Chapter 13
Landscape Influences on the Development of the Medieval–Early Renaissance City-states of Pisa, Florence, and Siena, Italy

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The objective of this chapter is to analyze how the local landscape and environmental conditions influenced the evolution of the city-states of Pisa, Florence (Firenze), and Siena, primarily from the High (~1000–1300 AD) to Late Medieval Age and early Renaissance (~1300–1500 AD). The three cities are located in the province of Tuscany in the central north-western part of Italy (Fig. 13.1).

13.1 The Physical Setting

13.1.1 Landform

Tuscany can be subdivided into three roughly NW–SE oriented zones: an eastern mountainous zone that includes the North Apennines divide, a hilly zone (where Siena is located) with relatively narrow fluvial valleys and wide intramontane basins (where Florence is located), and an irregular, relatively narrow alluvial- and coastal-plain zone to the west along the Tyrrhenian Sea coast where Pisa is located. During the Medieval Age the population was concentrated in major urban centers among which Florence, Pisa, and Siena and their territories ('contadi') (Fig. 13.1; Table 13.1; Day 2002; Pinto 2002).

13.1.2 Significant Geological Features

Tuscany is located in the inner (west) part of the Northern Apennines mountain complex that formed from about 30 million years ago through the collision of the European plate with the African plate (Vai 2001). The Northern Apennines are characterized by a series of imbricate thrust-fold belts that have accreted eastward in response to a westward-dipping subduction zone (Malinverno and Ryan 1986). The migration was not continuous nor homogeneous, rather differential movements occurred along several major SW–NE oriented transverse tectonic lineaments (~transfer faults) (Pascucci et al. 2007). As the main compression deformation zone migrated eastward, extension occurred in the western, inner part of the orogen superimposing an overall extensional (rift-like) basins on the pre-existent dormant imbricate thrust zones (Fig. 13.2; Martini and Sagri 1993; Martini et al. 2001; Bonini and Sani 2002; Benvenuti et al., this volume). The formation of these basins had a complex, debated history of reactivations but essentially they developed sequentially from the Tyrrhenian Sea eastward, a first group (central basins: west of the structural/geomorphologic divide of Albano Mt. and Chianti–Cetona Ridge) starting during late Miocene, and a second group (peripheral basins: east from that structural divide) forming mainly during the Pleistocene–Pliocene. The former contain marine and continental deposits, the latter only continental alluvial and lacustrine deposits. Pisa (Pi) and Siena (Si) are located in the central basins of Viareggio and Siena respectively, and Florence (Fi) in its homonymous peripheral basin (Fig. 13.2).

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See Plates 11, 13 in the Color Plate Section; also available at: extras.springer.com

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Fig. 13.1 Medieval map of Tuscany (white: low elevation tendentially planar areas; increasing darker gray indicated increased elevation areas (*Fi* Florence, *Pi* Pisa; *Si* Siena). (After Pinto 2002)

13.1.3 Climate

Tuscany is part of the Mediterranean biome. Consequently it is characterized by hot (average high/low of about 28–32/17°C) dry summers and cool (average high/low of about 12/3°C) wet winters. Current average annual rainfall ranges from approximately 780 mm in Siena to about 900 mm in Pisa and Florence. Peak, at times torrential, precipitation may occur during Spring and Fall and severe local floods and land-

Table 13.1 Various estimates for the populations of Firenze (Florence), Pisa, and Siena from the 1000s to the early 1300s before the Black Plague of 1348. (After Day 2002) (Dates in bold, number of individuals in italics)

Cities	Bairoch et al. (1988)	Ginatempo and Sandri (1990)	Pirillo (1994)	Russell (1972)	Other authors
Pisa	**1000**–*9000* **1200**–*17,000* **1300**–*38,000*	**1300/1338**–*40,000/50,000*	**1200/1249**–*20,000/25,000* **1250/1299**–*38,000*	**1200/1230**–*15,000/20,000* **1290/1300**–*38,000*	**1228**/*25,000/28,000* **1300**–*30,000*
Florence	**1300**–*95,000*	**1300/1338**–*100,000/120,000*	**1200/1249**–*15,000/20,000* **1250/1299**–*100,000* **1300/1325**–*110,000* **1326/1345**–*110,000*	**1172**–*10,000* **1200/1230**–*15,000/20,000* **1290/1300**–*96,000*	**1175**–*10,000* **1200**–*15,000* **1252**–*60,000* **1280**–*85,000* **1300**–*105,000* **1325/1328**–*120,000*
Siena	**1200**–*12,000* **1300**–*50,000*	**1300/1338**–*40,000/50,000*	**1200/1249**–(*10,000/15,000*) **1300/1325**–(*50,000*)	**1200/1230**–*10,000/15,000* **1290/1300**–*52,000*	

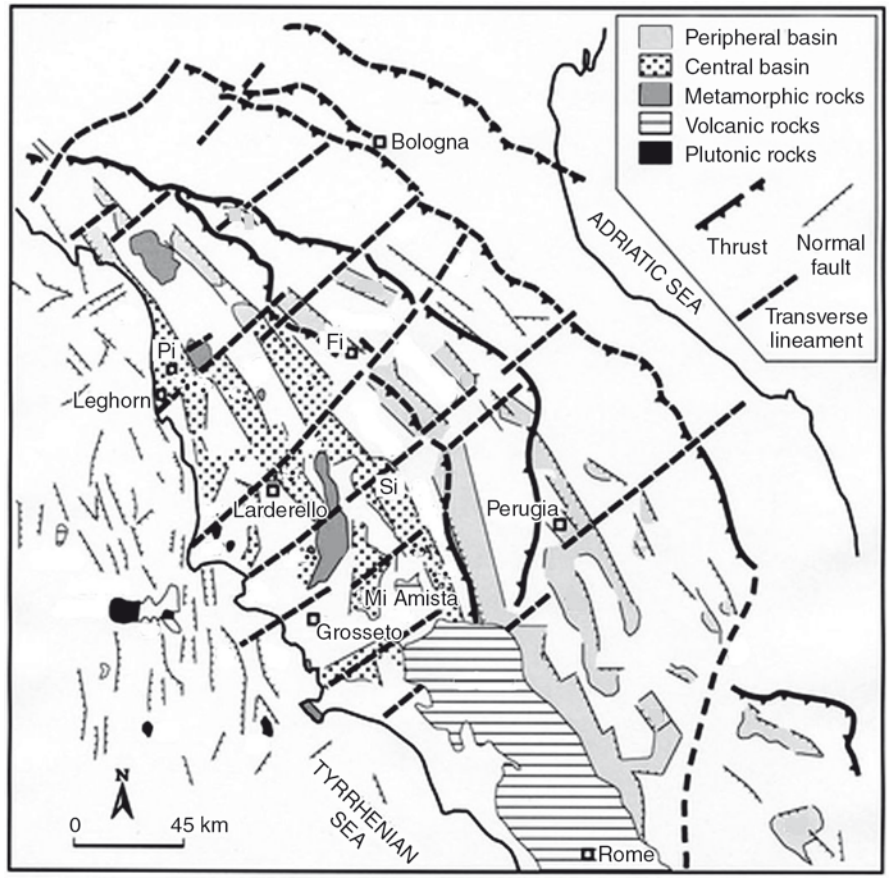

Fig. 13.2 Schematic tectonic map of the Northern Apennines (Peripheral basins: terrestrial deposits mainly Pleistocene; Central basins: marine and terrestrial deposits mainly Miocene to Pliocene with local thin Pleistocene cover; *Fi* Florence, *Pi* Pisa, *Si* Siena, *MTR* Middle Tuscany Ridge). (After Martini et al. 2001)

slides may develop. During medieval times Tuscany was affected by the so called global Medieval Warm Period (~800–1300 AD) (also called Medieval Climatic Anomaly) that produced prolonged droughts in some areas worldwide, for example of North America, and persistent rains in others (Fig. 13.3; Stine 1994; Mann et al. 1998; Bradley 2003).

