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GEOARCHAEOLOGY AS A TOOL FOR RECONSTRUCTING THE EVOLUTION OF THE APUO-VERSILIAN PLAIN (NW ITALY)

Abstract: BINI M., BARONI C. & RIBOLINI A., *Geoarchaeology as a tool for reconstructing the evolution of the Apuo-Versilian Plain (NW Italy).* (IT ISSN 0391-9838, 2013).

A geoarchaeological approach integrating geomorphological, stratigraphical and archaeologic data was adopted to reconstruct the palaeogeographic evolution of an area of the Apuo-Versilian plain since the Etruscan age. We produced a geomorphological map, analyzed stratigraphy data from sections/boreholes in the plain, and compiled a dataset of archaeological findings with a particular focus on the Acquarella site which is an outstanding settlement in the area.

The plotting of the archaeological findings on the geomorphological map allowed to better constraint the landforms surveyed by field work and remote sensing analyses.

The analyzed stratigraphic data suggests a discontinuous trend of coastal progradation. Oscillations in this trend are testified by four small scale transgressive - regressive parasequences that occurred after 4600 yrs cal B.C.. In agreement with the archaeological findings on the surface, the base of the uppermost sequence was dated to ca 500 cal AD, implying that since the Early Middles Ages the progradation trend has been continuous. Furthermore, a pronounced increase in progradation was observed after the 16th century, probably linked to both climatic influence (Little Ice Age) and human impacts (deforestation).

The Acquarella rustic building has developed in this coastal-piedmont context since the Etruscan age. The reason for its longevity (6th century B.C. - Early Middle Ages) was related to a suite of environmental aspects such as the protection offered by the surrounding hills, water availability, and the elevation above a coastal plain experiencing periodic flooding. Moreover, a crucial element was identified in the position of the site in respect to the main ancient roads connecting Pisa to Luni (*Via Aurelia/Aemilia*) and the coastal area with the inland.

The correlation of the geomorphology with the archeological data from Acquarella, along with the other findings along the coastal-piedmont area allowed to depict the landscape scenarios relative to the Etruscan, Roman, Early Middle ages and Modern ages.

KEY WORDS: Geoarchaeology, Late Holocene, Coastal progradation, Apuo-Versilian Plain (Italy).

RIASSUNTO: BINI M., BARONI C. & RIBOLINI A., *Geoarchaeologia come strumento per la ricostruzione dell'evoluzione della pianura Apuo-Versiliese (NW Italia).* (IT ISSN 0391-9838, 2013).

In questo lavoro viene utilizzato un approccio geoarcheologico, basato sull'integrazione di dati geomorfologici, stratigrafici e archeologici, per la ricostruzione dell'evoluzione di un settore della Pianura Apuo-Versiliese a partire dall'età etrusca.

In particolare è stata realizzata una carta geomorfologica, sono stati analizzati dati stratigrafici derivanti da sezioni e carotaggi effettuati nella pianura e sono stati descritti e catalogati tutti i ritrovamenti archeologici presenti nell'area. Particolare attenzione è stata posta al sito dell'Acquarella che è il più importante della zona di studio. Il posizionamento dei ritrovamenti archeologici sulla carta geomorfologica ha permesso di datare le forme individuate tramite rilevamento di campagna e telerilevamento. I dati stratigrafici suggeriscono una tendenza discontinua di progradazione della pianura, nella quale, a partire da 4600 anni fa, sono stati individuati quattro piccoli cicli trasgressivo - regressivi. In accordo con i ritrovamenti archeologici sulla superficie, la base della sequenza più alta è stata datata a 500 cal. d.C., suggerendo una progradazione continua solo a partire dal basso medioevo. Inoltre un pronunciato incremento nel tasso di progradazione è stato osservato dopo il XVI sec., probabilmente legato sia a cause climatiche (Piccola Età Glaciale), che all'impatto antropico (deforestazione).

L'insediamento dell'Acquarella nasce e si evolve in questo contesto costiero-pedemontano già a partire dall'età etrusca. Le ragioni della continuità insediativa di questo sito (VI secolo a.C. - Basso Medioevo) sono da ricercarsi in fattori ambientali quali la protezione offerta dai vicini rilievi, la disponibilità di acqua e la quota topografica leggermente elevata rispetto alla pianura oggetto di frequenti episodi alluvionali. Tuttavia, deve aver giocato un ruolo chiave anche la posizione del sito rispetto al sistema viario: l'Acquarella si colloca, infatti, in un punto nevralgico della viabilità antica, nell'area di snodo tra il percorso costiero che univa Pisa e Luni (via Aurelia/Aemilia) e quello che dalla costa si addentrava verso l'interno per raggiungere Lucca.

L'integrazione tra dati geomorfologici, stratigrafici e archeologici del sito dell'Aquarella e degli altri dell'area studiata ha permesso di ricostruire il paleopaesaggio costiero nei diversi periodi storici a partire dall'età etrusca fino all'età moderna, passando per l'età romana ed il basso medioevo.

TERMINI CHIAVE: Geoarcheologia, Tardo Olocene, Progradazione costiera, Pianura Apuo-Versiliese (Toscana).

INTRODUCTION

During the last 2 millennia, coastal areas in the Mediterranean region experienced important climatic changes

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that, along with from human activities have transformed the landscape in a way difficult to be disentangled (Luterbacher & *alii*, 2013; Mackelin & *alii*, 2012; Mercuri & Sadori, 2012; Zanchetta & *alii*, 2013). In this regards, a holistic geoarchaeological approach may contribute to understand the history of coastal areas encompassing both natural and human-induced changes (Butzer, 2011; Marriner & *alii*, 2013).

