Islamic glazed wares from ancient Termez (southern Uzbekistan). Raw materials and techniques

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Abstract

Ancient Termez, located on the southern border of Transoxiana/Mawarannahr, was an important pottery production centre during the Islamic period. Recent archaeological and archaeometric research carried out by the Spanish-Uzbek team evidenced the manufacture of glazed and unglazed vessels at the workshops found in the lower city (*shahristan*) and its suburbs (*rabad*). Glazed local products, mainly dated between the 9th and 16th/17th centuries, comprise slip-painted, underglaze and inglaze painted wares, splashed *sgraffiato*, and monochrome wares. The present study focuses on the chemical, mineralogical and petrographic examination of different types of glazed ceramics recovered at Termez excavations in order to identify the microstructure and composition of the glazes, the technological processes involved in their manufacture, and their evolution over the centuries. Thin polished sections were prepared and slips and glazes were analysed by optical microscopy (OM) and scanning electron microscopy (SEM). The results reveal that all the local/regional ceramics have a slip and a transparent glaze, with one exception. Colour decorations were applied over the slip, forming thinner or thicker layers depending on the desired final colour. Green (copper), red (iron) and brown/black (iron and in some cases iron plus manganese) pigments were used for the decorations. A high lead glaze was used in the ceramics found in the alluvial plain dating between the 9th and the 11th century, while an alkaline glaze is associated with ceramics collected in the *shahristan* dating between the 12th and the 17th century. An alumina rich clay mixed with lead oxide was used in the slip from the alluvial plain ceramics while the slip contained large quartz grains in the ceramics found in *shahristan*. Three imports from the Iraqi regions, a monochrome lustreware bowl and two white opaque glazed dishes dating from the 9th-10th centuries, were also recovered. They have the characteristic tin-opacified mixed lead-alkali glazes and fine calcareous pastes.

Keywords: Termez; slips; lead glazes; alkaline glazes; ancient ceramics

1. Geographical and Historical introduction

The site of ancient Termez is located in the southernmost limit of Uzbekistan, along the Oxus river or Amu Darya, lying 7 km south-east from the modern city. Its long history extended from the 3rd-2nd century BCE to the 18th century CE, with the Kushan (1st BCE-3rd century CE) and the Early Islamic (9th century-1220) periods being the most flourishing phases (Leriche and Pidaev, 2007, 2008). Since the Arab conquest in the late 7th century CE, ancient Termez was part of the region of Transoxiana, known in Arabic as Mā warā' al-Nahr/Mawarannahr. It was defined as the lands under Muslim control lying to the north of the Amu Darya, in contrast to the Iranian lands proper.

In the 9th-10th centuries, under the Samanid dynasty, the city greatly developed and prospered, reaching the remarkable extension of 500 hectares. It consisted of three fortified areas, each with its own walls. The citadel (*kohandez* or *ark*) is in a higher position than the rest of the city, being located on a rectangular mound along the river bank. North-west of it, there is the proper city or *shahristan*, densely inhabited. The suburbs, or *rabad*, occupy the larger area of the city, lying east and north-east of both citadel and *shahristan*; markets, caravanserais, and manufacturing workshops concentrated in the *rabad*, being the centre of the economic life (Leriche and Pidaev, 2007).

After the fall of the Samanids, between the 11th and the early 13th century, ancient Termez was contested between several Central Asian dynasties, who alternatively controlled this powerful stronghold. During the 11th century, the city and the lands surrounding Balkh were disputed between Kharakanids and Ghaznavids, the latter finally included them within their possessions. Around 1043-1044, the region came under the Seljuqs, that contributed to the further development of the city. Nonetheless, the Kharakhanids continuously tried to conquer those lands, with some success. From the mid-12th century, other powers began fighting each other for the control of this strategic site; the city was taken first by the Kara Khitays, by the Ghurids later and by the Khwarazm Shas in the first decade of the 13th century. In 1220 the Mongols of Genghis Khan took and largely destroyed ancient Termez (Leriche and Pidaev, 2008). Nonetheless, the city was able to recover afterwards, as testified by several archaeological finds, both structures and materials, dated from the 13th until the 17th/18th century (Martínez Ferreras et al., 2019a).

