KECK GEOLOGY CONSORTIUM

PROCEEDINGS OF THE TWENTY-SECOND ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

April 2009
Franklin & Marshall College, Lancaster PA.

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ISSN # 1528-7491

The Consortium Colleges National Science Foundation

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2008-2009 PROJECTS

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SEAFLOOR VOLCANIC AND HYDROTHERMAL PROCESSES PRESERVED IN THE ABITIBI GREENSTONE BELT OF ONTARIO AND QUEBEC, CANADA
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GEOARCHAEOLOGY OF THE PODERE FUNGHI, MUGELLO VALLEY ARCHAEOLOGICAL PROJECT, ITALY
Faculty: *ROB STERNBERG*: Franklin & Marshall College and *SARA BON-HARPER*: Monticello Department of Archaeology
Students: *AVERY R. COTA*: Minnesota State University Moorhead; *JANE DIDALEUSKY*: Smith College; *ROWAN HILL*: Colorado College; *ANNA PENDLEY*: Washington and Lee University; *MAIJA SIPOLA*: Carleton College; *STACEY SOSENKO*: Franklin and Marshall College

GEOLOGY OF THE HÖH SERH RANGE, MONGOLIAN ALTAI
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BLOCK ISLAND, RI: A MICROCOSM FOR THE STUDY OF ANTHROPOGENIC & NATURAL ENVIRONMENTAL CHANGE
Faculty: *JOHAN C. VAREKAMP*: Wesleyan University and *ELLEN THOMAS*: Yale University & Wesleyan University
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Funding Provided by: Keck Geology Consortium Member Institutions and NSF (NSF-REU: 0648782)

Keck Geology Consortium: Projects 2008-2009
Short Contributions – ITALY

GEOARCHAEOLOGY OF THE PODERE FUNGHI, MUGELLO VALLEY ARCHAEOLOGICAL PROJECT, ITALY

Project Director: ***ROB STERNBERG***: Franklin & Marshall College
Project Faculty: ***SARA BON-HARPER*****:** Monticello Department of Archaeology

MAGNETIC SUSCEPTIBILITY INVESTIGATIONS OF THE PODERE FUNGHI, ITALY

AVERY R. COTA**:** Minnesota State University Moorhead
Research Advisor: Dr. Rinita Dalan

GEOCHEMICAL AND MINERALOGICAL COMPARISON BETWEEN CLAYS AND CERAMICS FROM THE ETRUSCAN ARCHAEOLOGICAL SITES OF POGGIO COLLA AND PODERE FUNGHI, TUSCANY, ITALY

JANE DIDALEUSKY**:** Smith College
Research Advisors: Bosiljka Glumac and Robert Newton

PHOSPHORUS ANALYSIS OF THE PODERE FUNGHI

ROWAN HILL: Colorado College
Research Advisor: Paul Myrow

ARTIFACT DISTRIBUTION AND GEOARCHAEOLOGICAL INVESTIGATION OF THE PODERE FUNGHI

ANNA PENDLEY**:** Washington and Lee University
Research Advisors: Dr. Sara Bon-Harper, Dr. David Harbor, and Dr. Robert Sternberg

GEOMORPHIC AND ANTHROPOGENIC IMPACTS ON ARTIFACT DISTRIBUTION WITHIN THE PLOWZONE IN THE PODERE FUNGHI, TUSCANY, ITALY

MAIJA SIPOLA**:** Carleton College
Research Advisor: Mary Savina, Carleton College

MAGNETOMETRY IN THE PODERE FUNGHI AT THE ETRUSCAN ARCHAEOLOGICAL SITE OF POGGIO COLLA

STACEY SOSENKO: Franklin and Marshall College
Research Advisor: Rob Sternberg

Funding provided by: Keck Geology Consortium Member Institutions and NSF (NSF-REU: 0648782)

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JANE DIDALEUSKY: Smith College
Research Advisors: Bosiljka Glumac and Robert Newton

INTRODUCTION

In archaeological geology, provenance studies are aimed at discovering the source of raw materials used in the production of an artifact (Rapp and Hill, 2006). My research focuses on chemical and mineralogical comparison of clays and ceramic material. The purpose was to determine a possible provenance for the clay used by the Etruscan potters in ceramic production. The study was conducted using x-ray fluorescence, x-ray diffraction and thin-section petrography. The clay and ceramic samples were collected at the sites of Poggio Colla, Podere Funghi, the Northwest Trench and sites within the Mugello Valley in Tuscany, Italy (Fig. 1; also see Sternberg and Bon-Harper, this volume, Fig. 1). The Mugello Valley Archaeological Project is conducting excavations at the first three sites mentioned above. The sites are located on the western edge of the northern Apennines Mountain belt on the edge of known Etruscan territory.

