PRODUCTION OF MID-LATE NEOLITHIC 'SERRA D'ALTO' WARE IN THE BRADANIC TROUGH (SOUTH EASTERN ITALY)

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***Abstract**: This article explores the issue of circulation in different areas of southern Italy of Mid-Late Neolithic 'Serra d'Alto' pots, rather than the production model of this ware. Petrographic, mineralogical and chemical analyses of 54 pottery samples from Serra d'Alto and Trasano (Basilicata), and from Masseria Fragennaro (Apulia) have revealed that fine wares were produced using local Plio-Pleistocene marly clays; while almost all the coarse wares were produced using eluvial or colluvial deposits in a carbonatic area. These results confirm the hypothesis of widespread technological models of production in different areas. Serra d'Alto pottery would therefore seem to be a significant technological shift from Early Neolithic pottery production.*

***Keywords**: Mid-Late Neolithic, Bradanic Trough, Serra d'Alto ware, Argille Subappennine, mineralogical and chemical analyses*

THE SCIENTIFIC PROBLEM

Mid-Late Neolithic 'Serra d'Alto' ware was widespread in southern Italy during the fifth millennium cal. BC and exhibited homogeneous formal and technical features. This style was characterized by very fine yellow paste, decorated with exquisite curvilinear–geometric patterns in brown, and with finely modelled handles and lugs in animal- and bow-forms.

From a chronological point of view, this *facies* corresponds to the fifth millennium cal. BC and the beginning of the fourth millennium cal. BC. This can be seen from the ancient ^{14}C dates from Masseria Candelaro (Apulia), Santa Barbara (Apulia) and Stretto Partanna (Sicily) to the late dates from Cala Scizzo (Apulia), Cala Colombo (Apulia) and Skorba (Maltese Islands) (*Skeates 1994*).

Serra d'Alto's wide distribution even in northern Italy and its frequent occurrence in funerary/cultual contexts, have led many scholars (*Cassano 1993; Malone 2003*) to emphasize its exchange value. This ware would have been a prestige good, probably manufactured in a number of production sites in southern Italy and then widely distributed through a large network of middle and long distance exchange.

This work is part of a more extended archaeometric project (*Laviano & Muntoni 2006, in press*), aiming to verify the hypothesis of the circulation of finished ceramic pots, rather than of production models in different areas of southern Italy. The first efforts focused on building up an extensive database of the mineralogical, petrographic and chemical data of more than one hundred pottery samples from many of the excavated Neolithic villages in Apulia (Tavoliere and Murge) where this pottery type is largely documented (*Geniola et al. 2005; Muntoni et al. 2006*).

ARCHAEOLOGICAL CONTEXTS AND MATERIALS

This paper presents a new set of 54 pottery samples from three excavated Neolithic villages: Serra d'Alto (Basilicata), Trasano (Basilicata) and Masseria Fragennaro (Apulia). The sites, which were frequently surrounded by impressive and semi-fortified ditches, were excavated respectively by the Soprintendenza ai Beni Archeologici della Basilicata (*Lo Porto 1989*), by the Universities of Pisa and Toulouse (*Radi & Grifoni Cremonesi 1995*) and by the Soprintendenza ai Beni Archeologici della Puglia (*Venturo 1995*). In the three Serra d'Alto villages (A, B and C) circular cavities were frequently found inside the area delimited by the ditches, and these have been interpreted as 'hut bases' or silos. During this phase the excavated area at Trasano was used for food storage structures: numerous bell-shaped silos, with a narrow opening closed with a stone plug, have been found: one of these was successfully used for several inhumations.

The analysed sites are all situated on the western edge of the Murge Plateau and in the Bradanic Trough (**Fig. 1**), where Serra d'Alto ware was produced in large quantities during the Neolithic period and where it was first identified by the archaeologist *Ridola (1924-1926)*. Two different wares (**Fig. 2**) have been found in archaeological contexts: brown painted fine ware pots (n=40: SdA 1-14; TR1-3, 6-8, 10-12, 15-17; LFR1-8, 15-18, 23-24) and black household pots (n=14; TR4-5, 9, 13-14, 18-20; LFR9-14).

