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G. Schörner (ed.), The Vienna Orme and Pesa Valley Project
DOI: 10.25365/phaidra.239_08

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Geoarchaeology at the Pesa and Virginio Confluence

Reconnaissance and Soil Chemistry

Within the framework of the Vienna Orme and Pesa Valley Project, geoarchaeological investigations were conducted to situate the sites in the wider landscape and provide context for the main project objectives, including the nature of rural land use and the cultural processes affecting it, issues of site definition and site classification, and differing patterns of material culture. Reconnaissance geoarchaeological survey, coring systematic, and soil sampling was carried out between 2015 and 2016 to characterize sediments, collect samples for geochemical analyses, and place sites and artifacts in an environmental and geological context.

Keywords: *geoarchaeology; reconaissance surveys; soil chemistry; palaeoenvironment; Roman rural landscape*

1 Introduction to the geoarchaeological investigations

The Vienna Orme and Pesa valley Project (VOPP) investigates changes and continuities in human behavior and land-use during the Roman period at several sites within in a well-defined micro-region in central Tuscany. Geoarchaeology, as a cross-disciplinary approach linking human activities and the environment, provides data about human-environmental interactions and the formation of the archaeological record at multiple spatial and temporal scales. As such, geoarchaeological investigations are increasingly important aspect of archaeological research in Tuscany, the wider Mediterranean world and beyond.[1]

Geoarchaeological investigations were conducted to situate the sites in the wider landscape and provide context for the main project objectives, including the nature of rural land use and the cultural processes affecting it, issues of site definition and site classification, and differing patterns of material culture.[2] Specifically, we proposed to address the regional geomorphology, processes of erosion and sedimentation, and anthropogenic soil inputs. The goals of this research are to aid in reconstructing the ancient landscape and predict where archaeological deposits are likely to be hidden, exposed, or eroded by natural and anthropogenic processes. Reconnaissance geoarchaeological survey and coring was carried out in 2015 to characterize sediments, collect samples for geochemical analyses, and place sites and artifacts in an environmental and geological context. In 2016, systematic soil sampling was conducted at two

1 E.g. Bini et al. 2013; Bini et al. 2015; Butzer 2005; Butzer – Harris 2007; Ghilardi – Lespez 2017; Nicosia et al. 2013; Nicosia et al. 2012

2 E.g. Karkanas – Goldberg 2018

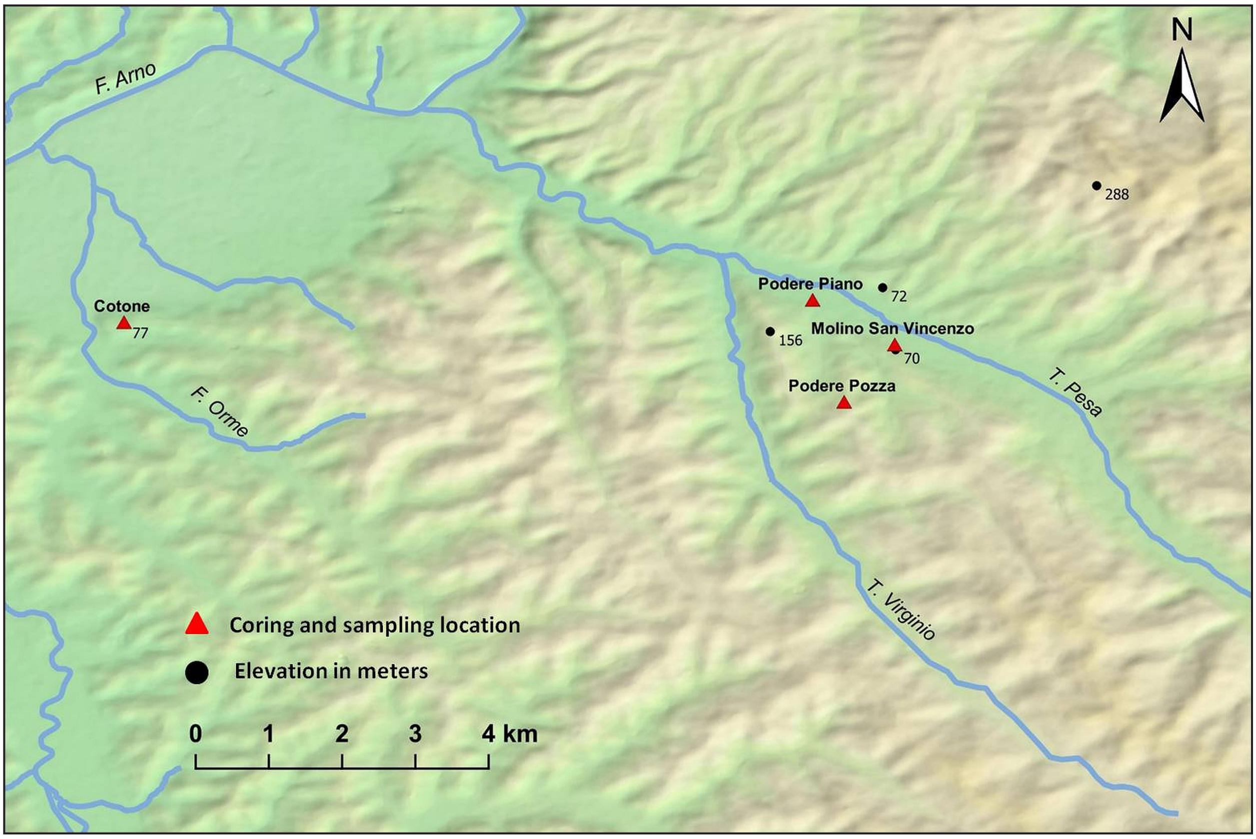

Fig. 1 Location of the project area in the Hilly region between the Arno plain and the mountains, and main sites discussed in the text within the Arno River basin of Tuscany, Italy (R. B. Salisbury, E. Draganits)

locations for soil phosphate survey. In addition, the regional geoarchaeological survey was extended with stratigraphic profiles, soil descriptions, and additional reconnaissance within the study area. The 2015 fieldwork was done by the authors. The 2016 fieldwork involved a team led by R. Salisbury. Dominik Hagmann and Andreas Steininger helped with planning, deploying the differential GPS, staking out survey grids, and aerial reconnaissance. Two students, Geronimo Finn and Martin Junker, did most of the coring and assisted in the survey work. This paper presents the regional, or study-area, scale reconnaissance results first, followed by site-level results.