13.1.4 Hydrology

A fundamental geological/geomorphologic event that determined the evolutionary trends of great parts of central Tuscany was the deviation during the Pleistocene of the Arno River from the Val di Chiana, where it ran as a tributary to the Tiber River, into the Valdarno, through the Florence basins and to the Pisa plain area (Fig. 13.1; Bartolini and Pranzini 1981). This mostly occurred naturally through differential tectonic moments of the various crustal blocks of the area, and it was finalized in the sixteenth century by efforts to drain waters from the Val di Chiana wetlands into the Arno River. The Arno River is the vital artery that has most benefited Florence, Pisa, and, indirectly, Siena. This river and its tributaries, however, have been responsible for extreme damaging floods as well (Table 13.2).

Table 13.2 Recorded floods in Florence from late 1100s to the present. (From Caporali et al. 2005)

Medium	12161; 1303; 1305; 1362; 1368; 1378; 1406; 1434; 1490; 1491; 1520; 1438; 1550; 1621; 1641; 1651; 1660; 1674; 1683; 1695; 1698; 1715; 1745; 1761
Large	1117; 1262; 1282; 1284; 1288; 1334; 1345; 1389; 1456; 1465; 1515; 1532; 1543; 1544; 1646; 1676; 1677; 1680; 1687; 1688; 1705; 1709; 1714; 1719
Exceptional	1333; 1547; 1557; 1589; 1740; 1758; 1844; 1966

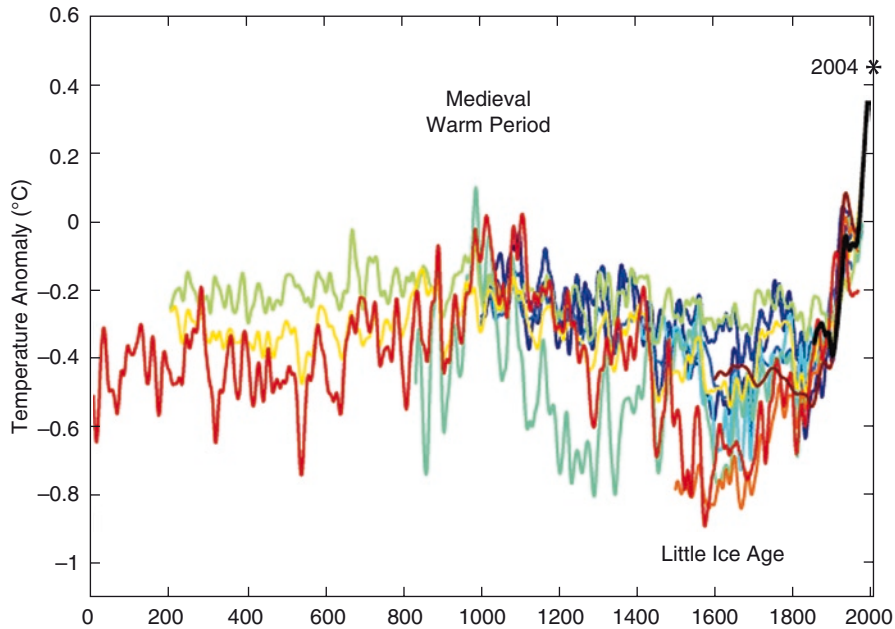

Fig. 13.3 Reconstructed climatic conditions of the last two millennia. (Observations and measurements by various researchers; After http://commons.wikimedia.org/wiki/Image:2000_Year_Temperature_Comparison.png)

Small lakes developed in intermountain valleys and more extensive wetlands formed along the course of the Arno River and its major tributaries. Relatively large wetlands developed in the Florence area, along secondary valley in between Florence and Pisa (Fucecchio and nearby Bientina), and much more extensively in the Pisa alluvial and coastal plain (Fig. 13.1). In certain areas and times, the wetlands were obstacles to overland travel and made certain types of agriculture difficult. In other areas and times, the opposite was the case, in terms of waterway communication, food resources (mainly fishing and hunting), and materials such as straw for fodder and constructions.

13.2 The Overall Human Dimension

Medieval to early Renaissance times were exciting, innovative, turbulent, difficult, and dangerous. Societies throughout Europe, Asia, and elsewhere strived for achievements in science, art, politics, commerce, and management of the environment and natural resources. The progress continued through the centuries in spurt punctuated by short-lived retreats. Difficult periods were imposed by environmental conditions and severe sicknesses in part due to poor hygiene and inadequate knowledge. These included two diseases: the endemic malaria in certain areas and the horrifying bubonic plague everywhere in Europe.

13.2.1 *Malaria*

Malaria has been recorded throughout Italy since Roman times, and is still present in some parts of the country. Differently from ancient Rome and its surrounding territory, however, there is no direct evidence of great impact of the deadly strain of malaria associated with wetlands in the three Tuscan cities, just a few cases having been recorded in Pisa (Torelli 1882; Sallares 2002). Nevertheless some territories, such as the Val di Chiana and particularly the Sienese-dominated Grosseto area (Maremma) suffered greatly (Fig. 13.1). The population of the town of Grosseto, for instance, was at times reduced to a few hundred people and the population of the area was sustained by continuing immigration. Indeed in 1333 Siena ordered the officials of Grosseto (under Siena at that time) to leave the city during July and August every year and to move to residences in higher hills to avoid contact with the malaria-carrying *Anopheles* mosquitoes (Sallares 2002). That area was important for Siena because it was agriculturally highly productive and offered accessibility to a small harbor (Talamone located about 23 km south of Grosseto).

13.2.2 Bubonic Plague

By contrast, the bubonic plague (called also the Black Death) had dramatic effects everywhere. In 1347–1348 the first of several occurrences of the bubonic plague swept throughout Europe devastating populations and drastically changing economic and power distribution. This plague was caused by the *Yersinian pestis* bacterium, transmitted by fleas carried by rats. It probably originated in Asia and was transported into Italy and Europe following trading routes. In Italy it entered through the main harbor cities, mainly Genoa, and spread rapidly because of people fleeing infected cities into the country and other towns. Because of poor sanitation, ignorance of the causes of the sickness, and the rapidly induced death, nobody was safe anywhere. Pisa, Florence, Siena and their territories, like most other European sites, lost up to 50–75% of their populations (Pinto 2002). The Black Death had a negative influence on all aspects of the society and on the surrounding environments. Cities contracted, planned buildings were abandoned, such as the large new cathedral in Siena, most lands in the countryside were abandoned everywhere because of lower demand of foodstuff and the very expensive remaining manpower. Similarly, work to reclaim wetlands or maintain already existing drainage canals, such as in the Pisa plain, was discontinued and the land returned to its original, locally unhealthy state. Valuable skills disappeared and the economy suffered, for instance many mills closed because of diminished demand of their services and products (Cartwright and Biddiss 2004; http://www.insecta-inspecta.com/fleas/bdeath/bdeath.html). At the end of it all, larger societies, such as that of Florence, rebounded relatively rapidly after each bout of the plague, others could not.

13.3 The Three Cities: Pisa, Florence, Siena

The development of the medieval societies of Pisa, Florence, and Siena was mostly dictated by changing socio-economic, socio-political conditions, including changes in leadership. The local landscape (settings and environments) did however influence somewhat the fortune of the three cities providing both benefits and risks. The following is a brief analysis of the advantages and limitations offered by the landscape at different times.

13.3.1 Pisa

Pisa (coordinates: ~43°43′N, 10°24′E) is located on a very flat plain (Pisa plain), 4 m asl, on the banks of the Arno River, about 10 km from the sea (Fig. 13.4a). It has now about 85,000 inhabitants.

