Journal of Archaeological Science 39 (2012) 234–246

Contents lists available at SciVerse ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

Using provenance data to assess archaeological landscapes: an example from Calabria, Italy

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ARTICLE INFO

Article history:
Received 27 April 2011
Received in revised form
18 August 2011
Accepted 28 August 2011

Keywords:
Landscape
Raw materials survey
Experimental projects
Optical microscopy
X-ray diffraction
Neutron activation analysis
Southern Italy

ABSTRACT

Ceramic provenance studies have helped archaeologists examine trade and exchange in multiple scales, the organization of production, and even vessel function. Yet, they may go even further, to provide a venue for the examination of past people's perception of their landscape. To do so, a methodology is needed that links the choices prehistoric potters made, as reflected in their ceramics, with the choices their landscape could afford them, as reflected in the extent and distribution of local clays, and the physical, chemical and mineralogical characteristics of these clays. Using the region of Bova Marina in southwestern Calabria as a case study, we have combined a raw materials survey with field and laboratory experiments, along with chemical and mineralogical analyses of the collected sediments to understand the distribution and the physical, chemical and mineralogical variability of locally available clays and provide baseline data against which prehistoric ceramic materials from the region may be compared. We show that the local sediments can be divided into three major units, based on their macroscopic, mineralogical and chemical characteristics, that correspond well with the major geological units outcropping in the study area. While two of these units have internally consistent properties, the third is variable.

1. Introduction

In the last forty years, ceramic provenance studies have revolutionized the way archaeologists examine interactions. Understanding the relation between where ceramics were produced and where they were deposited has allowed us to study trade and exchange at multiple scales – from long distance, to regional, and intra-regional – and to consider the social mechanisms that made possible the movement of pots (e.g., market economies) and were, in turn, enabled by the presence of 'exotics' in a community (e.g., status differences based on access to such goods) (e.g., Bauer and Agbe-Davies, 2010; Bishop and Blackman, 2002; Dillian and White, 2010 and references within).

Methodologically, such studies tend to focus on the mineralogical and/or chemical analysis of archaeological ceramics, using a wide variety of techniques, alone or in combination (e.g., petrography, X-ray diffraction, instrumental neutron activation, X-ray fluorescence or scanning electron microscopy)[1]. The results are then compared with geological maps and the literature to judge whether the ceramic pastes are (in)consistent with the local geology. Some times, daub is used as a proxy for the local materials, since one would not travel far to procure the quantities of clay required for architecture. Less frequently, a few geological samples from the vicinity of a site are also considered to strengthen or refute arguments for local production (e.g., Muntoni, 2002a,b; Skeates, 1992; Williams, 1980; see, however, projects such as Daszkiewicz et al., 2010; Gauss and Kiriatzi, in press; Kiriatzi, 2002; Minc and Sherman, 2011; Vaughn and Neff, 2004 where emphasis was put on the collection and analysis of local sediments).

Geological maps, however, are not always created to represent in detail the distribution and qualities of different clays. It is not always known from the examination of a map how (dis)similar the clays associated with different geological units are, or how (in)

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[1] By now the literature on provenance studies from all over the world is vast. Since a southern Italian case is discussed in this paper references will be drawn mostly from the work in that region.

0305-4403/$ – see front matter
doi:10.1016/j.jas.2011.08.034

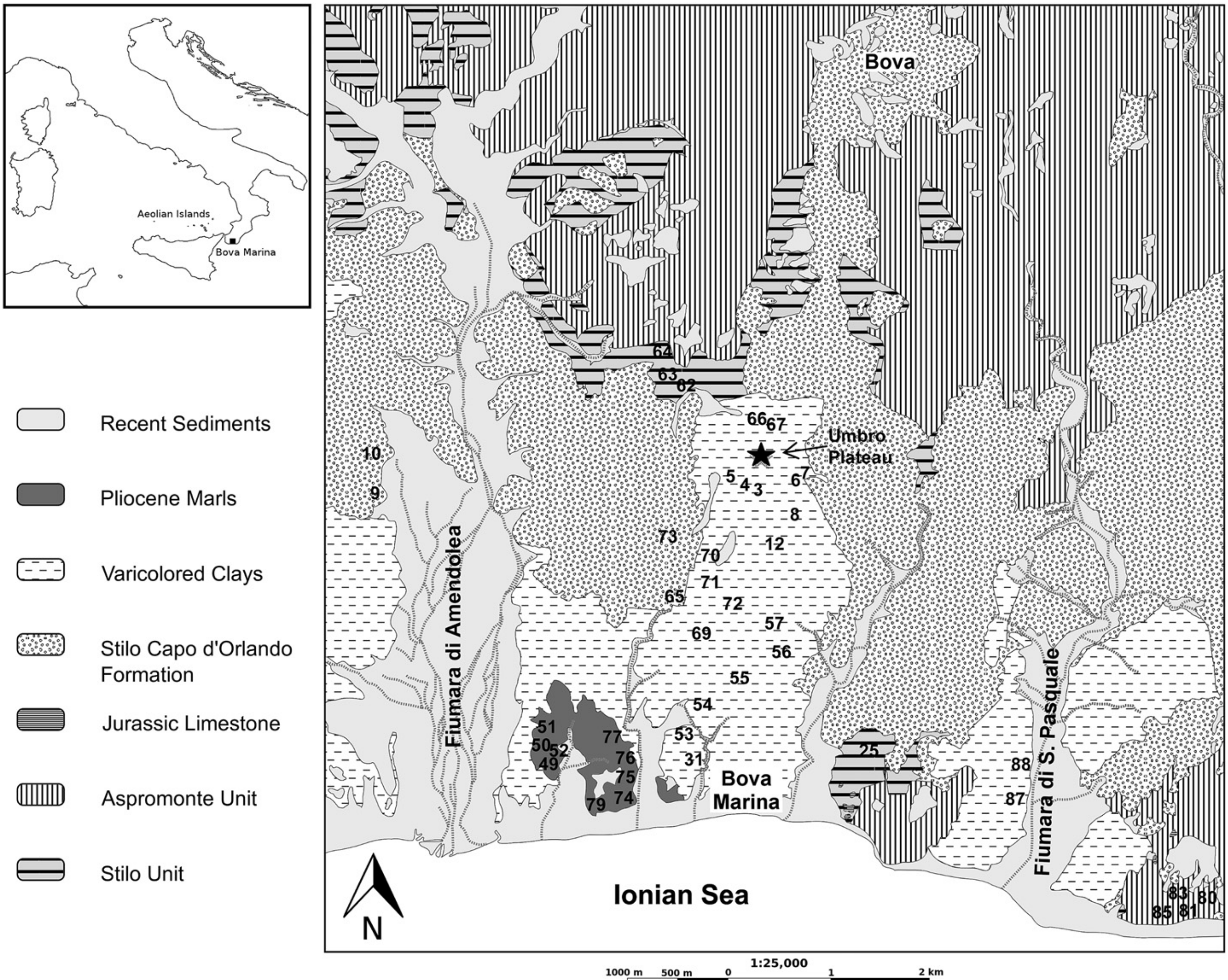

Fig. 1. Geological map of the Bova Marina region (modified after Davies et al., 1969 and Pezzino et al., 2008). Numbers correspond to the locations of our raw materials samples (RMS).

consistent may be the properties of the clays within a single unit. Thus, neither the reference to geological maps alone, nor the collection and analysis of a few 'token' sediments can adequately address the options a given landscape could have afforded ancient potters. Similarly, daub is neither technically, nor symbolically neutral and its relation to pottery and to the local landscape needs to be explored in each case rather than to be assumed.

Once it is shown that ceramics are local, attention turns to the description of ceramic pastes and what they suggest for vessel function and the organization of production (e.g., Geniola et al., 2005; Laviano and Muntoni, 2003, 2006; Muntoni, 1995, 1999, 2003, 2004; Spataro, 2009). Such analyses provide rich discussions of the choices potters made, yet without understanding the realm of choices the local landscape afforded potters, our appreciation of what they actually chose remains limited. Ingold (2000a,b) has argued that the experiences the landscape affords its dwellers, in combination with the activities in which people engage in their daily lives, are intimately connected to how people perceive their landscape. Gosselain and Livingstone Smith (2005) have shown that potters involved in small-scale production often discover clays as part of other activities that encourage them to inspect the soil carefully (e.g., working in their gardens). As a result, they build expectations of where clays are to be found and thus, although their landscape may afford them multiple, equally good and accessible clay sources, their daily activities unveil to them certain sources more than others.

Unless we can explore this relation between 'available' and 'chosen' sources we may be missing an opportunity to move beyond ceramic production, function and distribution, and gain insights into how daily life was organized. To do so, we need a methodology that links archaeological ceramics with a detailed understanding of the local raw materials, their physical properties, and distributions in the landscape. Such a methodology involves the combination of a raw materials survey with experimental projects, and with mineralogical and chemical analyses of the sediments collected. The results of these analyses can then be compared with the analyses of archaeological ceramics, but also with data on the distribution and characteristics of other resources (e.g., lithics, fauna, flora, site locations etc.) to reveal a richer picture of ancient landscapes.

It is exactly this methodology that one of us (KM) designed and implemented to explore ceramic production in prehistoric southwestern Calabria, Italy as a meaningful process tied to the landscape within which it was practiced. Since 1997 the Bova Marina

Archaeological Project (BMAP), a multi-period, multi-disciplinary project has been conducting a systematic survey and excavations at the region of Bova Marina and Bova in southwestern Calabria to understand the history of human habitation in the area (Fig. 1). Five archaeological sites in close proximity to each other (less than 1 km) have been excavated on the Umbro plateau, dating from the Early Neolithic (ca. 5800 BC cal.) to the Late Bronze Age (ca. 910 BC cal.- i.e. '*Bronzo Finale*' in the local chronologies) and representing a variety of site types (Foxhall, 2004, 2005, 2006; Foxhall et al., 2006; Robb, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2007a,b, 2008). It is the ceramics from these sites and the landscape around the Umbro plateau that form the basis of our research program.

In this paper, we present the results of three seasons (2004, 2006, 2008) of a raw materials survey, and the accompanying experiments and analyses of the clay sediments collected (Michelaki, 2004, 2008b; Michelaki et al., 2006). It is not our aim to identify specific sources used by the prehistoric inhabitants of the region, since erosion and alluviation have altered the landscape, or to generate a predictive model where our 'novice-potter' skills or laboratory criteria take precedence. Our aim is to show how the available raw materials were distributed and whether they were homogeneous in their properties, because, if they were not, they would have required different strategies of acquisition and preparation from the prehistoric potters.

This is only the first part of an on-going research program that aims to understand the ceramic technological traditions in southwestern Calabria throughout prehistory. Once we have understood the distributions and properties of the locally available clays we can examine how the potters of each time period used them, whether their choices differed from those of other southern Italian potters, or reflected widely shared technological knowledge, and how technological knowledge was transferred through time. We will be able to answer questions such as these: Did the Umbro plateau potters use all the locally available clays, or did they target particular ones? Did they use the same sediments for all their wares, or different ones for different wares? What does the targeted use of sediments suggest for the ways they perceived their landscape and for the meaning/value of the pots they made out of those sediments? How stable was the choice of clays through time? Did the social changes suggested by new pottery styles and burial customs during the late Neolithic, for example, necessitate fundamental reorganization of pottery production and landscape use? What can the detailed understanding of pottery technology in the same region over 5000 years teach us about how long-term traditions affect the dynamic relations between humans, landscapes and materials?

