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Undulating Band Style and Fringe Style Matt-Painted Pottery from the Sanctuary on the Timpone della Motta in the Sibaritide Area (CS) Calabria - southern Italy

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Abstract

This paper presents a comparison of two different classes of Matt-Painted pottery attributed to the 8th century B.C. from the sanctuary on the Timpone della Motta in the Sibaritide (CS), Calabria, southern Italy.

Matt-Painted pottery was widely produced in southern Italy during the early Iron Age, and finds from many indigenous sites underline that it was one of the favored pottery types both for dining and storage purposes. The term Matt-Painted refers to handmade vessels of typical indigenous shapes with applied decoration in a matt dark paint.

Traditional archaeological research divides Matt-painted pottery into a range of regional classes based on the decorative styles of each region. The thousands of fragments from the sanctuary on the Timpone della Motta, together with the finds of Matt-Painted vessels in indigenous graves and houses, show that two predominant styles were present in the Sibaritide. These two styles have been named the Undulating Band Style (Matt-Painted stile a Bande Ondulate) and the Fringe Style (Matt-Painted stile a frange) based on their many decorative elements.

Twenty-five fragments of Matt-Painted pottery (17 fragments of the Undulating Style Band class, which included, one over-fired sample, and 8 fragments of the Fringe Style class) have been submitted to petrographical analysis including optical microscopy, mineralogical XRD analysis and chemical XRF analysis in order to determine their provenances. The results show that the compositions of the clay fabric of the Undulating Band Style and the Fringe Style are similar.

Another important aim was to clarify whether the raw material used in the manufacture of the vessels corresponds to local clay deposits. For this purpose, the Matt-painted samples were compared to previously collected samples of clay sediments around the archaeological site.

Firing tests conducted on representative samples of these raw materials evidenced

morphological, mineralogical and textural similarities with the studied ceramics.
Finally, the SEM micro-morphological study, which determines firing temperatures, was carried out in order to distinguish between different production techniques.

Key words: Matt-painted pottery; Undulating Band Style; Fringe Style; Calabria; Technology; Provenance.

Introduction and previous study

The Timpone della Motta archaeological site is very important in the Sibaritide area for the knowledge of cultural and material evolution in southern Italy between c. 800 and 510 B.C. The site of Timpone della Motta is located on the top of a hill, a few kilometers from the town of Francavilla Marittima (province of Cosenza, northern Calabria), 12 km north of the Greek *apoikia* of Sybaris (Figure 1). The first settlement may be ascribed to the Middle Bronze Age, but the site developed when early in the 8th century B.C. it became a place of worship for the indigenous Oinotrians. Later, following the founding of the Achaean *apoikia* of Sybaris at the end of the 8th century B.C., the site became a mixed indigenous and Greek sanctuary.

The archaeological excavations in the sanctuary, at the summit of the Timpone della Motta hill, has carried out, since 1992, by the Groningen Institute of Archaeology (GIA), as well as in the inhabited areas on lower parts of the hill (Jacobsen and Handberg, 2009).

The pottery found at the site provides insights into the development of religious and mortuary practices, domestic life and the manufacturing processes applied to pottery and other objects within the indigenous community (Jacobsen, 2007). The archaeological material from the Timpone della Motta represents a unique selection of different classes of pottery of local, regional, interregional and Mediterranean provenances. The abundance of pottery from the site is explained by the fact that an important sanctuary developed on the summit of the Timpone della Motta from the beginning of the 8th century B.C. During this first part of the sanctuary´s life, massive quantities of pottery were used and deposited within the sanctuary, and during the following two centuries the sanctuary continued to receive high amounts of ceramic vessels.

Only few papers of archaeometric character have been performed and only few previous studies focusing on the provenances of pottery from Timpone della Motta and other archaeological sites in the region were confined to comparisons of typology and style. Analytical studies have been carried out on *impasto* pottery and *dolii* (Carrara et al., 1983; Levi et al., 1999; De Francesco et al., 2008) from the area (Figure 1), near ancient Sybaris with further references.

A preliminary study on a few Matt-painted pottery, Oinotrian-Euboean style ceramic fragments and colonial ware from the Timpone della Motta archaeological site (Andaloro et al., 2011), suggest a relatively high temperature major than 850 °C for almost all the analysed samples, together with purification processes, from the technological point of view. Regarding the production area, the chemical comparison between the ceramics and the local Early-Pleistocenic clayey sediments around the site, evidenced an high affinity, indicative of a dominant local production on the basis of these results. This archaometric study regards two stylistic groups of the Matt Painted pottery class, the hypothesized local ceramic of which only few samples have been studied in the previous paper of Andaloro et al. (2011). The purpose of this study is to compare, on a larger number of samples, the two groups of matt-painted ceramics in order to verify their compositional