The Pisa plain is bounded to the north and south by hills with mostly Tertiary sedimentary to slightly metamorphic rocks that constitute good building material and provide for good freshwater springs. Medieval Pisa obtained poor quality, unhealthy waters from relatively shallow wells and cisterns until 1600 AD. After-

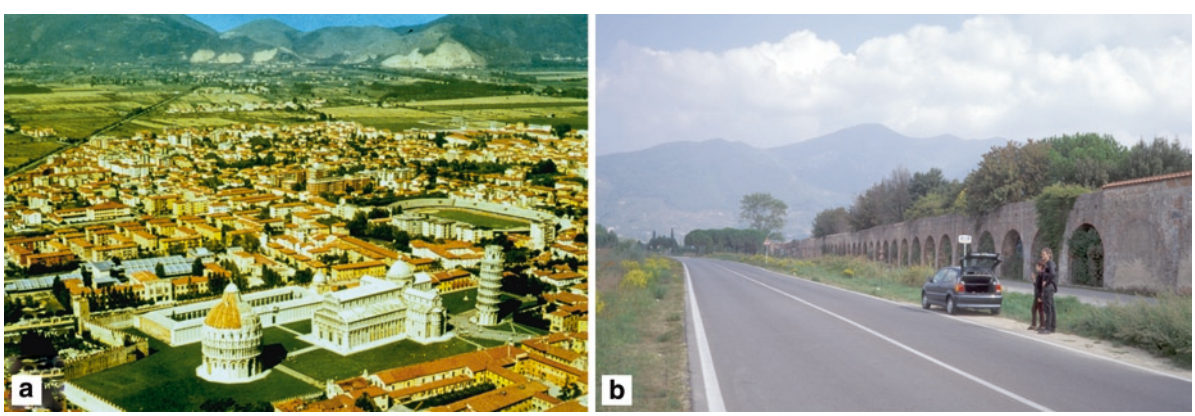

Fig. 13.4 **a** General view of modern Pisa with the "Piazza dei Miracoli" in the foreground and defaced (quarried) flanks of the Monte Pisano in the background. **b** Aqueduct (Aquedotto Mediceo) from Monte Pisano (in background) to Pisa

wards a major aqueduct was built by the Florentine Medici family from a locality (Asciano) on the flank of the Monte Pisano (Fig. 13.1). Remains of this aqueduct still run across the plain (Fig. 13.4b).

The basin fill consists of 2000 m thick, latest Miocene–early Pliocene to Holocene marine, lacustrine, and fluvial sediments (Federici and Mazzanti 1995; Pascucci et al. 2007). The town of Pisa rests directly on about 50 m of Holocene coastal to alluvial clays and sands parts of which constitute the fill of a paleovalley cut during the last glacial period (Aguzzi et al. 2007) (Fig. 13.5). The interlayered clay-sand substrate has created foundation problems for some bell towers with shallow foundations. The most famous one is the Leaning Tower (55.86 m high on one side and 56.70 m on the other) of the cathedral that started to tilt during construction (from 1173 to 1372 AD) (http://en.wikipedia.org/wiki/Leaning_Tower_of_Pisa). To compensate for that, builders chose to erect a curved, banana-like building such that its center of gravity remained within the footprint of foundations and the structure could withstand gravitational stresses (Fig. 13.6).

Medieval Pisa was surrounded by wetlands, up to the city walls on its south-western side, but some ancient representations also show some well-groomed, surrounding countryside (Fig. 13.7).

Waterworks have been major preoccupation in the Pisa plain since antiquity. Works were built for defense against floods from the larger rivers (Arno, Serchio) and the no-longer existing Auser River that flowed from the northwest to very close to town, at times acting as a defensive moat and as a navigable route of communication (Fig. 13.8a, b). Levees were built and canals were dug upstream from Pisa to deviate extremely-high floodwaters of the Arno River elsewhere (Cavazza 1994; Ceccarelli Lemut et al. 1994). To improve navigation, the course of the Arno River was straightened cutting off meander loops, and in 1606 the mouth of the Arno River was shifted a few kilometers northward to shelter it better from the direct impact of strong SW wind-driven storms that generated silting and obstructed water efflux causing floods upstream in Pisa (Fig. 13.8c, d; Pranzini 2001). Other works consisted in building canals both for reclamation of the numerous wetlands of the poorly drained plain caused by rainfalls and stream floods, and for navigability. Also of interest is the attempt by Florence to utilize river waters as a weapon against enemy cities such as Lucca, a city-state north of Pisa, and against Pisa itself (Fig. 13.1). In the first case the waters of the Serchio River were deviated to try to inundate the town. The plan failed because the town people erected

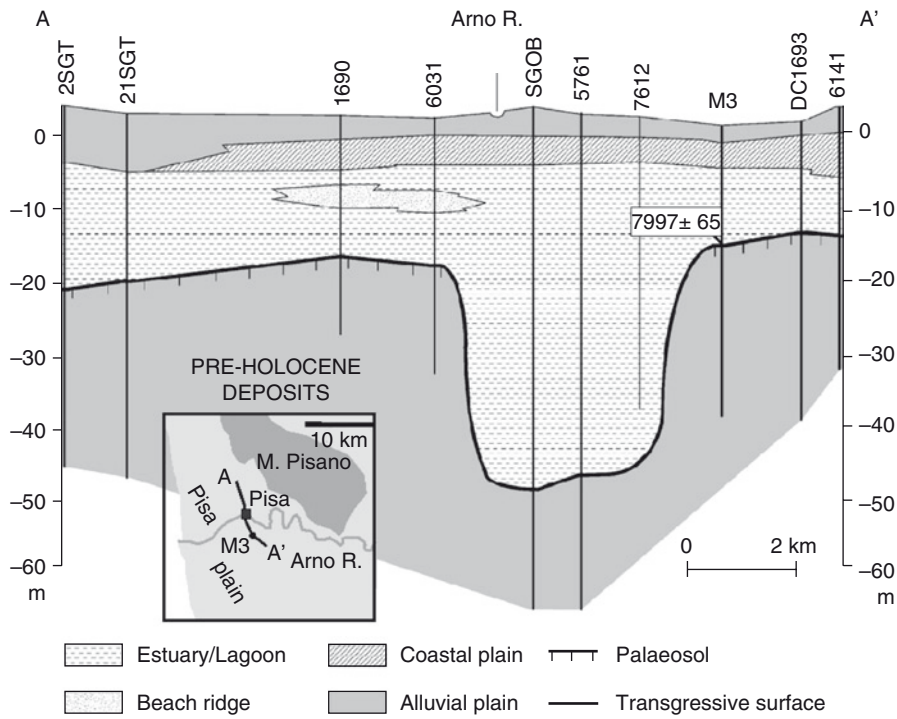

Fig. 13.5 Pisa plain (insert) and cross section showing Holocene deposits and the paleo-Arno River valley fill at Pisa (*Vertical lines* indicate core-logs; a C^{14} AMS uncalibrate date is reported in well M3). (After Aguzzi et al. 2007)

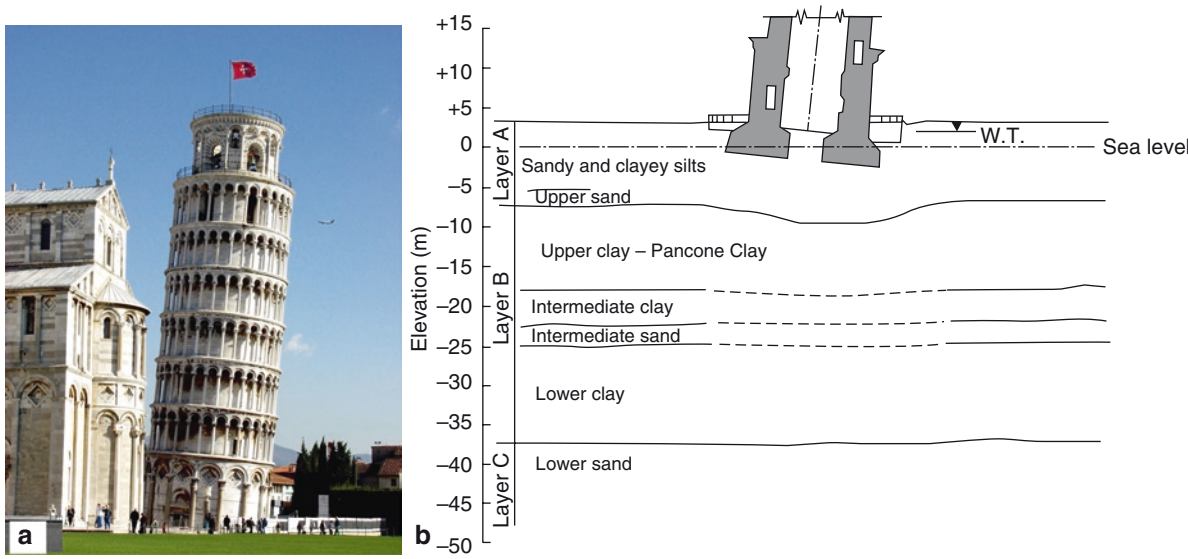

Fig. 13.6 Leaning Tower of Pisa. **a** The building shows strong inclination to the right and a slight left bend created by constructing the right flank slightly higher than the left one at various levels. **b** The tilting of the tower is caused by differential subsidence into the weak substrate, exacerbated during periods of water pumping from wells. (After Burland et al. 1998)

a higher levee on their bank of the river and eventually broke the opposite levee flooding the Florentine military camp. In the second case an ambitious plans was designed by Leonardo da Vinci at the beginning of 1500s to change the course of the Arno River upstream from Pisa (from point B on Fig. 13.8b) with the double purpose of cutting off water supply to the besieged town as well as opening an independent navigable canal to the sea for Florence (Masters 1998). The task was a difficult one, and in any case modified and botched by an incompetent, executive chief engineer. How difficult it was is demonstrated by subsequent unsuccessful attempts to construct canals to deviate floodwaters across the very flat Pisa plain. A partial success was not achieved until the late twentieth century.