2 Environmental landscape setting

The project area is a hilly region along the Pesa, Orme, and Virginio valleys, at the interface between the Arno plain to the northwest and the more mountainous inland territory to the east and south (fig. 1). The climate is one of dry summers with rainy seasons in late autumn and late winter.

2. 1 Topography and geomorphology

The topography of the project area consists of nearly level, fluvio-lacustrine sedimentary floodplains between a series of long, northwest-southeast ridges of Mesozoic and Tertiary flysch and calcareous rocks. Elevation near the Pesa-Virginio confluence ranges from about 70 m in San Vincenzo a Torri and at the site of Molino San Vincenzo to 156 m at Castiglioni on the ridge above the site, and 288 m at San Maria a Marciola to the northeast (fig. 1). The morphology of the uplands are slightly to moderately sloping and rounded, with slightly eroded summits and moderately to heavily eroded slopes.

Generally, this hilly landscape suffers from frequent erosion intensified by clay rich soils, which reduce infiltration capacity and commonly generate shrinkage cracks. Mass movements are very common in the whole area. This has led to the formation of heavy-textured Colluvic Regosols in the valleys and lower slopes, and young soils on upper slopes, which are unlike the early to middle Holocene soil.

2. 2 Hydrology

The project area lies within the catchment of the Arno river (fig. 1). The rivers in the study area have highly sinuous channels typical of low-gradient slopes and typically migrate laterally, generating complex systems of abandoned channels. With highly variable discharge between summer and winter, they have also experienced avulsions – i.e., the rapid abandonment of a river channel and the formation of new river channels. Large flood events have been reported in the Arno basin since at least the late Middle Ages.[3] River regulations since the Roman period have greatly influenced these natural processes. For example, 20th century channelization of the Pesa was done to prevent the river from migrating further north into the village of San Vincenzo a Torri. These interventions include straightening of the channel, construction of levees, and installation of bank protection. The results have been both positive, in protecting human habitation, and negative. Negative impacts include intensified river incision, i.e. the downcutting action of water, resulting in lowered groundwater levels, loss of sedimentation in agricultural fields, and damage to bridges.[4] The Pesa bed has lowered up to 2 m, which is not as extreme as the Arno, which has incised almost 9 m in places.[5]

2. 3 Geological framework

The region is comprised of Pleistocene, fluvio-lacustrine sand-, silt- and claystone with minor conglomerate and limestone covered by Holocene fluvial sediments of the Pesa.[6] Underlying geology in the eastern part of the study region is Pliocene and early Pleistocene (ca. 5.3–2 million years) fluvial-lacustrine sand, silt, clay, conglomerate, and limestone. The valleys, in-

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3 Caporali et al. 2005; Sarti et al. 2010.
4 Surian – Rinaldi 2003.
5 Rinaldi 2003.
6 Carmignani – Lazzarotto 2004.

cluding the terraces of the Molino San Vincenzo and Podere Piano sites, are comprised of Pliocene-Pleistocene fluvio-lacustrine sandstone, siltstone, and claystone with minor conglomerate and limestone covered by Holocene fluvial sediments. The ridge between the Pesa and Virginio, including the Podere Pozza site, is characterized by Pliocene limestone, sandstone, claystone, and conglomerate, while the ridge that forms the northern boundary of the project area on the north side of the Pesa comprises tectonic nappes of the Apennine with a variety of rocks of Cretaceous to Miocene shale, sandstone, conglomerate, and flysch-type sediments.[7]

The study area is geomorphologically complex, and soil cover is diverse. The main soil classes are Cambisols and Regosols forming on unconsolidated loamy and clayey fluvial sediments. Soil types include eroded soils showing reorganization of carbonates (Eutric and Calcaric Regosols and Calcaric Cambisols); soils with clay accumulation (Haplic and Calcic Luvisols); soils with vertic properties (Vertic Cambisols and Calcic Vertisols); and alluvial soils (Calcaric, Eutric and Gleyic Fluvisols).[8]

Cambisols are relatively young soils with some profile development, increased clay content, and reduced iron and carbonates. Earlier soil descriptions describe Cambisols as brown Mediterranean soils (*Braunerde*). Regosols are skeletal mineral soils showing little to no profile development, and are commonly found in alluvial (fluvisols) and eroded settings. Topsoils are typically brownish to reddish-brown in color, with yellowish to reddish subsoils, depending on parent material. Soils with high clay content tend towards vertic mixing (vertisols), which will mix soils and move cultural material down profile. Calcaric soils forming on limestone will contain carbonates that effervesce (react with) diluted hydrochloric acid ($HCl_{(aq)}$) and are slightly more alkaline than soils forming on sandstone. Soils with high clay content in the subsoil (luvisols) often form on alluvial and colluvial deposits, and were called grey brown podzolic soils (*Parabraunerde*) in earlier soil classification systems.

Near Martignana, the Orme river lies near the boundary between these sediments and the slightly earlier Pliocene (Zanclean – Piacenzian) marine silty and marly clay, conglomerate, sandstone, and bioclastic limestone. In the southwest of the Virginio and continuing west across the Orme valley towards Empoli is Pliocene clay. The morphology here is linear, with moderate to strong slopes subject to strong diffuse water erosion alternating to less eroded weakly sloping surfaces. Primary soils here are (in the FAO soil classification) Eutric, Calcaric, Vertic, and Fluvic Cambisols, Haplic Calcisols, and Calcaric Regosols.[9]

Soils in the study region are estimated to be slightly acidic, ranging from pH 5.5-6.5 according to an assessment of over 12,000 measurements from across Europe.[10] The FOREGS baseline map for pH, which is very coarse resolution, shows topsoils in study area as moderately acidic, with pH of 5.0-5.5. Subsoil is neutral, from 7.0-7.3.[11]

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7 Carmignani – Lazzarotto 2004.