Poggio Colla is proposed to represent a regional temple and political center. The area is significant, because it was occupied for the majority of Etruscan history, from approximately the 7th through the 2nd century BCE. The Podere Funghi was a ceramic production site; four pottery kilns, as well as a building and a midden or trash site were uncovered through excavations. Podere Funghi was probably occupied from the early 4th through the early 2nd century BCE (Warden et al., 2005). This site can provide insight into the lives of the ordinary Etruscan people.

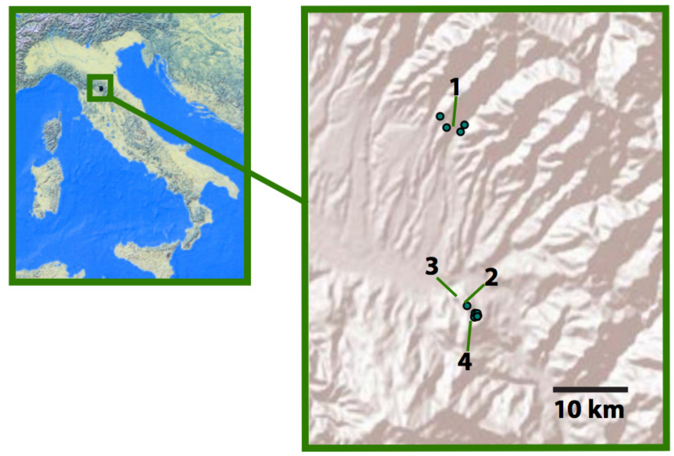

Figure 1: Location of the sites of sample collection (green dots): 1) three lithified clay samples and one sandstone sample collected from road cuts in the area surrounding the archaeological sites; 2) the Northwest Trench (unlithified clay); 3) Poggio Colla; 4) the Podere Funghi (unlithified clay).

GEOLOGICAL SETTING

The local geological setting is the Mugello Valley or Basin. The Mugello Basin is 25 kilometers long and 15 kilometers wide, and is an asymmetrical basin, which is primarily filled with Pliocene-Pleistocene lacustrine and alluvial sediments. Regionally there is evidence that the Mugello Basin formed as a result of tectonic compression and crustal extension (Benvenuti, 2003). Sedimentation within the Mugello Basin occurred during two periods: 1) a fluvial-lacustrine late Pliocene-early Pleistocene period; and 2) an alluvial early Pleistocene-Holocene phase. The alluvial phase led to the terraced appearance in the region today due to episodes of base level lowering and erosion (Benvenuti, 2003). During the Etruscan era there was an increase in agriculture that led to deforestation. This deforestation added to erosional processes, which could have exposed clay and other fine-grained sediments as potential source material for Etruscan pottery (Caporali et al., 2005). The study sites are located on a topographic high composed of sandstone and conglomerates of Miocene Age. The sites are surrounded by Pleistocene to Holocene fluvial to lacustrine limestone, sandstones, siltstones, and clay deposits (Sternberg and Bon-Harper, this volume, Fig. 3).

METHODS

The samples collected include unlithified clay samples and Etruscan ceramic sherds. The clay samples are labeled "cl" and the ceramics "cer". The objective was to collect clay to silty-clay samples that might have been the source material used in Etruscan ceramic production at the Podere Funghi. There were 44 clay samples obtained at the Podere Funghi using an auger and soil coring equipment at depths between 10 cm and 50 cm. The thickness of the clay rich beds varied from 6 cm to 2 m. At the Northwest Trench, 5 clay samples were collected using coring equipment from depths between 142 and 179 cm. There were also 3 lithified clay samples (cl 15, 17 and 18) collected from road cuts in the surrounding area (Fig. 1).