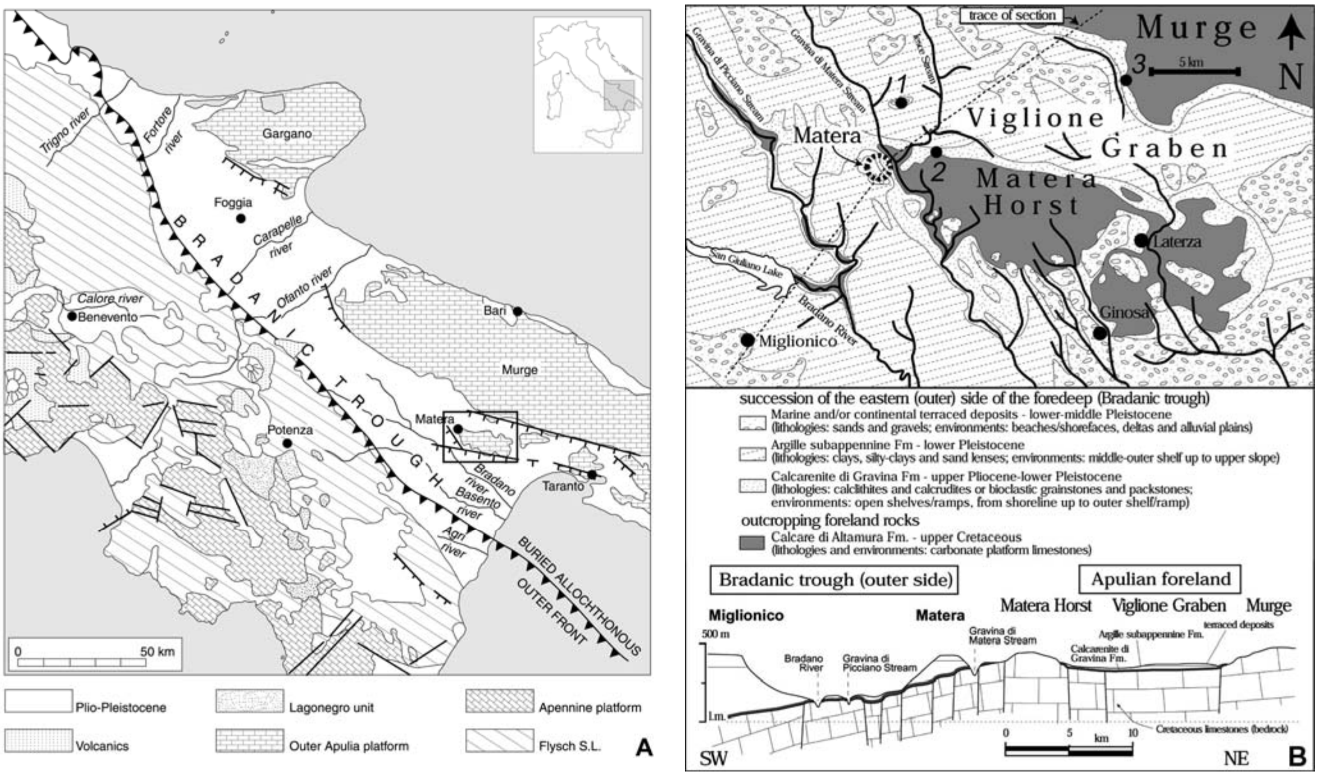

Fig. 1 Geological sketch map of (a) the Bradanic Trough (modified after *Sella et al. 1988*) and (b) the Matera area (modified after *Beneduce et al. 2004*) with location of sampled Mid Neolithic settlements: (1) Serra d'Alto; (2) Trasano; (3) Masseria Fragennaro

The 14 pottery fragments from Serra d'Alto villages were sampled from village A (SdA 1-10) excavated in 1931 (Fondo Contorti) and 1942 (Fondo Chico), and from village C (SdA 11-14) excavated in 1925 (Fondo Giacoia). The 20 pottery fragments from Trasano were sampled from the bell-shaped silos 8 (TR1-5), 9 (TR6-9), 10 (TR10-14) and 11 (TR15-20), all excavated in 1991. The 20 pottery fragments from Masseria Fragennaro were sampled from the second (LFR1-18) and the third (LFR23-24) archaeological levels of the ditch excavated in 1994. Some Early to Mid Neolithic pottery samples had previously been characterised by thin-section analysis from Serra d'Alto village A (*Mannoni 1988*) and Trasano (*Angeli & Fabbri 2005*).

THE GEOLOGICAL CONTEXT

The Murge Plateau (**Fig. 1**) is mainly made up of Calcare di Bari (Valanginian – late Cenomanian) and Calcare di Altamura (late Turonian – Maastrichtian) limestone formations (*Luperto Sinni 1996*), with *terra rossa* deposits present in the sequence. *Terra rossa* is formed of silty–clayey continental sedimentary deposits, very poor in carbonate, composed of dominant clay minerals (illite and kaolinite) and Fe-oxides or hydroxides, with subordinate quantities of quartz, feldspars, micas and rare pyroxenes. SiO_2, Al_2O_3 and Fe_2O_3 are the main oxides, both in the clay fraction and in the whole specimen (*Dell'Anna 1967; Dell'Anna et al. 1973*).

Fig. 2 Examples of analyzed pottery fragments from Masseria Fragennaro (Apulia): (a) brown painted fine ware

(LFR6); (b) household coarse ware (LFR10)