8 Costantini et al. 2012; Costantini et al. 2004.

9 Constantini et al. 2012.

10 Reuter et al. 2008.

11 Salminen et al. 2005.

2. 4 Vegetation and biogeography

The vegetation history and biogeography of the study area is poorly known.[12] Prior to archaeobotanical research within the VOPP project, a very broad palaeoenvironmental reconstruction could be inferred from data for the coastal plains to the west,[13] the region of Grosseto to the south,[14] and the Po valley to the north,[15] in conjunction with a superficial summary by Giordano.[16]

The general vegetation during the Roman period was most likely a mosaic that included oak woodlands in streambeds and on north facing slopes with Haplic Luvisols and Eutric Regosols. A Mediterranean macchia of dense evergreen thickets with large shrubs and small trees, particularly Holm oak, grow on Calcaric Regosols and Vertic Cambisols on slopes exposed to the sun. Open areas of pasture and agricultural fields cover much of the shallower slopes and flat areas. Partial deforestation, as indicated by decreasing counts for tree species in pollen spectra, occurred in the early Holocene in the region. Large-scale agriculture and increased grasslands for pasture are the expected markers for the Roman period.

3 Geoarchaeological reconnaissance survey

The 2015 reconnaissance consisted of studying exposed profiles throughout the study area, as well as targeted coring, stratigraphic descriptions, and some soil sampling. Given the area's physiographical features and the objectives of our fieldwork, the survey focused on developing a reliable picture of the nature and significance of the archaeological landscape. Exposed outcrops were examined in the field based on their visual and textural properties, including color, grain-size, bedding, bioturbation, organic fragments, and clasts. These data provide information about the general properties of the geological units and soil development. Exposed profiles within the Molino San Vincenzo (MSV) excavation block were also examined. Soil samples were collected by coring with a man-portable, hand-operated gouge auger manufactured by Eijkelkamp, with coordinates taken using a hand-held Garmin GPS with an error of ca. ± 3m. The gouge auger minimize mixing of soil horizons and is thus useful for both stratigraphic characterization and collecting samples for further analysis. Vertical stratigraphy of the sites was described in the field based on Munsell soil color, soil texture, inclusions, boundaries between soil layers, and the presence of cultural material (bits of ceramic, daub, bone, shell, and charcoal).

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12 See, however, Mercuri – Rattigheri in this volume.
13 Bellini et al. 2009.
14 Bowes et al. 2015.
15 Mercuri et al. 2012.
16 Giordano 2013.

Fig. 2 Exposed outcrop of Pliocene-Pleistocene sediments on the ridge road, 450 m north of Castiglione, southwest of the Molino San Vincenzo site (E. Draganits)

3. 1 Uplands in the project area

We examined several exposures, from the top of the ridge south of the Pesa river to the Pesa bed itself. An exposure on the Via Castiglione, near the top of the ridge, showed a soil layer ca. 30 cm thick of greyish-brown sandy loam under pine trees and some pebbles (fig. 2). Under this were typical fluvial beds of yellowish-brown sandy loam with many pebbles. Below this were bedded sandstone and conglomerate. Interestingly, numerous radiolarite pebbles were observed below ca. 60 cm. Locations were cored at an upland location at Cotone (fig. 1) overlooking the Orme valley as an exploratory method to gain a general understanding of soils and conditions. The soil in August 2015 was dry, hard and difficult to core. The top 5 cm compressed in the core under hammer percussion. Soil was a light olive-brown silty clay (Munsell 2.5Y 4/6), homogenous to a depth of at least ca. 90 cm below ground surface. The soil was dry and broke apart, but was not friable: under strong pressure, the soil compressed but did not break. Wetting the soil made a slippery smear and stained the fingers yellow. Soil did not effervesce on contact with HCl, indicating a lack of free calcium carbonate ($CaCO_3$). Small inclusions of detrital limestone, grit, and magnesium oxide or iron-manganese nodules were observed. No cultural material was identified in the cores. Two samples were taken from each core for testing. Available phosphate (Pav) measurements taken on these four samples yielded

