THE UNGLAZED CERAMIC PRODUCTIONS FROM THE MASJID-I-JUM‘A OF ISFAHAN: AN ARCHAEOLOGICAL AND ARCHAEOMETRIC APPROACH

Bruno Genito (Università degli Studi di Napoli “L’Orientale”)
Vincenzo Morra (Dipartimento di Scienze della Terra, dell'Ambiente e delle Risorse, Università degli Studi di Napoli “Federico II”)
Serena Massa (Università Cattolica, Milano)
Faribah Saiedi Anaraki (Iranian Centre for Archaeological Research, Isfahan, Iran)
Alberto De Bonis (Dipartimento di Scienze della Terra, dell'Ambiente e delle Risorse, Università degli Studi di Napoli “Federico II”)
Vincenza Guarino (Dipartimento di Scienze della Terra, dell'Ambiente e delle Risorse, Università degli Studi di Napoli “Federico II”)

An Archaeological History (by Bruno Genito)

The Italian activities of IsMEO in the masjid-i jum’a and in the main buildings of the city of Isfahan (Fig. 1), started with a restoration and conservation activity headed by Eugenio Galdieri in the 70s of the last century. Those activities were aimed in particular at identifying the earlier constructional phases of the building and clarifying, on an architectural basis, specific significant aspects of the monument. The successive Italian archaeological project of IsMEO, Istituto Universitario Orientale di Napoli (IUO) now Università degli Studi di Napoli “L’Orientale” (UNO) and the Università degli Studi di Roma “La Sapienza” in the same monument, headed by Umberto Scerrato, started in 1972 and continued up to 1978. The first preliminary results of the conservation work of Galdieri, together with the information by ancient sources about the existence of a village in the area of the mosque, led IsMEO to start a concrete extensive archaeological research and both to carryout trial-trenches, to verify the static condition of the foundations of the building and to complete the historical, archaeological and artistic knowledge of the monument in itself, and of the area on which it stands. After the Islamic Revolution an Italian team of archaeologists could go back again in Iran only in 2002, starting a new
project entitled ADAMJI\(^1\), in order to resume a digital catalogue of the archaeological data from the masjid-i jum’a (Fig. 2).

During the excavations very important contributions have been given to the historical reconstruction of the Mosque (Fig. 3). The presence under the area of the sanctuary (area 190) of a possibly important construction, marked by a column decorated in stucco identified and dated to the Sasanian period (Fig. 4), leads one to think that, most probably, the present courtyard of the mosque corresponded to a formerly-existing open space.

The excavation in the northern area was also most encouraging; it enabled to ascertain that the round columns which were out of plumb owe their condition to the precariousness of the foundations. In fact the mosque was built on mud-brick structures obliquely oriented (north-east-south-west) with respect to the axis of the qibla (Fig. 5). The northern structures in mud-brick seem to be attributable in part to the Sasanian period and were built and reused, even quite extensively, in the Islamic time, and must belong to the ancient town of Yahuddiyeh. The excavations carried out inside the pavilion of Taj al-Mulk to North, have shown that, from the very beginning, it was definitely closed on two sides. Found below the original Seljuq floor level of the Taj al-Mulk pavilion there was a filling containing numerous potsherds of a Seljuq type pottery, i.e. fritware, and others with painted decoration under a lead glaze, the latter being of rather inferior quality.

In the trial-trenches effected in the courtyard traces of the pre-existing mosque were unfortunately not found. It will be remembered that al-Māfarrūkhī, states that the masjid-i jum’a of Yahuddiyeh was founded by the Arabs of Tiran in the third quarter of the 8th century, rebuilt during the caliphate of al-Mu‘tasim in 840-841 and then extended under the caliphate of al-Mukhtadir (908-932).

The style of the stuccoes found \textit{in situ} in the northern area is not in contradiction with this interpretation. Amongst other important results, the activity has put definitely in evidence that the mosque was first built up on

\(^1\) The acronym of the archaeological project stands for “\textit{Archaeological Digital Archive of masjid-i jum’a, Isfahan}”. This project is based at the DAAM (Dipartimento Asia Africa e Mediterraneo) and CISA (Centro Interdipartimentale di Servizi di Archeologia) of Università degli Studi di Napoli “L’Orientale” (UNO), under the scientific direction of Professor B. Genito.
an already inhabited area, probably in 772, *i.e.* at the end of the al-Mansur (754-772 AD) caliphate. The wall discovered in the area of the sanctuary belongs to this first mosque and obliquely orientated, differently with regard to the plan of Seljuq time (Fig. 6); it presents polychrome stucco decoration comparable with those of the *masjid-i jum‘a* of Nayin and with those discovered in the Siraf mosque. The excavation has given evidence for about the half, the *qibli* of this first mosque, certainly one of the earliest datable, among those up to now known in Iran. The wall in mud bricks was constituted by few rows and contained a square-sh *mihrab*, not very much distant from the modern (Fig. 7); in the western side of the prayer hall the *qibli* is kept, at least, in other two sectors 204 and 205 for an height of about 0.90m and goes, then, in the sectors 218-219. According to Abu Nu‘aym, this could be the original mosque near Yahuddiyeh in 156 H./772 AD, *i.e.* towards the end of the al-Mansur caliphate. The *qibli* presented a rich molded stucco decoration, whose few traces remained in the *mihrab* niche. Its lower part has a small tendril motif, with thin grape leaves, originating from a sort of a central tree’s trunk; on the right side there are remains of a panel decorated by an interwoven band of roundels delimitating small grape leaves. Amongst those stuccoes up to now documented, these found at the *masjid-i jum‘a* of Isfahan constitute a rare, though perhaps not unique evidence of the stucco art in the Iranian territory and are of great importance also for the same art production in the Syro-Mesopotamian area, relatively less known as far as between the half of the 8th century and Samarra periods is concerned. Most part of the stuccoes models are clearly referable to a Syro-Alexandrine style tradition, but it is evident an early cultural contact with the Iranian Sasanian sensibility. Thus, whether one can easily recognize the Alexandrine iconography, the stylization and composition are Sasanian as it is evident in the symmetric composition with the grape or *acanthus* leaves. It is useful to compare the panels of the *qibli* at Isfahan with the stucco production of the second half of the 8th century, found in a Raqqa palace and datable to the time of Harun al-Rashid. On the other hand it is also natural to make comparisons with the stucco decorations of the late

---

2 Probably it is the famous village of Yahuddiyeh, contiguous to that of Yavan, information derived by the historian Abu Nu‘aym (quoted) (948-1038) who also locates at Isfahan the building of the mosque in the place of an old Nestorian church; by other sources it is known that in the Isfahan area, a bishop seat existed already in 430 AD.
Omayyad architecture, and with those of Khirbet al-Mafjar or Qasr al-Hayr al-Sharqi, which could be easily explained with the diffusion of the Sasanian interpretation of the vegetal Alexandrine motives, through the stucco art, basically belonging to the Iranian artistic culture.