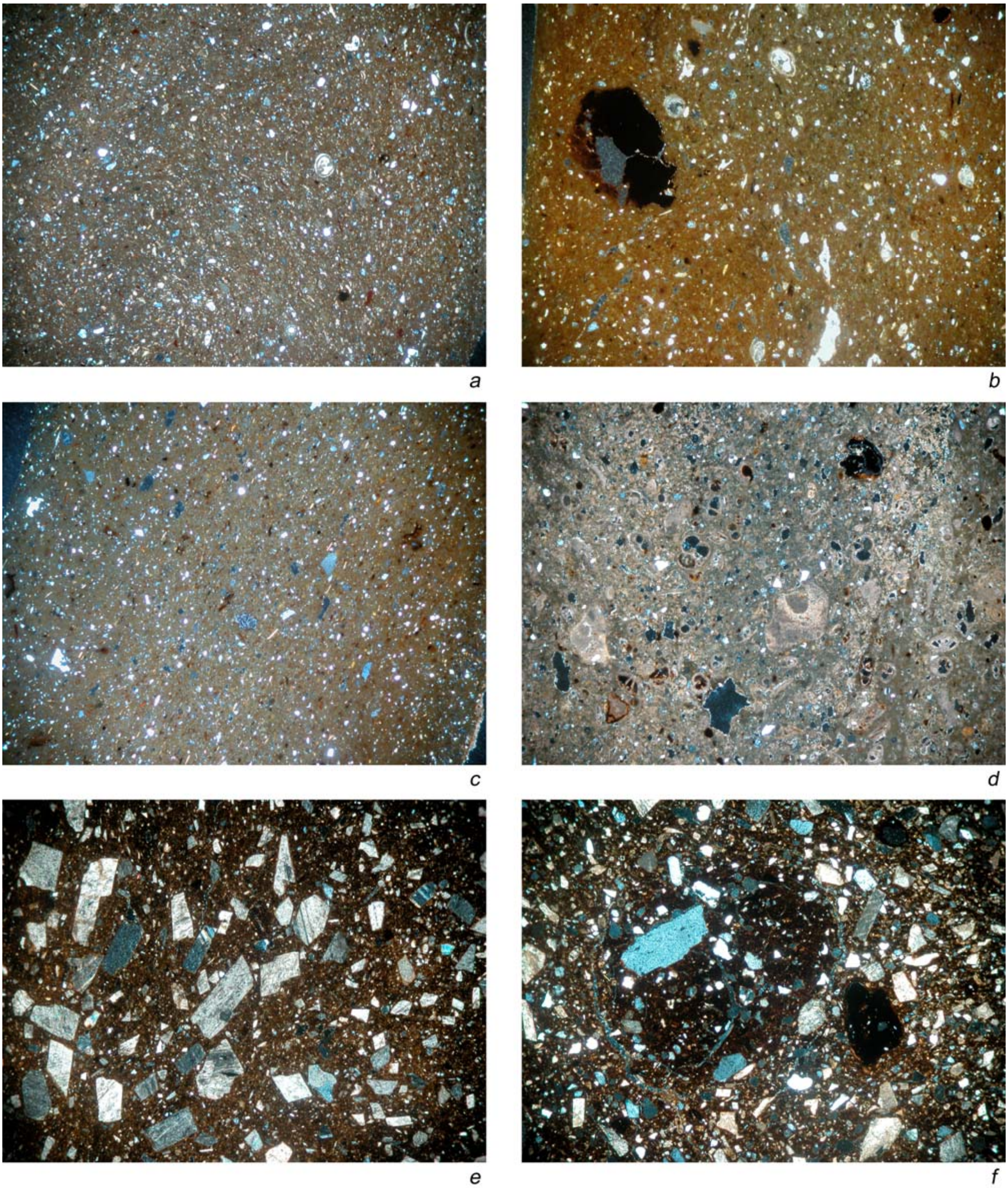

Fig. 3 Thin section photographs of different pottery fabrics (crossed polarized light; the length of frames is 4 mm): (a) QC fabric (LFR17); (b) QCF fabric (TR17); (c) QV fabric (TR10); (d) FC fabric (TR7); (e) CS fabric (TR19); (f) CQF fabric (LFR9)

Table 1 Petrographic features of Serra d'Alto pottery, as observed in thin section. Key: Srnk = shrinkage porosity; Txt = grain size distribution of non-plastic inclusions; D mode = prevalent grain size(s); unim = unimodal; bim = bimodal; vfs = very fine sand; ms = medium sand; cs = coarse sand; Qm = monocrystalline quartz; Qp = polycrystalline quartz; CcS = calcareous silt; sCal = spathic calcite; CRF = calcareous rock fragment; VRF = volcanic rock fragment; ARF = argillaceous rock fragment; Fe agg = iron aggregate; Psl = iron pisolith; For = foraminifera; E = echinids; Cal^2 = secondary calcite; Org = secondary pores of original organic matter; Px = pyroxene; Kfs = potassium-feldspar; Pl = plagioclase; Ch = chert.

