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KARST AND PALAEOENVIRONMENT OF SIENA AREA (CENTRAL ITALY)

Leader: V. Pascucci

Associate Leader: L. Dallai

Field Trip Guide Book - D02

Florence - Italy
August 20-28, 2004

During-Congress D02

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D02

Front Cover:
Speleothems inside the Buca a Frati cave

Leader: V. Pascucci
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Introduction

Field trip is dedicated to the analysis of some karst features of the Siena area developed during the last ice age and formed into Triassic limestones (Calcare Cavernoso) outcropping north-east of Siena (Mt. Maggio, part of the Middle Tuscany Ridge). Related to karsts is also the formation of several relatively small lakes, today drained (Fig. 1). Lakes allowed the establishing of several communities in the Siena area and, in the middle ages, they represented important economic sources. Villages such as Monteriggioni, Abbadia Isola, and S. Leonardo al Lago all developed thanks to the presence of these lakes, and special rules where established for their exploitation. Most of these lakes were drained artificially in the late 17th century and, the economy, the landscape, and climate of the Siena environs greatly changed.

Field trip is centred (Fig. 2) on the visit to one of the best caves (Buca a Frati, Stop 1) to other karst features (sinks, etc.) in the area, to one of the last drained lakes (Pian del Lago) with its drainage system (Canale del Gran Duca, Stop 2) and, finally, to the visit of two of the most important medieval villages of the area, which flourished thanks to the presence of the lakes (Monteriggioni and Abbadia Isola).

Figure 1 - Field trip area

Regional geologic setting

Vincenzo Pascucci

The Apennines are a complex mountain chain that has been developing since the Neogene due to the interaction between various microplates in the Africa-Eurasia collision belt (Fig. 3A). The Adria was a promontory of the Africa plate protruding into the Ligurian-Piedmont oceanic basin, a narrow western arm of the Jurassic Thetis. The Apennines are characterized by imbricate fold-thrust belts accreted eastward on the Adria microplate in response to the westward-dipping subduction zone (Fig. 3B).

Figure 2 - Map of the stops

The Apennines can be subdivided into two geological portions (Northern and Southern Apennines; Vai, 2001) or three geomorphologic segments (the northern, central and southern Apennines; Vai and Martini, 2001) (Fig. 3A). Here the tripartite geomorphologic nomenclature (indicated with "northern, central and southern" in low capitals) is adopted to emphasize the different lithological components of the northern

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part of the Apennines, which underlie the Neogene-Quaternary basins, the northern Apennines having primarily siliciclastic rocks and the central Apennines carbonates.

The *northern Apennines* are an arcuate, 300-km-long fold-and-thrust mountain chain extending from the Sestri-Voltaggio (sv) line in the north to the Olevano-Antrodoco (oa) transversal lineament to the south (Fig. 3A). The northern Apennines consist of deformed sedimentary successions belonging to different domains: the ophiolitic-bearing Ligurides derived from the Ligurian-Piedmont ocean, the Subligurides deposited adjacent to the Adria continental crust, and the Tuscan and Umbrian units formed on the Adria continental margin (Fig. 3B).

The Ligurides are composed of early Jurassic to Eocene rocks (ophiolites, radiolarites, pelagic carbonates, shales and turbidites). The Subligurides include shales, pelagic limestones, and turbiditic Eocene to Oligocene deposits. The Tuscan and Umbrian units consist primarily of Mesozoic carbonates, radiolarites, shales and thick Cenozoic turbidites (Macigno, Cervarola, Falterona (Tuscan) and Marnoso arenacea (Umbrian).

The Ligurian-Piedmont oceanic basin started closing in the Late Cretaceous, and the Ligurides began to be deformed and thrust eastward. Terrigenous sediments of late Eocene to Miocene age (the Epiligurides) were deposited unconformably onto the Ligurides in satellite (piggy-back) basins.

