Mediterranean Archaeology and Archaeometry, Vol. 16, No 1,(2016), pp. 23-52

DOI: 10.5281/zenodo.44773

COMPOSITIONAL PROPERTIES AND PROVENANCE OF HELLENISTIC POTTERY FROM THE NECROPOLIS OF ISSA WITH EVIDENCES ON THE CROSS-ADRIATIC AND THE MEDITERRANEAN-SCALE TRADE

Branimir Šegvić*[1], Marina Ugarković[2], Annette Süssenberger[1], Rafael Ferreiro Mählmann[3] and Andrea Moscariello[1]

[1] ***University of Geneva, Department of Earth Sciences, Rue des Maraîchers 13, 1205 Geneva, Switzerland***
[2]***Institute of Archaeology, Ljudevita Gaja 32, 10000 Zagreb, Croatia***
[3]***Technische Universität Darmstadt, Institute of Applied Geosciences, Technical Petrology, Schnittspanstr. 9, 64287 Darmstadt, Germany***

Received: 30/12/2015
Accepted: 25/01/2016
Corresponding author: Branimir Šegvić (Branimir.Segvic@unige.ch)

ABSTRACT

Excavations of Hellenistic necropolises in ancient Issa located on the island of Vis in coastal Croatia revealed significant amounts of pottery, mostly tableware, dated from the second half of the 4th to the 1st c. BCE. Recovered pottery contained different stylistic forms thought to have been produced locally or imported. The goal of this study was to report on technological and compositional aspects of pottery economics embedded in the frame of social development of Issaean society. For this purpose, a set of 42 samples was analysed by X-ray diffractometry, polarization and electron microscopy, X-ray fluorescence, and automated electron microscopy. The results of archeometric inquiry combined with stylistic traits showed most of the vessels were produced locally whereby the procurement of raw material was dependent on the local occurrences of Terra Rossa. This required a high level of manufacture organisation, defining Issa as a presumably well-established Hellenistic city already in the second half of the 4th c. BCE. At the time the city maintained a strong exchange with the Italian South as suggested by excavated red figure and Gnathia pottery characterized by the superior production technologically compared to local imitations. A rare example of recovered amphoriskoi and their distinct material characteristics provided a strong indication of the presence of Levantine pottery in Issaean graves which, until now, has not been attested in the Eastern Adriatic. Such a finding speaks of the involvement of Issa in the Late Hellenistic networks of economic and cultural seaborne connectivity between the Adriatic and the Eastern Mediterranean and introduces Issa as a far-flung market of, at the time popular Levantine luxury products.

KEYWORDS: ***Hellenistic pottery, Issa, Adriatic, manufacture technology, exchange, Terra Rossa, Levant, Vis.***

1. INTRODUCTION

The Adriatic seascape, as the northernmost extension of the Mediterranean, has always been a medium of communication, as well as an opportunity for the mobility of goods and people, and consequently, cultural traits as well (Forenbaher et al., 2009). As far as the archaeological evidence is concerned, one of the most common testimony of contacts between different areas and cultures are potsherds. The local networks of prehistoric maritime connectivity, with the establishment of different networks across and around the Adriatic, reached its peak during Iron Age. At that time, more specifically in the period from the 8th to the 6th c. BCE ancient Greeks intensified their overseas travel and endorsed the foundations of majority of their settlements (αποικίες) across the Mediterranean and the Black Sea (Tsetskhladze, 2008; Boardman, 2009; Descœudres, 2013). It was within this epoch that, for the Greeks, also the Adriatic started to gain on importance as a crossroad of trade and cultural exchanges. In particular, this was intensified in the 7th and 6th c. BCE, when first Greek settlements in the southern Adriatic were established (Cabanes, 2008). A stronger contact predominantly of economical nature, between indigenous communities and Greeks took place from the 6th c. BCE onwards, and the trading activities within the North Adriatic emporia were at their peak during the 5th c. BCE (Cabanes, 2008; Šešelj, 2009). However, when focusing on the central part of the Eastern Adriatic, contacts between different indigenous and Greek communities are documented in the material culture of the 6th and 5th c. BCE, yet the archaeological evidences can, for now, confirm that the settling of Greeks in this area, nowadays part of Croatia, took place at a somewhat later period during the Late Classical period. Two most important Greek settlements, *Pharos* (modern Stari Grad on the island of Hvar) and *Issa* (modern Vis on the island of Vis), were situated in middle Dalmatia (Fig. 1). Both were established during the first half of the 4th c. BCE, each of them small in size when compared to the other Greek settlements in south Italy and Albania, and yet both played an important role in the historical events that took place in the following centuries. Furthermore, the Greek presence and established trade and cultural interaction with the locals lead to the exchange of ideas with native communities and exemplified a great influence in shaping the cultural identity of the area (Kirigin, 2009; Šegvić et al., 2012).

This research has chosen the island of Vis and polis Issa as a case study. Focusing the socio-politically embedded aspects of the Issaean material culture, it is the aim of this study to achieve a deeper archaeological and historical understanding of life in the Hellenistic Issa, and its impacts on the regional scale. Key points of our research were placed on the Issaean pottery economics with potsherds recovered from a necropolis located on the northeast outskirts of the settlement. In other words, by interpreting the data obtained by a set of modern mineralogical and geochemical equipment, it is our aim to infer on the local ceramic production technology, manufacture organisation, provenance distribution and redistribution, knowledge transfer and exchange, both in the regional context of the local responses to the Greek cultural impulses, as well as in the wider frame of trade networks in the Adriatic and beyond.

2. ARCHAEOLOGICAL BACKGROUND

Issa was one of the latest Greek settlements founded in the Western Mediterranean. It was established on the island of Vis, in central Dalmatia (Fig. 1) during the first half of the 4th c. BCE (Čače, 1994). Ancient sources connect this event with the activities of Dionysius the Elder, the powerful tyrant of Syracuse in Sicily, and regard Issa as a Syracusean settlement (Stylianou, 1998). The settlement itself was rather small (ca. 10 ha), yet regionally prosperous and of urban character. It was set up on a slope, in proximity to the seashore and deep, well-protective natural harbour bay, and soon after protected by well-built fortification walls. Issa took advantage of its prominent geographical and strategic position, and shortly after the mid-4th c. BCE developed into an independent city-polis (Kirigin, 1996). Relying on the diverse economy and its seaborne connectivity Issa soon become a stable and successful community. In the following centuries that chronologically correspond to the Hellenistic period, Issa was the 'key player' that exercised an important political and cultural role in the region, shaping the various facets of cultural development of its surroundings. Although Issa had an established role in trade and economy on the regional scale, its territorial ambitions were focused at the middle and south Dalmatian islands and coast (Fig. 1). There, the new settlements were established or alliances with already existing indigenous settlements, from where the Issaean economic products, as well as the cultural traits found their way into the hinterland of the Balkans.

Given the outlined significance that Issa exhibited in the cultural history and economy of the Eastern Adriatic during the Hellenistic era, the settlement itself, its activities, and its impacts to the neighbouring native communities, as well as their response, are seriously under-researched. Since majority of the published material evidence from this locality comes from the mortuary sphere, we rely therefore on the study of material burial testimonies.

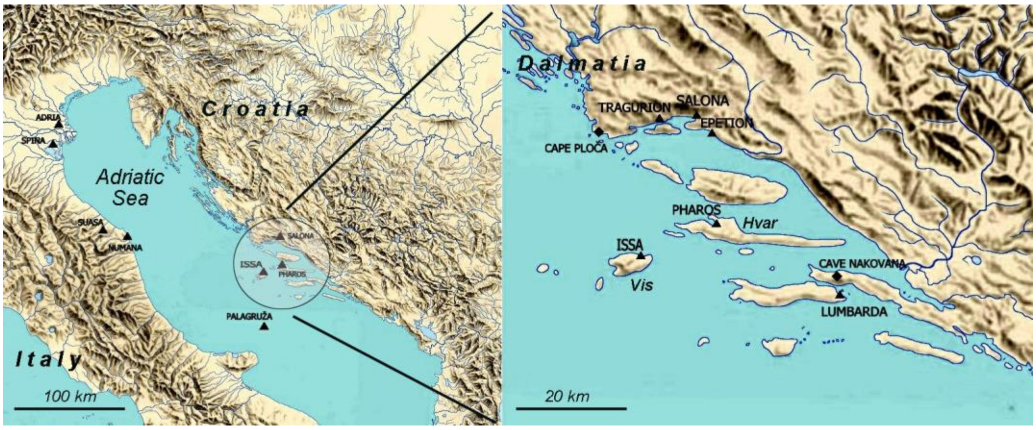

Figure 1. Geographic maps showing locations of relevant archaeological sites on the regional (left) and more detailed (right) scale. Names in the upright text denote archaeological sites referred in the text and those in italic stand for modern toponyms

Two Issaean necropoleis, Martvilo and Vlaška Njiva, were discovered and partially investigated, on the SW and E outskirts of the city walls (Cambi et al., 1980; Kirigin and Marin, 1985; Kirigin, 1985; Čargo, 2010; Ugarković, 2013; 2015). The political identity and city administration of the city was Greek in its nature, however, the analysis of different aspects of the burial ritual uncovered the complexity of the Issaean cultural identities. On the one side, the identity is built on various cultural contacts with both, Greek and indigenous settlements in Italy and beyond, while on the other side, it relies on the regional communication patterns that are defined through interactions with the local indigenous communities, leading consequently to the formation of a unique Issaean culture. In this regard, the research of material culture of the funerals, offers a good mean to portray the diverse and multifold aspects of Issaean identities. The multidisciplinary study of ceramic vessels, deposited as grave goods inside tombs, is thus the way to learn more about the characteristics of local pottery production and existing trade and cultural networks. In the past, the pottery manufacture in Issa was investigated based solely on the stylistic and morphological analyses. This encompassed tableware of different forms for everyday use, as well as containers for agricultural products, terracotta figurines and other ceramic forms that found their use in the life of a community (Kirigin et al., 2005; Čargo, 2008; Čargo and Miše, 2010). The evidence such as discovery of several kilns outside the city walls, unfortunately known mostly from the archives or thin archaeological documentation, as well as architectural remains related to the workshop, waste products and moulds support the presence of local pottery workshop(s) situated at the outskirts of the city (for details see Čargo and Miše, 2010). The most recent studies of Issaean pottery, based on the analysis of shape and decoration, suggested three phases in the local Hellenistic production, commencing in the mid-3rd c. BCE and lasting until the end of the Hellenistic era (Miše, 2010; 2013), whilst the production of domestic ware is hypothesised to have started already from the end of the 4th c. BCE (Kirigin, personal communication). On the other hand, imported pottery ware found in Issa is thought to have been principally produced in the workshops in southern, central and northern Italy, with some minor portions stemming from the Hellenistic settlements in Greece, Albania and Turkey (Šešelj, 2009; Miše, 2010; 2013; Ugarković, 2014; 2015).

Ceramic samples chosen for this study are described in detail in subchapter 4.1. They are singled out based on the stylistic and morphological characteristics indicative for their provenance. The selected sample set encompasses a variety of ceramic styles, like Gnathia, grey-slipped ware, red-slipped ware, plain painted ware, plain ware etc. Kirigin (1990; 1996) and Miše (2010; 2013) managed to distinguish the local from imported Gnathia, and based on the shape and decoration analysis, identified specific stylistic and morphological characteristics of Issaean Gnathia. On the other hand, the vessels thought to have been manufactured mostly in Italy (Apulia, and the Po valley and Marche region of the northern and central area of western Adriatic) imported to Issa are, according to the stylistic and morphological features, classified as red-figure ware, Apulian black painted ware, Alto-Adriatico ware, Gnathia and black-slipped. There are even indications of the products originating from a long-distanced Levant, (plain ware) documented for the first time in the whole central and northern part of Eastern Adriatic. Using the ceramic material investigation to confirm the hypothesis on the provenance of selected artefacts, it will be possible to infer more on the cultural contacts of Issa, as well as to estimate the levels of technological development by assessing the production technologies and recipes, especially within the same classes of ceramics assumed to represent locally produced ware (e.g. Gnathia).

Multidisciplinary research focusing the Hellenism from Eastern Adriatic has started relatively recently (Mileusnić et al., 2008a; Mileusnić et al., 2008b; Čargo and Miše, 2010). The preliminary mineralogical analyses of Issaean Gnathia argued on the existence of technological discrepancies between the locally produced and imported Gnathia wares (Miše, 2010; Čargo and Miše, 2010). A recent multi-methodological investigation on the provenance and manufacturing technology of pottery from the Hellenistic native communities of Middle Dalmatia strongly suggested the existence of local production (Šegvić et al., 2012). Material characteristics of several Issaean samples investigated within the same study showed a more sophisticated ceramic production on the island. Still, the analysed dataset did not encompass ceramic fineware, but rather large storage vessels, leaving no reliable archeometric evidences on the Issaean (Gnathia, and other fine ware) ceramic production.

3. GEOLOGICAL AND GEOGRAPHICAL SETTING

The Eastern Adriatic coastal area (Fig. 1) is predominantly karstic and consists of Jurassic and Cretaceous limestones, whereas Eocene limestones are reported only sporadically. Geologically, it makes part of the External Dinarides (Pamić and Hrvatović, 2003), with a present structural setting linked to the strong Palaeogene tectonic uplift, which produced high karst napes and the deposition of Eocene carbonate flysch along with a deformation-front that propagated into the Adriatic foredeep (Korbar, 2009). Under such geotectonic conditions a potential for substantial clay deposit formation is rather low. Still, local occurrences of clays are known from the Cretaceous paleosols, the Terra Rossa horizons developed at older carbonate substrates (Durn, 2003), and the alterations of Jurassic extrusive and pyroclastic sequences (Crnjaković, 2000). The island of Vis covers an area of 90.3 km^2 and extends in the east-west direction, forming an anticline that dips to the east at approximately 10° (Fig. 2; Borović et al., 1975). The anticline core is consisted of Upper Cretaceous layered limestones and dolomites with supposed thickness of ~1 km. Volcanic rocks are mainly exposed in the western part of the anticline, near the city of Komiža, and are consisted of basic Jurassic porphyric hypabyssal extrusives (Crnjaković, 2000). The wings of the Vis anticline are quite narrow, made of Upper Cretaceous limestones with an average thickness of 100 m.

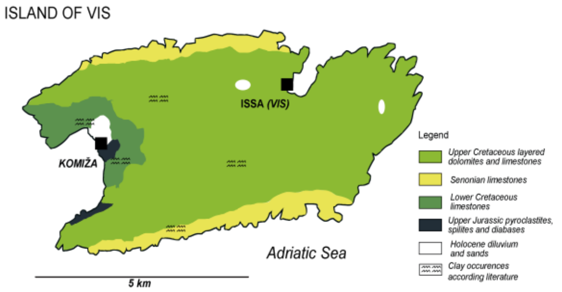

Figure 2. Geological map of the island of Vis (after the geological map of former Yugoslavia, sheet Vis, scale 1:100,000; Borović et al., 1975). Clay occurrences after Mileusnić et al. (2008a; 2008b) and Čargo and Miše (2010)

With exception of the central part of the island marked by the Quaternary extension forms (karstic polje) filled with Terra Rossa, the rest of the island's surface is predominantly rocky. A recent geological prospection of the island confirmed the existence of local clay occurrences at several locations (Mileusnić et al., 2008a).

4. MATERIALS AND METHODS

4.1 Sample description and ceramic styles

For the purpose of this research, 42 samples of ceramic sherds were chosen, originating from 17 tombs of the eastern Issaean necropolis discovered at the locality of Vlaška Njiva (Table I.). The entire set of sherds, dated from the second half of the 4th to the 1st c. BCE, represents fragments of pots that furnished Issaean tombs and were deposited together with the deceased during the funeral. The selection criteria of ceramic samples, as it is already mentioned, was based on the stylistic attributions, morphological characteristics, and presumed provenance. Analysed potsherds stand for different portions of ceramic vessels, i.e. body, rim, and handle fragments (Fig. 3). Morphologically, all analysed material belongs to ceramic containers that can be divided in two categories – open (e.g. kylix, skyphos, kantharos, lekane, bowl, krater and pixis) and closed (e.g. pelike, oinochoe, olpe, unguentarium and lekythos) forms. With regards to the functional classes or, in other words, the classification based on the intended or formal use, the analysed ware is mostly classified as tableware, whilst the rest of the dataset includes cosmetic (pyxis, lekane, Fig. 3j) or oil / ointment / perfume (unguentarium (Fig. 3f), lekythos (Fig. 3h), amphoriskos (Fig. 3g) and lamp containers. The tableware mainly includes different forms of drinking cups, e. g. skyphos (Fig. 3d), kylix (Fig. 3c), kantharos (Fig. 3e), and jugs for serving and pouring wine or other liquids (e. g. oinochoe (Fig. 3a), pelike and table amphora (Fig. 3b) – whereas vessels for mixing wine with water (krater) and vessels for serving food (bowls, Fig. 3i) are fewer.