Within the Mawarannahr, Termez was the major city of the Surkhan Darya valley. Indeed, its strategic position, at the confluence of this river with the Amu Darya, controlling the point where it is easier to cross the latter, gave the site a crucial political and military role, protecting the northern and southern boundaries of various political entities. Moreover, the city was located along one of the most important routes of the Silk Road, connecting Samarqand and Bukhara to the north with Balkh to the south, and from there to the Indian subcontinent; therefore, Termez also acquired an important commercial role, particularly during the 10th-12th centuries. This also affected the local craftsmanship, which became a leading activity in the economic life of the city. According to the historical sources, the city produced many different items, such as soaps, boats, metals and glasses, and it exported the herbal substance called asafoetida; ceramics should have been a well-developed manufacture, as Termez was also known for manufacturing jugs (Leriche and Pidaev, 2008: 117-118).

The archaeological research-works carried out so far, mainly by the Termez Archaeological Expedition (Pidaev, 1986) and by the MAFOuz team (Mission Archéologique Franco-Ouzbèke de Bactriane Septentrionale (Leriche et al., 2001), offer a quite comprehensive overview of the intense pottery production during the Islamic period at the site of ancient Termez. F. Lesguer (2015) recently published a synthesis of the ceramic workshops recovered in different areas of the city by previous archaeological missions. In 2018, the Uzbek-Spanish IPAEB team (International Pluridisciplinary Archaeological Expedition to Bactria) recovered new structures related to pottery manufacture. To date, a total of eight workshops and potter quarters dated to the Islamic period have been identified (Fig.1). In the *extra-moenia* area, north-west of the *rabad* and north of *shahristan*, there were four workshops; the northernmost one (no. 1) and the southernmost ones (nos 8 and 11) have one kiln, while workshop 2, close to the first one, has three kilns. From the archaeological evidence, it seems that workshops 1 and 2 mainly produced unglazed large containers. Workshop 8 was specialized in the production of glazed vessels and sphero-conical vessels; the latter are peculiar containers with a very narrow mouth, made of thick overfired ceramic body. Workshop 11, newly discovered by the IPAEB team, is probably connected with the production of unglazed fine jugs and sphero-conical vessels, but the kilns related to the latter manufacture have not yet been found. According to the pottery study and the C^{14} tests on organic material, these centres were active in the early Islamic period (i.e. 9^{th}-10^{th} century) (Martínez Ferreras et al., 2019a). In the northern part of the *rabad*, a workshop (no. 9) was specialized in manufacturing unglazed high-quality fine vessels. Sphero-conical vessels seem to be produced also in another workshop (no. 10) placed in the south-east sector of the *rabad* (Leriche and Pidaev, 2008: 109-114; Lesguer 2015: 435-436). On the opposite side of the site, west of the citadel, very close to the river bank, the French-Uzbek MAFOuz team found a kiln (workshop 4) dated to the 11^{th}-12^{th} century (Lesguer, 2015). Inside the *shahristan* a workshop (no. 5) was discovered by the MAFOuz mission and is being re-examined by the Uzbek-Spanish team. It has at least three kilns and one wasters pit. Recent ^{14}C analysis carried out on several charcoal samples found within one of the kilns provided two different absolute dates between the early 14^{th} and mid-15^{th} centuries AD: 1306-1363 cal AD (50.1%); 1385-1429 cal AD (45.3%); it manufactured unglazed moulded relief decorated jugs and flasks but also underglaze painted wares and probably monochrome turquoise vessels, suggesting that this workshop already operated during the 13^{th} century AD (Martínez Ferreras et al., 2019a; Fusaro et al., in press).