Since the Oligocene the Adria continental margin was involved in a continent-to-continent collision. During this collision, part of the Tuscan units underwent metamorphism, and thrust imbrication structures developed, with non-metamorphic units (the Tuscan Nappe) overriding the metamorphic rocks (the Metamorphic Tuscan Unit). After the Miocene, the thrust imbrication belt prograded eastward and the Ligurides overrode the thrust pile as a nappe (Fig. 1D). Resultant major structural features are the Middle Tuscany Ridge (MTA), the Chianti-Cetona thrust, and the Cervarola-Falterona thrust (Fig. 3C). On top and to the west of the MTR the Tuscan successions have been delaminated, locally bringing elements of

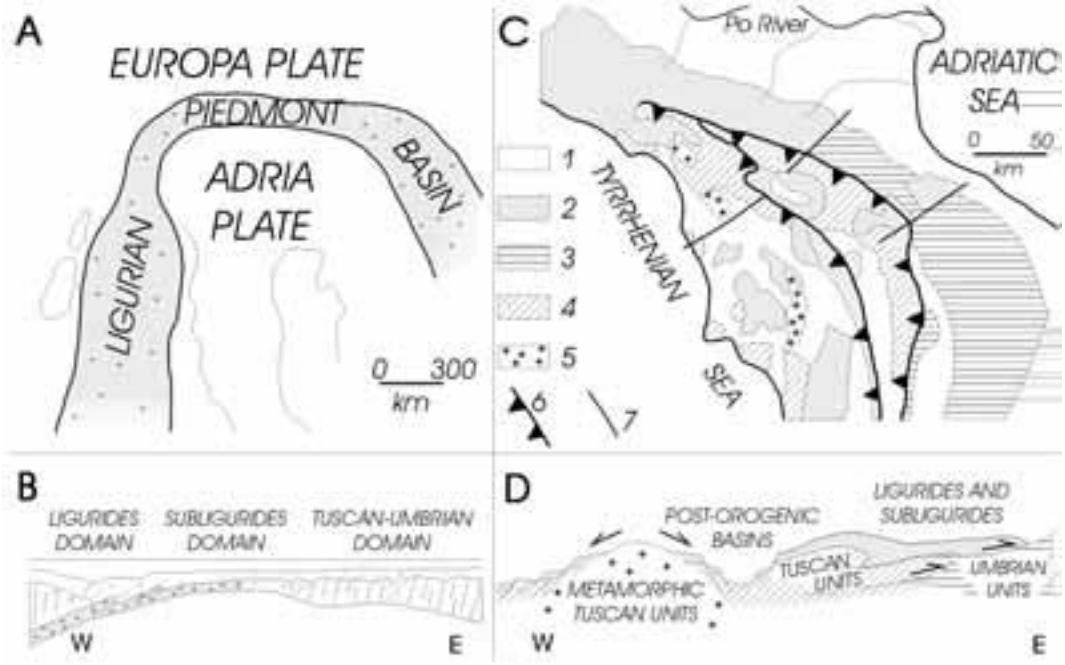

Figure 3 - Structural features of the northern Apennines: A. Paleogeographic map of the Ligurian-Piedmont basin; B. Cross-section showing original sedimentary domains of various units of the northern Apennines. C. General structural map of the northern Apennines with major structures and distribution of the tectono-sedimentary units; 1=Miocene to Quaternary deposits; 2=Ligurides; 3=Umbrian Units; 4=Tuscan Units; 5=Metamorphic Tuscan Unit; D. Schematic cross-section showing the relationships among the tectono-sedimentary units in the Northern Apennines.