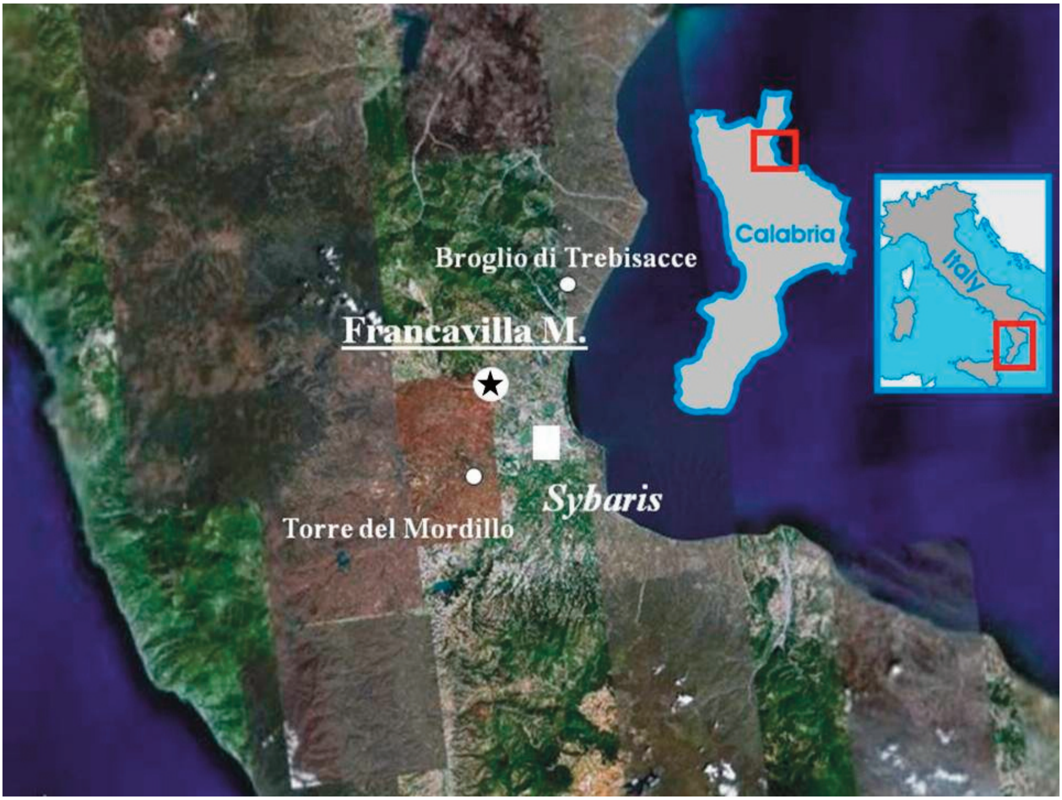

Figure 1. Location of the Timpone della Motta archaeological site (indicated with the star), close the archaeological area of Sybaris; other important archaeological sites are also indicated.

differences or homogeneity (in total 25 ceramic fragments). The firing test conducted on representative samples of the potential local clayey materials that may have been exploited (Andaloro et al., 2011), may provide important information around the employed production technology (temperature and firing conditions).

This information will be a significant contribution to the archaeological hypotheses on the production and technology of both Undulating Band and Fringe Stile ceramic groups, considering their differences in craftsmanship and chronology and may help to clarify the role of this site in the Magna Graecia world.

Materials and methods

Matt-painted pottery

Indigenous Matt-Painted pottery was produced at several southern Italian sites throughout the Iron Age. The vessels are either hand-made or formed on a slowly rotating wheel and decorated with indigenous mono- or bi-chrome motifs. The wide range of indigenous shapes demonstrates that this class of pottery was used both as tableware and for household and storage purposes. Fragments of two stylistic groups within the matt-painted samples were selected for analysis: the Undulating Band and the Fringe Style.

The Undulating Band and the Fringe Style are chronologically separated. The Undulating Band Style appeared around 800 B.C. at the latest. The style is simple but distinct and consists of a decorative combination of horizontal and undulating bands. The style is found on all types on Matt-Painted vessels from tableware to storage vessels. The Undulating Band Style is the most common type of indigenous Matt-Painted pottery in Francavilla Marittima and on other nearby sites during the first half of the 8th century B.C. (Kleibrink, 2008). The craftsmanship displayed in the Undulating Band Style is substantially varied, which may indicate that many different hands were involved in the production of the style. It is likely that vessels decorated in the Undulating Band Style were produced by individual families for their own use rather than by specialised pottery workshop. In Francavilla Marittima Matt-Painted vessels decorated in the Fringe Style are found in indigenous archaeological contexts datable to the period between c. 730 and 680 B.C. (Kleibrink, 2006). The style is characterized by closely set horizontal and vertical lines and it is found on all types of vessels. The Fringe Style production require skilled artisans, able to produce thin-wall vessels, finely decorated. Hence, the presence of specialized pottery workshops can be hypothesized. Both the Undulating Band Style and the Fringe Style occur regularly in indigenous domestic, funerary and sanctuary contexts.

The pottery in question has in the archaeological literature been regarded as a locally manufactured pottery group based on its limited geographic distribution, which is limited to Francavilla Marittima and a few other archaeological sites in the Sibaritide. The sherds analysed here consist of 25 samples: 17 fragments of the Undulating Band Style and 8 fragments of the Fringe style. Representative photographs of the sherds of the two matt-painted styles are shown in Figure 2.

Clayey samples

In order to confirm their provenance, the data obtained from a total of 20 Early Pleistocene clay

Figure 2. Representative fragments of the two matt-painted styles: a) Undulating band style (sample 1/87); b) Fringe style (sample SM13).

sediment samples (LAU 1-15 and LFR 1-5) collected from the more representative clay outcrop of the surrounding area of the Timpone della Motta (Figure 3a and 3b) and previously published in Andaloro et al., 2011, were used as comparison. Sampling criteria and extension of the outcrops are described in the same paper. The sampled sediments are reported as VSR_2 (Early Pleistocene), in the more recent geological maps - F. 535 Trebisacce and F. 543 Cassano allo Ionio - 1:50.000, and consists of poorly stratified blue-grey clays and silty clays; in the sampled area they are massive and homogeneous. In the old geological map of Francavilla Marittima - 1:50.000 F. 221 IINE, these sediments are indicated as P_a (Pliocene-Upper Pliocene).

Analytical methods

The sherds were examined with an integrated analytical approach; analytical techniques included petrographic analysis by optical microscopy, XRD mineralogical analysis, XRF chemical analysis and micro-morphological analysis by scanning electron microscopy (SEM).

A polarising optical microscope ZEISS Axioscope was employed for petrographic thin-section analyses and descriptions of samples were made following the scheme proposed by Whitbread (1995), in order to characterise the microstructure, groundmass and inclusions of the pottery. Micro-morphological analysis on the freshly fractured surfaces of all sherds were performed by a FEI/Philips Field Emission Gun (FEG) Quanta 200F scanning electron microscope equipped with a EDAX GENESIS 4000 microanalysis unit, working in energy-dispersive mode. The groundmass microstructure and the degree of vitrification were compared with the vitrification stages of Maniatis and Tite (1981).

Mineralogical compositions of ceramic samples were determined by XRD on Bruker D8 Advance diffractometer, with CuKa radiation. Samples were powdered by hand grinding in an agate mortar to produce an average particle smaller than 10 µm. The powder was then side-loaded into a glass sample holder to obtain a randomly-oriented specimen, thus minimising preferred orientations. Spectra were taken in the range 5° - 60° 2θ, with steps of 0.02° 2θ and step-times of 1 sec/step.