Sufficient waterpower exited in the territory of Pisa for numerous mills. The principal mill complexes were built along the Arno River within and near the city itself, as well as along the Serchio River and other secondary streams discharging from the nearby hills. These mills became particularly important after the Livorno (Leghorn) harbor became established in the early Renaissance when much wheat flower was required to bake the *biscotto* (hard bread) extensively used by sailors (Pult Quaglia 1994) (Fig. 13.8).

During medieval times the wetlands of the Pisa plain were used primarily for animal husbandry (mainly cattle and sheep in the 1400s) (Ceccarelli Lemut et al. 1994; Pult Quaglia 1994). It was only later in the 1500s that numerous canals were constructed to

Fig. 13.7 Medieval–early Renaissance Pisa. (From http://www.stilepisano.it/immagini/Pisa_foto_stampe_antiche.htm)

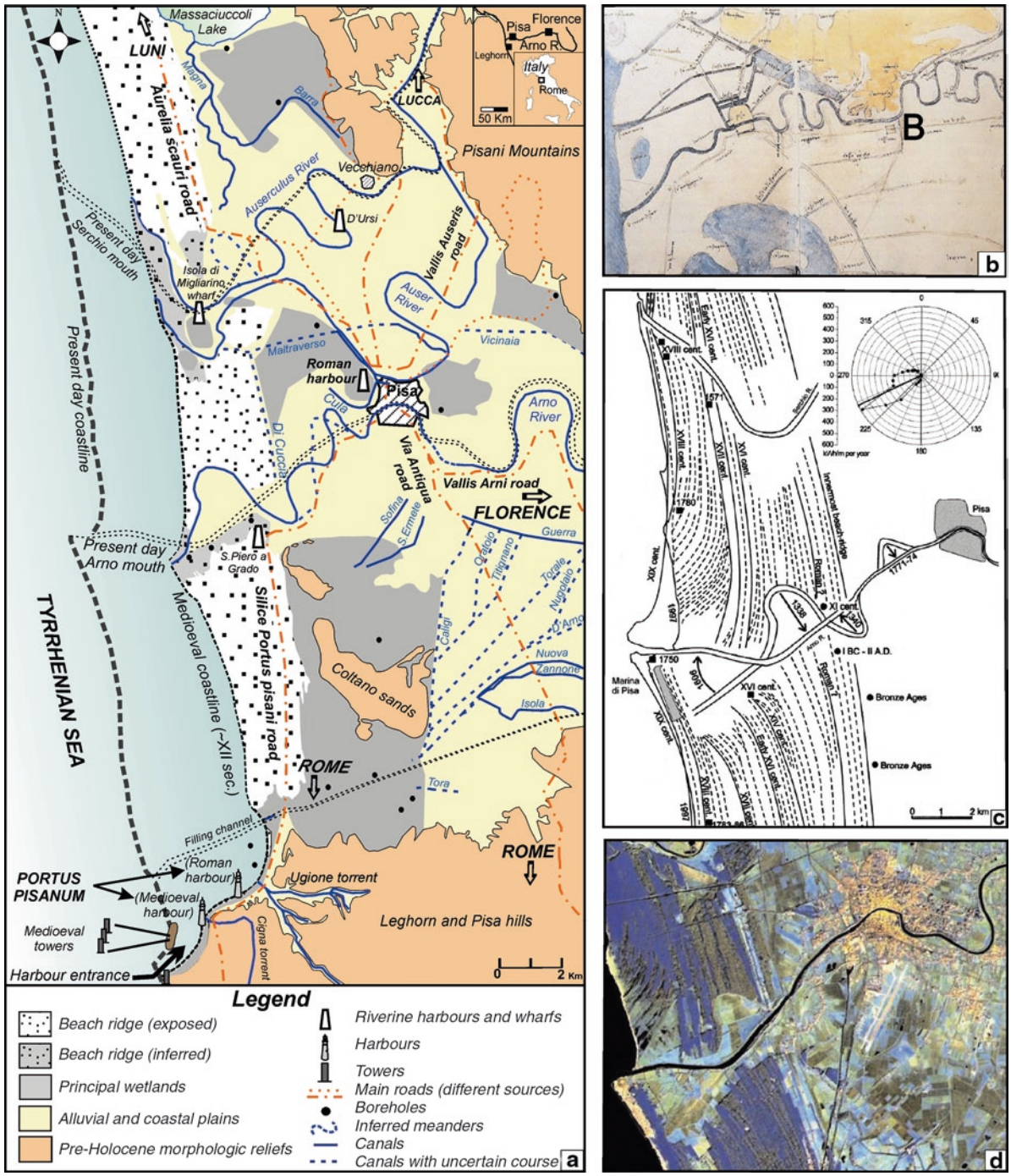

Fig. 13.8 Pisa plain area. **a** Map of the area for the tenth to twelfth centuries (After Carratori et al. 1994) (Plate 11). **b** Leonardo daVinci map of Arno River in the Pisa plain (After Starnazzi 2003) with indication of site (*point B*) where a unsuccessful major river diversion was planned in early 1500 (After da Vinci's Codice Madrid). **c** Modifications made to the lower course and river mouth of the Arno River (From Pranzini 2001). **d** Satellite image showing modern mouth area of Arno River traces of the ancient meanders and distributary channel downstream from Pisa. The small coastal city of Marina di Pisa between the ancient and recent mouth of the river is protected from erosion by artificial groins

partially drain the wetlands. Extensive grain cultivation was then implemented, provoked by the increasing demand of the growing populations of Florence and Pisa. In late 1500s the cultivation of the mulberry trees (for the silk industry), olive, and wine were introduced in the hills surrounding the Pisa plain (Pult Quaglia 1994).

All things considered, easy access to the sea was the prime asset and drawback of the town. As an asset, it allowed Pisa to become one of the first societies to flourish in Tuscany, reaching the apex of its development in the eleventh–twelfth centuries. This is when it became the dominant marine power of the Mediterranean area (http://en.wikipedia.org/wiki/Pisa) and also provided transport for the first Crusades. From those enterprises Pisa acquired great wealth and could afford to build its major monuments, such as the Piazza dei Miracoli (Fig. 13.4), and the numerous mansions that still ornament both banks of the Arno River. The drawback was the rivalry with other maritime powers such as Genoa. Genoa badly defeated Pisa in 1248 and impeded its development for one or two decades removing and imprisoning most of the male population and thus preventing the fathering of a new generation, and partially destroyed the main harbor ('Portus Pisanum', Fig. 13.8a). Furthermore Pisa harbors were necessary facilities to furnish industrial and sustenance materials for the landlocked Florence. So numerous battles were fought and eventually Pisa was subjugated first in 1406, then in 1494 after a brief revolt, and permanently in 1509.

13.3.2 Florence (Firenze)

Florence (coordinates: ~43°49′N, 11°19′E) is located on the banks of the Arno River at the southwest corner of a NW–SE elongated basin 10 km wide and 40 km long, ~50 m asl, ~100 km from the sea, and surrounded by hills (Fig. 13.9). It has now about 370,000 inhabitants.