Table I. List of analysed archaeological artefacts, vessel thicknesses, and applied analytical treatments

Sample	Morphology/Style/Function	Ceramic context	Thickness (mm)	Applied analytical methods
Vis 1	body of gray- slipped jug (table amphora)	grave good	4-5	XRF, XRD, OM
Vis 2	rim of Gnathia jug (oinochoe)	grave good	4-5	XRF, XRD, OM
Vis 3	rim and body of Gnathia drinking cup (kylix)	grave good	2-3	XRF, XRD
Vis 4	body of black- slipped drinking cup (thorn kantharos)	grave good	5-7	XRF, XRD, OM
Vis 5	rim/body and handle of black-slipped drinking cup (skyphos)	grave good	2-3	XRF, XRD
Vis 6	body of plain cup/small bowl (one handler)	grave good	4-5	XRF, XRD, OM, SEM
Vis 7	body and rim of Alto Adriatico jug (oinochoe)	grave good	2-3	XRF, XRD
Vis 8	body of plain painted unguentarium	grave good	4-5	XRF, XRD, OM
Vis 9	body and rim of black-slipped drinking cup (skyphos)	grave good	2-3	XRF, XRD
Vis 10	body of Gnathia jug (oinochoe)	grave good	4-5	XRF, XRD, OM
Vis 11	body of plain unguentarium	grave good	2-3	XRF, XRD, SEM, OM, QEMSCAN®
Vis 12	body of painted lid	grave good	3-4	XRF, XRD, OM
Vis 13	body of Gnathia jug (oinochoe)	grave good	7-9	XRF, XRD, OM, SEM
Vis 14	body of grey-slipped jug (ionochoe)	grave good	3-4	XRF, XRD, SEM, OM, QEMSCAN
Vis 15	neck of Gnathia jug (small jug with one handle)	grave good	4-5	XRF, XRD, OM
Vis 16	body of painted lekane	grave good	4-5	XRF, XRD, OM
Vis 17	body of Gnathia jug (oinochoe)	grave good	2-3	XRF, XRD
Vis 18	body of Gnathia jug (oinochoe)	grave good	4-5	XRF, XRD
Vis 19	body of Alto Adriatico jug	grave good	5-6	XRF, XRD, OM
Vis 20	body of painted jug	grave good	4-5	XRF, XRD, SEM, OM, QEMSCAN®
Vis 21	rim and body of Gnathia drinking cup (skyphos)	grave good	1-2	XRF, XRD
Vis 22	body of black- slipped drinking cup (skyphos)	grave good	2-3	XRF, XRD
Vis 23	body of Gnathia jug (oinochoe)	grave good	2-3	XRF, XRD
Vis 24	body of red- figured krater	grave good	8-10	XRF, XRD, SEM, OM, QEMSCAN®
Vis 25	rim and body of Gnathia jug (oinochoe)	grave good	5-6	XRF, XRD, OM
Vis 26	body of plain grey jug (oinochoe)	grave good	3-4	XRF, XRD
Vis 27	body and handle of gray-	grave good	2-3	XRF, XRD

	slipped jug (oinochoe)			
Vis 28	handle of red/brown-slipped drinking cup (cantharos)	grave good	3	XRF, XRD
Vis 29	body of Gnathia jug (pelike)	grave good	3-4	XRF, XRD
Vis 30	rim and body of painted pyxis	grave good	3-4	XRF, XRD, OM
Vis 31	body of Gnathia jug (oinochoe)	grave good	5-6	XRF, XRD, OM
Vis 32	body of Alto Adriatico jug (oinochoe)	grave good	5-6	XRF, XRD, OM
Vis 33	body of Gnathia jug	grave good	4-5	XRF, XRD
Vis 34	body of Gnathia jug	grave good	6-7	XRF, XRD, SEM, OM, QEMSCAN®
Vis 35	body of plain bowl	grave good	8-10	XRF, XRD, OM, SEM
Vis 36	body of plain amphoriskos	grave good	5-6	XRF, XRD, OM, SEM
Vis 37	rim and body of Alto Adriatico jug (oinochoe)	grave good	4-5	XRF, XRD, SEM, OM, QEMSCAN®
Vis 38	handle of black- slipped drinking cup (skyphos)	grave good	2-3	XRF, XRD
Vis 39	body of Alto Adriatico jug (oinochoe)	grave good	4-5	XRF, XRD, OM, SEM
Vis 40	body of brown slipped relief mould made lamp	grave good	5-6	XRF, XRD, OM
Vis 41	body of Apulian painted net lekythos	grave good	6-7	XRF, XRD, OM
Vis 42	body of black- slipped jug	grave good	4-5	XRF, XRD

Abbreviations: XRF = X-Ray Fluorescence; XRD = X-Ray Diffraction; OM = Optical Microscopy; SEM = Scanning Electron Microscopy; QEMSCAN® = Quantitative Evaluation of Minerals by Scanning Electron Microscopy, frag. = fragment.

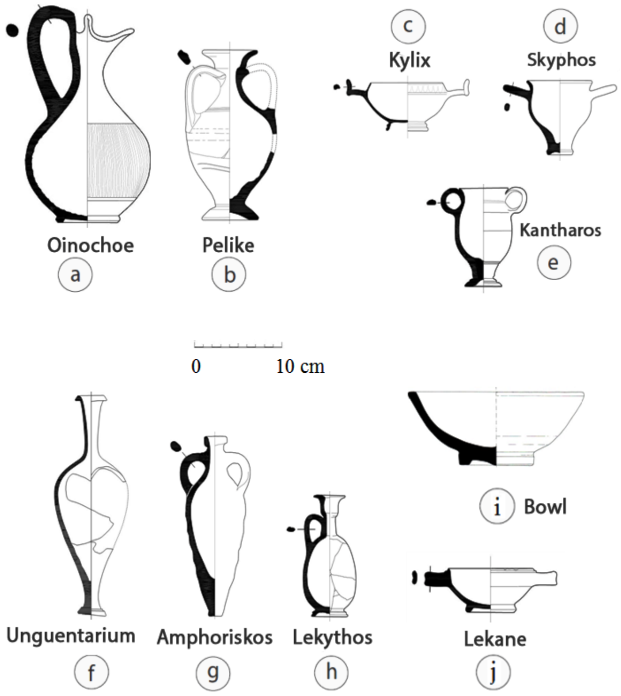

Figure 3. Representative Issaean vessel forms from which potsherds were analysed. All figures kindly drawn by J. Beneta

The actual use of described forms of these vessels was two-folded, meaning that some of them were used in everyday life prior to their re-contextualisation within the burial ritual, whilst the others might have been manufactured exclusively for funeral purposes. According to stylistic criteria, most of analysed ceramic sherds belonged to painted or slipped pots, whereas some were without decoration. Vessels with painted decoration are, furthermore classified as red-figured ware, Alto-Adriatico, Gnathia, plain-painted ware and Apulian black-painted ware, whilst the slipped pottery with no additional decoration belong to classes of black-slipped ware, grey-slipped ware, red-slipped ware, and brown-slipped and relief ware (Table I.). Pots with no decoration are considered as plain ware. Macroscopic observations showed that all types of pottery, except plain ware, have a fine-grained and homogenous fabric where the colour of ceramic body and its slip may differ pointing to different regional and chronological productions.

4.2 Analytical techniques

A dataset of 42 ceramic potsherds (Table I.) was examined by means of X-ray fluorescence (XRF) and

X-ray diffraction (XRD). The polarisation optical microscopy (OM) method was employed on a set of 25 potsherds, whereas scanning electron microscopy (SEM) and automated mineralogy/petrography analyses (QEMSCAN®) were performed on a set of 10 and 6 samples, respectively. The SEM/QEMSCAN® dataset includes potsherds estimated to present the highest, the medium, and the lowest firing temperatures, also covering different vessel morphologies and provenances. Analytical treatment performed on each potsherd sample is indicated in Table I. XRF, XRD, and OM investigations were performed at the Institute for Applied Geosciences (TU Darmstadt/Germany), whilst SEM and QEMSCAN® measurements were completed at the Department of Earth Sciences (University of Geneva, Switzerland).

XRD measurements were scanned at a rate of 0.02 °2Θ s^{-1} over the range of 3-65 °2Θ, using Phillips PW 1830 diffractometer with a CuKα radiation, graphite monochromator (U = 40 kV, I = 30 mA), and an automatic divergence slit. Diffraction patterns were interpreted on the basis of pattern dataset released by the International Centre for Diffraction Data (JCPDS-1996) using the Panalytical Highscore Plus software. XRF whole-rock chemical analyses were performed by means of the wavelength dispersive Bruker-AXS S8 Tiger device. Samples weighing approximately 5 g were grounded to fine powder of several microns in size before measuring, thus ensuring a homogenous particle-size distribution. No acid treatment was required. Major and minor element contents are given as wt% oxide normalised to 100 %, whereas trace element abundances are reported in ppm. For trace element determination, best detection version of the Quantexpress programme was used with a detection limit within the ppm range. A relative standard deviation for major elements was ± 5 %, whereas for trace elements it was ± 20%.

Aiming to discriminate between the hypothetical sources of ceramic pottery, we subjected the whole-rock chemistry of potsherds obtained by XRF to statistical multivariate techniques (principal component analysis – PCA and linear discriminant analysis – LDA), using the STATISTICA® software package (v. 12 for Windows), which resulted in a formation of discrete geochemical groups. It is generally assumed that ceramic raw clayey material has uniform chemical composition and, therefore, the changes in potsherd chemistry reflect differences of the supply origin of clays used (e.g. Rice, 2006).

In principle, a sample in statistical multivariate data analyses is represented by a point in multidimensional space, with each dimension corresponding to the content of the particular chemical element (e.g. Lebart et al., 1995). Hence, those samples, which do not vary significantly in composition, will be represented by the agglomerated (grouped) points. Principal component analysis is a tool commonly used in ceramic studies for identifying different compositional groups, whilst linear discriminant analysis uses a linear combination of features which separates two or more classes of objects (groups) the most, thus verifying the reliability of previously defined PCA groups. Prior to performing PCA, we $\log_{10}$-transformed the original raw data to reduce the risk of misleading object classification by standardising the available dataset to inter-comparable values (e.g. Hall, 2004; Papachristodoulou et al., 2010). Excluding a few samples with elevated P_2O_5 abundances (exceeding 3 wt%), the chemistry of the analysed potsherds suggests a low-level of post-depositional alterations (e.g. P_2O_5 ~0.6 wt%). A high P concentration usually serves as a measure of chemical changes induced after potsherds deposition because the partly amorphous ceramic material is chemically active matter, which promotes adsorption or precipitation of very fine-grained phosphate from the burial environment (Freestone et al., 1985). Further on, in the highly fired calcareous pottery, it is reported that Na-zeolite (analcime) readily forms after glass decomposition (Schwedt et al., 2006). Following a detection of zeolite in two potsherds, we omitted Na from the statistical dataset. As well, the trace elements considered to be easily mobilised were excluded from statistical treatment (e.g. Rb and Sr). Finally, a set of elements hereby used consisted of SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, K_2O, V, Cr, Co, Ni, Cu, Zn, Ga, Y, Nb, and Zr.

Having defined a few statistical groups based on their geochemistry, we used polarisation microscopy (Leica DM-LSP polarizing microscope) to report on their structural characteristics. In this paper, we use the term "inclusions", as recommended by Rice (2006) for all the petrographically identifiable materials present in the ceramic body, no matter whether the incorporation was intentional or not. Inclusions that are undoubtedly recognised as intentional additives are referred to as temper material (temper subdivision according to Stoltman, 1991). Automated mineral and textural characterization was performed using a FEI QEMSCAN® Quanta 650F facility. The QEMSCAN® technology is based on automated scanning electron microscopy (SEM) coupled with the EDS unit. Mineral phase identification relies on the combination of back-scattered electron (BSE) brightness values, low-count energy-dispersive X-ray spectra (EDS) and the X-ray count rate giving information on the elemental composition (Gottlieb et al., 2000). Following the acquisition, individual X-ray spectra are compared against a database of known spectra and a mineral name is assigned to each individual acquisition point. The X-ray EDS spectra database was provided by FEI Company and has been further developed in-house. By doing the sample mineralogical mapping, a texture and pore space geometry and distribution can be visualised. SEM system used is equipped with two Bruker QUANTAX light-element energy dispersive X-ray spectrometers. Measurements were performed at high vacuum, acceleration voltage of 15 kV and probe current of 10 nA on the carbon-coated samples. X-ray spectra acquisition time was 10 ms per pixel, using a point-spacing of 2.5 μm. Up to 122 individual fields were measured in each sample, with 1500 pixels per field. Morphology and EDS chemistry of clayey matrix and inclusion material were investigated by high-magnification SEM-EDS imaging using the same equipment at variable acceleration voltages and beam size conditions.

5. RESULTS

5.1 *XRD mineralogy*

Analysed potsherds display a variety of compositions defined by principal and minor mineral phases (Table II.; Fig. 4). The majority of samples are dominated by quartz, plagioclase, and diopside (Fe-Ca clinopyroxene) (Fig. 4a). Occasionally K-feldspar emerges within the same paragenesis, as well as the preserved relicts of 10-Å phyllosilicate (white mica). The rest of the potsherds is characterised by additional appearance of gehlenite (Ca-Al rich sorosilicate) and pigeonite (Ca-poor, Fe-Mg clinopyroxene) (Fig. 4b). The latter comes along with diopside, blurring its diffraction lines considerably. Two samples do not belong to neither of the above mentioned groups and have mineral compositions of quartz, plagioclase, K-feldspar, calcite, 10-Å phyllosilicate, and clay minerals (14 and 15-Å phyllosilicate) (Fig. 4c). The omnipresent minor phase in all samples is hematite, whereas calcite, ilmenite, andradite, gypsum and zeolite (wairakite) are detected only sporadically. A bulging between 15 and 35 °2Θ is a common feature in all samples and it is related to amorphous matter formed through the partial vitrification of the clayish raw material dominant clinopyroxene, Fe-Ca rich diopside, is of unclear origin being either a raw material component or a newly formed firing phase. A subordinated clinopyroxene, pigeonite, is distinguished by clear reflexes at 29.58 and 27.43 °2Θ (Brown et al., 1972). A weakly pronounced basal peak at 8.90 °2Θ and the lack of further diffraction lines corresponds to a dehydroxylated illite-like phase (Fig. 4a). Further on, the two diagnostic peaks at ~17.8 and ~19.9 °2Θ are reported in samples containing a dehydroxylated illite-like phase (e.g. Vis 17). They either stand for the incomplete obliteration of the illite structure during firing or could possibly be the indicators of clay mineral (smectite-type) neo-formation in the water-saturated depositional environment (e.g. Shoval et al., 1991; Dubacq et al., 2009).

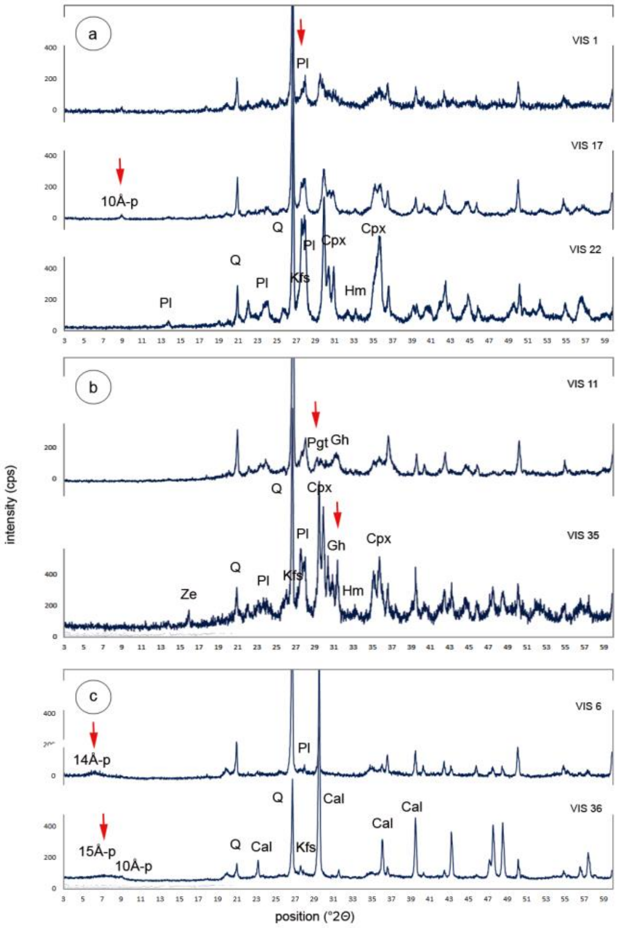

Figure 4. Some examples of XRD diffraction spectra of analysed pottery from Issa showing a variety of mineral assemblages. Mineral abbreviation: Q = quartz; Pl = plagioclase; 10Å-p = 10Å phyllosilicate (illite/mica); Cpx = clinopyroxene; Hm = hematite; Kfs = K-feldspar; Pgt = pigeonite; Gh = gehlenite; Ze = zeolite; 14Å-p = 14Å phyllosilicate (chlorite/vermiculite); 15Å-p = 15Å phyllosilicate (smectite); Cal = calcite

Table II. Mineral compositions of studied ceramics obtained by XRD and OM, as well as electron microscopy (SEM/QEMSCAN®)

Sample	XRD/OM Mineral Composition	SEM/QEMSCAN® Mineral Composition
Vis 1	Qtz, Cpx, Plag, 10Å-m	
Vis 2	Qtz, Cpx, Plag, Kfs, 10Å-m, Hem, Ilm	
Vis 3	Qtz, Cpx, Pl, Kfs, Pig, Gh, 10Å-m, Hem	
Vis 4	Qtz, Cpx, Pl, Kfs, Pig	
Vis 5	Qtz, Cpx, Pl, Pig, 10Å-m, Hem	
Vis 6	Qtz, Pl, 10Å-m, 14Å-p, Sme, Cal	Cpx, Am, Kfs,
Vis 7	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	
Vis 8	Qtz, Cpx, Pl, Kfs, Pig, Hem	
Vis 9	Qtz, Cpx, Pl, Kfs	
Vis 10	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	
Vis 11	Qtz, Cpx, Pl, Kfs, Pig, Gh, 10Å-m	14Å-p, Ap, Cal, Rt
Vis 12	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	
Vis 13	Qtz, Cpx, Pl, Kfs, Pig, 10Å-m, Hem	Ap, Gh (?)
Vis 14	Qtz, Cpx, Pl, Kfs, 10Å-m	14Å-p, Ap, Cal, Tit, Rt, Spr(?), Opx
Vis 15	Qtz, Cpx, Pl, Kfs, 10Å-m	
Vis 16	Qtz, Cpx, Pl, Kfs, Pig, Gh, 10Å-m, Hem, Gp	
Vis 17	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	
Vis 18	Qtz, Cpx, Pl, Kfs, 10Å-m, Sme, Hem	
Vis 19	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	
Vis 20	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	14Å-p, Ap, Cal, Chr, Crd
Vis 21	Qtz, Cpx, Pl, Kfs, Hem	
Vis 22	Qtz, Cpx, Pl, Kfs, Hem	
Vis 23	Qtz, Cpx, Pl, Kfs, Pig, Hem	
Vis 24	Qtz, Cpx, Pl, 10Å-m, Hem	14Å-p
Vis 25	Qtz, Cpx, Pl, Kfs, Hem	
Vis 26	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	
Vis 27	Qtz, Cpx, Pl, Kfs, 10Å-m, Ilm	
Vis 28	Qtz, Cpx, Pl, Kfs, Pig, Gh	
Vis 29	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	
Vis 30	Qtz, Cpx, Pl, Kfs	
Vis 31	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	
Vis 32	Qtz, Cpx, Pl, Kfs(?), 10Å-m, Hem	
Vis 33	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem, Ilm	
Vis 34	Qtz, Cpx, Pl, Kfs(?), Pig(?), 10Å-m, Hem, Cal	Rt, Chl, Tit, Ilm, 14Å-p, Gh (?)
Vis 35	Qtz, Cpx, Pl, Kfs, Gh, Pig(?), Hem, Cal, Wrk	Ilm, 10Å-m
Vis 36	Qtz, Kfs, 10Å-m, Sme, Cal	Ap, Pl, Cpx (?), Tit (?), Gh (?)
Vis 37	Qtz, Cpx, Pl, Kfs, Pig, Hem	14Å-p, Ap, Cal, Tit, 10Å-m
Vis 38	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	
Vis 39	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	
Vis 40	Qtz, Cpx, Pl, Kfs	
Vis 41	Qtz, Cpx, Pl, Kfs, Gh, 10Å-m, Hem	
Vis 42	Qtz, Cpx, Pl, Kfs, 10Å-m, Hem	

SEM/QEMSCAN® mineral composition shows only accessory phases, which were not identified by other listed methods. Mineral abbreviation after SCMR: Qtz = Quartz; Pl = plagioclase; Cpx = clinopyroxene; Kfs = K-feldspar; Cal = calcite; 10Å-m = 10Å mica (muscovite, illite); 14Å-p = 14Å phyllosilicate (chlorite/vermiculite); Sme = smectite; Grt = garnet; Hem = Hematite; Ilm = Ilmenite; Pig = pigeonite; Gh = gehlenite; Gp = gypsum; Wrk = wairakite (zeolite); Ap = apatite; Rt = rutile; Tit = titanite; Spr = sapphirine; Opx = orthopyroxene; Chr = chromite; Crd = cordierite; Am = amphibole. SCMR - The Subcommission on the Systematics of Metamorphic Rocks (SCMR) is a branch of the IUGS Commission on the Systematics in Petrology (CSP). XRD = X-Ray Diffraction; OM = Optical Microscopy; QEMSCAN® = Quantitative Evaluation of Minerals by Scanning Electron Microscopy.