Samples	Fabric	Matrix	Porosity		Non-plastic inclusions							Notes
			% vol	Srnk	Txt	D mode	Qm	Micas	Lithics	Fe agg	Fossils	
LFR01	QC		5		unim	silt	+	+	CcS	+	For	
LFR02	QC	zoned	5		unim	silt	+	+	CcS	+	For	
LFR03	QC		5		unim	silt	+	+	CcS	+	For	Cal^2
LFR04	QC	zoned	5		unim	silt	+	+	CcS	+	For	Cal^2
LFR05	QC		10		unim	silt	+	+	CcS	+	For	Cal^2
LFR06	QC		5		unim	silt	+	+	CcS	+	For	Cal^2
LFR07	QC		10		unim	silt	+	+	CcS	+	For	Cal^2
LFR08	QC		5		unim	silt	+	+	CcS	+	For	Cal^2
LFR15	QC		5		unim	silt	+	+	CcS	+	For	
LFR16	QC		5		unim	silt	+	+	CcS	+	For	
LFR17	QC		5		unim	silt	+	+	CcS	+	For	Cal^2
LFR18	QC	zoned	10		unim	silt	+	+	CcS	+	For	Cal^2
LFR23	QC		5		unim	silt	+	+	CcS	+	For	
LFR24	QC		5		unim	silt	+	+	CcS	+	For	ARF, Cal^2
SdA01	QC	zoned	5		unim	silt	+	+	CcS	++	For	Cal^2
SdA02	QC	zoned	10		unim	silt	+	+	CcS	+	For	Cal^2
SdA03	QC	zoned	5		unim	vfs	+	+	CcS	+	For	Cal^2
SdA04	QC		10		unim	vfs	+	+	CcS		For	ARF, Cal^2
SdA05	QC		10		unim	silt	+	+	CcS	+	For	Cal^2
SdA06	QC		5		unim	silt	+	+	CcS	++	For	Cal^2
SdA07	QC		5		unim	vfs	+	+	CcS	+	For	Cal^2
SdA08	QC		5		unim	silt	+	+	CcS	+	For	
SdA09	QC		5		unim	silt	+	+	CcS	+	For	Cal^2
SdA10	QC	zoned	5	+	unim	vfs	+	+	CcS	+	For	
SdA11	QC		10		unim	silt	+	+	CcS	+	For, E	Cal^2
SdA14	QC		5		unim	silt	+	+	CcS	++	For	Cal^2
TR01	QC	zoned	10		unim	vfs	+	+	CcS	+	For	Cal^2
TR02	QC	zoned	5		unim	silt	+	+	CcS	+	For	Cal^2
TR03	QC	zoned	10		unim	silt	+	+	CcS	+	For	Cal^2
TR06	QC	zoned	5		unim	silt	+	+	CcS		For	Cal^2
TR11	QC	zoned	10		unim	silt	+	+	CcS		For (tr)	Cal^2
TR12	QC		10		unim	vfs	+	+	CcS	+	For	Cal^2, Org
TR15	QC	zoned	10		unim	silt	+	+	CcS		For	Cal^2
TR16	QC		10		unim	vfs	+	++	CcS	+	For	Cal^2
TR08	QCF		15		unim	silt	+	tr	CcS	++		
TR17	QCF	zoned	10		unim	vfs	+	tr	CcS	++	For (tr), E	Cal^2, Org
TR10	QV	zoned	10		unim	silt	+	++	CcS, VRF	+		Ch, Px, Cal^2
TR07	FC		20		unim	ms	+		CcS, CRF	+	For (+)	Cal^2
SdA12	FC	zoned	10		unim	silt	+		CcS		For (+)	ARF, Cal^2
SdA13	FC		10		unim	silt	+		CcS	+	For (+)	Cal^2
TR04	CS	zoned	15	+	bim	silt+ms	tr		sCal			Org
TR05	CS		5		bim	silt+ms	tr		sCal		For (tr)	
TR09	CS	zoned	5		bim	silt+cs	tr		sCal			
TR13	CS	zoned	5		bim	vfs+cs	tr		sCal		For	Cal^2
TR14	CS	zoned	15	+	bim	vfs+cs	tr		sCal			
TR18	CS	zoned	5		bim	vfs+ms	tr		sCal		For (tr)	
TR19	CS		5		bim	vfs+ms	tr		sCal		For (tr)	
TR20	CS	zoned	5		bim	vfs+cs	tr		sCal			
LFR11	CS		10	+	unim	ms	tr	tr	sCal	+		Ch (tr)
LFR09	CQF	zoned	10	+	unim	ms	+	tr	sCal, VFR	Psl	For (tr)	ARF, Kfs (tr), Pl (tr)
LFR10	CQF	zoned	10	+	unim	ms	+	tr	sCal	Psl		Ch (tr), Qp (tr)
LFR12	CQF	zoned	10	+	unim	ms	+		sCal	Psl		Px (tr), Kfs (tr)
LFR13	CQF	zoned	10	+	unim	ms	+		sCal	Psl		Kfs (tr), Qp (tr)
LFR14	CQF	zoned	10	+	unim	ms	+		sCal	Psl		

Table 2 Chemical composition (by XRF) of brown-painted fine ware pottery samples: major and minor elements and L.O.I. (*wt %*). *m* = mean; σ = standard deviation