The discovery of several pottery kilns, with the associated dumps, wasters and elements of potter's furniture, such as moulds for jugs and flasks, unquestionably prove that the city was a very active centre manufacturing ceramics, both unglazed and glazed, and sphero-conical vessels. Along with the production of a large quantity of unglazed vessels, especially fine jugs and flasks, that confirmed the information given by the historical sources, the production of glazed vessels took a distinguished place in the ceramic manufacture of Termez during the Islamic period. Recent archaeological and archaeometric investigations conducted by the IPAEB team have defined the morphological and stylistic features of the most common Islamic wares produced at Termez, also in comparison with other ceramic productions from important coeval Iranian and Central Asian sites. The preliminary geo-chemical, mineralogical, and petrographic characterisation of the ceramic pastes has also contributed to detect differences among local products, distinguish local and imported items, and determine the main technological processes related to their manufacture (Martínez Ferreras et al., 2019a; Fusaro et al., in press). This study demonstrates that ancient Termez produced a wide range of unglazed and glazed wares, also including high-quality artefacts, which equalled the ceramics produced in other important Central Asian centres. Especially between the 9th and the 12th century, during the most flourishing phase of the city, at least five workshops were active within and outside the *rabad* (nos 1, 2, 4, 8, 11). After the Mongol conquest of the city, even if its importance and size dramatically decreased, ancient Termez continued manufacturing ceramics, as testified by the potters' quarter no. 5 discovered inside the *shahristan*.

In order to complete the characterization of the glazed vessels, the present study focuses on the chemical, mineralogical and petrographic examination of different types of glazed surfaces to identify the composition of the materials, the glaze recipes, the technological processes involved in their manufacture, and their evolution over the centuries. The aim is giving a comprehensive and exhaustive description of the most important glaze techniques related to the vessels found at the site during the Islamic period, and better defining the contemporary imported items.

2. Materials

A total of 21 glazed earthenware vessels were selected for the analysis of the surface treatments. They come from two different archaeological contexts at the site of Termez and are dated between the 9th and the 17th century. Thirteen of them (coded TA) were collected in sector AC2 during the excavation carried out in 2009 by the Uzbek-Spanish team in the alluvial plain of Termez (Fig. 1) (Martínez Ferreras, 2010). This sounding, located in the westernmost sector of the site, has been interpreted as a rubbish dump used during the Islamic period. The complex stratigraphy of the dump stands on an ancient canal that connected the Surkhan Darya with the Amu Darya through Termez. The area was disturbed by modern activities, nonetheless the stratigraphic units, from which the selected ceramics come, remain untouched and can be considered reliable. Radiocarbon analysis and the examination of the ceramic assemblages suggest that the dump was formed between the 9th and the 12th centuries. The other eight ceramic samples (coded TS) come from the area of the kiln 1 within the pottery workshop 5 located in the *shahristan* and excavated in 2009 by Larisa Baratova, member of the MAFOuz team (Fig.1). They cover a timespan from the 10th/11th to the 16th/17th centuries AD. Their finding in the area of the workshop does not mean that these ceramics were produced there. Indeed, as mentioned above, the *shahristan* was a densely inhabited area, where the citizens of Termez lived at least since the 9th-10th century; pottery could have circulated in the area since the early Islamic period. The pottery workshop 5 was created later, and it has been dated from the 13th century onwards (Martínez Ferreras et al., 2019a). Therefore, to date the provenance of at least some of the vessels analysed from this *shahristan* area cannot be directly attributed to the pottery workshop 5.

The specimens selected and analysed provide a general overview of the wares circulating at ancient Termez during the Islamic period. Vessels from the rubbish dump stylistically belong to the slip-painted ware (TA3, TA8, TA11, TA12), the underglaze painted ware (TA2, TA5, TA9, TA10, TA13), and the splashed *sgraffiato* ware (TA4, TA7) (Fig. 2). Based on archaeological data, morphological and stylistic criteria, and C^{14} results, these vessels can be dated between the 9th and the 11th century. Less frequent wares are represented by a lustre-painted bowl (TA1) and an opaque white glazed dish (TA6) dated to the 9th-10th centuries. Vessels from the pottery workshop in the *shahristan* consist of monochrome glazed wares (TS3, TS5, TS6), one of them also bearing *sgraffiato* decoration (TS7), dated to the late 12th-13th century, and underglaze/inglaze painted bowls (TS4, TS8) attributed to the 14th/15th and the 16th/17th century, respectively. The earliest glazed vessels analysed from this area are an opaque white glazed dish with turquoise splashes (TS1) and a slip-painted vessel (TS2) (Martínez Ferreras et al., 2019a; Fusaro et al., in press).