A Bruker S8 Tiger spectrometer was used for XRF analysis of all samples, in terms of major, minor and some trace elements. Loss on ignition (L.O.I.) was gravimetrically estimated after overnight heating at 950 °C and FeO content by wet titration. International geological standards were used for calibration.

The clay samples (Andaloro et al., 2011) from the area surrounding the Timpone della Motta, were subjected to grain-size analysis by the fractionated sedimentation method according to Dell'Anna and Laviano (1987).

Furthermore, three representative clay samples were specially prepared and experimentally fired, in order to obtain information on firing temperature.

Each sample was mixed with the quantity of water necessary to produce a plastic, homogeneous paste. Following, the paste was formed into handmade square test samples measuring 3.2 x 3.2 x 0.5 cm. A firing test was prepared for each sample and it was fired to 950 °C (De Francesco et al,. 2009; Pavìa, 2006), in a electric kiln, in order to simulate the possible conditions of ancient kiln firing. The firing cycle involved temperature increases of 100 °C/hour (Buxeda I Garrigòs et al., 2003), after which the test samples were exposed to the highest temperature for about 2 hours and then left to cool slowly. They were then pulverized and subjected to diffractometric analysis.

The samples submitted to the firing test contains not more than 5% of sand, though all the samples are rather homogeneous for the silt and clay contents.

No sand was added to the paste because of the

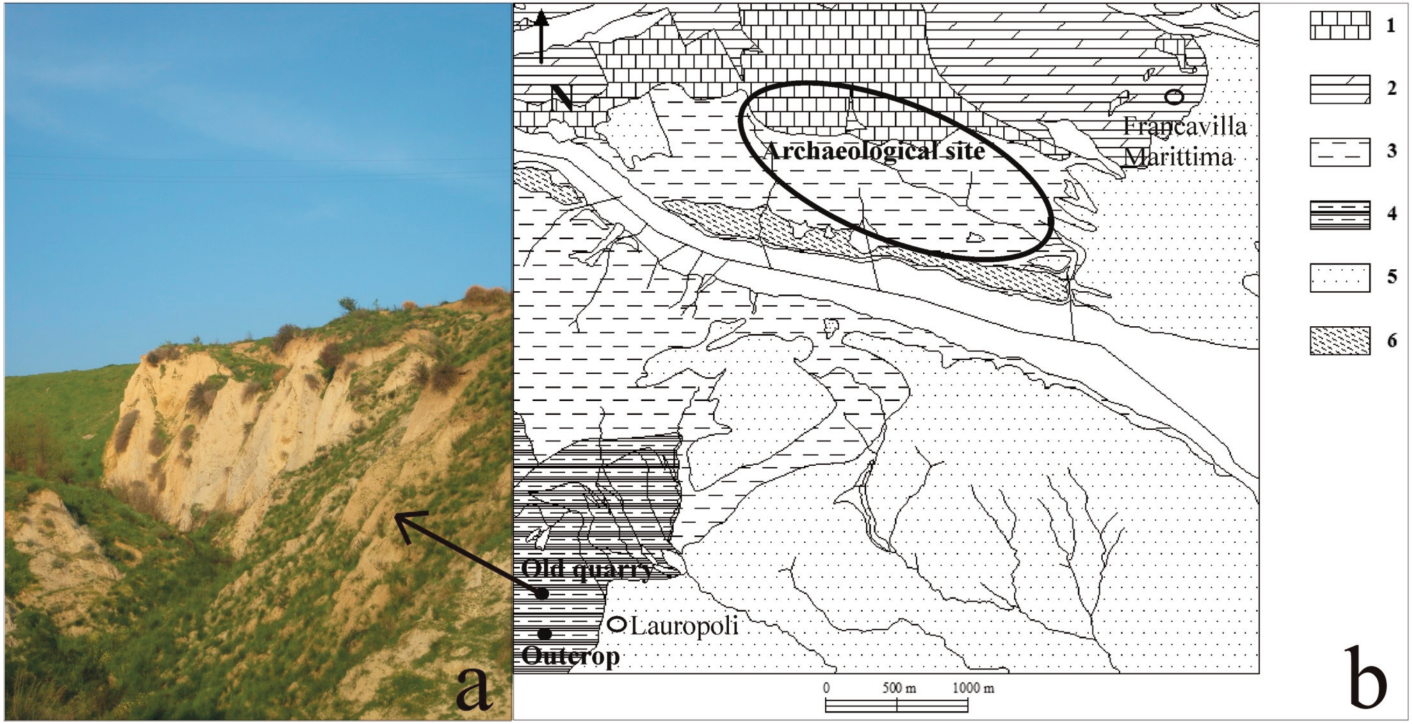

Figure 3. a) Old clay quarry in Lauropoli; b) Schematic geological sketch-map of Francavilla Marittima area (modified after Andaloro et al., 2011). 1 = Crystalline limestone and dolomitic limestone - Middle-Upper Cretaceous. 2 = Alternation of clay, fine-grained quartzitic sandstone and limestone - Lower Miocene. 3 = Polygenic conglomerates - Early Pleistocene. 4= Greyish-blue silty clay - Upper Pliocene in F. 221 II NE - Francavilla Marittima 1: 50.000; In the recent geological maps - F. 535 Trebisacce and F. 543 Cassano allo Ionio - 1:50.000 this sediments are reported as VSR2 (Early Pleistocene). 5 = Sand and polygenic conglomerates. 6 = Ancient river deposits - Pleistocene. Location of archaeological site and sampled clay outcrop are also indicated.

very scarce abundance of the aplastic inclusion, as will be highlighted in the optical microscopy analysis paragraph.

The choice of firing temperature and times was determined on the basis of the mineralogical phases detected by PXRD in both the ceramic groups, but also taking into account the neo-formed mineralogical phases during the experimental firing of a carbonate rich clay, as it is the sampled raw material (Peters and Iberg, 1978; Maniatis and Tite, 1981; Maggetti, 1982; Mazzoleni and Pezzino, 2001; Gliozzo et al., 2005).

