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# Archaeometric analyses on pottery from archaeological excavations in Messina (Sicily, Italy) from the Greek archaic to the Medieval age

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ABSTRACT. — In the present paper we report for the first time all the results obtained through a multidisciplinary investigation on some of the most representative ceramic classes (cooking pottery, tiles, *banded*, *Corinthian B*, *ionian-massaliote* and *pseudo-chian* amphorae, *Zancle type* cups, *Chalcidian*, *Attic*, *banded* and *a immersione* wares, *ionian banded B2*, black-glazed vessels and a arula sherd) coming from archaeological excavations in Messina, covering a period from Greek archaic to Medieval age. The aim of the present work is to characterize the pottery's production centers in Messina and to distinguish the local products from the imported ones; this will help us to get further information on the commercial network involving the «Strait Area». The samples were analysed by mineralogical-petrographic and chemical-physical techniques. In particular, X-Ray Diffraction (XRD), thin section analysis by Optical Microscopy (OM), Fourier Transform Infrared Absorption (FTIR), X-Ray Fluorescence (XRF), Inductively Coupled Plasma Mass Spectroscopy (ICP-MS), Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), and Scanning Electron Microscopy coupled with X-ray Energy Dispersion (SEM-EDX) were employed.

The obtained results have evidenced the local production of the coarse potteries (cooking pottery, tiles), contrary to the *ionian-massaliote* and *pseudo-chian* transport amphorae that result to be imported products from Locri and, in some cases, from a non located site in Campania; the production of the *Corinthian B* type amphorae can be attributed both to a Greek (Corfù) and to a colonial magno-Greek (Sibari) imported production center. Finally, for what concerns the fine pottery, the *Chalcidian*, *banded*, *ionian B2*, *a immersione* and *Zancle* potteries result produced in the «Strait area», whereas the *Attic* ceramics are imported from Greek production centers.

RIASSUNTO. — Il presente lavoro fa parte di un progetto interdisciplinare su alcune delle più rappresentative classi ceramiche (ceramiche da cucina, tegole, anfore *a bande*, anfore *corinzie tipo B*, *ioniche massaliote* e *pseudo-chiote*, coppe *tipo Zancle*, ceramiche *calcidesi*, *attiche*, e *a bande*, ioniche a bande B2, ceramiche a vernice nera e un frammento di arula) provenienti dagli scavi archeologici dell'area di Messina e risalenti a diversi periodi, dal greco arcaico a quello medioevale. Scopo della ricerca è la caratterizzazione delle antiche fabbriche di Messina e la distinzione dei prodotti locali da quelli importati, anche al fine di ottenere informazioni sugli scambi commerciali nell'area dello Stretto. I campioni sono stati sottoposti ad analisi mineralogiche-petrografiche e chimico-fisiche. In particolare, ciascun campione è stato analizzato tramite diffrazione a raggi X (XRD),

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microscopia ottica (OM), spettroscopia infrarossa in trasformata di Fourier (FTIR), fluorescenza a raggi X (XRF), spettrometria di emissione al plasma (ICP-MS), spettroscopia ottica di emissione al plasma (ICP-OES), and microscopia a scansione di elettroni accoppiata con dispersione di energia a raggi X (SEM-EDX). I risultati ottenuti hanno evidenziato che le ceramiche di tipo grossolano (ceramiche da cucina e tegole) sono di produzione locale (Messina). Le anfore da trasporto *ionico-massaliote* e *pseudo-chiote* sono invece importate e prodotte a Locri, in alcuni casi da una località della Campania non ben localizzata; le anfore di tipo *Corinzio B* sono importate un gruppo dalla Grecia (Corfù), un altro probabilmente da Sibari. Infine per quanto concerne la ceramica fine, la ceramica calcidese, a bande, *ad immersione,* ioniche B2 e *Zancle* sono di produzione dell'«area dello Stretto», mentre le ceramiche Attiche sono importate dalla Grecia.

Key Words: *coarse pottery, transport amphorae, fine pottery, local production Messina (Sicily), imported pottery, Greek-archaic age, Medieval age, archaeometric analysis*

## Introduction

In the present work we report the results of an oriented research, carried out through an interdisciplinary approach, aimed at characterizing 119 pottery's sherds all coming from archaeological excavations in Messina. Such a wide collection of investigated sherds, belonging to different typologies and chronological periods, testifies the considerable and flourishing pottery production in Messina from the Greek-archaic to the Medieval period.

From the beginning of our research, the archaeometric investigation revealed to be of fundamental importance to get a deeper knowledge of the local production centers in the «Messina Area».

The starting point of our investigation was a group of pottery's sherds coming from ancient workshops, chronologically different but all certainly produced in the «Messina Area». These samples have been used as a reference in order to identify the «Strait of Messina Area» products from the imported ones.

## Archeological materials and reference materials

The investigated sherds (119 samples) of pottery are representative of stylistically and functionally different classes, such as coarse and cooking pottery, transport amphorae and archaic fine ware. In particular, they include a group of coarse pottery's sherds found in kilns of Roman and Medieval age, such as cooking pottery (ME10, ME11, ME12, ME13, ME14, ME15, ME9, ME96, ME97, ME102, ME103), bricks and tiles (ME18, ME150, ME151, ME152, ME153, ME154, ME155) and *banded* amphorae (ME16, ME17); a group of archaic and classical transport amphorae, such as the so called *Corinthian B* (ME5, ME6, ME7, ME8, ME37, ME38), *ionian-massaliote* (ME2, ME95), *pseudo-chian* (ME4, ME43, ME44, ME94) and *Locrian* (ME1, ME3, ME40, ME41) types; a group of archaic fine pottery's sherds, such as the so called *Zancle type* cups (ME26, ME91, ME92), *Chalcidian* (ME23, ME24, ME67, ME68, ME69, ME70, ME72, ME73, ME74, ME75, ME76, ME111, ME113, ME114, ME117, ME118, ME119, ME131, ME133, ME134, ME140), *Attic* (ME25, ME77, ME78, ME79, ME80, ME87, ME145,ME146, ME147, ME148), *banded* and *a immersione* (ME27, ME29, ME55, ME56, ME59, ME60, ME84, ME85, ME86, ME112, ME115, ME121, ME128, ME130, ME139, ME144) potteries; *banded B2 ionian cups* (ME28, ME50, ME51, ME53, ME116, ME120, ME124, ME125, ME126, ME137, ME138, ME141, ME142, ME143); a small group of hellenistic black-glazed plates (ME57, ME58, ME88, ME90, ME129, ME132, ME135, ME136, ME149) and potteries (ME19, ME21, ME22); and finally an arula sample (ME66). A list of all the investigated samples together with the corresponding Munsell indexes are reported in Table 1.

As a reference material, sherds found in potter workshops, ME10, ME11, ME12, ME18, ME9, ME96, ME97, ME102, ME103, ME16 and ME17, and clays found in the nearby of Messina were also examined.

TABLE 1

*List of the samples analysed by OM, XRD, FTIR, SEM, XRF, ICP-MS, ICP-OES (see text for more details)*

| Samples | | Munsell | OM | XRD | FT-IR | SEM | XRF | ICP-MS | ICP-OES |
|---|---|---|---|---|---|---|---|---|---|
| Clays from Messina | GRAV, GRV3, ANN, ANNG | | | 4 | 4 | | 2 | 4 | |
| Cooking pottery and red glazed | ME10, ME11, ME12, ME13, ME14, ME15 ME9, ME96, ME97, ME102, ME103 | 2.5YR 4/4 - 2.5YR 5/8 | 8 | 11 | 7 | 1 | 9 | 1 | 8 |
| Bricks and tiles | ME18, ME150, ME151, ME152, ME153, ME154, ME155 | 2.5YR 5/8 - 2.5Y 8/4 | 6 | 7 | 1 | 7 | | 1 | |
| Medieval banded amphorae | ME16, ME17 | 5YR 7/6 - 10YR 7/3 | 2 | 2 | 2 | | 1 | 1 | |
| Corinthian B amphorae | ME6, ME7, ME8 | 5 Y 8/2 - 5Y 8/3 | 3 | 3 | 2 | | | 3 | |
| | ME5, ME37, ME38 | 10YR 7/4 - 2.5Y8/3 | 3 | 3 | 2 | | | 3 | |
| Locrian amphorae | ME1, ME3, ME40, ME41 | 7.5YR 7/4 - 2.5Y 8/3 | 3 | 4 | 4 | | | 4 | |
| Ionian-massaliote amphorae | ME2, ME95 | 5YR 6/8 | 2 | 2 | 2 | 1 | | | |
| Pseudo-chian amphorae | ME4, ME43, ME44, ME94 | 5YR 6/6 - 7.5YR 7/6 | 3 | 4 | 4 | 3 | | 1 | |
| Zancle cups | ME26, ME91, ME92 | 5YR 6/8 - 7.5YR7/6 | 3 | 3 | 3 | | | 3 | |
| Chalcidian pottery | ME23, ME24, ME67, ME68, ME69, ME70, ME72, ME73, ME74, ME75, ME76, ME111, ME113, ME114, ME117, ME118, ME119, ME131, ME133, ME134, ME140 | 2.5YR 6/8 - 7.5YR 7/6 | 3 | 17 | 11 | 6 | 10 | 6 | |
| Attic pottery | ME25, ME77, ME78, ME79, ME80, ME87, ME145, ME146, ME147, ME148 | 5YR 6/6 - 10YR 7/4 | 4 | 10 | 5 | 2 | 4 | 4 | |
| Banded and a immersione pottery | ME27, ME29, ME55, ME56, ME59, ME60, ME71, ME81, ME83, ME84, ME85, ME86, ME112, ME115, ME121, ME126, ME127, ME128, ME130,ME139, ME144 | 5YR 4/1 - 10YR 8/6 | 4 | 26 | 19 | 6 | 17 | 9 | |
| banded B2 ionian | ME28, ME50, ME51, ME53, ME116, ME120, ME124, ME125, ME126, ME137, ME138, ME141, ME142, ME143 | | | | | | | | |
| Black - glazed plates | ME57, ME58, ME88, ME89, ME90, ME129, ME132, ME135, ME136, ME149 | 5YR 6/6 - 7.5YR 7/8 | 2 | 10 | 5 | 1 | 5 | 5 | |
| Black - glazed pottery | ME19, ME21, ME22 | 2.5YR 6/8 - 7.5YR 7/6 | 2 | 4 | 4 | | | | |
| Arula | ME66 | 5YR 7/8 | 1 | 1 | 1 | | 1 | 1 | |

With reference to the elements present in traces, we observed differences in the Ba, Rb and Sr content, whereas the presence of Ni and Cr is comparable.

*2. Coarse pottery and tiles*

The group includes: cooking pottery's samples, red-glazed-inside pans and tiles of Greek age and one of Medieval age.

2a. Cooking pottery samples

The petrographical examination performed by optical microscopy on the cooking pottery samples (ME10, ME11, ME12, ME13, ME14 e ME15) shows different textures, with a temper varying between 10 and 30%. The clasts, between 0.8 and 1.6 mm, are heterogeneous and heterogranular without a preferential orientation and with sharp edges. The analysis showed the presence of a mica mixture with thick fragments of muscovite and biotite and a coarse metamorphic clast of medium high degree constituted by large fragments of quartz-feldspar, polycrystalline quartz, microcline K-feldspar, hematite and dull minerals. This temper fragments suggests a provenance from the Calabro-Peloritan region (Atzori *et al.* 1974; Amodio-Morelli *et al.* 1976; Atzori *et al.* 1979; Pezzino-Puglisi 1980; Ioppolo 1983; Ioppolo-Battaglia 1983; Messina-Russo 1993; Messina *et al.* 1994).