*The Digital Archive: The ceramic context* (by Serena Massa)

As part of the archaeological research carried out by the Italian Archaeological Mission in the Friday Mosque of Isfahan a significant amount of unglazed ceramic has been collected. As already mentioned in previous publications, the 416,000 fragments of unglazed, or common ceramic, were ranked starting from the macroscopic characteristics of the clay bodies.

Since the beginning, the macroscopic classification has also included the selection of samples for archaeometrical analysis, chosen on the base of their representativeness from the following points of view:

1. statistical: i.e. it has been considered to be able to identify a *fabric* on the basis of a sufficiently large number of admissions;
2. typological: the sample is relevant to a recognizable form and graphically reconstructed;
3. stratigraphical: the sample comes from well identified levels of the sequence.

Fifteen main fabrics have been recognized. Some of them were divided into sub-groups, leaving to the archaeometric analysis the task of an eventual their definite distinction or unification. A first series of tests were conducted at the laboratories of ISTEC-CNR - Institute of Science and

---

3 One may go for some preliminary results to some articles and works, Genito, Saiedi *et alii* (2009), Genito, Saiedi (2010); Genito, Massa (in press), and recently Genito (in press), Fontana (in press), Massa (in press). The macroscopic observation have been conducted with the help of a 10× lens, following the Normal Uni protocol, Norma 10739. The fragments of common pottery have been subdivided in diagnostic (46,000 rims, bases, functional elements, decorated walls) and un-diagnostic (415,000 walls typologically non identifiable). It is for the moment not possible a quantification based on the equivalent number of vessels (Estimated Vessel Equivalents, EVE, Orton *et alii* 1993, 168-173).
B. Genito, V. Morra et alii

Technology of Ceramic Materials (Fabbri, Gualtieri, Massa 2010), a second, more ample, is here presented.

Following the first analysis, carried out in 2005 with the use of optical microscopy in thin section, X-ray fluorescence spectrometry, X-ray diffraction, Fabrics 1 and 8, 4.2 and 12, 5.1 and 7.1 of the macroscopic classification have been grouped. To sum up, archaeometric analysis identified two distinct categories of ceramics, the first with high calcium content, which is the largest group, the second is clearly distinguished by a low calcium content. These differences are closely related to the function of the vessels and to the resulting technological choice from the potters with regard to raw materials, the intentional addition of tempered materials, temperatures and cooking atmosphere.

In their turn, the calcareous ceramics are primarily differentiated by the greater or lesser coarseness of the inclusions: fabrics with very thick walls, coarse inclusions, white in color (1.1, 1.2) (Figs. 8, 9); fabrics with white slip outside and thinner walls, but always with frequent inclusions (4.1, 4.3) (Figs. 10, 11); fabrics with white slip with very small and scattered inclusions (5.1, 5.2) (Figs. 12, 13); fabrics of white color without inclusions (6, 9, 11) (Figs. 14-16).

The more calcareous fabric, Fabric 6, represents the finest ceramic tableware, the so-called eggshell. At the macroscopic level this fabric comes with clay body compact, purified with neat fracture though with finely granular appearance, the color is white, sometimes variable between the light green and light yellow. Are not noticeable inclusions if not tiny, white, gray and brown. The outer surface is carefully smoothed and often decorated with motifs incised by small wheel and or imprinted. The internal surface is less carefully polished, are evident the signs of the lathe. This mixture occurs on closed forms or cups with very thin walls, with a maximum thickness of 3mm (Fig. 17).

Pottery of this type is absent from the levels prior to the ninth century, is attested, instead, with a very significant presence in the levels assigned to the 9th-12th century.

Always to the category of tableware Fabric 5.1 is pertinent, and it presents macroscopically quite compact clay body with sparse mica, material, neat fracture, very pale brown color near the surfaces and pink

---

4 For the analytical presentation of the contexts see Massa, in press.
“heart”, with scattered and very small angular mostly white and brown laminated inclusions. The surfaces are smoothed with a thin white slip/surface finishing, rather thick, smooth and uniform. It includes mostly bowls, cups and jugs in larger amounts than the previous year, mainly attested between the eleventh and twelfth centuries, absent in level III (Fig. 12).

A greater plurality of functions grouped, instead, Fabrics 4.3 and 7, which in addition to bowls and cups devoted to the use on the table, also include receptacles for the preparation and preservation of foods or substances. It is always ceramic with white surfaces with clay body with a hard looking finely porous and grainy, or more compact (Figs. 11, 18).

Also in this case the distribution on the stratigraphy mostly interests the 10th-11th century levels.

The group of artifacts of Fabric 14, mainly including jars and storage vessels is tied to a function of the pantry, with an aspect macroscopically very different from the previous. The clay body is in fact more or less dark gray colored, with jagged fracture. Often the surfaces present a smoothing cue that sometimes draws undulating motifs, in other cases there is an applied decoration (Figs. 19-20). Attested by a not elevated number of fragments, mostly on the Ic level, this fabric finds many comparisons in the late-Sasanian/early-Islamic in Iran between the end of the 7th and 8th century (Kennet 2004, 86).

Like the 14, Fabric 10 includes mainly jars, which are extremely homogeneous in color and decoration. The clay body looks hard, finely granular with jagged fracture, black due to uneven cooking. Small vacuoles are visible in some areas and frequent white inclusions. The outer surface is brown red in color, the inner surface is blackened. Often the surfaces are decorated by simple incised or impressed motifs (Fig. 21).

It is very interesting to observe the distribution of Fabric 10, which is very consistent in the II and Ic layers, whereas after, its sharp decline occurs. Fabric 1.1, consisting almost entirely of large basins presumably used for the washing, of macroscopically very rough look, clay pipes, lids and wellheads, presents a strong specialization. The clay body is very hard, compact, rugged, with jagged fracture, white colored. There are frequently inclusions in various sizes and morphology: lamellar black, reddish brown, large angular and irregular, more rare white rectangular (Fig. 22).
Of appearance and function markedly different from those seen so far, it is the group of artifacts characterized by *Fabric 4.2*. Macroscopically, this presents a clay body hard, not very compact, slightly lamellar in appearance, with jagged fracture, reddish brown pale colored with frequent mostly light gray, dark gray and white medium size inclusions.