The present paper cannot address all these questions. Its goal is to address the methodology that makes possible approaching such questions and to present in detail the locally available raw materials and their properties. Once we have described the 'options available' in this paper, we will address the 'options chosen' and their social implications in a series of papers to follow.

2. The Bova Marina geology and topography

The geology of southern Calabria can be broadly divided in two major units: a Hercynian metamorphosed crystalline basement that is up to Palaeozoic in age and a cover sequence of carbonate and clastic Neogene sediments (Fig. 1). Based on cartography (Davies et al., 1969) and research papers (Cavazza et al., 1997; Cavazza and Barone, 2010; Cavazza and DeCelles, 1993; Cavazza and Ingersoll, 2005; Heymes et al., 2008; Parise et al., 1997; Pezzino et al., 2008), the crystalline basement in our study area

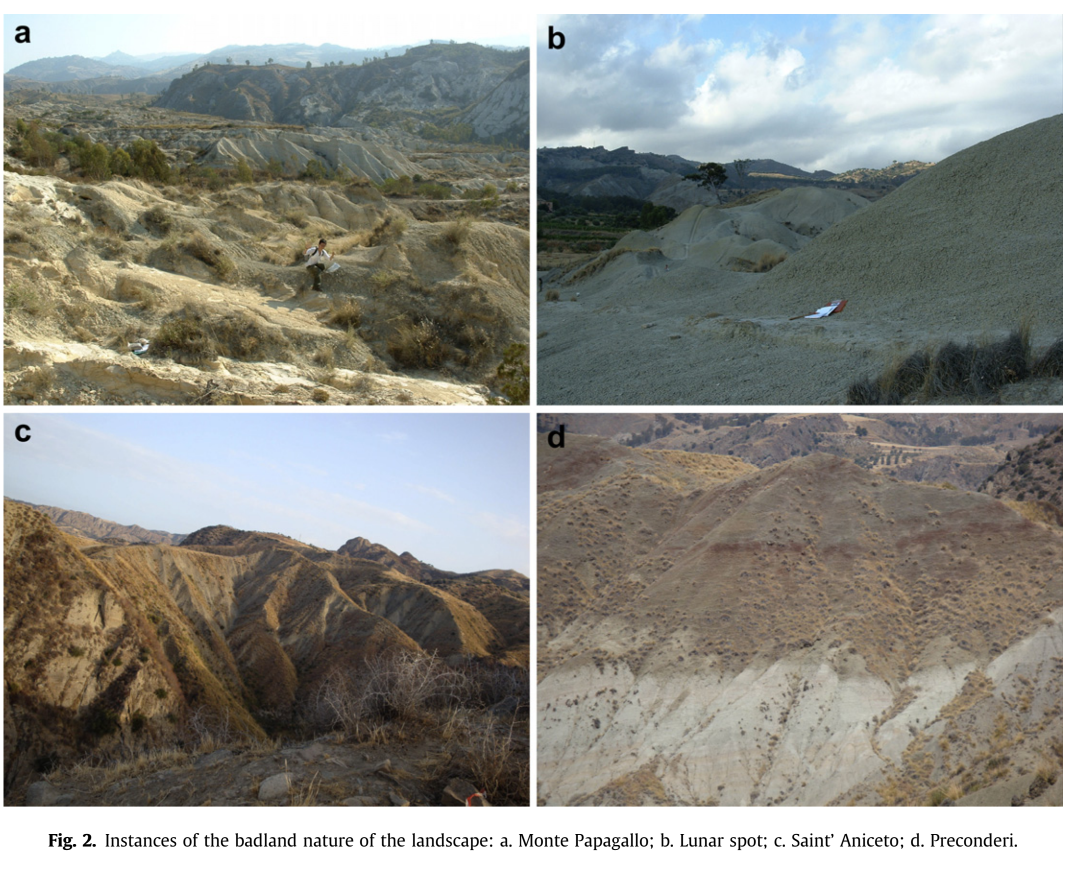

Fig. 2. Instances of the badland nature of the landscape: a. Monte Papagallo; b. Lunar spot; c. Saint' Aniceto; d. Preconderi.

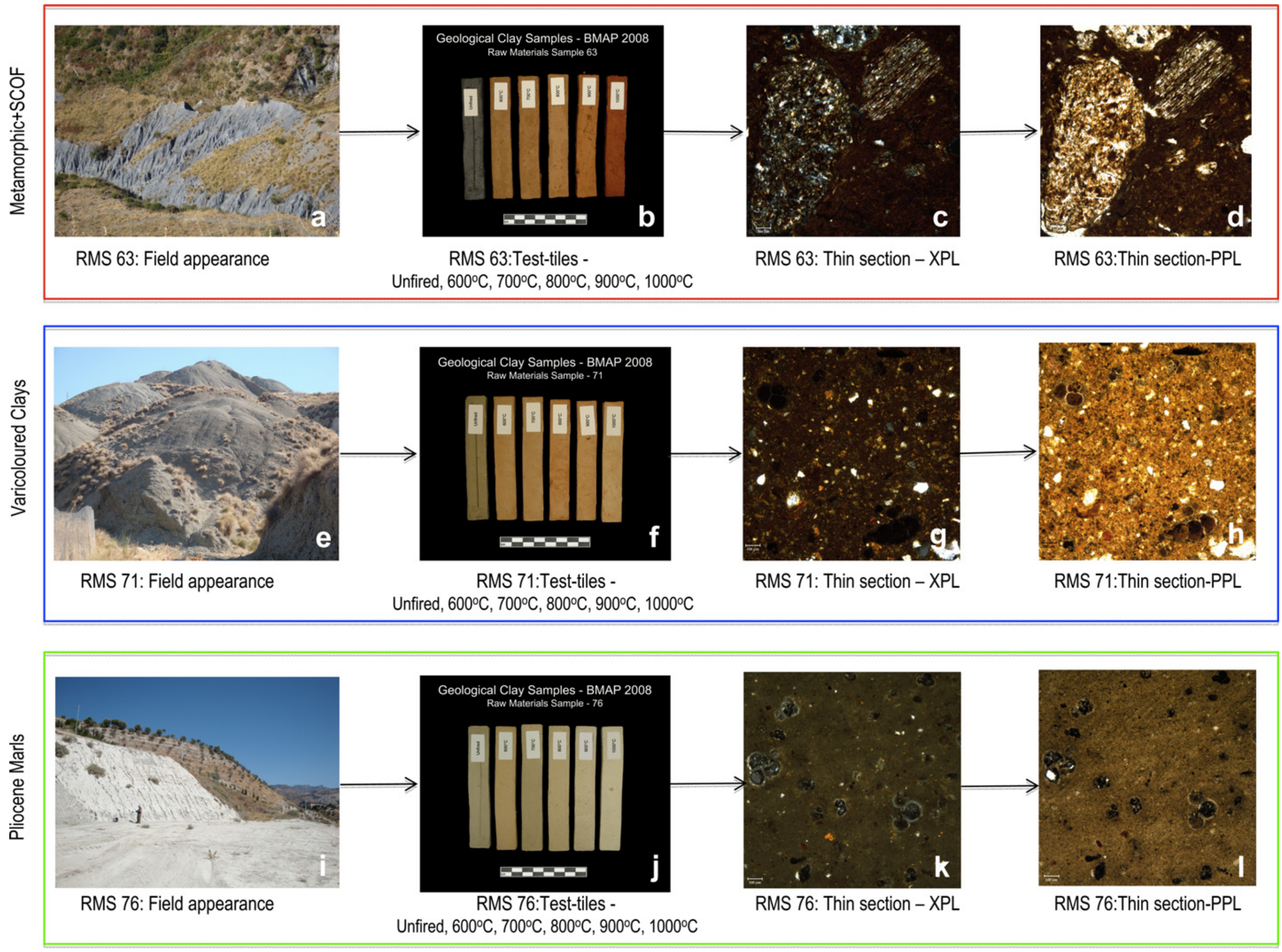

Fig. 3. Examples of clays as they appear in the field, in test-tiles and under a petrographic microscope from each unit identified in this paper: a–d. *Metamorphic + SCOF* sediments; e–h. *Varicoloured Clays*; i–l: *Pliocene Marls*.

can be divided into two units. The older, known as the *Stilo Unit* (*SU*), outcrops east of Bova Marina and in isolated klippen to the north. It was metamorphosed at greenschist to low amphibolite facies and intruded by granitoid bodies. It is characterized primarily by metamorphic phyllite and metarhyolite (Heymes et al., 2008: 5). The younger, known as the *Aspromonte Unit* (*AU*), was metamorphosed at a higher grade and is characterized by mica-schists amphibolite, marble intercalations, and large bodies of augen gneiss and intrusive granitoids. In our study area the *AU* occupies similar, although considerably more extensive regions to those of the *SU*. In a few localities, the crystalline complex is overlain by limestone of Jurassic–Cretaceous age (Heymes et al., 2008: 4–5).

The *Stilo Capo d'Orlando Formation* (*SCOF*) typically overlies the crystalline basement. It is Late Oligocene–Early Miocene in age (Cavazza and DeCelles, 1993: 1299; Cavazza and Ingersoll, 2005: 270) and composed of breccias and conglomerates at its base, covered by coarse grained sandstones, passing upward to finer sandstones and mudstones (Heymes et al., 2008: 6). The basal breccias consist almost exclusively of *SU* phyllites and Jurassic carbonates, while the conglomerates and the sandstones can be matched with both the *SU* phyllites and the high-grade metamorphics and granitoids of the *AU*, along with subordinate carbonate and volcanic clasts (porphyritic dacite and andesite) (Cavazza et al., 1997).

The *SCOF* is overlain by '*Varicoloured Clays*' (*VC*). They are a mélange of reddish-greenish to grey, highly sheared, pelitic matrix, containing Late Cretaceous microfossils, and less deformed blocks of variable size, made of Paleogene calcareous-marly turbidites as well as Oligocene–Early Miocene quartzo-feldspathic turbidites (Cavazza and Barone, 2010: 1935–1937; Cavazza and Ingersoll, 2005: 270).

The *SCOF* and *VC* pass upwards into intercalations of shallow marine sandstones, calcarenites and conglomerates. These pass up into Pliocene Marls rich in foraminifera with local intercalations of conglomerates. The Pleistocene and Holocene deposits are terrestrial: conglomerates and talus deposits.

Modern topography is characterized at the coastal strip by small fertile plains composed of recent alluvium, bracketed by fingers of older metamorphic rocks that reach into the sea. After the coastal plains the terrain rises steadily and is characterized by soft sedimentary rocks and minerals. Steep ravines heavily dissect this landscape approximately every 2 km. Between 5 km and 10 km inland, hard metamorphic rocks rise abruptly. Steep hillsides are the norm and gentle slopes are rare. By 10 km inland one reaches 1000 m above sea level into the thick forests of the Aspromonte massif. The Umbro plateau is located on the margin between the sedimentary rocks to the south and the beginning of Aspromonte's metamorphic rocks to the north (Fig. 1).

Table 1
List of all the clay sediments collected from the vicinity of the Umbro plateau and their macroscopic characteristics.