The surrounding hills are composed of Tertiary sedimentary rocks, predominantly limestones and sandstones that are good construction materials as can be observed in almost every large palace in town. Marble for the large monuments derived mostly from the Apuane Mountains along the Tyrrhenian Sea coast (Fig. 13.1). The city is provided with a reliable supply of freshwater obtained from springs along the flanks of the hills or filtered from the river itself.

The city substrate consists of fluvial and alluvial-fan gravels and sands and some lacustrine clays and sands dating from the latest Pliocene to Holocene. Under the city itself the sediments generally coarsen upward from basal clays, through sand and gravel at the top marking ancient river beds (Fig. 13.10).

Fig. 13.9 Panoramic view of modern Florence with the Arno River in the foreground, ancient monuments in the middle ground, and forested hills in the background

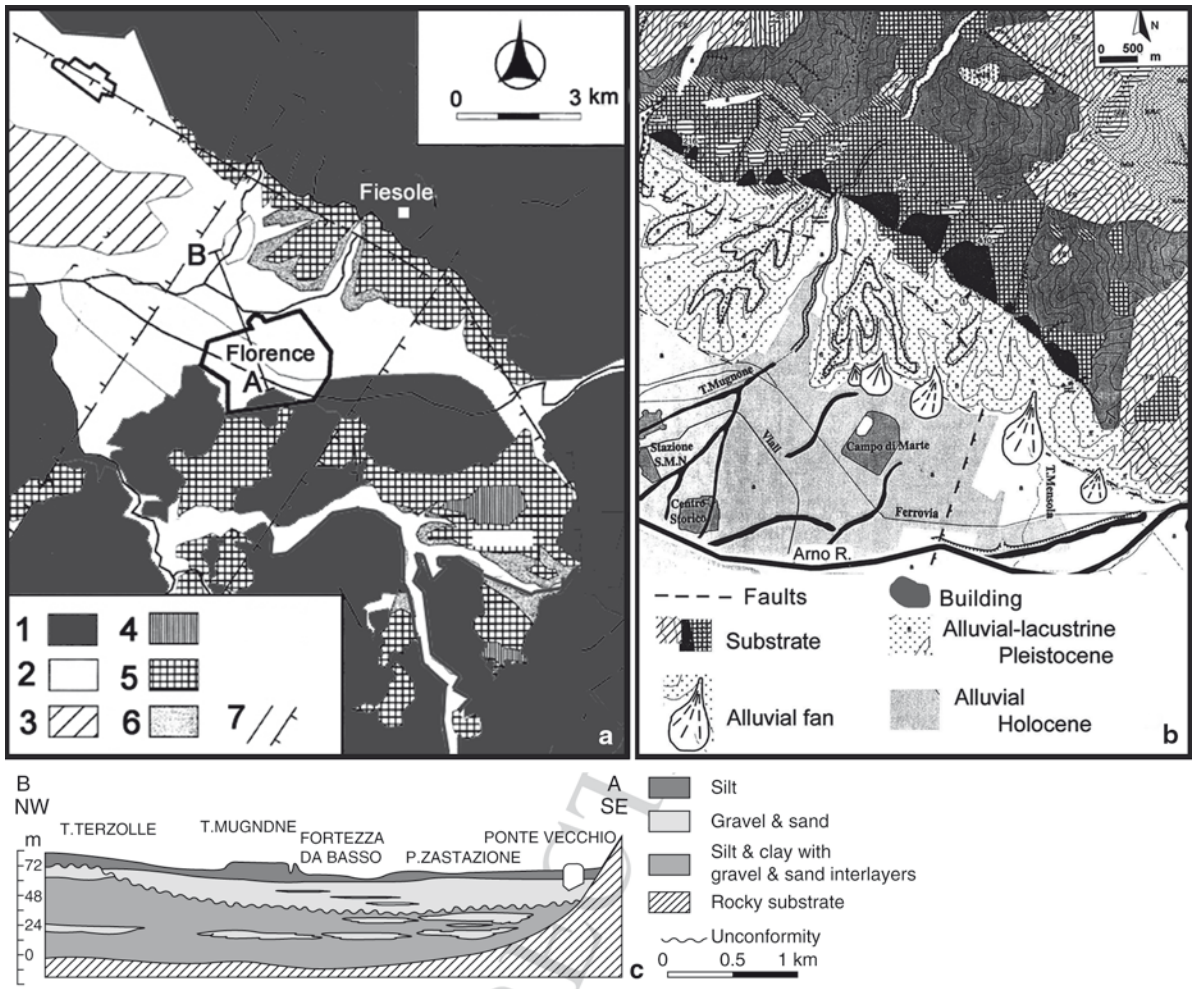

Fig. 13.10 Geology of the Florence area (After Boccaletti et al. 2001). **a** Schematic geological map (*1* Bedrock; **Holocene:** *2* fluvial gravel and sand, *3* fluvial silty clay; **Pleistocene:** *4* sandy clay with disseminated pebbles, *5* interbedded gravel, sand, and silty sand, *6* gravel with silty sand lenses; 7 faults, barbed ones indicate normal faults; A–B: trace of cross section). **b** Geomorphology. Note the different course of the Mugnone T. (creek) that was progressively trained toward the west at the margins of the growing medieval city. **c** Cross section showing Quaternary deposits under the city

Since Roman times when it was first founded at the junction of the Arno River and one of its tributaries, Florence has manipulated the local water courses to its advantage. As the city enlarged, the northern tributaries to the main river were diverted progressively westwards and in part utilized as defensives moats along the western town walls. The main streams were also canalized to prevent floods. Numerous water-powered establishments, such as gristmills (for grains) and fulling mills (‘gualcherie’, to make woollen cloth) were built along the Arno River, other minor streams, and along artificial canals deviating flows from these watercourses (Muendel 1984). The mills consisted either of large edifices on low banks of the river where water could be canalized off the main course, or of flat boats anchored in the middle of the river. Low dams (‘pescaie’) were built diagonally across the Arno River to divert part of the water into canals toward the wooden paddles of the mills (Fig. 13.11). Those early dams consisted of wooden piles driven into the river bottom, lateral twig brances, and sand and gravel fills.

The industry of making woollen cloth was one of the activities that made Florence rich, particularly from the early 1300s to mid 1400s. This city-state benefited from this industry over others because of its great availability of hydraulic energy. Several steps were required to fabricate good cloth, besides starting with good wool. Some of the first activities could be

Fig. 13.11 Ancient Florence. **a** Chain Map showing the walled town and various activities in the Arno River in the 1470s. **b** Details showing defensive constructions and pescaie (shallow dams) for mills (large structure on foreground bank) in Florence (After reproduction of lost work by Rosselli F. (1471–1482) located in the Florence, Historical and Topographic Museum "Firenze com'era", Florence, Italy) (Plate 13a)

performed directly by hand, such as cleaning, washing and selecting the wool, spinning the yarn and weaving the cloth. The next step of cleansing the cloth of oils, dirt, and other impurities, and softening and thickening it (fulling, 'gualcatura'), however, could only be efficiently done by heavy machines of the fulling mills driven by river currents (Salvini 1987). The cloth was impregnated with chemicals (usually animal and human urine as sources of ammonia), and was rhythmically beaten by wooden hammers driven by paddles of watermills. Originally several 'gualcherie' were located within Florence itself, but the continuous, loud beating noise and the stench of the ammonia (urine) forced them to be moved both upstream and downstream from the city.

The river was also a convenient waterway for small, flat-bottom crafts. However, the river constituted a risk as well, particularly as it was in part mismanaged. Numerous large floods occurred, inevitably because of the torrential regime of the rivers of Tuscany (Table 13.2). They became more damaging, though, because of canalization (restriction) of the river inside the growing city and the construction of the pescaie (low dams) for mills. These pescaie induced sedimentation and when the sand was not routinely dragged, the bed of the river rose and floods occurred (Table 13.2). Notably devastating medieval floods were those of 1269 and in particular the disastrous one of 1333 that lead to severe famine (Salvestrini 2005; Schenk 2007; http://www.liceoquadri.it/cittamed/citta_med.htm).