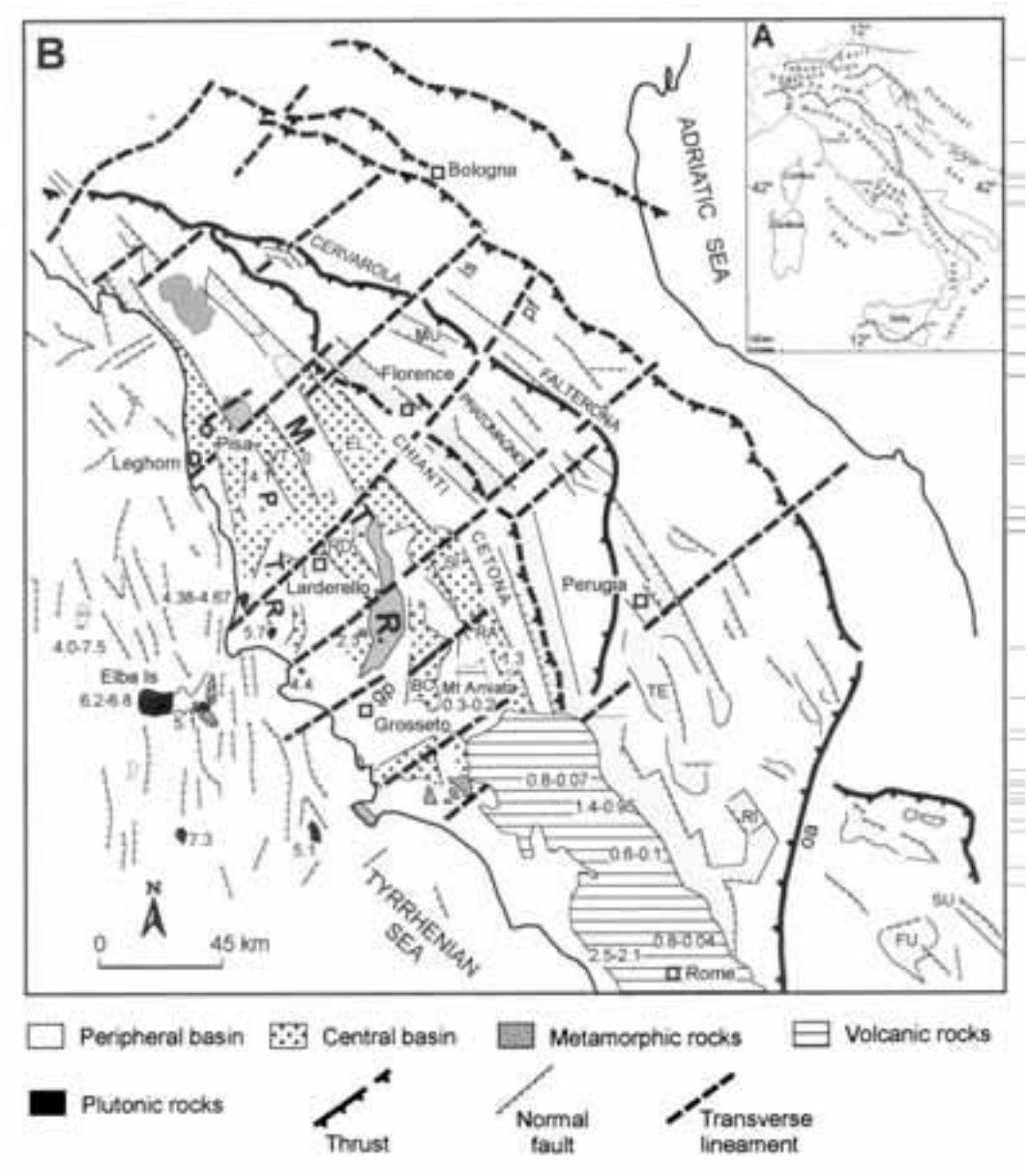

Figure 4 - Generalized structural maps of Italy: A. Map indicating major structures of Italy and geologic and geomorphic subdivisions of the Apennines; oa=Olevano-Antrodoco line; sv=Sestri-Voltaggio line; B. Neogene-Quaternary basins of the Northern Apennines; Basins: BC, Baccinello; EL, Elsa; FU, Fucino; MU, Mugello; RA, Radicofani; RD, Radicondoli; RI, Rieti; SI, Siena; SU, Sulmona; VT, Volterra; TE, Tiberino; Transverse lineaments: aa, Ancona-Anzio; gp, Grosseto-Pienza; ls, Livorno-Sillaro; pf, Piombino-Faenza; M.T.R.=Middle Tuscan Ridge; P.T.R.= Peri-Tyrrhenian Ridge; 3.5 radiometric age of igneous rocks in Ma.

the Ligurides directly over various lower Tuscan units ("serie toscana ridotta").

After the main, Early Miocene, compressional phases the inner, western part of the Apennines emerged, and basins 10-40 km long, 15-20 km wide, with up to 3 km of continental and marine sediment fill, de-

veloped (Fig. 4). For the most part these basins are now bounded by normal faults on at least one flank, many of Pleistocene formation or reactivation. They are separated longitudinally by transverse morphotectonic lineaments (Fig. 4).
These basins have been interpreted as half-graben, formed during an overall extensional regime, punctuated by short-lived compressional events (Martini and Sagri, 1993). They differ in age of initiation and depositional sequences. Those located to the SW (named "central" basins by Martini and Sagri (1993)) have developed since the Late Miocene and contain thick (up to 3500 m) continental and marine deposits. Those to the NE (named "peripheral" or "intermontane" by Martini and Sagri, 1993; Martini et al. 2001) have developed since the Pliocene to the west and since the Pleistocene to the east and contain relatively thin (about 600 m) continental successions. Furthermore, the area of the "central" basins is impactedby plutonism (such as Larderello) and Quaternary volcanism (such as Mt. Amiata and Radicofani) which have affected the preservation and the structure of some basins. The "central" basins exposed inland can be further differentiated between those located west and those located east of the Middle Tuscany Ridge (Fig. 4). Over a basal continental, gravelly, peat-bearing succession, the basins west of the MTR contain marine, gypsum-bearing upper Miocene deposits, in turn overlain by marine Pliocene materials. The basins east of the MTR have similar basal units overlain by still-continental, Upper Miocene deposits, in turn overlain by marine Pliocene sediments.
In the Quaternary, the MTR played an important role by separating areas with different climatic conditions: dry to the west, relatively humid to the east. These humid conditions allowed the development of a series of lakes and river systems.
Close to Siena (in the Mt. Maggio area), the maximum extension of lakes occurred during the last glacial time (25-30,000 – the Würm). Recently acquired radiometric data documented that karst processes in the Triassic limestones also started during this time