Results

Optical microscopy analysis

The thin-section analysis of both Undulating Band style (Figure 4a) and the Fringe style (Figure 4b) ceramics revealed no differences and they all exhibit the same textural and compositional features.

A detailed description of the Undulating Band style group (samples 13, 15, 16, 17, 18.2, 1/87, SM12, SM14, SM15, 42X, 43X, 41X, 40XSM, 46X, 47, 48, 4/5) and the Fringe style group (samples 14, 1/43, SM13, 44XB, 48X, 47X, 45XB, 49X) is given below (for abbreviations, see Whitbread, 1995) and listed in Table 1.

Fabric: fine.

Microstructure: (a) Common (SM15-1/43-17-18.2-48X-45XB-40XSM-41X-47X-13) to few (1/87-49X-46X-44XB-43X-SM12-42X-14-15-48-47-SM14-SM13-16) voids, occasionally partly rounded or filled with secondary calcite (47X-48X-49X,4/5,16,17,SM13,SM15,47,14). Frequent voids are only present in the over-fired sample 4/5.

Predominant to dominant mesovoids (vughs, vesicles, and linear), scarce microvoids (vesicles) and macrovoids (vughs and linear in 45XB e 4/5), rare megavoids (vughs and linear); in several samples voids show preferred orientation parallel to vessel margins (18.2, 1/43, SM12, 41X, 47X e 4/5); (b) grain-size distribution is unimodal; packing of inclusions is open-spaced.

Groundmass: (a) Generally homogeneous with a mica-rich groundmass;

(b) PPL colour is mainly reddish or brown, yellowish in the samples 18.2 and 48X at times with dark brown streaks; optical activity is normally low; b-fabric is speckled in 1/87 and

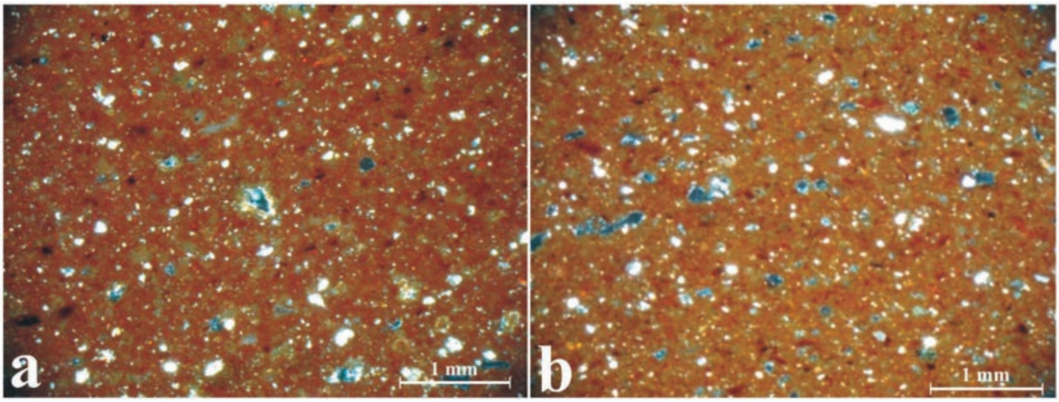

Figure 4. Microphotographs of thin sections for optical microscopy (OM) analyses under crossed nicols, showing the fabric of representative matt-painted samples: a) Undulating Band Style (sample 1/87); b) Fringe style (sample SM13). Magnification 15X.

Table 1. Typological-stylistic description and main microscopic features of the studied ceramic samples.

Sample	Typological class	Fabric	Colour	Voids	Aplastic inclusions	ACF Inclusions
13	Undulating band style	fine	7YR 3/1	common	quartz, feldspar, biotite and white mica	few, reddish-brown, Φ < 1 mm
15	Undulating band style	fine	5YR 3/3	few	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
16	Undulating band style	fine	2.5YR 3/2	few, partially filled by secondary calcite	quartz feldspar biotite and white mica, polycrystalline quartz	few, Φ variable from totally amorphous or with crystal inclusions
17	Undulating band style	fine	5YR 3/3	common, partially filled by secondary calcite	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
18.2	Undulating band style	fine	5YR 5/3	common, slight orientation parallel to margins	quartz feldspar biotite and white mica	few, few, Φ variable from totally amorphous or with crystal inclusions
1/87	Undulating band style	fine	5YR 3/1	few	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
SM12	Undulating band style	fine	7.5YR 4/2	few, partially filled by secondary calcite, slight orientation parallel to margins	quartz feldspar biotite and white mica, polycrystalline quartz	few, Φ variable from totally amorphous or with crystal inclusions
SM13	Fringe Style	fine	7.5YR 5/2	few, partially filled by secondary calcite	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
SM14	Undulating band style	fine	7.5YR 4/2	few	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
SM15	Undulating band style	fine	5YR 2.5/2	common	quartz feldspar biotite and white mica, chert and fossils mould	few, reddish-brown, Φ < 1 mm
42x	Undulating band style	fine	5YR 2.5/2	few	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
43x	Undulating band style	fine	7.5YR 3/2	few	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
41x	Undulating band style	fine	5YR 2.5/2	common, partially filled by secondary calcite, slight orientation parallel to margins	quartz feldspar biotite and white mica	few, Φ variable from totally amorphous or with crystal inclusions
40xsm	Undulating band style	fine	7.5YR 4/2	common	quartz feldspar biotite and white mica, chert and fossils mould	few, reddish-brown, Φ < 1 mm

Table 1. Continued ...