The Apuan-Versilia coastal plain (NW Italy) is of particular geological importance for Holocene stratigraphy. In fact, the *locus typicus* of the *Versilian* (corresponding to the Holocene transgression which followed the Last Glacial Maximum) was defined in this area (Blanc, 1937; 1942; Federici, 1993). Furthermore, this coastal plain was undoubtedly an area of great strategic importance from both a historical and archaeological viewpoint. Already at the end of the 3rd century B.C. it was much-desired by Rome as part of its expansionist designs, not only to establish its logistic bases for military operations towards the west, but also to ensure access to the trans-Apennine routes connecting the Tyrrhenian and Adriatic coasts. Land communication routes were a key element in this part of the plain, foremost the Aurelia/Aemilia road which probably already linked Rome to Pisa in 241 B.C. following the construction of *Portus Lunae* at the mouth of the river Magra (Fabiani, 2006; Paribeni & Fabiani, 2012).

A geoarchaeological approach has been widely used in the study of extremities of the Apuan-Versilia plain: the lower Val di Magra to the north (Bini & *alii*, 2012; 2010; 2009a, 2006; Bisson & Bini 2012; Delano Smith & *alii*, 1986) and the plain of Pisa to the south (Amorosi & *alii*, 2013; Mazzanti 1994). However, only a few preliminary (Bini & *alii*, 2009b) or regional-scale studies (Federici & Mazzanti, 1993; Mazzanti & Pasquinucci, 1983) are available for the intermediate area.

The stretch of coastline under study (fig. 1) was chosen because it includes all the typical geomorphological elements of the Apuan-Versilian plain and also hosts the Acquarella archaeological site, one of the most significant in the area. The aim of this work is to define the paleogeographical evolution of the plain and its relationship to the history of human occupation, using elements both at the landscape and site scales. Integrating and complementing the results of this work with the knowledge already available in the North and South areas the coastal plain may provide a starting point for a future regional synthesis.

FIG. 1 - Shaded relief of the Apuan Versilian plain and bordering Appenine chain. The study area and the position of the Enea Core are indicated. Hatched arrows show the direction of longshore drift.

GEOMORPHOLOGY

Geomorphologic surveys and remote sensing analyses were used to produce a detailed geomorphological map. Multi-temporal airborne photos (captured between 1938 and 2010) and satellite images (Quick bird, Aster, Landsat 7) supported the identification of the main palaeohydrographic features. Six geomorphological units were detected on the plain between the Acquarella archaeological site and the sea: 1) a major fan at the outlet of the Camaiore stream (in the following Camaiore alluvial fan), and minor fans draining the mountain facing the coast, 2) the alluvial plain, 3) costal dunes, 4) small marshes located in the interdune areas, 5) a major marsh area named Giardo, and 6) the present-day beach (fig. 2). The Camaiore alluvial fan covers an area of about 7 km^2 and records cyclic depositional and quiescent phases during the Late Pleistocene-Holocene. The alluvial fan reaches an elevation of 20 m in the foothills (apex) and decreases up to 2 m asl towards its distal area with a very low gradient (<2% average dip) (fig. 2). A channel migration from west to east is suggested by the identification of several palaeo-channel traces on the fan surface. Minor alluvial fans connect the coastal plain to the foothill of the Apuan Alps and locally overlap the Camaiore fan.

The Acquarella archaeological site is located on one of these small fans (fig. 2, n. 2). The hills surrounding the site northward and eastward are characterized by altitudes ranging between 20 and 300 m asl; bedrock lithology varies from calcareous to shale (Carmignani & *alii*, 2000). Westward of the archaeological site there is a small residual relief 11 m high and 200 m wide (fig. 2). Some palaeotraces consistent with an old course of the Acquarella stream

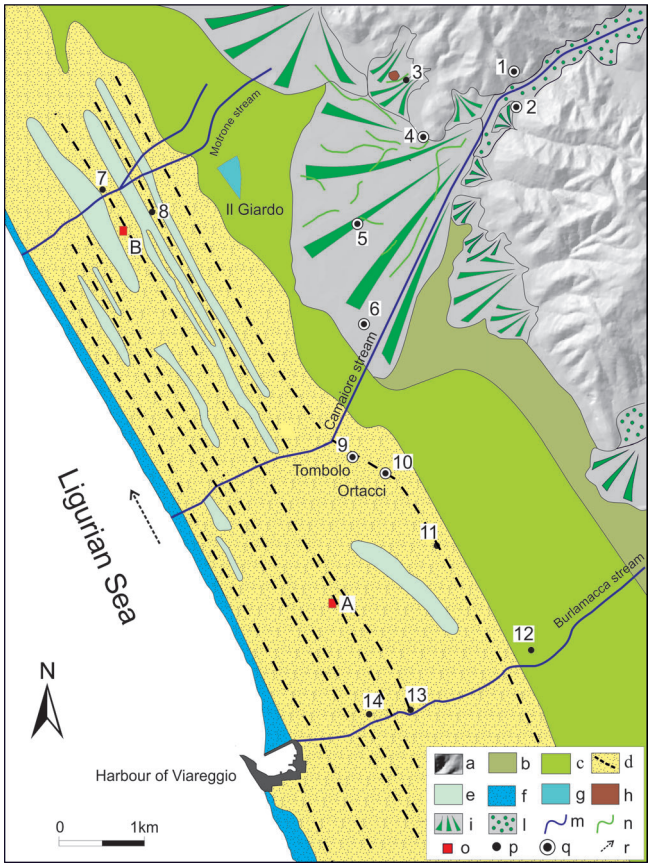

FIG. 2 - Geomorphological map with the location of the most important archaeological sites: a) bedrock; b) alluvial plain; c) Giardo marsh area; d) coastal plain with main crest ridges; e) interdune wet area; f) current beach; g) Giardo artificial lake; h) residual relief; i) alluvial fan; l) alluvial deposit; m) current hydrography; n) palaeo-hydrography; o) stratigraphic sections studied; p) archaeological findings; q) archaeological findings with uncertain location; r) longshore drift direction. Archaeological findings: 1) Capocavallo; 2) Villa Mansi; 3) Acquarella; 4) Capezzano; 5) Trebbiano; 6) Bucine; 7) Motrone Fort; 8) Tongo; 9)Tombolo; 10) Ortacci; 11) Migliarina; 12) San Rocchino; 13) Old castle of Viareggio; 14) Matilde Tower.