Figure 5 - Entrance to the Buca a Frati cave.

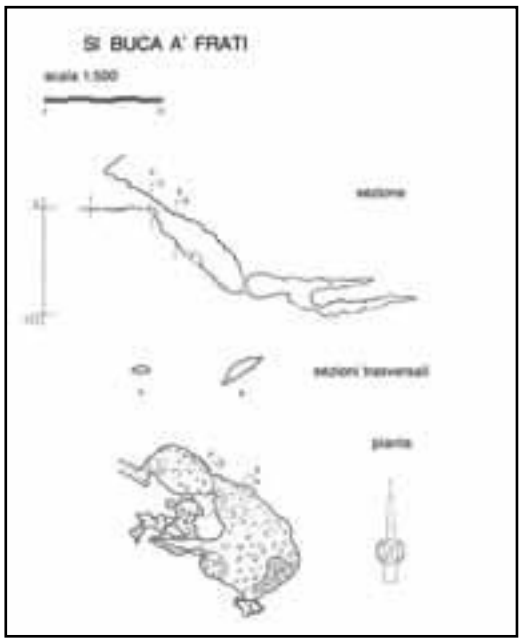

Figure 6 - Profile of the Buca a Frati Cave (from CAI, Sezione Speleologica, Siena).

(Pascucci and Bianciardi, 2002).
Most of these lakes were filled in the Late Pleistocene (200,000 years ago), others were drained in historical time between the XVI and the XVIII centuries to improve the environmental conditions and create new areas for agriculture. This induced a local change in the climatic conditions and a decrease in the available fresh water reserves. Although it has not yet been documented everywhere, this local change in the micro-climatic conditions of the Monte Maggio area induced a reduction of speleothem growth.

~ Km Notes

0 Fortezza da Basso. The Medici built this in 1534. Florence is located at the southeastern edge of the Firenze-Pistoia Plio-Pelistocene intermontane basin. It is crossed by the Arno River, which has experienced several large floods throughout the ages, the latest most-damaging one occurring in 1966.

- Follow the "Viali di Circonvalazione" to Porta Romana and take the road to Siena

5 Certosa del Galluzzo (Florence) was built in 1342 and housed the Certosini monks, and then became the Benedectine Cicestensis monks. It is located on the southern edge of the Florence-Pistoia basin, on carbonate turbidites of the Ligurides.

7 Start of the highway (superstrada) for Siena. Along the route note Oligo-Miocene turbidites of the Tuscan unit and of the Ligurides, and Pliocene conglomerates, sands and clay of the Neogene basins.

~ 31 Frontal view of S. Gimignano in the foreground. The S. Gimignano area was occupied by the Etruscans (III-II century BC). There are historical documents indicating that it was a village along the Via Francigena starting from 929 AC. The via Francigena was a pilgrimage route to Rome. Because of this route, money lending and other commerce activities (including that of saffron with several European and Middle Eastern cities grew, and so the town became prosperous, reaching its peak during the XII century. At its economic apex the town had 75 towers, which were symbols of power, and of which 15 are left. It became part of the Republic of Florence in 1351.

41 Poggibonsi

43 Note the superb cross-stratification in Pliocene shallow marine sandstones

46 Colle val d'Elsa. Ancient Etruscan (?) Roman settlement that became a free "comune" during medieval times (XII cent.). It became prosperous during the XIV century because of the wool, glass and paper

Figure 7 - Access to Buca a Frati.