Samples	Fabric	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
LFR01	QC	49.19	0.74	12.14	5.01	0.09	2.55	16.61	0.69	2.05	0.48	10.45
LFR02	QC	52.66	0.79	13.47	5.90	0.11	2.97	12.96	0.60	2.15	0.58	7.81
LFR03	QC	52.39	0.70	12.41	5.78	0.11	2.45	17.20	0.73	2.13	0.35	5.75
LFR04	QC	49.23	0.73	12.34	5.29	0.11	2.74	16.18	0.63	2.10	0.38	10.27
LFR05	QC	49.56	0.74	12.72	5.43	0.10	3.31	15.33	0.58	1.97	0.36	9.90
LFR06	QC	49.88	0.76	12.86	5.61	0.11	3.17	15.45	0.58	1.98	0.27	9.33
LFR07	QC	48.69	0.73	12.69	5.41	0.10	3.38	15.49	0.56	1.83	0.30	10.82
LFR08	QC	49.50	0.76	12.95	5.44	0.10	3.21	15.39	0.62	2.12	0.26	9.65
LFR15	QC	49.02	0.74	12.95	5.56	0.09	2.93	17.95	0.82	2.06	0.24	7.64
LFR16	QC	50.75	0.78	13.23	5.52	0.10	2.78	16.90	0.69	2.32	0.47	6.46
LFR17	QC	50.84	0.75	12.81	5.31	0.09	2.91	16.71	0.73	2.21	0.35	7.29
LFR18	QC	51.41	0.76	12.95	5.41	0.09	3.02	17.49	0.84	2.14	0.37	5.52
LFR23	QC	49.96	0.77	12.95	5.85	0.11	2.80	16.42	0.60	2.33	0.27	7.94
LFR24	QC	50.41	0.76	13.17	5.52	0.10	3.17	15.51	0.66	2.22	0.26	8.22
SdA01	QC	48.91	0.75	12.83	5.97	0.09	2.78	16.59	0.68	2.41	0.21	8.78
SdA02	QC	43.42	0.62	10.57	5.28	0.08	3.32	19.59	0.63	1.92	0.26	14.31
SdA03	QC	41.62	0.55	9.51	4.58	0.08	3.19	21.24	0.53	1.44	0.21	17.05
SdA04	QC	47.46	0.60	10.38	5.17	0.05	1.83	19.65	0.69	2.01	0.21	11.95
SdA05	QC	51.64	0.73	12.78	5.17	0.09	2.95	15.47	0.74	1.89	0.24	8.30
SdA06	QC	43.62	0.65	10.67	5.31	0.09	3.10	22.43	0.54	1.56	0.28	11.75
SdA07	QC	54.30	0.74	13.28	6.00	0.10	2.04	13.80	0.81	2.21	0.27	6.45
SdA08	QC	47.77	0.67	11.44	5.32	0.11	1.79	19.26	0.67	2.02	0.34	10.61
SdA09	QC	47.48	0.70	11.70	5.92	0.11	3.07	16.96	0.73	2.18	0.34	10.81
SdA10	QC	48.16	0.59	10.71	4.82	0.09	1.41	20.54	0.66	2.06	0.26	10.70
SdA13	QC	36.53	0.58	9.47	4.94	0.07	2.22	31.01	0.74	0.94	0.28	13.22
SdA14	QC	40.08	0.63	10.51	5.27	0.08	3.19	26.09	0.66	1.76	0.32	11.41
TR01	QC	36.31	0.50	8.86	4.08	0.09	2.08	26.28	0.50	1.53	0.27	19.50
TR02	QC	49.98	0.74	13.00	5.54	0.09	2.71	15.71	0.60	2.33	0.27	9.03
TR03	QC	50.04	0.75	12.84	5.52	0.09	2.46	15.46	0.63	2.40	0.28	9.53
TR06	QC	42.68	0.82	13.58	7.07	0.11	2.67	17.33	0.32	1.32	0.26	13.84
TR11	QC	50.62	0.87	14.60	6.63	0.13	2.46	13.46	0.56	2.07	0.42	8.18
TR12	QC	36.71	0.58	9.82	4.57	0.09	2.13	24.82	0.36	1.23	0.24	19.45
TR15	QC	42.69	0.67	11.22	5.74	0.09	2.46	22.96	0.49	1.94	0.27	11.47
TR16	QC	48.23	0.68	11.66	5.79	0.10	3.04	17.50	0.77	2.23	0.26	9.74
m		47.40	0.70	12.03	5.46	0.10	2.71	18.29	0.64	1.97	0.31	10.39
σ		4.75	0.08	1.39	0.55	0.01	0.49	4.06	0.12	0.35	0.08	3.39
TR08	QCF	50.62	0.89	14.82	6.42	0.10	2.66	12.73	0.62	2.05	0.20	8.89
TR17	QCF	48.08	0.73	12.58	5.86	0.09	2.86	16.46	0.62	2.17	0.25	10.30
m		49.35	0.81	13.70	6.14	0.10	2.76	14.60	0.62	2.11	0.23	9.60
σ		1.80	0.11	1.58	0.40	0.01	0.14	2.64	0.00	0.08	0.04	1.00
TR10	QV	48.75	0.80	13.90	6.67	0.12	3.19	14.14	0.67	2.32	0.41	9.03
TR07	FC	31.28	0.43	7.66	3.78	0.07	1.05	31.39	0.32	0.65	0.26	23.11
SdA11	FC	46.66	0.70	11.93	5.71	0.10	2.94	20.38	0.90	2.10	0.23	8.35
SdA12	FC	41.35	0.68	11.18	5.81	0.08	2.66	27.51	0.91	1.14	0.29	8.39
m		39.76	0.60	10.26	5.10	0.08	2.22	26.43	0.71	1.30	0.26	13.28
σ		7.81	0.15	2.28	1.14	0.02	1.02	5.58	0.34	0.74	0.03	8.51

Table 3 Chemical composition (by XRF) of black household pottery samples: major and minor elements and L.O.I. (*wt %*). *m* = mean; *σ* = standard deviation

Samples	Fabric	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
TR04	CS	22.96	0.40	7.01	3.16	0.05	1.20	34.93	0.19	0.93	0.13	29.04
TR05	CS	33.35	0.51	8.98	3.71	0.06	1.63	27.15	0.32	1.20	0.14	22.95
TR09	CS	37.01	0.54	9.74	3.94	0.07	1.88	25.12	0.48	1.37	0.23	19.62
TR13	CS	19.73	0.31	5.34	2.50	0.05	0.93	38.99	0.21	0.63	0.19	31.12
TR14	CS	20.26	0.40	6.85	2.78	0.04	1.01	37.04	0.19	0.82	0.11	30.50
TR18	CS	21.47	0.32	6.01	2.41	0.05	1.14	37.65	0.23	0.71	0.10	29.91
TR19	CS	28.89	0.43	7.65	3.25	0.06	1.32	31.08	0.30	1.23	0.27	25.52
TR20	CS	33.18	0.54	9.47	4.27	0.06	1.57	27.00	0.29	1.24	0.15	22.23
LFR11	CS	20.11	0.39	6.71	2.97	0.06	1.19	38.03	0.15	0.79	0.24	29.36
m		26.33	0.43	7.53	3.22	0.06	1.32	33.00	0.26	0.99	0.17	26.69
σ		6.81	0.09	1.55	0.64	0.01	0.31	5.46	0.10	0.27	0.06	4.22
LFR09	CQF	39.33	0.54	10.35	4.64	0.21	1.38	22.74	0.34	1.37	0.22	18.88
LFR10	CQF	35.01	0.50	9.15	4.33	0.20	1.04	26.94	0.31	1.23	0.17	21.12
LFR12	CQF	34.40	0.47	8.75	4.22	0.19	0.86	27.34	0.29	1.13	0.27	22.08
LFR13	CQF	34.83	0.50	8.98	4.32	0.18	0.89	27.79	0.30	1.16	0.28	20.77
LFR14	CQF	34.66	0.50	9.01	4.39	0.21	0.98	27.86	0.30	1.25	0.20	20.64
m		35.65	0.50	9.25	4.38	0.20	1.03	26.53	0.31	1.23	0.23	20.70
σ		2.07	0.02	0.63	0.16	0.01	0.21	2.15	0.02	0.09	0.05	1.16