were identified in the small alluvial fan. The Giardo marsh is located between the Camaiore alluvial fan and the oldest dune ridge alignment, and it corresponds to a lowland about 1.8 km long and 1.5 km wide. It is occupied by a small permanent lake and several ephemeral marshes. The jointed dune ridges and respective crests, recording the position of the shoreline during the Late Holocene, are located between the Giardo marsh and the present-day coastline (fig. 2). These dunes form an articulate ridge system closely spaced with interdune marshes. The landward dune (Migliarina ridge dune in fig. 2 n. 11) located in front of the Massaciuccoli Lake area is the most elevated (1.5 m asl) and the best preserved. The last geomorphological unit moving seaward is the approximately 100 m wide present-day beach. This beach is not presently experiencing relevant erosion or accretion processes (Gruppo Nazionale per la Ricerca sull'Ambiente Costiero, 2006).

CHRONOSTRATIGRAPHY OF THE LAST 6,000 YRS

New radiocarbon ages (tab. 1) enable to constrain the interpretation of the two cross sections (A, B) already studied adopting the concepts of facies analyses by Bini & *alii*, 2009b.

TABLE 1 - ^{14}C results (Centrum voor Isotopen Onderzoek, Groningen). Ages-calibrated by means IntCal09 and Marine09 (Reimer & *alii*, 2009), probability of occurrence according to the 2σ range (95.4%), marine shells corrected for the reservoir effect

Sample name	Depth	Sample description	Conventional age yrs BP	2σ min, max yrs cal AD
GrA 32901	-2.4 m	FOC2	1595±30	408-541
GrA 32109	-1.4 m	FOC6	1100±35	1221-1355

Section A (6 m deep and 100 m wide) and section B (3 m depth and 15 m wide) are located to the South and to the North of the studied area respectively (fig. 3, 4), and are cut in the same geomorphological unit (coastal dunes).

The stratigraphic correlation with the ENEA core (Antonioli & *alii*, 2000) about 10 km south-east of the study area (fig. 2; see fig. 1 for the location) allowed to assign an age of about 6675-6577 yrs cal. BP to the base of the A section (Bini & *alii*, 2009b).

Detailed facies analysis of Section A showed the presence of 4 transgressive/regressive cycles (A1, A2, A3, A4, in fig. 3) within the overall regressive trend passing upward from shallow-marine to coastal-dune deposits (Bini & *alii*, 2009b). These cycles show that the coastal progradation has not occurred continuously but experienced phases of both stability and retrogradation. Section B allows a chronological description of almost the totality of the last cycle (A4). This latter starts with a backshore to upper shoreface deposits, grades into a centimetric layer of peat related to a paralic environment now dated back at 408-541 yrs cal. BP, and terminates with a 2.5 m thick pedogenized dune deposits (fig. 3).

ARCHAEOLOGICAL DATA

Human settlements in this part of Apuo-Versilia plain are testified by archaeological findings which have been recorded since the 16th century. All the findings were plotted on the geomorphological map (fig. 2). The Acquarella site (fig. 2, n. 3) shows a remarkable continuity of human settlement since the Roman Archaic period to the early Middle-Ages (Paribeni & *alii*, 2006; Paribeni & Fabiani 2012). The burial site which was found at Villa Mansi, close to Acquarella (fig. 2, n. 2), perhaps part of a necropolis, suggests the existence of a village and demonstrates the vitality of the area since the end of the 7th century B.C. (Ciampoltrini 1990). On the coast, the relevance of the maritime commercial activity is demonstrated by the settlement of San Rocchino (fig. 2, n. 12). This site was in-