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Figure 8 - The first floor of the cave with inactive spelethems. Only small recent (200 yrs old) stalactites are growing on the roof of the cave. The maximum height of the colums is 4 m.

industries. In the second half of the XV century it developed one of the first printing establishments of Italy. The glass industry is still very active: its crystal glass is famous.
50 Exit the superstrada at "Monteriggioni". Monteriggioni castle visible on the south side of the road. It was built by Siena in 1203 to protect the territory against Florence. It endured various battles and subsequent rebuildings of its walls, the latest occurring in 1260-70 after having been destroyed by Florence in 1244. The wall has 14 square towers.
54 Turn to the right, heading towards Colle val d'Elsa

Figure 9 - First floor. Column 2.5 m high (scale in black is 10 cm).

and, at the first intesection, turn to the left, towards Abbadia Isola.
57 At the Abbey take the gravelly road to the right and drive uphill for 3 km. At the second of a series of bends there is a path to the Buca a Frati cave (300 m).

Stop 1:

Buca A Frati Cave

Vincenzo Pascucci, Guido Bianciardi & Desirè Manganelli

Throughout the Monte Maggio several caves are visible and rich in speleothems. The Buca a Frati cave is one of the most accessible and especially offers a complete vision of the genesis and filling-in of the Monte Maggio caves (Fig. 5). The cave is developed over three floors and records three different stages of karst evolution (Fig. 6).

Figure 10 - Second floor. Active stalactites. The average high is 10 cm, but larger may be found as well.

Access to the Cave

The access to the cave is possible with a 30 m rope

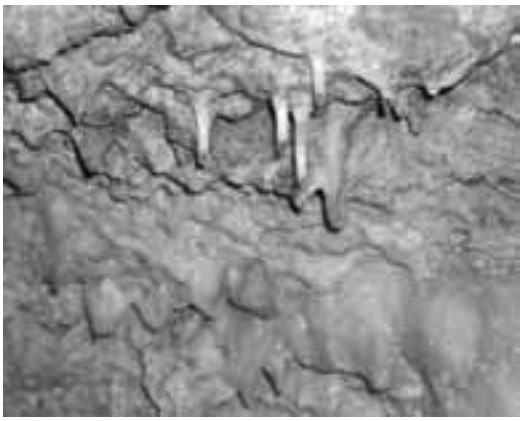

Figure 11 - Detail of 5-10 cm high stalactites.

Figure 12 - Layered calcite filling a pool. Scale is 10 cm

Figure 13 - Calcite deposits.

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and normal speleologicalequipment. Several anchorage points are present at the entrance(Fig. 7).
The second floor is accessible without any rope, whereas a rope is suggested for the lowermost, third one.
The first floor is characterised by rooms separated by columns, and represents the no longer active part of the cave. Most of the speleothems are inactive but fascinating for their colours, which change from white to red with all of the shades in between (Figs. 8, 9).
The second floor is the active part of the cave, with active stalactites and stalagmites (Figs. 10, 11). The third floor was probably flooded for a long
time and the evolution of several cave pools may be observed (Fig. 12). In this part of the cave several calcite layers are present. These were quarried, and traces of these activities are still visible (Fig. 13).

Water, lakes, fish ponds and monasteries
Luisa Dallai

The theme of water assumes a central importance in the history of the city of Siena; the chronic lack of water forced the local authorities to construct one of the most enduring works of civil engineering, back in the XIIIth-XIVth century, the so called "bottini", a subterraneous net of galleries created to collect and send to the springs the water retrieved around Siena. This extraordinary work is still in use and carries water to the fountains of the ancient city.
On the other hand, the countryside surrounding Siena was much richer in water, especially where, due to the geomorphology of the soils, vast ponds were formed. This is the case of the flat area nowadays completely drained, but still called "Pian del Lago", or that of the the "Pian del Casone", located between Monteriggioni and Colle Val d'Elsa, where the pond which existed during the middle ages is now attested to by two small lakes, the so called "Lago di S. Antonio" and "Lago Scuro", the last relicts of the land reclamation carried out in the XIXth century.
During the Middle Ages and, in some areas, even later in modern times, the presence of ponds and marshes, both near the cities and in the countryside, were of crucial importance to many aspects of the economy.
Since Roman times, a careful management of resources deriving from the presence of ponds was typical both of the coastal area, where the vast salted lakes had connoted and dramatically oriented the economy of numerous small and larger communities (let us mention, as an example, the economical system of two important medieval cities, Pisa and Lucca, which was partly based on the exploitation of the Arno

Figure 14 - Reconstruction of the Abbey of Abbadia Isola.

mouth) (Wickham, 2001) till the time between the two world wars (Rombai-Signorini, 1993), as well as of the inland areas. In medieval Tuscany, for a great number of local communities and for many cities, ponds were anything but marginal areas. For this reason, their management, together with the use of pond vegetation in agriculture (the ditch reeds were used, for example, as a light support for vineyards, or as a building material for huts) (Cammarosano, 1983), the use of fishing resources, the development of hunting activities, became good reasons to deliberately choose to maintain the marshes, rather than reclaim them. This last activity – the reclaiming -- was, by the way, extremely complicated and very expensive.