Sample	Typological class	Fabric	Colour	Voids	Aplastic inclusions	ACF Inclusions
46x	Undulating band style	fine	5YR 3/2	few	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
47	Undulating band style	fine	5YR 3/2	few, partially filled by secondary calcite	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
48	Undulating band style	fine	5YR 3/2	few	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
4.5	Undulating band style	fine	7.5YR 3/1	frequent, predominant to dominant mesovoids, partially filled by secondary calcite	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
14	Fringe Style	fine	5YR 2.5/1	few, partially filled by secondary calcite	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
1/43	Fringe Style	fine	5YR 2.5/1	common, partially filled by secondary calcite, slight orientation parallel to margins	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
44xb	Fringe Style	fine	7.5YR 2.5/2	few	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
48x	Fringe Style	fine	10YR 2/1	common, partially filled by secondary calcite	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
47x	Fringe Style	fine	7.5YR 3/2	common, partially filled by secondary calcite	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
45xb	Fringe Style	fine	7.5YR 2.5/2	common, predominant to dominant mesovoids	quartz feldspar biotite and white mica	few, reddish-brown, Φ < 1 mm
49x	Fringe Style	fine	7.5YR 2.5/1	few, partially filled by secondary calcite	quartz feldspar biotite and white mica, chert and fossils mould	few, reddish-brown, Φ < 1 mm

47x samples, striated in 18.2 sample, sometimes strial (17, 41X, 48, SM12, SM15) and crystallitic in the remaining samples.

The over-fired 4/5 sample, shows absent optical activity and the matrix colour is grey-black with the exception of a red streak in the central part of the fragment.

(c) The abundance of aplastic inclusions is scarce to very scarce, with a c:f ratio ranging from 5:95 for the most of the samples, 8:92 in 48X, 47, 48 and 47X samples, and 2:98 in 45XB and 46X; grains are very well-sorted.

Composition and frequency of the aplastic inclusions: Predominant to dominant:

monocrystalline quartz.

Frequent: feldspar.

Common: biotite and muscovite.

Few to rare: polycrystalline quartz (quartzite rock fragments occur in samples 16 and SM12),

Very rare: chert and fossils mould in samples 49X, 40XSM and SM15.

Amorphous concentration features: Acf: 2-3% of the total field. Acf consist of small-sized nodules, mainly pure in nature, with dark red colour in both PPL and XPL. About 7% in the samples 16, 18.2, 41X and SM12.

Grain-size analysis on clayey materials

Ten representative samples of the collected clayey materials subjected to granulometric analysis have a percentage of sand between 0.4% and 11.8%, silt between 64.6% and 73.5% and clay between 21.5% and 31.8%. According to Shepard (1954) can be classified as "clayey silt" (Andaloro et al., 2011). On the basis of Pettijohn

Table 2: Mineralogical phases and relative abundances identified by XRD analysis of sherds.

Sample	Qtz	Pl	Kfs	Cal	Di	Gh	He	Ill/Ms
Matt-painted "Undulating Band Style"								
13	****	***	**			*	*	
15	****	**	**			*	*	*
16	****	***	**			tr	*	
17	****	***	**			*	*	
18.2	****	***	**			tr	*	
1/87	****	***	*		*		*	
SM12	****	**	*		tr	**	*	
SM14	****	**	**		*	tr	*	tr
SM15	****	**	**	*	*	*	*	tr
42X	****	**	**		*	*	*	*
43X	****	***	**		*	*	*	
41X	****	***	**	tr	*	*		
40XSM	****	***	**		*	*	*	*
46X	****	***	**		*	*	*	*
47	****	**	**		*	**	*	tr
48	****	**	**		*	*	*	tr
4.5	****	***	**		**	**	*	
Matt-painted "FringeStyle"								
14	****	**	**			tr		tr
1/43	****	***	**	**	*		*	*
SM13	****	**	*		*	*	*	
44XB	****	***	**		*	*	*	
48X	****	***	**	tr	**	*	*	
47X	****	***	**	tr	**	*	*	
45XB	****	**	**		tr	**	*	*
49X	****	**	**		*	*	*	*

Qtz: quartz; Pl: plagioclase; Kfs: K-feldspar; Cal: calcite; Di: diopside; Gh: gehlenite; He: haematite; Ill/Ms: illite/muscovite.
**** = very abundant; *** = abundant; ** = present; * = scarce; tr = traces.

(1987) nomenclature of sedimentary rocks, they may be classified as "mud".

XRD analysis of pottery, clay sediments and firing tests

A summary of mineralogical phases identified in each ceramic sample is listed in Table 2, which also shows the relative abundances estimated on the basis of the intensity of peaks in the XRD spectra.

From a mineralogical point of view, the matt-painted pottery of local styles contain an abundance of quartz, plagioclase and K-feldspar (Table 2); calcite is only present in 5 samples (1/43, SM15, 41X, 47X, 48X) and certainly of secondary origin, as observed microscopically. In addition, XRD shows the presence of diopside, gehlenite and hematite in almost all samples; finally illite/muscovite was found, usually in trace amounts, in few ceramic fragments.

XRD data on the clay samples (Andaloro et al., 2011) show the marked homogeneity of the mineralogical composition in all specimens. Quartz is always the most abundant phase, followed by calcite, chlorite, illite/muscovite and plagioclase, in decreasing order of abundance. In addition, variable amounts of dolomite (in all samples) and traces of K-feldspar (in most specimens) were likewise identified.

Representative local clay samples (Figure 5), fired at 950 °C, present very good characteristics; they show homogeneous red color (2.5YR 5/6) according to the Munsell Color Chart and "cracks" due to the shrinkage during firing are absent.

The XRD patterns obtained through the firing tests show the following mineralogical composition: quartz, gehlenite, plagioclase, K-feldspar, diopside, hematite and illite/muscovite, in decreasing order of abundance.

XRF analysis of pottery and clay sediments

The concentrations of major (in wt%), minor and some trace elements (in ppm) of the pottery fragments obtained by XRF analysis are listed in Tables 3 and 4. In order to understanding the relations between the two ceramic groups as well as to compare them with the sampled raw clay materials, results of XRF chemical analysis were processed graphically and compared with chemical data of the local sampled clayey

Figure 5. Experimental tests with the local clay samples fired at 950 °C.

Table 3. Major elements (wt%) composition obtained by XRF analysis of ceramic samples.