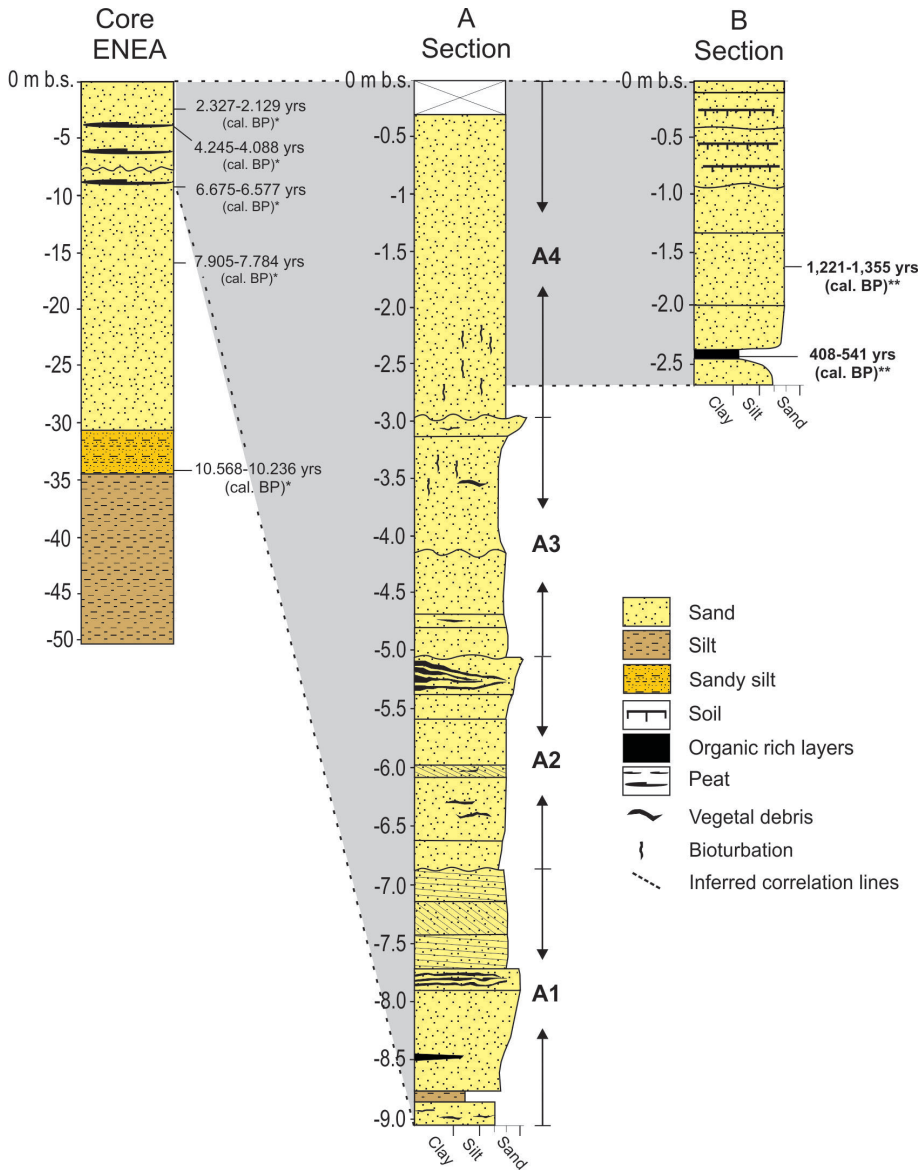

FIG. 3 - Stratigraphy of the sections A and B correlated to the Enea core (modified and updated after Bini & *alii*, 2009b). Enea core data (stratigraphy and radiocarbon data) have been derived from Antonioli & *alii*, 2000.

habited from the end of the 8th century B.C. up to the 3rd century B.C., and was situated on the border of an ancient lagoon area. After foundation, this settlement was devoted to the commercial economy and was visited constantly by sailors coming from south-Etruria, Greece, and the area east of Greece. The Migliarina site (fig. 2, n. 11), a productive and specialized settlement dating to the end of the 7th century B.C., was located on a coastal dune deposit marking the coast line during this time. Behind the dune, a marsh area connected to the sea developed. One of its purposes was, perhaps, salt production (Ciampoltrini, 2005). For the Roman age, in addition to the Acquarella site (Fabiani & Paribeni, 2012), weak traces of centuriation, together with occasional discoveries (fig. 2, n. 1, 4, 5, 6) on the coastal dune (fig. 2, n. 8, 9, 10), confirm the settlement of this area (Bini & *alii*, 2009b). The most important elements of Roman times are the land roads attested in this area by ancient sources, maps and airborne analyses and archaeological remains (Fabiani, 2006). An important road, which could be identified with the Aurelia/Aemilia Scauri, ran along the past coast, while another one was placed along the foot-hill (fig. 5). Both roads link Pisa to Luni. A further road connecting the inland (i.e. Lucca) to the viability of the coast is documented in the Camaiore valley near the Acquarella site (fig. 5). All these roads cross the territory at least since the III Century B.C. (Paribeni & Fabiani, 2012).

The Fortress of Motrone (fig. 2, n. 7), erected *in maris littore* (Giannotti, 2006), and the Old Castle of Viareggio (fig. 2, n. 13), which was built during the 12th Century A.D., are important reference points for dating the coastal dune deposits in the Middle-Ages. In Viareggio town, the building of the new Tower Matilde (fig. 2, n. 14) during the 16th Century, in a more advanced position than the old fortress, demonstrates the gradual advance of the coastline.

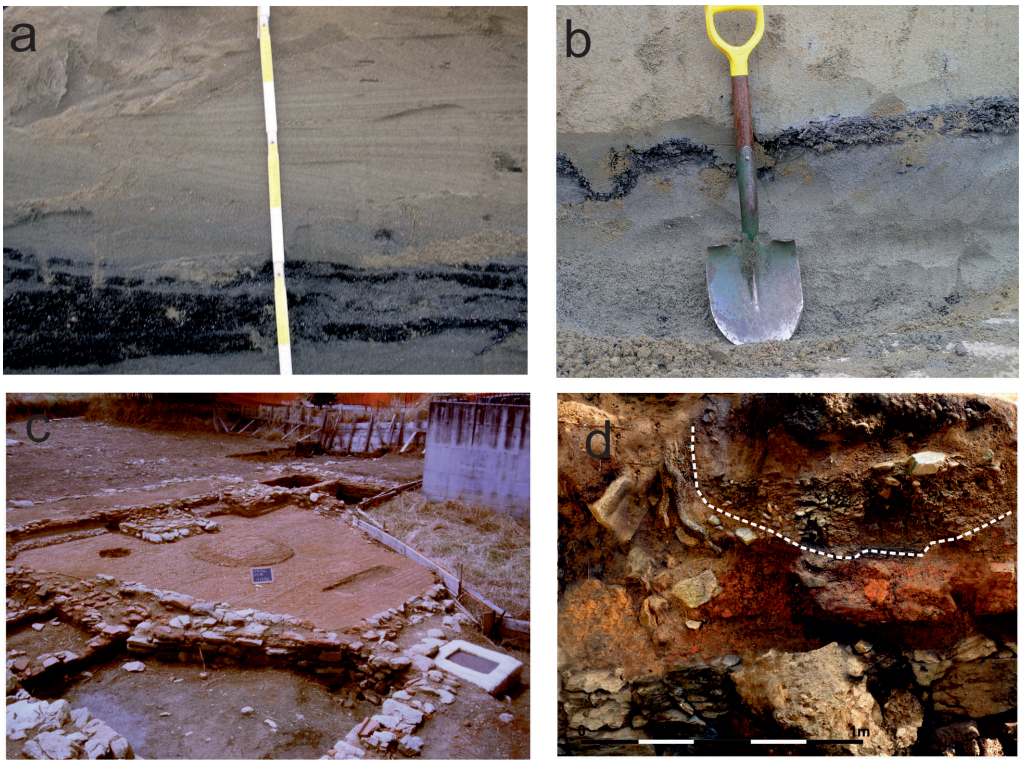

FIG. 4 - Detail of stratigraphic sections B and A both showing a peat layer at the bottom and upper part of the dune ridge deposits (4a and 4b); a detail of the olive oil press in the archaeological site of Acquarella (4c) and the stratigraphic section showing the palaeochannel deposits alimented by the Acquarella stream (4d).