As reported in Table 4 the samples show a very similar composition with the presence of quartz, plagioclase, K-feldspar, and illite together with a small quantity of oxides and traces of calcite.

The XRF, ICP-MS and ICP-OES analyses (see Table 5) revealed a different $Al_2O_3$ content ranging between 18.02 wt% and 20.73 wt%, and a MgO content between 1.06 e 1.53 wt% (Fig. 1a). The presence of Cr is less than 100 ppm, the Ni content is between 16 and 272 ppm, and Co is between 8 and 232 ppm. Rb presence has been revealed only in the ME10 sample (Fig. 1b, c).

The comparison between the cooking potteries and the clays from Messina area, revealed a composition more similar to the clays from the Annunziata stream than to the Gravitelli clays. In particular, according to Maniatis and Tite (1978), these potteries belong to the same class of calcareous clays of the sample ANN.

All these findings suggest that the products from Messina belong to the pole 3 (good making cooking pottery) in the frame of the coarse pottery's classification by M. Picon and G. Olcese (1995). In fact, it's probable that the cooking potteries produced in Messina were exported in other Sicilian cities, as testified by the numerous cooking pottery sherds, produced in Messina, found in Siracusa (Agodi *et al.* 1996) and Segesta.

2b. Red-glazed-inside pans

A group of red-glazed-inside pans (ME9, ME96, ME97, ME102 e ME103), has been also studied. These samples, coming from local workshops, have been differently classified for typology, style and period (Sannino, 1997, 1998). The archaeometric analyses showed to be particularly suitable in this case, because of the wide diffusion and the numerous imitations of this pottery class.

These samples evidenced a composition similar to the cooking potteries (Table 5 and Fig. 1a, b) but with different textures. In particular, the content of Ni and Cr is perfectly comparable, except for the sample ME9, the Ni content of which is higher (270 ppm).

In these samples temper fragments were revealed (30%) together with homogranular clasts with sharp edges and without orientation, with a dimension varying between 0.24 mm and 0.32 mm. The presence of quartz, sometimes polycrystalline quartz, plagioclase and K-feldspar was also revealed. Moreover, very sparse fragments of rock of lower metamorphic degree, but certainly of Peloritan provenance, are present. The diffractometric analysis (Table 4) evidenced the presence of Quartz, plagioclase and K-feldspar, oxides, calcite traces, biotite, muscovite and illite.

TABLE 4

*Cooking pottery: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | I | Mont | K | Mu | Bi | Amph | C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME10 | + | tr | + | tr | + | ++ | - | tr | + | + | - | - |
| ME11 | + | tr | + | tr | + | ++ | - | tr | + | + | - | - |
| ME12 | + | tr | + | tr | + | ++ | - | tr | + | + | - | - |
| ME13 | + | tr | + | tr | + | ++ | - | tr | + | + | - | - |
| ME14 | + | + | tr | tr | + | ++ | - | - | + | + | - | + |
| ME15 | + | + | + | tr | tr | ++ | - | - | + | + | - | + |
| ME9 | + | + | tr | tr | + | ++ | - | - | + | + | - | - |
| ME96 | + | - | - | + | - | - | - | - | + | - | - | - |
| ME97 | + | - | tr | + | tr | + | - | - | tr | tr | + | - |
| ME102 | + | - | tr | + | - | - | - | - | tr | - | - | - |
| ME103 | + | tr | tr | tr | + | + | - | - | + | + | - | - |

TABLE 5

*Cooking pottery: experimental data obtained by chemical analyses (XRF; ICP-MS; ICP-OES).*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME12 | 62.63 | 1.03 | 19.82 | 7.93 | 0.15 | 1.37 | 1.34 | 1.54 | 2.59 | 0.18 |
| ME13 | 62.40 | 1.04 | 20.69 | 8.11 | 0.10 | 1.16 | 0.86 | 1.15 | 2.88 | 0.15 |
| ME14 | 56.02 | 0.85 | 18.02 | 7.00 | 0.08 | 1.30 | 2.62 | 1.03 | 2.49 | 1.47 |
| ME15 | 55.85 | 1.00 | 20.22 | 8.53 | 0.14 | 1.38 | 2.25 | 1.11 | 2.52 | 1.54 |
| ME9 | 63.59 | 0.98 | 18.95 | 7.02 | 0.14 | 1.07 | 1.53 | 1.73 | 2.60 | 0.15 |
| ME96 | 57.97 | 1.06 | 20.73 | 8.47 | 0.14 | 1.53 | 1.81 | 1.11 | 2.24 | 0.22 |
| ME97 | 56.38 | 1.01 | 19.43 | 8.14 | 0.12 | 1.45 | 2.01 | 1.03 | 2.32 | 0.22 |
| ME102 | 59.49 | 1.03 | 20.61 | 7.93 | 0.12 | 1.44 | 1.35 | 1.30 | 2.67 | 0.17 |
| ME103 | 56.21 | 0.96 | 20.12 | 8.26 | 0.11 | 1.06 | 1.73 | 1.05 | 2.57 | 0.22 |

| | V | Cr | Co | Ni | Rb | Sr | Ba |
|---|---|---|---|---|---|---|---|
| ME10 | 133 | 10 | 21 | 48 | 118 | 340 | 612 |
| ME11 | n.d. | 76 | 26 | 40 | n.d. | 488 | 624 |
| ME12 | n.d. | 56 | 84 | 64 | n.d. | 294 | 605 |
| ME13 | n.d. | 68 | 232 | 124 | n.d. | 176 | 568 |
| ME14 | n.d. | 30 | 8 | 16 | n.d. | 1120 | 880 |
| ME15 | n.d. | 48 | 76 | 60 | n.d. | 960 | 880 |
| ME9 | n.d. | 52 | 20 | 272 | n.d. | 320 | 600 |
| ME96 | n.d. | 74 | 120 | 72 | n.d. | 400 | 624 |
| ME97 | n.d. | 36 | 160 | 96 | n.d. | 616 | 600 |

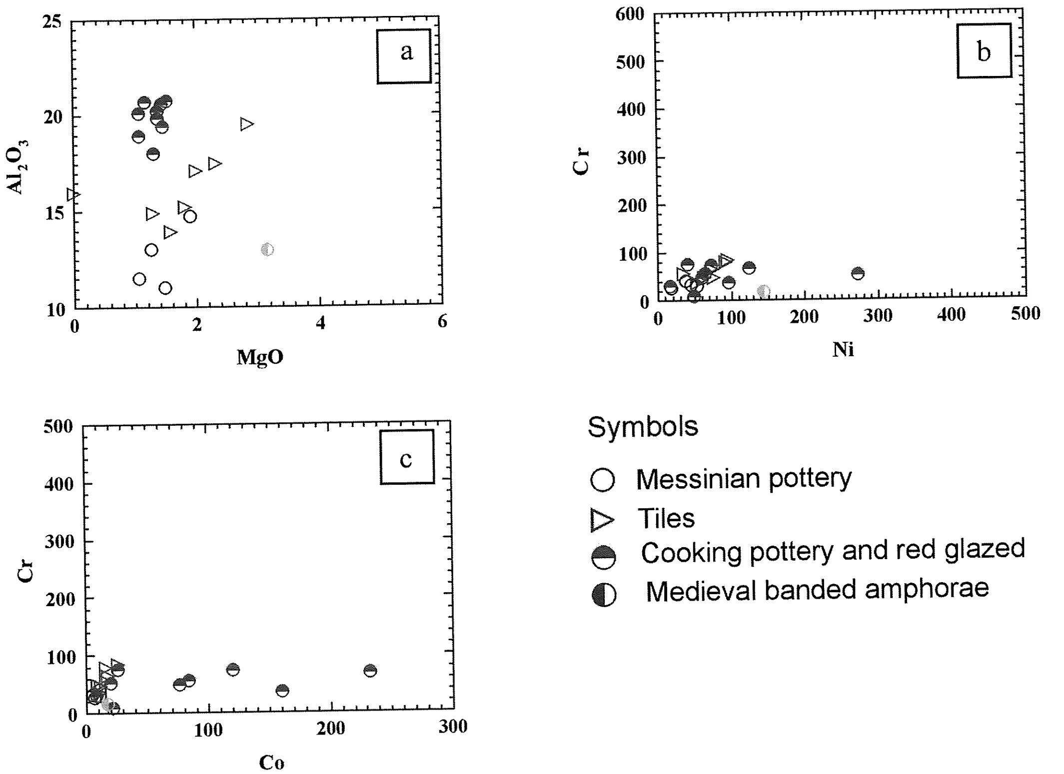


Fig. 1 – Compositional diagrams of clays from Messina and local pottery. Oxides and elements are expressed in wt% and in p.p.m. respectively.

2c. Tiles

To better solving the problems related to the identification of the local productions, a group of tiles, of supposed local production, (ME18, ME150, ME151, ME152, ME153, ME154 e ME155) were also studied.

The petrographic analysis revealed a texture sometimes compact and sometimes vesicular; temper around 10%; heterogeneous and heterogranular clasts, around 1.2 mm, often with sharp edges and without orientation. The inclusions are mainly constituted of large biotite crystals (5 mm), lengthened muscovite lamels, mono and polycrystalline quartz with undulatory extintion, K-feldspar, plagioclase, and numerous iron oxides. Moreover, Foraminifera moulds are also present. Fragments of metamorphic clasts with roundshaped edge and chamotte are rare.

The diffractometric analysis (Table 6) evidenced the presence of quartz, illite, plagioclase, K-feldspar, montmorillonite, hematite (which is absent in the ME152), secondary calcite (absent in ME152), muscovite, biotite, traces of gehlenite (absent in ME155), and wollastonite (present only ME152, ME153 and ME154). The presence of wollastonite can be connected to a baking temperature of 900°C (Capel *et al.*, 1985; Duminuco *et al.*, 1996).