Geological unit	Geological period	Location	Raw material sample	Unfired colour		Colour-700 °C		Colour-800 °C		Colour-900 °C		Bioclasts	Schist	Shrinkage (in mm)
Stilo Unit	Upper Palaeozoic	Limbia	25	5Y 7/1	Light grey	7.5YR 6/6	Reddish yellow	5 YR 6/4	Light reddish brown	5 YR 6/6	Reddish yellow	Absent	Present	0.1
Stilo Unit	Upper Palaeozoic	Fragiacomo	62	Gley1 6N	Grey	5YR 6/4	Light reddish brown	5YR 6/4	Light reddish brown	2.5YR 6/4	Light reddish brown	Absent	Present	0
Stilo Unit	Upper Palaeozoic	Fragiacomo	63	Gley1 5/10B	Bluish grey	5YR 6/4	Light reddish brown	5YR 7/4	Pink	2.5YR 6/6	Light red	Absent	Present	0.5
Stilo Unit	Upper Palaeozoic	Fragiacomo	64	Gley1 5/10B	Bluish grey	5YR 6/4	Light reddish brown	2.5YR 6/4	Light reddish brown	2.5YR 6/6	Light red	Absent	Present	0.2
Aspromonte Unit	Upper Palaeozoic	Deri	80	5Y 6/1	Grey	5YR 6/4	Light reddish brown	5YR 6/6	Reddish yellow	5YR 7/6	Reddish yellow	Absent	Present	0
Aspromonte Unit	Upper Palaeozoic	Deri	81	5Y 8/3	Pale yellow	7.5YR 7/4	Pink	5YR 7/6	Reddish yellow	2.5YR 7/6	Light red	Absent	Absent	0.1
Aspromonte Unit	Upper Palaeozoic	Deri	83	5Y 6/1	Grey	5YR 6/4	Light reddish brown	2.5YR 7/4	Light reddish brown	2.5YR 7/6	Light red	Absent	Present	0.3
Aspromonte Unit	Upper Palaeozoic	Deri	85	Gley1 6N	Grey	5YR 6/4	Light reddish brown	5YR 6/4	Light reddish brown	2.5YR 6/4	Light reddish brown	Absent	Present	0
Stilo Capo d' Orlando Formation	Miocene/ Oligocene	W. Amendolea	9	2.5Y 7/1	Light grey	5YR 6/4	Light reddish brown	5YR 6/6	Reddish yellow	5YR 5/6	Yellowish red	Very Few	Absent	0.6
Stilo Capo d' Orlando Formation	Miocene/ Oligocene	W. Amendolea	10	2.5Y 7/1	Light grey	5YR 6/4	Light reddish brown	5YR 6/6	Reddish yellow	5YR 6/6	Reddish yellow	Very Few	Absent	0.5
Stilo Capo d' Orlando Formation	Miocene/ Oligocene	S. Aniceto	65	5Y 7/1	Light grey	7.5YR 6/4	Light brown	5YR 6/6	Reddish yellow	5YR 6/6	Reddish yellow	Very Few	Absent	0.6
Stilo Capo d' Orlando Formation	Miocene/ Oligocene	Rosario	73	Gley1 7/10Y	Light greenish grey	7.5YR 6/6	Reddish yellow	5YR 6/6	Reddish yellow	5YR 5/6	Yellowish red	Absent	Present	0.4
Varicoloured Clays	Miocene/ Oligocene	Penitenzeria	3	2.5Y 6/3	Light yellowish brown	7.5YR 6/6	Reddish yellow	5YR 7/6	Reddish yellow	5YR 7/6	Reddish yellow	Few	Absent	0.7
Varicoloured Clays	Miocene/ Oligocene	Penitenzeria	4	2.5Y 6/2	Light brownish grey	5YR 6/6	Reddish yellow	5YR 5/6	Yellowish red	5YR 6/4	Light reddish brown	Common	Absent	0.7
Varicoloured Clays	Miocene/ Oligocene	Penitenzeria	5	2.5Y 6/4	Light brownish grey	5YR 5/6	Yellowish red	2.5YR 5/6	Red	2.5YR 4/6	Red	Few	Absent	1.05
Varicoloured Clays	Miocene/ Oligocene	Umbro	6	5YR 4/2	Dark reddish grey	10R 5/6	Red	2.5YR 3/6	Dark red	10R 4/8	Red	Absent	Absent	1.45
Varicoloured Clays	Miocene/ Oligocene	Umbro	7	5Y 6/2	Light olive grey	10YR 6/4	Light yellowish brown	7.5YR 6/6	Reddish yellow	5YR 5/6	Yellowish red	Few	Absent	1.3
Varicoloured Clays	Miocene/ Oligocene	Vaghi	8	2.5Y 6/2	Light brownish grey	5YR 6/4	Light reddish brown	5YR 7/6	Reddish yellow	5YR 6/6	Reddish yellow	Few	Absent	1.15
Varicoloured Clays	Miocene/ Oligocene	Gesu Maria	12	5Y 6/2	Light olive grey	5YR 6/4	Light reddish brown	5YR 6/6	Reddish yellow	5YR 6/8	Reddish yellow	Few	Absent	0.8
Varicoloured Clays	Miocene/ Oligocene	Campo Sportivo	53	2.5Y 7/2	Light grey	7.5YR 6/3	Light brown	5YR 6/6	Reddish yellow	5YR 5/6	Yellowish red	Common	Absent	0.6
Varicoloured Clays	Miocene/ Oligocene	Campo Sportivo	54	2.5Y 6/2	Light brownish grey	7.5YR 7/4	Pink	2.5YR 7/6	Light red	2.5YR 6/6	Light red	Few	Absent	0.65
Varicoloured Clays	Miocene/ Oligocene	Lunar Spot	55	5Y 7/2	Light grey	7.5YR 6/3	Reddish yellow	5YR 6/6	Reddish yellow	2.5YR 6/6	Light red	Few	Absent	0.95
Varicoloured Clays	Miocene/ Oligocene	Lunar Spot	56	2.5Y 7/2	Light grey	5YR 6/6	Reddish yellow	5YR 5/6	Yellowish red	2.5YR 6/6	Light red	Common	Absent	0.7
Varicoloured Clays	Miocene/ Oligocene	Lunar Spot	57	5Y 7/2	Light grey	7.5YR 6/4	Light brown	5YR 7/6	Reddish yellow	5YR 6/6	Reddish yellow	Few	Absent	0.8
Varicoloured Clays	Miocene/ Oligocene	Umbro	66	5Y 6/2	Light olive grey	5YR 6/6	Reddish yellow	5YR 6/6	Reddish yellow	5YR 6/8	Reddish yellow	Absent	Absent	1
Varicoloured Clays	Miocene/ Oligocene	Umbro	67	10R 4/2	Weak red	10R 5/6	Red	10YR 6/6	Light red	10R 6/8	Light red	Frequent	Absent	0.8
Varicoloured Clays	Miocene/ Oligocene	S. Aniceto	69	5Y 7/1	Light grey	7.5YR 7/4	Pink	7.5YR 6/6	Reddish yellow	5YR 7/6	Reddish yellow	Common	Absent	1
Varicoloured Clays	Miocene/ Oligocene	Preconderi	70	5Y 6/2	Light olive grey	7.5YR 6/4	Light brown	5YR 6/6	Reddish yellow	5YR 6/6	Reddish yellow	Common	Absent	0.8

Varicoloured Clays	Miocene/ Oligocene	Preconderi	71	5Y 7/2	Light grey	7.5YR 7/4	Pink	5YR 6/6	Reddish yellow	5YR 7/6	Reddish yellow	Common	Absent	1
Varicoloured Clays	Miocene/ Oligocene	Preconderi	72	5Y 6/2	Light olive grey	7.5YR 6/4	Light brown	5YR 6/6	Reddish yellow	5YR 5/6	Yellowish red	Few	Absent	1
Varicoloured Clays	Miocene/ Oligocene	S. Pasquale	87	5Y 6/2	Light olive grey	7.5YR 6/4	Light brown	7.5YR 5/6	Strong brown	5YR 5/6	Yellowish red	Dominant	Absent	0.7
Varicoloured Clays	Miocene/ Oligocene	S. Pasquale	88	2.5YR 4/3	Reddish brown	10R 5/6	Red	10R 5/8	Red	10R 5/8	Red	Absent	Absent	1.4
Recent sediments (marls)	Pliocene	M. Papagallo	49	2.5Y 8/2	Pale yellow	10YR 7/3	Very pale brown	10YR 7/3	Very pale brown	10YR 7/4	Very pale brown	Dominant	Absent	0.35
Recent sediments (marls)	Pliocene	M. Papagallo	50	2.5Y 7/4	Pale yellow	7.5YR 8/4	Pink	10YR 7/3	Very pale brown	10YR 8/2	Very pale brown	Dominant	Absent	0.45
Recent sediments (marls)	Pliocene	M. Papagallo	51	10YR 7/4	Very pale brown	7.5YR 8/3	Pink	10YR 7/2	Light grey	10YR 8/2	Very pale brown	Dominant	Absent	0.45
Recent sediments (marls)	Pliocene	M. Papagallo	52	2.5Y 7/3	Pale yellow	7.5YR 8/3	Pink	7.5YR 7/4	Pink	7.5YR 7/4	Pink	Dominant	Absent	0.85
Recent sediments (marls)	Pliocene	Calamitta	74	5Y 7/1	Light grey	7.5YR 8/3	Pink	7.5YR 8/2	Pinkish white	10YR 8/2	Very pale brown	Common	Absent	0.6
Recent sediments (marls)	Pliocene	Calamitta	75	5Y 7/2	Light grey	10YR 8/3	Very pale brown	10YR 8/2	Very pale brown	2.5Y 8/3	Pale yellow	Common	Absent	0.6
Recent sediments (marls)	Pliocene	M. Calamitta	76	5Y 8/1	White	10YR 8/2	Very pale brown	10YR 8/3	Very pale brown	10YR 8/1	White	Dominant	Absent	0.7
Recent sediments (marls)	Pliocene	M. Calamitta	77	2.5Y 8/2	Pale yellow	10YR 8/2	Very pale brown	7.5YR 8/2	Pinkish white	10YR 8/1	White	Dominant	Absent	0.8
Recent sediments (marls)	Pliocene	M. Calamitta	78	5Y 7/4	Pale yellow	7.5YR 8/2	Pinkish white	2.5Y 7/2	Light grey	2.5Y 8/3	Pale yellow	Dominant	Absent	0.6
Recent sediments (marls)	Pliocene	M. Calamitta	79	10YR 8/2	Very pale brown	10YR 7/2	Light grey	10YR 8/2	Very pale brown	2.5Y 8/2	Pale yellow	Dominant	Absent	0.5

The three shades of grey clearly mark the clay samples that belong to the three clay units identified in this paper. Light grey = Metamorphic + SCOF; Darker grey = Varicoloured Clays; Darkest grey = Pliocene Marls.

3. Methods

3.1. Raw materials survey

The focus of our raw materials survey is the Umbro plateau, where a cluster of prehistoric sites has been excavated by BMAP. The extent of our project is defined by the *fiumara di Amendolea* to the west, the *fiumara di San Pasquale* to the east, the Ionian Sea to the south and the town of Bova (Superiore) to the north (Fig. 1). These landmarks define a radius of approximately 4 km around Umbro, that, besides capturing all the major geological units characteristic of southwestern Calabria, is also in accordance with ethnoarchaeological data on the distance within which potters tend to acquire their raw materials, in cases of non-economically specialized, small-scale production (Arnold, 1985; Gosselain and Livingstone Smith, 2005).