Along the western edge of the Murge Plateau, where the archaeological sites are located, marine Plio-Pleistocene clays of the Bradanic cycle, also known as Argille Subappennine, extensively crop out (*Dell'Anna & Laviano 1991, Tropeano et al. 2003, Beneduce et al. 2004*). The depth of the outcrops varies from a few meters to 350 m. The clays consist of silty clay or clayey silt, with little sand, and have very similar mineralogical compositions (clay minerals, carbonates, quartz and feldspars). The clay minerals are a mixture of 2M illite, Mg-bearing smectite, Fe-bearing chlorite, kaolinite and randomly interstratified illite/smectite. Due to their mainly calcareous composition (up to 17 wt% CaO) they can be classified as marly clays. Clay fractions (<2μm) have a lower CaO content than the whole specimens, whereas the Al_2O_3 and Fe_2O_3 concentrations are higher (*Dell'Anna & Laviano 1991*).

ANALYTICAL METHODS

Mineralogical studies were carried out by X-ray powder diffraction analysis (PXRD) using a Philips diffractometer (PW 1710) with Ni-filtered CuKα radiation, and employing NaF as the internal standard. These studies have been completed with petrological observation of thin sections using a polarized light microscope. Major elements determination was performed by X-ray fluorescence (XRF), using a Philips PW 1480/10 spectrometer (Cr anode for major and minor elements), following analytical techniques outlined by *Franzini et al. (1972, 1975)* and *Leoni & Saitta (1976)*.

Loss on ignition (LOI) was determined by heating the samples at 1,000°C for 12 hours.

RESULTS AND DISCUSSION

The samples from Masseria Fragennaro are more homogeneous than those from Trasano and Serra d'Alto from a petrographic point of view. Five petrographic groups and one sub-group with different composition and grain-size distribution can be distinguished (**Table 1**).

The majority of fine ware pottery samples from the three sites belong to the QC group (n = 34) and show a fairly fat clay matrix (**Fig. 3a**), with some muscovite crystals (~100 μm) still detectable. The clayey calcareous matrix is mostly reddish-yellow; only a few samples show greyish-brown core zoning. Non-plastic inclusions are homogeneous fine-grained (≤125 μm) monocrystalline quartz, calcareous clasts and carbonate fossils (mainly benthonic Foraminifera). Clasts of potassium-feldspar and ferruginous aggregates are also present. Primary porosity and drying shrinkage are generally low, and they are sometimes filled with secondary calcite crystals.

Two samples from Trasano form the QCF sub-group and they have been distinguished from the rest of the QC group by a lesser amount of muscovite and Foraminifera and a greater amount of ferruginous aggregates (**Fig. 3b**). One sample from Trasano (QV group) has been distinguished by a greater amount of muscovite crystals, the absence of calcareous clasts and carbonate fossils, and

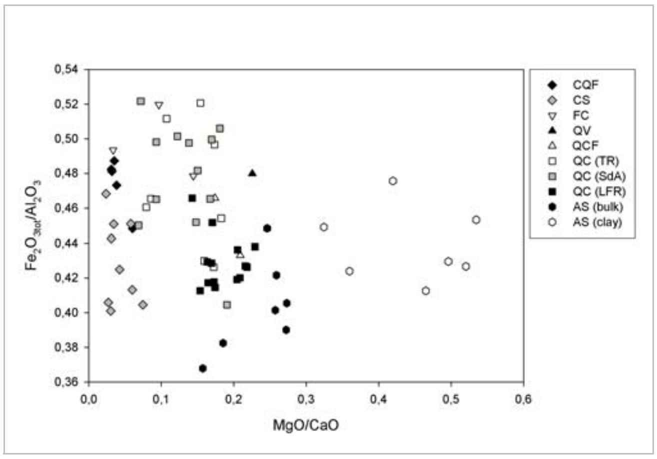

Fig. 4 The bivariate plot MgO/CaO *vs.* Fe_2O_{3tot}/Al_2O_3 show a similar MgO/CaO ratio for the fine ware and bulk Argille Subappennine from the Bradanic Trough (data from *Laviano & Muntoni 2007*, tab. 14). The coarse ware is characterized by a low MgO/CaO ratio which accounts for different raw materials (see text).

the presence of small amounts of chert, augitic pyroxene and rare volcanic rock fragments (**Fig. 3c**). Three samples from Trasano and Serra d'Alto (FC group) contain a larger quantity of fossil inclusions and no muscovite crystals (**Fig. 3d**).

Coarse ware from Masseria Fragennaro and Trasano was tempered with spathic calcite clasts. The clayey calcareous groundmass is mostly medium dark brown and some samples are zoned. Two petrographic groups have been identified. All coarse ware samples from Trasano and one sample from Masseria Fragennaro (CS group; n = 9) contain angular spathic calcite clasts, comprising 10-60 vol.% of the total (**Fig. 3e**). In thin section these fragments are readily distinguished by their large size (≥ 250 µm up to 1.2-2.8 mm). The other coarse samples from Masseria Fragennaro (CQF group; n = 5) contain the same angular spathic calcite clasts (**Fig. 3f**), but clastic particles comprise 35-40 vol.% of the total and appear in only one size population (≥ 250 µm up to 1.2-1.6 mm). Non-plastic inclusions also include low quantities of polycrystalline quartz, chert, rounded Fe-pisoliths of lateritic origin, plagioclase and potassium-feldspar. The differences observed in thin section between these two groups point to a common paste processing which must have occurred in different places with different raw materials. As observed under the microscope, the calcite temper was not significantly affected by firing and appeared unaltered. This characteristic was favoured by the coarse size of calcite clasts and the prevalent reducing conditions during firing, as attested by the carbonaceous matter still present in the ceramic body. The presence of shrinkage in the matrix accounted for low sintering, as well as the loss of water and organic matter. As opposed to what is observed in the fine ware, the matrix of the coarse ware is not very calcareous and this points to two different clayey raw materials for the two wares.