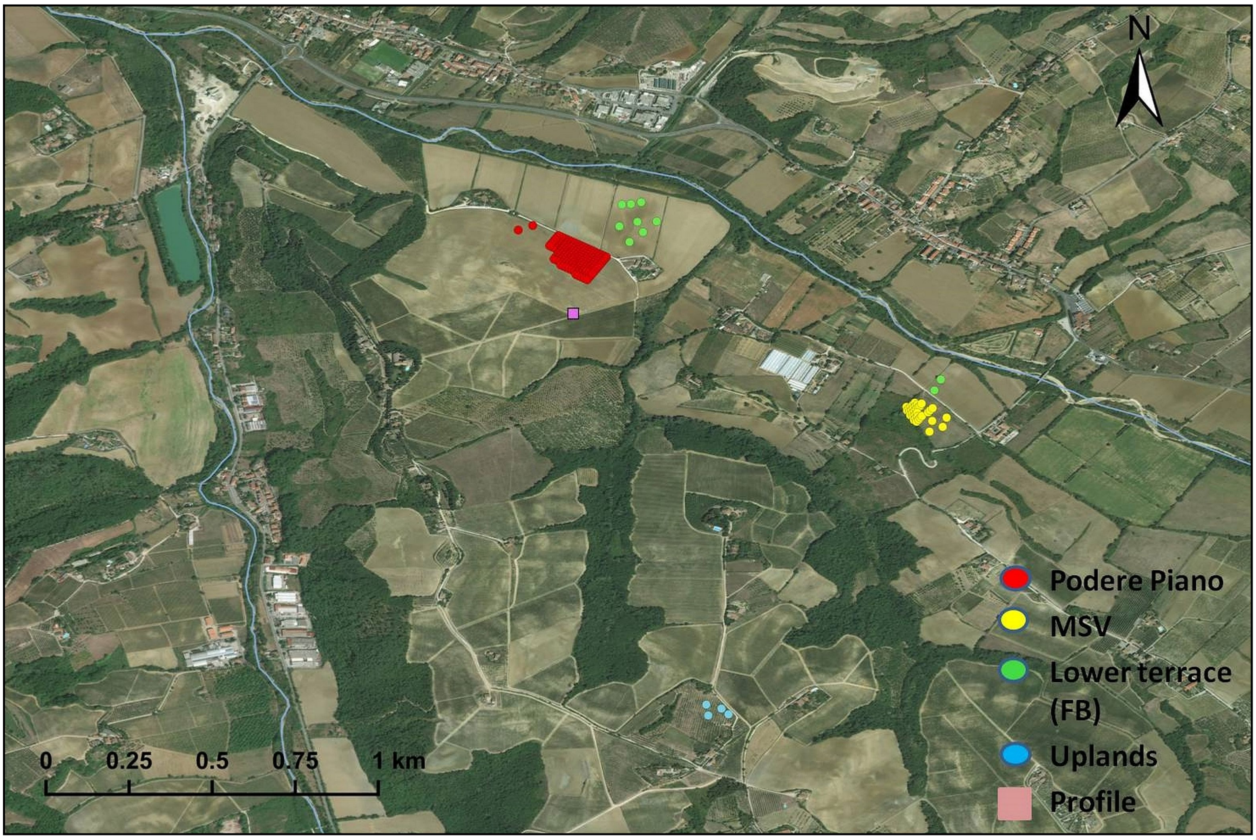

Fig. 3 Locations of the cores and samples taken during the 2015-2016 geoarchaeological surveys (Basemap source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community; R. Salisbury)

moderate to high values for all samples. Four cores were done within an artifact scatter on the upper slope of a ridge approx. 1200 m south of the MSV site near Podere Pozza (fig. 1 and 3). Conditions at the time of the geoarchaeological survey were hot and dry, and surface vegetation was an olive grove with plowed strips containing some weeds and grass between the trees. Soils are relatively homogeneous, with the primary variation being an increase in clay and moisture down profile. Stone and inclusion content varies slightly, with some cores having little to no stone content, and others showing pebbles in the upper part. Although there are some ceramic, brick, and tile fragments on the surface, only one core contained cultural material in the upper part. Average depth of the upper part at this locale was 64 cm below ground surface, and average depth of cores was 90 cm below ground surface. The upper part was further separated into a 45 cm deep plowzone, and a possible second plowzone representing older deep plowing. Pav values for most samples was low to moderately-low (1-2)[17] with the exception of the upper part of core #2. This core showed a darker upper horizon (A-horizon), indicating enrichment in organic matter, which gave a moderate Pav value (3) and a pH measurement of 7.52. All samples had a strongly effervescent reaction to HCl, indicating the presence of primary or secondary carbonates.

17 Following Eidt 1973.

Fig. 4 Current and paleochannels of the Pesa River within the VOPP study area. (4a) bed of the Torrente Pesa and exposed bank deposit northeast, or upstream, of the MSV site. (4b) Pebble beds on the floodplain south of the modern Pesa riverbed, indicating older channels. (4c) Water-worn ceramics and tiles on a paleochannel south of the modern Pesa (R. B.Salisbury, Photo 4c by E. Draganits)

3. 2 Pesa valley in the project area

The riverbed of the Pesa is composed of large pebbles and cobbles, mostly of marl, sandstone, and granite gneiss (fig. 4a). No radiolarite or other microcrystalline quartz was observed, unlike the stone mixture on the surface of MSV or outcrops on the upper slopes south of the river.

Two Pesa paleochannels were documented during the geoarchaeological survey. These are pebble beds running in bands across the floodplain south of the Pesa river, roughly parallel with the river and the road (fig. 4b). These bands of pebbles indicate two older channels of the Pesa, and the angle of the road appears to follow the southern-most band. Many small and water-worn pieces of ceramic tile and brick in the bed closest to the modern Pesa channel (fig. 4c) indicate that this channel was active during the Etruscan or post-Etruscan period. Although there is no absolute date for these objects or the riverbed, the objects indicate site activity in upstream areas and that artifacts have been carried within fast moving water for quite some distance.

	Depth (cm)	Description	Inclusions
Upper part	0-62	10YR 4/4 Dk YBrn ClLo	pebbles
Lower part	62+	10YR 5/4 Dk YBrn SiCl	

Tab. 1 Lower terrace and floodplain soil properties (R. Salisbury, E. Draganits)

	Depth (cm)	Description	Inclusions
MSV site	0-40	10YR 4/4 Dk YBrn SaLo	pebbles, artifacts
	40+	10YR 4/4 Dk YBrn SaClLo	grit
Terrace	0-58	10YR 4/4 Dk YBrn ClLo	pebbles, artifacts
	58-64	10YR 4/4 Dk YBrn SiCl	--
	64+	SaCl regolith	grit, rock fragments

Tab. 2 Upper terrace soil properties (R. Salisbury, E. Draganits)

3. 2. 1 Lower terrace and floodplain sediments

Ten cores were done on lands owned by the Frescobaldi family on the lower terrace north of the Podere Piano and MSV sites, between the Via Bartolomeo Intieri and the current channel of the Pesa (fig. 3). This location was generically called Frescobaldi (FB), although the name does not itself indicate a specific location. Conditions at the time of the 2015 geoarchaeological survey were hot and dry, and the surface vegetation varied from fallow, covered with some weeds and grass, to sunflowers.

Soils are relatively homogeneous throughout the lower Pesa floodplain terrace, with the primary variation being a decrease in sand and pebbles and an increase in clay and moisture content down profile (tab. 1). Stone and inclusion content varies slightly, with some cores having little to no stone content, and others showing pebbles in the upper part. The lower part is interpreted as well-sorted alluvial sediments. Although there are some water-worn ceramic, brick and tile fragments on the surface, no cultural material was observed in the cores. Average depth reached with cores was 89 cm below ground surface, including two cores where rock prevented continuation of the core below 67 cm, and max. depth of any cores was 106 cm.

In all cores, the section from roughly 50–60 cm is disturbed. This could be the base of the modern plowzone, where organic matter driven down by the plow is tearing out a section of the core. This is borne out by the higher clay content and more homogeneous layer below ca. 60 cm, which does not appear to have been plowed in recent years. Available phosphate measurements were taken on 22 samples from this area. Values varied from low to high in the upper part. Samples from ca. 50 cm depth, near the transition from the upper to lower part, were more consistently low to moderate. Samples from within the lower part were taken from six cores, and these again showed a greater variability from low to high.

Based on these preliminary results, the floodplain between the northern paleochannel and the upper terrace was not in an active waterway during the period of interest. Therefore, this area could be suitable for soil phosphate surveying to search for agricultural plots and other areas of activity if the depth of Roman occupation or activity on this floodplain can be determined. However, we did not observe any distinctive bedding aside from the discontinuity at ca. 50–60 cm, and retrieved no evidence for a specifically Roman-period layer.

