LRA 5/6 sherds were found, attesting continuity of life in the area at least up to the VI-

⁴⁰⁵ Also found in the contexts of the Garden of the Archbishop's residence and dated between the IV and VI-start of the VII century.

⁴⁰⁶ The petrographic analyses do not exclude this (ALBERTI 2011).

⁴⁰⁷ 2 sherds are attested = 2 vessels (ALBERTI 2009).

⁴⁰⁸ 2 sherds are attested = 2 vessels (ALBERTI 2009).

⁴⁰⁹ SANPAOLESI 1956-7.

⁴¹⁰ DUCCI *et alii* 2008a.

VII century. It is evident that between the VI and start of the VII century, landing places in Pisa were busy and, on the basis of the provenance of goods, the commercial area of reference was still Byzantine. During the VII century, the market of reference was still the same, yet commercial flows were kept to a minimum with a rare presence of African (Keay 62 var. Bonifay 1986 fig 12.55) and Eastern (LRA 3, LRA4) vessels. At the end of the VII or start of the VIII century, Pisa had a short-range market which revolved around the western Mediterranean. A few examples of globular amphorae can be seen, including an interesting rim perhaps attributable to the early-medieval shapes of the bay of Naples (Miseno) which probably reached the city only on an occasional basis (COSTANTINI 2011). In addition to a very high amount of residual Roman pottery⁴¹¹, the VIII-X century contexts of piazza Dante⁴¹² also revealed associations composed of fine ware – a part of which Broad-line painted ware but in both cases closed forms – and coarse cooking ware⁴¹³. The presence of red painted pottery amounts to around 1/5 of all total finds (ABELA 1993c; ABELA, BERTI 1998:30). These are artefacts partly attributable, based upon mineralogical analyses, to workshops situated in Campania and Lazio, although some parts are similar to unglazed fine ware the greater part of which are considered of local production (ABELA, BERTI 1998:24). Data from the VII-IX stratifications of the excavation of piazza dei Cavalieri (MENCHELLI, RENZI RIZZO 2000:123) and piazza Dante reveal the

presence of coarse ware closed forms attributable to scarcely defined morphologies, but related to small and medium sized handled vessels, for the majority of local production, shaped on a small wheel. No open forms were found, while sherds of burnished ware, probably dating back to the VII-VIII century were found, but in secondary context related to the first half of the XI century (MENCHELLI, RENZI RIZZO 2000:150). Regarding cooking ware, *testelli* are attested in VII-VIII century contexts, which disappeared over the next centuries and then reappeared at the end of the X century, perhaps due to the production context of the area (ABELA 2000b: 189). In the contexts of piazza Dante, *testelli* may be seen in VIII-X century stratifications⁴¹⁴, although the too wide VI Period chronological range does not allow us to make more detailed evaluations. Soapstone vessels seem to disappear in the VIII century and reappear in the X-XI century⁴¹⁵.

Forum ware and sparse glazed ware deserve special mention. The most ancient attestations of *Forum* ware refer to the IX-start of the X century contexts of piazza dei Cavalieri (ABELA 2000a), with the presence of closed vessels with rod handle attached under the rim, and *Forum* ware, with chronologies between the IX and XI century; more doubtful are the IX century contexts of the excavation in vicolo del Porton Rosso (FEBBRARO, MEO 2009), where sherds⁴¹⁶ were apparently documented regarding closed *Forum* ware with pine scales, in association with broad-line painted ware decorated with incised wavy lines and curly

⁴¹¹ 70% residuality was calculated (ABELA, BERTI 1998:30).

⁴¹² The VI Period, defined by the excavation periodisation. Unfortunately the too wide chronological range adopted made a detailed analysis very difficult.

⁴¹³ Fine ware represents 90% in these contexts (ABELA, BERTI 1998:26).

⁴¹⁴ *Testelli* represent over 60% of the ceramic artefacts attested in VIII-X century contexts (ABELA, BERTI 1998: 26).

⁴¹⁵ These data are confirmed by the significant samples related to the production of the Western Alps; in northern Italy sites, western production consistently dropped and disappeared from the market by the VII century, when soapstone from the valleys of the central-western Alps was almost exclusively used. There seems to be a gap between these two moments of attestation perhaps justifiable in the continuity of certain Tuscan ports under the Byzantine domain until 643 (Pisa, Cosa), as regards the most ancient phase of attestation, and in the reorganisation of maritime traffic and the affirmation of Pisa from the X century for the second phase in which soapstone vessels are documented in Tuscany (ALBERTI 2009).

⁴¹⁶ This uncertainty is necessary pending the definite publication of the excavation data; the ceramic association described is even attributable to more later contexts (X-XI century).

dotted stripes. *Forum* ware and sparse glazed ware, evidenced in the excavation of piazza Dante⁴¹⁷, appear together almost exclusively⁴¹⁸ in mid X – start of the XI century contexts in essentially identical amounts. Only a very small sherd attests *Forum* ware with pine scales. Generally, these products should be related to the period in which they gradually stopped being produced, when the most elaborate shapes were abandoned (PAROLI 1990:321). They belonged, therefore, to the period of late circulation found both in Rome and Tuscan sites (ABELA 1993a; ABELA 2000a), although a part of the glazed ware of the Lazio area already circulated from the IX century, though we do not know to which extent.

3.2.5.1.2 X century – start of XI century

Contexts from the X-start of the XI century begin to provide us with a more exhaustive picture of pottery circulation. The end of the X-start of the XI century contexts of piazza dei Cavalieri and piazza Dante⁴¹⁹ mainly include closed, unglazed fine ware, the majority probably⁴²⁰ small-sized vessels, which often reveal a lighter colour of the surface made during firing⁴²¹, and, when present, decorations with wavy lines (MENCHELLI, RENZI RIZZO 2000; MENCHELLI 1993). Fine ware can also be found in broad-line painted ware both in the contexts of piazza Dante (ABELA 1993c) and piazza dei Cavalieri (ABELA 2000), with similar incidence, reaching a peak between the end of the X and beginning of the

XI century. These consist of table pitchers and jugs but also larger sized vessels. They have a flat base with no feet and a ribbon handle attached slightly underneath the rim. The surface has an extremely simple decoration with red vertical stripes. The latter are probably large pitchers with a ribbon handle attached just under the rim and vertical broad-line decoration. Between the X century and the start of the XI century, closed cooking ware was difficult to find, often characterised by thick lines on the outer surface, which completely covered the body of the vessel, with the exception of the rim and base (ABELA 2000:181, C.6), whereas both *testelli* and *tegami* (pans) could be found⁴²² (ABELA 2000b). In these contexts, as previously seen, *Forum* ware from Lazio continued to be used, as confirmed in the excavation of vicolo del Porton Rosso, with examples of late *Forum* ware. It is in these contexts that soapstone vessels reappear⁴²³. Only medium-sized pots can be seen with unrestricted frustum. They have a concave base with outer ridges typical of pots hanging over a fire, thickly ridged inside and smoothed on the outside with strips of thick wheel lines. Talco-schist was used for these pots, which was quarried in the central-western Alps. Their presence according to ALBERTI 2009 may be considered a good marker for X-XI century contexts. The appearance of pottery in Pisa from various Mediterranean countries was sudden from the end of the X century. This pottery,

⁴¹⁷ The excavation of piazza Dante was the first to provide stratigraphic evidence of the presence of *Forum* ware in Pisa. Previously a not better identified sherd of *Forum* ware had been found and defined “of the more diffused and ancient type with clear and granular body, pine scales and thick green glass” at the excavations of Palazzo Vitelli (REDI 1982).