The inner surface is smoothed in a very summary manner (inclusions cropping), while the outside is covered with whitish slip, usually stretched up to about half of the body. And it is the ceramic body typical of two-handled cookware with a convex base, which implies the use of braces, also of very large dimensions, often decorated with incisions with wave pattern under the rim, of saucepans and lids.

Frequent areas of blackening on the outside wall also indicate the use of fire (Fig. 23).

A confirmation about the specialized function of these various kinds of fabrics came from the archaeometrical analyses, as reported *infra*.

It is known that in cooking ware manufacture the technical requisites have in antiquity a prominent character, we could say exceptional in comparison with ware with different function, due to the fact that cooking ware cannot be manufactured with any clay and any firing temperature. Having to resist thermal shocks, i.e. the tensions arising from their use on fire, they must be manufactured under strict rules (Blondé, Picon 2000).

Fire resisting ware may obviously be produced using any clay if they are fired at low temperature and have thick walls: it is a method known since Neolithic in Near East and used until today in some Mediterranean regions. Nevertheless, it is a ceramic of poor quality, with little resistance to mechanical shocks and too much temper to be manufactured at wheel.

Reducing size and quantity of the temper would allow firing at higher temperatures: but the majority of clays in such conditions result in ware, which cannot be put on the fire, as being too rigid, with a bad resistance to thermal tensions. This means that improvements in cooking ware quality are bound to the presence, nearby the atelier, of specific clays, relatively seldom, which make such improvement possible, keeping at the same time a good resistance to thermal shocks.

The high quality of these cooking vessels, which combine thin walls with good thermal resistance, imply a highly specialized manufacture mainly for two reasons: the preparation of clay and the conduction of kilns.
Therefore, we can imagine the structure of Isfahan pottery manufacture marked with strong specializations and largely differentiated, probably structured by independent potters, who produced only some ceramic categories with specific techniques, different from who manufactured other ceramic categories in the same city.

Strictly bound by the organization of the productive structure are then the aspects relating to the trading of the different wares individuated, which are to be evaluated in relationship with multiple factors, among which very meaningful are the cultural, technological and discard habits. Further the access variability in pottery supply during time of a particular society, which imply the understanding of the economical frame within which sets also pottery production and distribution.

For this purpose it is essential to dispose of the global chronological seriation of the Mosque ceramic assemblages, work that is in progress.

Geological outlines of the Isfahan area (by A. De Bonis, V. Guarino, V. Morra)

The Isfahan area is part of the Sanandaj-Sirjan tectonic belt, bounded by the magmatic group Urumieh-Dokhtar to the North and by the fold belt of the Zagros Mountains to the South (Alavi 1994). The city is located in a North West-South-East oriented plain at about 1500m above sea level, and is crossed by the Zayandeh river, which runs to the South-East, ending in the inland basin of the Gavkhoni playa lake area.

Rocks in the Isfahan area span from Precambrian to Quaternary (Zahedi 1976). Precambrian rocks are mostly schists, gneisses, and metamorphosed andesites, outcropping West of Isfahan. In the North-East outcrop sandstones and quartzites of the Lower Devonian, followed in succession by dolomitic limestone and calcarenite (Middle-Upper Devonian); fossiliferrous marly limestones (Lower Carboniferous) are present in the SE. Middle-Upper Permian successions, consisting of sandstones, shales and conglomerates, passing upward fossiliferous limestones outcrop in the North East and South of Isfahan.

Triassic sequences of carbonates (limestone and dolomite) with terrigenous deposits (shales and sandstones) at the top are found in the south-eastern, north-eastern, and north-western sectors of the Isfahan plain.

Jurassic sediments can be divided into two groups: shales and sandstones with inter-bedded conglomerate outcropping North-East of
Isfahan, and those in the West and South-West, consisting of shales and sandstones with inter-bedded limestone and volcanics. Intrusive bodies (granodiorite) of the same age also outcrop in the NE sector of the plain.

Limestone, marl and shale of Cretaceous age are exposed almost everywhere in the area and, in particular, to the S of Isfahan. Eocene sediments (conglomerates and limestones) are represented in the SE of Isfahan. The tertiary plateau in the North-East mainly consists of andesitic lavas and pyroclastics, rhyolitic tuffs and rhyodacite, sandstones with interbedded volcanics. Occasionally occur nummulitic lime stones, oligo-Miocene fossiliferous limestones and mio-pliocenic sediments mainly consisting of conglomerates, calcarenites and marls. A granodiorite intrusive body (Neogene) outcrop in the North-East.

Quaternary deposits are mainly represented by terraces and alluvial sediments, widely outcropping throughout the territory of Isfahan and surrounding areas. They are represented by fine conglomerates and lacustrine-marsh sediments (silt and clays), deriving from transport of inland rivers. In the plain of Isfahan mainly outcrop grayish/brownish clays, often with abundant fossils and plant remains (Marini 1984).

Materials and analytical methods

The archaeometric investigation was focused on 23 unglazed pottery fragments (Table I) found in the masjid-i jum‘a of Isfahan. They were selected among the most representative fabrics identified via macroscopic observation of pottery finds.

Macroscopic analyses were carried out in order to describe colour (Munsell Soil Colour Chart), hardness, tactile feel, thickness, and weight of pottery (Table I).

Polarised light Microscopy (PLM; Leitz Laborlux 12 POL microscope) in thin section was performed in order to investigate the textural features and the petrographic composition of the ceramic samples. Image acquisition and measurement of grain size were carried out using a Leica DFC280 camera and a Leica Q Win image analysis software.

Chemical analyses of major oxides (wt.% of SiO₂, TiO₂, Al₂O₃, Fe₂O₃, MnO, MgO, CaO, Na₂O, K₂O, P₂O₅) and trace elements (ppm of Rb, Sr, Y, Zr, Nb, Ba, Cr, Ni, Sc, V, La, Ce) were carried out via X-ray
fluorescence (XRF; PANalyticalAxios instrument). Loss on ignition (LOI) was determined by heating 1 g sample powder at 1000 °C.

Microchemical analyses were performed on representative thin sections by Scanning Electron Microscopy (SEM; Jeol JSM-5310) and Energy Dispersive Spectroscopy (EDS; Oxford INCA X-act) in order to assess the chemical composition of individual crystals.