The economical importance of ponds clearly shows up from the laws and regulations imposed to protect them, as well as from the legal disputes concerning areas, which, nowadays, we would define "economically disadvantaged".

An emblematic example of the importance assumed by the marshes in the economy of the city of Siena is represented by the historical events linked to the so called "Padule del Canneto", in other words, the lake located in the Pian del Casone area, in the flat valley near Monteriggioni. In this area, very close to the pond, on the 4th of February of the year 1001, the countess Ava, widow of a noble of Lombard origin and ruler of Staggia, founded the monastery of Abbadia a Isola (Fig. 14). The monastery was called "dell'Isola", "of the Island", because of the tight connection it had with the water since its founding. The church was located along the "via Francigena" pilgrimage route along the Elsa valley. The initial core was formed by a small church with a single nave, of which only a few traces are still visible in the actual crypt; in contrast, the majority of the structures still standing of the monastic complex were realized under the abbot Ugo, by the first half of the XIIth century.

Among the priorities given to the monks of the abbey since its founding one was the management of the fragile environmental equilibrium, which made the marsh offer a whole spectrum of resources. The monks applied themselves to the maintenance and improvement of their properties, especially agricultural land properties. As time passed they tried more than once to reclaim the marsh in order to gain more land for agriculture; the community had grown and, by the half of the XIIIth century, aside the monastery a village had formed, with approximately 70 families. The monastery itself had enlarged, with new buildings, new cells for the monks, a cloister with a porch and a lodge, a hospital and, during the XIVth century, the fortifications realized by the Sienese. The abbey had, in fact, a strategic position, facing the Florentine army.

For all these historical reasons, and, most of all, because the Sienese government considered the marsh potentially a very good agricultural area to assign to the families living in the castle of Monteriggioni, the place was the set of numerous fights. The monks reacted several times to the policy of Siena; in some occasions their protests became tangible activities of remonstrance carried out in the marsh: for example they would cut hay for the animals of the abbey, or collect ditch reeds for vines and shrubs for bedding (Cammarosano, 1983).

In 1276 the Sienese local authority, the Comune, urged by the monks of Abbadia a Isola to undertake works in order to maintain the area in good condition, resolved, on the contrary, to flood the entire plan. In this way the city intended to solve the problem of stagnated water at its root, gaining, at the same time, a vast fishpond, extremely useful to easily obtain a certain quantity of food.

Figure 15 - Paleoenvironment reconstruction of the area between Monteriggioni and Siena.

Siena already had a specific area of fish and wood provision, an area close to the city completely under public control, strictly protected by rules written for its maintenance. The written documents call it "*Silva lacus*", the "wood of the lake", and it is equivalent to a part of the Monte Maggio relief and to the cur-

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rent "Pian del Lago", a toponym which still refers to a time not so far away (the reclamation of Pian del Lago dates back to the XVIIIth century), during which the waters covered a good part of the plan (Pellegrini, 2000).

Specific laws intended to protect and limit the use of these resources highlight the importance and profitability of this area. In the "*Silva lacus*" the local authority established a strict limit to fishing activities, and the punishments were listed in a specific chapter of the Sienese Consitution, dating back to 1262, entitled: "*De pena piscantium in lacu Silve*" (about the punishments for fishing in Lake Silva): "*…Et in lacu de Silva piscari non permittam in toto meo termino; et si quis contra fecerit, totiens XL sol. sibi auferam, quotiens contra fecerit et ibi piscatus fuerit…*"

The application of this law was entrusted to a special guard corps, called *forestarii*; "*…teneatur dicti forestarii rumpere et frangere tramallium et guadam et rete et omne argumentum, cum quo aliquis piscatur, ita minutatim quod ab inde in antea non possit cum eo piscari; et potestati renunctiare postea teneatur, qualiter et quomodo fecerint…*"(Zdekauer, 1974, *Il Constituto del Comune di Siena, anno 1262, III distinzione, rubrica CCCV*)

The rude attitude of the *forestarii*, so clearly described in the Sienese laws is extremely similar to that of the "silvani" or "custodes" which were engaged by the canonicals of the cathedral of Santa Maria in Pisa, in order to dissuade the abbot of the monastery of San Rossore from the use of the Silva Tumulus, the tombolo located north of the Arno mouth, the ownership of which was disputed between the two ecclesiastic entities (these documents refer to the years 1155-1156). (Wickham, 2001)