⁴¹⁸ Just one vessel related to the contexts of the mid XI- XIII century.

⁴¹⁹ The contexts of piazza Dante reveal that 60% are composed of unglazed fineware (around 1/3), almost all closed forms, and of cooking ware (just less than 2/3), with a ratio between closed and open forms of 4 to 3; 29.5% are broad-line painted ware, *Forum* ware and sparse glazed ware, in practically equal shares, and the remaining 10.5% of glazed ware from Islamic production centres in the western Mediterranean (BRUNI *et alii* 2000).

⁴²⁰ This uncertainty is necessary since it is not possible to define the morphologies up to the first half of the XI century.

⁴²¹ The lighter colour of the surface is connected to the oxidating firing atmosphere and could be related to the non optimal control of the production process.

⁴²² This term is referred to cooking ware with unrestricted frustum, and tall, thin sides, similar in technology to *testelli*, but with a greater capacity and more suitable for cooking liquids.

⁴²³ Piazza Dante; via dei Facchini; vicolo del Porton Rosso. The soapstone vessels found in the excavation of piazza Dante, where the chronological range is too wide have high residuality (ALBERTI 2009).

mainly glazed tableware, was richly coloured and ornated, and was in sharp contrast with the local production of this period which, as seen, comprised unglazed artefacts, with prevalently closed shapes (for storing), suitable for cooking or preserving liquid or solid foodstuffs⁴²⁴. These products, which immediately reached the city in great quantity, were used as architectural decorations, to adorn the exteriors of mainly religious buildings and for domestic use, as clearly attested in the archaeological contexts (BALDASSARRI, BERTI 2009; BALDASSARRI, GIORGIO 2010; BERTI, GIORGIO 2011; GIORGIO 2013). These lead-glazed products came from the Islamic area and were found in the stratifications from the mid X – start of the XI century: Tunisian and Tunisian/Sicilian production (BERTI 2000), Andalusian/Moroccan production⁴²⁵, such as the *cuerda seca* pottery found in piazza Dante and vicolo del Porton Rosso (BERTI, GARCÍA PORRAS 2006; FEBBRARO, MEO 2009), and Majorcan production (BERTI 1993). These are evidently high-quality products which can be found in extremely small percentages in the stratigraphy, and clearly attest their wide commercial circulation from the second half/end of the X century (BERTI 1997a). Comparison between excavation contexts and walled basins (*bacini*)⁴²⁶ of the second half of the X – start of the XI century, shows how together with products found in excavation contexts, products of greater quality circulated in Pisa, deriving from Egyptian/Mid-Eastern production centres, attested in the basins in percentages of around 10% (BERTI 1997; ABELA, BERTI 1998:27; BALDASSARRI, BERTI 2009:68; GIORGIO 2013).

3.2.5.1.3 First half of XI century

Even the contexts of the first half of the XI century comprise both unglazed fine ware and cooking ware. The real novelty is the percentage of fine ware products, which show a leap in the technological quality of local artefacts. Unglazed fine and semi-fine ware (MENCHELLI, RENZI RIZZO 2000; MENCHELLI 1993) mainly comprises closed, small-sized vessels (jars used for storing and as tableware), with trilobed rim and short cylindrical neck with unrestricted frustum, often featuring a lighter, uneven colour of the surface⁴²⁷. In terms of decoration, incised horizontal lines or wavy lines may be seen often crossed by parallel lines. Open forms are not attested. Together with these vessels, medium and large morphological type may also be seen, featuring ribbon handles over 4 cm wide attached to the top of the rim (MENCHELLI, RENZI RIZZO 2000; MENCHELLI 1993). Open forms appear in contexts belonging to the first half of the XI century: hemispherical basins, basins with unrestricted frustum and brimmed bowls (RENZI RIZZO 2000). This fine ware is still associated with Broad-line painted ware (ABELA 2000). The first half of the XI century, instead, both in piazza dei Cavalieri (ABELA 2000b) and piazza Dante (MENCHELLI 1993) contexts, reveals a significant quantitative and qualitative development of closed cooking ware, morphologically characterised by olla, without ridges, and open ware (*testelli*)⁴²⁸ and pans). Among the import materials, products from the area of Lazio – such as *Forum* ware and sparse glazed ware in the contexts of piazza Dante

⁴²⁴ For a more detailed analysis see BERTI, GELICHI 1995 and BERTI, MENCHELLI 1998.

⁴²⁵ The attribution of certain products to Spanish (Al Andalus and Balearic Islands) and Moroccan centres is determined by the fact that similar pottery was partly made in the two areas, as was also the case for certain productions in Tunisia and Islamic Sicily (ABELA, BERTI 1998:27; BERTI, GARCÍA PORRAS 2006).

⁴²⁶ For many years, given the absence of confirmation from excavation stratigraphic contexts, basins were considered as extraordinary arrivals aimed at decorating specific monuments and not indicators of trade exchange, as demonstrated by the archaeological contexts. For an idea on the problem and new considerations see BERTI 1990:103; BERTI, CAPPELLI 1994:133; BERTI 1997a:346; BALDASSARRI, BERTI 2009; BERTI, GIORGIO 2011.

⁴²⁷ The lighter colour of the surface could be related to a non optimal control of the production process.

⁴²⁸ *Testelli* relating to the first half of the XI century represent 57% of all *testelli* found in the excavation of piazza dei Cavalieri (ABELA 2000b:189).

(ABELA 1993a), piazza dei Cavalieri (ABELA 2000a) and vicolo del Porton Rosso (FEBBRARO, MEO 2009) –, lead-glazed ware of Tunisian, Tunisian/Sicilian and Spanish origin, and Tunisian tin-glazed ware (BERTI 1993; BERTI 2000) are attested.

3.2.5.1.4 Second half of XI - start of XII century

A greater amount of contexts are available from the second half of the XI century, providing a more detailed overview. Ceramic associations change compared to the previous period, especially in relation to a greater quantitative and qualitative presence of import materials. Above all, excavations attest the presence of both coarse and fine unglazed ware⁴²⁹, including broad-line painted ware, since characterised by the same technological and morphological features, i.e. jugs and pitchers, as already seen for the previous periods. The remaining examples, instead, regard the presence of import material, especially from western Islam. Unglazed fine ware in this chronological phase⁴³⁰ consists of closed forms: jugs and pitchers with a rounded or trilobed mouth and a short cylindrical neck, nearly always with a thin incised line around the shoulder; the ovoid body, without feet, has a ribbon handle attached underneath or (more rarely) to the rim, and its surface often has an uneven lighter colour. Medium-sized vessels have a cylindrical opening, handles attached to the top of the rim in the most ancient examples, rims with flat tops and vertical necks, similar to the previous period. Open forms can also be seen, consisting of hemispherical