The chemistry of most elements is quite homogeneous (see Table 7), with little variations in the content of $Al_2O_3$, $Fe_2O_3$ e

TABLE 6

*Bricks and tiles: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | I | Pl | Kf | Mont | Hm | Cc | Mu | Bi | Geh | Wo |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ME18 | ++ | + | ++ | + | - | tr | + | + | + | + | - |
| ME150 | + | + | + | + | + | + | + | + | + | + | - |
| ME151 | + | + | ++ | + | + | + | ++ | + | + | + | - |
| ME152 | + | + | + | + | + | - | - | + | + | tr | + |
| ME153 | + | + | + | + | + | + | + | + | + | tr | + |
| ME154 | + | + | + | + | + | + | + | + | + | tr | + |
| ME155 | + | + | + | + | + | + | ++ | + | + | - | - |

TABLE 7

*Bricks and tiles: experimental data obtained by chemical analyses (XRF; ICP-OES). Oxides are expressed in wt% and elements in p.p.m.*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME18 | 59.62 | 1.03 | 19.54 | 7.82 | 0.11 | 2.86 | 2.43 | 1.64 | 3.70 | 0.23 |
| ME150 | 61.06 | 0.67 | 13.95 | 5.85 | 0.12 | 1.57 | 12.73 | 1.10 | 2.70 | 0.26 |
| ME151 | 53.43 | 0.89 | 17.11 | 9.74 | 0.17 | 1.99 | 11.65 | 1.03 | 3.52 | 0.47 |
| ME152 | 58.90 | 0.70 | 15.96 | 7.21 | 0.12 | 0.00 | 12.77 | 1.77 | 2.24 | 0.31 |
| ME153 | 57.66 | 0.68 | 15.20 | 6.38 | 0.12 | 1.80 | 13.67 | 1.26 | 2.90 | 0.34 |
| ME154 | 58.58 | 0.82 | 17.48 | 8.46 | 0.14 | 2.31 | 7.30 | 1.75 | 2.93 | 0.23 |
| ME155 | 58.72 | 0.77 | 14.92 | 6.86 | 0.10 | 1.29 | 12.79 | 0.81 | 2.88 | 0.86 |

| | V | Cr | Co | Ni | Rb | Sr | Ba |
|---|---|---|---|---|---|---|---|
| ME18 | n.d. | 56 | 16 | 34 | n.d. | 216 | 592 |
| ME150 | 98 | 47 | 11 | 75 | 34 | 317 | 697 |
| ME151 | 129 | 64 | 18 | 74 | 87 | 609 | 1270 |
| ME152 | 132 | 80 | 16 | 92 | 90 | 626 | 1203 |
| ME153 | 62 | 36 | 11 | 53 | 70 | 400 | 859 |
| ME154 | 175 | 84 | 26 | 95 | 59 | 229 | 586 |
| ME155 | 98 | 48 | 9 | 63 | 5 | 734 | 1448 |

CaO. Generally, the $Al_2O_3$ content is lower in comparison with the value of cooking pottery, whereas the values of the elements present in traces are well comparable (Fig. 1).

In view of the obtained results, we can attribute the production of the investigated tiles to local workshops.

2d. Medieval banded amphorae

With reference to the Medieval *banded* amphorae (ME16 and ME17), the petrographic examination performed by optical microscopy revealed the presence of temper, around 20%, and heterogeneous and heterogranular clasts, between 0.16 a 0.6 mm, with sharp edges and without orientation. A mica mixture with thick fragments of muscovite and biotite and a metamorphic clast of medium-high degree, similar to that of the cooking pottery was also revealed. However, as evidenced by diffractometric analysis (Table 8), they are different from the cooking potteries both quantitatively, because of the presence of quartz, plagioclase, K-feldspar, and illite, and qualitatively because of the total absence of kaolinite and the presence of gehlenite in ME17.

The chemical analyses (Table 9 e Fig. 1) revealed a Ni, Cr, Co composition similar to that observed in the other coarse potteries.

### 3. *Transport amphorae*

Archaic and classical transport amphorae (Spagnolo, 2003) were examined in order to identify their provenance, presumably localizable in Southern Italy or in Sicily.

The research includes the so-called *Corinthian B*, *ionian-massaliote* and *pseudo-chian* types, whose origin and geographical provenance is still under discussion (Spagnolo, 2003 and references therein). Even if we analyzed a limited number of samples, our results can be considered fairly realistic.

#### 3a. Corinthian B type

As regards the *Corinthian B* type, the production of which has been located by archaeologists or in Corinth or in an uncertain western-Greek colony (Spagnolo 2003), the samples have been divided in two distinct groups depending on the macroscopic, mineralogical and chemical composition. The first group includes the ME5, ME37 and ME38 samples (5Y 8/2 – 5Y 8/3, Table 1). They have similar clasts with a thin grain mixture, temper (5 and 10%), and heterogeneous and heterogranular clasts, 0.16 a 0.8 mm, with sharp, sometimes sub-rounded, edges, without an orientation. Quartz, plagioclase, fragments of flint (up to 2mm length) and K-feldspar traces are also present (Table 10). Only in the sample ME37 muscovite and biotite fragments were revealed. By optical microscopy the first group seems very similar to the *Corinthian B* amphorae classified as *«fabric 1»* and doubtfully attributed to Corinth by Whitbread (1995). Moreover, by using FTIR the presence

TABLE 8

*Medieval banded amphorae: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | I | Mont | Mu | Bi | Geh | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ME16 | ++ | + | ++ | - | tr | + | - | + | + | - | - |
| ME17 | ++ | ++ | ++ | - | + | + | tr | + | + | + | |

TABLE 9

*Medieval banded amphorae: experimental data obtained by chemical analyses (XRF; ICP-MS).*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME17 | 51.35 | 0.57 | 12.97 | 5.39 | 0.43 | 3.15 | 14.2 | 0.89 | 3.07 | 0.31 |
| | V | Cr | Co | Ni | Rb | Sr | Ba | | | |
| ME16 | 101 | 17 | 17.8 | 144 | 146.84 | 509.38 | 561.26 | | | |

TABLE 10

*Corinthian B amphorae: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | Mont | K | Se | Mu | Bi | Geh | Ep | Fl | Amph |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME5 | + | - | + | - | tr | tr | ++ | - | - | - | - | ++ | + | - |
| ME37 | + | + | + | - | + | tr | + | - | tr | + | - | + | + | - |
| ME38 | + | tr | + | - | tr | - | + | - | - | - | - | + | + | - |
| ME6 | + | - | + | + | tr | - | - | + | + | - | tr | - | - | - |
| ME7 | + | - | + | + | tr | - | - | + | ++ | - | - | - | - | - |
| ME8 | + | - | + | + | tr | - | - | + | + | - | - | - | - | + |

of kaolinite was identified on the surface of the three samples investigated.

The ME6, ME7 and ME8 samples belong to the second group (10YR 7/4 – 2.5Y 8/3, Table 1), characterized by a temper varying between 5 and 20%, heterogeneous and heterogranular clasts with sharp, sometimes sub-rounded, edges. The texture presents no orientation for the sample ME6 and ME8, and a prevalent orientation of the mica in the sample ME7. The average dimension of the clasts is around 0.8 mm, with a maximum dimension of 2 mm. Thick or large inclusions of hematite, quartz , muscovite, sericite together with K-feldspar and traces of calcite microcrystallina and gehlenite are present (Table 10); in ME6 the clasts are composed of fragments of metamorphic rocks. In ME7 a higher mica content was revealed in the mixture; finally in the ME8 sample amphibole minerals (chloritized horneblende) are also distinguished.

In Figure 2a and 2b the IR spectra of the sample ME5 and ME6 are reported, respectively. As can be seen, the presence of

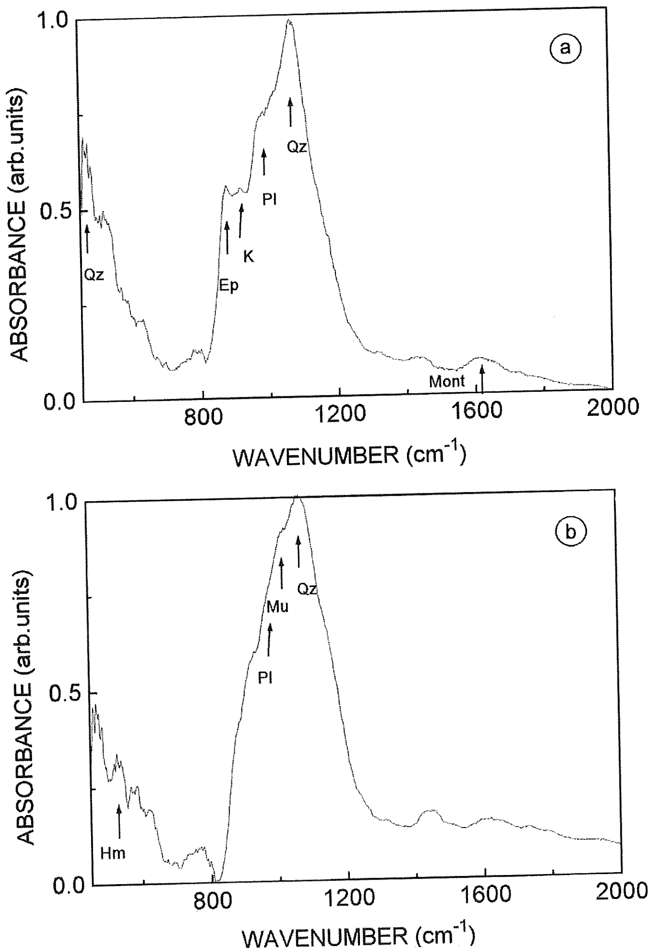


Fig. 2 – Experimental FT-IR absorbance spectra: a) «Corinthian B» amphora, sample ME5; b) «Corinthian B» amphora, sample ME6.

kaolinite and epidote was revealed only in the sample ME5.

The chemical analysis (ICP-MS) results to be particularly significant especially for what concerns the trace elements (Table 11, Fig. 3). As it has been demonstrated, the concentration of some elements, in particular of Ni and Cr, differs sensibly from Greece to South Italy - being the chemical composition of the clays strictly connected to the geographical areas (Jones, 1986; Jones and Orvini, 1994; Levi *et al.*, 1999; Barone *et al.*, 2002, part II). In our case, concentration values of these elements allows us to divide the samples into the two groups already recognized by the petrographic examinations and which can be connected to geographically different production centers.

The analysis of the samples ME6, ME7, and ME8, characterized by a low Ni and Cr content (Fig. 3a), suggests a location of the production center in a western-Greek region, in particular in the Calabro-Peloritan region. According to archeological reports, the provenance from the Calabrian Ionic coast is supported by the results of the comparison of petrographical and chemical analyses performed on potteries from Calabrian area. In particular, we refer to the chemical anlyses (ICP-OES) recently performed on: i) trade amphorae produced in Locri (Mirti-Casoli 1995; Barra-Bagnasco *et al.* 2001); ii) chemical analyses by means of INAA on protostoric wares from Sibari's area (Jones-Orvini 1994; Levi *et al.* 1999); iii) petrographical analyses on roman amphorae coming from Trebisacce (Luppino-Sangineto 1992) and on amphorae Keay LII from Lazzaro, Pellaro, Bova Marina and Casignana Palazzi (Capelli 1998); iv) mineralogical-petrographical and chemical analyses on Medieval and post-Medieval terracotta objects (so called «caroselli») from several places in Calabria, such as Crotone (Gattuso *et al.* 2000).

In comparison with the results on pottery's samples from Locri (Barra Bagnasco *et al.* 2001) and Crotone (Gattuso *et al.* 2000), in our samples we find a lower content of Ni and Cr (Fig. 3a), and, in some cases, of Rb. The Ba content is lower in comparison with the Locrian sherds but is slightly higher in comparison with the ones from Crotone (Fig. 3d,e). ME6, ME7 and ME8 are more similar to the sherds from southern Sibaritide (Jones-Orvini 1994; Levi *et al.* 1999), mostly for the Cr, Co, Rb, (Fig. 3b, d), Cs and the rare earths content.