The same kind of discussions and arguments are found in the territory of the ancient city of Populonia (along the coast, south of Leghorn). In this area the salted lake of Piombino and the numerous economical activities gravitating around it had formed, since the XIth century, the principal income of the Benedictine monastery of San Giustiniano, which had been founded by the noble Gherardeschi family in the year 1022. (Ceccarelli, 1972). Precise details concerning the relation between the monastery and the pond emerge from the reading of the papal *bulla* dating to 1258. In this official document the pope Alessandro the IVth conferred to the monastery all the rights on several lands and churches in the area of Piombino and Campiglia Marittima. At that time the Benedictines had left the monastery of San Giustiniano, where the Clarisse of Massa Marittima were living. The pope wrote to them, in order to confirm all the rights and privileges previously claimed by the Benedictines. Talking about the pond the document mentions the "*…redditus quos habetis in…terras, possessiones, decimas frumenti et vini, stagnum, salinas foce …*". The *redditus* (the incomes) of this monastery, as well as those of many others, Abbadia a Isola included, were obviously varied and different, but a relevant part of them, as well as for the city of Siena, Pisa and Lucca, was based on the existence of ponds and marshes. For this reason the area of Pian del Casone and the abbey of Abbadia a Isola can be considered a very good example of this specific aspect of medieval economy.

St. Leonardo al lago Verano and St. Salvatore a Lecceto

Roberta Tracchini

The monastery of S. Leonardo al Lago had an important role in the expliotation of the resources related to the lake of Pian del Lago. The life itself of the reli-

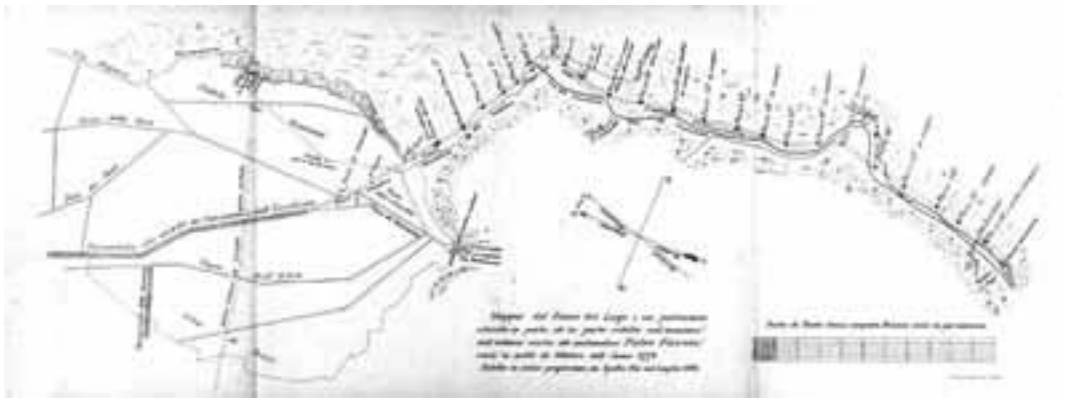

Figure 16 - Map of the Canale del Granduca (after Apelle Dei 1).

Figure 17 - The entrance to the Canale del Gran Duca

gious community was so strongly related to the products of the lake, that when the lake was reclaimed, its economic importance decreased (Fig. 15).
Here is a brief summary of the S. Leonardo and Lecceto monasteries (Figs. 2, 15).
In 1243 under Pope Innocenzo IV, all the Tuscan heremitages become Agostinian; this happened also for St. Leonardo alla Selva del Lago, and St. Salvatore a Lecceto, monasteries established in the XI centuries. The two monasteries were very close and often confused, until the 1782 when the Grand Duke, Leopoldo of Tuscany joined together the religious communities of St. Leonardo and Leceto.
The St. Leonardo convent in 1300 hosted Beato Agostino Novello, who established the order of Disciplinati.
The church of St. Leonardo goes back to the 1350 when, thanks to donations, the previous church was enlarged. Lippo Vanni, a Sienese painter, who lived between 1341 and 1372, frescoed the new church around 1360-70 with episodes from the Virgin's life. On the back wall of the main nave the "Annunciation" is visible and, laterally, "The temple presentation" and "The wedding". In the vault angels playing music can be seen, while below St. Leonardo (the protector of prisoners), and four miracles of the saint are depicted.

Figure 18 - Exit of the Canale del Gran Duca.

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Figure 19 - The Canale del Gran Duca - Inside view.