The fertile countryside around Florence and other parts of its territory were used for varied cultivations, cereals in particular (Pinto 2002). The cultivation of plants such vines, olive, and of mulberry in the later medieval–early Renaissance times were important as well. The local agricultural production was generally barely sufficient for the growing town population and it was subject to sudden crises due to climatic adverse conditions and floods. Crop failures occurred and famines developed, those at the beginning of the 1300s being particularly severe. Food from neighboring as well as oversea states was imported.

There was also a great demand for cattle for milk, meat and leather, and of sheep for the same things and mainly for wool. The Florentine cloth manufacturers utilized local low-quality wool supplemented by better material imported from other central Apennine areas and high prized quality wools from as far as England. Freshwater fish, partly dictated by religious practices, was a valuable staple and it was obtained from very

productive rivers, ponds, and shallow lakes. The Chain Map image showing net fishing in the Arno River downstream from the city is intriguing and indicative of the poor health consciousness of those times (Fig. 13.11); on the river right bank of the fishing area shown on the map was the dump of garbage of any sort including leftover from butchering. The Arno River was indeed much polluted due to injections from the industries and of raw sewage, a situation that continued until quite recently.

13.3.3 Siena

Siena (coordinates: ~43°20′N, 11°20′E) is located on a hill at the western corner of an uplifted elongated Pliocene basin. It is at 322 m asl and about 65 km from the sea (Fig. 13.12). It has now about 56,000 city dwellers (http://en.wikipedia.org/wiki/Siena).

The Siena basin is surrounded primarily by some Mesozoic metamorphic rocks and mostly by Tertiary sedimentary and local volcanic rocks. Some of these rocks were used in the construction of older palaces, towers, and major monumental churches. Brick, though, has been the most common building material since medieval times. Marine clay from the Pliocene basin provided the raw material, and wood was obtained from the surrounding hills. Numerous furnaces originally located in town were banded to the outskirts because of fire hazards. Of the three cities discussed here, Siena had the richest territory in minerals (such as iron, copper, and silver) that were mined in the hills (Colline Metallifere) separating the Siena basin from the Tyrrhenian Sea (Mare Tirreno) area (Fig. 13.1). The city itself is underlain by Pliocene poorly cemented marine sandstones (locally called ‘tufo’) and conglomerates overlaying marine clays.

Siena is bounded on three sides by steep, high hill-flanks, and has a flattish, elongated hilltop to the northwest (Figs. 13.13, 13.14). This gives a characteristic inverted Y plan to the town map.

The location greatly benefited the city during its early developmental stages because it offered three readily defensible sides, and was crossed by the main route (Via Francigena) followed by the pilgrims to Rome during the thirteenth and fourteenth centuries (Fig. 13.15). The pilgrims transiting through Tuscany preferred hill routes to those of the lowlands that were covered by potentially unhealthy wetlands, some being infested by malaria. The Senesi took full advantage of this opportunity catering well to the travellers constructing hospitals, providing money changing facilities and banking, and assuring security in their territory against robbers that infested the lands. This, combined with international banking and commerce primarily of wool cloth across Italy and Europe, made Siena prosperous. It reached maximum development during the last part of the thirteenth century and the first few decades of the fourteenth century. Siena reached it maximum population of about 60,000 peo-

Fig. 13.12 Siena. **a** General view of the Town Hall (Palazzo Pubblico) and the surrounding territory. The Palazzo Pubblico and its characteristically shell-shaped antecedent square were built between 1298 and 1348 AD near the apex of the Montone valley, one of those that indent the hill of Siena. **b** S. Ansano valley, another one that indents the hill of Siena. Note ancient town wall in the middle ground also enclosing cultivated fields called “orti”. (See location of valleys in Fig. 13.13)

Fig. 13.13 Maps of Siena with flanks deeply cut by narrow steep valleys (After images reported in Bortolotti 1988). **a** 1869 AD map (Accademia dei Fisiocritici, Siena) (Note the San Domenico–Fortezza viaduct (*V*) just started across valley *S* (Rastrello); Palazzo Public and adjacent squares already completed (1298 AD) at the head of Montone (*M*) valley). **b** 1965 AD map (Distance between *M* and *T* is ~500 m; note San Domenico–Fortezza viaduct and Stadium completed at the head of valley *S*). (Valleys: *M* Montone; *G* Gavina; *A* St Ansano; *F* Fontebranda; *S* Rastrello; *P* Pescaia; *N* Fontenova; *O* Follonica; *T* Pispini)

ple in early 1300 living in the confined, walled space of approximately 2 km^2.

The location of Siena had disadvantages as well, primarily (a) the lack of sufficient space for expansion and (b) waterpower for its industry.

(a) Siena developed through the amalgamation of initial centers – 'castellari': castle-like communities – that settled three nearby hilltops. As the city grew several progressively wider town-walls were built to protect dwellings but also cultivable land (the 'orti' (fields) that still exist) that could produce food during also during sieges. The cathedral was built on one of the hilltops after it was partially levelled off. Flattening and carving spaces for building, roads, squares from the easy to excavate sandstone substrate (locally called 'tufo') has been the continuous practice of Siena to our present times. Other building spaces were obtained by reclaiming the upper part of the steep valleys indenting the main hilltops. Retention walls were built across the valleys and the upper parts were partially filled with

Fig. 13.14 Mid-1900s view of Siena showing still existing bounding, steep, northeastern scarp; on the lower right corner of the image is the Camollia entrance to the city from the only flatter northern side of town vulnerable to invasions. (After Etiennez (1852) reported in Bortolotti 1988)

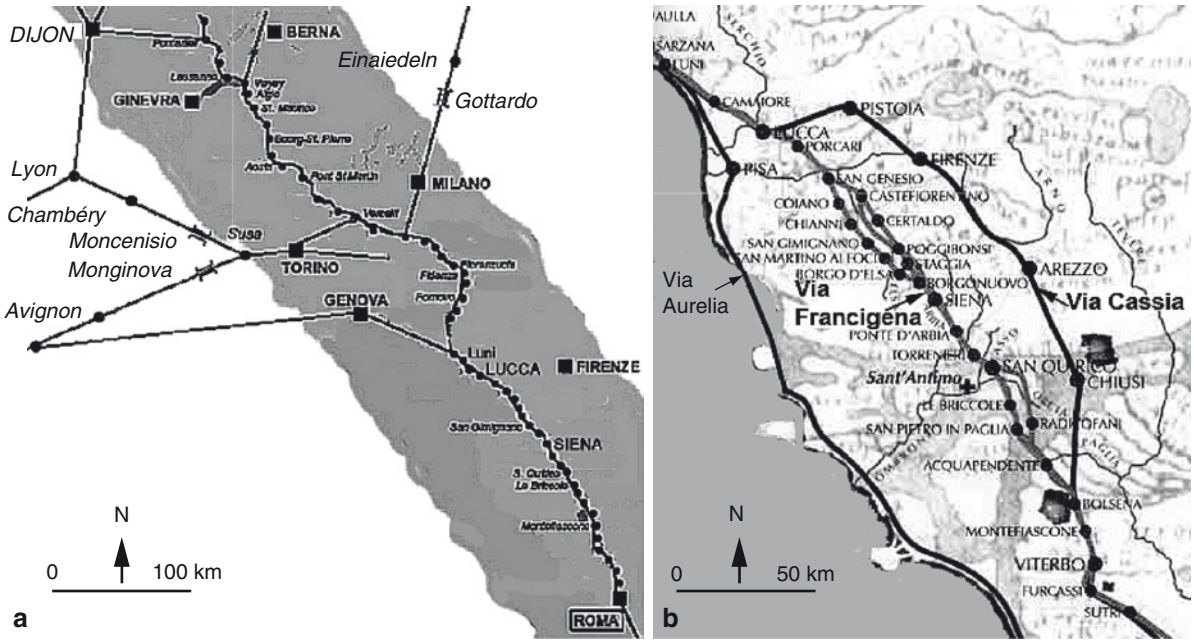

Fig. 13.15 Pre-modern principal routes in central north Italy. **a** Main pilgrim route (Via Francigena) in Italy and south-central Europe (After http://www.francigena.ch/). **b** Detailed map of the routes in central-north Italy with slight variations in the Via Francigena toward Siena, and other routes (Via Aurelia and Via Cassia) built and used by Romans and again in late medieval and subsequent times. (After Adrian Fletcher 2000–2008 http://www.paradoxplace.com/Perspectives/Maps/Via%20Francigena.htm)

sediment removed from other places and/or dump rubble and other debris generated by earthquakes, such as the one in 1319. The famous Piazza del Campo and the Palazzo Pubblico (City Hall) was built in the 1100s at the head of one of these valleys (Figs. 13.12, 13.16); the viaduct between the of church of S. Domenico and the Medicea Fortress was partly built using rubble from the 1798 earthquake across the upper part of another deep, steep valley to the NW of the city. In recent times a soccer field was constructed at its head