basins and basins with unrestricted frustum, mainly provided with a brim (RENZI RIZZO 2000). Broad-line painted ware⁴³¹ has the same characteristics: few forms attested, only jugs and pitchers; morphological characteristics similar to fine ware; and decorations consisting of curly dotted stripes or narrow lines with rather simple decoration. This type of pottery was supposedly produced locally or more generically in the area of Valdarno (ABELA 2000; ANICHINI, GATTIGLIA 2008). Furthermore, a series of semi-fine ware jugs can be seen, blackened by the fire, without feet, with a rather coarse ribbon handle attached to the top of the rim, often used to heat water⁴³². Coarse cooking ware comprises small-sized olla with everted rim or vessels with cylindrical opening. Examples with combed decorations on the body disappear, at least in the contexts of piazza dei Cavalieri (ABELA 2000b) and the number of *testelli* and pans drops. Of note is also the presence, albeit to a lesser extent, of coarse, green lead-glazed ware; in rare examples the body of these vessels, with sparse glaze⁴³³, is similar to the body of Broad-line painted jugs, which are supposed to have been produced locally. Alongside this local production, pottery was also imported, although in lower percentages: *Forum* ware disappeared and a greater amount of products from the western (mainly) and the eastern Mediterranean were imported, including transport and storage vessels and, above all, tableware (GIORGIO 2013). The former included Maghrebin or Sicilian vessels such as the amphorae *a cannellures*, found in the

⁴²⁹ The contexts of via dei Facchini (BALDASSARRI, MILANESE 2004a) indicate a 33% presence of coarse unglazed ware and 63% presence of fine ware. Within the latter, around 1% is composed of fine ware painted with curly dotted stripes.

⁴³⁰ Attested in the contexts of via dei Facchini (BALDASSARRI, MILANESE 2004a; GIORGIO, TROMBETTA 2008), via degli Uffizi (ANICHINI, GATTIGLIA 2008), piazza dei Cavalieri (MENCHELLI, RENZI RIZZO 2000:124), piazza Dante (MENCHELLI 1993).

⁴³¹ Attested in the contexts of via dei Facchini (BALDASSARRI, MILANESE 2004a), via degli Uffizi (ANICHINI, GATTIGLIA 2008), piazza dei Cavalieri (ABELA 2000), piazza Dante (ABELA 1993c), vicolo del Porton Rosso (FEBBRARO, MEO 2009) and residual traces in the layers of the second half of the XII century, in via Consoli del Mare (GATTIGLIA, GIORGIO 2007; ANICHINI, GATTIGLIA 2008).

⁴³² These jugs have been found in the contexts of piazza Dante (MENCHELLI 1993:478), piazza dei Cavalieri (MENCHELLI, RENZI RIZZO 2000:127) and via dei Facchini (BALDASSARRI, MILANESE 2004a:139; GIORGIO, TROMBETTA 2008). For their poly-functional nature see FRANCOVICH, VANNINI 1989:15, for their use for water purification see BALDASSARRI 2008a:108.

⁴³³ Comparable with “B” type (PAROLI, SAGUI 1990: 321; ABELA 1993a).

contexts of piazza Dante (MENCHELLI 1993:520) and of piazza dei Cavalieri (RENZI RIZZO 2000:160), and pottery of probable Byzantine production such as that of via Consoli del Mare (BALDASSARRI, GIORGIO 2010: 38). If we analyse the presence of tableware import products, considering the cases already mentioned of the basins, during this period, a very large amount of examples came from the Islamic area of the Mediterranean (Tunisia, Maghreb, Sicily, Spain) and eastern area (Greek/Byzantine). The contexts can be analysed to check differences. In the area north of the Arno River, the contexts of piazza dei Cavalieri, piazza Dante and piazza Sant'Omobono may be taken into consideration. The contexts of piazza dei Cavalieri (BERTI 2000) reveal Tunisian, Tunisian/Sicilian and Spanish lead-glazed products, and tin-glazed products from the Spanish area (Andalusian and Moroccan) and of Egyptian production. Byzantine glazed and slipped ware can also be seen. Similar associations can be found in the contexts of piazza Dante, where both Egyptian and Byzantine productions, however, are absent (BERTI 1993). The contexts of piazza Sant'Omobono only show the presence of Islamic products, with a sharp prevalence from the western Mediterranean: for the majority, tin-glazed and lead-glazed products of Tunisian or Sicilian origin, but also Spanish/Moroccan products⁴³⁴ (including a pair of examples decorated with *cuerta seca* technique) and pottery produced in Egypt and the Near East (BALDASSARRI, BERTI 2009:74). South of the Arno River, contexts were found in the excavations of via dei Facchini and via degli Uffizi. The former brought to light

Tunisian/Sicilian and Spanish/Moroccan lead-glazed ware; alkaline-glazed ware from the Near East and probably an Egyptian lustre-decorated plate, as well as products from the Attic/Aegean area (BALDASSARRI, BERTI 2009:69ss). Vessels were almost exclusively attested in via degli Uffizi, mainly open, tin-glazed or lead-glazed from both North Africa (Tunisia or Maghreb) and southern Spain, whilst just one sherd evidences the presence of lustre ware from the Near East (BALDASSARRI, GIORGIO 2010).

3.2.5.1.5 Second quarter of XII – start of XIII century

The contexts of the second half of the XII – start of the XIII century differ from the previous due to the appearance of distinctive features: products imported from Islamic areas (Tunisian cobalt-manganese tin-glazed ware, Spanish green lead-glazed ware from Murcia) and Italian products (lead-glazed pottery from Savona, Spiral ware from Campania, products from Puglia such as RMR and proto-majolica) as well as products of still unknown provenance, defined 'pseudoligurian'⁴³⁵ (cooking lead-glazed ware). During this period, the presence of fine ware and coarse cooking ware reached percentages⁴³⁶ similar to the previous period. Among the fine ware, broad-line painted jugs disappeared⁴³⁷, whereas the number and dimensional variety of closed vessels increased. Small trilobite forms appeared, with rounded rims and cylindrical necks, as well as larger vessels with a slightly disc-shaped foot and medium-large vessels with thicker, rounded rims and fairly

⁴³⁴ The attribution of certain products to Spanish (Al Andalus and Balearic Islands) and Moroccan centres is due to the fact that both areas produced pottery that was very similar, as also happened for certain productions in Tunisia and Islamic Sicily (ABELA, BERTI 1998:27; BERTI, GARCÍA PORRAS 2006).

⁴³⁵ Its provenance seems to be related to various western Mediterranean (Provence, Savona and Ligurian areas, eastern Sicily) and Aegean-Anatolian areas (BALDASSARRI, GIORGIO 2010: 37).

⁴³⁶ See, for example, the percentages published for via dei Facchini where unglazed fineware fluctuated between 60 and 65% and coarse cooking ware totalled 33-34% in the contexts belonging to this period (BALDASSARRI, MILANESE 2004a:140ss).