5.2 XRF chemistry and statistical analysis

The XRF data for major and some minor elements of 42 potsherds are given in Table III. The silica content of analysed ceramics is generally high, exceeding 40 wt% for a great majority of the samples. The abundances of other major elements are varying, as shown in the cases of Al_2O_3 (9.57-20.29 wt%), Fe_2O_3 (5.17-13.47 wt%), MgO (1.23-6.77 wt%) and in particular CaO (6.44-30.30 wt%). The concentrations of the latter are all above 6 wt%, proving the calcareous nature of analysed artefacts. Still, based on the Ca content, analysed ceramics are clustered in three groups – low-CaO (~8-10 wt%), medium-CaO (~11-13 wt%) and high-CaO (>16 wt%) artefacts. Such discrepancies are attributed either to the differences in clayey raw material or to the paste optimisation performed by the potter (e.g. Grifa et al., 2009). The alkalies show somewhat uniform concentrations (Na_2O ~ 1 ± 0.5 wt%, K_2O ~ 2 ± 0.7 wt%) except for samples featured by the presence of the supposed smectite component (Vis 35 and 36, Table III.). Chlorine depicts extremely heterogeneous concentrations (150-7930 ppm) most probably due to the contamination with water soluble ground salts during the deposition. The rest of trace elements show the uniform abundances (e.g. Zn, Cu, Ga, and Nb) or, alternatively, two compositional groups are formed (i.e. low and high contents, Ni: 0-100 and 300-400 ppm; Cr: 50-150 and 250-410 ppm). The elemental correlation matrix (Table IV.) provides information on the behaviour of some of chosen elements. Important is the content of SiO_2 well correlating with Al_2O_3, MgO, Na_2O and K_2O, strongly suggesting that the content of all outlined elements was controlled by their concentration in the raw material. A good correlation of alkalies and SiO_2 is probably governed by feldspar present as inclusions in ceramic matrix. On the other hand Fe_2O_3 shows only a weak correspondence to silica, alumina, and calcia, whereas the strong affinity is placed towards MnO, TiO_2, Cr, Ni, and partly MgO. Affiliation toward a set of compatible elements was attributed to the presence of a variety of peculiar temper material or natural impurities such as magnetite, ilmenite, and eventually Fe-rich pyroxene and/or amphibole. Analogue affinities are established for some trace elements, like Cu and Zn. The CaO content shows a negative correlation with all the analysed elements but Sr. Given the geochemical similarities between the two, this clearly calls for calcite and other Ca-contained paste inclusions to have effectively conditioned the CaO abundances in analysed material. The correlation patterns here discussed are shown in Figure 5a, with Fe_2O_3 and related elements (Ni, Cr, MnO, and TiO_2) weighting positively the first and the second principal component, whereas the rest of major elements (K_2O, MgO, SiO_2, and Al_2O_3) weight positively the first and negatively the second principal component. Such grouping defines the PCA (Principal component analysis) diagram (Fig. 5b), wherein the first three components account for 62.41 % of the total variance (27.05 %, 21.32 %, and 14.04 %, respectively). Studying the space formed by the first (PC1) and the second (PC2) principal component, it becomes apparent that most of the samples are discriminated into the two discrete homogenous groups. The first one – named Group 1 hereafter – weight positively both PCs (samples: 17, 18, 19, 20, 21, 22, 23, 25, 27, 29, 31, 34, 38, 39, 40, and 42). The second group, hereafter named Group 2, comparatively less homogenous weights positively PC1 and negatively PC2 (samples: 1, 2, 4, 5, 6, 10, 12, 13, and 14). Based on the analysis of the morphology and the decoration of the pots in question, both groups are presumed to be of local manufacture. The differences between Groups 1 and 2 lie in the fact that members of the former are relatively impoverished in SiO_2 (~43 vs. ~48 wt%), MgO (~3 vs. ~6 wt%) and Al_2O_3 (~13 vs. ~16 wt%), whilst enriched in Fe_2O_3 (~12 vs. ~9 wt%) and CaO (~11 vs. ~9 wt%). Further on, Group 1 is featured by high content of trace elements characteristic for igneous rocks (Ni and Nb, Table III.). Intriguing are the samples found at the outskirts of Groups' 1 and 2 projections areas (samples 16, 32 and 37, Group 3 hereafter and samples 3, 24, and 41, Group 4 hereafter) thought to be of North and South Italian origin, respectively. In fact, their statistical definitions are somewhat arbitrary (low internal cohesion in PCA plot, Fig. 5b), still treated as discrete groups due to strong archaeological indications of their common origin (Group 3 – Alto Adriatico vases with painted decoration characteristic for North Adriatic workshops of Adria, Spina, and Numana in Marche region; Group 4 – decoration and forms vessels characteristic for Apulian red-figured ware, Gnathia, and Apulian black-painted ware). The rest of analysed potsherds (28, 35, 36, 7, 8, 9, 11, and 15) show no clear affiliation with any defined statistical groups and is considered to present statistical outliers. LDA (Linear Discriminant Analysis) was also performed in order to 'test' the PCA grouping by maximising the separation between multiple statistical classes, or in our case ceramic groups. The most important discrimination significance is thus shown by Co, Ni, Nb, SiO_2, Cu and Y (LDA F-factor ≥ 2.00). The first and second statistical group are shown to be well discriminated (Fig. 5c). Further on, the samples of hypothesised South Italian origin are clearly distinguished from the established groups of local pottery, whereas the ceramics thought to be of North Italian provenance (Alto Adriatico wares) cannot be distinguished from the local wares of Group 1.

Table III. XRF chemical analyses of pottery samples from Issa

Sample	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	*MnO*	*MgO*	*CaO*	Na_2O	K_2O	P_2O_5	CO_2	*TOTAL*	*S*	*Cl*	*V*	*Cr*	*Co*	*Ni*	*Cu*	*Zn*	*Ga*
Vis 1	46.25	0.80	15.19	8.72	0.12	6.19	10.48	0.81	2.54	0.47	8.22	99.78	130	230	193	340	8	313	61	135	15
Vis 2	46.97	0.82	15.66	8.66	0.12	6.31	9.53	1.38	2.59	0.20	7.49	99.72	130	843	170	332	12	339	62	122	0
Vis 3	42.71	0.97	11.59	9.17	0.14	2.31	15.38	0.54	2.86	1.28	12.07	99.01	200	7930	0	209	0	152	33	158	14
Vis 4	51.09	0.84	16.36	7.44	0.13	4.38	8.07	1.72	2.52	0.84	6.34	99.71	170	1120	130	198	0	189	63	130	15
Vis 5	45.62	0.78	16.40	8.26	0.14	5.44	11.46	0.75	1.55	0.37	8.98	99.75	58	752	170	367	17	331	52	109	0
Vis 6	53.90	1.01	19.01	6.83	0.14	2.24	8.04	0.53	1.41	0.31	6.30	99.71	120	1070	170	313	6	173	51	134	16
Vis 7	49.73	0.89	15.67	8.77	0.15	5.93	12.28	0.60	1.31	0.37	4.02	99.71	120	1270	0	422	18	331	59	85	17
Vis 8	50.70	0.78	17.87	6.41	0.16	3.08	9.41	1.40	2.18	0.33	7.39	99.72	110	1210	0	134	21	85	68	123	0
Vis 9	50.53	0.71	17.42	6.03	0.09	3.15	9.42	1.61	2.30	1.13	7.40	99.78	58	657	170	152	20	65	47	99	13
Vis 10	48.24	0.85	15.86	9.03	0.11	5.60	8.90	1.34	2.45	0.29	6.99	99.65	52	1570	150	355	4	298	60	123	19
Vis 11	52.66	0.99	20.29	7.64	0.14	3.18	6.44	1.07	2.07	0.19	5.05	99.73	140	885	0	298	41	218	46	116	20
Vis 12	43.46	0.80	16.06	8.10	0.17	4.31	11.82	0.48	1.81	3.44	9.28	99.73	140	723	0	359	0	279	78	130	0
Vis 13	48.29	0.82	16.36	8.10	0.13	5.75	8.44	1.03	2.30	1.82	6.62	99.65	140	1690	0	334	0	301	54	122	0
Vis 14	49.01	0.81	16.41	8.12	0.11	5.79	8.23	1.31	2.74	0.74	6.47	99.74	110	396	0	355	7	308	61	137	13
Vis 15	49.91	0.76	16.61	7.55	0.11	6.77	7.82	1.35	2.48	0.26	6.14	99.76	46	641	0	362	42	321	57	133	19
Vis 16	37.67	0.96	12.17	10.99	0.23	2.24	16.38	0.26	2.14	3.42	12.84	99.31	4120	617	150	295		290	58	141	0
Vis 17	43.53	1.11	13.47	12.20	0.16	3.46	11.50	0.46	2.69	2.14	9.01	99.74	59	723	0	378	0	340	54	129	24
Vis 18	44.84	1.00	13.16	10.96	0.16	4.43	12.04	0.56	2.52	0.65	9.45	99.75	0	569	130	383	0	363	89	129	16
Vis 19	42.78	1.09	12.76	11.63	0.19	3.97	13.19	0.45	2.52	0.84	10.35	99.78	0	290	0	422	0	372	77	137	20
Vis 20	46.57	1.11	13.28	12.27	0.19	4.21	9.82	0.43	2.86	0.81	7.70	99.25	68	5590	0	413	0	388	71	140	21
Vis 21	42.11	1.16	13.04	12.93	0.18	4.76	11.90	0.68	2.77	0.58	9.33	99.43	0	3880	0	411	0	385	87	161	23
Vis 22	43.76	0.95	12.85	10.49	0.18	4.37	13.01	0.74	2.68	0.52	10.21	99.76	0	568	0	405	0	362	59	117	15
Vis 23	44.45	1.21	13.26	13.06	0.17	4.70	10.38	0.47	2.57	0.81	8.15	99.23	0	5690	180	397	0	409	63	156	19
Vis 24	45.24	1.08	14.46	9.52	0.17	2.01	13.19	0.55	2.77	0.53	10.33	99.85	89	0	0	145	0	77	69	152	21
Vis 25	43.29	1.02	12.02	11.13	0.17	3.78	13.83	0.51	2.61	0.55	10.86	99.76	69	340	0	403	0	361	71	158	21
Vis 26	45.82	1.29	13.86	13.47	0.21	4.62	9.47	0.42	2.00	1.08	7.43	99.66	377	860	200	487	0	410	66	173	20
Vis 27	50.56	1.23	11.29	9.14	0.14	3.01	11.81	0.42	2.13	0.57	9.28	99.57	86	2460	0	482	0	276	49	129	17
Vis 28	39.54	0.88	9.75	9.03	0.17	1.89	15.86	0.37	2.66	6.94	12.44	99.54	600	2230	0	268	0	193	56	109	15
Vis 29	43.63	1.23	12.06	12.84	0.18	3.84	12.74	0.42	2.15	0.62	9.98	99.69	110	1100	0	424	0	384	63	134	20
Vis 30	42.49	1.12	11.94	12.31	0.18	3.05	13.63	0.55	2.98	0.79	10.70	99.74	0	665	0	376	0	315	60	124	0
Vis 31	44.66	1.02	13.18	11.09	0.16	4.25	12.04	0.53	2.82	0.58	9.45	99.78	88	210	0	387	0	354	78	119	18
Vis 32	44.16	0.98	13.85	10.69	0.15	3.78	12.75	0.48	2.39	0.52	10.00	99.76	62	558	0	398	0	364	58	99	15
Vis 33	44.02	1.14	14.78	11.85	0.19	5.32	10.49	0.55	2.32	0.78	8.23	99.66	100	1380	0	445	0	403	88	162	21
Vis 34	45.78	1.10	13.59	11.83	0.19	3.89	10.86	0.46	2.88	0.64	8.52	99.74	150	290	140	351	0	346	75	148	15
Vis 35	40.45	0.66	10.05	5.97	0.08	2.81	20.45	1.00	1.62	0.69	16.04	99.83	343	150	0	130	0	67	47	91	0
Vis 36	27.15	0.68	9.57	5.17	0.01	1.23	30.30	0.00	1.33	0.61	23.78	99.85	160	180	0	130	0	61	52	128	15
Vis 37	41.13	1.04	12.65	11.26	0.19	3.52	15.37	0.24	1.54	0.72	12.06	99.73	140	1080	0	387	0	346	60	102	0
Vis 38	43.04	1.05	12.88	11.26	0.16	3.79	13.45	0.42	2.40	0.71	10.56	99.71	68	890	0	394	0	366	62	126	19
Vis 39	45.63	1.11	13.90	11.98	0.16	3.62	10.99	0.38	2.66	0.74	8.62	99.80	0	0	0	412	0	383	54	118	21
Vis 40	43.81	1.03	13.57	11.50	0.17	4.41	11.97	0.60	2.52	0.68	9.40	99.65	68	1540	0	400	0	380	84	143	20
Vis 41	48.10	1.13	17.00	9.84	0.16	2.23	9.73	0.57	2.66	0.66	7.65	99.74	80	942	170	143	0	86	53	145	24
Vis 42	46.84	1.07	14.51	11.48	0.18	4.36	9.68	0.66	2.37	0.89	7.60	99.64	86	1590	0	448	0	388	76	149	17

Oxides are expressed in wt% and elements in ppm

Table III. XRF chemical analyses of pottery samples from Issa (continuation)

Sample	*As*	*Rb*	*Sr*	*Y*	*Zr*	*Nb*	*Ba*
Vis 1	20	103	197	19	107	8	330
Vis 2	13	107	261	0	105	10	320
Vis 3	28	105	392	16	298	37	330
Vis 4	24	97	243	20	109	10	400
Vis 5	20	38	213	0	117	11	230
Vis 6	14	97	91	26	227	16	360
Vis 7	16	23	194	21	127	10	140
Vis 8	6	120	250	24	189	18	440
Vis 9	19	85	300	26	146	12	320
Vis 10	13	88	247	0	117	11	430
Vis 11	19	111	122	30	221	18	420
Vis 12	35	62	348	23	102	7	460
Vis 13	17	84	245	0	102	0	400
Vis 14	385	116	234	0	105	12	360
Vis 15	6	101	239	0	114	0	330
Vis 16	62	67	428	0	87	0	630
Vis 17	20	86	308	16	109	32	360
Vis 18	27	90	255	0	104	0	310
Vis 19	21	69	275	25	115	8	380
Vis 20	22	98	251	18	124	10	310
Vis 21	12	75	253	19	110	22	240
Vis 22	17	74	264	0	119	13	390
Vis 23	18	59	267	24	128	12	230
Vis 24	17	97	280	23	127	15	360
Vis 25	18	67	295	0	116	10	520
Vis 26	5	38	216	24	147	11	340
Vis 27	11	53	249	15	140	10	340
Vis 28	25	91	429	0	175	0	390
Vis 29	16	46	235	21	135	9	390
Vis 30	12	74	258	0	303	29	420
Vis 31	18	103	260	0	111	11	410
Vis 32	13	79	245	0	111	13	410
Vis 33	0	54	245	23	136	13	360
Vis 34	21	92	233	0	275	30	450
Vis 35	0	63	278	21	107	0	400
Vis 36	13	64	423	0	83	0	230
Vis 37	16	35	251	24	115	0	190
Vis 38	21	77	257	23	108	9	470
Vis 39	15	89	226	19	121	10	490
Vis 40	251	24	115	0	190	0	350
Vis 41	13	101	276	20	136	19	380
Vis 42	16	70	210	18	124	11	380

Oxides are expressed in wt% and elements in ppm

Table IV. Correlation matrix of chosen elements from pottery samples recovered at Issa. Marked correlation are significant at $p < 0.05$