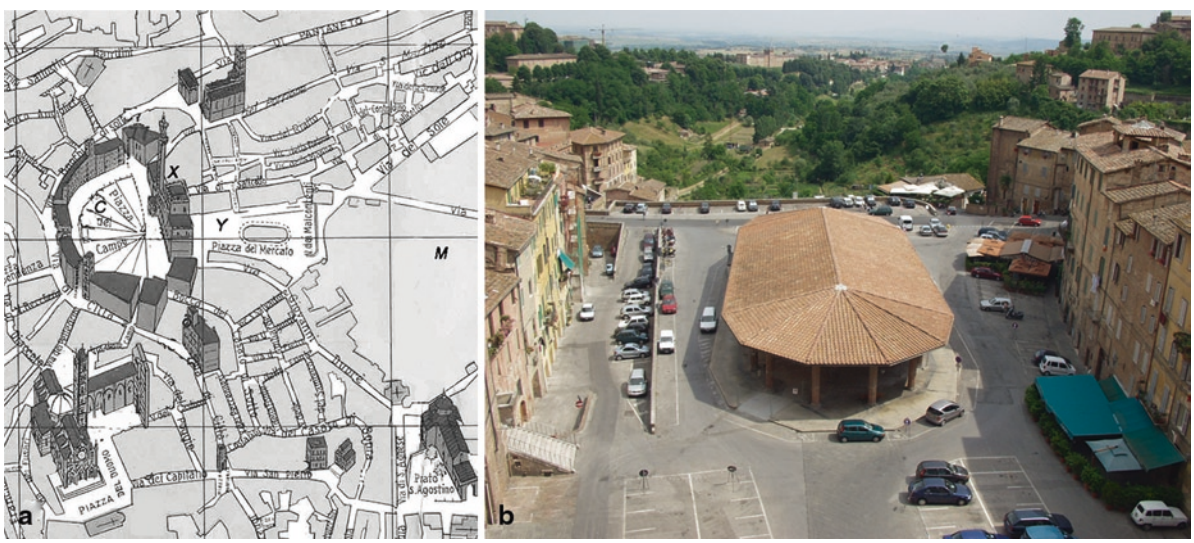

Fig. 13.16 **a** Map of Siena showing: Piazza del Campo (*C*), Palazzo Pubblico (*X*), Piazza del Mercato Vecchio (*Y*), and Montone valley (*M*). **b** Piazza del Mercato Vecchio looking eastward toward the lower part of the Montone valley (see also Fig. 13.13). The first head-valley retaining wall was built at the outer eastern edge of this square

(compare the S valley on Fig. 13.13a without viaduct V, and on Fig. 13.13b after the viaduct and the soccer field had been built).

(b) No large springs, productive water wells, or permanently flowing streams exist in the city area, and only few ephemeral torrents occur in the nearby valleys. At times cisterns collecting rainwater were used but not extensively, and their water was unhealthy and insufficient for the population. Small springs exist at the bottom of the hill, and some of these were eventually included within the town walls. Siena, the town without water, developed a water culture through extreme efforts to find it, bring it to town, implement multiple uses of it, and conserve as much as possible. The Senesi enhanced output of valley bottom springs by excavating tunnels along the boundary between the underlying clay (aquifuge) and the overlying porous sandstone (aquitard), and constructing long (approximately 25 km) underground aqueducts (tunnels, locally called 'bottini', similar to the 'qanats' of ancient Middle East and north Africa people, and to Roman underground aqueducts) to tap small springs on the hills northwest of the city (Figs. 13.17, 13.18; Kucher 2005). One of two major aqueducts carried waters to the base of the hills (Fontebranda, Fig. 13.19), the other directly inside the town (Fonte Gaia, in the main city square in front to the Palazzo Pubblico). These aqueducts still function mainly for watering gardens and other non-potable uses. However, water was never enough for medieval Siena and this eventually crippled its industries.

Although much of the countryside of the Siena basin has clay soils that desiccate quickly in summer, it could produce wheat. Wine, olive oil, and other produces were obtained from the fertile hills around. More agricultural and husbandry supply were also obtained from its distant, fertile, although unhealthy, Maremma territory. Nevertheless famines recurred and other difficult periods were caused by both natural causes as well as by wars and by disruptions caused by companies of jobless, marauding, mercenary soldiers during times of peace between major cities (Bortolotti 1988).

Notwithstanding the poor hygiene common to most medieval towns, and although it had less water than

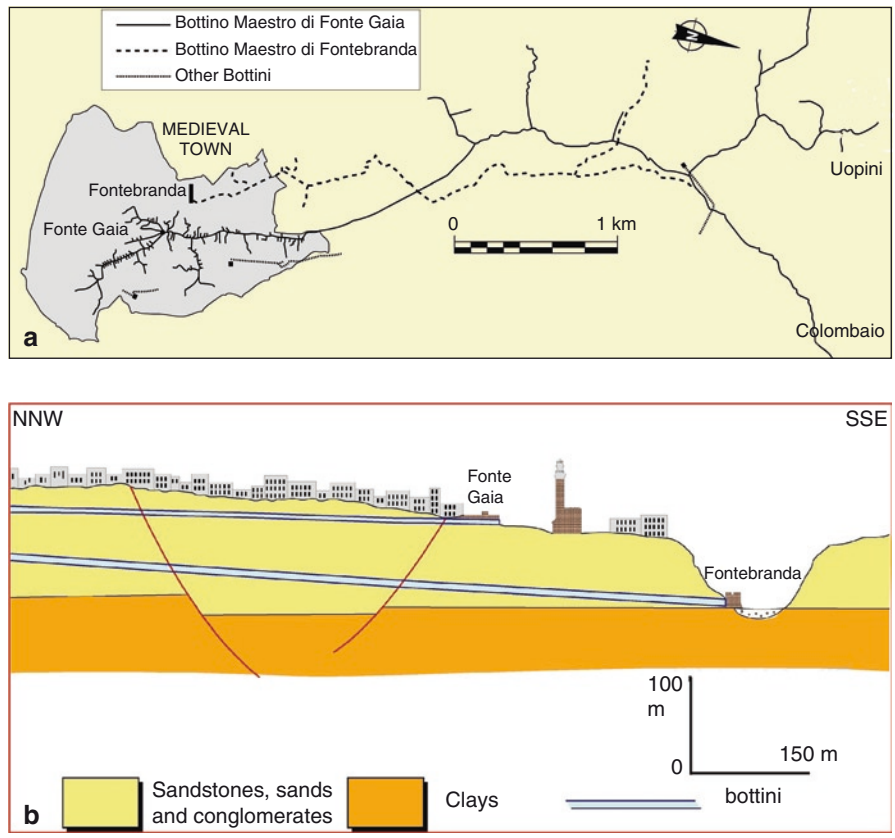

Fig. 13.17 Bottini (tunnels of underground aqueduct) of Siena. **a** Map of the underground aqueducts showing main (maestro) tunnels (Fontebranda and Fonte Gaia) and secondary (other) ones excavated to improve local water outputs or distribute waters from the Bottino Maestro di Fonte Gaia (After Marchi 1869). **b** Schematic geological cross section under the town showing the relative position of the two main aqueducts (Curved, sub-vertical lines are traces of major normal faults; scales are approximate)

Fig. 13.18 Portion of the Bottino Maestro di Fonte Gaia. Fossiliferous sandstone and conglomerate layers are exposed on the ~3 m high walls. The small channel (gorello) in the floor is carrying the waters of the underground aqueduct

others, Siena did not particularly suffer from major sicknesses, except for the Black Death. In about three months in 1348 AD approximately two third of the population died (Bowsky 1964; Mucciarelli et al. 2000). The death rate was so high that there was no time for proper burial. Many bodies were simply thrown in a deep well inside the Spedale di Santa Maria della Scala (City Hospital), and sparingly covered with lime. It is still possible to see in a cross-section the horrific stratification of bones and sediments. Siena never fully recovered in the post-plague world and its landscape had some influence in making it incapable of competion with the archrival neighboring Florence. As Italy and Europe were emerging from the terrible plague a tendency to industrialism was taking place at least in the old wool and later new silk cloth manufacturing and commerce. Being forced out of step with the times in part because of landscape limitations, many affluent families retrenched their interest and wealth in country properties. Siena progressively declined to eventually surrender after an 18 month horrendous siege in 1555 to the Spaniards who sold it to their ally Florence in 1557 (http://en.wikipedia.org/wiki/Siena) when only about 8000 people were left in Siena.