⁴³⁷ This absence is confirmed by the contexts of via dei Facchini (BALDASSARRI, MILANESE 2004a), via Consoli del Mare (GATTIGLIA, GIORGIO 2007), piazza dei Cavalieri (ABELA 2000), and piazza Dante (ABELA 1993c).

everted necks⁴³⁸, still characterised by an uneven, lighter colour on the surface. Open vessels can also be seen, such as hemispherical basins or basins with restricted frustum, the majority brimmed (ALBERTI 1993; RENZI RIZZO 2000). Micro jars and moneyboxes appear in the contexts of via dei Facchini (GIORGIO, TROMBETTA 2008: 150). The number of semi-fine pitchers used to heat liquids increased, while coarse closed vessels (olla) were used less. The number of *testelli* also declined, whereas the amount of pans of various morphology increased. While this period marked the end of closed lead-glazed vessels obtained with single firing, a new coarse lead-glazed ware appeared obtained with double firing (productions defined as ‘pseudoligurian’⁴³⁹). This ware comprised yellowish or greenish lead-glazed pans (a greater number can be found from early XIII century contexts), and yellow or brown lead-glazed olla, with the outer surface smoothed with a tool or cloth. Regarding imported tableware, it is important to analyse the single contexts in order to highlight both differences and similitudes. The contexts of piazza dei Cavalieri reveal the presence of Tunisian products, including cobalt-manganese majolica, of Spanish and Byzantine products, whereas Egyptian products are absent (BERTI 2000). The contexts of the nearby excavation of via Consoli del Mare are marked by the presence of cobalt-manganese majolica (mainly brimmed basins or bowls, but also medium-sized jugs) associated with Spanish majolica and lead-glazed ware from the Murcia area (brimmed bowls), green lead-glazed ware probably from Savona and Byzantine pottery (GATTIGLIA, GIORGIO 2007; BALDASSARRI, GIORGIO 2010: 38). In piazza Dante, the contexts are similar to those of piazza dei Cavalieri, apart

from the absence of Byzantine pottery (BERTI 1993). The contexts of piazza delle Vettovaglie reveal the presence of Byzantine products, including a closed form, Spanish/Moroccan products and both open and closed Tunisian/Sicilian ware. In the contexts of Borgo Stretto, tin-glazed examples of Spanish/Moroccan provenance were found as well as lead-glazed or tin-glazed Tunisian/Sicilian sherds, with a sharp prevalence of cobalt-manganese decorated ware, and open proto-majolica ware from southern Italy. In the area south of the Arno River, the contexts of via dei Facchini brought to light a large number of western Mediterranean products: Tunisian/Sicilian lead-glazed or tin-glazed ware of which the majority with cobalt-manganese decoration, mainly open forms; open and closed Spanish/Moroccan products, including some tin-glazed on one side and lead-glazed on the other, whose area of provenance was identified with the Valencian productions of the Murcia area (BERTI 1993); alkaline-glazed examples from the eastern Mediterranean; and products from the Byzantine area including Zeuxippus Ware class II⁴⁴⁰. Proto-majolica from southern Italy is also attested (BALDASSARRI, BERTI 2009; BALDASSARRI, GIORGIO 2010). The contexts of via degli Uffizi reveal the presence of Islamic products from the western Mediterranean especially Spanish/Moroccan and Tunisian/Sicilian productions, and Byzantine Zeuxippus Ware Class II type, whilst alkaline-glazed sherds attributable to Egyptian or more probably Syrian manufacture, as well as lead-glazed brimmed bowls of Spanish production from the Murcia area ascribable to the contexts described, were found as residual material in XIV century layers (ANICHINI, GATTIGLIA 2008; BALDASSARRI, GIORGIO 2010).

⁴³⁸ The data for these ceramic classes come primarily from the contexts of via dei Facchini (BALDASSARRI, MILANESE 2004a), via Consoli del Mare, piazza dei Cavalieri – where, however, starting from this chronological phase, archaeological documentation thins out due to the removal of the buildings’ layers (MENCHELLI, RENZI RIZZO 2000:129) – and of piazza Dante (MENCHELLI 1993), which are less distinctive for the large chronological range adopted.

⁴³⁹ Appearing in the contexts of via dei Facchini, via Toselli, via Consoli del Mare (BALDASSARRI, GIORGIO 2010) and via Sant’Antonio (personal information from Monica Baldassarri).

⁴⁴⁰ Mediterranean products also include the foot of Hedwig beakers from Fatimid Egypt (BALDASSARRI, MILANESE 2004a: 142).

3.2.5.1.6 Second quarter XIII-start XIV century

The main novelty that appeared in XIII century contexts is the presence of Maiolica Arcaica (BERTI 1997; GIORGIO 2009) and locally-produced fine lead-glazed ware⁴⁴¹, as well as the introduction of Tyrrhenian Graffita Arcaica (Archaic Sgraffito ware) ware (VARALDO 2001). Regarding unglazed fine ware, jugs and pitchers continued to be used, now with surfaces that have an even lighter colour, at times decorated with seal impressions on the handles (BERTI, GELICHI 1995). As well as a certain standardization of closed forms and a greater control of the production techniques, morphological and functional improvements were also achieved: basins with unrestricted frustum and with a series of seal impressions on the brim, brimmed bowls, mustard and salt pots, strainers and moneyboxes (GIORGIO, TROMBETTA 2008). The presence of lead-glazed cooking ware, which arrived during the previous period, led to the drastic decline in closed and open unglazed cooking vessels. The majority of open forms for both individual and collective use recorded in these contexts, however, comprise lead-glazed products, mainly jugs, basins with unrestricted frustum and brimmed bowls. The different morphological types are associated with a different coloured lead-glaze: green lead-glaze is mainly used for brimmed basins with unrestricted frustum and ring foot, and generally for closed forms; yellow lead-glaze is used for flat-rimmed hemispherical bowls and for small hemispherical bowls with thin, flat brims; colourless or brown (rarer) lead-glaze is used for carinated bowls and jugs. This type of production, especially during

its initial phases, had many more uses compared to tin-glazed products, as evidenced, for example, by the small jars used for storing liquids. Between the mid XIII century and start of the XIV century, production mainly consisted of open forms, whereas bowls and certain types of jugs gradually disappeared. The morphology and characteristics of the clay suggest that they were made in the same workshops that produced Maiolica Arcaica, but were more affordable, at least in this period when decorated tin-glazed ware was still a luxury good (GIORGIO 2009:224ss). Starting from the twenties of the XIII century, the deposits record the immediate and widespread diffusion of the new locally produced majolica⁴⁴², offering a wide spectrum of morphologies (jugs, brimmed bowls, basins, bowls and small jars for the table; small jars, basins, pitchers for storage, lamps and inkpots) (GIORGIO 2012). Local majolica is associated with basins, brimmed bowls and cobalt-manganese majolica jugs, especially during the first half of the XIII century, with brimmed Graffita Arcaica bowls from Savona⁴⁴³, and in some cases with lead-glazed ware most probably from the same Savona workshops. Brown painted majolica is also recorded, probably of Spanish origin, as well as tin-glazed and lead-glazed products, attributable to the Maghrebin area, and products from southern Italy such as Spiral ware⁴⁴⁴ and proto-majolica jugs and brimmed bowls⁴⁴⁵, whilst examples from the eastern Mediterranean are rare (GIORGIO 2012: 592). Glassware also has homogenous features in these associations, comprising mainly mould-blown glasses and bottles with foot.

⁴⁴¹ These productions have been recently studied (GIORGIO 2009: 224).

⁴⁴² This immediate appearance is especially visible in the contexts of via dei Facchini, via degli Uffizi and via Consoli del Mare, although the first two contexts differ from the third for the higher quality of pottery found (GIORGIO 2009).