3. 2. 2 Upper terrace sediments

The MSV and Podere Piano sites occupy an upper terrace south of the Pesa river. Unexcavated portions of the upper terrace near the MSV site were under sunflower at the time of coring in 2015, while the section of terrace near Podere Piano had some grassy growth over a formerly plowed and disked field. The surface at MSV was covered with cobbles and pebbles, and there was clear evidence for soil cracking and potential vertic mixing; observed cracks were up to 30 cm deep. Soils at the MSV site are somewhat different from those near Podere Piano and on the eastern part of the terrace, and these will be described separately (summarized in tab. 2).

Upper terrace away from the MSV site: Soils outside of the architectural features and excavation area are composed mainly of ca. 58 cm of dark yellowish-brown crumbly clay loam with pebbles in the upper part. In general, stone content is very high, organic content is low, and therefore productivity is relatively low. The lower part comprised dark yellowish-brown silty clay with some grit and ferromanganese concretions indicative of wetting and drying cycles.

Upper terrace within the MSV site boundaries: Soils within the site boundaries include ca. 40 cm of dark yellowish-brown sandy loam with pebbles and cultural material in the upper part, and silty clay with no cultural material in the lower part. Changes are almost entirely textural. Subsoil, when reached, is a dark yellowish-brown sandy clay loam with sandstone fragments that presents a reddish color because of the oxidation of sandstone, and a gritty texture because of the decomposing sandstone. This appears to be the regolith and parent material for soil formation.

3. 3 Virginio valley

The riverbed of the Virginio is likewise composed of large pebbles and cobbles that are similar in kind to those in the Pesa (fig. 5). Numerous water-worn tiles and ceramic fragments were observed. Unlike the Pesa, the bed of the Virginio appears to have been stable for some time, with no evidence for considerable channel migration during the late Holocene.

During the Virginio survey, a possible Roman or antique archaeological site was identified where several tiles were identified on the ground surface of the terrace above the current Virginio floodplain. The terrace itself is located nearly 200 cm above the present bed of the Virginio, and is composed of homogeneous yellowish-brown fine grained sediments with some pebble and cobble inclusions. This terrace is being eroded by flooding of the Virginio.

Fig. 5 The bed of the Torrente Virginio and exposed bank deposit showing fluvial bedding of pebbles, facing northwest (R. B. Salisbury)

3. 4 Erosion potential and evidence

Erosion in the region is high. Indications for erosion by sheet, rill, and gully erosion were commonly observed in the fields and vineyards along the ridge and going down slope towards the Pesa. Regosol soils, which are common in the area, are very prone to erosion and mass movement. In a study of landslide risk in the Arno basin, Catani and colleagues observed, "The great majority of the mapped mass movements are rotational slides (75%), solifluctions and other shallow slow movements (17%) and flows (5%)".[18] Furthermore, they found a strong relationship between environmental factors, in particular land cover and topographic relief, and landslide processes. These findings, and soil movement processes, are important in our geoarchaeological survey because they indicate the potential influence of soil mass movements on the visibility and preservation of archaeological remains. Management of erosion risk would also aid in the preservation of archaeological heritage in the region.

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18 Catani et al. 2005, 329.

4 Site-Level Geoarchaeology

Site-level geoarchaeological investigations included stratigraphic descriptions and sediment sampling for phosphate surveys and sediment analyses. Samples were collected from the MSV and Podere Piano sites at 10 m intervals on a systematic grid using the Eijkelkamp gouge auger and an Oakfield soil sampler. Sampling locations were selected in consultation with project directors and key staff based on the results of the geoarchaeological survey, surface collections and geophysical survey. Samples in 2015 were placed with attention on spatial coverage of the terrace containing archaeological sites of interest. The 2016 sampling campaign at MSV and Podere Piano employed a regular grid marked with a differential GPS (dGPS) in a UTM grid. Samples were taken from the largely undifferentiated horizons at arbitrary depths of c. 40-60 cm and 70-80 cm. Samples were placed in re-sealable clear poly bags and labeled according to the project protocol.

Samples collected for soil phosphate analysis were processed at the Vienna Institute for Archaeological Science (VIAS) (n=396). Phosphorus, in the form of phosphates, is an element that remains fixed in the soil and is not easily removed through day-to-day processes of plowing or natural chemical activity. Available, or labile, phosphates (Pav) in soils are enriched primarily through the deposition of organic matter, especially bone, blood, and dung, and high levels of phosphorus therefore strongly correlate with human activity.

Pav values were derived using a ring chromatography tests, or spot test, based on the method developed by Gundlach and modified by Eidt.[19] This method has proven especially useful for determining the horizontal and vertical limits of sites and for giving a general location of activities resulting in organic inputs,[20] and integrates well with surface collection and geophysical survey.[21] The process involves a fast, weak-acid digestion and the addition of molybdenum blue (ammonium molybdate) to produce rings, or spots, and radiating lines. All samples were air-dried, dry sieved to remove organics, stones, and artifacts, pulverized, and sieved through 2mm wire mesh. Sub-samples of approx. 50 mg were laid out on ashless phosphate-free filter paper and reagents were applied, resulting in a blue colored spot. Intensity of sample color is ranked 1-5, where 1 = no color at all and 5 = very dark blue.[22] Samples are retained at Vienna Institute for Archaeological Science (VIAS) for possible future analyses (e.g., multi-element chemistry). Spatial analysis and results were mapped using open-source software packages Quantum GIS 2.14. All data were stored in spreadsheets with x,y coordinates in spatial reference system UTM Zone 32N, datum WGS84, EPSG:32632. These data were used to create point shapefiles, which were then interpolated and statistically interpreted in the GIS.

19 Gundlach 1961; Eidt 1973.
20 Holliday – Gartner 2007; Salisbury 2012.
21 Salisbury et al. 2013.
22 Colorization derived from Eidt 1973 with modification by Bjelajac et al. 1996.