STRATIGRAPHY OF THE ARCHAEOLOGICAL SITE OF ACQUARELLA

The long-lasting settlement of the Acquarella site enables to connect some of the natural consequences of the plain transformation to the characteristics of the human frequency. The stratigraphy of the archaeological site is summarized in fig. 6.

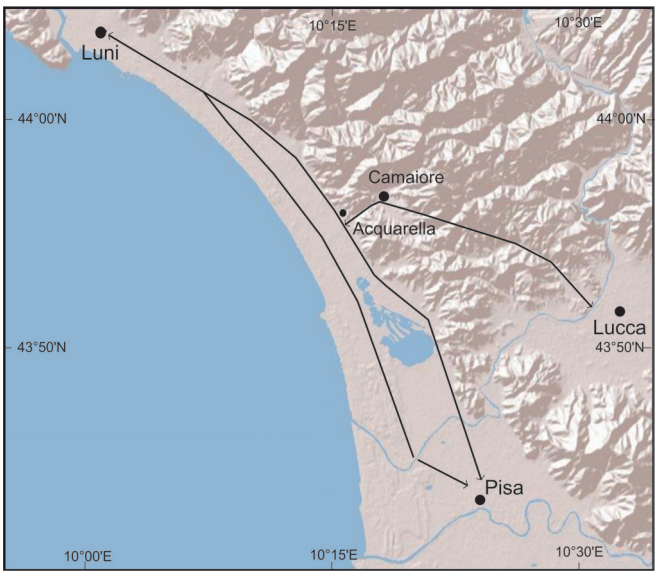

FIG. 5 - Main road lines directions connecting Pisa Luni and Lucca during Roman time (by Fabiani & Paribeni, 2012).

The first settlement goes back to the end of the 6th Century B.C. (Paribeni & Fabiani, 2012) documented by significant of ceramic remains (not in stratigraphic sequence) found during the excavation for the construction of a modern house. A wall of schist stone (in section a1) is the only evidence of the Preroman period in the stratigraphic sequence. The main architectonic evidence is consistent with the Roman period. In fact, the site shows the construction phases of a rustic building which was reorganized many times, from the Republic age up to late-Antiquity (fig. 6). In particular an olive oil press with related storehouse has been discovered (fig. 6 and 4c). Concerning the Roman age, a stone bank that should have been created for purposes of protection against floods (likely of Acquarella stream) has been identified in section c. During the Early Middle Ages a settlement of huts took place in this area, as testified in some stratigraphic sequences (i.e. settling ponds). Alluvial deposits cover the Roman floor over much of the site, testifying to a reworking of superficial stratigraphy with the discontinuous erosion of Middle ages stratigraphy. The deposits infilling a small palaeochannel of the Acquarella stream have been identified in the a1 section (fig. 4d). These alluvial deposits cover an archaeological site already ruined (fig. 6).

DISCUSSION

The Acquarella archaeological site is located in a protected area. The elevation slightly higher than the alluvial plain, the surrounding hills and particularly a small resid-