The archaeometric characterisation of the selected glazed vessels previously conducted comprised the chemical analysis by wavelength Dispersive X-ray Fluorescence (WD-XRF), the mineralogical analysis by X-ray Diffraction (XRD) and the petrographic analysis through thin-section optical microscopy (OM) of the ceramic bodies. This investigation was carried out at the Scientific and Technological Centres of the University of Barcelona and allowed distinguishing three main groups of vessels (A, B and C), interpreted as local or regional products, and three imports (Table 1) (Martínez Ferreras et al., 2019a; Fusaro et al., in press).

Group A comprises glazed vessels from the *shahristan* area —the green monochrome (TS3), the turquoise monochrome (TS5, TS6 and TS7), and the underglaze/inglaze painted bowls (TS4, TS8)— dated between the 12th and the 16th/17th century (Fig. 2). Group B includes five vessels from the rubbish dump in the alluvial plain —two slip-painted bowls (TA3, TA11), a splashed *sgraffiato* bowl (TA7) and two underglaze painted bowls (TA5, TA10)—, attributed to the timespan of the 9th-11th centuries. Even if some chemical differences have been detected among the vessels classified in groups A and B, all of them have been considered as local products. They consist of calcareous pastes (CaO: 10-11 wt%) with similar chemical composition to the local productions from Termez related to the pre-Islamic period (Tsantini et al., 2016; Martínez Ferreras et al., 2019b). Indeed, the mineralogical and petrographic composition of these vessels is consistent with the local raw materials (clayey sediments) also analysed from Termez and with the geological composition of the region.

Group C comprises underglaze painted (TA2, TA13), slip-painted (TA8, TA12) and splashed *sgraffiato* specimens (TA4) from the alluvial plain, dated between the 9th and the 11th century (Fig. 2). They have been attributed to a local-regional origin since their chemical composition slightly differs from that of the local products. Thus, these wares exhibit higher Nb, Zr, Y and

Ga content than the vessels from the chemical groups A and B. Nevertheless, the petrographic composition is compatible with the geological environment of the city and that of the Amu Darya-Surkhan Darya floodplain. In some cases, their morphological-decorative features, recalling the productions of other Central Asian sites, support a different manufacturing centre within the region.

Within the assemblage analysed, the only sure imported items from farthermost lands are three vessels belonging to the opaque glazed wares, TA1 and TA6 recovered in sector AC2, and TS1 from *shahristan* (Fig. 2, Table 1). They are very fine calcareous fabrics and exhibit a significantly different chemical and petrographic composition with respect to the local-regional glazed vessels. TA1 is a bowl that belongs to the lustre-painted ware and it can be dated to the 9th century, as suggested by its polychrome decoration and its form. It largely conforms to the lustre-painted production typical of the southern Iraqi area. This suggested provenance has been confirmed by the matching of its ceramic body with the Basra petrofabric (Frierman et al., 1979; Mason and Keall, 1991; Mason 1997a, 1997b, 2004; Mason and Tite, 1997; Pradell et al., 2008). TA6 and TS1 are two large shallow dishes with a wide everted flat rim, that can be dated to the 9th-10th centuries. They are completely covered with a well-opacified white glaze, TS1 is also characterized by smaller turquoise splashes dripping from the rim. The chemical compositions of the pastes differ from each other, thus suggesting two different productions. Especially the fabric of TA6 exhibits similar chemical composition to that of the plain opaque glazed wares from Samarra and Basra in Iraq (Mason and Keall, 1991; Mason, 1997a, 2004; Mason and Tite, 1997).

3. Experimental methods

To examine the surface coatings of the selected vessels, thin polished sections were prepared and glazes and slips were analysed by optical microscopy (OM) and scanning electron microscopy (SEM). The thin section of each sample was examined at the Universitat de Vic – Universitat Central de Catalunya both in transmitted and reflected light with an optical microscope (OM, LEICA), and with a scanning electron microscope (SEM, GEMINI (Shottky FE) at the Universitat Politècnica de Catalunya. Glazes, slips and decorations were analysed by SEM-EDS (INCAPentaFETx3 detector, 30mm2, ATW2 window, resolution 123 eV at the Mn Kα energy line), operated at 20-kV acceleration voltage with 1.1 nm lateral resolution, 20 nA current, 7 mm working distance, and 120 s measuring times. The results were normalized and then averaged (totals of glaze varied between 98 and 102%). The EDS elemental microanalysis system was calibrated with various oxide and minerals while for the lead a high-lead glass standard (K229, Geller Microanalytical Laboratory, MA, USA) was used. Typical detection limits are 0.1% for Na, Mg, Al, P, K, Ca, Ti, and Fe; 0.2 for Si and Cu; 0.3 for Sn; and 0.4 for Pb. The microstructures of the glazes, slips and decorations layers were studied and recorded in back-scattered electron (BSE) mode in which the different phases present could be distinguished on the basis of their atomic number contrast. BSE images of the microstructures were obtained at 20 kV acceleration voltages.