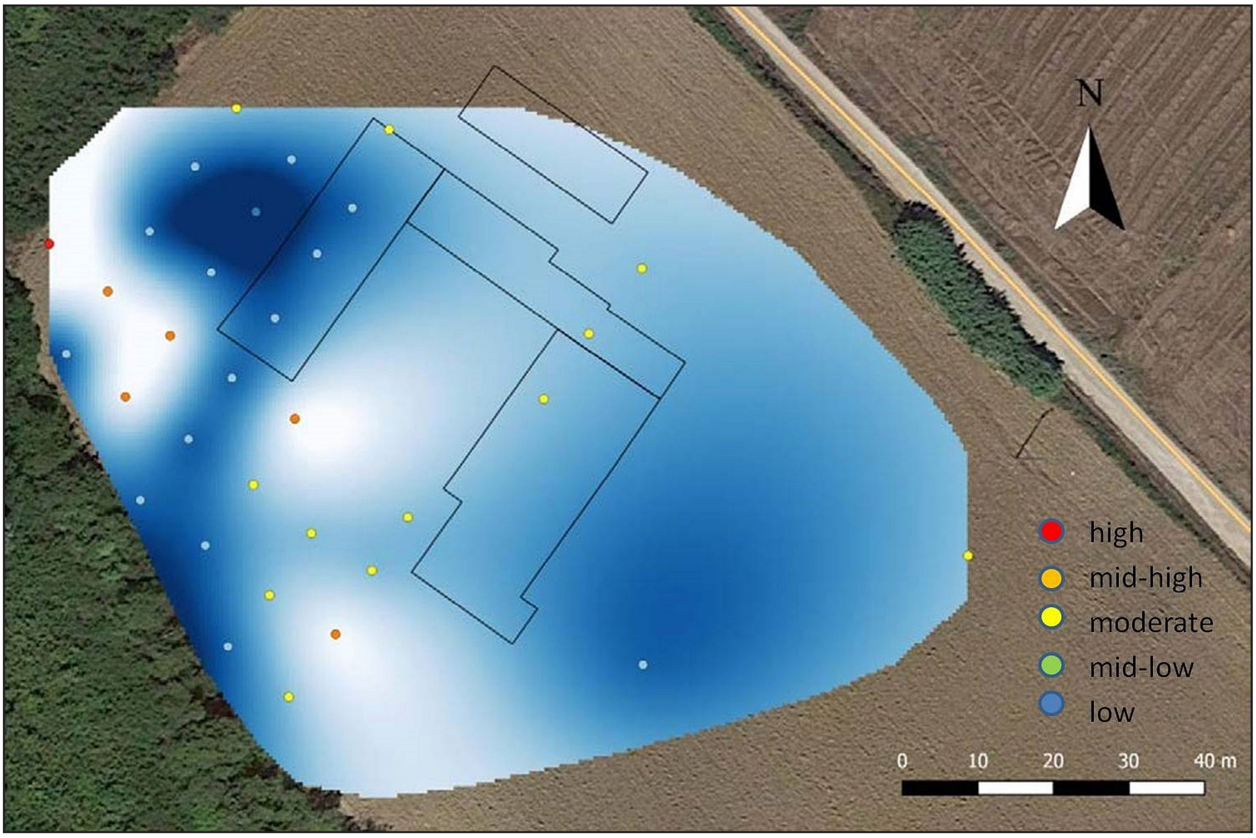

Fig. 6 Sediment sample location at Molino San Vincenzo showing Pav values from ca. 45-55 cm depth and interpolated Pav surface (light is elevated Pav and dark is low Pav in the interpolation) (R. Salisbury)

4. 1 Molino San Vincenzo

The Molino San Vincenzo (MSV) site is located in agricultural fields on the upper terrace south of the Via Viottolone and the Pesa river. Twenty-six cores were taken on a regular 10 m grid on the west side of Molino San Vincenzo in 2016, and samples were analyzed with seven samples from 2015 (fig. 6). Unexcavated portions of the site area had been recently deep-plowed field at the time of 2016 sampling. The surface was covered with cobbles and pebbles, and there was clear evidence for the reddish, iron-rich substrate on the surface, suggesting that any remains of the Roman site have been cut by the plow.

4. 1. 1 Molino San Vincenzo phosphates

Pav measurements were taken on samples from the combined 40 cores at MSV. Pav values varied from moderately-low to high (values 2-5; fig. 6). The spatial distribution of these results suggests that some record of phosphate enrichment may be retained in the soil, despite the apparent poor conditions. That is, the presence of fine-grained silt and clay at MSV may somewhat offset the fact that these are well-drained soils prone to vertic mixing and erosion, and disturbed by deep plowing. Samples north of the excavation trenches have lower Pav in the upper layer, while samples to the south show higher values. There is an area of low Pav in the western part of the field, with evidence for elevated levels of Pav around the known archaeological features and at the edges of the field. These results correlate well with results from 2015 samples taken within the defined archaeological features, which show moderate levels of phosphate: no low values were recorded from the excavation samples. pH measurements for four samples from MSV have an average pH of 7.33 and a range of 0.13, slightly higher than the predicted values for the study area.

Based on these results, the eastern portion of the field with the MSV site could be suitable for soil phosphate surveying during the wetter part of the year, with samples taken consistently from a depth of ca. 45-50 cm. However, no cultural layer was observed in the cores, and the soil conditions, including vertic cracking and high drainage, make it unlikely that chemical remains from the Roman period are retained outside of the architectural structures. The high incidence of erosion in the region represents an additional challenge. Much like at Podere Piano, the southernmost part of the MSV field has deeper soils, probably representing colluvium, and we do not know how deep these are, or how much soil has eroded from above the site.

4. 1. 2 Samples from MSV excavation block

Nine samples were taken from MSV excavation contexts. Pav values from the samples range from moderate to high, and are in general more elevated than other samples from MSV and other tested locations in the region. It is not surprising that Pav values are elevated within the excavated structure, as phosphorus is enriched through several cultural activities such as stabling, butchering and food preparation, organic refuse disposal, using latrines, and fertilization. However, indoor space is typically lower in phosphorus because organic material is generally not kept inside houses, and interior spaces are generally cleaned. These observations, along with the very high value recorded for a burnt feature (F 11.300 in the excavation stratigraphic plan) and the space between this feature and a charcoal deposit (F 12.200), indicate that more rigorous sampling of all contexts would be valuable in interpreting the use of space within the villa. Intense burning, on its own, should not elevate phosphorus in the soil. Other samples taken within the architectural remains show moderate levels of phosphate: no low values were recorded from the excavation samples.