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	S	Cl	Cr	Co	Ni	Cu	Zn	Rb	Sr
SiO_2	1.00	**0.37**	**0.96**	-0.06	0.23	**0.65**	**-0.37**	**0.81**	**0.40**	-0.22	-0.23	-0.18	-0.10	**0.74**	-0.17	-0.17	**-0.31**	0.25	**-0.59**
TiO_2	**0.37**	1.00	**0.35**	**0.66**	**0.61**	0.21	**-0.59**	-0.02	0.06	**-0.35**	-0.22	0.02	**0.54**	0.21	**0.43**	0.23	0.27	-0.20	**-0.66**
Al_2O_3	**0.96**	**0.35**	1.00	-0.08	0.24	**0.60**	-0.30	**0.77**	**0.37**	-0.17	-0.17	-0.23	-0.18	**0.75**	-0.22	-0.14	-0.26	0.29	**-0.53**
Fe_2O_3	-0.06	**0.66**	-0.08	1.00	**0.67**	**0.33**	**-0.53**	-0.24	0.15	-0.19	-0.08	0.04	**0.81**	-0.13	**0.88**	**0.55**	**0.32**	**-0.33**	**-0.35**
MnO	0.23	**0.61**	0.24	**0.67**	1.00	0.21	**-0.55**	-0.04	0.08	0.12	0.20	-0.03	**0.46**	0.07	**0.47**	**0.43**	0.17	-0.20	**-0.30**
MgO	**0.65**	0.21	**0.60**	**0.33**	0.21	1.00	-0.29	**0.59**	**0.42**	-0.21	-0.23	-0.13	**0.34**	**0.49**	**0.39**	0.17	-0.14	-0.01	**-0.43**
CaO	**-0.37**	**-0.59**	-0.30	**-0.53**	**-0.55**	-0.29	1.00	-0.28	**-0.56**	0.09	0.14	-0.19	**-0.38**	-0.13	**-0.39**	-0.19	**-0.32**	**-0.35**	**0.53**
Na_2O	**0.81**	-0.02	**0.77**	-0.24	-0.04	**0.59**	-0.28	1.00	**0.62**	-0.17	-0.16	-0.14	**-0.34**	**0.63**	-0.30	-0.18	-0.27	**0.44**	-0.29
K_2O	**0.40**	0.06	**0.37**	0.15	0.08	**0.42**	**-0.56**	**0.62**	1.00	-0.11	-0.22	0.00	-0.04	0.30	0.08	0.15	0.15	**0.70**	-0.12
P_2O_5	-0.22	**-0.35**	-0.17	-0.19	0.12	-0.21	0.09	-0.17	-0.11	1.00	**0.41**	0.06	-0.11	-0.21	-0.12	-0.04	-0.08	-0.04	**0.62**
S	-0.23	-0.22	-0.17	-0.08	0.20	-0.23	0.14	-0.16	-0.22	**0.41**	1.00	-0.06	-0.12	-0.08	-0.06	-0.10	0.07	-0.09	**0.44**
Cl	-0.18	0.02	-0.23	0.04	-0.03	-0.13	-0.19	-0.14	0.00	0.06	-0.06	1.00	0.06	-0.14	0.07	-0.13	**0.34**	0.04	0.18
Cr	-0.10	**0.54**	-0.18	**0.81**	**0.46**	**0.34**	**-0.38**	**-0.34**	-0.04	-0.11	-0.12	0.06	1.00	-0.16	**0.94**	**0.42**	0.20	**-0.43**	**-0.35**
Co	**0.74**	0.21	**0.75**	-0.13	0.07	**0.49**	-0.13	**0.63**	0.30	-0.21	-0.08	-0.14	-0.16	1.00	-0.19	-0.28	-0.30	0.25	**-0.36**
Ni	-0.17	**0.43**	-0.22	**0.88**	**0.47**	**0.39**	**-0.39**	-0.30	0.08	-0.12	-0.06	0.07	**0.94**	-0.19	1.00	**0.51**	0.24	**-0.34**	-0.28
Cu	-0.17	0.23	-0.14	**0.55**	**0.43**	0.17	-0.19	-0.18	0.15	-0.04	-0.10	-0.13	**0.42**	-0.28	**0.51**	1.00	**0.40**	-0.09	-0.09
Zn	**-0.31**	0.27	-0.26	**0.32**	0.17	-0.14	**-0.32**	-0.27	0.15	-0.08	0.07	**0.34**	0.20	-0.30	0.24	**0.40**	1.00	0.09	0.06
Rb	0.25	-0.20	0.29	**-0.33**	-0.20	-0.01	**-0.35**	**0.44**	**0.70**	-0.04	-0.09	0.04	**-0.43**	0.25	**-0.34**	-0.09	0.09	1.00	-0.04
Sr	**-0.59**	**-0.66**	**-0.53**	**-0.35**	**-0.30**	**-0.43**	**0.53**	-0.29	-0.12	**0.62**	**0.44**	0.18	**-0.35**	**-0.36**	-0.28	-0.09	0.06	-0.04	1.00
Y	0.20	**0.43**	0.21	0.05	0.21	-0.17	-0.18	0.02	-0.22	-0.10	-0.18	0.17	-0.10	0.09	-0.19	-0.07	0.09	-0.13	**-0.31**
Zr	0.00	0.10	0.00	-0.14	0.07	**-0.32**	-0.24	-0.05	0.02	-0.05	-0.12	0.30	-0.13	0.12	-0.20	-0.26	0.13	0.23	-0.13
Nb	-0.04	0.21	-0.01	0.10	0.08	-0.22	**-0.35**	-0.03	0.21	-0.22	-0.23	**0.31**	-0.04	-0.03	-0.06	-0.15	0.29	0.27	-0.13

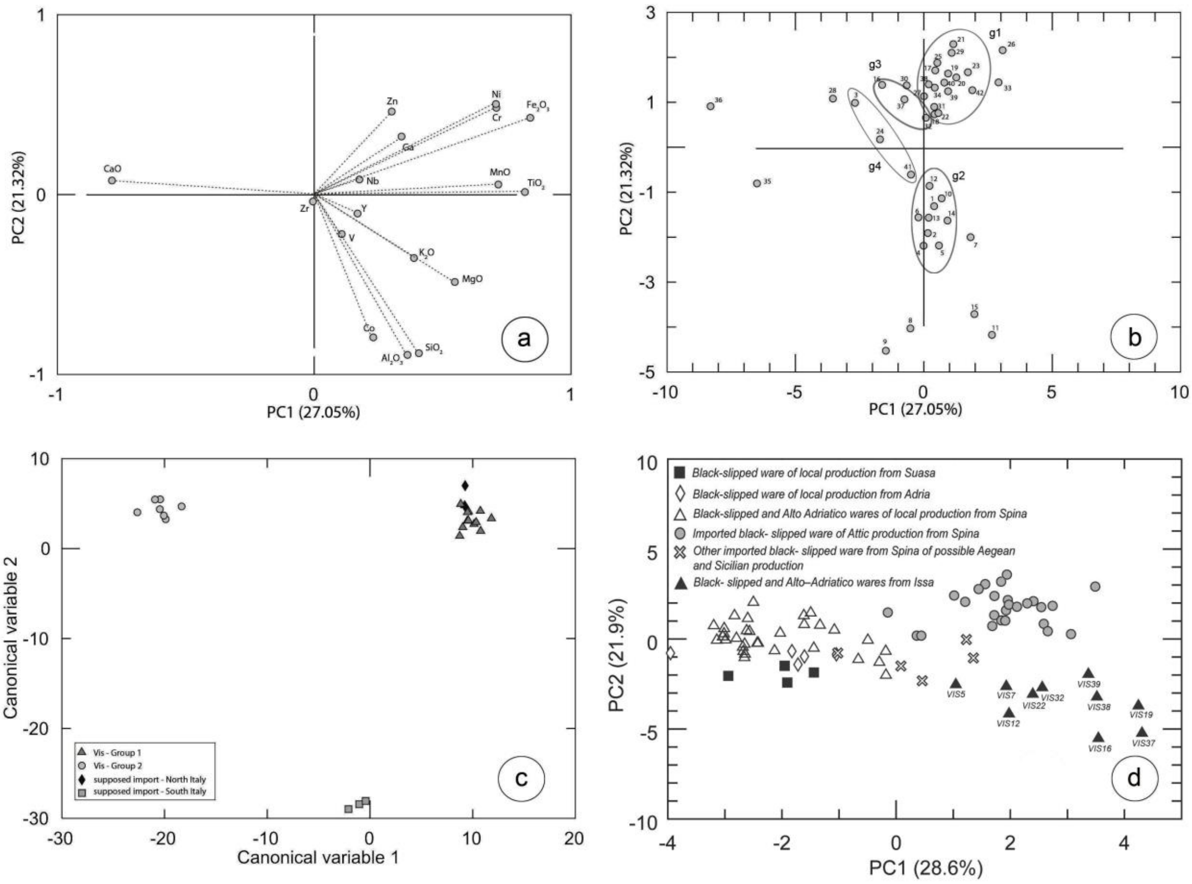

Figure 5. The principal component biplot (PC1 and PC2) depicting: projections of discriminating variables (elements) (a); grouping of analysed ceramic potsherds where the provisional chemical groups are marked with g1-g4. The biplot showing results of discrimination analysis in a space defined by two canonical variables with three main groups being clearly distinguished (c); A comparative PCA analysis between analysed artefacts from Issa and **those from various Northern and Middle Italian provenances (d)**

5.3 Polarization microscopy and SEM/EDS study

Speaking of ceramic petrography and microstructures, the potsherds belonging to the geochemically defined groups (Fig. 5a-b) showed a well pronounced intra-group homogeneity. On the other hand, the inter-group differences seemed to be less sharp for local artefacts, whereas in the case of hypothesised alien wares these differences were particularly well established.

The ceramic matrix of *Group 1* is well sintered and its colour is reddish to brownish. It comes across as insufficiently blended or even hardly prepared, displaying randomly distributed light and dark zones with the former preferentially found in the centre of the ceramic body (Fig. 6a). A pattern of secondary porosity and mineral inclusions of quartz and mica define the material structure (Fig. 6b-c, 7a). Two types of coarse composite inclusions are recognised and interpreted to represent the well-rounded clay textural features (TCF) of unclear origin (Fig. 6b, 7a). The difference between the two is essentially in the grain size distribution and in the homogeneity of their respective matrixes. TCFs typically appear as rounded egg-like forms stuffed with the inclusions of silicate minerals (Fig. 7b). In general, the ceramic matrix has a stable chemistry (Fig. 7c, spectrum marked with ●) presenting a thermally processed clayey raw material. Its illite-characteristic Al/Si ratio, pronounced Mg and Ca abundances, as well as traces of K define the clayey raw material as essentially illitic, presumably mixed with small portions of Mg-Fe clay phases. An excess of Ca, normally too high to be accommodated even by the Ca-rich clay minerals, like Ca-montmorillonites for instance (e.g. Velde and Meunier, 2008), was explained through the temperature breakdown of fine-grained calcite. During firing, the released Ca is readily held within the structure of raw clay, giving rise to the peculiar matrix composition hereby referred to as the *Ca-Mg illitic matrix*. Firing artefacts were further documented in well-defined individual grains of plagioclase and quartz, showing up to several microns deep and sharp diffusion fronts of K and Al/Ca, respectively (Fig. 7d, spectrum marked with ■). Such fronts represent thermally-activated fluxes of ions liberated from illitic matrix, eventually yielding to mineral metasomatism (Brady, 1983; Ionescu et al., 2011). The appearance of newly formed Mg-cordierite marked by regular shapes and characteristic EDS spectra (Fig. 7d, spectrum marked with □) is in line with the assumption of raw clays enriched in ferromagnesian component. Further on, particles with vermiculite and chlorite-like chemistry (high Mg and Si, low Al, Fig. 7d, spectrum marked with ✦) were also reported. Microstructural characteristics of ceramic material of *Group 2* were considered analogue to the previous ceramic group. The exception renders a regular matrix zonation perceived as layering (Fig. 6d). In addition to feldspar and quartz inclusions, additional phases were reported numbering orthopyroxene (enstatite, spectrum marked with ■ in Fig. 8a), garnet, biotite, titanite and TiO_2-phase. The matrix is largely consisted of Ca-Mg illite (spectrum marked with ⊄ in Fig. 8b), whilst minor constituents are 14-Å chlorite/vermiculite and Mg-rich mica (spectrum marked with ✦ in Fig. 8b), reflecting raw material constituents. Sporadic occurring clinopyroxene (spectrum marked with ● in Fig. 8b) and K-feldspar reported in a reticular matrix are, however, the newborn firing phases. Mineral content and microstructure of samples from *Group 3* (hypothesised North Italian import) tend to be in line with the most of already reported material characteristics. Still, high pore content and numerous clay pellet agglomerations can seem to be a distinguishable feature of this group (Fig. 6e-f).

A striking difference depicted by the artefacts from *Group 4* is a highly sintered and partly vitrified clayey matrix defined by the system of secondary porosity with ellipsoidal and isolated pore spaces (Fig. 6g, 8c). The rounded clay pellets (Fig. 6i) are numerous, isometric and attain up to 0.2 mm in size. Usually such rounded and small inclusions make a sign of incomplete clay processing or they may well be naturally occurring (e.g. Heimann and Maggetti, 2014). A large content of mineral inclusions numbers quartz, mica, chlorite, diopside, and feldspar (Fig. 6h). In addition, the compound (multi-layered) minerals are here typically found emerging either as single grains or as mineralization attached to quartz and feldspar (Fig. 8d). Strictly speaking, these consist of a variety of intimate interlayering of 10-Å mica and Fe-rich 14-Å chlorite/vermiculite. The former has been replaced by Fe-rich 14-Å clay minerals represented as light grey domains in Fig. 8d (spectrum marked with ▲), whilst the white laminas in the same picture stand for solid-state mobilised Fe, originally located at mica octahedral sites and subsequently released along the 001 crystal planes of 14-Å clay minerals (Hirt et al., 1993).

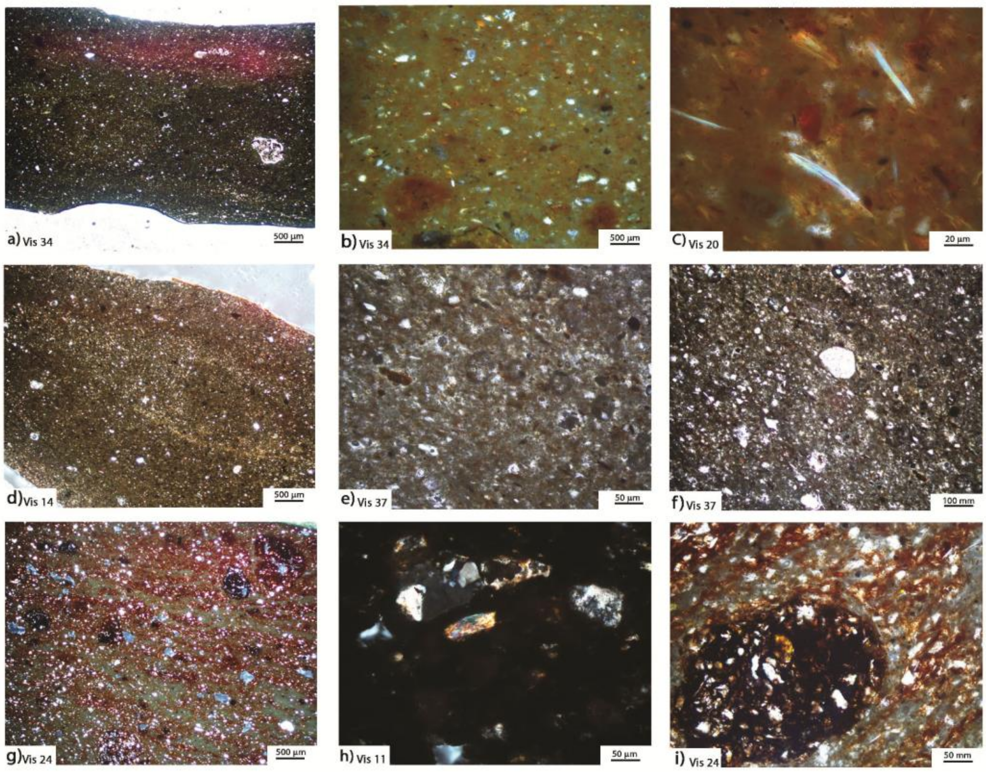

Figure 6. Microphotographs of thin sections of the potsherds from Issa taken under crossed polars

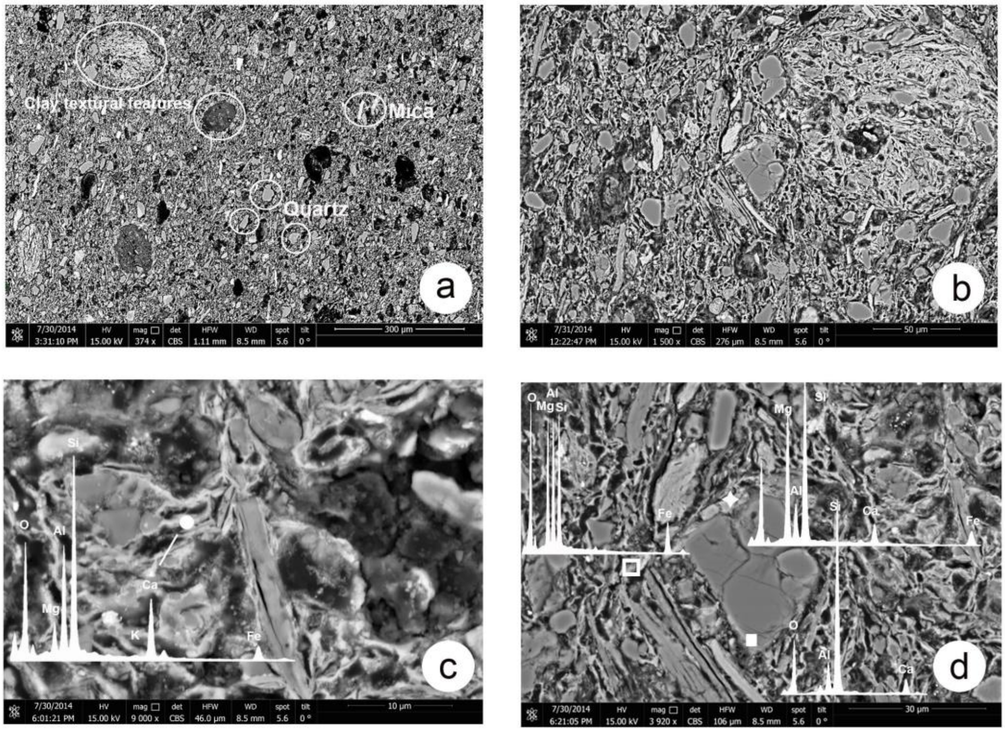

Figure 7. **SEM imagery of Group 1 pottery showing: a developed secondary porosity and a variety of inclusions present (a); morphology and composition of clay textural features – TCF (b); a detailed insight in the ceramic matrix with the enclosed EDS spectrum showing its composition (c); ceramic matrix with inclusions marked by K and Al/Ca diffusion fronts (EDS spectrum ■), appearance of Mg-cordierite (EDS spectrum □), particles of characteristic vermiculite and chlorite-like chemistry (EDS spectrum ✦) (d)**