On the contrary ME5, ME37 and ME38 show high concentrations of Ni and Cr (Ni $\geq$ 238 ppm, Cr $\geq$ 387 ppm) (Table 11, Fig. 3a), so

TABLE 11

*Corinthian B amphorae: experimental data obtained by chemical analyses (ICP-MS). Oxides are expressed in wt% and elements in p.p.m.*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME37 | 58.71 | 12.31 | 5.70 | 0.14 | 3.55 | 9.97 | 1.55 | 2.42 | 0.66 | 0.38 |
| ME38 | 54.86 | 13.12 | 6.47 | 0.09 | 4.42 | 14.23 | 1.90 | 1.26 | 0.67 | 0.20 |

| | V | Cr | Co | Ni | Rb | Sr | Ba |
|---|---|---|---|---|---|---|---|
| ME5 | 110 | 387 | 20 | 262 | 53.66 | 778 | 549 |
| ME37 | 107 | 398 | 29 | 248 | 89.00 | 870 | 427 |
| ME38 | 120 | 438 | 27 | 238 | 31.80 | 719 | 266 |
| ME6 | 89 | 17 | 11 | 42 | 77.02 | 581 | 538 |
| ME7 | 119 | 40 | 12 | 56 | 122.77 | 725 | 534 |
| ME8 | 120 | 42 | 13 | 42 | 77.35 | 425 | 378 |

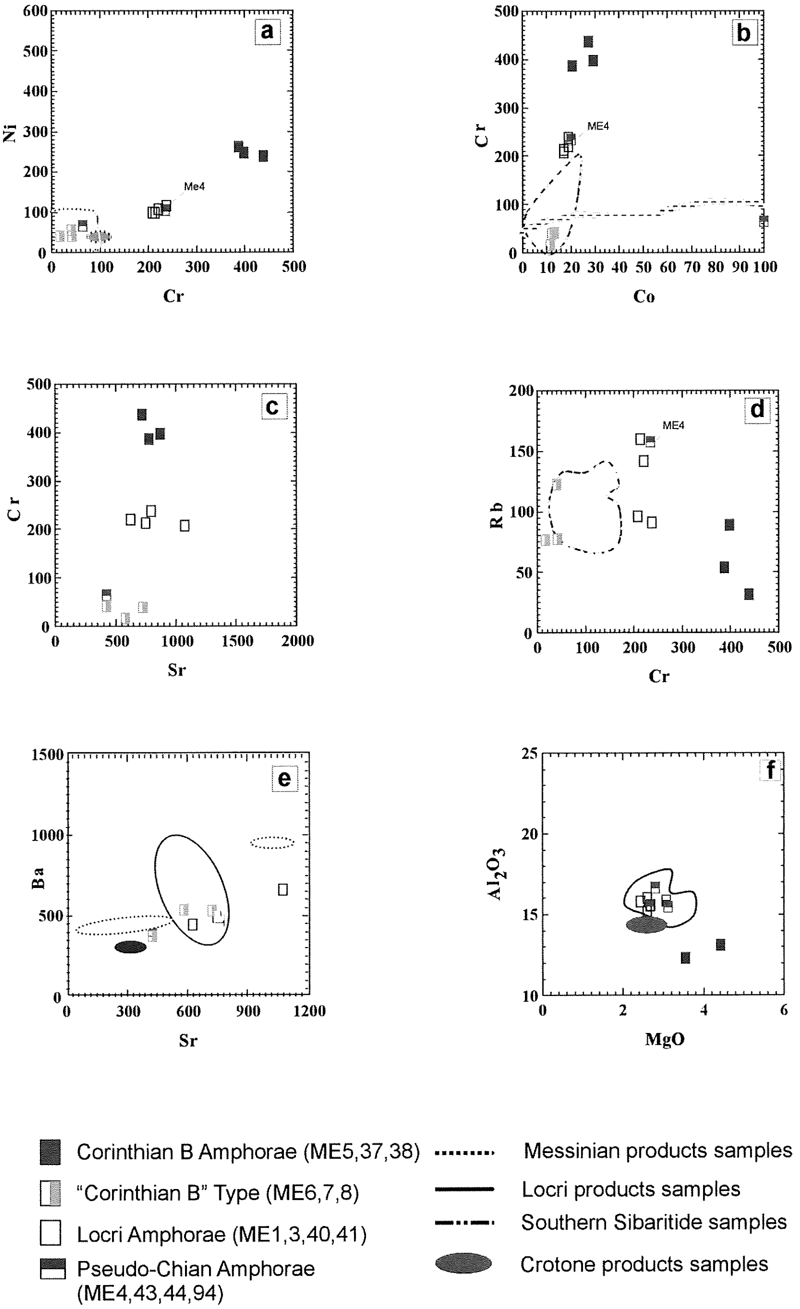


Fig. 3 – Compositional diagrams for transport amphorae. For comparison, local bricks and cooking pottery samples, (see. supra, Fig. 2), Locrian transport amphorae (ICP-OES data by BARRA BAGNASCO *et al.* 2001), protostoric pottery from Southern Sibaritide (INAA data by LEVI *et al.* 1999) terracotta objects from Crotone (ICP-MS and INAA data by GATTUSO *et al.* 2000) are also reported. Oxides and elements are expressed in wt% and in p.p.m. respectively.

their provenance from Greece can be hypothesized (Jones 1986; Levi *et al.* 1999). However, following the Whitbread's suggestions, it is difficult to demonstrate that they have been produced in Corinth. In fact, the chemical composition of the *Corinthian* potteries is very similar to that of the potteries coming from Corfù (Jones 1986). Being our values comparable with Farnsworth's results on potteries from Corfù (Farnsworth *et al.* 1977), the hypothesis of a corcirean provenance cannot really be discarded.

3b. Ionian-massaliote and pseudo-chian amphorae

An interesting problem concerns the so called *ionian-massaliote* and *pseudo-chian* amphorae. The samples were divided into three groups.

1) ME1, ME40 and ME41, classified as *ionian-massaliote* amphorae, and ME3, classified as *pseudo-chian* amphora, belonging to the first group, are characterised by a morphologic affinity and a macroscopic similarity of the paste comparable with the products of the Locrian area previously reported. Therefore the analyses have been aimed at verifying the provenance from this site.

The mixture shows the characteristics of the above mentioned geological formation of the Calabro-Peloritano region (Table 12). All samples show small spherical features (about 5 mm) of iron oxide, metamorphic rock clasts with a blastic structure and polycrystalline quartz with undulating extinction, plagioclase, traces of biotite, K-feldspar and muscovite. This latter presents an iso-orientation in ME1 and ME3. Thin section analysis showed a slight different texture. The heterogeneous and heterogranular inert amounts to about 10-15 % with a maximum dimension of 1.2 mm. Only in the sample ME3, the inert, more abundant and bigger (0.24 mm), results homogranular. A frequent presence of microfossils, in particular Foraminifera samples, and. The presence of foraminifera, in the ME1 and ME3, and Foraminifera moulds in the ME40 and ME41 samples, generally present in Locrian clays, as well known, (Pliocene medio calabriano) (M.P. Marchetti 1970), together with the presence of iron oxide (zona di Platì, Casignana) (Conato *et al.* 1981), could support a probable Locrian provenance. Some differences in the texture in comparison with the Locrian samples can be probably ascribed to the existence of several production centers in the same area (Barra Bagnasco *et al.* 2001).

The data obtained from the chemical analyses (ICP-MS) (Table 13), agree very well with those published on Locrian amphorae (Mirti-Casoli 1995; Barra Bagnasco *et al.* 2001), in particular as regards the content of MgO, $Al_2O_3$ (Fig. 3f), Cr, Sr and Ba (Fig. 3e).

By comparing the trace elements content with that of local potteries from Messina, amphorae presumably from Sibari, as well as terracotta objects from Crotone (Gattuso *et al.* 2000), the Locrian samples show a higher content of Ni and Cr (Fig. 3a). Moreover, it is

TABLE 12

*Locrian amphorae: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | I | Mu | Se | Bi | Geh |
|---|---|---|---|---|---|---|---|---|---|---|
| ME1 | + | + | + | + | tr | + | + | - | tr | - |
| ME3 | + | + | + | + | tr | + | + | - | tr | - |
| ME40 | + | + | + | + | tr | + | + | - | tr | - |
| ME41 | + | + | + | + | tr | + | + | - | tr | - |

Table 13

*Locrian amphorae: experimental data obtained by chemical analyses (ICP-MS). Oxides are expressed in wt% and elements in p.p.m.*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME 1 | 54.23 | 0.69 | 15.83 | 4.69 | 0.08 | 2.43 | 9.52 | 1.49 | 2.93 | 0.25 |
| ME 3 | 51.81 | 0.71 | 16.05 | 5.63 | 0.08 | 2.59 | 10.08 | 1.34 | 3.01 | 0.18 |
| ME40 | 54.17 | 0.66 | 15.20 | 5.20 | 0.09 | 2.59 | 11.47 | 1.96 | 2.31 | 0.47 |
| ME 41 | 49.60 | 0.71 | 15.61 | 5.36 | 0.08 | 2.68 | 12.99 | 1.83 | 2.11 | 0.82 |

| | V | Cr | Co | Ni | Rb | Sr | Ba |
|---|---|---|---|---|---|---|---|
| ME 1 | 94 | 213 | 17 | 100 | 160 | 749 | 497 |
| ME 3 | 103 | 221 | 19 | 107 | 142 | 626 | 449 |
| ME40 | 96 | 238 | 19 | 117 | 91 | 792 | 524 |
| ME 41 | 105 | 208 | 17 | 99 | 96 | 1.075 | 652 |

possible to evidence a higher $Al_2O_3$ percentage in comparison with the sherds from Crotone (Fig. 3f), and a sensibly higher CaO + MgO content in comparison with the samples produced in Messina.

2) A second group of *ionian-massaliote* and *pseudo-chian* amphorae (5YR 6/8 Table 1) is composed by the samples ME2 and ME95, well distinguishable for a red mixture and a white slip.

Optical microscopy reveals in both the samples rare volcanic inclusions and an heterogeneous and heterogranular inert (35 %) mainly composed of quartz, plagioclase, pyroxene, monocrystalline calcite and iron oxides. The clasts have sharp edges with an average dimension of 0.16 mm.

X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FTIR) (Table 14) confirm previous results, revealing the presence of quartz, plagioclase, pyroxene, and calcite. The white slip of ME95, analysed by scanning electron microscopy (SEM-EDX), shows a noticeable amount of Al, Si, Ca and Fe and traces of Na, K and Mg.

Because of the very fragmentary conditions of the two samples, the employment of the chemical analyses have not been retained suitable. Anyway, we can formulate some hypothesises about their provenance: in fact, the presence of volcanic could indicate a provenance from Campanian or Aetnean area. Archaeological data seem to support the first hypothesis.

3) ME4, ME43, ME44 and ME94 (5YR 6/6 – 7.5YR 7/6 Table 1, Table 15) belong to a third group of samples, including *pseudo-chian* amphorae with pink or reddish paste. All the samples reveal an heterogeneous paste and heterogranular sharp edge inclusions. The inert percentage is around 20-30%. The sample ME4 presents the most heterogeneous paste and the biggest inert (0.8 mm on average). The presence of quartz, plagioclase, K-feldspar, muscovite and biotite, with metamorphic inclusions in a gneissic structure were detected by petrographic analysis. These are temper fragments related to the Calabro-Peloritan region, and, in particular, to the metamorphic clast typical of the Aspromonte and Peloritani Mountains («Strait Area» *sensu lato*).