The ceramic sherd samples came from the Mugello Valley Archaeological Project excavations at Poggio Colla and the Northwest Trench (Fig. 2). These samples represent a variety of ceramic styles including: 1) fine-ware pottery with fine sand size mineral inclusions (14 samples); 2) coarse-ware or impasto pottery with sand to granule size mineral inclusions (23 samples); and 3) bucchero pottery which is burnished before firing in a reducing environment and has fine to medium sand sized mineral inclusions (4 samples). The samples from Poggio Colla include cer 1-29, and they date to the late 4th-3rd centuries BCE. The samples from the Northwest Trench include cer 30-41. These samples were erosionally emplaced and could date from any time during the site occupation from approximately the 7th through the 2nd century BCE (Fig. 2).

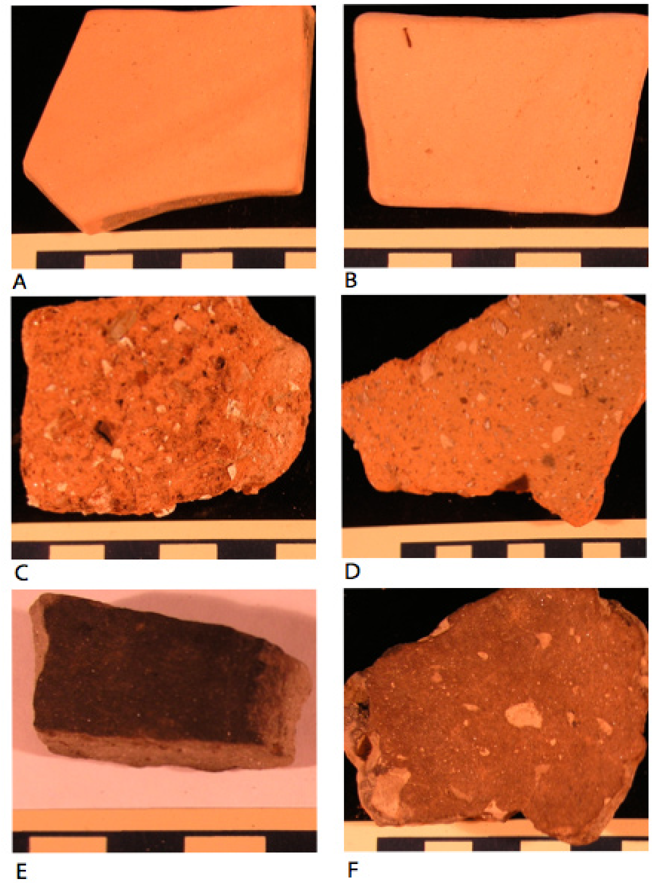

Figure 2: Photographs of ceramic sherds. A & B) fine-ware (cer 1 & 4); C & D) coarse-ware (cer 31 &22); E) thick Bucchero (cer 38); F) coarse-ware (cer 23) fired in a reducing atmosphere.

Petrographic thin-sections of 16 ceramic samples were made following standard procedures (Chinn, 2002). The coarse-ware ceramics samples are friable and had to be impregnated with epoxy before they were cut and polished. X-ray fluorescence was employed to analyze the major elements (Si, Ti, Al. Fe, Mn, Mg, Ca, Na, K, and P) and trace elements (Nb, Zr, Y, Sr, Rb, Th, Pb, Ga, Zn, Ni, Cr, V, Ba, Ce, La, U, Sc, Co, and Cu) in the clay and ceramics samples by standard procedures (Rhodes, 1996; Franklin & Marshall College, 2008). X-ray diffraction was used to analyze the mineral composition of the clay samples (Moore and Reynolds, 1997). The bulk mineral composition, including the matrix and inclusions, was obtained for a group of the ceramic samples (Dutrow and Clark, 2009).

X-RAY DIFFRACTION RESULTS

X-ray diffraction patterns were obtained for 10 unlithified and 2 lithified clay samples. The soil samples have a similar mineral composition including montmorillonite/illite, kaolinite, quartz (Fig. 3a). The lithified clay samples, cl 17 and cl 18, collected from outcrops around the outskirts of the basin (Fig. 1) are similar to the unlithified clay samples, except they contain no kaolinite. X-ray diffraction patterns were also obtained for 19 ceramic samples. The majority of the ceramic samples contain quartz, plagioclase and possibly an amorphous phase, which is the result of fusing or sintering of the clay minerals (Fig. 3a) (Ekosse and Mulaba-Bafibiandi, 2008). Ceramic sample cer 31 also contains dolomite.