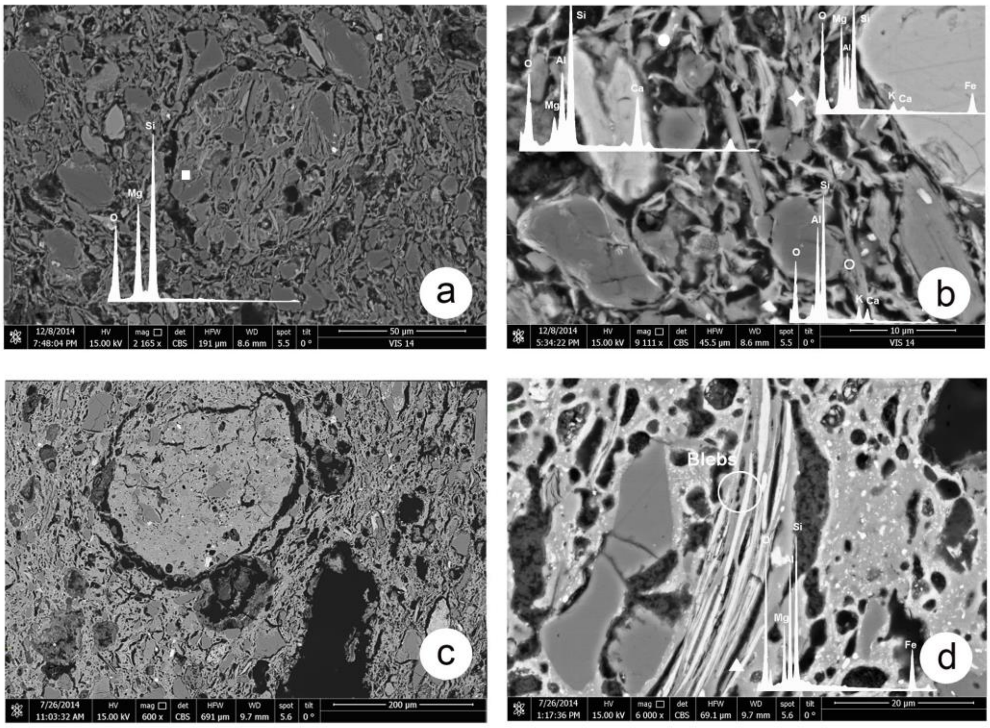

Figure 8. **SEM imagery of Group 2 pottery showing: a similar microstructure like that of the first group with some additional inclusions present (orthopyroxene, EDS spectrum ■) (a); a characteristic composition of ceramic matrix (EDS spectrum ○) with an indication of 14-Å chlorite/vermiculite (EDS spectrum ✦), and clinopyroxene (EDS spectrum ●) (b); SEM imagery of Group 4 pottery showing: a highly sintered and partly vitrified clayey matrix defined by the system of secondary porosity (c); an intimate interlayering of 10-Å mica and Fe-rich 14-Å chlorite/vermiculite ('metamorphic vermiculite', EDS spectrum ▲) (d)**

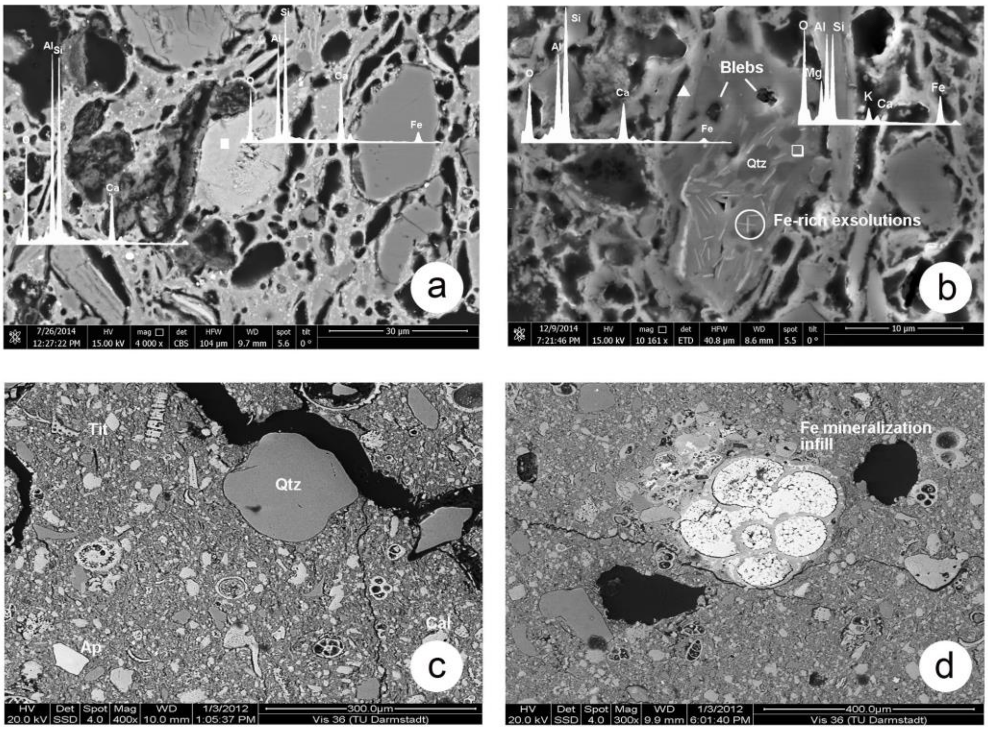

Figure 9. SEM imagery of Group 4 pottery showing a crystallisation of a range of new Ca-silicates, like gehlenite (EDS spectrum ■) and anorthite (EDS spectrum ●) (a) and Fe-rich Ca clinopyroxene (esseneite-augite) (EDS spectrum ▲) with mica dissolution relicts, showing melting blebs and a compositionally zoned remaining material (EDS spectrum □) (b); SEM imagery of Levantine plain ware amphoriskos showing: a large amount of silt-size inclusions and calcareous and silica microfossils remains (c); Palaeogene planktonic foraminifera (Subbotina sp.) filled with Fe-mineralization (d)

Minerals featured by such peculiar multi layering are usually referred to as high-temperature or "metamorphic" vermiculite (Velde, 1978). Metamorphic vermiculite show further signs of incipient exfoliation, usually accompanied by bleb-like melt pockets (Fig. 8d). Hillier et al. (2013) ascribe a similar exfoliation phenomenon to rapid steam production, forcing the phyllosilicate layers to open. Other manifestations of high-temperature changes in 10/14-Å mixed-layers are needle-shaped Fe-Al oxide segregations. TEM studies on thermal evolution of dehydroxylated mica showed that such segregations appear to be the defect and metastable Fe-rich Al spinels (γ-Al_2O_3, Devineau et al., 2006). In the experimental work of Rathossi and Pontikes (2010), it has been demonstrated that under the atmospheric pressure such mica-chlorite minerals can retain its lamellar structure up to 1050°C, thus effectively constraining the furnace conditions. A crystallisation of a range of new phases, like gehlenite (spectrum marked with ■ in Fig. 9a), Ca-feldspar (anorthite, spectrum marked with ● in Fig. 9a), and Fe-rich Ca clinopyroxene (esseneite-augite composition, spectrum marked with ▲ in Fig. 9b) is conformable to the phenomenon of extensive matrix vitrification. Ceramic matrix is illitic to smectitic and in terms of the Ca content and ratios of major cations (Si, Al, and Mg) clearly different than previously reported. A significant portion of matrix is, however, found consisted of clinopyroxene. We hereby propose a reaction sequence that assumes a phyllosilicate thermal instability giving rise to the pyroxene formation and SiO_2 release, presumably in the form of quartz. An illustration can be drawn from the mica relicts, showing melting blebs and a compositionally zoned remaining material (Fig. 9b). The areas in the vicinity of blebs are still largely 'micaceous' (spectrum marked with □), whereas the main portions of former mica is SiO_2-dominated. As the temperature raises, Si is mobilised and the Fe content gets progressively augmented, eventually leading to the exsolution of needle-shaped Fe (-Al) oxide(s) (Fig. 9b). Along mica rims where the Ca content is sufficient, Ca-clinopyroxene is formed, entirely surrounding the original mica. Newly-formed Ca-silicates are characteristic for carbonate-rich materials fired at temperatures from 800 to 1100°C (e.g. Riccardi et al., 1999; Cultrone et al., 2001). Their size is found in a range of several microns with an exception of the minerals from melilite group (gehlenite?) attaining up to 10 μm (Fig. 9a).

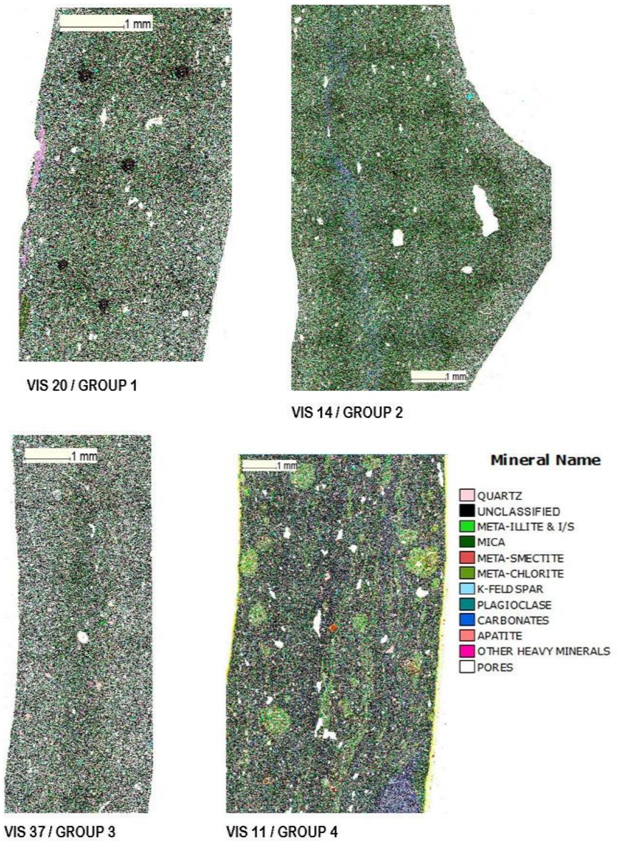

Figure 10. Fieldscan QEMSCAN® images of analysed ceramics from Issa depicting different artefacts' fabrics

Not belonging to any established statistical and microstructural groups, being however of high importance is sample *Vis 36,* outlier in Figure 5a. It is a rare example of plain ware amphoriskos (Table I.) with a clean and powdery texture that leaves a dusty film on the fingers upon handling. This sample is also featured by peculiar Ca-rich and Si-Mg-Fe poor geochemistry (Table III; Fig. 5) and XRD mineralogy (low content of pyroxene and feldspar, presence of 15-Å phyllosilicates and calcite, Table II., Fig. 4c). The SEM inquiry showed a large amount of silt size inclusions counting the sub-rounded and sub-angular grains of feldspar, quartz, calcite, and apatite, along with a smaller amount of mica, amphibole, and clinopyroxene (Fig. 9c). A relatively high amount of fossil remains is reported, containing both calcareous and silica microfossils. The former are consisted of micritic to palisade calcite and number the chambered shells of marine protozoa (bentic and plactonic foraminiferas), the bivalve shells (ostracods) and miscellaneous skeletal remains of several different groups, like bryozoans and marine algae. The latter are presented by radiolarians and sponge spicules (Fig. 9c-d). The total fossil content is estimated between 15 and 20% of the volume. The clay matrix depicts a low degree of sintering and preserved crystals morphology of its sheet mineral constituents in form of flattened and elongated clay agglomerations. Calcium in the matrix is linked to the minor calcite presence or it originates from essentially Ca-rich clay raw material (smectite?), as suggested by XRD measurements (Fig. 4c). An interesting feature makes a presence of Palaeogene planktonic foraminifera (*Subbotina sp.*, genus determination M. Dunčić, pers. comm.) filled with Fe-mineralization (Fig. 9d). A 'ferrization process' follows an incipient coating of inner-shell calcite with ferric material, eventually causing a complete removal of carbonates. However, the source of Fe is unknown, especially bearing in mind that total Fe of this sample is comparatively lower (Table III.). Berlin and Frankel (2012) reported on a similar phenomenon in the Phoenician semi-fine A clayware arguing for Fe to have been mobilised from Fe-oxide bearing layer within the clay deposit. Thus, it can be hypothesised that the ancient potters of Levant were aware of the fluxing property of Fe, crucial for lowering sintering temperatures (Gopher et al., 1992). Mentioned Phoenician pottery is dated to the period from 6th to 4th c. BCE and is thought to have remained in a continuous production until the 1st c. BCE (Berlin and Frankel, 2012). According to our best knowledge, this is a sole analogue within the circum Mediterranean Hellenistic realm, which in terms of ceramic petrography and microstructure, could be related to analysed Issean amphoriskos.

5.4 QEMSCAN® study

The QEMSCAN® technology offers an advantageous visual insight into a range of ceramic features reported by SEM/EDS observations. The fieldscan images depicting artefacts' fabrics are shown in Figure 10, whereas the comparative modal mineralogy is available in Figure 11. Analyses of ceramic fabrics showed a random arrangements of areas of different matrix density, along with an uneven distribution of porosity and clayey textural features in Group 1. On the other hand, in Group 2, a layering developed along the sample rims is nicely depicted. Myriad of clay pellets reported by SEM in Group 3 is not recognised in QEMSCAN® images owing to the resemblance of pellet and matrix phase compositions. On the contrary, in Group 4, higher vitrification of matrix is well perceived, along with numerous clay pellets essentially consisted of illitic and chlorite-like minerals, whilst the matrix was reported to be somewhat enriched in smectite. This may call upon a technological procedure that included a deliberate addition of spherical particles (clay mixing?) and/or a range of other inclusions needed for paste optimisation and enhancement of ceramic strength and durability (e.g. Rice, 2006). Analysing the QEMSCAN® modal mineralogy, a high content of 'unclassified' is reported in a ceramic micromass. This reflects homogenous clayey raw material consisted of Ca-Mg illite substrate and other non-stoichiometric phases all formed through the firing of clays. EDS-spectra databases do not subsume information on non-standard metastable matter, giving rise to the failure of pixel definition in terms of mineral classification (e.g. Pirrie and Rollinson, 2011). Summing up the 'unclassified' with the amounts of meta-illite and meta-chlorite the approximately 40-50% of matrix clayey substrate for all analysed ceramic groups was inferred. The amounts of quartz and feldspars as main natural inclusions in all the groups was between 20 and 25%. Such proportions of clays and mineral inclusions are considered optimal in terms of the ceramic physical properties upon firing (Rice, 2006).

A key feature of QEMSCAN® analyses pertain to ceramic studies are the grain-size distribution analyses performed on a chosen mineral population, here also comprising the assessment of porous space distribution. As the naturally occurring clays rarely occur as pure inclusion-free deposits, a population of main mineral inclusions – quartz and feldspars – was investigated in order to infer on the raw-material similarities both in terms of natural and added particles (Fig. 12). This histogram shows a predominance of fine silt size particles (2-5 μm) ranging between 60-70% of the total count population in all the ceramic groups analysed. Somewhat coarser fractions (5-8 and 8-15 μm) count for a lesser share of 10-20 and 7-15%, respectively. Inclusions exceeding 15 μm in size are encountered only in amounts of several percentages. Such a pattern is very much in favour of the hypothetical grain-size distribution in clays used for the production of ceramics (Grimshaw, 1971). In agreement with a choice of favourable deposits is the constant feldspar/quartz ratio reported from all groups, ranging from ~1:8 to ~1:10 (Fig. 11). Quartz is a chemically inert material and influences the physical properties of clays and ceramics (shrinkage, hardness, strength, etc.), whilst alkali minerals, like feldspar, are known as fluxing agents (Riccardi et al., 1999; Papachristodoulou et al., 2010). In general, the QEMSCAN® study showed very similar results in terms of the modal mineralogy, ceramic texture, and mineral distribution patterns for Groups 1-3. The total particle number of selected natural inclusions, however, shows certain differences between the groups, whereas Group 4 remains quite distinct given the all stipulated parameters.

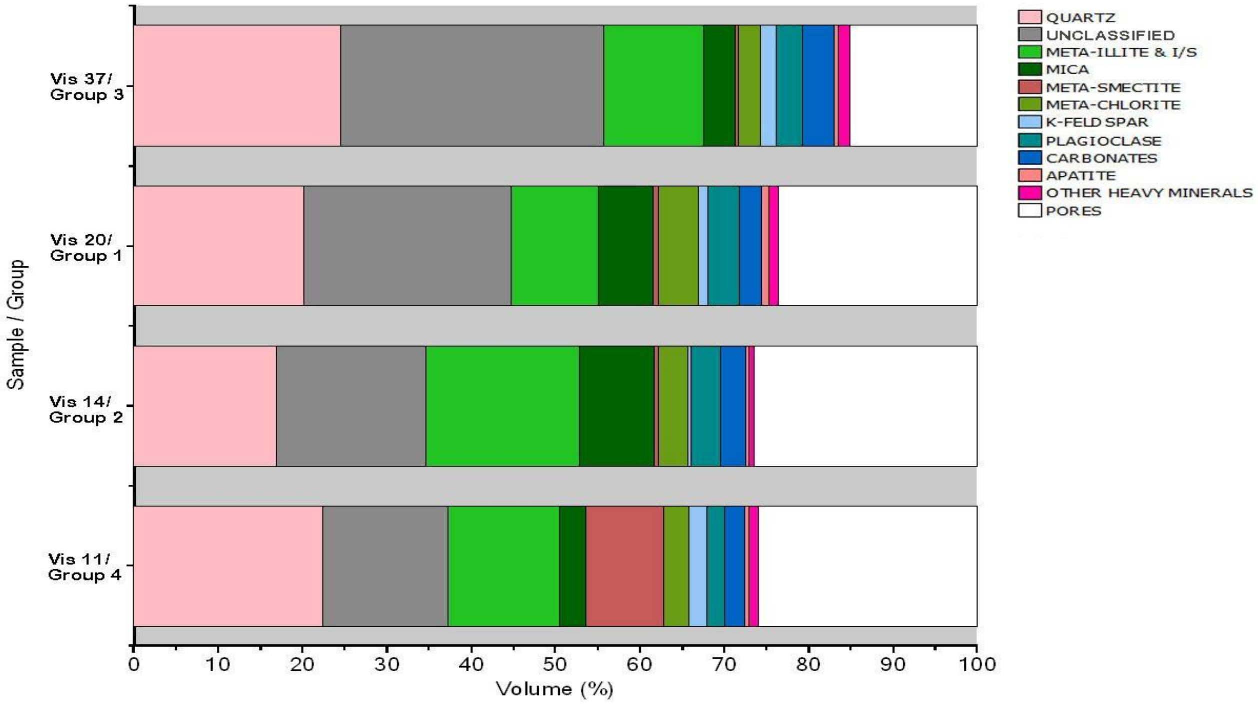

Figure 11. QEMSCAN® comparative modal mineralogy of different ceramic groups from Issa.