The chemical analysis (Table 16) reveals a composition of the ME4 sample similar to the supposed Locrian amphorae due to the comparable Ni, Cr, Rb, and Co content (Fig. 3a, b, d). Contrary, the sample ME44 is very similar (Table 15-16) to the supposed Sibari's amphorae and to the local pottery from Messina, because of the Ni, Cr, Sr, and Ba content; in particular, the higher Co content

TABLE 14

*Ionian-massaliote and pseudo-chian amphorae with a red paste: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | I | Mu | Se | Bi | Px | Geh |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ME2 | + | + | + | tr | + | + | + | + | - | + | tr |
| ME95 | + | + | + | tr | - | + | + | - | - | + | tr |

TABLE 15

*Pseudo-chian amphorae: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | I | Mu | Se | Bi | Px | Geh |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ME4 | + | + | ++ | tr | + | + | + | + | + | - | - |
| ME43 | + | + | + | tr | + | + | + | + | ++ | - | - |
| ME44 | + | + | + | tr | + | + | + | + | + | - | - |
| ME94 | + | + | ++ | tr | + | + | + | + | + | - | - |

TABLE 16

*Pseudo-chian amphorae: experimental data obtained by chemical analyses (XRF; ICP-MS; ICP-OES). Oxides are expressed in wt% and elements in p.p.m.*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME43 | 58.77 | 0.78 | 16.65 | 6.17 | 0.09 | 2.8 | 7.95 | 1.23 | 2.88 | 0.2 |
| ME44 | 59.91 | 0.81 | 15.51 | 6.3 | 0.17 | 3.11 | 7.95 | 1.12 | 2.67 | 0.2 |
| ME94 | 59.34 | 0.72 | 15.52 | 5.79 | 0.09 | 2.67 | 8.74 | 1.29 | 2.94 | 0.2 |

| | V | Cr | Co | Ni | Rb | Sr | Ba |
|---|---|---|---|---|---|---|---|
| ME 4 | n.d. | 234 | 20 | 105 | 158 | n.d. | n.d. |
| ME44 | n.d. | 64 | 100 | 68 | n.d. | 424 | 408 |

gets it more similar to the products from Messina (Fig. 3a, b, e). All these data allow us to localize the production of these *pseudo-chian* amphorae in the «Strait» area or in its neighbourhood. However, this hypothesis has to be further verified by analysing a wider number of samples.

### 4. *Fine pottery*

The collection of fine pottery includes few ceramic classes for which archaeological evidences recently proved a local provenance (Tigano 2000).

It is important to stress that, in comparison with the ceramic classes analysed up to now, the fine pottery have rised more complex problem concerning the characterization of the ceramic mixture and therefore the identification of the provenance site.

#### 4a. Zancle cups

Inside the rich collection of archaic ceramics from Zancle, we only analyzed some fragments of the so called «*a vasca carenata*» cups (ME26, ME91 and ME92) characterized by a linear subgeometric decoration. As it has been shown in previous archaeological studies performed on *banded* wares (Tigano 2000), these ceramics present features characteristic of the production center of the L group of the Ionian cups from Gravisca. For these latter wares, the provenance from the «Strait Area»has been recently suggested (Bacci and Spigo 1986; Bacci 1998; Boldrini 1994, 1999).

On the basis of the macroscopic analysis, the fine Zancle ceramics (ME26, ME91, ME92) are characterized by a reddish-orange matrix (5YR 7/6, 6/6, 8/6), with variations towards beige-orange more or less rosy (7.5 YR 7/6, 7/4, 6/6) (Table 1). Moreover the ceramic appears with irregular fractures, porous, a little bit powdery with shiny mica, and, in some cases, with white inclusions.

Inside this group, the petrography examination has shown the presence of a heterogeneous mixture, around 10 %, with homogranular inclusions, metamorphic clasts with sharp edges, quartz-feldspar (0.8 mm), a high muscovite content, biotite and oxides. This clast composition is typical of the Peloritani Mountains, supporting the archaeological hypothesis of a local production center. In Table 17 XRD results are reported.

The chemical analyses (Table 18) evidenced that the MgO, $Al_2O_3$, together with Ni and Cr content is well comparable with the values obtained from the so called *Chalcidian banded* wares (Fig. 4).

The results obtained by using different techniques and the subsequent comparison with other ceramic classes produced in Zancle, support the archaeological hypothesis that this type of cups is one of the most common among the ceramic products in the «Strait Area» (Barone *et al.* 2002, part I).

#### 4b. Chalcidian ware

As regards the archaic pottery, we also analysed a considerable number of *Chalcidian* and *banded* wares (Tigano 2000; see for more details Morel 1999), that, mostly in the late

TABLE 17

*«Zancle type» cups : experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Kf | I | K | Mont | Mu | Bi | Hm |
|---|---|---|---|---|---|---|---|---|---|---|
| ME26 | + | + | + | + | + | - | - | + | + | - |
| ME91 | + | + | + | + | + | - | - | + | + | tr |
| ME92 | + | + | + | + | + | - | - | + | + | tr |

TABLE 18

*«Zancle type» cups : experimental data obtained by chemical analyses (ICP-MS). Oxides are expressed in wt% and elements in p.p.m.*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME26 | 56.76 | 0.84 | 16.09 | 6.26 | 0.08 | 2.47 | 8.77 | 1.76 | 3.12 | 0.26 |
| ME91 | 56.37 | 0.72 | 16.15 | 6.13 | 0.08 | 2.46 | 9.40 | 1.73 | 3.08 | 0.30 |
| ME92 | 57.09 | 0.73 | 17.41 | 6.48 | 0.08 | 1.93 | 7.80 | 1.49 | 3.80 | 0.21 |

| | V | Cr | Co | Ni | Rb | Sr | Ba |
|---|---|---|---|---|---|---|---|
| ME26 | 124 | 105 | 18.5 | 44 | 118.40 | 563.60 | 673.80 |
| ME91 | 127 | 95 | 16.7 | 39 | 121.90 | 605.40 | 704.70 |
| ME92 | 99 | 86 | 20.4 | 44 | 170.20 | 507.40 | 567.90 |

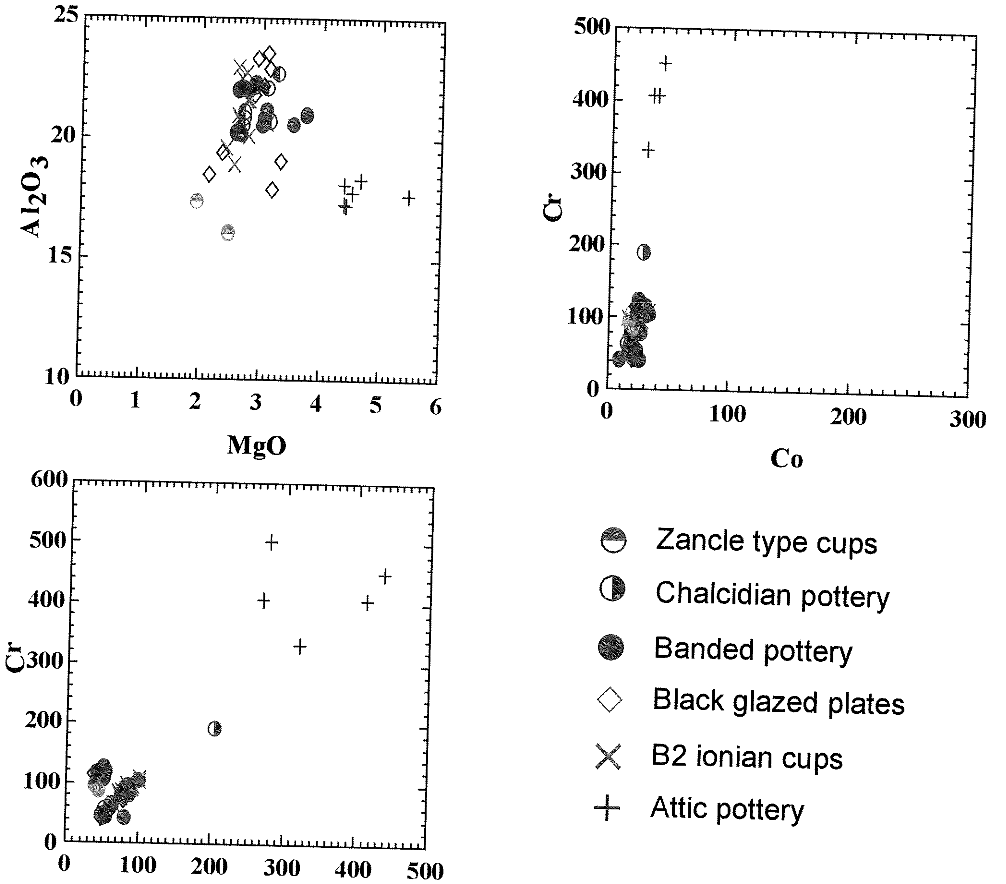


Fig. 4 – Compositional diagrams of fine pottery. Oxides and elements are expressed in wt% and in p.p.m. respectively.

archaic period, were the most diffuse in the «Strait Area».

The so called *Chalcidian* ceramic (2.5YR 6/8 – 7.5YR 7/6 Table 1), known in literature especially for the figured series, is well documented in Messina mostly with the aniconic series recently analysed by Iozzo 1993, 1996 (for *Chalcidian* figured fragment see Bacci and Spigo 1986).

Seventeen samples (ME23, ME67, ME68, ME69, ME70, ME72, ME73, ME75, ME76, ME111, ME113, ME114, ME117, ME131, ME133, ME134 and ME140) belonging to the above cited aniconic series (Tigano 2000; for this class, see Iozzo 1993; Iozzo 1996) have been analyzed: particular attention has been paied on the skyphos type. Moreover, because of the morphological and technical similarities with the *Chalcidian* ceramic, four samples of black-glazed small stemmed bowls have been included in the analysis. These are the samples labelled ME24, ME74, ME118, and ME119.

The petrographical analysis of the *Chalcidian* samples have evidenced, absence the of temper, small muscovite needles and rarely subrounded quartz with a maximum dimension of 0.08 mm. In particular, the sample ME69 shows a rough micaceous mixture which is different from the other samples for the mica orientation closely related to clay manufacturing.

XRD analyses evidenced the presence of quartz, plagioclase, K-feldspar, illite, muscovite, and hematite concentration (Table 19).

The results of the ICP-MS analyses show (Table 20) that the *Chalcidian* samples are characterized by a low concentration of Ni (52-204 ppm) and Cr (44-191 ppm) (Fig. 4). A comparison with another fine pottery class, produced in a western Greek colony, revealed to be particularly interesting: this is the black glazed ceramic of Thurii, in which the chemical analyses, recently performed by means of ICP-OES, have evidenced a constant Cr concentration equals to 150 ppm (Mirti *et al.* 1998) (Fig. 5).