Semi-quantitative X-ray powder diffraction (XRPD; PANalyticalX’Pert PRO 3040/60 PW diffractometer) was performed to detect the mineralogical composition of the most representative samples and, in particular, the transformations taking place upon firing. Data acquired via XRPD were compared with SEM observation in order to evaluate the sintering degree (progressive aggregation of the clay particles leading to the consolidation of the ceramic body) of the ceramic microstructure and estimate the firing temperature of samples (Maniatis and Tite 1981).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fabric</th>
<th>Colour (core)</th>
<th>Colour (margin)</th>
<th>Hardness</th>
<th>Feel</th>
<th>Thickness (mm)</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MJ59</td>
<td>1.1</td>
<td>2.5Y 8/2 (pale yellow)</td>
<td>2.5Y 8/2 (pale yellow)</td>
<td>Hard</td>
<td>Smooth</td>
<td>18</td>
<td>29</td>
</tr>
<tr>
<td>MJ64</td>
<td>1.2</td>
<td>10YR 7/3 (very pale brown)</td>
<td>10YR 7/3 (very pale brown)</td>
<td>Hard</td>
<td>Smooth</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>MJ67</td>
<td>2</td>
<td>7.5YR 6/4 (light brown)</td>
<td>7.5YR 6/4 (light brown)</td>
<td>Soft</td>
<td>Rough</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>MJ69</td>
<td>3</td>
<td>5YR 6/6 (reddish yellow)</td>
<td>5YR 6/6 (reddish yellow)</td>
<td>Soft</td>
<td>Rough</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>MJ71</td>
<td>4.1</td>
<td>7.5YR 6/4 (light brown)</td>
<td>7.5YR 6/4 (light brown)</td>
<td>Hard</td>
<td>Rough</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>MJ74</td>
<td>4.2</td>
<td>5YR 5/6 (yellowish red)</td>
<td>5YR 5/6 (yellowish red)</td>
<td>Hard</td>
<td>Smooth</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>MJ78</td>
<td>4.3</td>
<td>7.5YR 6/3 (light brown)</td>
<td>7.5YR 6/3 (light brown)</td>
<td>Hard</td>
<td>Smooth</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>MJ79</td>
<td>4.3</td>
<td>7.5YR 6/4 (light brown)</td>
<td>7.5YR 6/4 (light brown)</td>
<td>Hard</td>
<td>Rough</td>
<td>33</td>
<td>41</td>
</tr>
<tr>
<td>MJ80</td>
<td>5.1</td>
<td>7.5YR 7/4 (pink)</td>
<td>2.5Y 8/2 (pale yellow)</td>
<td>Hard</td>
<td>Smooth</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>MJ85</td>
<td>5.2</td>
<td>5YR 8/2 (light grey)</td>
<td>5YR 8/2 (light grey)</td>
<td>Hard</td>
<td>Smooth</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>MJ86</td>
<td>5.2</td>
<td>5YR 5/6 (yellowish red)</td>
<td>5YR 5/6 (yellowish red)</td>
<td>Hard</td>
<td>Smooth</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>MJ89</td>
<td>6</td>
<td>5Y 7/1 (light grey)</td>
<td>5Y 7/1 (light grey)</td>
<td>Hard</td>
<td>Smooth</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>MJ90</td>
<td>7</td>
<td>5Y 8/2 (pale yellow)</td>
<td>5Y 8/2 (pale yellow)</td>
<td>Hard</td>
<td>Smooth</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>MJ92</td>
<td>7.1</td>
<td>5Y 7/2 (light grey)</td>
<td>5Y 7/2 (light grey)</td>
<td>Hard</td>
<td>Smooth</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>MJ94</td>
<td>7.1</td>
<td>5Y 7/2 (light grey)</td>
<td>5Y 7/2 (light grey)</td>
<td>Hard</td>
<td>Rough</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>MJ95</td>
<td>8</td>
<td>5Y 6/3 (pale olive)</td>
<td>5Y 6/3 (pale olive)</td>
<td>Friable</td>
<td>Rough</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>MJ96</td>
<td>9</td>
<td>10YR 7/3 (very pale brown)</td>
<td>10YR 7/3 (very pale brown)</td>
<td>Hard</td>
<td>Smooth</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>MJ97</td>
<td>10</td>
<td>2.5YR 3/2 (dusky red)</td>
<td>2.5YR 5/6 (red)</td>
<td>Hard</td>
<td>Smooth</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>MJ98</td>
<td>11</td>
<td>5Y 7/2 (light grey)</td>
<td>5Y 7/2 (light grey)</td>
<td>Hard</td>
<td>Smooth</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>MJ99</td>
<td>12</td>
<td>2.5YR 4/6 (red)</td>
<td>2.5YR 4/6 (red)</td>
<td>Hard</td>
<td>Smooth</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

Table I List of the analysed samples and their main macroscopic features.
Petrography and microanalyses

Polarised Light Microscopy (PLM) observation highlighted similar petrographic features or differences of the investigated samples.

Eight samples (MJ59, 64, 67, 69, 71, 79, 94, 95) showed a very coarse and non-homogeneous texture (Fig. 24a). Colour of the ceramic body was either orange (MJ64, 67, 69, 71, 79) or olive/grey (MJ59, 94, 95). Ceramic matrix was optically isotropic, with the exception of MJ69 and MJ71, which showed a marked birefringence (Fig. 24b); a weak birefringence was noticed for MJ95. All samples of this group showed a medium (MJ59, 64, 67, 69, 71, 94) or medium-high (MJ71, 79, 94, 95) porosity, which was characterised by elongated pores in two samples (MJ94, 95). Inclusions showed a bimodal distribution with an estimated abundance of 5-15% (MJ59), 10-20% (MJ67, 69, 71, 94), and 20-30% (MJ64, 79, 95). Fine fraction was scarce and only represented by tiny crystals of quartz, slightly more abundant in MJ64 and MJ67. Grains, ranging from 200 to 400 μm in size, composed the coarse fraction; in six samples (MJ67, 69, 71, 79, 94, 95) also larger (1000 μm) or very elongated (MJ 95) grains were found. These grains were mainly represented by arenites showing a variable degree of textural maturity. Very mature sandstones were only visible in MJ79 and MJ94. Siltites and mudstones (sub-rounded and frequently elongated) were observed in most samples (MJ59, 64, 67, 69, 71, 79, 94); in MJ69 siltites of variable size (250-1000μm) represented the majority of grains. Sparse fragments of metamorphic rocks (schist, gneiss, quartzite) and chert were observed in MJ79 and MJ94. Some of these samples contained isolated crystals of angular quartz (MJ64, 79, 94), rare plagioclase (MJ64, 67, 94, 95), alkali feldspar (MJ94) or muscovite (MJ64). Carbonate microfossils fragments were noticed in MJ71 and MJ79, and micrite grains in MJ94. The sample MJ59 showed a birefringent fabric (b-fabric; Kemp, 1985) due to the presence of microcrystalline calcite widespread in the matrix; in this sample a high amount of secondary sparry calcite was observed as filling of voids (Fig. 24c). Secondary calcite was also visible in variable amount in all fragments.
The sample MJ90 showed a similar petrographic composition with the samples of the previous group, but it differentiated for a finer texture. A greyish ceramic body with abundant microcrystalline calcite in the matrix and pores, very similar to that of MJ59, was observed.