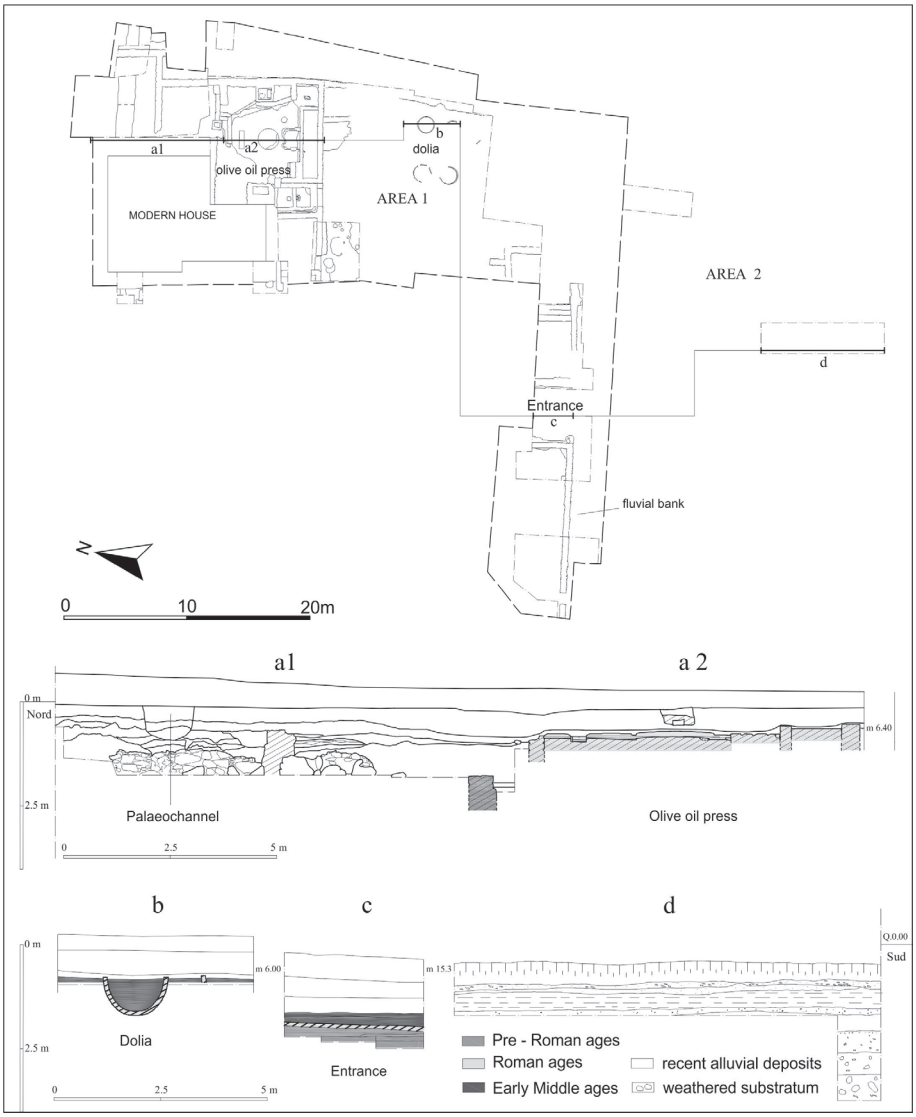

FIG. 6 - Stratigraphy of Acquarella archaeological site. Area1 = The rustic building interior; Area 2 = The rustic building peripheral; a1 = Fortuitous section with no chronological constraints; a2, b and c = section of archaeological extensive excavation with chronological constraints; d = stratigraphic section outside of archeological excavation.

ual relief protect it from major floods. Furthermore, the small Acquarella stream has been a resource for production activities. Nevertheless, the reasons for the prolonged prosperity of the site can only be understood by contextualizing the site in relation to the palaeogeographic evolution of the coastal plain.

The palaeogeographic evolution of the Apuo-Versilian plain in the Late Holocene can be reconstructed by integrating the geomorphological, stratigraphical and archaeological data.

Etruscan age

The landscape around 2600 yrs ago (fig. 7) was characterized by a coastline located about 2.5 km landward in respect to its present-day position, behind the beach ridge of Migliarina, a wide protected brackish wet area (Giardo) developed, probably connected to the northward extension of the Massaciuccoli lake system. An alluvial fan system (Camaiore Fan) periodically connected with the Giardo marsh characterized the hillfoot area. The Acquarella site became an important centre in the commercial trades between the sea, coast, and inland areas. Its importance may also be due to its proximity to the back dune wet area of Giardo, developed around the 7th Century B.C. and likely in connection with the Massaciuccoli Lake area to the south. This connection may have provided an access to the sea, according to the features of the San Rocchino site (fig. 2, n. 11) settled from the end of the 8th Century B.C. up to the 3rd Century B.C and devoted to shipping traffic.

Roman age

During the Roman age the archaeological site of Acquarella experienced its heyday, the small stream flowing in the south east area of site (as evidenced by the protective wall) was a resource for production activities (fig. 7b). However, the reasons for the prosperity of this site during