Chemical data indicate that the *Chalcidian* ceramics were produced probably in a western-

TABLE 19

*Chalcidian pottery: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | I | Mu | Mont | Bi | Geh | Wo |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ME23 | + | - | + | + | ++ | + | + | - | - | - | - |
| ME24 | + | - | + | ++ | ++ | ++ | + | tr | - | - | - |
| ME67 | + | - | + | + | ++ | + | + | - | - | - | - |
| ME69 | + | - | + | + | ++ | + | + | - | - | - | - |
| ME70 | + | - | + | + | ++ | + | + | - | - | - | - |
| ME72 | + | - | + | tr | ++ | + | + | tr | - | - | - |
| ME73 | + | - | + | + | ++ | + | + | - | - | - | - |
| ME111 | + | tr | ++ | + | + | + | + | + | + | - | + |
| ME113 | + | tr | + | + | + | + | + | + | + | + | tr |
| ME114 | + | tr | + | ++ | ++ | + | + | + | + | tr | + |
| ME117 | + | tr | + | + | + | + | + | + | + | - | + |
| ME118 | + | tr | + | + | + | + | + | + | + | - | + |
| ME119 | + | - | + | + | + | + | + | + | + | - | + |
| ME131 | + | - | + | + | + | + | + | + | + | tr | + |
| ME133 | + | - | + | + | + | + | + | - | + | - | + |
| ME134 | + | - | + | + | + | + | + | + | + | - | + |
| ME140 | + | - | + | + | + | + | + | + | + | - | + |

TABLE 20

*Chalcidian pottery: experimental data obtained by chemical analyses (XRF; ICP-MS). Oxides are expressed in wt% and elements in p.p.m.*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME70 | 51.96 | 0.71 | 22.14 | 8.49 | 0.10 | 3.08 | 7.92 | 1.06 | 4.10 | 0.20 |
| ME72 | 52.47 | 0.86 | 22.73 | 9.61 | 0.13 | 3.25 | 4.24 | 1.23 | 4.21 | 0.26 |
| ME73 | 53.01 | 0.89 | 20.73 | 8.82 | 0.15 | 3.14 | 6.90 | 1.28 | 3.55 | 0.28 |
| ME 111 | 54.75 | 0.77 | 20.90 | 8.92 | 0.11 | 2.69 | 6.73 | 1.14 | 3.81 | 0.19 |
| ME 113 | 53.99 | 0.72 | 22.10 | 9.38 | 0.11 | 2.65 | 5.52 | 0.99 | 4.28 | 0.28 |
| ME 114 | 54.38 | 0.73 | 20.60 | 8.45 | 0.12 | 2.68 | 7.99 | 1.09 | 3.75 | 0.21 |
| ME 131 | 51.51 | 0.71 | 22.22 | 9.82 | 0.12 | 2.87 | 7.53 | 0.89 | 4.15 | 0.19 |
| ME 133 | 52.87 | 0.70 | 22.17 | 9.38 | 0.10 | 2.68 | 6.64 | 0.99 | 4.26 | 0.20 |
| ME134 | 53.68 | 0.75 | 21.14 | 8.99 | 0.10 | 2.70 | 7.43 | 0.89 | 4.11 | 0.21 |
| ME140 | 53.03 | 0.74 | 22.02 | 9.38 | 0.11 | 2.59 | 7.01 | 1.00 | 3.94 | 0.19 |

| | V | Cr | Co | Ni | Rb | Sr | Ba |
|---|---|---|---|---|---|---|---|
| ME23 | 129 | 191 | 27.8 | 204 | 172.03 | 362.16 | 614.93 |
| ME24 | 147 | 56 | 23.6 | 53 | 191.17 | 391.71 | 644.84 |
| ME69 | 130 | 44 | 21.3 | 56 | 176.66 | 320.81 | 627.13 |
| ME70 | 152 | 119 | 28.7 | 54 | 172.20 | 367.40 | 591.10 |
| ME72 | 151 | 112 | 25.3 | 53 | 180.00 | 413.80 | 756.80 |
| ME73 | 147 | 106 | 33.3 | 52 | 157.30 | 486.30 | 725.60 |
| ME 111 | 158 | 79 | 19 | 77 | 61.98 | 140.98 | 310.83 |
| ME 113 | 143 | 62 | 18 | 64 | 71.33 | 154.24 | 357.45 |
| ME 114 | 130 | 83 | 18 | 77 | 75.41 | 116.95 | 254.62 |
| ME 131 | 123 | 57 | 17 | 60 | 50.93 | 113.86 | 248.11 |
| ME 133 | 126 | 64 | 15 | 62 | 71.08 | 126.56 | 299.92 |
| ME134 | 163 | 83 | 20 | 78 | 103.05 | 231.74 | 541.74 |
| ME140 | 196 | 96 | 23 | 85 | 105.93 | 220.10 | 470.38 |

TABLE 21

*Attic pottery : experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | I | Mu | Mont | Bi | Geh | Wo |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ME25 | ++ | - | + | ++ | + | + | - | - | - | - | - |
| ME77 | ++ | - | + | ++ | + | + | - | - | - | - | - |
| ME78 | ++ | - | + | ++ | + | + | - | - | - | - | - |
| ME79 | ++ | - | + | ++ | + | + | - | - | - | - | - |
| ME80 | ++ | - | + | ++ | + | + | - | - | - | - | - |
| ME87 | ++ | - | + | + | + | + | - | tr | - | - | - |
| ME145 | + | - | + | + | + | + | - | tr | - | tr | - |
| ME146 | + | - | + | + | + | ++ | - | tr | - | tr | - |
| ME147 | + | - | + | + | + | + | - | + | - | - | + |
| ME148 | + | - | + | + | + | + | - | tr | - | tr | - |

Table 22

*Attic pottery: experimental data obtained by chemical analyses (XRF; ICP-MS). Oxides are expressed in wt% and elements in p.p.m.*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME78 | 54.22 | 0.85 | 17.67 | 8.33 | 0.09 | 5.46 | 5.81 | 0.85 | 3.52 | 0.24 |
| ME87 | 57.77 | 0.87 | 17.26 | 8.15 | 0.09 | 4.42 | 4.86 | 0.87 | 3.32 | 0.17 |
| ME145 | 55.63 | 0.86 | 18.31 | 9.65 | 0.10 | 4.66 | 6.31 | 0.76 | 3.53 | 0.19 |
| ME146 | 55.00 | 0.88 | 17.81 | 10.24 | 0.12 | 4.53 | 6.80 | 0.70 | 3.67 | 0.25 |
| ME147 | 56.20 | 0.88 | 17.30 | 9.94 | 0.14 | 4.39 | 6.81 | 0.76 | 3.41 | 0.16 |
| ME148 | 56.47 | 0.88 | 18.12 | 10.14 | 0.10 | 4.39 | 5.44 | 0.70 | 3.59 | 0.18 |

| | V | Cr | Co | Ni | Rb | Sr | Ba |
|---|---|---|---|---|---|---|---|
| ME25 | 133 | 406 | 37.3 | 412 | 162.40 | 362.16 | 530.54 |
| ME78 | 136 | 504 | 30.4 | 277 | 138.40 | 320.00 | 519.00 |
| ME80 | 141 | 452 | 41.6 | 436 | 163.94 | 277.97 | 542.75 |
| ME87 | 113 | 406 | 33.2 | 268 | 136.70 | 301.90 | 523.20 |
| ME147 | 132 | 332 | 29 | 320 | 31.34 | 95.37 | 237.20 |

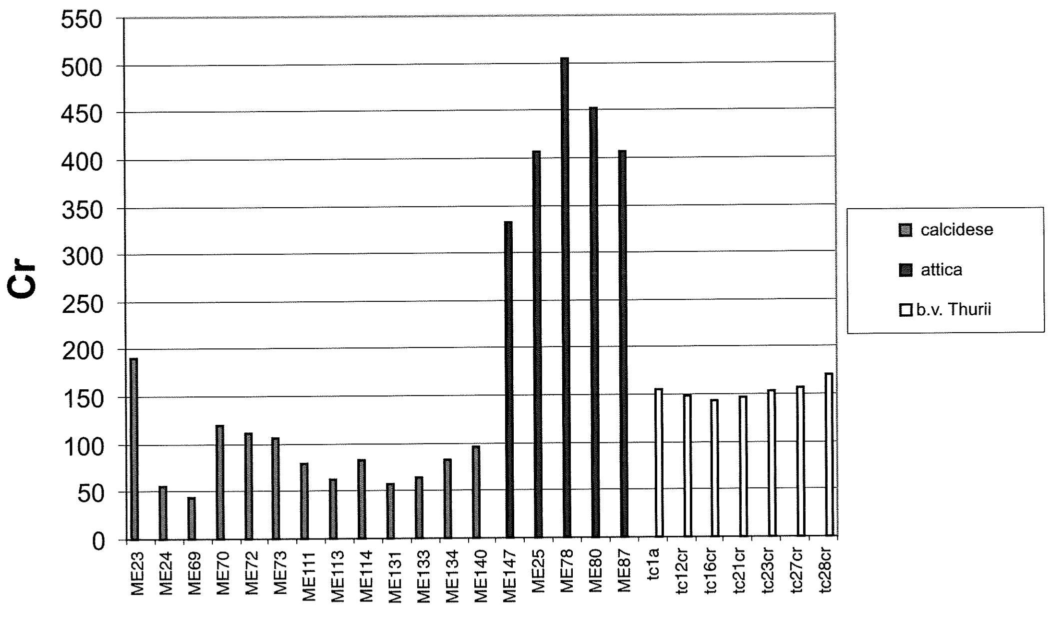


Fig. 5 – Contents of Cr (p.p.m.) for Chalcidian and Attic pottery, and for comparison, for black-glazed pottery from Thurii (ICP-OES data by Mirti-Aceto-Preacco Ancona 1998).

Greek colonial site, probably located within the «Calabrian-Peloritan region». Therefore, the hypothesis advanced in archaeological literature about a workshop situated in the «Strait Area» (Iozzo 1993) can be retained as realistic.

4c. Attic ceramic

In order to perform a significative comparison, together with the above cited samples, ten fragments of *Attic* ceramic (5YR 6/6 – 10YR 7/4)-both figured and black glazed-showing macroscopic characteristics very similar to the *Chalcidian* sherds, have been analyzed. These are the samples labelled ME25, ME77, ME78, ME79, ME80, ME87, ME145, ME146, ME147 and ME148.

The petrographical analysis evidenced the absence of temper and of muscovite, and the presence of subrounded quartz (around 0.08 mm). XRD analyses evidenced a very similar composition for the *Chalcidian* and *Attic* samples. However, it has to be noted that muscovite and K-feldspar are present only in the *Chalcidian* samples (Table 21).

The results of the ICP-MS analyses (Table 22) show that the *Attic* ceramics are characterized by a higher concentration of Ni (268-436 ppm) and Cr (332-504 ppm). The Ni and Cr content is higher in the Greek imported samples (Fig. 4).

Finally, the SEM-EDX techniques revealed a similar composition for the different samples characterized by the presence of Al, Si, Ca, K, Fe, Mg and traces of Ti. As concerns the black glazed, no compositional or quantitative difference between the *Chalcidian* and *Attic* samples was noted, confirming the same manufacturing technique.

4d. Banded pottery, «a immersione» ware and B2 ionian cups

Samples of *banded* pottery (ME27, ME29, ME55, ME56, ME59, ME60, ME71, ME81, ME83, ME84, ME85, ME86, ME112, ME115, ME121, ME127, ME128, ME139, ME144), *banded B2 ionian cups* (ME28, ME50, ME51, ME53, ME116, ME120, ME124, ME125, ME126, ME137, ME138, ME141, ME142, ME143) and one sample of *«a immersione»* ceramic (ME130) were examined.

It has to be pointed out that the similarity observed between this class and the aniconic *Chalcidian* class concerns, as suggested by a macroscopic examination, not only the morphological features (Tigano 2000), but also the manufacturing technique. On the other hand, the hypothesis of a same provenance for the aniconic *Chalcidian* and the *banded* ware has been previously suggested by Vallet (1958) and by more recent studies (Iozzo 1993; Tigano 2000; Boldrini 1999).