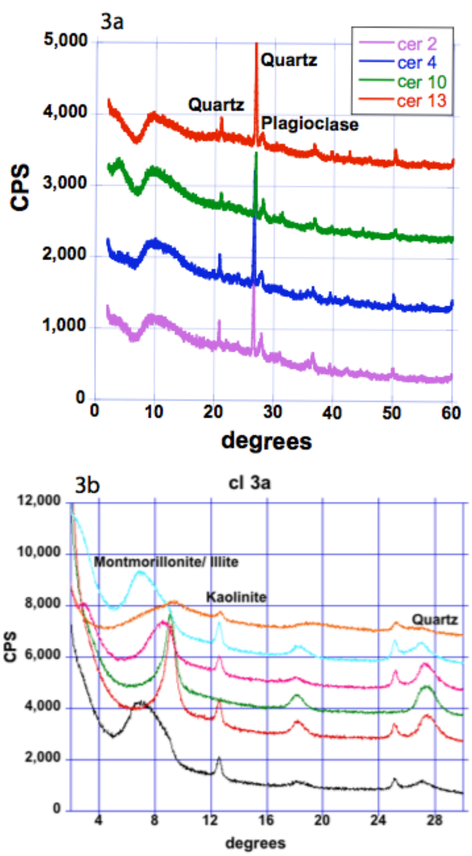

Figure 3a &b: X-ray diffraction patterns. 3a) Representative samples of ceramics. They contain an amorphous phase, quartz and plagioclase. 3b) Representative sample of unlithified clay (cl 3a). The different colors indicate the various chemical and heat treatment tests performed to determine the mineralogy of the sample. It contains interstratified montmorillonite/illite, kaolinite and quartz.

THIN-SECTION PETROGRAPHY RESULTS

Petrographic thin-sections were examined for 6 fine-ware and 12 coarse-ware ceramic sherds (Fig. 4). All of the samples contain a clay size matrix composed of fused clay minerals that are now in an amorphous state. The fine-ware contains inclusions of quartz, mica, Fe-oxides, and two samples also contain grog, which are pieces of previously fired clay or ceramic sherds (Rice, 1987). The fine-ware inclusions range in shape from sub-angular to rounded and in size from fine to medium sand. The coarse-ware samples contain inclusions of quartz, plagioclase, mica, Fe-oxides, grog and some samples also contain lithic fragments. All these inclusions range in shape from angular to rounded and the sizes range from fine sand to granules. One coarse-ware sample (cer 31) contains pyroxene and relatively large inclusions of plagioclase (Figure 4b), and there is one gastropod fossil (in cer 28).

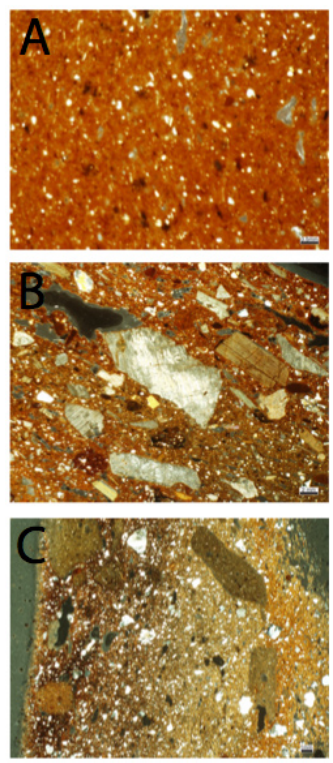

Figure 4: Photomicrographs of ceramic thin-sections in cross-polarized light. A) fine-ware composed of a matrix of amorphous fused clay minerals and inclusions of quartz, mica, feldspar and iron oxides (cer 11); B) coarse-ware of similar composition, and it also contains grog and pyroxene (cer 31); C) coarse-ware of the same composition with the addition of grog (cer 24).

X-RAY FLUORESCENCE RESULTS

Major and trace element concentrations were obtained for 21 clay samples, 13 fine-ware samples and 21 coarse-ware samples (Table 1). In order to analyze the x-ray fluorescence data, STATA statistical software was utilized and the Kruskal-Wallis test was employed to evaluate the similarities and differences between varieties of data groupings (Moore and McCabe, 2003). The three tests that revealed a statistically significant similarity for all elements are the comparison between unlithified clay and lithified clay (Fig. 1), fine-ware and lithified clay, and coarse-ware and lithified clay. However, the sample size for the lithified clay was small (3 samples, cl 15, 17 & 18; Table 1).