Sample	SiO_2	TiO_2	Al_2O_3	Fe_20_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI
Matt-painted Undulating Band Style												
13	59.98	0.90	18.19	7.33	0.33	0.12	3.86	5.27	0.84	3.33	0.18	2.73
15	59.15	0.92	18.58	7.46	0.35	0.10	3.88	5.46	0.90	3.31	0.24	2.03
16	61.44	0.88	17.26	6.85	0.44	0.10	3.76	5.67	0.84	3.02	0.16	3.96
17	57.97	0.89	17.81	6.80	0.26	0.11	4.07	8.04	0.85	3.25	0.21	4.05
18.2	57.12	0.97	20.70	7.69	0.81	0.16	3.80	5.17	0.84	3.40	0.16	2.35
1/87	58.45	0.93	18.69	7.47	0.45	0.10	4.10	5.97	0.92	3.19	0.17	2.38
SM12	58.20	0.94	19.57	7.58	0.44	0.13	3.86	5.47	0.87	3.18	0.20	3.74
SM14	61.30	0.87	18.12	7.20	0.33	0.10	3.88	4.37	0.90	3.05	0.21	3.32
SM15	59.22	0.80	16.16	6.10	0.61	0.11	3.69	9.82	1.03	2.77	0.29	5.36
42X	57.62	0.96	19.45	7.79	0.22	0.11	3.86	5.98	0.91	3.09	0.21	3.50
43X	56.12	0.99	19.68	7.87	0.25	0.10	4.07	6.58	1.07	3.32	0.21	2.28
41X	57.67	0.99	21.87	8.23	0.22	0.16	3.25	3.65	0.67	3.31	0.18	6.15
40XSM	54.09	1.00	21.14	7.45	1.06	0.12	4.37	7.30	0.86	3.50	0.18	1.86
46X	57.59	0.96	19.85	8.14	0.16	0.18	3.62	5.60	0.82	3.07	0.19	1.81
47	57.25	0.92	18.17	7.95	0.36	0.16	4.09	7.18	1.03	3.08	0.18	2.74
48	58.87	0.89	17.90	7.36	0.17	0.12	3.59	7.10	0.93	2.97	0.27	4.20
4.5	55.71	1.17	21.55	8.71	3.77	0.17	3.65	4.42	0.77	3.71	0.13	0.77
Matt-painted Fringe Style												
14	59.67	0.90	17.93	7.68	0.40	0.13	4.22	5.08	0.85	3.32	0.22	3.23
1/43	60.76	0.82	16.97	6.69	0.35	0.12	3.85	6.46	0.87	3.25	0.22	3.92
SM13	60.85	0.81	17.05	6.76	0.14	0.12	3.75	6.48	0.95	2.98	0.25	3.99
44XB	57.57	0.94	19.06	7.90	0.28	0.14	3.72	6.29	0.99	3.10	0.28	2.90
48X	58.54	0.85	17.21	6.74	0.19	0.13	4.12	8.32	1.02	2.89	0.20	2.90
47X	54.62	0.95	18.30	7.61	0.21	0.17	4.39	9.55	0.98	3.16	0.26	5.91
45XB	57.02	1.05	22.11	7.99	0.27	0.15	3.33	3.94	0.66	3.60	0.16	2.95
49X	57.54	0.86	17.47	6.95	0.40	0.14	4.05	8.71	0.84	3.10	0.34	6.78

materials of Andaloro et al., 2011. Chemical comparisons are evaluated in more detail in the binary diagrams of Figure 6.

Specifically, the SiO_2 vs. CaO plot (Figure 6a) shows that the local clays generally have higher CaO contents (6.8% to 9.9%) and lower SiO_2 percentages (53.7% to 55.7%) with respect to the studied samples, the values of which range from 3.6% to 9.8% for CaO, and from 54.1% to 61.4% for SiO_2.

The MgO vs. Fe_2O_3 diagram (Figure 6b) shows a high compatibility between the ceramic fragments and the sampled raw materials. Most of the fragments have Fe_2O_3 contents varying from 6.1% and 8.7%, while the Fe_2O_3 values of sampled clays vary between 6.1% and 7.6%; also the MgO values are very similar, between 3.3% and 4.4% for the pottery fragments and between 3.6% and 4.2% for the Early Pleistocene clay.

A similar behaviour (Andaloro et al., 2011) is reflected in the diagram Rb vs. Sr (Figure 6c),

Table 4. Minor and trace elements (ppm) composition obtained by XRF analysis of ceramic samples.

Sample	Ni	Cr	V	La	Ce	Co	Ba	Nb	Y	Sr	Zr	Rb
Matt-painted Undulating Band Style												
13	83	162	148	45	93	23	505	19	25	207	163	142
15	80	151	148	42	97	25	498	19	26	226	168	138
16	86	155	143	44	86	21	510	19	24	236	158	131
17	80	144	147	36	82	20	546	18	26	263	156	132
18.2	98	167	183	59	110	22	569	22	30	197	167	149
1/87	86	155	152	48	90	22	434	19	25	216	168	138
SM12	88	163	172	45	97	23	873	17	30	271	174	140
SM14	84	155	128	40	92	23	819	17	25	236	164	137
SM15	66	119	130	26	80	18	530	15	28	474	171	120
42X	85	154	157	39	88	22	1098	18	34	220	163	135
43X	88	161	165	42	100	23	562	18	32	231	159	141
41X	96	181	178	52	92	26	1982	19	31	158	167	139
40XSM	91	173	192	42	101	22	821	18	32	298	160	153
46X	95	164	160	51	90	26	872	17	29	231	150	131
47	61	154	140	35	72	25	1321	17	30	277	171	132
48	53	141	138	36	64	21	1891	16	30	292	171	126
4.5	100	198	216	55	133	26	481	20	45	162	175	164
14	95	164	148	45	85	23	839	19	26	237	172	134
1/43	84	138	128	45	78	20	870	19	25	291	178	133
SM13	79	134	123	28	67	19	1604	16	27	301	179	130
44XB	100	162	149	35	73	22	1465	17	32	232	162	135
48X	77	133	122	37	65	20	1270	16	29	336	166	126
47X	90	159	158	30	82	21	1281	16	34	282	162	126
45XB	99	188	176	53	117	25	1187	20	36	172	175	159
49X	77	129	134	39	61	18	1571	16	33	338	163	125

where even in this case, the compatibility between the matt-painted pottery and the sampled clays can be noted.