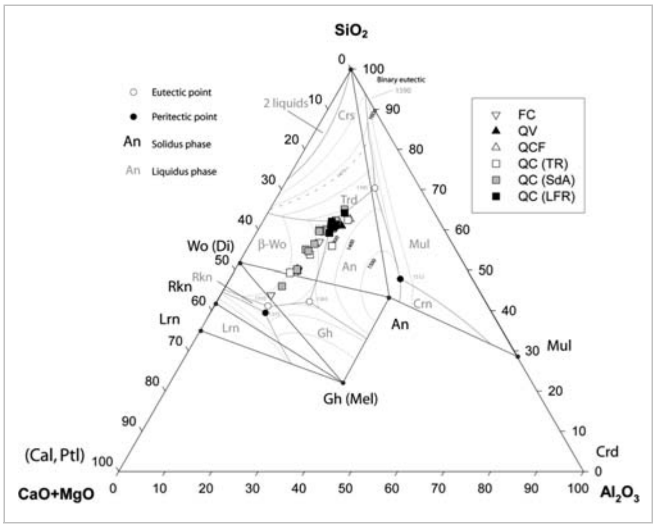

Fig. 5 Most of the compositional points of the analyzed fine ware plotted in the ternary phase diagram CaO-Al_2O_3-SiO_2 (after *Osborn & Muan* 1960) fall in the Wo-SiO_2-An Alkemade triangle, but only the QC samples from Masseria Fragennaro are centered on the ternary eutectic (symbols as in *Kretz 1983*)

Chemical analyses (XRF) evidenced that SiO_2, Al_2O_3 and CaO were the main oxides, with some variations with regards to the percentage of CaO, Na_2O, K_2O and MgO (**Tables 2-3**). The bivariate plot MgO/CaO *vs.* Fe_2O_{3tot}/Al_2O_3 (**Fig. 4**) show a low correlation between the two oxide ratios and more dispersed fine ware compositions. As a whole, the fine ware from Trasano and Serra d'Alto has a lower or equal MgO/CaO ratio than those from Masseria Fragennaro and a relatively higher Fe_2O_{3tot}/Al_2O_3 ratio as well. This may be related to their geographical position: the former are positioned on the western side of the Viglione Graben (**Fig. 1**), the latter is located on its eastern side. Although the overall petrographic, mineralogical and chemical compositions of the analyzed fine ware is comparable with that of the Argille Subappennine clays reported in literature (*Dell'Anna & Laviano 1991; Laviano & Muntoni 2007*), the differences may account for different exploitation sites within the same geological basin. Furthermore, any elutriation of Argille Subappennine would still give a marly clay, but it would increase the MgO/CaO ratio (**Fig. 5**). Thus, it can be supposed that no elutriation was practiced in clay processing for the fine ware. With regards to the coarse ware, the low MgO/CaO ratio agrees with the supposed speleothemic origin of spathic calcite temper (*Tucker 2001*), while the Fe_2O_{3tot}/Al_2O_3 ratio discriminates the iron pisolith-bearing samples (the CQF group) from the rest (the CS group). The occurrence of carbonaceous matter in the ceramic body points to the original presence of organic matter in the *terra rossa*

Table 4 Mineralogical composition (by PXRD) of brown-painted fine ware pottery samples. C.M.: clay minerals; Ms: muscovite; Qtz: quartz; Feld: K-feldspar + plagioclase; Cal: calcite; Px: pyroxene; Gh: gehlenite (symbols as in *Kretz 1983*); number of X is in relation to the mineralogical phase abundance; tr: traces.

Samples	Fabric	Ms	Qtz	Feld	Cal	Px	Gh
LFR01	QC	x	xxxxx	xxx	xxx	x	x
LFR02	QC		xxxx	xxx	x	x	x
LFR03	QC		xxxx	xxx	xx	xx	xx
LFR04	QC	tr	xxxx	xxx	xx	xx	xx
LFR05	QC	tr	xxxx	xxx	xxx	xx	xx
LFR06	QC	tr	xxxx	xxx	xxx	xx	xx
LFR07	QC	tr	xxxx	xxx	xxx	xx	xx
LFR08	QC	tr	xxxx	xxx	xx	xx	xx
LFR15	QC	tr	xxxx	xxx	xx	xxx	xx
LFR16	QC	tr	xxxx	xxx	xx	xx	xx
LFR17	QC		xxxx	xxx	xx	x	xx
LFR18	QC		xxx	xxxx	x	xxxx	x
LFR23	QC	tr	xxxx	xx	xxx	xx	x
LFR24	QC	tr	xxxx	xxx	xx	x	x
SdA01	QC	tr	xxx	xx	xx	x	xx
SdA02	QC	tr	xxxx	xx	xxx		
SdA03	QC	tr	xxx	xx	xx	x	xx
SdA04	QC	tr	xxxx	xx	xxx	tr	x
SdA05	QC	tr	xxxx	xxx	xx	x	xx
SdA06	QC		xxxx	xx	xxx	x	xx
SdA07	QC		xxxx	xxx	tr	xx	xx
SdA08	QC	tr	xxxx	xx	xx	x	xx
SdA09	QC	tr	xxxx	xxx	xxx	x	xx
SdA10	QC	tr	xxxx	xx	xxx	x	xx
SdA13	QC	tr	xxxx	xx	xxx	x	xxx
SdA14	QC		xxx	x	xxx	x	xx
TR01	QC		xxxx	xx	xxxx	x	x
TR02	QC	tr	xxxxx	xx	xxxx	tr	xx
TR03	QC	tr	xxxx	xxx	xxx	tr	xx
TR06	QC	tr	xxxx	xxx	xxx	xx	tr
TR11	QC	tr	xxxx	xxx	x	xx	
TR12	QC	tr	xxx	xx	xxxx		
TR15	QC	tr	xxxx	xx	xx	xx	xx
TR16	QC	tr	xxxx	xx	xx	xx	xx
TR08	QCF		xxxx	xxx	x	xx	x
TR17	QCF	tr	xxxx	xxx	xxx	tr	xx
TR10	QV	tr	xxxx	xxx	x	xx	tr
TR07	FC		xxx	x	xxxx		xx
SdA11	FC	tr	xxxx	xx	xx	xx	xx
SdA12	FC		xx	x	xx	x	xxx