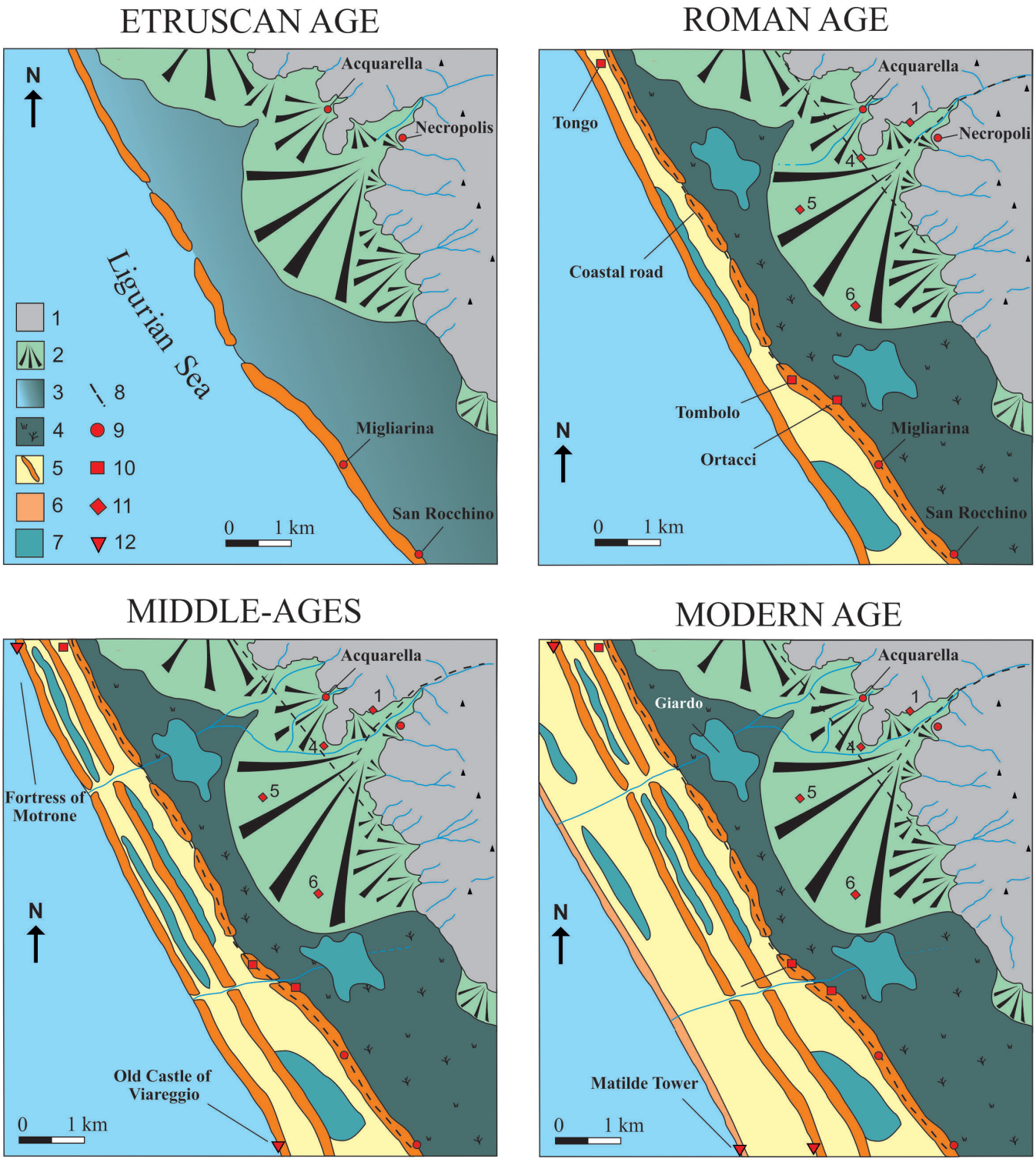

FIG. 7 - Palaeogeographic reconstructions of the study area during Etruscan, Roman, Middle and Modern ages. 1: bedrock; 2: fluvial deposit and alluvial fan; 3: lagoon; 4: marsh; 5: coastal deposits with dune ridge; 6: modern beach; 7: brackish water locally interdunal; 8: roman road; 9: archaeological site; 10: archaeological findings; 11: site reported by historical sources; 12: coastal tower.

the Roman age are most likely to be found in its strategic position with respect to the roads network. In fact, it was located in the roads junction from inland and costal directions linking Pisa to Luni and Lucca. These roads, together with centuriation on the Camaiore alluvial fan, are a clear sign of romanization of this territory since the 3rd

Century BC. In the Giardo area there are not archaeological findings and neither of centuriation. Even if a chronological constraint is not provided, it could still be a wet area in this period. The coastline during the Roman period was located between the Migliarina dune and the dune ridge where Motrone fort and Old Castle of Viareggio are located, slightly seaward of the coastal Roman road (fig. 7).

Middle Ages and later periods

The Acquarella site became a settlement of huts in the high Middle ages, and after this it was abandoned. A shift of the small Acquarella stream from south east to north west occurred. In the 15th century the Camaiore stream is also attested in a different position with respect to the present course. On the basis of fluvial palaeotrace identified in fig. 2, an historical map of the 15th Century shows a course flowing along the northern boundary of the study area (fig. 8). While the wet area of Giardo underwent a progressive infilling, the coastline experienced a progradation that can be chronologically constrained by archaeological data (fig. 7). Around the 12th Century the coastline is attested in proximity to the dune alignments where Motrone Fort and the Old castle of Viareggio (fig. 2 n. 7, 13; fig. 7; fig. 8) were built. Four centuries later the coastline had again moved seaward by about 500 m to the position where the Matilde Tower (fig. 2, n. 14) was erected. From the 16th Century to the present time the progradation of the coastline has proceeded of about 700 m. Interdune wet areas were employed as fish tanks (Benzio, 1986) from the Early Middle ages up to the 18th century and represented an important economic resource for the local community.

Progradation of coastal plain versus climatic-human factors

Despite a slowdown in the rate of increase of sea level since 6000 yrs (Antonioli & *alii*, 2004; Lambeck & *alii*, 2004; Morhange & *alii*, 2013), the progradation of this coastal plain occurred only since about 3000 yrs. A similar onset in the coastal progradation has been documented in the area of the principal river mouths of Western Italy: Magra River (Bini & *alii*, 2012), the Arno (Della Rocca & *alii*, 1987; Pranzini, 2001), the Cecina (Benvenuti & *alii*, 2008), the Ombrone (Bellotti & *alii*, 2004, Innocenti & Pranzini, 1993), and the Tevere (Giraudi, 2011; Gruppo Nazionale per lo Studio dell'Ambiente Costiero, 2006). This synchroneity suggests that the progradation of this part of Mediterranean coast was forced by global rather than local factors.

During the last 2700 years, the Versilian coastal plain experienced a progradation of about 2000 m, with an average rate of 0.7 m/yr. Nevertheless, it is worth noting that this rate does not consider all the fluctuations that have occurred during this timel interval (e.g., increase or reductions of the rate of progradation, or even phases of retrogradation of the coastline). These fluctuations, documented in several lower coastal plains of Italy and also along sectors of NW Mediterranean region (i.e. Carozza & *alii*, 2012; Rey & *alii*, 2009; Vella & *alii*, 2005) have been evidenced in the study area by the 4 four small cycles documented since about 6600 yrs BP (fig. 3 section A). The radiocarbon data for section B indicate that only after the 12th century no retrogradations have occurred, and the trend of progradation became continuous. For this reason the evaluation of the progradation rate is more reliable af-