4. 1. 3 Excavated pebble bed

Excavations at MSV in 2016 exposed a level expanse of pebbles that resembled a floor or ancient riverbed (fig. 7). Comparison of the profile after excavation with exposed layers in the Virginio suggest that this is the remains of coarse slopewash deposits or possibly cultural leveling on. This pebble bed has been plowed out in much of the MSV field. Probing with the soil auger suggests that the remaining pebble bed is restricted to a very small area on the west side of the field.

Fig. 7 *Surface (7a) and profile (7b) of pebbles exposed during 2016 excavations at MSV. Comparison with exposed bedding in the Virginio (7c) suggest that the excavations at MSV uncovered coarse slopewash deposits or cultural leveling (R. B. Salisbury)*

Fig. 8 *Coring team and general field conditions at Podere Piano in 2016, facing southwest (R. Salisbury)*

4. 2 Podere Piano

The Podere Piano site is on a terrace above the Pesa floodplain, south of the Via Bartolomeo Intieri and approx. 350 m from the river. Surface conditions at the time of the 2015 survey were some grassy growth on a plowed field (fig. 8). Numerous artifacts were observed on the surface, including tile fragments, ceramic sherds, slag, and one polishing or sharpening stone. Aside from a few large cobbles, there were few stones on the surface. Nine locations were cored at the Podere Piano (PP) site in order to get a general idea about site soils and preliminary Pav spatial patterning. Soils were consistently dark yellowish-brown in color and clay loam to silty clay in texture . Sand content decreased and clay content increased down profile, resulting in the textural change. Most cultural material was observed in the first 60 cm, presumably within the modern plowzone. At about 90 cm depth the C-horizon (subsoil) was reached, consisting of yellowish-brown clay, which appears reddish-brown due to oxidation, with grit and fragments of decomposing sandstone. No cultural layer was observed in the cores. Pav values varied from low to moderately-high (values 1 - 4) in the upper part, ca. 30 cm depth. In all cases, samples from ca. 50 cm and ca. 65 cm have values the same or lower than in the upper part.

4. 2. 1 Pesa Terrace profile from Podere Piano

In 2016, an exposed soil profile in a drainage ditch in the southeast corner of the Podere Piano field was cut back and cleaned to 70 cm wide and 100 cm deep. The gouge auger was used to drive a core an additional 90 cm down from the base of the profile. Soils were consistent throughout (fig. 9), 10YR 4/6 dark yellowish-brown in color and clayey loam in texture, with a few small pebbles as the only inclusions. Moisture and clay content increased slightly down profile. No definitive subsoil or substrate was identified, and no cultural material was observed in the profile or the core.

As discussed above, erosion in the region is high. The evidence suggests that the soils below the slope south of Podere Piano are most likely colluvium deposited from the hill above the site. It appears that a deep (200 cm or more) layer of colluvium overlies the original ground surface, and the exact depth to Roman-period soils remains unknown.

4. 2. 2 Podere Piano phosphates

182 points were cored on a regular 10 m grid at the Podere Piano site in 2016 (fig. 10) for archaeological soil phosphate survey. Surface conditions at the time of the sample collection campaign were recently deep-plowed field, with large clods of dried clayey soil that had baked hard in the sun (fig. 8). The surface was covered with cobbles and pebbles, and there was clear evidence for the reddish, iron-rich substrate on the surface, indicating that any remains of the site have been cut by the plow. Numerous artifacts were observed on the surface, particularly in the northwestern portion of the survey grid, including ancient and modern tile fragments, ceramic sherds, and a fist-sized chunk of iron slag.

Pav measurements were taken on 353 samples taken at arbitrary depths of approx. 45-60 cm and, in most cases, a second from approx. 70-80 cm. Values varied from low to moderately-high (values 1 to 4) . These values were interpolated using a thin-plate spline algorithm (fig. 10). The

Fig. 9 Exposed profile in a drainage ditch southeast of Podere Piano showing depth and consistency of sediments in this section of the Pesa valley (R. Salisbury)