The volume and extent of clays and marls in our study area (Fig. 2) made the systematic collection of sediments impossible. Instead, we began by collecting samples that represent the clay colours apparent in the landscape within each of the geological units identifiable on the map, since great colour variability characterized the local sediments, ranging from white and yellow, to brown, to deep red, to grey (Fig. 3a, e, i). The unfired colour of clay does not correspond to its fired colour, yet it is related to depositional conditions and local chemistry. Although we covered all the geological units and clay colours, the extremely steep topography and a number of absentee landowners with fenced plots of land made certain deposits unreachable.

To date, we have collected 88 sediment, mineral and rock samples. Of those, 42 are plastic and are the focus of the present paper (Fig. 1 and Table 1). Our samples weighed approximately 5 kg each and were collected practically from the surface, since we rarely had to remove any surficial soil or organic materials given the badland nature of most of our landscape (Fig. 2).

Half of each sediment collected was kept in our field base, while the other half was transferred to the Laboratory for Interdisciplinary Research on Archaeological Ceramics (LIRAC) at the Department of Anthropology, McMaster University for laboratory experiments. Although the laboratory experiments were controlled and accurate, the creation of test-tiles with a metal mould (see below) hardly reflected the requirements of making actual pots. In our field experiments, although we lacked accuracy, since none of us was an accomplished potter, we were able to test the clays under more realistic conditions. Our goal was not to judge what were the 'best' or 'worst' materials; only to assess how materials compared to each other when treated in similar ways. We further wanted to know whether clays collected from the same geological unit were consistent in their properties, in which case our results could be applicable beyond our specific sampling locations, and whether they differed measurably between units, in which case it would indeed be feasible to connect particular archaeological wares with particular sediment units.

3.2. Field experiments

Our experiments were inspired by previous and contemporaneous work to ours by Vitelli (1984), Cassano et al. (1995a,b), and Purri (2007). Our typical process in the field involved pulverizing each dry sediment, adding water, kneading the paste and dividing it into clay balls marked with their 'raw materials sample' (RMS) number. KM made small open bowls, approximately 10 cm in diameter and 7 cm in height, using each sediment, and pinching and coil building methods, without adding any temper, so that the clays could be compared to each other under similar conditions. However, we also made an array of objects with the same clays, ranging from beads and stamps to bowls, cups, jars, miniature amphorae, plates and bottles using pinching, coil building and moulding techniques. Tempering materials, such as sand, were kept separate, to be added as needed. By allowing such freedom in clay pastes, forming techniques and vessel shapes/sizes, we wanted to assess how the properties of each sediment might afford different options/strategies to potters who were trying to achieve different goals. For example, it was only when we tried to make a large and deep bowl that we understood how much harder it was to keep the walls from slumping when we used *Pliocene Marls*, rather than *Metamorphic + SCOF* sediments (see below). Our creations were then left to dry and monitored for cracks. Firing took place in open fires on the beach, using dried tree branches and cow dung patties. Through the years, we used multiple firing strategies, manipulating mostly the amount and size of fuel, the relation of vessels to the fuel and the presence of a pre-firing stage. Our firings lasted 3 h on average and produced pots that did not deteriorate, when washed under water, suggesting that sufficient temperatures were sustained long enough to create pottery.

We were not surprised to lose a large percentage of our production each time, or to be unable to produce the consistent orange/brown, black/grey or buff colours one encounters on the prehistoric pottery of the region. We were surprised to realize, however, that even in our inexperience we had managed, over time, to produce pottery with all of the clay sediments collected.

3.3. Laboratory analyses

3.3.1. Clay test-tiles – shrinkage and firing

At LIRAC enough sediment from each sample was added to individual glass beakers up to the 400 ml line and then topped to the 700 ml line with de-ionized water. The sediments were left to dissolve over several days, with occasional stirring. Once the clay had dissolved, excess water was removed and the clay was left to dry until it was workable. Six test-tiles of standardized size (12 cm × 2 cm) were prepared from each sediment using a metal mould (Fig. 3b, f, j).

One tile was kept unfired, while the remaining were fired respectively at 600 °C, 700 °C, 800 °C, 900 °C and 1000 °C, after they had thoroughly dried for several days (Tables 1, 2). All the firings took place in a Lindberg/Blue M 1200 °C Box Furnace under oxidizing conditions. The maximum temperature was achieved gradually in 60, 70, 80, 90 and 100 min respectively, and was then kept stable for 1 h, after which time the furnace was turned off and allowed to cool down overnight.

On each unfired test-tile we engraved a 10 cm line, while it was still damp. Once the test-tile had dried completely we re-measured the line and recorded its length. The difference between the original 10 cm and the dried length of the same line gave us a quasi-systematic estimate of how much each tile had shrunk (Table 1).

3.3.2. X-ray diffraction (XRD)

Samples of 16 geological sediments collected during the first two survey seasons and representing all the units described below (see Results) were submitted to "The Mineral Lab, Inc." for XRD (Table 3). Hardware consisted of a Siemens 'D5000matic' system equipped with a ceramic Cu tube, graphite monochromator, computer-controlled theta-compensating slit, sample spinner and automated sample changers. A representative portion of each sample was ground to circa −400 mesh in a steel swing mill, packed into a well-type plastic holder and scanned with the diffractometer over the range 3–61° 2θ using Cu-Kα radiation. To identify the clay minerals a portion of each ground sample was further prepared as an oriented mount by mixing the ground sample with distilled water, drawing the mixture onto a cellulose acetate filter and rolling the deposited material onto a glass disk. The oriented mounts were scanned over the range 2–30°, treated with glycol and re-scanned over the range 2–22°. The scan results were summarized as approximate mineral weight percent concentrations. Estimates of mineral concentrations were made using the lab's X-ray fluorescence determined elemental compositions and the relative peak heights/areas on the XRD scans. The detection limit for an average mineral in the samples is ~1–3% and the analytical reproducibility is approximately equal to the square root of that amount.

3.3.3. Optical microscopy (OM)

Petrographic analysis was undertaken for each of the 42 clay sediments. Thin sections of the 800 °C test-tiles were examined under a polarizing microscope (Nikon Eclipse E600WPOL), since preliminary data suggested that local prehistoric pottery was fired above 700 °C and below 900 °C. Qualitative and textural observations regarding the clay matrix were made following a version of Whitbread's (1995: 365–396) technique. Quantitative measurements were made in two stages. First, an area of the thin-section was randomly selected using a grid overlay. Within it, the mineralogy of each grain larger than 20 μm was identified at 100× magnification and its maximum length was measured using Nikon imaging software (NIS Elements D 3.0). When all grains had been measured and identified, a new area was randomly selected, until at least 150 grains (or, if the clay had an exceedingly low inclusion frequency, half the area of the thin-section) had been examined. When grains composed of more than one mineral were encountered they were classified according to their texture, proportions of mineral constituents, and origin. Finally, a high-resolution digital image of the entire thin-section was captured at 20× magnification. Open-source software (ImageJ 1.42) was used to threshold and analyze the image, providing the overall relative grain abundance.

3.3.4. Instrumental neutron activation analysis (INAA)

A 2 × 2 cm portion of the 900 °C test-tile of each of the 42 clay sediments was submitted for INAA at the Centre for Neutron Activation Analysis (CNAA), at the McMaster Nuclear Reactor. Each piece was pulverized in an agate mortar. The powder was dumped into a filter paper cone and transferred into a labelled liquid scintillation vial. The samples were then dried in a desiccating oven at 100 °C for 48 h.

At the CNAA, two irradiations and four countings were made on each sample to generate elemental concentration data from both short and long-lived radioisotopes. Approximately 1 g of each powdered sample was transferred into a polyethylene vial. Samples were irradiated sequentially for 10 s at a neutron flux of 5×10^{13} n cm^{-2} s^{-1}. Each sample was left to decay for 10 min and the radioactivity was counted for 5 min using a γ-ray spectrometer. The elements measured for the short-lived procedure included: Al, Ba, Br, Ca, Co, Cl, Dy, K, Mg, Na, Ti and V. After an overnight decay, a second 5 min count was performed to collect data on Eu, Ga, K, La, Mn, Na and Sm. The same samples were then bundled together along with standard reference materials and control samples and were irradiated for 2 h at a neutron flux of 5×10^{13} n cm^{-2} s^{-1}. After decaying for 7–10 days they were counted for 15 min to measure for: As, Ba, Br, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Lu, Na, Nd, Sb, Sc, Sm, Ta, Tb, Th and Yb. Elemental concentrations were calculated using the comparator method.

The analytical data were checked for reliability using visual assessments and bivariate plots (see Michelaki and Hancock, 2011 for process and rationale). The data were then assessed using bivariate plots and principal component analysis (PCA) with different numbers of elements (*ibid*).

Table 2
Colour ranges of the clays collected from the vicinity of the Umbro plateau.

Firing temperature	*Metamorphic + SCOF*	*Varicoloured Clays*	*Pliocene Marls*
Unfired	Gley 1/2.5Y/5Y	10R/2.5YR/5YR/10YR	10YR/2.5Y/5Y
Colour description	Bluish grey, grey, light greenish grey, light grey (RMS 81: Pale yellow)	Weak red, reddish brown, light yellowish brown, light brownish grey, light grey, dark reddish grey, light olive grey	Very pale brown, pale yellow, light grey, white
700 °C	5YR/7.5YR	10R/5YR/7.5YR/10YR	7.5YR/10YR
Colour Description	Light reddish brown, reddish yellow, light brown (RMS 81: Pink)	Red, light yellowish brown, yellowish red, light reddish brown, reddish yellow, light brown, pink	Pink, pinkish white, light grey, very pale brown
800 °C	2.5YR/5YR	10R/2.5YR/5YR/7.5YR/10YR	7.5YR/10YR/2.5Y
Colour description	Light reddish brown, reddish yellow (RMS 63: Pink)	Dark red, red, light red, yellowish red, reddish yellow	Pink, pinkish white, light grey, very pale brown
900 °C	2.5YR/5YR	10R/2.5YR/5YR	7.5YR/10YR/2.5Y
Colour description	Reddish yellow, yellowish red, light red, light reddish brown	Reddish yellow, yellowish red, light reddish brown	Pink, very pale brown, white, pale yellow
1000 °C	10R/2.5YR/5YR/7.5YR	10R/2.5YR/5YR	7.5YR/10YR/2.5Y
Colour description	Red, light red, yellowish red, reddish yellow (RMS 81: Pink)	Red, weak red, dark reddish brown, light reddish brown, light red, reddish yellow, reddish brown	Pink, white, pale yellow, very pale brown

All firings completed in an electrical kiln under oxidizing conditions. Colours recorded under natural light according to the Munsell soil colour chart. The sequence of hues from darker to lighter is as follows: Gley 1, Gley 2, 10R, 2.5YR, 5YR, 7.5YR, 10YR, 2.5Y, 5Y.