Mostly of these samples (5YR 4/1 – 10YR 8/6, Table 1) belong to peculiar forms of the class, such as the controversial cups of «B2 Vallet-Villard» type, but also to other more rare forms for which the identification of the provenance site was necessary (for more details about the «B2 Vallet-Villard» type cups see Boldrini 1994 and Van Compernolle 1996; for the Messina cups see Tigano 2000).

The mineralogical-petrographic analysis (Table 23) evidenced an heterogeneous matrix with the presence of temper (5%), subrounded and quartz (0.08 mm), and a micaceous mixture very similar to that of the local products.

The SEM-EDX technique revealed the presence of Al, Si, Ca, K, Fe, Mg, and traces of Ti. The ratio of the detected elements are in line with those discovered in the *Chalcidian* ceramics.

Once more, the chemical analyses evidenced the western-Greek origin of these samples (Table 24, Fig. 4). Therefore, from a geological-petrographic point of view, the hypothesis of a local provenance for the *banded* ceramics results realistic and it is further supported by the presence, in the same group, of three hyper-baked fragments, evidently kiln refuses (ME81, ME82, and ME83 samples. For more details see Tigano 2000). These samples were investigated only by means of FTIR technique which furnishes mineralogical results comparable with those of the other *banded* samples.

TABLE 23

*Banded «a immersione» and Ionian B2 pottery: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | I | K | Mu | Bi | Mont | Geh | Wo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME27 | + | - | + | tr | + | - | + | + | + | tr | - | - |
| ME29 | + | - | + | tr | + | - | + | + | + | tr | - | - |
| ME59 | ++ | - | + | + | ++ | - | + | ++ | + | + | - | - |
| ME60 | ++ | - | + | tr | + | - | + | + | + | + | - | - |
| ME112 | + | - | + | + | + | + | - | + | + | - | + | + |
| ME115 | + | - | ++ | + | + | + | - | + | + | - | - | + |
| ME121 | + | - | + | + | + | + | - | + | + | + | + | + |
| ME137 | + | - | + | + | + | + | - | + | + | tr | - | + |
| ME138 | + | tr | + | + | + | + | - | + | + | tr | tr | + |
| ME139 | + | tr | + | + | + | + | - | + | + | - | tr | + |
| ME144 | + | - | + | + | + | + | - | + | + | tr | + | + |
| ME28 | ++ | - | + | tr | + | - | + | + | + | tr | - | - |
| ME50 | ++ | - | + | tr | ++ | - | + | + | + | - | - | - |
| ME51 | + | - | + | tr | + | - | + | + | + | - | - | - |
| ME53 | + | tr | + | + | ++ | - | + | ++ | + | - | - | - |
| ME116 | + | + | + | + | + | + | - | + | + | tr | + | + |
| ME120 | ++ | - | + | + | ++ | + | - | + | + | + | - | + |
| ME124 | + | - | + | + | + | + | - | + | + | - | + | + |
| ME125 | + | - | + | + | + | + | - | + | + | - | + | + |
| ME126 | + | - | + | + | + | + | - | + | + | tr | - | + |
| ME127 | + | - | + | + | + | + | - | + | + | + | - | + |
| ME128 | + | - | + | + | + | + | - | + | + | + | - | + |
| ME130 | + | tr | + | + | + | + | - | + | + | + | - | + |
| ME141 | + | tr | + | ++ | + | + | - | + | + | tr | tr | + |
| ME142 | + | tr | + | + | + | + | - | + | + | tr | + | + |
| ME143 | + | tr | + | + | + | + | - | + | + | tr | + | + |

4e. Black-glazed plates

Inside the black-glazed classes particular attention has been devoted also to a very frequent form in the late archaic context: the stemmed plate (for the shape see Tigano 2000). The petrography investigations (Table 25) evidenced a fine grained texture (<0.08 mm), the presence of metamorphic quartz, and a high content of muscovite and biotite. The chemical analyses indicate, as usual, a low content of Ni and Cr (Table 26).

Therefore, also for this ceramic class, we can hypothesise a provenance from a western Greek colony, probably localized in the «Strait Area». These researches are still in progress.

4f. Black glazed pottery of hellenistic age

Up to now, a very small number of black-glazed vases of hellenistic age (for the so called «dello stretto» hellenistic black-glazed wares, see Spigo 2003; Tigano 2000; Pavia 2001) has been analysed. For this reason, the results don't

TABLE 24

*Banded «a immersione» and Ionian B2 pottery: experimental data obtained by chemical analyses (XRF; ICP-MS). Oxides are expressed in wt% and elements in p.p.m.*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME55 | 53.65 | 0.87 | 20.35 | 8.82 | 0.14 | 2.84 | 4.75 | 1.26 | 3.60 | 0.40 |
| ME59 | 52.16 | 0.70 | 22.76 | 8.54 | 0.10 | 3.07 | 6.03 | 1.10 | 4.15 | 0.28 |
| ME84 | 52.98 | 0.77 | 21.21 | 8.19 | 0.10 | 3.06 | 7.75 | 1.08 | 3.75 | 0.23 |
| ME85 | 52.22 | 0.75 | 20.90 | 7.88 | 0.10 | 3.04 | 9.79 | 1.15 | 3.73 | 0.26 |
| ME86 | 48.61 | 0.80 | 20.58 | 8.86 | 0.13 | 3.00 | 5.65 | 1.19 | 3.63 | 0.23 |
| ME 112 | 54.00 | 0.98 | 20.62 | 11.23 | 0.16 | 3.52 | 4.20 | 1.46 | 3.59 | 0.24 |
| ME 115 | 52.96 | 1.01 | 21.04 | 12.29 | 0.16 | 3.73 | 3.94 | 1.14 | 3.42 | 0.31 |
| ME121 | 54.80 | 0.78 | 20.27 | 8.58 | 0.12 | 2.57 | 7.82 | 0.85 | 3.93 | 0.28 |
| ME 127 | 53.00 | 0.82 | 22.35 | 10.11 | 0.15 | 2.89 | 5.28 | 1.13 | 4.06 | 0.20 |
| ME 128 | 52.62 | 0.72 | 22.10 | 9.41 | 0.11 | 2.77 | 6.82 | 0.93 | 4.34 | 0.19 |
| ME139 | 53.29 | 0.98 | 20.19 | 10.88 | 0.18 | 2.65 | 7.13 | 1.12 | 3.29 | 0.30 |
| ME144 | 53.18 | 0.90 | 21.61 | 10.70 | 0.16 | 2.75 | 5.34 | 1.09 | 3.98 | 0.29 |
| ME53 | 51.85 | 0.69 | 22.41 | 8.51 | 0.09 | 3.03 | 6.59 | 1.09 | 4.17 | 0.20 |
| ME116 | 53.03 | 0.68 | 22.96 | 9.66 | 0.11 | 2.60 | 5.08 | 0.92 | 4.72 | 0.25 |
| ME120 | 53.03 | 0.81 | 20.63 | 9.94 | 0.12 | 3.09 | 7.25 | 1.05 | 3.86 | 0.21 |
| ME124 | 57.85 | 0.91 | 18.90 | 8.39 | 0.08 | 2.54 | 7.28 | 0.88 | 2.97 | 0.20 |
| ME125 | 52.41 | 0.91 | 22.73 | 10.74 | 0.12 | 2.73 | 5.03 | 1.07 | 4.08 | 0.20 |
| ME126 | 52.54 | 0.89 | 22.53 | 10.06 | 0.11 | 2.65 | 5.90 | 1.03 | 4.06 | 0.23 |
| ME137 | 54.49 | 0.82 | 21.63 | 9.94 | 0.12 | 2.78 | 4.76 | 1.26 | 3.95 | 0.25 |
| ME138 | 52.86 | 0.72 | 20.80 | 9.01 | 0.11 | 2.61 | 8.54 | 1.17 | 3.92 | 0.27 |
| ME141 | 56.57 | 0.85 | 19.64 | 8.64 | 0.12 | 2.41 | 6.97 | 1.12 | 3.37 | 0.31 |
| ME142 | 53.23 | 0.99 | 20.13 | 11.12 | 0.19 | 2.78 | 6.71 | 1.08 | 3.30 | 0.48 |
| ME143 | 52.57 | 0.78 | 20.94 | 9.16 | 0.11 | 2.59 | 8.93 | 1.03 | 3.69 | 0.20 |

| | V | Cr | Co | Ni | Rb | Sr | Ba |
|---|---|---|---|---|---|---|---|
| ME27 | 144 | 42 | 25.8 | 81 | 170.87 | 437.79 | 748.66 |
| ME55 | 134 | 102 | 22.4 | 47 | 154.00 | 529.50 | 742.00 |
| Me59 | 142 | 114 | 26.3 | 48 | 174.90 | 324.50 | 663.60 |
| ME60 | 139 | 46 | 20 | 49 | 161.94 | 390.14 | 573.61 |
| ME84 | 137 | 114 | 23.2 | 46 | 145.80 | 376.60 | 585.90 |
| ME85 | 151 | 116 | 29.8 | 42 | 144.80 | 458.20 | 516.40 |
| ME86 | 130 | 98 | 24.9 | 40 | 154.90 | 421.70 | 679.10 |
| ME 112 | 199 | 104 | 31 | 101 | 70.22 | 142.21 | 286.29 |
| ME 115 | 160 | 80 | 27 | 88 | 64.30 | 147.46 | 315.31 |
| ME121 | 84 | 42 | 9 | 51 | 52.79 | 83.29 | 236.36 |
| ME 127 | 117 | 56 | 17 | 61 | 51.43 | 42.49 | 116.57 |
| ME 128 | 172 | 90 | 23 | 81 | 113.50 | 206.56 | 534.73 |
| ME139 | 166 | 80 | 22 | 79 | 91.15 | 386.62 | 906.16 |
| ME144 | 185 | 95 | 27 | 94 | 64.64 | 196.17 | 435.25 |
| ME28 | 132 | 47 | 19.9 | 52 | 170.23 | 373.64 | 568.80 |
| ME53 | 150 | 124 | 24.1 | 51 | 176.90 | 350.00 | 655.80 |
| ME116 | 171 | 86 | 23 | 76 | 113.09 | 195.14 | 428.44 |
| ME120 | 171 | 94 | 22 | 85 | 74.37 | 206.26 | 500.47 |
| ME124 | 191 | 98 | 16 | 83 | 48.79 | 203.04 | 543.73 |
| ME125 | 195 | 76 | 20 | 76 | 102.97 | 122.11 | 264.45 |
| ME126 | 169 | 65 | 16 | 66 | 75.64 | 124.22 | 270.01 |
| ME137 | 186 | 107 | 33 | 102 | 115.72 | 222.62 | 417.60 |
| ME138 | 165 | 84 | 18 | 73 | 75.88 | 210.12 | 485.46 |
| ME141 | 207 | 104 | 25 | 102 | 135.93 | 427.72 | 869.21 |
| ME142 | 183 | 90 | 27 | 92 | 101.02 | 587.88 | 1152.49 |
| ME143 | 152 | 80 | 20 | 74 | 75.70 | 193.48 | 489.82 |