In conclusion, all pottery and clay samples show a Rb content varying between 117 and 164 ppm and a Sr content ranging from 158 and 338 ppm, excluding the SM15 sample which has an higher value (474 ppm).

Lastly, the Zr vs. Y plot (Figure 6d), shows that the pottery groups display high similarity in these two elements (Zr: 150-179 ppm; Y: 24-45 ppm), and a good relationship can also be observed with the local clay sediments.

Micro-morphology of pottery by SEM

Micro-morphological analysis by scanning electron microscopy allows assessment of the textural features of the groundmass, yielding information on the degree of vitrification reached by the samples during firing. In addition, it yields a rough estimate of the equivalent firing temperatures, especially when this information

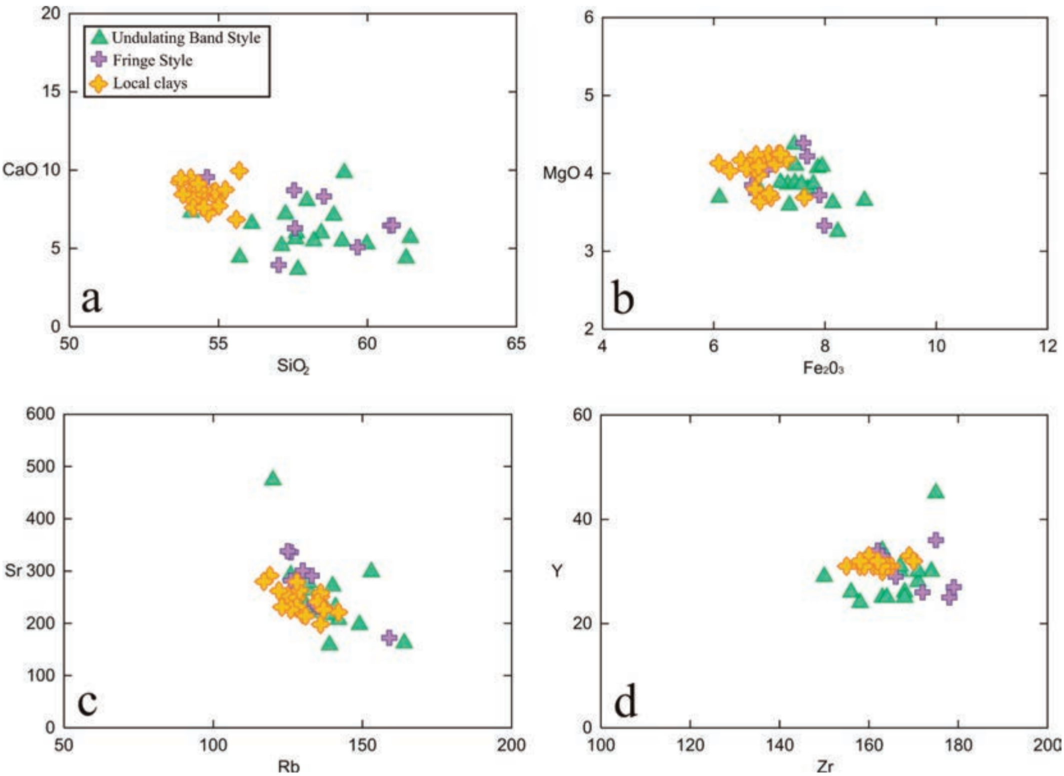

Figure 6. Comparisons between chemical composition of matt-painted pottery and the local Early Pleistocene clay sediments.

is combined with petrographic and mineralogical data (Maniatis and Tite, 1981; Kilikoglou, 1994; Tite et al., 1982). Observations showed that almost all the matt-painted samples display initial vitrification (Figure 7a).

Only the over-fired sample *4/5* shows continuous vitrification accompanied by the development of medium to coarse bloating pores (Figure 7b).

Discussion

The petrographic analysis of matt-painted Undulating band and Fringe styles pottery has evidenced a great homogeneity of the compositional and textural characteristics.

All the samples have a "fine fabric" with a matrix, generally homogeneous, mostly reddish or brown in color (PPL), yellowish in few samples; the optical activity is generally low and the b-fabric is often crystallitic, speckled in some cases, strial or striated. The 4/5 fragment, the only over-fired sample, has no optical activity and presents matrix of gray-black color except for a thin red band. The non-plastic fraction abundance is low, with a c:f value around 5:95 for most of the fragments and the grains are very well selected. The distribution is unimodal and the packing is well-spaced in all the fragments. The voids are common to a few, frequent only in the fragment 4/5, sometimes partially filled by secondary calcite.

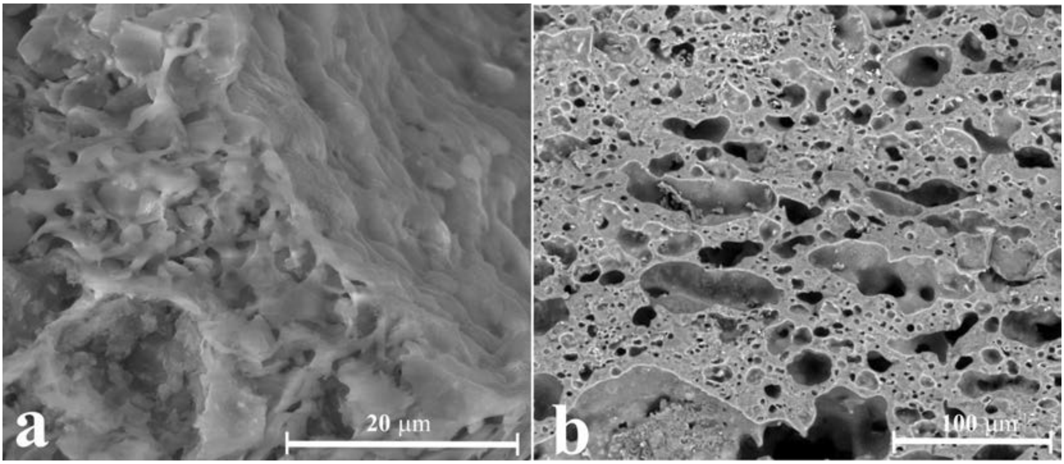

Figure 7. SEM photomicrographs of sample SM14 with initial vitrification degree (a), and over-fired sample 4/5 (b) exhibiting a continuous vitrification with bloating pores.