On the opposite side, St. Augustine is at the top of a frame with St. Monica and St. Augustine. In the council room there is the magnificent crucifixion from the 1400s painted by Giovanni di Paolo (1403-1483).
St. Leonardo was fortified in 1366 to offer shelter to the local population of the nearby village of S. Colomba, as testified by the surrounding wall and two towers.
The monastery of St. Salvatore a Lecceto was founded in 1200. It has been enlarged several times, in the 1700s reaching its present-day dimensions; in the 1500s the cloister was added and, in 1708, the tower. The portico in front of the church is, instead, dated to the 1300s. The monastery of Lecceto was suppressed under the Napoleonic government in 1808 and uninhabited until 1972, when a community of Augustinian nuns moved there.
Frescos inside the church, dated to 1374, were covered with plaster in the 1600s, in accordance with the Barocque fashion of the time, and only recently rediscovered. The quality of the frescos is, however, poor and probably done by the same unknown author.
Definitely better is the Archangel Michael, attributed to Ambrogio Lorenzetti, a fragment of a bigger fresco, unfortunately lost.
Six tabernacles in plaster hosted canvases with episodes of the life of the "Beati Leccetani". The only still preserved canvas, by Raffaello Vanni (1630), represents Pope Pio II visiting the "Beatus Landucci".
64 Drive back to Monteriggioni. Take the SS. 2 Cassia towards Siena.
74 Arrive at Pian del Lago. Follow the directions to S. Colmba.
80 Pass the intersection to go to S. Colomba and continue on for about 1 km. Take the gravelly road to the left, after about 500 m, to the right the path-way to go to S. Leonardo al lago, and after a bend park the car and take the path to the left with red and white signs. After 1 km you'll reach the entrance to the Canale del Gran Duca. The erntrance is indicated by a travertine piramide.

Stop 2:

Pian del lago and the canale del gran duca
Vincenzo Pascucci, Desirè Manganelli & Luigi Dallai

Pian del Lago is a lake which developed during the late Quaternary. It formed as a poljie on the Triassic limestones of the Tuscan Nappe (the Calcare Cavernoso Formation). The depression is N-S oriented, 4.5 km long, and 12 km wide (Fig. 2). The lake never exceeded 6 m in depth, and it was mainly a swamp plain during the dry season. The lake depression is filled with 20 to 30 m of a reddish silty-clayey succession
The chronic lack of water that vexed Siena during the medieval period explains the town's preoccupation with gathering and using any fresh water resource. However, the problem of the low water lake level had as its main effect malaria. This, linked with a strong bad stink, that during the dry period reached the nearby city of Siena, induced a nobleman, Francesco Bindi Sergardi, to reclaim the lake in 1766. A 2,124 m tunnel was excavated in the Triassic limestones to connect the Pian del Lago lake with Rigo creek. The project costs exceeded 37,000 scudi and did not obtain the expected results. The lake was drained, but quite often the tunnel was filled with debris and the lake swamped up again. In 1777 Pietro Leopoldo Grand Duke of Tuscany definitively reclaimed the Pian del Lago lake by paving and extending by 197 m the underground draining canal (Fig. 15). The canal is called the" *Canale del Gran Duca"* in honor of the Duke, and in recent time, thanks to the volunteers of the La Diana Association, the canal can be visited.
The starting altitude (Fig. 16) of the canal is at 252 m

Figure 20 - Stalactites in the vault of the Canale del Gran Duca.

a.s.l., and the exit (Fig. 17) is at 247 m a.s.l.. Altitude difference is therefore of 5 m, with a dip of 0,2 %.
Twenty-two wells for air are present along the canal-length. These were also used to carry out the excavated material. The canal is for the most part paved (Fig. 18) but, in places, solid walls of Triassic limestones are still visible. In several places diffuse karst features are forming. Stalactites whose lengths are comprised between 5 to 10 cm (Fig. 19), small pools, and drapes are present at several localities. The presence of these speleothems has allowed some comparison between the newly formed stalactites and the old ones present in caves.
The tunnel was terminated in 1777, and possibly initially, it was cleaned and well maintained. It is possible, therefore, to assume that all the speleothems present have developed in the last two centuries. This implies that the maximum growth of a stalactite is 5 cm every 100 years. If this were true we may assume that the 0.5 mm per year could be the average growth of a stalactite in the Triassic limestones of the Montagnola Senese area. No data however, are available for stalagmites.

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Back Cover:
Map of Tuscany where the stops of the field trip are indicated

FIELD TRIP MAP

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