SEM observation of ceramic microstructure of two representative fragments showed a non-vitrified body for MJ69 (Fig. 25a) and an extensive vitrification for MJ90.

A group composed of three samples (MJ78, 80, 92) was characterised by well sorted grains (Fig. 24d). Colour of these samples was light brown (MJ78) and light grey (MJ92); MJ80 showed a zoned body with orange core and pale yellow margin. Ceramic matrix was isotropic, except for sample MJ80. Porosity varied from medium low (MJ92) to medium (MJ78, 80), with elongated voids in MJ80. Grains were present in the amount from 10-20% (MJ80, MJ92) to 20-30% (MJ78), with a size mainly ranging from 150 to 200 μm. Only very rare tiny crystals of quartz represented the fine fraction. Metamorphic fragments (schist, gneiss, quartzite) were frequently observed in MJ80 and MJ78 (Fig. 24e), and in minor amount in MJ92. Frequent sandstone and siltite were present in MJ78 and MJ92; arenite with lower textural maturity were observed in MJ80. Sporadic fragments of chert were also observed in all samples of this group. Loose crystals of plagioclase (MJ80, 92), clinopyroxene analysed as augite (MJ92), alkali feldspar (MJ78, 80), biotite (MJ78), epidote (MJ80, 92), and monazite (MJ92) were also present. Secondary calcite was present on the pore rims of MJ80 and MJ92. Coarse sub-rounded micrite grains were observed in MJ78, along with carbonate microfossils fragments. SEM observation pointed out, for the representative sample MJ80, a transition vitrification structure from initial to extensive (Fig. 25b).

Two samples (MJ96, 98) were characterised by fine texture, light grey ceramic body and optically isotropic matrix. Porosity was low (MJ98) or medium low (MJ96), with rare elongated voids. Inclusions showed a serial distribution and an amount of about 15% (Fig. 24f). Tiny sandstone fragments, occasionally of coarser size (MJ96), were also observed. Mica was represented by either muscovite (MJ98) or biotite (MJ96). Alkali feldspar was observed in the two samples; in MJ98 was also noticed plagioclase. Clinopyroxene was rarely identified in the two samples. Secondary calcite was observed on pore rims.
The samples MJ85 and MJ89 were characterised by a very fine texture (Fig. 24g). Colour was pale yellow (MJ85) or light grey (MJ89). The matrix was in both cases optically inactive. The porosity was very low in MJ89 and medium-low in MJ85. Inclusion amount was very scarce, close to 5% in the sample MJ85 and even less than 5% in sample MJ89. The only inclusions observed were tiny crystals of quartz (very rare in MJ89) and, only in MJ85, rare muscovite.

Samples MJ99 and MJ101 showed reddish (MJ99) or dark grey (MJ101) colour of the ceramic body and isotropic matrix. Porosity was medium low in MJ99 and medium, with some elongated voids, in MJ101. Inclusions were mostly represented by fine (10 to 100 μm) crystals of quartz in the amount of about 10% in MJ99, or slightly higher (10-20%) in MJ101; sporadic coarser (250-500 μm) grains also occurred (Fig. 24h). Siltites and mudstones, occasionally represented by elongated fragments, occurred in MJ101 and, more rarely, in MJ99. In the latter sample grog was also recognized. Chert fragments were visible in MJ101, while sporadic mica (muscovite and biotite) and rare plagioclase also occurred in the two samples. Rare secondary calcite was ubiquitous, whereas in MJ99 also occurred lime lumps.

The sample MJ74 showed a similar texture to that of samples MJ99 and MJ101, except for the higher abundance of coarser grains. The ceramic body was red, the matrix optically isotropic, and porosity medium low. Inclusions were present in hiatal distribution in the amount of 10-20%. Fine fraction (10-100 μm) was abundant and mostly composed of quartz and rare biotite. Coarser grains (250-500 μm) were frequent and mostly represented by elongated clasts of arenites with a variable degree of textural maturity; siltite and mudstone fragments were in lower amount. Rare secondary calcite and lime lumps also occurred.

The sample MJ103 was characterised by a coarse texture and poorly sorted inclusions. Its colour was red and the matrix optically isotropic. Porosity was medium high with frequent elongated voids. Inclusion were abundant (25-35%) and showed bimodal distribution (Fig. 24i). Abundant angular quartz crystals composed the fine fraction. Coarse grains were represented by frequent sandstone fragments, plagioclase crystals, and sporadic metamorphic clasts (schist, gneiss, quartzite). Acidic igneous rock fragments also occurred. They were composed of k-feldspar, quartz, and albite, in association with amphibole (magnesio-hornblende), quartz, and
accessory apatite. Epidote-quartz bearing lithics and loose epidote crystals were analysed, along with magnetite and titanite. An extensive vitrification was observed for MJ103 (Fig. 25c).

The sample MJ97 showed a colour zoning of the clay body, the core and the inner edge of the vessel was dark, while the external margin reddish. The clay matrix is birefringent. The texture was coarse with bimodal distributed inclusions in the amount of 25-35%; porosity was medium low. Frequent crystals of quartz formed the fine fraction, whereas coarse fraction was mostly composed of angular calcite fragments of about 200 μm average size (Fig. 24j). Sandstones and sporadic siltite fragments also occurred, along with loose crystals of plagioclase, amphibole (actinolite), and rutile. SEM observation showed a non-vitrified structure of the MJ97 ceramic body (Fig. 25d).

A reddish ceramic body and birefringent matrix characterised the sample MJ86. Porosity was low. Inclusions were in the amount of 10-15% and showed a serial size distribution mainly ranging from 50 to 200 μm (Fig. 24k). Finer particles were formed of angular crystals of quartz and mica (muscovite and biotite). Amphibole was present in moderate amount with crystals of different size. Coarser fragments were mainly represented by sandstone and mudstone. Rare secondary calcite was also noticed.