⁴⁴³ Attested in the contexts of via dei Facchini (BALDASSARRI, MILANESE 2004a), via degli Uffizi (ANICHINI, GATTIGLIA 2008), piazza Dante (BERTI 1993b), piazza dei Cavalieri (BERTI 2000), where its presence is not significantly high, and via Consoli del Mare, where it is significantly attested, associated with lead-glazed products, revealing textures and morphological types similar to the Graffita Arcaica examples from Savona (ANICHINI, GATTIGLIA 2008). Scarse sherds are also attested in via Palestro (REDI 1994:133ss).

⁴⁴⁴ Attested in via Consoli del Mare (ANICHINI, GATTIGLIA 2009) and piazza Dante (BERTI 1993a).

⁴⁴⁵ Protomajolica seems to have different production centres, although comparisons with the Salento areas in Puglia have been found for a small, rather homogeneous nucleus (RIAVEZ 2000: 444).

3.2.5.1.7 XIV century

There are no novelties in the unglazed ware produced: unglazed fine ware produced in Pisa and used for storing purposes (pitchers, jugs and basins) are still attested, while lead-glazed products (olla and pans) are still widely used for cooking food and *testelli* are only marginally used. Perhaps the lead-glazing used for waterproofing vessels as well as certain changes introduced in diets between the XIII and XIV century, led to the disappearance of the jugs used to heat liquids, so numerous during the previous periods. Open and closed Maiolica Arcaica produced in Pisa can still be seen, especially carinated brimmed bowls and basins, but also jugs and brimmed bowls, with very simple decorations and a limited use of colour, especially during the last part of the century. Undecorated tin-glazed pottery is frequent as also products from the lower area of Valdarno (GIORGIO 2009). During the XIV century, fine lead-glazed ware is used less, probably due to a decline in production⁴⁴⁶; larger sized morphological types are increasingly less attested, which seem to be replaced by tin-glazed basins whose value dropped in this period. At the same time, the contexts of via dei Facchini (BALDASSARRI, MILANESE 2004a), via degli Uffizi and via Consoli del Mare (ANICHINI, GATTIGLIA 2008) document the presence of Catalan tin-glazed ware with blue and blue and lustre decorations, together with conservation and transport containers which given the formal characteristics of the body, seem to refer to the same area. Hispano-Moresque majolica from Valencia is also attested (bowls and brimmed bowls, more rarely jugs), decorated with a radiating pattern in metal lustre dating back to between 1330 and 1370, and decorated with a *bryonia* leaf and six petal flower pattern belonging to the last quarter of the XIV century in the contexts of via Consoli del Mare. The presence of Hispano-Moresque majolica may have been

favoured by the agreements entered into between the *Comune* of Pisa and King James II of Aragon. In specific contexts, such as the convent of San Matteo, products from the Far East are attested, such as Celadon ware and blue alkaline-glazed ware from the Mameluke age (GIORGIO 2012). End of XIV – start of XV century contexts evidence the production of *zaffera a rilievo* (blue relief) majolica from Montelupo Fiorentino, especially jugs, attested almost exclusively in wealthy environments (ANICHINI, GATTIGLIA 2008; GIORGIO 2012).

3.2.5.1.8 Trade

The variation in ceramic associations throughout the area of Pisa provides a picture of the main routes of commercial exchange with the Mediterranean during the centuries. It also allows us to make economic considerations underlying this traffic flow, although it is important to take into account a number of factors:

- the partial nature of the source: pottery is only one of the many traded goods and, moreover, a subsidiary good;
- the imbalance of incoming traffic data: the lack of export data regarding local productions, especially related to specific categories of pottery and known only from the XIII century, does not allow us to understand Pisa's outgoing commercial flows.

Given these preliminary remarks, the following points may be summarised:

- commercial exchange networks seem to continue even after the end of the Byzantine traffic during the second half of the VII century, although short range traffic may be seen, with peninsular/Tyrrhenian routes, which confirm continuity of maritime transport also during the Early Middle Ages;

⁴⁴⁶ The colour of the glaze always distinguishes the morphological types (GIORGIO 2009:225).



Fig. 3.73 The main Mediterranean areas of provenance of the pottery attested in Pisa between the VI and VIII century.

- trade in Pisa, both during the Late Roman/ Early Medieval and Late Medieval Ages, is directed to the western Mediterranean, with greater preference for the African and then for the western Islam market, rather than the eastern Mediterranean, with coexistence of long and short range destinations. Geographical position and winds certainly had a key role when choosing the routes, which appear to be the same despite the changing historical scenarios;
- imports included not only high quality objects and tableware but also functional objects (storage vessels and cooking ware).

The early medieval trade network is still rather difficult to understand. Pisa was included in the Byzantine commercial system up to the first decades of the VII century. Traffic and routes already varied during the second half of the VII century, under Longobard pressure, and radically changed during the VIII century (figs. 3.73, 3.74). Nonetheless, periods of autarchy cannot be seen and commercial trade (although on a lower scale) continued at peninsular and Tyrrhenian level. The existence of a network of landing places during the Early Middle Ages favoured small-scale trade along the Tyrrhenian coasts and the Campania-Lazio area, as attested by the presence of globular amphorae, Broad-line painted ware and, later on, *Forum* ware. The true shift occurred at the end of the X century, when data show maritime traffic (which we can imagine to be consistent) in some way related to an ever increasing number of merchants⁴⁴⁷. From the end

⁴⁴⁷ The figure of the merchant had not disappeared during the previous centuries; simply, traffic volumes were lower and so the number of people involved in business (McCORMICK 2007). Indeed, we cannot but notice coincidence with the so-called *Commercial revolution* (TANGHERONI 1996: 127-129). The sudden appearance of this pottery would appear to have been caused, therefore, by a series of political, economic and historical factors, rather than their recent fabrication. This uncertainty is necessary due to the scarce early-medieval ceramic contexts which, however, reveal a short range network of exchanges. Written sources also evidence more diplomatic rather than commercial exchanges before the end of the X century (BALDASSARRI, BERTI 2009).