Differences arose for the following tests: fine-ware differ from coarse-ware in the amount of Ce, Rb, Sr, Th, Y, Mg, Ca and K, with the fine-ware having higher concentrations. Cer 31 is an outlier for Ba, Ce, Sr, Th, M, Ca and K (Table 1). The fine-ware differs from all the clay (lithified and unlithified) samples in the amount of Ba, Th and P, with fine-ware having higher concentrations of these elements. The coarse-ware differs from all the clay samples in the amount of Ba, Ga, Rb, Mg, K and P, with the clay having higher concentrations of all these elements except Ba and P (Table 1).

	Unlithified Soil (n=18)		Lithified Soil (n=3)		Fine-ware (n=13)		Coarse-ware (n=21)		Cer 31
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	
Ba (ppm)	366	225-592	355	312-386	839	616-1069	859	580-1718	376
Ce (ppm)	103	63.0-160	50.4	45.7-53.2	89.7	79.3-104	77.0	59.8-92.7	44.0
Co (ppm)	26.4	20.4-45.0	18.5	14.3-21.5	22.5	20.5-25.0	21.9	11.6-34.4	25.9
Cr (ppm)	136	72.0-156	163	110-217	152	131-166	123	90.1-188	752
Cu (ppm)	51.0	22.5-78.8	24.2	20.2-27.1	37.8	22.3-44.4	34.0	20.8-66	28.8
Ga (ppm)	22.8	16.0-27.0	16.3	13.4-17.8	20.8	19.1-24.0	18.5	15.0-21.9	15.6
La (ppm)	59.0	27.0-120	28.6	23.8-35.2	39.2	34.3-45.0	35.2	24.6-42.6	26.5
Nb (ppm)	29.0	15.0-43.0	13.4	11.6-14.4	21.5	19.4-22.9	20.7	16.8-31.5	15.2
Ni (ppm)	73.3	26.0-156	72.9	52.2-90.4	85.2	77.4-93.2	74.4	42.0-160	158
Pb (ppm)	22.8	9.90-35.4	15.3	14.7-16.5	24.6	19.0-30.8	28.2	20.7-40.5	16.2
Rb (ppm)	159	112-225	139	128-145	137	101-152	104	77.1-134	53.1
Sc (ppm)	17.3	15.5-18.8	22.2	20.4-23.2	18.5	17.1-19.4	16.2	14.2-20.2	31.2
Sr (ppm)	114	82.4-305	261	213-288	170	112-208	111	58.5-200	159
Th (ppm)	12.7	10.0-15.0	11.0	9.95-11.8	14.6	13.5-15.8	12.4	9.80-15.0	7.20
U (ppm)	1.50	0-3.0	2.30	1.70-2.70	2.41	1.30-4.60	2.73	1.20-6.50	1.10
V (ppm)	147	74.0-183	127	109-138	122	85.0-141	130	87.5-162	140
Y (ppm)	47.4	20.3-146	28.4	20.6-34.7	36.9	32.6-42.1	27.0	20.2-34.5	18.5
Zn (ppm)	125.9	72.0-184	119	115-128	150	139-164	126	87.5-216	90.3
Zr (ppm)	197	144-298	125	107-158	189	181-197	n.d.	n.d.	n.d.
Ti (%)	0.888	0.710-1.09	0.626	0.530-0.690	0.86	0.84-0.88	n.d.	n.d.	n.d.
SiO_2 (%)	63.7	55.8-75.9	54.8	53.1-57.9	62.1	58.7-64.9	65.7	62.1-70.5	58.8
TiO_2 (%)	0.969	0.686-1.21	0.717	0.626-0.784	0.904	0.868-0.981	0.851	0.718-1.01	0.66
Al_2O_3 (%)	19.8	13.8-23.9	15.7	14.2-16.8	19.4	18.5-20.9	18.3	15.6-20.8	21.1
Fe_2O_3 (%)	7.24	4.0-9.61	7.34	5.80-9.26	6.37	5.94-6.95	6.73	5.23-8.46	6.80
MnO (%)	0.156	0.022-0.376	0.077	0.072-0.088	0.07	0.045-0.109	0.074	0.035-0.206	0.103
MgO (%)	2.42	1.34-3.26	3.81	2.83-5.70	2.66	1.86-3.06	1.56	0.967-2.74	3.93
CaO (%)	1.44	0.479-11.8	13.3	8.89-15.6	2.55	0.728-4.63	0.632	0.17-1.84	2.77
Na_2O (%)	0.689	0.075-1.91	0.953	0.890-1.03	1.03	0.715-1.38	0.999	0.420-1.50	2.01
K_2O (%)	2.97	2.10-4.20	3.12	2.95-3.26	2.82	2.47-3.01	2.18	1.68-2.50	1.26
P_2O_5 (%)	0.117	0.059-0.129	0.171	0.139-0.212	1.81	0.64-4.35	1.94	0.602-4.29	1.56