6. DISCUSSION

6.1 Reaction mineralogy and constraints on manufacture technology

Ceramic material recovered from Issaean tombs primarily consisted of a Ca-Mg illitic matrix enriched in a variety of mineral inclusions (Table II.). The latter is particularly related to Group 4 where a fairly higher number of coarse (> 50 µm) angular to subangular silicates and rounded clay pellets was reported (Fig. 10). Natural inclusions are found in a range from 20 to 25 % and encompass quartz, plagioclase, K-feldspar, mica, and occasionally 14-Å sheet silicates, apatite, diopside, orthopyroxene, garnet, titanite, Fe-Ti oxides, and clay pellets (Groups 1-3, Fig. 11). The pellets, except in Group 4, usually have the same composition as their immediate surroundings, indicating their pristine origin from the clay raw material (Whitbread, 1995). A practically unimodal grain-size distribution of quartz and feldspars, where fine silt characteristic for natural clays used in the pottery production (Fig. 12) prevailed over coarser fractions, is in line with a distribution trend. It is, therefore, believed that paste optimisation was elementary and, excluding Group 4, did not involve extensive treatments with respect to preparation practices (e.g. tempering, sifting, levigation) (e.g. Schriever, 2008). A small social distance must have also played a role in case of Issaean domestic wares (i.e. small island), having shaped the production traditions and expectations on what was an acceptable vessel and how it should have been produced (Kohler et al., 2004). The insular potters of the time must have acted conformably to such constraints, having a conservative approach to the experimentation with recipes and choices of clayey material.

Natural inclusions of fine grained calcite or, alternatively, Ca-rich interlayers of raw clays served as sources of Ca, an indispensable fluxing agent. Upon dissociation (>800 °C) calcite turns into quicklime that in contact with moisture, may induce cracking and expansion of an unyielding fired clay body of low to medium vitrification (Rice, 2006). However, if calcite emerges as fine-grained natural inclusion, than the forces of lime expansion are not sufficient to crack the fired clay (e.g. Zamek, 2009). No such damages have been reported from analysed ceramics and we, therefore, presume that additional tempering of ceramic paste with calcite was not performed by the potters. This goes along with a wide-spread standpoint arguing that potters from technology advanced ancient societies knew how to recognise favourable Ca-rich deposits (Rice, 2006), being aware of their advantages both in terms of clay-working and enhanced sintering (Velde and Druc, 1999). On the other hand, pottery produced by Hellenistic native communities of Eastern Adriatic do show cracks and conical holes in their structure normally interpreted as popping effects (Šegvić et al., 2012).

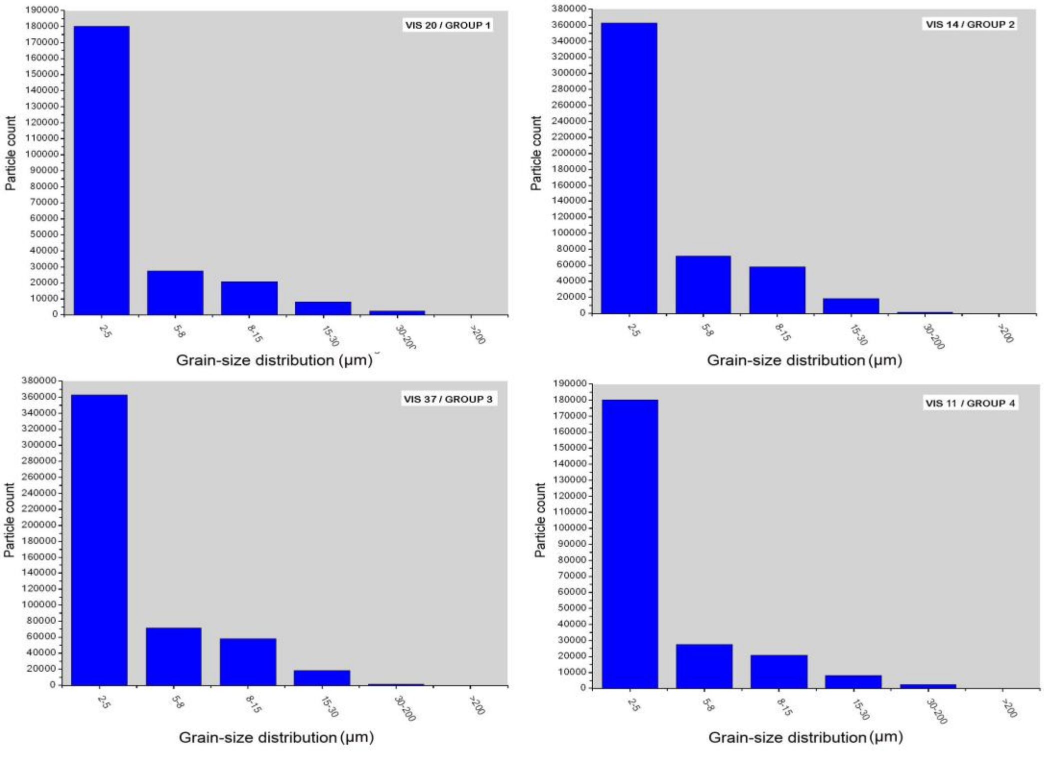

Figure 12. QEMSCAN® results on the grain-size distribution of different mineral inclusions in analysed ceramics from Issa

The presence of 10-Å phyllosilicates in analysed potsherds offers the first piece of information on the pottery firing conditions (Table II.; Fig. 4). That being said, it is imperative to differentiate mica abundances reported by QEMSCAN® (10-15 % after pore-out normalisation, Fig. 11) from those inferred from XRD basal reflexes of mica (~2-3 %, given the detection limit of the instrument, Fig. 4). The former value, in fact, matches the real amounts of mica in raw clays that is upon firing commonly consisted of partially or entirely dehydroxylated illite-like phases. Such 'meta-illites' are featured by EDS-spectra matching those of fresh mica, which is essential for QEMSCAN® phase classification (Haberlah et al., 2011). The latter, XRD amounts of mica, are however solely related to incompletely dehydroxylated mica that have retained, fully or partially, its crystal periodicity after firing. Thermal stability of different mica species under atmospheric conditions generally depends on the type of octahedral cation present. Thus, $2M_1$ muscovite (illite) is stable to about 850 ºC, with a twofold dehydroxylation pattern at apparently 550 and 750 ºC (Guggenheim et al., 1987). On the other hand, there are three stages in the thermal decomposition of biotite (Vedder, 1969). The OH group attached to the empty octahedral sites will be liberated firstly, starting with 400 ºC in an oxidizing atmosphere, whilst those hydroxyls associated to Fe^{2+} at different structural positions (M2, M1) will be lost at temperatures near 850 ºC (Rancourt et al., 1993). Finally, OH groups linked to Mg ions in the octahedral layer will disappear at about 1000 ºC, marking the final break down of biotite (Hogg and Meads, 1970). Yet, a final decomposition of pure phlogopite will take place at about 1080 ºC (Guggenheim et al., 1987). The EDS analyses confirmed the presence of both types of mica (i.e. biotite and muscovite subgroups) in all Issaean ceramic groups and, in line with the QEMSCAN® and XRD estimations of mica contents, it effectively constrained the firing temperatures to the range of ~850 to ~1000 ºC, conformant to the discussed stability ranges of muscovite and biotite, respectively.

The reaction mineralogy and microstructure of each ceramic group is used to provide further information on furnace conditions. Thus, in the ceramic Group 4, a high vitrification is coupled with (1) dense vesicular voids, (2) a range of newly formed Ca-silicates comprising clinopyroxene, gehlenite, and anorthite (Fig. 9a-b), and (3) an enhanced partial melting of mica (Fig. 9b). All firing phases are fibro- to nematoblastic and present a second mineral generation emerging as reaction rims within the ceramic matrix. Consistent with their micron-size, we assume a process lying behind the silicate formation to be essentially diffusion driven. In ceramics, anorthite feldspar is normally formed at the expense of sheet silicate substrate, released ions of Ca, and an additional source of silica (e.g. quartz) at temperatures approaching 1000 °C (Riccardi et al., 1999). Analogue temperatures are inferred from the appearance of clinopyroxene that emerges in Ca-rich ceramics at minimal temperatures of 950 °C (Dondi et al., 1998; Cultrone et al., 2001). A crystallisation of sub-calcic pigeonite instead of Ca-rich clinopyroxene occasionally reported in this ceramic group may be explained by preferential uptake of available Ca by coexisting anorthite (Šegvić et al., 2012). Moreover, the emanation of gehlenite, a mineral from the mellilite group, reaches its peak rate at about 900 °C (Cultrone et al., 2001). Thermal transformations in 10/14-Å compound (inter-layered) minerals, like incipient exfoliation, partial melting and Fe-Al oxide segregation (Fig. 9b), fit a suggested temperature range. Upper stability limits of such layered minerals are normally set to about 1050 °C, which is documented by quite a few experimental studies (Rathossi and Pontikes, 2010). Generally, from the available mineralogical evidences, it is inferred that vessels from Group 4 were fired at highest temperatures (~900-1050 °C). The amount of vitreous matter, as well as the frequency and the size of newly formed crystallites (average: ~1-3 µm; maximum: ~20 µm) suggest that firing lasted for at least several hours with a controlled heat rate increase. The latter is documented in moderate exfoliation of phyllosilicates, normally taking place at a high rate with abrupt firing due to rapid steam production, making silicate layers open widely whilst fluids left the structure (Hillier et al., 2013).

Material structures and the mineralogy of remaining ware (Groups 1-3) are similar, pointing to complement furnace conditions and comparable production technologies. Maximal temperatures were about 850-900 °C as indicated by higher values of primary matrix porosity, complete calcite dissolution, and partial dehydroxylation of mica (Fig. 4). The nucleation of cordierite, documented in Group 1, also took place at those temperatures (Khalfaoui et al., 2006). Potassium and Ca/Al metasomatism in quartz and feldspar typically observed in the material from local workshops follows a dissolution of calcite and the onset of illite dehydroxylation at ~700 °C with a subsequent thermal reaction of the former with illitic matrix (e.g. Trindade et al., 2009). Sanidine is also occasionally reported as a reaction phase structured within the reticular clayey matrix along with clinopyroxene. Both phases are formed at the expense of illite at temperatures higher than 800 °C (Cultrone et al., 2001). Still, the content of high-temperature phases is much lower than in potsherds from Group 4, and clay substrate is found preferentially transformed into amorphous metastable compounds. Such reaction products and an insufficiently blended ceramic fabric indicate a relatively fast firing that lasted for a short time at peak furnace temperatures (e.g. Ionescu et al., 2011).

The firing conditions valid for amphoriskos of supposed Phoenician origin are determined by 15-Å phyllosilicates (Fig. 4c) and calcite from microfossils' skeletons readily preserved in the ceramic matrix (Table II.). Taking into account their thermal stability ranges (Smykatz-Kloss, 1982; Guggenheim et al., 1987, respectively) firing temperatures at about 600 ±100 °C were suggested.

6.2 *Types and provenance of ceramic raw material*

Ethnoarchaeological studies show that the choices of raw material for pottery production (clays and temper) are hardly random, they are always consciously procured for some particular reasons (Costin, 2000). In case of the analysed Issaean pottery where for most of it has been indicated to be of local origin (Groups 1 and 2, Fig. 5), these reasons are primarily related to the local geology that controls the clay availability and variations of its chemical and mineralogical compositions. The island of Vis is entirely consisted of Upper Cretaceous layered limestones with some Jurassic basic extrusives and pyroclastic material (tuffs and volcanic agglomerates) at its western corner (Crnjaković, 2000) and, as already mentioned, no occurrences of clays in terms of substantial deposits are to be expected. A detailed geological prospection of the island reported in Mileusnić et al. (2008a; 2008b) showed only local clay mineral occurrences (1) in Terra Rossa and Pleistocene paleosols filling Quaternary extension forms (karstic polje, dominantly 10-Å clays), (2) in weathering crusts of volcanic rocks (14-Å and 7-Å dominated clays), and (3) in vertical cracks within Cretaceous limestones and in some other restricted areas of the island (relatively pure clays). Indeed, the pottery presumed to have been produced locally showed peculiar compositional characteristics visualised in the two distinct PCA groups (Fig. 5). Geochemical discrepancies between the two counts for the comparative impoverishment of some major elements (SiO_2, MgO, and Al_2O_3, Table III.) in Group 1, whilst in the same group, critical trace elements, distinctive for igneous suites (Ni, Nb, Zr, Table III.), are more abundant. Further on, in terms of material provenance, the mineralogy of Issaean pottery is especially instructive. In both groups, the matrix is mainly composed of illite enriched in Fe-Mg clay mineral component (e.g. chlorite, vermiculite), which defined its unusual Ca-Mg illite composition. Still, in the first group, certain domains of the matrix are reported to be exclusively composed of the former 14-Å like sheet silicates. On the other hand, the second Issaean group has fewer such constituents but a higher content of natural inclusions of clear magmatic provenance, like enstatite orthopyroxene and Fe-Ti oxides. All compositional characteristics provided are in favour of Terra Rossa from Vis as the most plausible clay raw material. This reddish to silty-clayey type of Mediterranean soil is dominant in some parts of the Croatian Adriatic region (Istria and central Dalmatian islands). It is predominantly composed of clay and silt-sized particles, with particles of sand forming less than 4 % (Durn et al., 1999). Its clay mineral content is dominantly illitic and kaolinitic, and only in subordinate amounts chloritic and vermiculitic (Durn et al., 1999; Durn, 2003). Within the clay fraction of Terra Rossa apart clay minerals some other phases like quartz, plagioclase, K-feldspar, and mica are readily found. A dehydroxylation of kaolinite takes place around 520 °C (Yeskis et al., 1985) and, knowing that firing temperatures of analysed artefacts were much higher, makes the Terra Rossa clay fraction very much compositionally correspondent to that of the matrix of Issaean wares. On top of that, the grain size distribution of ceramic material reported by QEMSCAN® (~90 % clay and silt particles) along with the reported content of former phyllosilicates in the matrix (~50 %), the amounts of quartz and feldspar (~25 %), and the ratios between the two (~1:10) are the parameters in line with those of Terra Rossa (Fig. 11; Durn et al., 1999). Elevated trace element abundances (Cr, Nb and Ni) in the Issaean wares (Table III.) could be related to the complex origin of Terra Rossa presuming a range of source material, like aeolian dust or volcanic pyroclasts that were brought on carbonate terrain by different transport mechanisms (Bronger and Bruhn-Lobin, 1997). Still, the air-fall pyroclastic material from the region is generally of acidic to intermediate magmatic nature, with much lower concentrations of compatible trace elements (e.g. Cr, Ni, and Nb, Šegvić et al., 2014 and references therein) than it is reported in Issaean potsherds. We, therefore, rather link the enrichment of those elements to the influence of weathered basaltic extrusives that crop out in the western part of the island (Crnjaković, 2000). In line with such reasoning is a report on 14-Å clay minerals found in Issaean ceramics (Group 1, 5-10%, Fig. 8d) in the amounts exceeding the usual vermiculite and chlorite contents of Terra Rossa (Durn et al., 1999). Moreover, 14-Å clay phases are known from the weathering crust of igneous extrusives from the island of Vis (Mileusnić et al., 2008b). We, therefore, propose the Terra Rossa from the island's central parts (Borović et al., 1975) as a clay raw material that was in use for the pottery production of ancient Issa. The exploited material was influenced to a greater or lesser extent (ceramic Groups 1 and 2, respectively) by a volcanic component associated to the weathering of basic extrusives from the western part of the island. Thus, it may be hypothesised that two exploitation areas existed at the time, one in the south-central portion of the Vis anticlinal, where Terra Rossa soils reach the sea (Group 2), and the other in the area of the Bay of Komiža (Group 1), both conveniently located on the sea route to the Issaean settlement (Fig. 1).

XRD and QEMSCAN® mineralogy and in particular the ceramic microstructure studied by SEM showed the samples from Group 3 to be quite similar with those from the first two ceramic groups. Yet, the PCA grouping (Fig. 5b) indicated a degree of chemical distinction of some artefacts from Group 3, especially visible for samples having a typical North Italian typology such as the Alto Adriatico vases with painted decoration. These are known to have been produced in Italian North from late 4th to early 3rd c. BCE (Berti, 1997; Bonomi, 1997; Landolfi, 1997). The biggest centres at the time in the north-western coastal region of the Adriatic were Spina and Adria, former Etruscan ports and trading posts near present-day Venice (Fig. 1). Another nearby area that maintained continuous contacts with the Eastern Adriatic was the Marche region, ancient Picenum, with Numana as its biggest centre. We examined chemical compositions of selected artefacts from three north Italian locations – presumed to have locally produced black-slipped wares from Suasa and Adria (Mazzeo Saracino, 2007) and locally produced and imported black-slipped and Alto Adriatico wares from Spina (Gaucci, 2014) – comparing it with the compositions of selected vessels from our dataset (Group 3 and other artefacts within locally defined groups 1 and 2 that may be stylistically attributed to Alto Adriatico and black-slipped ware for which, in the archaeological inquiry, a North Italian origin is assumed). As no adequate data are presently available for ceramic ware produced in Numana, we used analyses of ceramics from Suasa – another settlement in Marche region. Using statistical multivariate data analyses (PCA, computing parameters same as earlier – Fig. 5), it has been demonstrated that selected Issaean samples do not show any compositional resemblance with the reference material from the literature (Fig. 5d). In more detail, the first three principal components account for 63.96 % of the total variance (28.63 %, 21.93 %, and 13.43 %, respectively) and in the PC1-PC2 space the selected Issaean samples form a somewhat homogenous but clearly distinguishable sample cluster. These results corroborate the mineralogical and microstructural analogy of the vessels from Group 3 with the rest of locally produced Issaean wares and we, therefore, propose the Alto Adriatico and black-slipped ware from Issa to have been locally produced. With regard to the vessels from Group 4, their distinct material properties in terms of highly sintered and vitrified clayey matrix, peculiar natural inclusions (numerous clay pellets), high-temperature changes (exfoliation of 10/14-Å compound layers, new mineral formation - gehlenite, anorthite, and Fe-rich Ca clinopyroxene), distinguish themselves from the Issaean locally produced wares. The type of raw material was essentially illitic but with a significant smectite portion inferred from the content of Ca and compositional ratios of key cations (Si, Al, and Mg). The decoration and forms of the vessels in question are characteristic for the Apulian red-figured ware, Apulian Gnathia, and Apulian black-painted wares. At present, about the precise source area of those artefacts one can only speculate having in mind an outburst of Hellenistic production centres in the area of the South of Italy (e.g. Schierup and Sabetai, 2014; Carpenter et al., 2014; Miše, 2010 with the references therein for Gnathia pottery, respectively). Henceforth, this important question of complex patterns of exchange between Hellenistic centres on the Italian South and eastern Adriatic coast remains to be addressed in some future studies.