The sample MJ100 (Fig. 24l) was characterised by a colour zoning of the ceramic body, with reddish birefringent margins and a black and weakly birefringent core. Porosity was low. Inclusions were in the amount of about 10% and were composed of tiny (5-50 μm) and serial distributed crystal of quartz and sporadic muscovite.

**Chemical analysis**

The most evident chemical distinction between the pottery samples of this study was due to the content of calcium oxide (CaO). Most samples (MJ59, 64, 67, 69, 71, 78, 79, 80, 90, 92, 94, 95, 96, 97) showed a high-CaO (hereafter *HC*) content (CaO> 6%; Maniatis, Tite 1981) ranging between 11.2 and 18.9 wt.%. Only slight differences among samples of this group were evidenced. Samples MJ59 and MJ90 showed higher CaO, whereas MJ69 and MJ96 were characterised by lower values; other samples showed a quite homogeneous CaO content (Fig. 26a).

331
A group of four samples (MJ74, 99, 101, 103) was characterised by low-CaO (hereafter LC) values, ranging from 1.40 to 4.95 wt.%. Also, lower SiO₂ values were noticed for all HC samples (52.7-57.9 wt.%) compared to the LC ones. Silica of LC samples ranged from 61.1 to 68.6 wt.%, and the higher value was relieved for MJ103 (Fig. 26a). This sample (MJ103) slightly differentiated from the others for lower Al₂O₃ (13.5 wt.%), TiO₂ (0.70%), and Fe₂O₃ (6.22%) compared to the average of LC samples (Table II). MJ103 was also characterised by the highest value of Na₂O observed, while the lowest content was that of M197 (Table II; Fig. 26b). Higher K₂O values were recorded for three LC (MJ74, 99, 101) and two HC (MJ69, 71) samples compared to the other pottery fragments (Table II; Fig. 26b).

The distinction between HC and LC group was still evident considering trace elements. Higher average values of Rb, Y, Zr, Nb, Ba, Cr, and V were recorded for LC group, whereas Sr showed a lower average value (Table II; Figs. 26c and 26d). Also in this case the sample MJ103 frequently showed compositional differences from other LC samples (MJ74, 99, 101).
Table II Chemical analyses (XRF). Minimum, maximum and average values of major oxides (wt.%), LOI (wt.%), and trace elements (ppm) for the high-CaO (HC) and low-CaO (LC) samples. Standard deviation (σ) was also reported.

<table>
<thead>
<tr>
<th></th>
<th>SiO₂</th>
<th>TiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>MnO</th>
<th>MgO</th>
<th>CaO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>P₂O₅</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>52.69</td>
<td>0.57</td>
<td>12.00</td>
<td>5.53</td>
<td>0.09</td>
<td>3.83</td>
<td>11.19</td>
<td>0.42</td>
<td>1.53</td>
<td>0.14</td>
<td>100</td>
</tr>
<tr>
<td>Max</td>
<td>57.92</td>
<td>0.77</td>
<td>16.55</td>
<td>7.31</td>
<td>0.14</td>
<td>6.03</td>
<td>18.85</td>
<td>1.64</td>
<td>3.00</td>
<td>0.33</td>
<td>100</td>
</tr>
<tr>
<td>Average</td>
<td>55.27</td>
<td>0.68</td>
<td>13.71</td>
<td>6.57</td>
<td>0.11</td>
<td>4.85</td>
<td>15.37</td>
<td>1.04</td>
<td>2.21</td>
<td>0.19</td>
<td>100</td>
</tr>
<tr>
<td>σ</td>
<td>1.53</td>
<td>0.05</td>
<td>1.28</td>
<td>0.41</td>
<td>0.02</td>
<td>0.72</td>
<td>2.18</td>
<td>0.34</td>
<td>0.44</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td><strong>LC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>61.13</td>
<td>0.70</td>
<td>13.52</td>
<td>6.22</td>
<td>0.05</td>
<td>3.26</td>
<td>1.40</td>
<td>1.59</td>
<td>2.12</td>
<td>0.05</td>
<td>100</td>
</tr>
<tr>
<td>Max</td>
<td>68.59</td>
<td>0.95</td>
<td>15.61</td>
<td>8.12</td>
<td>0.23</td>
<td>5.34</td>
<td>4.95</td>
<td>2.79</td>
<td>3.33</td>
<td>0.17</td>
<td>100</td>
</tr>
<tr>
<td>Average</td>
<td>64.18</td>
<td>0.86</td>
<td>14.82</td>
<td>7.35</td>
<td>0.10</td>
<td>4.38</td>
<td>3.23</td>
<td>1.96</td>
<td>3.00</td>
<td>0.12</td>
<td>100</td>
</tr>
<tr>
<td>σ</td>
<td>3.31</td>
<td>0.11</td>
<td>0.95</td>
<td>0.81</td>
<td>0.09</td>
<td>0.93</td>
<td>1.54</td>
<td>0.56</td>
<td>0.59</td>
<td>0.06</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>LOI</th>
<th>Rb</th>
<th>Sr</th>
<th>Y</th>
<th>Zr</th>
<th>Nb</th>
<th>Ba</th>
<th>Cr</th>
<th>Ni</th>
<th>Se</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>1.56</td>
<td>54</td>
<td>219</td>
<td>13</td>
<td>109</td>
<td>4</td>
<td>280</td>
<td>121</td>
<td>70</td>
<td>19</td>
<td>135</td>
</tr>
<tr>
<td>Max</td>
<td>16.36</td>
<td>101</td>
<td>539</td>
<td>32</td>
<td>175</td>
<td>12</td>
<td>399</td>
<td>234</td>
<td>134</td>
<td>23</td>
<td>220</td>
</tr>
<tr>
<td>Average</td>
<td>14.78</td>
<td>77</td>
<td>406</td>
<td>21</td>
<td>143</td>
<td>9</td>
<td>336</td>
<td>152</td>
<td>98</td>
<td>21</td>
<td>170</td>
</tr>
<tr>
<td>σ</td>
<td>27.85</td>
<td>15</td>
<td>78</td>
<td>4</td>
<td>17</td>
<td>2</td>
<td>33</td>
<td>35</td>
<td>17</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td><strong>LC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>0.87</td>
<td>72</td>
<td>211</td>
<td>24</td>
<td>160</td>
<td>9</td>
<td>461</td>
<td>130</td>
<td>45</td>
<td>17</td>
<td>155</td>
</tr>
<tr>
<td>Max</td>
<td>2.19</td>
<td>115</td>
<td>346</td>
<td>34</td>
<td>225</td>
<td>17</td>
<td>499</td>
<td>295</td>
<td>127</td>
<td>19</td>
<td>270</td>
</tr>
<tr>
<td>Average</td>
<td>1.41</td>
<td>102</td>
<td>286</td>
<td>30</td>
<td>203</td>
<td>14</td>
<td>488</td>
<td>214</td>
<td>96</td>
<td>19</td>
<td>205</td>
</tr>
<tr>
<td>σ</td>
<td>0.56</td>
<td>21</td>
<td>56</td>
<td>4</td>
<td>31</td>
<td>3</td>
<td>18</td>
<td>69</td>
<td>38</td>
<td>1</td>
<td>48</td>
</tr>
</tbody>
</table>