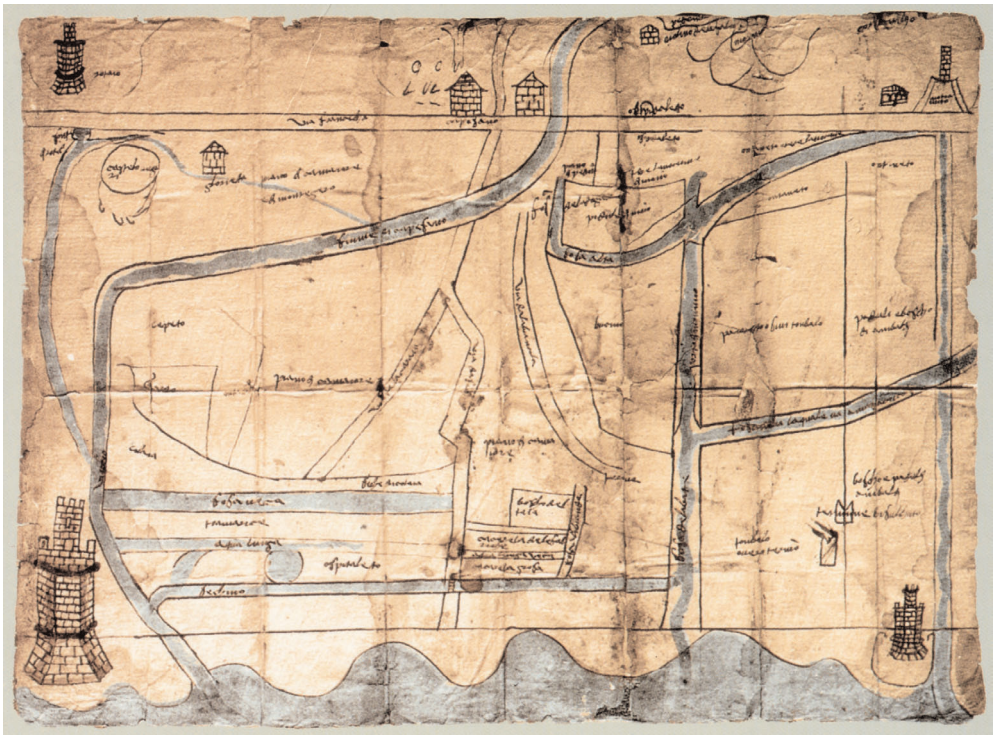

FIG. 8 - An hystorical map of 15th century from the historical archives of Camaiore village.

ter the 12th Century (Tab.2). The rapid increase after the 16th Century (up to 2.5 m /yrs), appears to be relevant and fits with the results from important river mouths along the western Italian coast (Gruppo Nazionale per lo Studio dell'Ambiente Costiero, 2006). Specifically for the centre-norther Tyrrhenian coast, the progradation rate of the study area and the Arno, Ombrone and Tiber rivers shows a similar trend, with the less entity in the Versilian plain coherent with the fact that it is not a deltaic area (fig. 9). Interestingly, the analysis of flood frequencies of selected European rivers during the 16th Century (Brazdil, 1999) reveals that in northern-central Italy there were very frequent floods during the first half of this century (Benvenuti & *alii*, 2008; Luterbacher & *alii*, 2013). Similar conditions are also documented also for the Rhône delta (Rey *alii*, 2009; Vella & *alii*, 2005) and for several other western Mediterranean deltas (Carozza & *alii*, 2012). In this regards, the increase of progradation rate of coastal plains, Versilia included, could be linked to enhanced sediment supply (Bellotti & *alii*, 2004) during the cooler, wetter conditions of the Little Ice Age (Luterbacher & *alii*, 2013) driven by an increase in the frequency of floods.

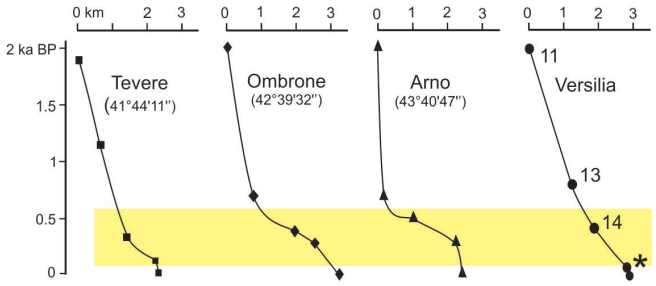

FIG. 9 - Progradation rate of the Apuo-Versilia plain since roman time (this work), compared with data reconstructed from the deltaic areas of Tiber (Giraudi, 2011; Gruppo Nazionale per lo Studio dell'Ambiente Costiero, 2006.), Arno (Della Rocca & *alii*, 1987; Pranzini, 2001) and Ombrone (Innocenti & Pranzini, 1993; Pranzini 2001; Gruppo Nazionale per lo Studio dell'Ambienti Costieri 2006) rivers. 11, 12 and 13 in the Apuo-Versilia curve, correspond to the Migliarina roman dune, the Old castle of Viareggio and the Matilde Tower (see fig. 2 for location); * datum is the coastline retrieved by a 1903 historical map (Istituto Geografico Militare archive).

It should also be noted also that deforestation and grazing activities probably overlapped with climatic factors, exacerbating the landscape transformation *via* soil erosion and consequent increasing of river load. Pollens analyses and archaeological data from central Italy documented that at least since 1500 yrs BP humans have modified the vegetation through farming practices both in mountains (Northern Appenine) and in lowlands (Massaciuccoli and Accesa lakes) (Colombaroli 2007; Branch & Marini, 2013; Luterbacher & *alii*, 2013 and references therein).

CONCLUSIONS

A geoarchaeological approach may provide a complete history of coastal plain transformations temporally refining the progradation/retrogradation phases and discerning between natural causes and human forcing in variations in sedimentary budget specifically for the Apuo-Versilian plain the main results obtained can be summarized in three points:

- the palaeogeographic recontructions carried out for the Etruscan, Roman and Middle ages are coherent with the timing and characteristics of coastal progradation depicted by the geomorphology and subsurface data of the area.
- four small scale fluctuations in the general trend of progradation were identified by the stratigraphic data since ca. 6600 cal yrs BP (4600 yrs BC). A discontinuous progradation of the coastline was described between the 7th Century BC up to the 12th Century AD. The bottom part of the last cycle was chronologically constrained to the Early Middle ages (12th Century AD). The increase of progradation rate occurred after the 16th Century AD may be related to an increase in flood frequencies, tentatively interpreted as the overlapping of climate events (colder and wetter conditions during the Little Ice Age) and humans impact (deforestation).

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