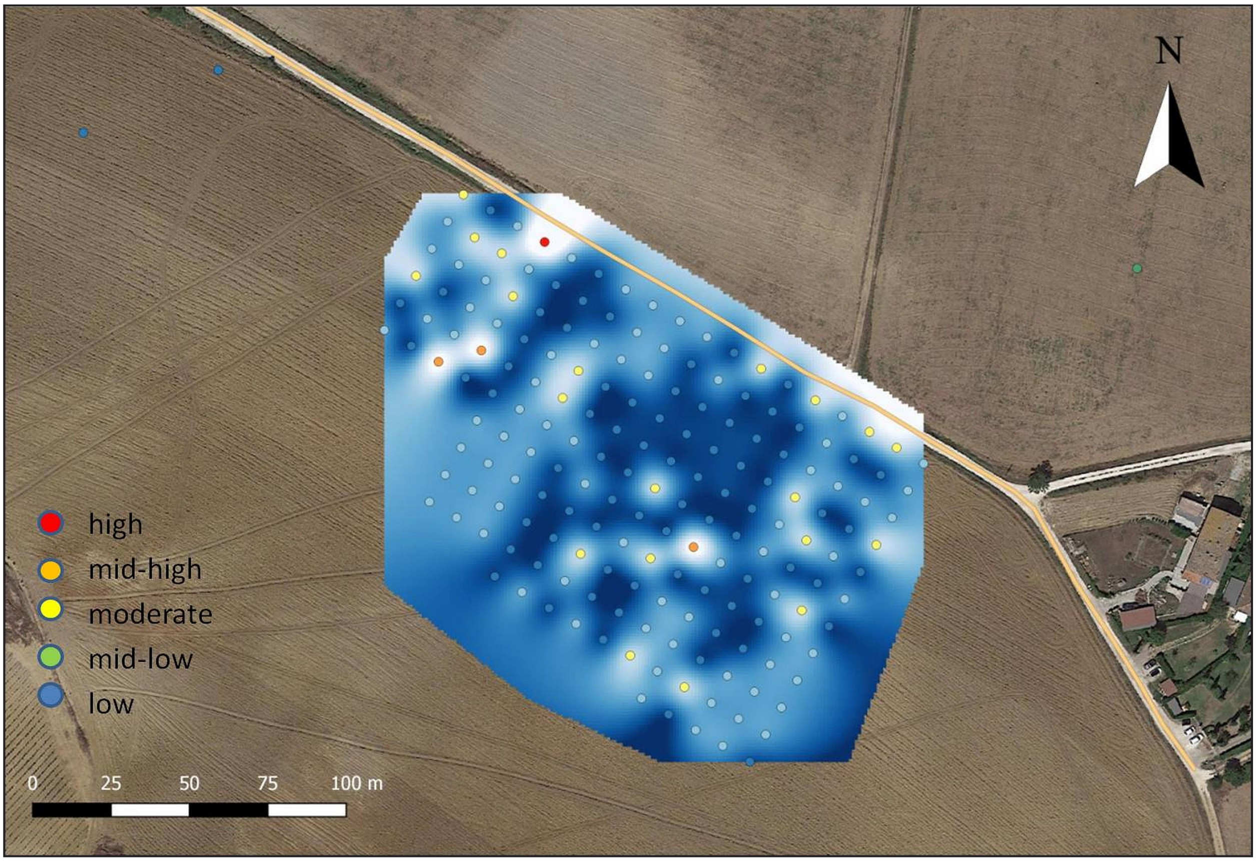

Fig. 10 Sediment sample location at Podere Piano showing Pav values from ca. 40-60 cm depth and interpolated Pav surface (light is elevated Pav and dark is low Pav in the interpolation) (R. B. Salisbury)

results indicate little to no phosphate enrichment within the upper 80 cm of soil across most of the field. The most obvious exceptions are along the road, and around the known archaeological features. When considering these results, the following points must be noted:

1. there is a difference in depth to substrate across the field, with the site and road situated on c. 50-75 cm of soil over an ancient pebble bed and the rest of the field having 100+ cm of soil, and
2. the deeper soils are most likely colluvium.

Soil pH measurements for nine samples average 6.97 and range from 6.5 to 7.13. These values are slightly less acidic than the expected values derived from regional and macro-regional soil surveys. This could be the result of human activity, or could be local variation within this part of the study area.

4. 2. 3 Podere Piano metal detector survey

A metal detector survey was undertaken by the coring team at Podere Piano on 9 September 2016. The goal of the survey was to find out whether or not slag could be located using a metal detector. One fist-sized piece of slag was identified at the site in 2015 and another in 2016. Although we knew that there was significant iron debris in the soils at the site, we still thought it worthwhile to attempt to find additional slag that might be associated with ancient activities. The results indicate that there is a low-level of iron within the site soils, presumably associated with the reddish colored substrate. Because of the continuous low-level detection of iron, no slag was identified, and the only change in reading from the detector was from contact with very large pieces of modern iron debris.

5 Summary and Conclusions

The combined results of the geoarchaeological reconnaissance survey suggest that the Pesa river at one time extended closer to the terrace where the MSV and Podere Piano sites are situated. Today the Pesa is artificially confined in the middle of the valley. The floodplain terrace north of the Molino San Vincenzo and Podere Piano sites – between the sites and the current bed of the Pesa – acquired its current form after the end of the Roman period. Furthermore, it is likely that in its natural state the river used a wider area of the valley, and thus was a lower energy river even during flood. Additional soil phosphate survey in this area is therefore not recommended, although efforts to acquire absolute dates for the channels are recommended. The 2016 survey suggests that the Virginio bed has been stable for a longer period, and has been slowly migrating south, away from the road and modern village. Current incutting by the river during flood is removing archaeological sites along its western banks. Fluvial activity and its timing should receive additional attention in order to model the placement of archaeological sites in relation to local hydrology, and to model site preservation.

Soil and geomorphological conditions are influencing survey results in at least two ways. First, the combination of topography, lithology, land cover and land use leads to a high risk for erosion. Erosion is both removing archaeological remains from slopes and re-depositing them in the valley floors, and covering archaeologically relevant features and surfaces beneath colluvium. Additionally, wide and deep shrinkage cracks allow for down-movement of artifacts. Second, iron-rich sediments from the substrate have the potential to confound magnetometry surveys. Anthropogenic factors, in particular deep plowing on lower slopes and terraces, is exacerbating this latter phenomenon, as well as mixing and removing archaeological deposits and features. Results of future geophysical surveys should take into consideration the high iron content of the soils along the ancient river terrace where the MSV and Piano sites are located. This iron content gives the substrate its reddish color, and is brought to the surface by deep plowing. The substrate produces a low but continuous magnetic reading across the entire site, as evidenced by the results of a metal detector survey conducted at Podere Piano. Erosion modelling for this section of the Pesa valley would be useful for guiding future research if such is planned.

The sites of Podere Piano and MSV were cored and sampled for soil phosphate survey. Results are ambiguous. An area of elevated phosphates is evident around the subsurface structural remains at Podere Piano, and a causal relation can be assumed. A second area of moderate elevation was identified to the east and southeast of the known site, but this is more difficult to interpret. Since most of the surveyed area is in deep colluvial sediments and is regularly deep plowed to a depth of 50 cm or more, the depth, relative preservation and characteristics of the Roman period surface is unknown. Slightly elevated Pav and pH suggest anthropogenic activity, but this cannot be assigned to any culture historical period, and may even be related to activities on the slopes above the site. No cultural layers or anthropogenic soil horizons were identified below the plowzone in any of the examined sites. Slightly higher pH values on the Pesa terrace may be caused by mixing of subsoil with topsoil in the colluvium. Molino San Vincenzo is equally ambiguous, but surveying the eastern half of the site terrace may be beneficial for comparative purposes. Whether the results would prove to represent the Roman occupation at MSV is impossible to say at this time.

The Vienna Orme and Pesa valley Project study area is located in an anthropogenic landscape shaped by deforestation, regulated hydrology, agriculture, and increased erosion potential. Results of the geoarchaeological surveys are interesting in part because within this section of the Pesa valley, at least, we might not be able to see the Roman occupation except in the badly damaged remains of architectural structures and displaced surface scatters. In a wider sense, outside the project itself, these results are interesting in that the formation processes, especially anthropogenic processes, vary between river valleys – the Pesa, Virginio, and Orme – and have very localized impacts to the archaeology. In any case, archaeological resources are badly damaged.

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