Mineralogical analysis

All pottery samples showed abundant quartz, except for MJ89 in which this phase was detected in scarce amount. Feldspar was scarce in all samples and in trace in MJ97. Variable amounts of pyroxene were detected in several fragments, except in MJ69, MJ86, MJ97, and MJ103; in two samples (MJ74, 99) it was detected only in traces.

Calcite was detected in variable amounts in most HC samples, except in MJ89; in two fragments (MJ85, 92) was relieved only in traces. Traces of calcite were also noticed in the LC sample MJ74.

Variable amounts of pyroxene were detected in most fragments, especially in HC samples where it was found as newly formed phase originated during firing. Pyroxene was abundant in MJ89, frequent in six
samples (MJ59, 80, 85, 90, 92, 94), and scarce in MJ79. It was also detected in traces in two LC samples (MJ74, 101).

Newly formed gehlenite (melilite group) was relieved only in HC samples either in abundant (MJ85) or frequent (MJ90) amounts. In the other HC samples this phase was scarce (MJ59, 89, 92) or in traces (MJ79, 80), whereas was absent in MJ69, MJ86, MJ97.

Trivalent iron oxides, represented by hematite and maghemite, were found together in traces in several samples (MJ59, 80, 85, 90, 101). Hematite was relieved in scarce amount (MJ74) or in traces (MJ79, 86, 103), while only maghemite was detected in MJ89 and MJ92. Bivalent iron oxides (magnetite and hercynite) were detected in scarce amount in MJ90.

Minerals of the illite/muscovite group represented clay phases. They were detected in six samples in scarce (MJ80) and frequent (MJ69, 97) amounts, or in traces (MJ74, 86, 101).

Analcime was detected in scarce amount (MJ89) or in traces (MJ85, 90). Amphibole was detected in traces in MJ103.

**Discussion and conclusive remarks**

The analyses carried out in this study showed that most of the unglazed pottery fragments from the masjid-i jum'a of Isfahan were characterised by a broadly similar petrographic composition. The differences observed in thin section were mainly related to textural features, such as the abundance and distribution of the inclusions.

Petrography allowed us to distinguish a group of samples (MJ59, 64, 67, 69, 71, 79, 94, 95) characterised by a coarse and non-homogeneous texture, containing variable amount of arenites, siltites, mudstone, and occasional metamorphic rocks (MJ79, 94). MJ90 was very similar to the previous mentioned samples and it only differentiated for a finer texture. Three samples (MJ78, 80, 92) showed a similar petrographic composition, but were characterised by well sorted grains in a very fine matrix. Two fragments (MJ96, 98) were characterised by a serial size distribution of fine inclusions, with occasional coarse arenites (MJ96). The samples MJ85 and MJ89 showed a very fine texture, characterised by a very compact matrix and almost no inclusions.
Samples MJ74, MJ99, and MJ101 were characterised by an abundant quartzose fine fraction with sporadic coarser grains mostly composed of siltites and mudstone (more abundant in MJ74).

Also the other observed samples were characterised by the ubiquitous presence of arenitic and/or metamorphic fragments in variable amount and size, but differed from each other and from the previous samples for some peculiar petrographic features. The sample MJ103 was characterised by a coarse texture, frequent plagioclase, and acidic igneous rock fragments. The sample MJ97 represented a unique specimen due to the presence of coarse calcite crystals as temper and minor plagioclase and amphibole (actinolite). MJ86 was characterised by poorly sorted inclusions mostly composed of quartz, mica and arenites. MJ100 contained tiny (5-50 μm) crystal of quartz and sparse muscovite.

From the technological point of view, the unglazed pottery from the masjid-i jum’a of Isfahan showed some petrographic and chemical features probably related to the end use of the artefacts. The different textures identified among the high-CaO samples were likely related to pottery of different function. Most of the coarse and non-homogeneous samples represented by thick-walled pottery were probably large basins used as storage ware (MJ59, 67, 69, 71, 95); other samples (MJ79, 94) with similar texture could be ascribed to tableware or cooking ware (MJ64).

Samples with thinner walls, including the ones containing well sorted inclusions (MJ78, 80, 92) and those with fine (MJ96, 98) or very fine (MJ85, 89, 90) ceramic body, were likely used as tableware.

The use of high-CaO clay allowed potters to obtain ceramic products with a good strength, as required by their end use (e.g., storage and tableware). Indeed, high-CaO ceramics yield a particularly stable microstructure over a wide firing temperature range, from about 850 to 1100 °C, which provides excellent physico-mechanical properties (De Bonis et alii 2014 and references therein). In fact, firing temperatures estimated for most high-CaO samples of this study were comprised in that range. Several samples (MJ59, 79, 85, 89, 90, 92, 94) showed firing temperatures ranging between 900 and 1050 °C, due to the absence of illite/muscovite (decomposing at about 900 °C; Cultrone et alii, 2001; Rathossi and Pontikes, 2010) and to the presence of gehlenite (stable up to about 1050 °C; Cultrone et alii, 2001; Grifa et alii, 2009). Lower temperatures (800-900 °C) were estimated for the sample MJ80, which showed initial vitrification
at SEM, together with the presence of illite/muscovite and traces of gehlenite. Firing temperatures between 750 and 800 °C were estimated for MJ86, due to the coexistence of hematite (detectable nearly above 750 °C; Nodari et alii 2007) with illite/muscovite and calcite (persisting up to about 800 °C; Fabbri et alii, 2014). For MJ69 were estimated firing temperatures even lower than about 750 °C, due to the abundant presence of clay phases (illite/muscovite) and the non-vitrified structure.