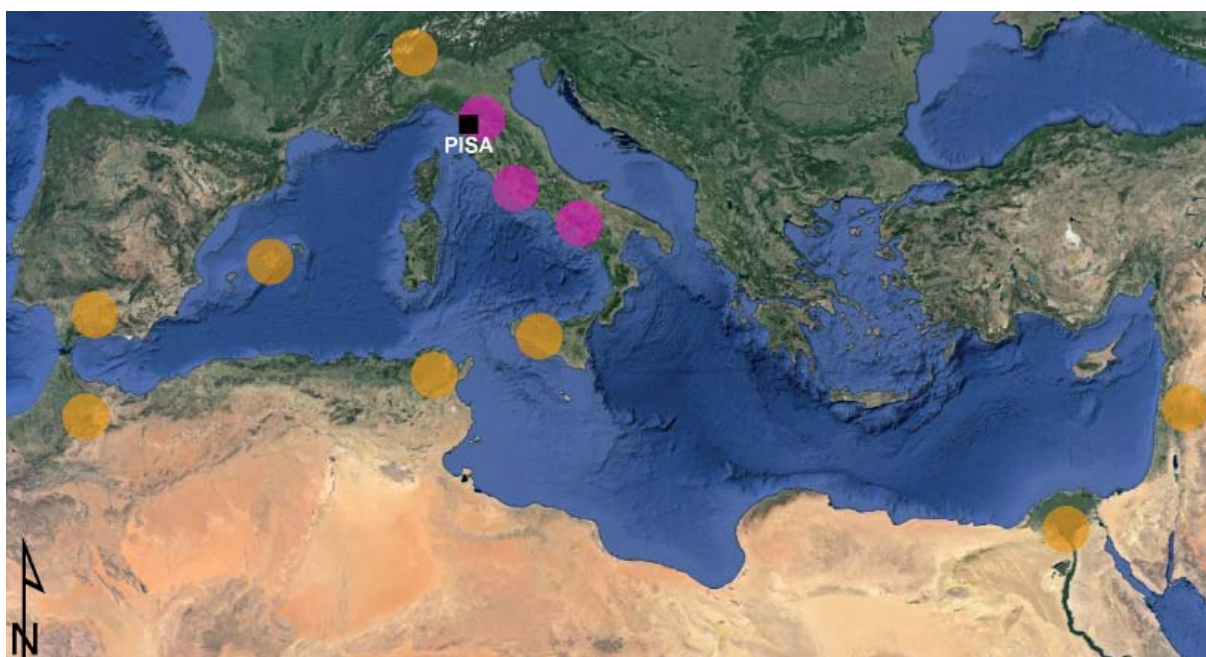


Fig. 3.74 The main areas Mediterranean of provenance of the pottery attested in Pisa between the VIII and second half of the X century (in fuchsia) and between the end of the X – start of the XI century, with the restart of Mediterranean traffic (in yellow).

of the X until the first half of the XI century, pottery evidences commercial relations above all with the western Mediterranean, especially with Tunisian, Tunisian/Sicilian and Spanish/Moroccan centres (GIORGIO 2013). Relations are also held with eastern areas, especially with Egyptian⁴⁴⁸/mid-eastern centres, which however are fewer and attested only in walled basins (*bacini*) and not in buried archaeological stratifications. The scarce arrival of these products probably means that they were very precious objects and so were less present in the domestic contexts investigated, perhaps only within the means of the higher wealthy classes or not available for citizens' tables. With the second half of the XI – start of the XII century, the amount of import artefacts significantly increased. These objects represent the only fine ware found on the tables of Pisa's citizens. Alongside the commercial routes already previously used, products also arrived from the Byzantine centres of the Attic/

Aegean, and homes started to use both tableware and transport and storage vessels of Maghreb and Sicilian production⁴⁴⁹. Pottery from Egyptian/mid-eastern production centres can also be found in the buried stratigraphic contexts, indicating greater commercialisation of these products, their lower intrinsic value and, therefore, greater purchasing capacity, at least by the higher classes. The different quantity of import products indicates that privileged routes towards the western Mediterranean were maintained and that the routes towards the eastern Mediterranean were intensified, although with rather limited traffic levels. While the markets of origin are substantially the same during the XII century, interesting phenomena can be seen. Import products comprise not only tableware or transport containers, as during the previous period, but also cooking ware: lead-glazed cooking pans, called pseudoligurian. These vessels were more technologically advanced⁴⁵⁰ and perhaps

⁴⁴⁸ The eastern Mediterranean also includes Egyptian finds.

⁴⁴⁹ These vessels are considered as "used" goods, i.e. sold on Pisa markets once their primary transport function had been completed (BALDASSARRI, BERTI 2009).

⁴⁵⁰ The progress of pot glazing, especially for liquids, is evident.

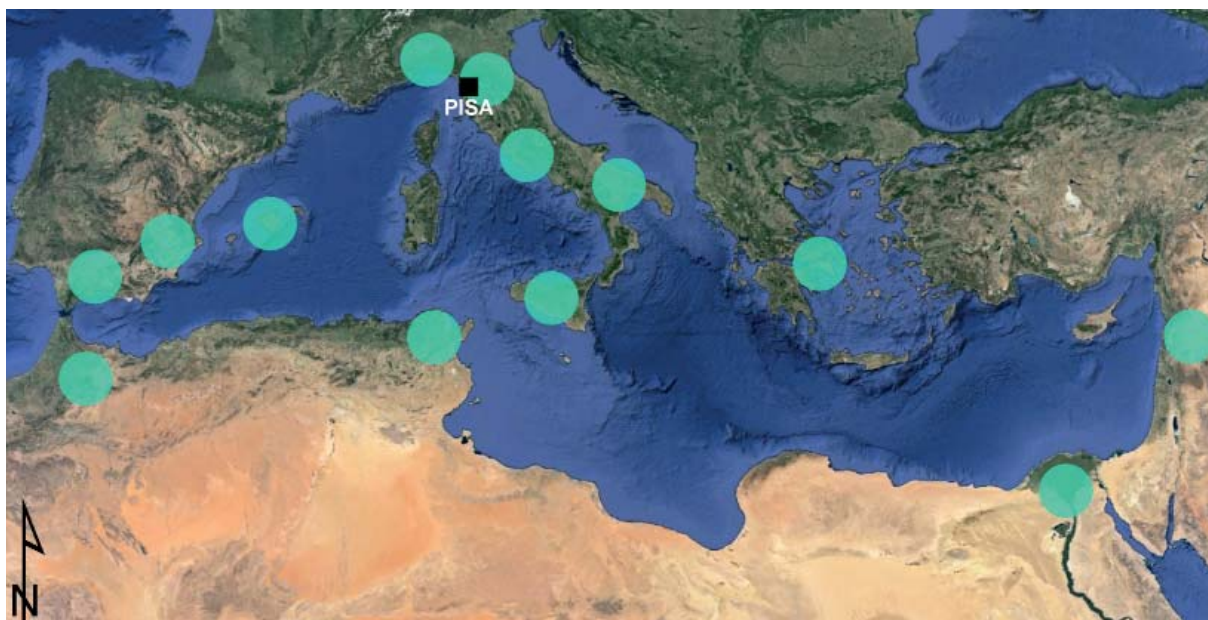


Fig. 3.75 The main Mediterranean areas of provenance of the pottery attested in Pisa between the second half of the XI and start of the XIII century, prior to the local production of Maiolica Arcaica. Of note, the arrival of ware from the Byzantine area during this period.

more suitable for new ways of cooking food. During the XII century imports from Tunisian, Spanish/Moroccan, Egyptian/mid-eastern and Byzantine areas continued. Imports from Spanish centres sharply increased, especially from the area of Majorca and Andalusia, with numbers rising above Tunisian products⁴⁵¹ (BERTI 1997a; GIORGIO 2013). From the second half - last quarter of the XII century, new pottery appeared on the scene: a real invasion of cobalt-manganese Tunisian products⁴⁵²; products from the Spanish area of Murcia; materials from southern Italy, especially from Puglia⁴⁵³ and Sicily⁴⁵⁴; and, probably the

first slipped and lead-glazed ware from Savona, precursors of Graffita Arcaica ware. If relations with Sicily were already held during the previous centuries, of note are the relations held with the coasts of the southern Adriatic (fig. 3.75). Starting from the XIII century, the situation underwent significant changes. From the second decade of this century, Pisa became a production centre of the fine tin-glazed and lead-glazed ware that it had previously had to import. It is probable, therefore, that data related to the ceramic contexts of Pisa are less significant for understanding the commercial dynamics of the XIII and XIV century, during

⁴⁵¹ The decline in Tunisian products between the XI and XII century must be explained: between the end of the X - start of the XI century, the amount of products from the Tunisian centres to the south of Tunisi (Mahadia, Kairouan) and from western Islamic Sicily were practically equal, whereas African products prevailed from the second half of the XI to the first half of the XII century. The few Sicilian examples come from different centres than before (Siracusa, Agrigento) and from the second half of the XII-start of the XIII century, Sicily (no longer Islamic) must be considered as part of southern Italy. Overall, therefore, this area of Maghreb would seem to cover a practically constant portion of imported products (BERTI 1997a; BALDASSARRI, BERTI 2009).