As regard the composition and frequency of the non plastic inclusions, the dominant mineral is certainly the quartz (sometimes polycrystalline) and, subject, feldspar, biotite and muscovite. Presence of chert fragments and very rarely quartzite and microfossils is observed in very few samples. Likewise present are (2-3%) small sized amorphous nodules, dark red in color in both PPL and XPL.

Figure 8 show the comparison between optical microscope features of a representative matt-painted fragments (SM13) and the thin section of the representative sample of the local sampled clay (LAU1) after the firing test. In general the groundmass of Matt-painted pottery, Undulating band and Fringe styles, as well as the size, the abundance and the composition of the non plastic fraction, are not different from the clayey material samples subjected to the experimental firing of the clayey materials; it is important to take into account the great skill and expertise of the craftsmen of the period that probably

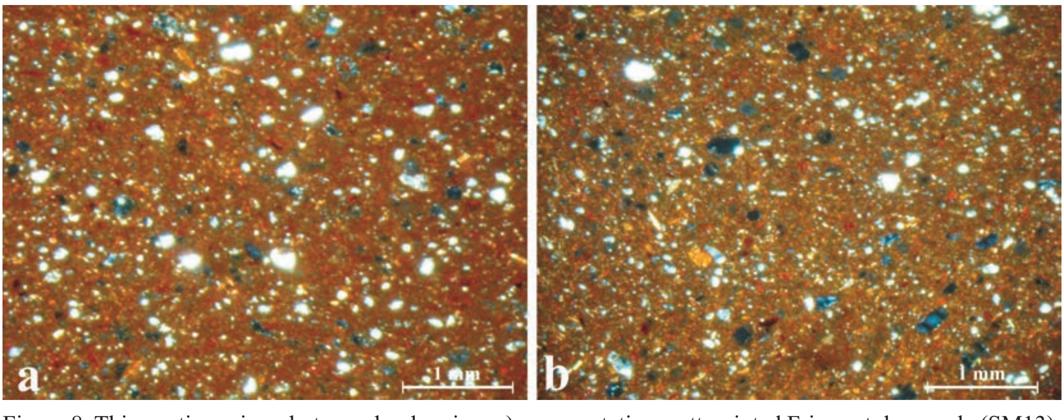

Figure 8. Thin-section microphotographs showing: a) representative matt-painted Fringe style sample (SM13); b) representative firing test of local clayey materials (LAU1). All images were taken in XPL.

subjected to some kind of processing the raw materials before the ceramic production.
From the mineralogical point of view, abundant quartz, plagioclase and K-feldspar were detected by XRD in the two matt-painted pottery styles (Table 2). Calcite is only present in 5 fragments (in 3 only traces) and it is certainly of secondary origin, as observed microscopically. In addition, XRD showed the presence of diopside, gehlenite and hematite in almost all samples, and finally illite/muscovite is present in few samples, usually in trace amounts.
The XRD analysis of the test firing of the local sampled clays, fired at 950 °C, revealed the presence of quartz, gehlenite, plagioclase, K-feldspar, diopside, hematite and illite/muscovite, as in the matt-painted pottery. Consequently, the mineralogical composition of the fired clay samples is fully compatible with the ceramics studied.
The combined information about XRD data and micro-morphological observations by SEM yielded a rough estimate of firing temperatures. Specifically, as the XRD spectra revealed the occurrence of newly formed Ca-rich phases, and SEM analysis highlighted initial vitrification microstructures, temperatures major than 850 °C are suggested for almost all samples (Peters and Iberg, 1978; Maniatis and Tite, 1981; Maggetti, 1982; Mazzoleni and Pezzino, 2001; Gliozzo et al., 2005), only the over-fired sample 4/5 certainly exceeded 1000 °C.
As already noted, the two groups of ceramic Undulating band and Fringe styles show the same chemical composition based on the results of chemical analysis XRF, this suggest the employ of the same raw materials for both matt-painted styles production.
The comparison between XRF data obtained on ceramics and on the sampled local clay sediments, indicate that the Matt-painted pottery of local styles are compositionally similar to the sediments (Figure 6), but the two pottery classes are slightly richer in SiO_2 and poorest in CaO respect to the local clays (Figure 6a).
These small differences may be explained by the purification process, which raw materials undergone (Andaloro et al., 2011), which resulted in the removal not only of larger grains but also of calcareous fossils, which are sometimes present in this type of clay. Such a technological process may explain the indirect decrease in calcium and the increase in silica in the worked clays (Kilikoglou et al., 1988; Fabbri, 1996).

Conclusions

On the combined basis of the obtained results, it is evident that the two groups of matt-painted ceramics were produced with the same raw materials.
From a technological point of view, the combined petrographic, mineralogical and chemical results indicate that almost all the examined sherds were fired at relatively high temperatures (> 850 °C).
The comparison of the pottery and the local clay sediments XRF data, shows that the Matt-painted pottery of local styles are compositionally similar to these sediments.
The tests on the Early Pleistocene clays, fired at 950 °C, show the presence of diopside and hematite mineralogical phases gehlenite, in the PXRD spectra, as in most of the pottery fragments; the matrix is also microscopically very similar to the ceramic samples matrix and suggests that the Early Pleistocene clay might be the used raw material.
The large-scale pottery production in this area could be justified by the extensive outcrop of such clay sediments near the archaeological site. However, in general, the sherds are slightly richer in SiO_2 and poorer in CaO than the local clays, but the conducted purification process may explain the indirect decrease in calcium and the increase in silica in the worked clays.
The data presented in this archaeometric study

has helped to clarify the complex aspects of material provenance and pottery workshop organization at the Timpone della Motta at Francavilla Marittima, providing a significant contribution to the archaeological interpretation of the material culture. In particular the study shows a great similarity between the Matt-painted Undulating band style and Fringe style pottery with the local clayey materials, which clearly suggest a local provenance for these classes, supporting the assumptions and the archaeological interpretations.

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