In this investigation, we analysed a sample of plain ware amphoriskos (Table I.), for which we presented evidences of Phoenician origin. Namely, a peculiar geochemistry (calcium enrichment and deficiency on other major cations, Table III.) and XRD mineralogy that documented the presence of preserved 15-Å sheet silicates make such a composition practically unique. A smectite nature of raw material is further corroborated by SEM investigations showing a matrix full of flattened and elongated clayey agglomerations enriched in Ca. Silica and calcareous microfossils are reported in significant proportions, forming ~20 % of the matrix (Fig. 9c). The Palaeogene planktonic foraminifera (Subbotina sp.) are frequently encountered, filled with Fe-mineralization (Fig. 9d). This ferrization phenomenon and the rest of the compositional and morpho-stylistic characteristics was solely reported from the Phoenician semi-fine A clayware (Berlin and Frankel, 2012). A hypothesis of Levantine origin of Issaean amphoriskos, however, needs to be further verified using a larger number of samples and an analytical pursuit that would include a comparative geochemical and mineralogical inquiry.

6.3 Archaeological implications of this study

If one is to address the described and discussed results of the scientific study of ceramic pots from the Issaean burials within the broader archaeological context they bring forth some new implications regarding various aspects of Issaean activities. Firstly, one can reflect upon the ideas about the organisation of crafts as part of the local economy. High correlation of mineralogical and geochemical characteristics of analysed ceramic ware whose morphological and stylistic traits suggested local production, makes a strong indication of the existence of ceramic workshop(s) at Issa during the Hellenistic period. The procurement of raw material, as previously hypothesised, was dependent on local occurrences of Terra Rossa, from the area of Komiža (for geochemical Group 1) and the southern-central area (for geochemical Group 2). The transport of clay to Issa demanded functional networks of connectivity across or around the island, and the most plausible means of transit were by sea, aboard ships, along the southern coast of the island. Material traces of Hellenistic times have been preserved in both of the mentioned areas, with a significantly greater concentration in the southern-central part (Kirigin et al., 2006). However, memories of this period in the Komiža area might have also been preserved within the name itself, as one of the proposed etymologies suggests, it can be derived from Kóme Issaía which, in literal translation means 'the Issean village' or 'settlement nearby Issa' (Suić, 2003). A further prerequisite for the manufacture of clay, besides the clay itself, was the availability of water. According to some indications, natural sources of water occurred within the Issaean bay and were usable in antiquity (Gabričević, 1968). As for the reason why the ceramicists from Issa used clays from different localities, we may, at this point, only hypothesise that it was due to restricted access to usable clay materials, as the island of Vis does not have unlimited occurrences of clay. There is no evidence to suggest that raw material from a specific location was preferred for a specific type of wares, or during a more precise period. In other words, the samples of Gnathia, Late Gnathia, black-slipped, grey-slipped, as well as plain-painted wares, that are, according to morphological and stylistic studies, dated from the mid-3rd c. BCE to the end of the Hellenistic period, are presented in both groups. Moreover, for the arbitrarily defined Group 3 the archeometric evidences showed prevailing affinities for local origin, which is also the case for some samples that are located within groups 1 and 2, belonging to Alto Adriatico (oinochoe) and black-slipped ware (skyphos). The idea that some of the Alto Adriatico vases may have been also produced in Issa is not new (Šešelj, 2009), but was never followed upon. If we accept this new evidence, it allows us to hypothesise an earlier date for the beginning of the Issaean ceramic tableware production, in other words, at latest, at the end of the 4th c. BCE. By the mid-4th c. BCE, Issa was already established as a city, and the material remains of the second half of this century bear evidence of different crafts, for example coin minting. Therefore, the role of ceramic craft and its place within the local crafts and economy from the beginning of the Hellenistic period does not come as a surprise. Earlier defined ceramic groups, interpreted as local, will have further applicability in future studies as the archeometric references for Issa.

Further merits of this study can be observed within the context of cultural and economic contacts of Issa during Hellenistic times. The communication with the central and northern area of the Western side of the Adriatic, at the beginning of the Hellenistic period, is evidenced through imported Alto Adriatico ware (Miše, 2012). Samples of such pottery included in this study (e.g. sample n. 7) do not, as it appears, provenance from Spina or Adria, although more caution should be exercised in the final conclusion regarding the latter. This leaves Numana as the most probable source, which unfortunately at this point cannot be confirmed since there is no available geochemical reference for the clay material from this area. However, some previously observed stylistic analogies between several Alto Adriatico vessels from Issa, that are not included in this study, and pots from the Numana necropolis speak favourably on this hypothesis, indicating stronger contacts between the central areas of the Western and Eastern Adriatic coasts. Issa maintained strong communication with the South Italian area which is reflected through diverse material records (pottery, coins, etc.), out of which some was included in this study. More detailed analysis of such contacts goes beyond the scope of this study. However, limited samples have shown differences between imported and local Gnathia ware, suggesting diverse technologies used in ceramic manufacture. The information obtained through the combination of morphological studies, ceramic petrography and material microstructure presents the first evidence of Levantine pottery (amphoriskoi in Phoenician Semi-Fine A fabric) in Issaean graves. These findings offer new insight into the distribution patterns for products originating from the area of modern Lebanon, the Southern coast of Israel and the Northern Coastal Plain. The Phoenician amphoriskoi had indeed a wide range of distribution, without doubt, for the sake of their contents, and have previously been documented on several different localities in the East and Central Mediterranean, as well as the Black Sea (Berlin, 1997; Rotroff, 2006; Regev, 2009/2010; Papuci-Wladyka, 2012). However, until now, their presence has not been attested in the Eastern Adriatic. This new evidence can only be examined in the context of Mediterranean economic patterns, which in the Adriatic area indicated a change from the end of the 3rd c. BCE onwards, when goods from the Eastern Mediterranean started to appear. This is particularly well attested along Western Adriatic where luxurious objects and craft objects started to arrive in major harbours, and consequently appeared in tomb assemblages as well (Yntema, 2013). Such a change was, presumably, brought forth by the political and military events that struck Italy during the end of the 4th and 3rd c. BCE (Šešelj, 2009). Although Dalmatia must have been involved in such new networks, this change was not clearly inferred from the recovered Issaean ceramics probably due to a self-sufficient local ceramic production (Šešelj, 2009). Material evidences presented in this research reporting on the ceramics from the E necropolis of Issa, at least for tableware, are in line with such a reasoning. Still the number of objects from Issaean tombs that provenance from the Eastern Mediterranean, such as ceramic lamps, ointment vessels or coins, has either increased or those items have been documented for the first time, like the Phoenician amphoriskoi. This testifies to the participation of Issa, and therefore Dalmatia, in the interactive networks of economic and cultural seaborne connectivity between the Adriatic and Eastern Mediterranean, as well as introduces Issa as a far-flung market of a popular Levantine product that was transported within the specified container amphoriskoi. The corroboration of cultural contacts of Issa with the Levant can further be reflected in the findings of a coin from Aradus, in ancient Phoenicia (Bonačić Mandinić and Visona, 2002), as well as with the small stone altar, dedicated to the Syrian goddess Atargatis (Dea Suria), that testifies to the introduction of this cult in Issa (Kirigin, 1996; Šešelj, 2009). It was argued that Syrian merchants played a major role in spreading this cult outside its autochthonous area (Šešelj, 2009). The worship of such a goddess is attested on several sites in the Aegean area, and particularly well on the island of Delos (Horster, 2012), from which it disseminated further to the west, firstly to Sicily, and then to other sites, to which Issa can be added. The important role of Delos, in the connectivity between the eastern and western Mediterranean, especially from the 2nd c. BCE onwards when it became a free port, has been emphasised (Šešelj, 2009), and the Phoenician amphoriskoi can be taken as further evidence in this direction, as they were also documented on this island (Bruneau, 1970).

7. CONCLUSIONS

Based on the presented results and the related discussion, the following conclusions can be put forth:

(1) Ceramics analysed in this study originate from Hellenistic tombs of the eastern Issaean necropolis and are dated from the second half of the 4th to the 1st c. BCE, encompassing open and close ceramic forms mostly used as tableware, ointment vessels and cosmetic recipients.

(2) Geochemically, the investigated ceramic material shows a range of compositions and is divided into four compositional groups which are, based on their morphology and decoration patterns, presumed to be either of local origin (Groups 1-3) or imported (Group 4). XRD mineralogy shows a predominance of quartz, plagioclase and Fe-Ca clinopyroxene (diopside), with an occasional occurrence of preserved relicts of 10-Å phyllosilicate, gehlenite and Fe-Mg clinopyroxene (pigeonite). Only in a few cases a striking difference in XRD mineralogy is reported counted on a presence of different expandable and non-expandable clay minerals (14 and 15-Å phyllosilicate).

(3) Optical and electron microscopy (SEM, QEMSCAN®) further showed that ceramic matrix in all the groups consisted of Ca-Mg illite and a range of silicate natural inclusions and clay pellets. A distribution pattern of key mineral inclusions – quartz and feldspars – with a prevalence of fine silt over a coarser fraction is found to match the composition of natural clays exploited in the pottery production. A sample featured by the presence of swelling clays was proved to have distinct morphological and archeometric characteristics, such as a Ca-rich and Si-Mg-Fe-poor geochemistry, preserved calcite mineralization, and ceramic matrix full of calcareous and silica microfossils filled with Fe-mineralization. All these particularities strongly argue in favour of the Levantine origin of the artefact in question.

(4) Regardless of some differences in the structure of four groups of Issaean ceramics, the raw clayey material contained a significant amount of inclusions, naturally seen in clays, which argued for simple paste preparation devoid of tempering or granulometric separation.

(5) Conformant to the stability ranges of 10-Å phyllosilicate and their respective abundances in the Issean ceramic material determined by QEMSCAN® and XRD measurements, the firing temperatures for Issean ware were determined to be in the range of ~850 to ~1000 °C. The microstructural differences between ceramic groups enabled additional fine-tuning of furnace conditions. Thus, the pottery from Group 4 was reported featured by highly vitrified ceramic micromass which contained a system of dense vesicular voids and high-temperature mineral assemblages consisted of fibro to lath-shaped Ca-silicates, like anorthite, clinopyroxene, and gehlenite, emerging as reaction rims within the ceramic matrix. Their appearance and amount of vitreous matter effectively constrained the firing temperatures in this ceramic group to the range of ~900 to 1050 °C. Artefacts belonging to groups 1 to 3 showed similar microstructural characteristics and are practically devoid of newly-formed Ca-silicates. In addition the illitic matrix was preferentially transformed into amorphous metastable compounds thus supporting a relatively short time of firing at peak temperatures.

Based on the high values of porosity, partial dehydroxylation of mica, and calcite obliteration, the utmost firing temperatures were estimated to span from ~850 to 900 °C. For the artefact of supposed Levantine origin, a presence of expandable clay minerals and calcite from the microfossils' skeletons suggested the firing conditions to be at about 600 ±100 °C.

(6) The majority of Issaean pottery, although similar in terms of mineral composition and ceramic microstructure, showed some peculiar geochemical discrepancies well visualised in PCA grouping. These differences stemmed from the impoverishment and enrichment of certain major and critical minor elements in groups 1 and 2. Matrix composition consisting of illite enriched in Fe-Mg clay minerals and a range of natural inclusions strongly called for Terra Rossa outcropping at the island as a potential raw material. This assumption was corroborated by the peculiar grain-size distribution and the ratios and abundances of former sheet silicates versus quartz and feldspar shown to be in line with the values reported for Terra Rossa from the Croatian coastal regions. Variations in the chemistry between the groups is explained by the impact of volcanic rocks weathering present at western part of the island. Artefacts from Group 3, exhibiting a special typology and style (Alto Adriatico vases with painted decoration) typical for North Adriatic provenance were suggested to be locally produced. A somewhat altering geochemistry and an exceptional ceramic microstructure of vessels from Group 4 are in favour of technologically advanced production centre(s) that were located at Italian South. This hypothesis remains, however, to be further investigated.

(7) The Hellenistic age of Issaean artefacts of a presumably local origin, as suggested by stylistic and archeometric evidences, make the existence of ceramic workshop(s) in Hellenistic Issa highly plausible. The onset of the ceramic production on the island must have commenced at the latest by the end of the 4th c. BCE, instead of by the mid-3rd c. BCE, as previously considered. This is supported by the earlier pottery included in this research, which encompassed the Alto Adriatico ware typically provenanced from the North of Italy (Kirigin, 1992), here however proved to present local imitations (Group 3). The remaining local ware manufactured during the last three centuries of pre-Christian era included Gnathia, Late Gnathia and other similar ware, black-slipped, grey-slipped, and plain-painted wares. Spatial constraints defined by insularity conditioned only limited occurrences of suitable raw clays on the island of Vis, which must have prompted ancient Issaeans to procure raw material, usually Terra Rossa, at different locations from the far-western city of Komiža to the south-central coastal areas. This required a good organisation of ceramic manufacture and the existence of functional networks of connectivity across or around the island, most probably strongly relying on ships.

(8) Hellenistic Issa maintained strong and continuous contacts with the Western Adriatic, as well as central and southern areas of the Apennine peninsula. A shift in economic activities in the Mediterranean and related changes in social habits started to take place from the 3rd c. BCE onwards. This resulted in a stronger contact between the Adriatic region and the Eastern Mediterranean. Issa actively participated in such an exchange, being included in the seaborne networks, expanding its market for new products, even from the far-distanced Levant. This is visualised in the demand for new, special commodities transported within unguentaria and amphoriskoi, where the latter made part of the analysed dataset. On the other hand, the local production of tableware and cosmetic containers, as inferred from the available mortuary evidences, seem to have been sufficient at least for funeral purposes.

ACKNOWLEDGEMENTS

Our sincere gratitude goes to B. Kirigin (Archaeological Museum Split, Croatia) who led the excavations of Eastern Issean Necropolis, generously providing us with the material needed for this research. We want to extend our appreciation to everyone who helped us in preparation of this manuscript, in particular to C. Ionescu (Babeş - Bolyai University, Romania) for her fruitful comments and A. Gaucci (Università di Bologna, Italy) for providing us with valuable data. N. Laskowski (TU Darmstadt, Germany) is greatly appreciated for his kind assistance during XRF measurements. J. Beneta (Archaeological Museum Split, Croatia) is acknowledged for providing us with the documentation on ceramic material. F. Gischig (University of Geneva, Switzerland) is thanked for the preparation of high quality thin-sections. We thank A. Ristić and I. Schrunk (University of St. Thomas, Minnesota, U.S.A.) for improvements in English. M. Dunčić (Gazprom Neft, Serbia) kindly helped with microfossils determination. Financial support for this paper was provided by the Croatian Ministry of Science, Technology and Sport (MZOS) (project no: 197-1970685-0682), FG Technische Petrologie (TU Darmstadt/Germany), and Reservoir Geology and Sedimentary Basin Analyses Group (University of Geneva, Switzerland). Financial support for conservation and documentation of analysed pottery from the locality Vlaška Njiva was provided by the Croatian Ministry of Culture.

REFERENCES

Berlin, A. (1997) The Plain wares. *Journal of Roman Archaeology*, Supplementary Series 10,2,1. Ann Arbor.

Berlin, A. and Frankel, R. (2012) The Sanctuary at Mizpe Yammim: Phoenician Cult and Territory in the Upper Galilee during the Persian Period. *Bulletin of American School of Orient Research,* Vol. 366, 25-78.

Berti, F. (1997) I vasi alto-adriatici di Spina. In *Classico Anticlassico, Vasi alto-adriatico tra Piceno, Spina e Adria. Edizioni Aspasia*, F. Berti, S. Bonomi and M. Landolfi (eds.), Bologna, pp 35-51.

Boardman, J. (2009) *The Greeks Overseas the Early Colonies and Trade*. Thames & Hudson, London.

Bonačić Mandinić, M. and Visonà, P. (2002) Monetary circulation on the island of Vis (Issa), c. 350 B.C.- A. D. 600. In *Grčki utjecaj na istočnoj obali Jadrana,* N. Cambi, S. Čače and B. Kirigin (eds.). Abstract book - Split, 24 - 26 September 1998, pp 319-374.

Bonomi, S. (1997) I vasi alto-adriatici di Adria. In *Classico Anticlassico, Vasi alto-adriatico tra Piceno, Spina e Adria*. F. Berti, S. Bonomi and M. Landolfi (eds.), Edizioni Aspasia Bologna, pp 51-81.

Borović, I., Martinčić, S. and Majcen, Ž. (1975) *Basic geological map of SFR Yugoslavia. Sheet Vis, scale 1:100000*, Geological Survey, Zagreb-Federal Geological Survey, Belgrade.

Brady, J.B. (1983) Intergranular difusion in metamorhic rocks. *American Journal of Sciences,* Vol. 283, 181-200.

Bronger, A. and Bruhn-Lobin, N. (1997) Paleopedology of Terrae rossae-Rhodoxeralfs from Quaternary calcarenites in NW Morocco. *Catena,* Vol. 3-4, 279-295.

Brown, G.E., Prewitt, C.T., Papike, J.J. and Sueno, S. (1972) A comparison of the structures of low and high pigeonite. *Journal of Geophysical Research,* Vol. 77, 5778-5789. doi:10.1029/JB077i029p05778

Bruneau, P. (1970) La veaisselle. In *L'îlot de la Maisondes Comédiens. Exploration archéologique de Délos XXVI,* P. Bruneau, C. Vatin, G. Siebert, E. Lévy and V. Grace (eds.), De Boccard Paris, 239-263.

Cabanes, P. (2008) Greek colonisation in the Adriatic. In *Greek Colonisation. An account of Greek colonies and other settlements overseas,* G. R. Tsetskhladze (ed.), vol. 2. Mnemosyne supplementum 193, Brill, Leiden and Boston, pp 155-187

Cambi, N., Kirigin, B., Marin, E. (1980) *Excavations at Issa, Island of Vis, Yugoslavia 1976,1979- A Preliminary Report*, Rivista di archeologia, Vol. 4, Roma-Venezia, 83-86.

Carpenter, T. H., Lynch, K. M. and Robinson, E. G. D. (2014) *The Italic People of Ancient Apulia. New Evidence from Pottery for Workshops*, Markets and Customs, Cambridge University Press, New York.

Čače, S. (1994) Prilozi raspravi o osnivanju grčkih naseobina na Jadranu u 4. stoljeću pr. Kr. *Radovi Filozofskog fakulteta u Zadru*, Vol. 33, 15-32.

Čargo, B. (2008) Nove spoznaje o proizvodnji terakotnih figura u Issi. *Archaeologica Adriatica Zadar*, Vol. 11, 191-200.

Čargo, B. (2010) *Istraživanja jugozapadne isejske nekropole do 1970/Research into the south-west Issa necropolis up to 1970*. Arheološki muzej Split, Split.

Čargo, B. and Miše, M. (2010) Pottery Production in Issa. Vjesnik za arheologiju i povijest dalmatinsku, Vol. 1, 7-40.