n.d. - not determined

Table 1: The mean and range of the x-ray fluorescence results for lithified clay (3 samples), unlithified clay (18 samples), fine-ware (13 samples) and coarse-ware (21 samples). Coarse-ware sample Cer 31is listed separately because of its unique composition.

DISCUSSION

The Etruscans of Poggio Colla probably chose this site for the defensive advantage given by the topographic high, and for the good agricultural land in the Mugello Valley. Ceramics were an important part of their culture. They were used for ceremonial purposes, as household goods and building material. Thus, the Mugello Valley with its extensive clay deposits was an ideal place for ceramic production. It appears that the Podere Funghi was an important producer of the ceramics used at Poggio Colla.

The statistical tests of the x-ray fluorescence results seem to support the conclusion that there is a correlation between the clays at the Podere Funghi and the ceramics found at Poggio Colla. The clay samples collected are statistically similar to each other. The differences found between the clay samples and the ceramics could be due to the archaeological sites being a combination of forested area and agricultural land, thus adding organic matter to the clay. The differences can also be due to post-depositional changes to the ceramics, such as in the case of P and Ba, which become concentrated in the ceramic sherds (Freestone, 2001). The higher levels of Ca in the fine-ware could be due to the addition of calcium bearing material as a temper. This addition of Ca enables the pottery to withstand greater thermal stresses (Rice, 1987). The reasons for the other element differences are as of yet unknown.

Mineralogical changes occur as the clay is heated in the process of turning it into a ceramic. As the clay is heated it begins to loose water in the crystal lattice structure. At approximately 500°C, the density increases and the porosity decreases. This process, called sintering, is when clay minerals begin to fuse together and new silicates begin to form in their place. Kaolins (kaolinite group) form metakaolin at 500°C, and at higher temperatures spinel and quartz form. Expandable clays, like montmorillonite, undergo mineral changes around 800-900°C, and the main new minerals formed include spinel and quartz (Henderson, 2000). The x-ray diffraction results are consistent with the above information, as Figure 3a illustrates the presence of quartz and plagioclase in x-ray patterns. There must have been plagioclase present in the clay or it was added as an inclusion.

Inclusions were added to the clay to possibly correct for stickiness, reduce shrinkage, decrease drying time, reduce deformation in drying, and in the case of small inclusions, lower the melting temperature, especially with expandable clays, such as those found in the x-ray diffraction analysis (Rice, 1987). The addition of inclusions is evident from the grog found in almost all the ceramic samples. As well, it could be argued that the large angular mineral and lithic inclusions indicate added material.

There is possible evidence of trade between ceramic production sites found in the coarse-ware sample cer 31 (Fig. 2c). It is the only ceramic sample containing pyroxene (Fig. 4b) and is consistently an outlier in the x-ray fluorescence analysis (Table 1). A comparison between the chemical and mineral signature of cer 31 to studies of Etruscan ceramics from other areas might lead to a provenance of this sample.

ACKNOWLEDGEMENTS

This research project would not have been possible
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without the guidance and support from the following people and organizations: The Keck Geology Consortium, Marshall Schalk Fund, Thomlinson Funds, Mugello Valley Archaeological Project, Sara Bon-Harper, Rob Sternberg, Bosiljka Glumac, Robert Newton, Andy de Wet, John Brady, Mark Brandriss, Sara Pruss, Amy L. Rhodes, Tony Caldanaro, Kathy Richardson, J. Michael Rhodes, Pete Dawson, Karen Miller, Mike Vollinger, Steve Sylvester, Karen R. Mertzman, Gregory P. Warden, Michael L. Thomas, Ann Steiner, Gretchen Meyers, Isaac Weaver, Susanne Nimmrichter, Nick Horton, Kristin Tyler, my fellow Keck students and all the students and staff at the Poggio Colla field school.

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