4. Results

4.1. Field experiments

In the field, the *Pliocene Marls* stood out as spatially restricted mountains of yellow and white sediments by the coast. No other sediments looked like them. They were fine and powdery in texture without many aplastics, except for tiny shell fossils that would float to the surface when the clays were immersed in water and stirred, or would appear as white dots on the surfaces of our drying vessels (Table 1; Fig. 3i). They were easy to pulverize, but had a narrow plastic range. However, they were consistent in their response to water: seeing a light-coloured sediment always meant water had to be added carefully. Once a workable paste was achieved, it was always very soft, making the raising of walls tricky. We either had to blend these clays with another sediment to make them stiffer, or be patient building our vessels, allowing the walls to dry and become stronger. In that way, pinching was a less problematic technique than coil/slab building, and smaller sizes easier to make than larger ones. Once pots were formed, the fine texture of the clay made it possible to scrape them evenly, achieving thin walls and very smooth surfaces. Cracks were easily manageable and usually superficial.

The sediments most juxtaposed to the *Pliocene Marls* were coarse and had grey colours (Table 1, Fig. 3a). They were more widely available than the *Pliocene Marls*, from near Umbro all the way to the coast, yet always in association with bedrock or conglomerate outcrops. Thus, although in terms of colour they blended with other local sediments, in terms of texture and landscape associations they were easily identifiable. They came from the metamorphic (*Aspromonte* and *Stilo*) and the *SCOF* units. Within these sediments typical aplastics were schist/phyllite and sandstone grains, while fossils, if they existed at all, were extremely rare (Table 1). They were harder to pulverize than the *Pliocene Marls* and had to be 'cleaned' before we could use them. They had a wide plastic range and enough stiffness to make building by pinching, coils or slabs equally easy. It was easier to tackle larger vessel sizes with them. Their gritty texture made the achievement of rougher textured surfaces easy, but even wall thickness and smooth surfaces were considerably harder to produce. Drying cracks were ubiquitous, but easily managed.

The last group of clay sediments was also widely accessible, from Umbro to the coast, forming large rolling hills in colours that varied from light grey, to brown, to very deep red (Table 1, Fig. 3e). As their name (*Varicoloured Clays*) suggests, variability in colour and texture was their main characteristic: although usually fine, they could also be medium (e.g., RMS 4, 54) or even coarse (RMS 67,72, 87). They differed from the *Metamorphic + SCOF* sediments because they had fewer and smaller inclusions, lacked schist fragments, and contained larger quantities of fossils. They differed from the *Pliocene Marls* because they were never yellow/white in colour, were not powdery and contained more variable quantities of fossils. These materials were 'unpredictable' and hard to prepare. Some were too hard for us to pulverize. When we tried to dissolve them in water, two weeks later, after repeated stirrings and manipulation, they still were not ready. Clays from locations only a few metres apart from each other, looking similar and treated similarly, would differ: one being very stiff, the other very plastic. When we collected a sediment from this unit we could not predict how we should proceed in building a vessel, unlike when working with the *Pliocene Marls* or the *Metamorphic + SCOF* sediments.

None of the descriptions above are intended as objective. Even through our limited interaction with these materials our familiarity and comfort with them grew. What had appeared 'difficult' early on became 'easier' as time passed. However, there is no doubt that both skilled potters and novices, despite different and personal judgements, would have recognized these materials as distinct from each other and would have treated them differently.

Table 3
X-ray diffraction descriptions of clay sediments collected from the vicinity of the Umbro plateau.

Mineral	*Metamorphic + SCOF*	*Varicoloured Clays*	*Pliocene Marls*
Sample numbers	*RMS 10, 25*	*RMS 3,4,7,8,53,54,55,56,57*	*RMS 49,50,51,52*
Quartz	20–27%	10–25%	12–18%
K-Feldspar	11–16%	0–11%	0–<3%
Plagioclase	0–<3%	0–10%	<3–<5%
Mica/Illite	**24–32**%	<**5–25**%	**5–10**%
Smectite	**0**%	**10–65**%	**0**–<**10**%
Chlorite	**15–28**%	**0–25**%	**0–10**%
Salinity	0–7%	0–15%	0–<5%
Calcite	**0**% (*RMS 10*: 14%)	**11–30**% (*RMS 6* = 0%)	**55–64**%
Dolomite	0%	0–2%	0–<3%
Gypsum	0%	0–3%	0%
Haematite	0%	0–5%	0%

Values in bold highlight the main differences between the three clay units identified around the Umbro plateau.

4.2. Test-tiles

The creation of test-tiles in the laboratory gave us the opportunity to describe more accurately and test the validity of our field observations.

An examination of the unfired colours of our clay sediments using a Munsell soil colour chart revealed three broad categories (Tables 1 & 2, Fig. 3b, f, j): The *Metamorphic* + *SCOF* sediments were characterized by dark greyish colours, while the *Pliocene Marls*, at the other extreme, were primarily light yellowish. The *Varicoloured Clays* were the most variable, although characterized mostly by reddish/brownish colours. When we began firing the clays the *Metamorphic* + *SCOF* and the *Varicoloured Clays* started looking similar to each other, firing primarily in orange/reddish colours. However, the *Varicoloured Clays* continued to show greater variability, with some sediments firing in light brown and pink colours, similar to those of the *Pliocene Marls*, in temperatures below 800 °C. The *Pliocene Marls* remained distinct, characterized by consistently lighter colours.

When looking at the relative shrinkage of our clays (Table 1) it was notable that the three broad categories suggested by the unfired colours of the clays (i.e. *Metamorphic* + *SCOF*, *Varicoloured Clays* and *Pliocene Marls*) differed from one another significantly (Kruskal–Wallis results: $\chi^2 = 28.6$; d.f. $= 2$; $p < 0.0001$). The sediments that shrank the most were the *Varicoloured Clays*, which is not surprizing, given that they were characterized primarily by smectite (see X-ray diffraction results below).

4.3. X-ray diffraction (XRD)

XRD also separated the *Metamorphic* + *SCOF* sediments from the *Varicoloured Clays* and the *Pliocene Marls* (Table 3), mostly based on the presence and amount of calcite, as well as on the clay minerals that characterized the sediments. The *Metamorphic* + *SCOF* sediments lacked calcite and smectite and were rich in mica/illite and chlorite. In the *Varicoloured Clays* calcite was common (11–30%) and the predominant clay mineral was smectite. In the *Pliocene Marls* calcite was dominant (55–64%), while the clay minerals existed in amounts up to 10% each.

4.4. Optical microscopy

The same pattern was further supported by petrographic analysis of thin sections (Table 4). The *Metamorphic* + *SCOF* sediments were primarily coarse in texture and mostly lacked carbonates, while they consistently included a few grains of schist (3–12%) and sandstone (3–19%) (Fig. 3c and d). They were often characterized by a biotite dominated micromass, while they also had greater amounts of muscovite (3–21%) in comparison to the *Varicoloured Clays* and the *Pliocene Marls*, whose sediments included less than 4% muscovite. The *Pliocene Marls* were mostly dominated by carbonates in the form of foraminifera and bioclasts, but also grains of carbonate mudstone. They lacked both grains of schist and sandstone (Fig. 3k–l). Finally, the *Varicoloured Clays* were the most variable, including primarily fine sediments, but also medium and coarse. They were typically rich in bioclasts (except RMS 66 and 88), with a small, yet consistent presence of sandstone grains (2–5%) (Fig. 3g and h).

4.5. Instrumental neutron activation analysis (INAA)

INAA further supported the presence of clays that were overall similar, yet differed based on their calcium- (Ca) or silica-dilutions. Table 5 shows how similar the three groups of sediments are, and highlights the elements that vary the most among groups. Because of the much higher Ca in the *Pliocene Marls*, the concentrations of most other elements in them are about 60% of what was found in the other two sediment groups.

Fig. 4a shows a PCA of the clays using all the reliably measured elements (Ti, Na, V, Al, Ca, Mn, K, Th, Ba, Fe, Cr, Hf, Cs, Sc, Co, Ta, La, Ce, Nd, Sm, Eu, Tb, Dy, Yb and Lu). PC1 separates clearly the *Pliocene Marls* and suggests a further separation between the *Metamorphic* + *SCOF* sediments and the *Varicoloured Clays*.

Scatterplots of Ca with any of the major, minor or trace elements that form silicates show the presence of $CaCO_3$ dilution. Looking at the % K versus % Ca plot (Fig. 4b), the $CaCO_3$ dilution is represented by a line drawn from 3% K down to 40% Ca – this dilution is supplemented by silica/silicate dilutions that draw samples from this line towards the origin. In the K–Ca plot, the *Metamorphic* + *SCOF* sediments tend towards the top left, the *Varicoloured Clays* are at, or a little below the Ca-dilution line, while the *Pliocene Marls* form the lower right end of the Ca-dilution line, suggesting that the clays are differentiable chemically by geological unit.

The *Pliocene Marls* are high in Ca, with all but two being very high in Ca. The *Metamorphic* + *SCOF* sediments have low Ca contents, with two exceptions, and all but two samples are not Si-diluted. They probably represent the parent material of the area. The *Varicoloured Clays* are interesting in that some appear to be either Ca- and/or Si-diluted. This combined effect results in their samples fitting near to or below the $CaCO_3$ dilution line.

The ppm Cr versus % Ca plot (Fig. 4c) shows that the *Varicoloured Clays* are higher in Cr than are the *Metamorphic* + *SCOF* sediments. If we plot the Cr/K ratio against the % Ca in each sample, the three different geological sediments tend to pull apart a little more, with the *Metamorphic* + *SCOF* sediments in the lower left corner, the *Varicoloured Clays* above them and to their right, and the *Pliocene Marls* to the far right (Fig. 4d).

5. Summary and discussion

Our goal was to examine the range and variability of local raw materials. We showed that our study area was rich in sediments that could all be used successfully in the production of pottery. However, these materials had neither even nor identical distributions on the landscape, nor did they possess the same properties. Moreover, we showed that the local sediments can be divided into three units, based on their macroscopic, mineralogical and chemical characteristics, which correspond well with the geological units that outcrop in our study area: *Pliocene Marls*, *Metamorphic* + *SCOF* sediments and *Varicoloured Clays*.

The *Pliocene Marls* define one extreme of the spectrum of local materials. They are spatially limited to the coast and have characteristic light colours, which they retain even after firing under oxidizing conditions. They are very rich in calcite and include only small percentages of clay minerals. They are fossiliferous and very high in Ca. They lack schist and sandstone grains and have very fine textures. They are very plastic and have a small plastic range. However, they do not shrink a lot, and dry evenly. Smaller vessels and a pinching building technique are the easiest to achieve, since these sediments are soft and vessel walls can easily slump. Yet, once a pot is formed, their fine texture makes it easy to produce very thin, even, and smooth walls.

The *Metamorphic* + *SCOF* sediments occupy the other extreme. They are widely distributed from immediately north of the Umbro plateau to the coast, always in association with rock outcrops and conglomerate exposures. In the field, they are primarily dark greyish but when fired under oxidizing conditions they turn reddish/brownish. They are rich in illite and chlorite, contain small quantities of kaolinite and lack smectite or any significant amounts of calcite. They rarely contain bioclasts and are very low in Ca. They

Table 4
Optical microscopy descriptions of clay sediments collected from the vicinity of the Umbro plateau.