⁴⁵² Cobalt-manganese tin-glazed products are a true index fossil guide for all contexts of the end of the XII-start of the XIII century, given their widespread presence and significant amount. For a more thorough picture on the amount of these materials in Pisa, the numerous sherds found during occasional interventions carried out immediately after the second post-war period, must be taken into account (BERTI, TONGIORGI 1972).

⁴⁵³ Present up to the mid-XIII century.

⁴⁵⁴ From the second half of the XII-start of the XIII century, products from Sicily (no longer Islamic) are included among the productions of southern Italy.

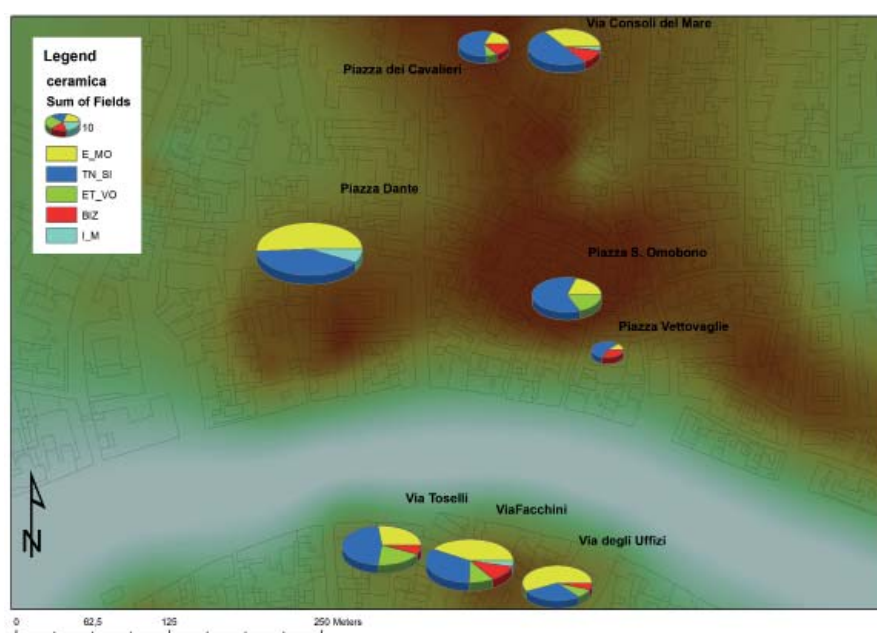


Fig. 3.76 The graphs intuitively show the different percentage of imported ware in contexts spanning from the XI and start of the XIII century. The different size of the single graphs indicates the overall greater or lesser amount of ware found. The data have been drawn and re-elaborated from BALDASSARRI, BERTI 2009 and BALDASSARRI, GIORGIO 2010. E_MO = Spanish/Moroccan; TN_SI = Tunisian/Sicilian; ET_VO = Egyptian/Near-East; BIZ = Byzantine; I_M = Southern Italy.

which eastern Mediterranean products were no longer imported and the amount of imported pottery from the western Mediterranean started to decrease. During the first half of the XIII century, glazed and slipped ware and Graffita Arcaica ware from Savona appeared, whilst products from the Catalan area arrived during the XIV century. From the mid-XIV century products from the Valencian area appeared and, at the end of the century, products from Florentine area, thus revealing a completely different context. For a more thorough picture, it is worth considering the material exported from Pisa after the second – third decade of the XIII century, i.e. when local workshops started to produce lead-glazed ware, especially tin-glazed pottery. It was exported internationally mainly by sea and is attested already before the mid XIV century not only in nearby areas, inside and outside Pisa, mainly along the coast of Tuscany, but also in Rome, Sicily, Sardinia, Corse,

Liguria and southern France (BERTI 1997a). The fact that Pisa was a production centre also during the previous centuries, producing unglazed fine ware certainly had an economic impact on the city, however, today, although the internal widespread diffusion of its local products is clear, the same cannot be said for the external diffusion of its products, which is essential to understand the economic scope of this phenomenon.

3.2.5.1.9 Social status

In order to analyse the economic/social status of certain city areas based upon contexts, first and foremost it is necessary to reaggregate data at topographic level (fig. 3.76) and then evidence the parameters of the analysis to allow their correct reading:

- ceramic associations⁴⁵⁵ are regarded as a valid indicator of the economic/social status of the archaeological contexts

⁴⁵⁵ Since pottery imported from the Mediterranean greatly influences this evaluation, it is pointed out that all contexts considered include Mediterranean, Islamic and Byzantine imported pottery, whereas there are differences in the composition of the associations with respect to both quantity and production environments.

- examined⁴⁵⁶;
- this analysis is possible only for contexts from the X century, i.e. from the period in which we have sufficient data in various areas of the city;
 - this kind of analysis is highly specific and cannot be generalised for wider contexts;
 - the sample available is still rather small to reach definite conclusions;
 - quantification sheets available as open data are lacking, which would allow not only a complete check, but also a proper reuse.

From the X to the third quarter of the XI century, the mere presence of Mediterranean pottery seems to indicate rather high social levels (BALDASSARRI, BERTI 2009; BALDASSARRI, GIORGIO 2010), instead, from the end of the XI to the first decades of the XIII century⁴⁵⁷, it is no longer sufficient to demonstrate social standing, which seems rather to derive from the variety of the provenances and the type of attested morphologies. The extreme diffusion, for example, of cobalt-manganese Tunisian majolica in all excavated contexts⁴⁵⁸, reveals that the product was highly diffused, evidently easy to find on the market and, therefore, not too expensive. As in the case of Spanish products, it reached the tables of “middle but not particularly privileged social” classes (BERTI 1997a: 346). The contexts of piazza Dante and Borgo Stretto⁴⁵⁹ do not reveal materials from the eastern Mediterranean, whereas in the contexts of piazza delle Vettovaglie, piazza Sant’Omobono and piazza dei Cavalieri, around 60% of the pottery is of Tunisian/Sicilian origin, and the remaining

part is composed of variable proportions of artefacts from the Spanish, Byzantine and near-eastern Islamic areas, as well as southern Italy (BERTI, BALDASSARRI 2009). Such high percentages of Tunisian/Sicilian products could suggest popular contexts, however, the few sherds of piazza delle Vettovaglie, makes the figures related to this area barely reliable. The situation in the contexts of via Consoli del Mare, via Toselli, via degli Uffizi and above all via dei Facchini reveal a different situation (BALDASSARRI, GIORGIO 2010). They are the only contexts that evidence the concurrent presence of Tunisian/Sicilian, Spanish/Moroccan, Byzantine, near-eastern Islamic and southern Italian material. The most varied contexts are in via dei Facchini. They derive mainly from the excavation of an alley/rubbish dump (*chiasso*) and reveal a quantitatively greater incidence of materials imported from the Byzantine and mid-East area with respect to all other sites, where, as already seen, the predominance of western Mediterranean pottery is evident, primarily composed of Tunisian/Sicilian ware and accompanied by a significant percentage of Spanish and Moroccan pottery. The nearby excavation in via degli Uffizi, however, where the contexts were heavily influenced by post-depositional processes, which compromised the medieval stratifications, reveals Tunisian/Sicilian and Spanish/Moroccan materials, associated with metal lustre majolica from the Near East as well as products from the Byzantine area and southern Italy. They show that the inhabitants of the tower houses belonged to rather wealthy classes, to the point that they could afford good quality and refined pottery from the entire Mediterranean area. The contexts of via Consoli

⁴⁵⁶ I believe these compositions indicate economic/social status, rather than casual supply or personal taste (BERTI, BALDASSARRI 2009). Indeed, although the contexts (even if still numerically low) may suggest presumed casuality – although the evidence, in my opinion, leads to another direction – personal taste is the direct consequence of the economic/social level of belonging.