Costin, C.L. (2000) The Use of Ethnoarchaeology for the Archaeological Study of Ceramic Production. *Journal of Archaeological Method and Theory*, Vol. 7, 377-403.

Crnjaković, M. (2000) *Vulkani na jadranskim otocima?* Prirodoslovni muzej Split, Split.

Cultrone, G., Molina, E., Grifa, C. and Sebastián, E. (2011) Iberian Ceramic Production from Basti (Baza, Spain): First Geochemical, Mineralogical and Textural Characterization. *Archaeometry*, Vol. 53, 340-363. doi: 10.1111/j.1475-4754.2010.00545.x

Cultrone, G., Rodriguez-Navarro, C., Sebastián, E., Cazalla, O. and De La Torre, M.J. (2001) Carbonate and silicate phase reactions during ceramic firing. *European Journal of Mineralogy,* Vol. 13, 621-634. doi: 10.1127/0935-1221/2001/0013-0621

Descœudres, J.-P. (2013) *Greek colonization movement, 8th-6th c. BCE*. The Encyclopedia of Global Human Migration, Blackwell publishing Ltd. doi: 10.1002/9781444351071.wbeghm260

Devineau, K., Devouard, B., Villiéras, F., Faure, F., Devidal, J.-L. and Kohler, A. (2006) Evolution of product phase assemblages during thermal decomposition of muscovite under strong disequilibrium conditions. *American Mineralogist*, Vol. 91, 413-424.

Dondi, M., Ercolani, G., Fabbri, B. and Marsigli, M. (1998) An approach to the chemistry of pyroxenes formed during the firing of Ca-rich silicate ceramics. *Clay Minerals,* Vol. 33, 443-452. doi: 10.1180/000985598545741

Dubacq, B., Vidal, O. and Andrade, V.D. (2009) Dehydration of dioctahedral aluminous phyllosilicates: thermodynamic modelling and implications for thermobarometric estimates. *Contributions to Mineralogy and Petrology,* Vol. 159, 159-174. doi: 10.1007/s00410-009-0421-6

Durn, G., Ottner, F. and Slovenec, D. (1999) Mineralogical and geochemical indicators of the polygenetic nature of terra rossa in Istria, Croatia. *Geoderma*, Vol. 91, 125-150.

Durn, G. (2003) Terra Rossa in the Mediterranean Region: Parent Materials, Composition and Origin. *Geologia Croatica,* Vol. 56, 83-100.

Forenbaher, S. (ed.) (2009) *A connecting Sea: Maritime Interaction in Adriatic Prehistory*. BAR International series 2037, Archaeopress, Oxford.

Forti, L. (1965) *La ceramica di Gnathia*. Machiaroli, Naples.

Freestone, I.C., Meeks, N.D. and Middleton, A.P. (1985) Retention of Phosphate in Buried Ceramics: An Electron Microbeam Approach. *Archaeometry*, Vol. 27, 161-177. doi: 10.1111/j.1475-4754.1985.tb00359.x

Gabričević, B. (1968) Antički spomenici grada Visa. *Prilozi povijesti umjetnosti u Dalmaciji*, Vol. 17, 5-59.

Gaucci, A. (2014) Necropoli etrusca di Valle Trebba (Spina). Studio di un lotto di tombe del "Dosso E" e indagini archeometriche sulla ceramica a vernice nera dei relativi corredi. Ph.D. Thesis, Department of Earth Sciences, University of Padua.

Gopher, A., Sadeh, S. and Gophna, R. (1992) The pottery assemblage of Nahal Beset I: A neolithic site in the Upper Galilee. *Israel Exploration Journal*, Vol 42, 4-16.

Gottlieb, P., Wilkie, G., Sutherland, D., et al (2000) Using quantitative electron microscopy for process mineralogy applications. *JOM*, Vol. 52, 24-25. doi: 10.1007/s11837-000-0126-9

Grifa, C., Morra, V., Langella, A. and Munzi, P. (2009) Byzantine Ceramic Production from Cuma (campi Flegrei, Napoli). *Archaeometry*, Vol. 51, 75–94. doi: 10.1111/j.1475-4754.2008.00416.x

Grimshaw, R.W. (1971) *The Chemistry and Physics of Clays and Allied Ceramic Materials*. Techbooks, Herndon, VA.

Guggenheim, S., Chang, Y-H. and van Groos, A.F.K. (1987) Muscovite dehydroxylation; high-temperature studies. *American Mineralogist,* Vol. 72, 537-550.

Haberlah, D., Owen, M., Botha, P.W.S.K. and Gottlieb, G (2011) SEM-EDS-based protocol for subsurface drilling mineral indentification and petrological classification. *Proceedings of Broekmans M.A.T.M*, Trondheim, Norway.

Hall, M.E. (2004) Pottery production during the Late Jomon period: insights from the chemical analyses of Kasori B pottery. *Journal of Archaeological Science*, Vol 31, 1439-1450. doi: 10.1016/j.jas.2004.03.004

Heimann, R.B. and Maggetti, R.B.H.M. (2014) *Ancient and Historical Ceramics*. Schweizerbart Science Publishers, Stuttgart, Germany.

Hein, A., Day, P.M., Cau Ontiveros, M.A. and Kilikoglou, V. (2004) Red clays from Central and Eastern Crete: geochemical and mineralogical properties in view of provenance studies on ancient ceramics. *Applied Clay Science*, Vol. 24, 245-255. doi: 10.1016/j.clay.2003.07.009

Hillier, S., Marwa, E.M.M. and Rice, C.M. (2013) On the mechanism of exfoliation of "Vermiculite.". *Clay Minerals*, Vol. 48, 563-582. doi: 10.1180/claymin.2013.048.4.01

Hirt, A.M., Banin, A. and Gehring, A.U. (1993) Thermal generation of ferromagnetic minerals from iron-enriched smectites. *Geophysical Journal International,* Vol. 115, 1161-1168. doi: 10.1111/j.1365-246X.1993.tb01518.x

Hogg, C.S. and Meads, R.E. (1970) The Mössbauer spectra of several micas and related minerals. *Mineralogical Magazine*, Vol. 37, 606-614.

Horster, M. (2012) Priests, priesthoods, cult personnel – traditional and new approaches. In *Civic Priests. Cult Personnel in Athens from the Hellenistic Period to Late Antiquity,* M. Horster and A. Klöckner (eds.). De Gruyter Berlin, 5-26.

Ionescu, C., Hoeck, V. and Ghergari, L. (2011) Electron microprobe analysis of ancient ceramics: A case study from Romania. *Applied Clay Science*, Vol. 53, 466-475. doi: 10.1016/j.clay.2010.09.009

Khalfaoui, A., Kacim, S. and Hajjaji, M. (2006) Sintering mechanism and ceramic phases of an illitic-chloritic raw clay. *Journal of the European Ceramic Society*, Vol. 26, 161-167.

Kirigin, B. (1990) Late Gnathia: a Glimpse at the Issa Case. In *B'Epistemoniki Synantesi Gia Ten Ellenistiki Kerameiki,* E. Drougou (ed). Athens, 57-65 .

Kirigin, B. (1985) Zapažanja o helenističkoj nekropoli Isse. *Materijali*, Vol. 20, 91-104.

Kirigin, B. (1986) *Issa, Otok Vis v helenizmu, exhibition catalogue*. National Museum of Slovenia, Ljubljana.

Kirigin, B. (1992) Vaze tipa ''Alto Adriatico'' iz Isse. *Prilozi povijesti umjetnosti u Dalmaciji*, Vol. 32, 79-88.

Kirigin, B. (1996) *Issa*. Matica hrvatska, Zagreb.

Krigin, B. (2009) Ancient Greeks in Croatia. In *Aspects of Art, Architecture and Cultural Heritage,* J. Bersford Peirse (ed.), Frances Lincon Limited, London, pp. 20-31.

Kirigin, B. and Marin, E. (1985) Issa'80: preliminarni izvještaj sa zaštitnih arheoloških iskopavanja helenističke nekropole Martvilo u Visu: Novi i neobjelodanjeni natpisi iz Visa. *Vjesnik za arheologiju i historiju dalmatinsku,* Vol. 78, 45-72.

Kirigin, B., Katunarić, T. and Šešelj, L. (2005) Amfore i fina keramika (od 4. do 1. st. pr. Kr.) iz srednje Dalmacije: preliminarni ekonomski i socijalni pokazatelji. *Vjesnik za arheologiju i povijest dalmatinsku*, Vol 1, 7-21.

Kirigin, B., Vujnović, N., Burmaz, J., Čače, S., Gaffney, V. and Podobnikar, T. (2006) *The Adriatic Islands Project. The Archaeological Heritage of Vis, Biševo, Svetac, Palagruža and Šolta*. Volume 3, Archaeopress, Oxford.

Kohler, T.A., Van Buskirk, S. and Ruscavage-Barz, S. (2004) Vessels and villages: evidence for conformist transmission in early village aggregations on the Pajarito Plateau, New Mexico. *Journal of Anthropological Archaeology,* Vol. 23, 100-118.

Korbar, T. (2009) Orogenic evolution of the External Dinarides in the NE Adriatic region: a model constrained by tectonostratigraphy of Upper Cretaceous to Paleogene carbonates. *Earth-Science Reviews,* Vol. 96, 296-312. doi: 10.1016/j.earscirev.2009.07.004

Landolfi, M. (1997) I vasi alto- adriatici da Numana e dal piceno. In *Classico Anticlassico, Vasi alto-adriatico tra Piceno, Spina e Adria,* F. Berti, S. Bonomi and M. Landolfi (eds.), Edizioni Aspasia, Bologna,11-35.

Lebart, L., Morineau, A. and Piron, M. (1995) *Statistique exploratoire multidimensionnelle*. Dunod, Paris

Mazzeo Saracino, L. (2007) Ceramica a vernice nera volterrana da una domus repubblicana di Suasa (AN). *Picus,* Vol. 27, 181-209.

Meunier, A. and Velde, B.D. (2004) *Illite - Origins, Evolution and Metamorphism*, Springer Verlag, Berlin, Heidelberg.

Mileusnić, M., Miše, M. and Čargo, B. (2008a) Possible raw material for manufacture of Hellenistic pottery on the island of Vis, Croatia. *Abstract book of Mineralogia – Special Papers*, Zakopane, Poland.

Mileusnić, M., Miše, M. and Čargo, B. (2008b) Provenance and ceramic technology of Gnathia ceramic from Greek settlement of Issa, island of Vis, Croatia. *Abstract book of 37th International Symposium on Archeometry*, University of Siena, Italy.

Miše, M. (2010) Keramika tipa "Gnathia" na istočnoj obali Jadrana (od 4.-do 1. st. pr. K.). Dissertation, University of Zagreb .

Miše, M. (2012) Trgovački kontakti dvaju jadranskih obala krajem 4. i u 3. st. pr. Kr. na primjeru slikane keramike. *Histria Antiqua,* Vol. 21, 231–240.

Miše, M. (2013) A contribution to the study of Gnathia ware from Issa. *Vjesnik za arheologiju i historiju dalmatinsku*, Vol. 106, 99-130.

Pamić, J. and Hrvatović, H. (2003) Main large thrust structures in the Dinarides - a proposal for their classification. *Nafta,* Vol. 54, 443-464.

Papachristodoulou, C., Gravani, K., Oikonomou, A. and Ioannides, K. (2010) On the provenance and manufacture of red-slipped fine ware from ancient Cassope (NW Greece): evidence by X-ray analytical methods. *Journal of Archaeological Science*, Vol. 37, 2146-2154. doi: 10.1016/j.jas.2010.02.013

Papuci-Wladyka, E. (2012) A Phoenician amphoriskos from Olbia in the collection of Jagiellonian University in Kraków. Notes on our research in the Ukraine. In: Blajer, J. (ed) Peregrinationes archaeologicae in Asia et Europa. Wydawnictwo Profil-Archeo, Kraków, 565-576.

Pirrie, D. and Rollinson, G.K. (2011) *The story in the sand: Geological Forensic Analysis of Soils and Sediments*. British Science Festival, Bradford, United Kingdom.

Rancourt, D.G., McDonald, A.M. and Lalonde, A.E. (1993) Mössbauer absorber thicknesses for accurate site populations in Fe-bearing minerals. *American Mineralogist,* Vol. 78, 1-7.

Rathossi, C. and Pontikes, Y. (2010) Effect of firing temperature and atmosphere on ceramics made of NW Peloponnese clay sediments: Part II. Chemistry of pyrometamorphic minerals and comparison with ancient ceramics. *Journal of the European Ceramic Society*, Vol. 30, 1853-1866. doi: 10.1016/j.jeurceramsoc.2010.02.003

Regev, D. (2009/2010) Akko-Ptolemais, a Phoenician city: The Hellenistic pottery. *Mediterranean Archaeology*, Vol. 22/23, 115-191.

Riccardi, M.P., Messiga, B. and Duminuco P (1999) An approach to the dynamics of clay firing. *Applied Clay Science*, Vol. 15, 393-409. doi: 10.1016/S0169-1317(99)00032-0

Rice, P.M. (2006) *Pottery Analysis: A Sourcebook*. University Of Chicago Press, Chicago.

Rottrof, S. (2006) *Hellenistic Pottery: the Plain Wares*. The Athenian Agora vol. XXXIII, Princeton, New Jersey.

Schriever, B.A. (2008) Informal identity and the mimbers phenomenon: Investigating regional identity and archaeological cultures in the Mimbres Mogollon. Ph.D. Thesis, Department of Anthropology, University of Oklahoma.

Schwedt, A., Mommsen, H., Zacharias, N. and Garrigós, J.B.I. (2006) Analcime Crystallization and Compositional Profiles—Comparing Approaches to Detect Post-Depositional Alterations in Archaeological Pottery. *Archaeometry,* Vol. 48, 237-251. doi: 10.1111/j.1475-4754.2006.00254.x

Šegvić, B., Šešelj, L., Slovenec, D., Lugović, B. and Ferreiro Mählmann, R. (2012) Composition, Technology of Manufacture, and Circulation of Hellenistic Pottery from the Eastern Adriatic: A Case Study of Three Archaeological Sites along the Dalmatian Coast, Croatia. *Geoarchaeology*, Vol. 27, 63-87. doi: 10.1002/gea.21379

Šegvić, B., Mileusnić, M., Aljinović, D., Vranjković, A., Mandic, O., Pavelić, D., Dragičević, I. and Ferreiro Mählmann, R. (2014) Magmatic provenance and diagenesis of Miocene tuffs from the Dinaride Lake System (the Sinj Basin, Croatia). *European Journal of Mineralogy,* Vol. 26, 83-101. doi: 10.1127/0935-1221/2013/0025-2350

Šešelj, L. (2009) Promunturium Diomedis: Svetište na rtu Ploča i jadranska pomorska trgovina u helenističkom razdoblju. Ph.D. Thesis, Department of Archaeology, University of Zadar.

Schierup, S. and Sabetai, V. (Eds) (2014) *The Regional Production of Red-figure Pottery: Greece, Magna Graecia and Etruria*. Aarhus Universitetsforlag, Aarhus.

Shoval, S., Beck, P., Kirsh, Y., Levy, D., Gaft, M. and Yadin, E. (1991) Rehydroxyiation of clay minerals and hydration in ancient pottery from the "Land of Geshur.". *Journal of Thermal Analysis*, Vol. 37, 1579-1592. doi: 10.1007/BF01913490

Smykatz-Kloss, W. (1982) Application of differential thermal analysis in mineralogy. *Journal of Thermal Analysis,* Vol. 23, 15-44. doi:10.1007/BF01908484

Stoltman, J.B. (1991) Ceramic Petrography as a Technique for Documenting Cultural Interaction: An Example from the Upper Mississippi Valley. *American Antiquity,* Vol. 56, 103-120. doi: 10.2307/280976

Stylianou, P.J. (1998) *A historical Comentary on Diodorus Siculus*. Clarendon Press, Oxford.

Suić, M. (2003) *Antički grad na istočnom Jadranu*, Golden marketing, Zagreb.

Trindade, M.J., Dias, M.I., Coroado, J. and Rocha, F. (2009) Mineralogical transformations of calcareous rich clays with firing: A comparative study between calcite and dolomite rich clays from Algarve, Portugal. *Applied Clay Science,* Vol. 42, 345-355. doi: 10.1016/j.clay.2008.02.008

Tsetskhladze, G.R. (ed) (2008) *Greek Colonisation. An account of Greek colonies and other settlements overseas*, vol. 2. Mnemosyne supplementum 193, Brill, Leiden and Boston.

Ugarković, M. (2013) Red-figure fish plate from Issa. *Vjesnik za arheologiju i povijest dalmatinsku*, Vol. 106, 75-98.

Ugarković, M. (2014) Oil-lamps from the Graeco-Hellenistic collection of the Archaeological Museum in Split, *Vjesnik za historiju i arheologiju dalmatinsku*, Vol. 107, 161-200.

Ugarković, M. (2015) Pogrebni običaji grčke Isse na temelju arheoloških iskopavanja na položaju Vlaška njiva u Visu. Ph.D. Thesis, Faculty of Humanities and Social Sciences, University of Zagreb.

Vedder, W. (1969) Dehydroxylation and rehydroxylation, oxidation and reduction of micas. *American Mineralogist*, Vol. 54, 482-509.

Velde, B. (1978) High temperature or metamorphic vermiculites. *Contribution to mineralogy and petrology*, Vol. 66, 319-323. doi: 10.1007/BF00373416

Velde, B.D. and Druc, I. (1999) *Archaeological Ceramic Materials - Origin and Utilization*. Springer-Verlag, Berlin, Heidelberg.

Velde, B.D. and Meunier, A. (2008) *The Origin of Clay Minerals in Soils and Weathered Rocks*. Springer-Verlag, Berlin, Heidelberg.

Welton, J.E. (1984) *SEM Petrology Atlas*. The American Association of Petroleum Geologists. Tulsa, Oklahoma.

Whitbread, I.K. (1995) *Greek Transport Amphorae. A Petrological and Archaeological Study*. The British School at Athens. Athens, Greece.

Yeskis, D., van Groos, K.A.F. and Guggenheim, S. (1985) The dehydroxylation of kaolinite. *American Mineralogist*, Vol. 70, 159-164.

Yntema, D. (2013) *The Archaeology of South-East Italy in the first millennium BC, Greek and native societies of Apulia and Lucania between the 10th and the 1st century BC*. Amsterdam University Press.

Zamek, J. (2009) *The Potter's Studio Clay and Glaze Handbook: An Essential Guide to Choosing, Working, and Designing with Clay and Glaze in the Ceramic Studio*, Backyard Series. Quarry Books, Beverly.