	Metamorphic + SCOF	*Varicoloured Clays*	*Pliocene Marls*
Overall Inclusion %	*25–40%*	*3–30%*	*5–25%*
Range of max. size	1340–5520	314–5494	403–8040
Range of mean size	106–269	44–161	68–180
Sorting	V. Poor–Fair	V. Poor–Fair	Poor–Fair
Quartz%	*12–25%*	*11–23%* (*RMS 66*: 60%)	*7–25%*
Range of max. size	193–723	61–360	79–481
Range of mean size	51–137	26–62	42–67
Sorting	Poor–Fair	Moderate–V. Good	Moderate–Good
Shape	SA, SR, R (*RMS 62* also A)	SA, SR, R	A, SA, SR, R
K-Feldspar %	*13–39%* (*RMS 73*: 60%)	*16–40%*	*11–25%*
Range of max. size	165–1056	88–3286	192–1122
Range of mean size	51–111	45–273	52–111
Sorting	Poor–Moderate	V. Poor–Fair	Moderate–good
Shape	SA, SR, R	SA, SR, R	SA, SR, R
Plagioclase %	*0–2%*	*0–2%*	*0–3%*
Range of max. size	240–423	210–861	35–760
Range of mean size	147–263	121–861	35–244
Sorting	Poor–Fair	V. Poor–Fair	Moderate–V. Good
Shape	SA	SA	SA, SR
Biotite %	*14–40%* (*RMS 64*: 5%)	*3–31%* (*RMS 66*: 0%)	*10–43%*
Range of max. size	210–873	57–457	87–508
Range of mean size	49–195	47–103	38–67
Sorting	V. Poor–Moderate	Moderate–V. Good	Poor–Fair
Muscovite %	*3–21%*	*0–4%*	*0–4%*
Range of max. size	109–536	61–227	45–193
Range of mean size	48–171	51–115	33–113
Sorting	Poor–Fair	Fair–V. Good	Poor–V. Good
Carbonates %	*0%* (*RMS 62:* 0.6%; *65:* 10%)	*19–57%* (*RMS 66, 88*: 0%)	*19–54%*
Range of max. size	618–4345	335–5494	403–2645
Range of mean size	166–4345	90–359	101–313
Schist	*3–12%* (*RMS 65, 73, 81*: 0–0.7%)	*0%*	*0%*
Range of max. size	887–4465	–	–
Range of mean sizes	752–1533	–	–
Shape	SA, SR, R	–	–
Sandstone	*3–19%*	*2–5%* (*RMS 71, 72*: 0%; *67*: 12%)	*0%*
Range of max. size	1615–5521	183–945	–
Range of mean sizes	571–800	86–648	–
Sorting	V. Poor	V. Poor–Fair	–
Shape	SR, R	SR, R	–
Trace grains	Chlorite, epidote, zoisite, devitrified pyroclastic sediment	Chlorite, epidote, plagioclase, devitrified pyroclastic sediment	Chlorite, epidote, zoisite
Further details			
K-Feldspar	Orthoclase (*RMS 73*: microcline)	Orthoclase, microcline, spherulite	Orthoclase (*RMS 74*: microcline)
Carbonates	Foraminifera, corals, limestone	Foraminifera, corals, bryozoans, (*RMS 67*: mudstone, packstone; *RMS 87*: bioclast limestone, micritic limestone)	Bioclasts, foraminifera, (*RMS 74,75*: carbonate mudstone)
Schist	Phyllite, phyllite-muscovite, quartzo-feldspathic muscovite	–	–
Sandstone	Schisto-quartzitic with or without muscovite; with biotite and orthoclase; chloritic/biotitic; quartzitic	Quartz, quartzo-feldspathic, chlorite/biotite/quartz, quartzite	–
Micromass	*RMS 64, 80, 85*: Dominated by biotite	–	–

Quartz often metamorphosed. Feldspars often sericitized. Schists/Micas often chloritized. Sizes measured in μm.

are coarse sediments that typically contain schist/phyllite and sandstone grains. They have a wide plastic range and a balance of stiffness and plasticity that makes it equally easy to make vessels of various shapes and sizes using multiple hand-building techniques. They shrink very little. Producing rougher textures is easy with these sediments, although depending on how much one is willing to 'clean' them, it is possible to achieve very smooth surfaces as well.

Between the two extremes are the *Varicoloured Clays*, exhibiting the greatest variability along all the lines of evidence considered. In the field, they are distributed from the immediate vicinity of the Umbro plateau to the coast on large rolling hills, with colours that vary from light greys to deep reds. When fired under oxidizing conditions, they produce colours that turn typically reddish/brownish, but also very light brown and pink at lower temperatures. They can be very rich in smectite, while they also contain illite and chlorite and small quantities of kaolinite. They often include calcite in the form of bioclasts, but in varying quantities and never in the amounts characteristic of the *Pliocene Marls*. Accordingly, their Ca can vary considerably. Their texture varies from coarse to fine and they often include sandstone grains, although not any schist. The range and degree of their plasticity is variable and so is their shrinkage, which on average is the most severe among all the local sediments. What the easiest vessel shape and size is to achieve, and what the easiest forming method is to use, has to be determined on a case-by-case basis.

Table 5
Means and standard deviations of all elements measured by INAA for clay sediments collected from the vicinity of the Umbro plateau.

Element	*Metamorphic + SCOF*	*Varicoloured clays*	*Pliocene Marls*
Al %	9.1 ± 1.3	8.4 ± 1.4	5.6 ± 1.3
Ca %	**3.1** ± **3.6**	**5.9** ± **3.4**	**28.5** ± **6.5**
Fe %	4.7 ± 0.8	4.6 ± 1.5	2.7 ± 0.4
K %	2.61 ± 0.3	1.8 ± 0.27	0.94 ± 0.43
Na %	1.11 ± 0.38	0.91 ± 0.33	0.70 ± 0.32
Ti %	0.48 ± 0.06	0.44 ± 0.09	0.29 ± 0.05
Ba ppm	**680** ± **230**	**290** ± **100**	**270** ± **110**
Co ppm	18 ± 5	15 ± 3	13 ± 3
Cr ppm	**81** ± **17**	**103** ± **25**	**63** ± **13**
Cs ppm	**7.7** ± **0.9**	**6.0** ± **1.2**	**1.9** ± **0.8**
Hf ppm	5.9 ± 0.9	5.1 ± 1.0	3.3 ± 1.0
Mn ppm	600 ± 240	710 ± 320	1560 ± 1080
Sc ppm	17.8 ± 1.9	16.0 ± 2.8	10.1 ± 1.8
Ta ppm	1.3 ± 0.2	1.3 ± 0.2	0.8 ± 0.1
Th ppm	**15** ± **1**	**12** ± **2**	**8** ± **2**
V ppm	**142** ± **45**	**149** ± **44**	**99** ± **23**
La ppm	44 ± 4	37 ± 4	26 ± 4
Ce ppm	94 ± 10	79 ± 8	52 ± 9
Nd ppm	38 ± 4	32 ± 3	23 ± 4
Sm ppm	7.9 ± 1.0	6.2 ± 0.7	4.5 ± 0.8
Eu ppm	1.3 ± 0.1	1.1 ± 0.1	0.8 ± 0.1
Tb ppm	0.99 ± 0.25	0.84 ± 0.17	0.56 ± 0.12
Dy ppm	4.4 ± 0.8	3.6 ± 0.8	2.8 ± 0.4
Yb ppm	3.0 ± 0.3	2.4 ± 0.3	1.8 ± 0.3
Lu ppm	0.51 ± 0.06	0.39 ± 0.05	0.29 ± 0.05

Test-tiles fired at 900 °C used for the analysis.
Values in bold highlight the main differences between the three clay units identified around the Umbro plateau.

Raw materials surveys that consider as many sediment samples from as small an area as our project are not very common. Local sediments are rarely collected and used mostly to assess whether the ceramics found in the vicinity are a match, or can be shown to be exotic. The data collected with a methodology such as the one advocated in this paper, however, can open up wider avenues of enquiry into how prehistoric people perceived their landscapes and, through their activities, came to be skilful members of their communities (Boivin, 2008; Boivin and Owoc, 2004; Bradley, 2000; Ingold, 2007; Jones, 2007; Michelaki, 2008a).

For example, in the Neolithic layers of the sites of Penitenzeria and Umbro Neolithic, two of the sites excavated by BMAP on the Umbro plateau, we find a small percentage (less than 4% of the total early to middle Neolithic assemblage) of sherds that are very fine in texture and buff in colour (i.e. very light brown to pink). Previously, based on the archaeological principle of abundance, it had been hypothesized that this 'non-abundant' ware in Calabria must be exotic and its origins were searched into the similarly buff coloured and fine textured finewares of Apulia and/or northern Calabria (Malone, 1985, 2003; Morter and Iceland, 1995; Tiné, 2004). Traditional archaeometric concerns would focus only on verifying or refuting the local or exotic origin of these vessels. Indeed, work in north Calabria (Muntoni and Laviano, 2008; Muntoni et al., 2009) has shown that, at least at the site of Favella, they were locally produced (although see Spataro, 2009 for an argument of regional production and distribution in south-eastern Italy). Our work, however, shows that local Neolithic potters of the Umbro plateau had access to two different sources of clays that could be used in the production of such vessels: the *Pliocene Marls* and some of the *Varicoloured Clays*. Forthcoming analyses of buff ceramics from Penitenzeria and Umbro Neolithic show that they are consistent only with the *Varicoloured Clays* and not with the *Pliocene Marls*. In other words, not only were potters producing them locally, but they also targeted only one of the two local units of sediments that could have been used. This piece of information re-orients our attention away from 'local-exotic' concerns and opens up new and intriguing social questions about knowledge and skill, and how people perceived their landscape and resources.

It is interesting, for example, that the Umbro plateau is itself located on *Varicoloured Clays*, yet these clays are only used in the production of the least common ceramic ware. It is probably not a coincidence that the *Varicoloured Clays* are the most unpredictable,