deposits, which is supposed to be the clayey raw material for this pottery class.

Mineralogical analyses (PXRD) revealed the predominant presence of quartz and feldspars, with small quantities of muscovite, and a variable amount of calcite. The occurrence of new phases, such as diopsidic pyroxene and gehlenite, was also observed in all fine ware samples (**Table 4**). The samples from Masseria Fragennaro show, as a whole, a lower content of calcite and a higher content of feldspars than those from Serra d'Alto and Trasano, while diopsidic pyroxenes are less abundant in the samples from Serra d'Alto than in the rest of the QC group. The degree of sintering and the complete oxidation of the ceramic body points to kiln firing at temperatures in the range of 800-1,000°C in an oxidizing atmosphere, as previously proposed in *Geniola et al. (2005)* and *Muntoni et al. (2006)*. However, the samples from Masseria Fragennaro (the QC group) seem to be more sinterized than the rest of the fine ware. This may be explained by their very homogeneous composition, compared to the rest of the fine wares, which falls on the ternary eutectic in the silica-anorthite-wollastonite Alkemade triangle (*Osborn & Muan 1960*). Microstructural features and low birefringence of the matrix confirm the high degree of sintering.

Table 5 Mineralogical composition (by PXRD) of black household pottery samples. C.M.: clay minerals; Ms: muscovite; Qtz: quartz; Feld: K-feldspar + plagioclase; Cal: calcite (symbols as in Kretz 1983); number of 'X' is in relation to the mineralogical phase abundance; tr: traces.

Samples	Fabric	C.M	Ms	Qtz	Feld	Cal
TR04	CS	tr	tr	xx	tr	xxxxx
TR05	CS	x	tr	xxx	x	xxxx
TR09	CS	xx	x	xxx	xx	xxxx
TR13	CS	tr		xx	tr	xxxxx
TR14	CS	tr	tr	xx	tr	xxxxx
TR18	CS	tr	tr	xx	tr	xxxxx
TR19	CS	tr	x	xxx	x	xxxxx
TR20	CS	x	x	xxx	x	xxxxx
LFR11	CS	x	tr	xx	tr	xxxxx
LFR09	CQF	x	x	xxx	x	xxxxx
LFR10	CQF	tr	tr	xxx	x	xxxxx
LFR12	CQF	tr	tr	xxx	x	xxxxx
LFR13	CQF		tr	xxx	x	xxxxx
LFR14	CQF	tr	tr	xxx	xx	xxxxx

On the contrary, coarse ware did not show new formed phases, such as gehlenite and pyroxenes, due to low Ca activity during firing (**Table 5**). Microstructural evidence of medium-low sintering is given by frequent shrinkage porosity and unaltered spathic calcite. The carbonaceous matter still present in the ceramic body and the overall dark matrix indicates a controlled reducing atmosphere during firing. A range of firing temperature between 700 and 900°C in a kiln is estimated.

SERRA D'ALTO WARE: LOCAL PRODUCTION AND MODEL CIRCULATION

Fine ware was produced using marly clays, which are compatible with Plio-Pleistocene Argille Subappennine. These clays were then used for the production of Serra d'Alto ware, without significant elutriation, as inferred from the very fine texture and chemical composition of both the ceramic body and the Argille Subappennine clays.

Coarse ware was produced using eluvial or colluvial deposits of residual *terra rossa* in a carbonatic geological basin, tempered with mineral spathic calcite of speleothemic origin.

Karstic cave and doline are typical forms in the calcareous Murge landscape and they were frequently used in the Mid-Late Neolithic period for ritual and/or funerary activity. Burials and ritual activities (faunal remains of wild animals, stone enclosures, wall-paintings, human figurines, red-painted pebbles) are the major sources of cult evidence (*Whitehouse 1992*).

The deliberate use of different raw materials and paste processes according to the vessel function observed in Serra d'Alto ware, as well as the compositional differences within the same pottery class (i.e. fine or coarse ware) suggests a polycentric production based on a common technological background. The hypothesis of circulation of finished ceramic pots was not validated while a widespread technological model probably occurred in different areas of southern Italy (*Muntoni & Laviano in press*).

Serra d'Alto pottery would appear to be a significant technological shift in comparison to Early Neolithic ceramic productions, as suggested by the selection and supply of specific raw materials, the improvement in forming and finishing techniques, and the relevant technological shifts in firing technology.

All data point to a more complex social mode of production that might evolve from a 'domestic mode of production' to an 'incipient-specialization stage', according to the models of *Rice (1981)* and *Van der Leeuw (1984)*.

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