TABLE 25

*Black-glazed plates: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | I | Mont | K | Mu | Bi | Dol | Geh | Wo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME57 | + | - | + | - | + | - | - | tr | + | + | - | - | - |
| ME58 | + | - | + | - | ++ | - | - | + | + | + | - | - | - |
| ME88 | + | - | + | + | ++ | - | - | + | + | + | - | - | - |
| ME89 | + | - | + | tr | + | - | - | + | + | + | - | - | - |
| ME90 | + | - | + | + | + | - | - | + | + | + | - | - | - |
| ME129 | + | + | + | + | + | + | tr | - | + | + | + | + | + |
| ME132 | + | + | + | + | + | + | tr | - | + | + | + | + | + |
| ME135 | + | - | + | ++ | + | + | tr | - | + | + | + | + | + |
| ME136 | + | - | + | + | + | + | tr | - | + | + | + | + | + |
| ME149 | + | - | + | + | + | + | + | - | + | + | - | - | + |

TABLE 26

*Black-glazed plates: experimental data obtained by chemical analyses (XRF; ICP-MS). Oxides are expressed in wt% and elements in p.p.m.*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME88 | 51.92 | 0.63 | 22.92 | 8.63 | 0.10 | 3.12 | 6.07 | 1.20 | 4.49 | 0.20 |
| ME89 | 52.51 | 0.70 | 22.18 | 8.21 | 0.10 | 3.01 | 7.00 | 1.09 | 4.18 | 0.20 |
| ME90 | 50.83 | 0.66 | 23.53 | 9.13 | 0.10 | 3.09 | 5.86 | 1.17 | 4.12 | 0.19 |
| ME129 | 52.82 | 0.72 | 21.82 | 9.49 | 0.11 | 2.86 | 6.75 | 1.03 | 4.20 | 0.20 |
| ME132 | 53.12 | 0.89 | 23.34 | 10.44 | 0.12 | 2.92 | 3.46 | 1.12 | 4.40 | 0.19 |
| ME135 | 53.22 | 0.94 | 19.09 | 10.49 | 0.16 | 3.31 | 7.48 | 1.24 | 3.58 | 0.49 |
| ME136 | 55.26 | 0.77 | 19.39 | 8.64 | 0.11 | 2.35 | 8.29 | 1.07 | 3.70 | 0.47 |
| ME149 | 48.51 | 0.90 | 17.91 | 10.44 | 0.19 | 3.18 | 15.09 | 0.87 | 2.66 | 0.25 |

| | V | Cr | Co | Ni | Rb | Sr | Ba |
|---|---|---|---|---|---|---|---|
| ME58 | 134 | 41 | 20 | 48 | 171.52 | 413.46 | 611.74 |
| ME88 | 144 | 112 | 24.4 | 47 | 187.90 | 303.50 | 712.60 |
| ME89 | 141 | 115 | 21.6 | 38 | 167.30 | 325.10 | 643.70 |
| ME90 | 150 | 117 | 27.1 | 43 | 177.20 | 279.10 | 717.00 |
| ME132 | 181 | 87 | 25 | 78 | 108.96 | 142.48 | 279.80 |
| ME135 | 122 | 71 | 21 | 79 | 61.98 | 397.35 | 896.47 |
| ME136 | 169 | 80 | 18 | 76 | 86.78 | 386.36 | 854.10 |
| ME149 | 124 | 78 | 21 | 79 | 77.14 | 623.47 | 1308.25 |

allow us to advance any hypothesis about this ceramic class.

The three examined samples, ME19, ME20, ME21, and ME22 (2.5YR 6/8 – 7.5YR 7/6, Table 1) belong to the III sec. B.C most common shapes.

The specimen ME19 is classified as «série MOREL 3210» (Morel 1999). It has a red colour texture (M2.5YR6/8) with fine whitish inclusions. The specimen ME20 is classified as «série MOREL 1522» and presents a reddish-yellow colour texture (M7.5YR7/6), with fine inclusions of mica needles. The black glaze is mat.

The samples ME21 and ME22 belong to «série MOREL 1534» (Morel 1999). The sample ME21 has a light brown clay (M 7.5 YR 6/4), hyper-baked like the black glaze (M7.5YR6/4). The sample ME22 has a pale yellow texture (M2.5Y 8/3), and it is not glazed.

The presence of similar mixtures composed of quartz, calcite, plagioclase, K-feldspar and kaolinite traces characterizes the samples ME20, ME21 and ME22 (Table 27). The presence of kaolinite in high firing temperature pottery, is presumably connected with the weathering of feldspars during post firing burial period.

Microscopic examination revealed also the presence of muscovite sheets and oxides. The composition and the quantity of mineralogical phases is peculiar in the ME19 sample. In fact, the absence of illite and muscovite and the presence of gehlenite are evident in the mixture. Moreover, the aspect appears more homogeneous with clasts containing quartz and K-feldspar.

On the basis of these results the existence of two different production centers can be presumed, even if it is not possible until now, to locate them exactly.

## *5. Arulae*

Finally, a sherd of terracotta arula (ME66) (5YR 7/8, Table 1), typologically similar to a series of arulae produced in Locri, has been also analyzed (Tigano 2003).

The thin section analysis evidenced a mixture with a vesicular texture and the presence of heterogranular temper (10%) with dimensions varying between 0.24 and 1.6mm; the dominant inclusions are mono and polycrystalline quartz, K-feldspar, zoned plagioclase and iron oxides. Rare crystals of biotite and lengthened muscovite lamels, and microcrystalline calcite are also present.

By means of the diffractometric analyses it was possible to evidence the presence of quartz, plagioclase, K-feldspar, wollastonite and hematite (Table 28).

TABLE 27

*Black-glazed pottery from Strait: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | I | Mont | K | Mu | Geh |
|---|---|---|---|---|---|---|---|---|---|---|
| ME19 | + | + | + | - | tr | - | tr | tr | - | + |
| ME20 | + | + | ++ | tr | + | + | tr | tr | + | tr |
| ME21 | + | + | + | - | + | + | + | tr | + | tr |
| ME22 | + | + | + | - | tr | + | + | tr | + | tr |

TABLE 28

*Arule: experimental results obtained by X-Ray Diffraction (XRD) and Fourier Transform Infrared Absorption (FT-IR). Symbols as Tab. 2.*

| | Qz | Cc | Pl | Hm | Kf | I | Mu | Bi | Mont | Wo |
|---|---|---|---|---|---|---|---|---|---|---|
| ME66 | + | + | + | + | + | + | + | tr | - | + |

Infrared spectroscopy, besides confirming the results obtained by XRD diffractometry, evidenced the presence of traces of muscovite and biotite.

These experimental findings, compatible with those of the transport amphorae above discussed and assigned to Locri (Table 29), seem to identify the provenance of the arula itself from Locri, as previously hypothesised by a typological and stilistic classification (Tigano 2003).

## CONCLUSIONS

In the present work we report for the first time all the results obtained by using different techniques on many ceramic classes coming from archaeological excavations in Messina and dated from Greek to Medieval period.

First of all, the examination of a group of vessels found in ancient local workshops (pots of Roman and Medieval age, red glazed pans, Medieval tiles, sherds of Medieval banded amphorae) and, at the same time, the analysis of clays collected in Messina area (Gravitelli and Annunziata), allowed us to evidence important features of the local ceramic production.

In the local pottery (cooking pottery and tiles of Greek and Medieval age) the mineralogical-petrography analyses evidenced temper fragments of high and medium metamorphic degree, which are perfectly compatible with the geological composition of the «Calabrian-Peloritan region», whom Messina belongs to. But, since this geological formation is quite wide, one of the main efforts of our research was devoted at identifying the peculiarities of the Messina area in comparison with the other regions which form the same system (Calabrian-Peloritan). In particular, even if inside the Strait area the Sicilian coast does not appear geologically distinguishable from the Calabrian coast, the chemical analyses performed on our samples, jointly with the available literature data on Calabrian ceramics, allowed us to characterize more precisely the «Strait Area» *sensu lato*, in comparison with other zones of the Calabrian-Peloritan region, such as Locride, Sibaritide, ecc.

The chemical investigations, through the analytic determination of both the principal elements and the trace elements, were fundamental to characterize the clayey matrix and the clasts. The presence of elements such as Ni, Cr, Co, Sr, Ba, Rb, Mg and Al appeared a very significative «*marker*» to identify the pottery provenance.

Mostly of the ancient ceramics, found a Messina, have a composition very similar to the clay extracted from Gravitelli, with the exception of the cooking potteries, that, because of the lower calcite content, are better comparable with the clay extracted from the Annunziata torrent. We can therefore hypothesise that, in the antiquity, different quarries were used in Messina, even if they were not necessarily the same we have investigated or however the same actually known.

TABLE 29

*Arule: experimental data obtained by chemical analyses (XRF; ICP-MS). Oxides are expressed in wt% and elements in p.p.m.*

| | $SiO_2$ | $TiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | MgO | CaO | $Na_2O$ | $K_2O$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ME 66 | 53.23 | 0.68 | 15.87 | 5.50 | 0.10 | 3.06 | 11.72 | 2.23 | 1.89 | 0.70 |

| | V | Cr | Co | Ni | Rb | Sr | Ba |
|---|---|---|---|---|---|---|---|
| ME 66 | 104 | 282 | 21 | 57 | 25.00 | 155.00 | 4.10 |

On the other side, it is well known that the ancient potters made a selection of clays, according to the use of pottery. In particular, to produce a high quality cooking pottery they preferred the non calcareous clays and especially the kaolinitic ones (Picon-Olcese 1995, pole 3), because this kind of clays exhibits a low dilation coefficient, that is necessary in the domestic use for the resistance to high temperatures. The non calcareous and kaolinitic cooking pottery produced in Messina, can be therefore considered a suitable production. The obtained data agree very well with the archaeological evidence, and more precisely with the hypothesis of a high level specialization in cooking pottery manufacturing in the «Strait Area» since the Greek period. In fact, numerous cooking pottery sherds produced in Messina were found in Siracusa and Segesta.

Moreover, the data obtained on sherds coming from potters' workshops have allowed us to identify as local production also some late archaic fine ceramics. In particular, *Zancle type* cups, *Chalcidian* wares, *banded, black glazed* and *a immersione* wares show, from the chemical point of view, numerous affinities.

So, it is clear that in Zancle-Messana there was also an intense production of fine ceramics. Further investigations will be devoted to clarify the connection between the Zancle production and that of other sites in the «Strait Area», and to define the diffusion network of these ceramics.

For what concerns the *Attic* ceramics, they result imported from Greek production centers.

The archaeometric analyses also evidenced the location in the «Strait Area», or in the nearby, of a production center of *pseudo-chian* type transport amphorae (end V - beginning IV sec. B.C.), but this hypothesis has still to be confirmed by the examinations of a wider group of samples.

On the other side, the study on the archaic and classical transport amphorae allowed us to identify in Messina some imported products, among which a special emphasis has been reserved to the discussed western-Greek products. More precisely, the so called archaic *Corinthian B* type amphorae have been divided into two groups, corresponding to two production centers at least: a Greek imported production center, likely from Corfù, and a colonial magno-Greek production center, maybe from Sibari.

Finally, with regard to *ionian-massaliote* and *pseudo-chian* type amphorae, the analysis, and the comparison with the available literature data, evidenced the presence of numerous samples imported from Locri and a few samples from a non located site in Campania.

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