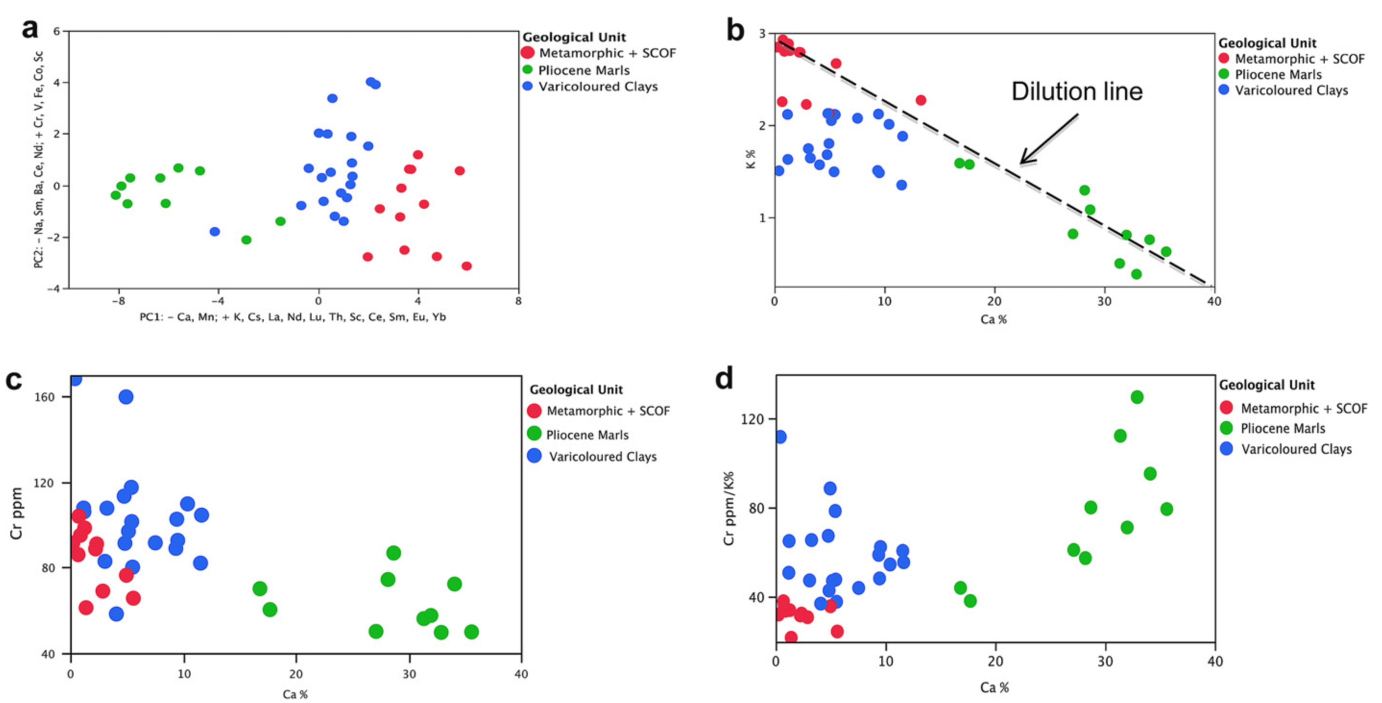

Fig. 4. Results from the chemical analysis (INAA) of 42 sediments from the Bova Marina region: a. PCA including all accurately measured elements; b. Scatterplot of % K versus % Ca; c. Scatterplot of ppm Cr versus % Ca; d. Scatterplot of ppm Cr/% K versus % Ca.

the hardest to work with and require careful monitoring of firing conditions to produce buff colours. The difficulty of controlling such materials may have indeed made them 'ideal' in the production of the rare buff ware and given the opportunity to the people who had the access/skill/knowledge to manipulate them to differentiate themselves from other members of their small Neolithic communities.

Once we have understood in detail the choices potters made during each time period at each of the sites at the Umbro plateau, we shall compare them to each other to build a long-term picture of ceramic technology in the region. We can then correlate continuities and disruptions in technology and landscape use with other archaeological data suggesting social reorganization of southern Italy (e.g., new burial customs and/or new spatial distributions of new pottery types) to examine how long-term technological traditions respond to broader social change and affect the interactions between humans, landscapes and materials. Similarly, once we understand potters' choices in each time period at the Umbro plateau, we can compare them to published data from other sites in Calabria and southern Italy (e.g., Morter and Iceland, 1995; Muntoni and Laviano, 2008; Spataro, 2009; Williams, 1980) to understand the degree to which technological knowledge was shared over wide regions and what this suggests about regional and inter-regional social interactions.

6. Conclusions

In this study, we showed that the local clay sediments in the region of Bova Marina, Calabria, can be divided into three main units which differ measurably from each other in their macroscopic, mineralogical and chemical characteristics. Furthermore, we showed that each unit, except for the *Varicoloured Clays*, is consistent in its properties. This means that the local landscape could afford multiple options for the potters of the Umbro plateau. An assessment of *the choices the potters actually made*, as reflected in their ceramics, in the context of *choices that were available, but were not made*, can give us insights not only into how prehistoric potters built a sense of landscape through their quotidian activities, but also into how the knowledge and skill required to manipulate the 'proper' materials provided venues for people to become skilful and knowledgeable members of their communities. Our methodology combined a raw materials survey with field and laboratory experiments and mineralogical and chemical analyses of the collected sediments. Such a methodology is applicable beyond the confines of southwestern Calabria and can bring provenance studies more in tune with current anthropological and archaeological understanding of the importance of raw materials and the landscapes within which they were explored. It can re-orient our focus beyond the exploration of the local or exotic origins of pottery and give us a new way of approaching the knowledge and skill involved in the quotidian activities that guided the use and perception of past landscapes.

Acknowledgements

This research would have not been possible without the support of a Canada Foundation for Innovation, a Social Sciences and Humanities Research Council-Standard Research Grant, a Social Sciences and Humanities Research Council-Research Development Initiatives, an Arts Research Board and two McMaster Incentive Program Research Grants. We owe a lot to the Soprintendenza Archeologica della Calabria, the whole crew of the Bova Marina Archaeological Project, and the McMaster Nuclear Reactor. Eric Siu, Sam Craigie and Christine Sally, undergraduate students at McMaster University, helped with the creation, documentation and analysis of the test tiles. Ruth Siddall (University College London) and Kelin Whipple (Arizona State University) helped us make sense of the geology. Sean Bergin and Isaac Ullah, graduate students at the School of Human Evolution and Social Change made Fig. 1. David Abbott and two anonymous reviewers gave us helpful comments that significantly improved this paper. We thank them all. Dr. Michelaki was on research leave from McMaster University and a Fitch Senior Visiting Fellow while part of this paper was prepared and benefited greatly from the resources of the Fitch Laboratory.

References

Arnold, D.E., 1985. Ceramic Theory and Cultural Process. Cambridge University Press, Cambridge.
Bauer, A.A., Agbe-Davies, A.S. (Eds.), 2010. Social Archaeologies of Trade and Exchange: Exploring Relationships Among People, Places, and Things. Left Coast Press Inc, Walnut Creek, California.
Bishop, R.L., Blackman, M.J., 2002. Instrumental neutron activation analysis: scale and interpretation. Accounts of Chemical Research 35, 603–610.
Boivin, N., 2008. Material Cultures, Material Minds: The Impact of Things on Human Thought, Society and Evolution. Cambridge University Press, Cambridge.
Boivin, N., Owoc, M.A. (Eds.), 2004. Soils, Stones and Symbols: Cultural Perceptions of the Mineral World. UCL Press, London.
Bradley, R., 2000. An Archaeology of Natural Places. Routledge, London.
Cassano, S.M., Muntoni, I.M., Conati Barbaro, C., 1995a. Dall'argilla al vaso: Fabbricazione della ceramica in una comunità neolitica di 7000 anni fa. Università di Roma "La Sapienza". Dipartimento di scienze storiche, archeologiche e antropologiche dell'antichità. Museo delle Origini, Àrgos Edizioni, Roma.
Cassano, S.M., Eygun, G., Garidel, Y., Muntoni, I.M., 1995b. Pottery making in southern Italy: an experimental study. In: Vendrell-Saz, M., Pradell, T., Molera, J., Garcia, M. (Eds.), Estudis sobre ceràmica antiga, Ponències del Congrès Europeu sobre ceràmica antiga. Generalitat de Catalunya, Departament de Cultura, Barcelona, pp. 11–16.
Cavazza, W., Blenkinsop, J., De Celles, P.G., Patterson, R.T., Reinhardt, E.G., 1997. Stratigrafia e sedimentologia della sequenza sedimentaria Oligocenico-Quaternaria del bacino Calabro-Ionico. Bolletino della Società Geologica Italiana 116, 51–77.
Cavazza, W., Barone, M., 2010. Large-scale sedimentary recycling of tectonic mélange in a forearc setting: the Ionian basin (Oligocene–Quaternary, southern Italy). Geological Society of America Bulletin 122 (11/12), 1932–1949.
Cavazza, W., DeCelles, P.G., 1993. Geometry of a Miocene submarine canyon and associated sedimentary facies in southeastern Calabria, southern Italy. Geological Society of America Bulletin 105, 1297–1309.
Cavazza, W., Ingersoll, R., 2005. Detrital modes of the Ionian forearch basin fill (Oligocene–Quaternary) reflect the tectonic evolution of the Calabria-Peloritani terrane (southern Italy). Journal of Sedimentary Research 75 (2), 268–279.
Daszkiewicz, M., Cottica, D., Bobryk, E., Schneider, G., 2010. Clay raw material and late antique pots from Hierapolis (Turkey): a preliminary approach. In: Menchelli, S., Santoro, S., Pasquinucci, M., Guiducci, G. (Eds.), Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean: Archaeology and Archaeometry. Comparison between Western and Eastern Mediterranean. BAR International Series, vol. 2185 (II), pp. 751–760. Oxford.
Davies, R.G., Brown, N.B., Bayliss, D.D., (Cartographer), 1969. Carta Geological della Calabria, 1:25,000; Sheet 263 Bova Marina.
Dillian, C.D., White, C.L., 2010. Trade and Exchange: Archaeological Studies from History and Prehistory. Springer, New York.
Foxhall, L. (Ed.), 2004. Bova Marina Archaeological Project: Preliminary Report, 2004 Season. Report Submitted to the soprintendenza archeologica della Calabria. School of Archaeology and Ancient History, University of Leicester. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.
Foxhall, L. (Ed.), 2005. Bova Marina Archaeological Project: Preliminary Report, 2005 Season. Report Submitted to the soprintendenza archeologica della Calabria. School of Archaeology and Ancient History, University of Leicester. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.
Foxhall, L. (Ed.), 2006. Bova Marina Archaeological Project: Preliminary Report, 2006 Season. Report Submitted to the soprintendenza archeologica della Calabria. School of Archaeology and Ancient History, University of Leicester. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.
Foxhall, L., Lazrus, P., Michelaki, K., Robb, J., Van Hove, D., Yoon, D., 2006. The changing landscapes of Bova Marina, Calabria. In: Fitzjohn, M. (Ed.), Uplands of Ancient Sicily and Calabria: The Archaeology of Landscape Revisited, vol. 13, pp. 19–34.
Gauss, W., Kiriatzi, E., in press. Pottery production and supply at Bronze Age Kolonna, Aegina: an integrated archaeological and scientitif study of a ceramic landscape. Ägina Kolonna, Forschungen und Ergebnisse 5. Contributions to the Chronology of the Eastern Mediterranean. Österreichische Akademie der Wissenschaften.
Geniola, A., Laviano, R., Muntoni, I.M., 2005. Pottery production in Late Neolithic cult sites of Santa Barbara and Cala Scizzo (Apulia, southeast Italy). In: Prudêncio, M.I., Dias, M.I., Waerenborgh, J.C. (Eds.), Understanding people through their pottery. Proceedings of the 7th European Meeting on Ancient Ceramics (EMAC'03), October 27–31, Lisbon. Trabalhos de Arqueologia, vol. 42. Istituto Português de Arqueologia, Lisbon, pp. 89–101.

Gosselain, O.P., Livingstone Smith, A., 2005. The source: clay selection and processing practices in sub-Saharan Africa. In: Livingstone Smith, A., Bosquet, D., Martineau, R. (Eds.), Pottery Manufacturing Processes: Reconstitution and Interpretation. BAR International Series, vol. 1349, pp. 33–47. Oxford.

Heymes, T., Bouillin, J.-P., Pêcher, A., Monié, P., Compagnoni, R., 2008. Middle Oligocene extension in the Mediterranean Calabro-Peloritan belo (southern Italy): insights from the Aspromonte nappes pile. Tectonics 27, 1–14.

Ingold, T., 2000a. Building, dwelling, living: how animals and people make themselves at home in the world. In: Ingold, T. (Ed.), The Perception of the Environment: Essays on Livelihood, Dwelling and Skill. Routledge, London and New York, pp. 172–188.