13.4 Synthesis

The development of the three city-states of Pisa, Florence, and Siena in the Middle Ages–early Renaissance is closely interwoven, complex, and primarily determined by socio-political and socio-economical conditions. Those were difficult times and each society strived to emerge or to survive, as the case might have been, with variable fortune associated to factors such enterprising citizens, the selection and loss of powerful allies, the continuous strife of internal discord and external wars, and the scourge of soldiers of fortune that from time to time pillaged the territories. Beyond this socio-political morass there were also environmental and sanitary factors that greatly contributed to the diverse success of the three societies. Some factors, such as the great scourge of the Black Plague starting in 1347–1348, affected all equally, albeit with different results commensurate to the size of the populations. Florence had the largest population at that time and although drastically reduced, it could rebound more readily.

Other factors were tied to the settings (landscape) of the three cities; one of these related to the viability by water and overland. Pisa was never an industrial power, nor did it produce great quantities of foodstuff from its vast, partially wet plain. Pisa, though, was located near the sea on a river that was navigable for much of the early part of medieval times, and could utilize good sea harbors, such as the 'Portus Pisanus', for large ships. Pisa catered to sea transport and travels thorough the Mediterranean including servicing the first Crusades and in doing so its society thrived. Pisa was also a bottleneck for landlocked towns such as Florence that had to use it for its commerce, for materials needed for its industry, and for importing foodstuff during recurring periods of famine. It was therefore a prize to be obtained and eventually it fell definitively under Florentine rule in 1509.

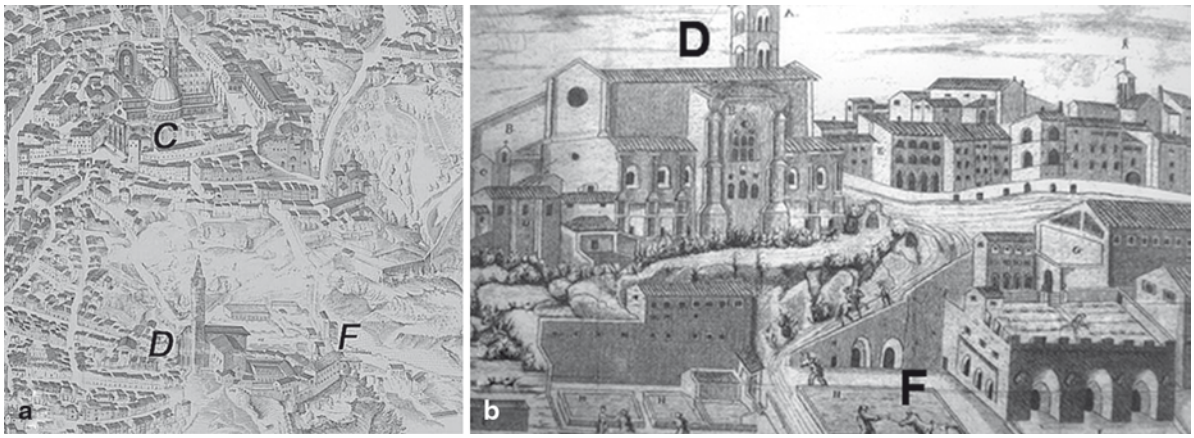

Fig. 13.19 Fontebranda area: the main industrial area of medieval Siena. **a** Detail of Vanni map (Vanni early 1595). San Domenico (*D*) with its original bell tower still standing: it was toppled by an earthquake in 1798; the Cathedral (*C*) was built on a flattened hilltop and the Baptistery in a quarry excavation just to the left (*F:* Fontebranda bottom valley with various water edifices). **b** Complex of Fontebranda showing arched building containing the main pool for potable water, and, sequentially to the left: pool for animals, pool for washing clothes, pool for washing animals, and, farther to the left and outside the walls (see Fig. 13.18a), water was used for running mills, and finally to water the fields. Parallel to this, cisterns were used for washing wools, washing and tanning pelts, for butchering and so on. Note gardens on top of the main arched-pool building. In previous times this top was used as 'tiratorio'; that is, an area where to stretch and dry colored wool cloth

Florence in the early part of the thirteenth century was surrounded by powerful towns among which were Pisa and Siena. The city was excluded from the benefits derived from major transport routes and apparently had limited prospects of success. It did not have access to the sea, the river was difficult to navigate (and only with small crafts), it was far from the principal pilgrimage routes, and it did not have primary resources. Even some of the wool and dies for the cloth industry had to be imported through the harbor of the often antagonistic Pisa. In spite of all, within a few decades it succeeded in reversing the situation. A major communication route shifted from the old Via Francigena to one crossing Florence (the ancient Roman via Cassia, Fig. 13.15b). Powerful new alliances were struck, particularly with the Vatican and other states. The city started to use profitably the great hydraulic resources of the Arno River, increasing greatly the productivity of its cloth and later its silk industries. In 1252 it coined the 'Fiorino', golden coin that overtook the coinage of Siena slowly depreciating as less and less silver was used to mint it. Florence grew to reach about 100,000 inhabitants by the end of the thirteenth century. Nevertheless the subsequent development of Florence to major power status was not a linear one. It suffered strong setbacks such as during the 1333 large flood and crop failure, and its weakening continued reaching bottom during the plague of 1347–1348 and subsequent Black Death bouts. Florence, though, weathered the difficulties better than others in part because of the benefits it derived from the fertile lands of its territory and hydropower it had. As industry evolved and grew, the commerce expanded and competitive practices were implemented such as flooding the markets with less expensive goods. Siena and other societies of Tuscany could not keep pace.

Siena is located on a hilly country away from water courses. Albeit distant, it had an opening to the sea with a small harbor (Talamone) in central south Tuscany, the Maremma. More importantly, during the religious fervour that brought thousands of pilgrims to Rome during the early High Middle Ages, Siena found itself located on one of the preferred pilgrimage route (Via Francigena) because safer and healthier than those of the adjacent bottom valleys locally inundated by wetlands infested by biting insects. The city catered well to the pilgrims offering some degree of security, hospitality, health support, and, most of all, money exchange and banking facilities. This eventually led to the temporary dominance of the Sienese silver coin and to expansion of its commerce throughout Europe. However Siena had strong landscape limitations that impeded its competiveness in expanded markets and industrial development of wool-cloth manufacturing. It had enough space and water in its major, bottom-valley, industrial area of Fontebranda to remain com-

petitive with others during the early part of the High Middle Ages, but it simply did not have enough natural resources to compete later on. Siena like most of Tuscany became subservient to Florence by the mid sixteenth century.

As a whole, the three cities and their territories provide abundant examples of the ways in which humanity is an integral component of landscape, with two-way traffic between the two. The constraints laid upon human development by the landscape, and our attempts to minimize those constraints by the invention of appropriate technologies produce possibilities of complex feedback at all stages. Generally, our victories are short lived, and we are forced to devise new strategies on a continuing basis. We call this progress, for want of a more honest label.

Acknowledgements Research like these protracted over many years has benefited from the help of colleagues, students and enthusiastic local peoples like some witty Florentines and 'bottinieri' of Siena. Sarti likes to single out for a special thank M. Bini, S. Giacomelli, G. Gattiglia and M. Baldassarri of Pisa.

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