It is worth noting that in some high-CaO samples (MJ59, 79, 80, 90, 94) calcite was also detected by XRPD in association with newly formed calcium silicates (pyroxene, gehlenite), which form at the expense of calcite when it decomposes upon firing starting from about 800 °C (Cultrone et alii, 2001).

A special attention is due to the cooking ware fragment MJ97, which it was tempered with coarse calcite grains. Thus this sample is the result of a precise technological choice, since calcite was frequently used as a good tempering material for cooking ware, especially by early potters, due to its low thermal expansion coefficient (Rye 1976; Maritan et alii, 2007). MJ97 would have been fired at temperatures lower than about 750 °C, as it showed by the non-vitrified structure, the presence of clay minerals and calcite, and the absence of hematite.

In some samples (MJ59, 89, 92, 94) the presence of analcime was due to the post depositional weathering of ceramic glass formed at high firing temperatures (Schwedt et alii, 2006).

The low-CaO composition of samples MJ74, MJ99, MJ101, MJ103 could also be related to technological purposes. In particular for the production of high quality cooking ware, since the use of low-CaO clays greatly improves toughness and thermal shock resistance (Tite et alii, 2001).

Firing temperatures evaluated for samples MJ74 and MJ101 ranged between 800 and 900 °C. This was suggested by the presence of pyroxene which formed as the CaO content in these samples was relatively high (4-5 wt.%), as well as by presence of illite/muscovite. The sample MJ103 was probably fired from 850 to 950 °C, according to the extensive vitrification observed at SEM.

Finally, several fragments of this study showed different colours. This was largely due to the firing conditions, in particular the oxidising/reducing composition of the atmosphere in the kiln (Maritan et alii 2006). Some samples (MJ59, 80, 85, 89, 90, 92, 101) have experienced
partially reducing conditions during firing according to the presence of maghemite and/or bivalent iron oxides (magnetite/hercynite). This would be related to a variability of the kiln atmosphere (Molera et alii 1998; Morra et alii 2013), thus suggesting a rather inaccurate control of the firing process.

As far as provenance of pottery is concerned, we noticed that the inclusions observed in thin section showed a petrographic composition compatible with the main lithologies outcropping in the Isfahan area and in the drainage basin of the Zayandeh river. In particular, arenites, metamorphic rocks (schist and gneiss), and chert (Pakzad 2003; Pakzad, Ajalloeian 2007). Thus, one may hypothesize a production of unglazed pottery in the Isfahan area.

Chemical data did not reflect the petrographic differences observed in thin section. The main chemical evidence was given by the distinction from high-CaO (MJ59, 64, 67, 69, 71, 78, 79, 80, 90, 92, 94, 95, 96, 97) and low-CaO (MJ74, 99, 101, 103) samples. This distinction was evident also considering other chemical variables.

In particular the high-CaO composition, which characterised most samples of this study, might suggest the widespread availability of high-CaO clayey raw materials in the Isfahan area.

Also low-CaO samples were probably produced in the same area, but it is not to exclude a provenance from other locations. Especially for sample MJ103, which frequently showed an atypical chemical behaviour compared to other low-CaO samples and contains some different inclusions (acidic igneous rock). The distribution of igneous outcrops, mainly located to tens of kilometres far from Isfahan, in the north-western sector of the Zayandeh river drainage basin, would explain the rarity of igneous lithics in the pottery.
REFERENCES


The Unglazed Ceramic …Isfahan: an Archaeological and Archaeometric Approach

ACKNOWLEDGEMENTS:

Islamic Republic of Iran:
- Research Center of the Iranian Cultural Heritage, Handicrafts and Tourism Organization (RCICHHTO), Tehran
- Iranian Centre for Archaeological Research (ICAR) of RCICHHTO, Iran
- Iranian Cultural Heritage, Handicrafts and Tourism Organization (ICHHTO), Tehran
- Iranian Cultural Heritage, Handicrafts and Tourism Organization (ICHHTO), Isfahan

- The Embassy of Italy at Tehran

Republic of Italy:
- Ministry of Foreign Affairs (DGCS & DGPRC)
- Istituto Italiano per l’Africa e l’Oriente (IsIAO)
  - Università degli Studi di Napoli, Federico II
  - Università degli Studi di Napoli “L’Orientale”
  - Dipartimento Asia, Africa e Mediterraneo
  - Centro Interdipartimentale di Servizi per l’Archeologia (CISA)

- The Embassy of Islamic Republic of Iran, Rome
FIGURES
Fig. 1 - General view of the Masjid-i Jum’a of Isfahan

Fig. 2 - The scheme of the ADAMJI Project
Fig. 3 - General plan of the Masjid-i Jum’a of Isfahan, with the trial-trenches effected from 1972 to 1978
Fig. 4 - The excavations in the northern portico
Fig. 5 - The excavation in sector no 190, southern Dome, with the qibli and the sasanian-type column

Fig. 6 - The qibli with the stucco decoration in the sector 101 and 102 to West of the southern Dome
Fig. 7 - The excavation in sector no 190, southern Dome, with the qibli with the stucco decoration

Fig. 8 - Sample of Fabric 1.1

Fig. 9 - Sample of Fabric 1.2

Fig. 10 - Sample of Fabric 4.1
Fig. 11 - Sample of *Fabric 4.3*

Fig. 12 - Sample of *Fabric 5.1*

Fig. 13 - Sample of *Fabric 5.2*

Fig. 14 - Sample of *Fabric 6*
Fig. 15 - Sample of Fabric 9

Fig. 16 - Sample of Fabric 11

Fig. 17 - Fabric 6, cup with incised decoration

Fig. 18 - Sample of Fabric 7
Fig. 19 - Fabric 14, jars with incised wave decoration

Fig. 20 - Fabric 14, jars with applied and burnished decoration
The Unglazed Ceramic …Isfahan: an Archaeological and Archaeometric Approach

Fig. 21 - Fabric 10, jars with impressed (first on the left) or incised wave decoration

Fig. 22 - Basin, Fabric 1.1
Fig. 23 - Cooking pot, Fabric 4.2
Fig. 25 SEM images of ceramic microstructure of some representative samples. a) MJ69. Non-vitrified structure. b) MJ80. Initial to extensive vitrification. c) MJ103. Extensive vitrification. d) MJ97. Non-vitrified structure.

Fig. 26 - XRF binary diagrams, showing major oxides (wt%) and trace elements (ppm) of high-CaO (HC) and low-CaO (LC) samples.