Ingold, T., 2000b. The temporality of the landscape. In: Ingold, T. (Ed.), The Perception of the Environment: Essays on Livelihood, Dwelling and Skill. Routledge, London and New York, pp. 189–208.

Ingold, T., 2007. Materials against materiality. Archaeological Dialogues 14 (1), 1–16.

Jones, A., 2007. Memory and Material Culture. Cambridge University Press, Cambridge.

Kiriatzi, E., 2002. Sherds, fabrics and clay sources: reconstructing the ceramic landscapes of prehistoric Kythera. In: Foster, K.P., Laffineur, R., (Eds.), METRON: Measuring the Aegean Bronze Age. Proceedings of the 9th International Aegean Conference, New Haven, Yale University, 18–21 April 2002. Université de Liège, Aegaeum 24, pp. 123–130.

Laviano, R., Muntoni, I.M., 2003. Early and Middle Neolithic pottery production at "Pulo di Molfetta" (Apulia, Italy): social chronological and functional implications of raw materials variability. In: Di Pierro, S., Serneels, V., Maggetti, M. (Eds.), Ceramic in the Society. Proceedings of the 6th European Meeting on Ancient Ceramics, Fribourg, Switzerland 3–6 October 2001. Department of Geosciences, Mineralogy and Petrography, Fribourg, pp. 163–173.

Laviano, R., Muntoni, I.M., 2006. Provenance and technology of Apulian Neolithic pottery. In: Maggetti, M., Messiga, B. (Eds.), Geomaterials in Cultural Heritage, vol. 157. Geological Society, London, Special Publications, London, pp. 49–62.

Malone, C., 1985. Pots, prestige and ritual in Neolithic southern Italy. In: Malone C., Stoddart, S. (Eds.), Papers in Italian Archaeology IV: The Cambridge Conference, Part II: Prehistory, vol. 244. British Archaeological Reports, Oxford, pp. 118–151.

Malone, C., 2003. The Italian Neolithic: a synthesis of research. Journal of World Prehistory 17 (3), 235–312.

Michelaki, K., 2004. The ceramic technology analysis. In: Foxhall, L. (Ed.), Bova Marina Archaeological Project: Preliminary Report, 2004 Season. Report Submitted to the soprintendenza archeologica della Calabria. School of Archaeology and Ancient History, University of Leicester, pp. 40–56. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Michelaki, K., 2008a. Making pots and potters in the Bronze age Maros villages of Kiszombor-Új-Élet and Klárafalva-Hajdova. Cambridge Archaeological Journal 18 (3), 327–352.

Michelaki, K., 2008b. Technological studies of Prehistoric Pottery and raw material survey. In: Robb, J. (Ed.), Bova Marina Archaeological Project: Preliminary Report, 2008 Season. Report Submitted to the soprintendenza archeologica della Calabria. Department of Archaeology, University of Cambridge, pp. 47–53. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Michelaki, K., Hancock, R.G.V., 2011. Chemistry versus data dispersion: is there a better way to assess and interpret archaeometrical data? Archaeometry 53. doi:10.1111/j.1475-4754.2011.00590.x.

Michelaki, K., Robb, J., Scarcella, S., 2006. Prehistoric archaeology: post-excavation analysis and other activities. In: Foxhall, L. (Ed.), Bova Marina Archaeological Project: Preliminary Report, 2006 Season. Report Submitted to the soprintendenza archeologica della Calabria. School of Archaeology and Ancient History, University of Leicester, pp. 40–49. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Minc, L.D., Sherman, R.J., 2011. Assessing natural clay composition in the valley of Oazaca as a basis for ceramic provenance studies. Archaeometry 53 (2), 285–328.

Morter, J., Iceland, H., 1995. Notes on an eastern Calabrian assemblage in the Stentinello tradition. In: Vincenzini, P. (Ed.), The Ceramics Cultural Heritage. Proceedings of the International Symposium. The ceramics Heritage of the 8th CIMTEC-world Ceramics Congress and Forum on New Materials. Florence, Italy, pp. 241–249.

Muntoni, I.M., 1995. A technological approach to the Neolithic pottery production at Masseria Candelaro (FG – Italy). In: Vincenzini, P. (Ed.), The ceramics cultural heritage: Proceedings of the international symposium. The ceramics heritage of the 8th CIMTEC-world Ceramics Congress and Forum on New Materials. Florence, Italy, pp. 301–308.

Muntoni, I.M., 1999. From ceramic production to vessel use: a multi-level approach to the Neolithic communities of the Tavoliere (southern Italy). In: Owen, L.R., Porr, M. (Eds.), Ethno-analogy and the Reconstruction of Prehistoric Artefact Use and Production, vol. 14. Mo Vince Verlag, Tübingen, pp. 237–254.

Muntoni, I.M., 2002a. The application of archaeometric analyses to the study of Italian Neolithic pottery: some methodological considerations. In: Archaeometry in Europe in the Third Millennium. Atti del convegno internazionale, Roma, 29–30 Marzo 2001. Roma: Accademia Nazionale dei Lincei, Roma, pp. 203–213.

Muntoni, I.M., 2002b. Le analisi archeometriche di ceramiche Neolitiche in Italia: Storia degli studi, strategie di campionamento, techniche analitiche e obiettivi delle ricerche. Origini: Rivista di preistoria e protostoria delle civiltà antiche XXIV, 165–234.

Muntoni, I.M., 2003. Modellare l' argilla: Vasai del Neolitico antico e medio nelle Murge pugliesi. Istituto Italiano di Preistoria e Protostoria, Firenze.

Muntoni, I.M., 2004. Analisi archeometriche sulle ceramiche impresse di Favella: Caratterizzazione delle materia prime e tecnologia di manifattura. In: Preistoria e ptorostoria della Calabria. Atti della XXXVII riunione scientifica, Scalea, Papasidero, Praia a Mare, Tortora, 29 Settembre–4 Ottobre 2002, Istituto Italiano di Preistoria e Protostoria, Firenze, pp. 703–709.

Muntoni, I.M., Laviano, R., 2008. Archaeometric data on production and circulation of Neolithic Serra d'Alto ware in southern Italy during the fifth millennium BC. ArchéoSciences 32, 125–135.

Muntoni, I.M., Acquafredda, P., Laviano, R., 2009. Analisi archeometriche sulle ceramiche del Neolitico recente. In: Tinè, V. (Ed.), Favella. Un villaggio neolitico nella Sibiaritide. Ministero per i beni e le attività culturali. Soprintendenza al Museo Nazionale Preistorico Etnografico 'L. Pigorini.' Istituto Poligrafico e Zecca dello Stato, Roma, pp. 553–571.

Parise, M., Sorriso-Valvo, M., Tansi, C., 1997. Mass movements related to tectonics in the Aspromonte massif (southern Italy). Engineering Geology 47, 89–106.

Pezzino, A., Anzí, G., Fazio, E., Finnacca, P., Lo Giudice, A., Ortolano, G., et al., 2008. Alpine metamorphism in the Aspromonte Massif: implications for a new framework for the southern sector of the Calabria-Peloritani Orogen, Italy. International Geology Review 50, 423–441.

Purri, R., 2007. Elementi di cultural materiale nel Neolitico Lamentino: Ricerca e sperimentazioni su manufatti del Neolitico di Piana di Curinga, Lamezia Terme, Calabria Letteraria Editrice.

Robb, J. (Ed.), 1997. Bova Marina Field Survey: Preliminary Report, 1997 Season. Report Submitted to the soprintendenza archeologica della Calabria. Department of Archaeology, University of Southampton. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Robb, J. (Ed.), 1998. Bova Marina Archaeological Project Survey and Excavations: Preliminary Report, 1998 Season. Report Submitted to the soprintendenza archeologica della Calabria. Department of Archaeology, University of Southampton. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Robb, J. (Ed.), 1999. Bova Marina Archaeological Project Survey and Excavations: Preliminary Report, 1999 Season. Report Submitted to the soprintendenza archeologica della Calabria. Department of Archaeology, University of Southampton. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Robb, J. (Ed.), 2000. Bova Marina Archaeological Project Survey and Excavations: Preliminary Report, 2000 Season. Report Submitted to the soprintendenza archeologica della Calabria. Department of Archaeology, University of Southampton. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Robb, J. (Ed.), 2001. Bova Marina Archaeological Project Survey and Excavations: Preliminary Report, 2001 Season. Report Submitted to the soprintendenza archeologica della Calabria. Department of Archaeology, University of Cambridge. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Robb, J. (Ed.), 2002. Bova Marina Archaeological Project Survey and Excavations: Preliminary Report, 2002 Season. Report Submitted to the soprintendenza archeologica della Calabria. Department of Archaeology, University of Cambridge. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Robb, J. (Ed.), 2003. Bova Marina Archaeological Project Survey and Excavations: Preliminary Report, 2003 Season. Report Submitted to the soprintendenza archeologica della Calabria. Department of Archaeology, University of Cambridge. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Robb, J., 2007a. The Early Mediterranean Village: Agency, Material Culture, and Social Change in Neolithic Italy. Cambridge University Press, Cambridge.

Robb, J. (Ed.), 2007b. Bova Marina Archaeological Project: Preliminary Report, 2007 Season. Report Submitted to the soprintendenza archeologica della Calabria. Department of Archaeology, University of Cambridge. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Robb, J. (Ed.), 2008. Bova Marina Archaeological Project: Preliminary Report, 2008 Season. Report Submitted to the soprintendenza archeologica della Calabria. Department of Archaeology, University of Cambridge. http://www.arch.cam.ac.uk/~jer39/BMAP/Reports.html.

Skeates, R., 1992. Thin-section analysis of Italian Neolithic pottery. In: Herring, E., Whitehouse, R., Wilkins, J. (Eds.), Papers of the Fourth Conference of Italian Archaeology, vol. 3, Accordia Research Centre, London, pp. 29–34.

Spataro, M., 2009. The first specialised potters of the Adriatic region: the makers of Neolithic figulina ware. In: Forenbaher, S. (Ed.), A Connecting Sea: Maritime Interaction in Adriatic Prehistory. BAR International Series, vol. 2037, pp. 59–72. Oxford.

Tiné, V., 2004. Il Neolitico in Calabria. In: Preistoria e protostoria della Calabria. Atti della 37^{a} riunione scientifica. Istituto Italiano di preistoria e protostoria, pp. 115–140.

Vaughn, K.J., Neff, H., 2004. Tracing the clay source of Nasca polychrome pottery: results from a preliminary raw material survey. Journal of Archaeological Science 31, 1577–1586.

Vitelli, K.D., 1984. Greek Neolithic pottery by experiment. In: Rice, P.M. (Ed.), Pots and Potters: Current Approaches in Ceramic Archaeology. Monograph, vol. XXIV. Institute of Archaeology, University of California, Los Angeles, pp. 113–131.

Whitbread, I.K., 1995. Greek Transport Amphorae: a Petrological and Archaeological Study. In: Fitch Laboratory Occasional Paper, vol. 4 The British School at Athens.

Williams, J., 1980. Appendice VII: a petrological examination of the prehistoric pottery from the excavations in the Castello and Diana plain of Lipari. In: Bernabò Brea, L., Cavalier, M. (Eds.), Meligunis Lipára, vol. IV. S.F. Flaccovio, Palermo, pp. 845–868.