⁴⁵⁷ The end of this chronological period is determined by the start of the local production of Maiolica Arcaica.

⁴⁵⁸ Also in walled basins (*bacini*) and occasional recoveries.

⁴⁵⁹ Unlike others, however, in addition to the small size of the excavation this is mainly due to a road, not a living context.

del Mare, which instead belong mainly to a production area situated behind a habitation, include artefacts from the western Mediterranean and products from Egyptian/Syrian and Byzantine areas, the latter related both to transport and storage ware and to tableware, associated with materials from southern Italy, such as proto-majolica and Spiral ware. The contexts of via Toselli partly refer to the presence of a furrier's workshop and show the presence of Spanish/Moroccan and Sicilian/Tunisian pottery and of Egyptian and Byzantine products. Therefore, while a first distinction can be made between the presence or less of eastern Mediterranean products, the absence of which indicates that piazza Dante was a craft area, as also attested by written sources, the presence of these products on their own is not an indicator of high social status. It is rather the abundance of associations and the quantity and quality (represented by the morphological types) of the most precious materials (mid-eastern and Byzantine) which make the difference, as in via dei Facchini where they represent almost 20% of imported materials. There is a high resemblance with the associations of via degli Uffizi, bearing in mind the different state of conservation of the excavated contexts. Indeed, it is the quality and functional differentiation of the pottery of the contexts of via dei Facchini and via degli Uffizi that indicate that this was a highly aristocratic area with economic standards above average, and that the inhabitants of the tower houses in this area of Chinzica were much higher up the social ladder. The contexts ranging from the neighbouring building of via Toselli and via Consoli del Mare show an

extremely varied provenance but less qualitative/typological and quantitative abundance. This is in line, in the first case, with specialised craftsmen such as furriers, as demonstrated by BALDASSARRI, GIORGIO 201: 42 through an attentive study of the different alleys/rubbish dump (*chiasso*) used, and in the second case, with representatives of the entrepreneurial elite of *fabri*, who were not able, however, to compete with the economic standards of the aristocratic families. It is important to notice the positioning of these contexts, which overlook alleys and internal courtyards, not the street. The only new aspect is the presence, in the contexts of via Consoli del Mare, of an almost double percentage of pottery from Savona. This lead-glazed and slipped ware was initially considered a poor product or at least not very elaborate in terms of shape, technology and aesthetic quality⁴⁶⁰, and seems to indicate how accessible new products arriving on the international market were, a characteristic that is well in line with the itinerant and seasonal profession of blacksmiths⁴⁶¹. The study carried out by BALDASSARRI, GIORGIO 2010: 45 on morphological types and on the relations between individual and collective shapes, evidences the predominance of individual shapes only in the contexts of via Consoli del Mare and via degli Uffizi. Even though the contexts studied from this viewpoint are still too few to make general considerations, the type of analysis is promising, although it should be remembered that individual tableware vessels could have been used such as wooden cutting boards and/or multi-functional shapes such as *testelli*, even in higher social environments. With the arrival of lead-glazed and of tin-glazed ware produced in

⁴⁶⁰ It is not surprising, therefore, that they can be found both on the tables of blacksmiths and of the aristocratic tower houses.

⁴⁶¹ The easy supply of a wide variety of ceramic artefacts could be explained by the blacksmith profession itself. Blacksmiths moved from Pisa to Elba for six months and had the chance to travel and visit ports where ships arrived transporting pottery as secondary trade product. This could have helped them come into their possession. It should also be noted that, apart from proto-majolica and cobalt-manganese majolica (highly diffused), the other pottery is lead-glazed and has hardly any decoration, probably indicating that it cost less compared to tin-glazed ware.

Pisa, imported pottery is no longer an indicator of economic and social differences. The contexts of via dei Facchini and via degli Uffizi show the presence of Maiolica Arcaica in its first production phase, which is also qualitatively the best, with firm preference for very fine products with rich decorations. The contexts of via Consoli del Mare also show the presence of Maiolica Arcaica immediately during its first production phase, thus indicating how easy it was to purchase the goods circulating on the market during this period, but with lower levels in terms of quality (lower quality products, mainly white undecorated majolica or without elaborate decorations) and quantity (fewer examples were found compared to lead-glazed products which evidently cost less⁴⁶²). The economic level of these two contexts does not appear to change even with the arrival of tin-glazed ware produced in Pisa. The inhabitants of Chinzica maintained a higher living standard whilst those of via Consoli del Mare were simply able to purchase different products within a middle/upper economic and social context⁴⁶³. Between the start and the third quarter of the XIV century, the economic status of the inhabitants of via degli Uffizi appears to drop compared to the previous period. Maiolica Arcaica produced in

Pisa and Valdarno is the most attested class, after unglazed ware, but it is by now considered a low-standard product. The situation seems to change around the end of the century, during which Valencian lustre ware and the first *zaffera a rilievo* (blue relief) majolica from Montelupo Fiorentino is attested, a sign of the easiness with which the finest products that the market has to offer can be purchased, even if in limited quantity. This could be related to the presence of the Gambacorti family, however, the presence of merchants from Florence and Prato attested in the area in 1385 must also be considered; they may have imported these products already during the first phases of production (REDI 1991:193; ANICHINI, GATTIGLIA 2008). The social contraction experienced during the first three quarters of the century, which may be seen in the contexts of via degli Uffizi, resembles the situation experienced in piazza Consoli del Mare from the start of the XIV century. Goods can no longer be found on the market with such easiness, to the point that requests are limited to mainly locally and regionally manufactured products, and this seems to indicate a general and widespread decline in the city's living standards.

⁴⁶² In the contexts of via dei Facchini, Maiolica Arcaica has refined shapes and decorations and can be found in greater quantities compared to fine lead-glazed ware. If related to the above excavation of piazza dei Consoli del Mare, this shows how the people who lived in this area and used these artefacts belonged to middle social classes.

⁴⁶³ Considering both data regarding ceramic contexts and those related to production transformation, I have the impression, albeit difficult to support, that with the end of the ironwork structure and the start of the copper alloy workshop, the inhabitants of via Consoli del Mare had lower living standards.

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Finito di stampare nel mese di luglio 2014
con tecnologia *print on demand*
presso il Centro Stampa "Nuova Cultura"
p.le Aldo Moro n.5, 00185 Roma
www.nuovacultura.it
per ordini: ordini@nuovacultura.it

[INT_9788868120948_A4col_LN05]