4. Results

The analysis of the chemical composition of the glazes (Table 2) shows clear technological differences among the samples. All the local-regional specimens, with a single exception (TS3), have a slip under the glaze, either white or coloured, and all are covered with a transparent glaze; the three imported ceramics (TS1, TA1, TA6) are tin-glazed and none of them are slipped. Most of the local-regional ceramics found in the alluvial plain and dated to the 9^{th}-11^{th} centuries (TA2, TA3, TA4, TA5, TA7, TA8, TA9, TA10, TA11, TA12, TA13) as well as samples TS2 and TS3 from the *shahristan*, attributed to the 10^{th}-12^{th} centuries, are lead-glazed. Differently, the surfaces of the rest of the vessels from the *shahristan* dated to the 12^{th}-17^{th} centuries are alkaline-glazed (TS4, TS5, TS6, TS7, TS8). The compositional differences among the samples are clearly shown in the bivariant plots Na_2O-PbO and Na_2O-K_2O of Fig. 3.

4.1. Ceramics with transparent Lead Glazes

The ceramic vessels found in the alluvial plain and dated from the 9^{th} to the 11^{th} century, belonging to the slip-painted (TA3, TA8, TA11, TA12), underglaze painted (TA2, TA5, TA9, TA10, TA13), and splashed sgraffiato wares (TA4, TA7), as well as the slip-painted vessel TS2 (10^{th} – 11^{th} century) from the *shahristan*, have all the same characteristics. All of them have a white slip decorated with different colours and a transparent lead glaze over the slipped surface, the results of the chemical analysis of the glazes are shown in Table 2 and those of the slips in Table 3; bivariant plots PbO-SiO_2 and Al_2O_3-SiO_2 of the slips are shown in Fig. 4. The glaze is lead-rich with 53 wt% of PbO, 37 wt% SiO_2 and 2.5 wt% of Al_2O_3 as major components and low contents (below 2 wt%) of K_2O + Na_2O and CaO. The microstructures of the glazes, slips, and decorations layers were studied and recorded with optical microscopy in reflected and polarised light and in back-scattered electron (BSE) mode. The glaze does not contain raw inclusions, neither bubbles, nor crystals developed at the interface between the glaze and the slip (Fig. 5), indicating that the glaze might have been applied in a second firing. This is to say that white slips were applied over the dried clay body and decorated previous to the first firing.

The thickness of the white slips varies between 40 and 70 microns (Fig. 5A). The slips were made using a rich aluminium clay with low CaO content. The content of Al_2O_3 (ranging from 16 to 25 wt%) is higher than that found in the ceramic body (Table 3 and Fig. 4A). The slips also contain PbO varying between 10% and 22 wt%. PbO should be considered as a component of the slip because the content is too high to be attributed exclusively to the interaction between glaze and slip (Table 3). The addition of PbO to the slip is a good practice because it helps the bonding with the ceramic body, which is important when a double firing is performed. Other fluxes such as Na_2O (ranging from 0.9 to 2.8 wt%) may also have been added to help the bonding of the slip with paste and glaze.

With respect to the composition of the glazes, it is possible to determine if PbO was applied directly over the slip or was previously mixed with sand and then applied over the slip. Figure 4B shows the silica content of the glazes and of the slips after subtracting the PbO and renormalizing; the SiO_2 of the glazes is above the dissolution line, indicating that a mixture of PbO+SiO_2 was used.

Decorations in green, red, brown, or yellow were applied over the slip and under the glaze. The green colour was made adding copper which appears completely dissolved into the glaze.

The other colours appear over the slip forming a thin or sometimes a thick layer, and can be clearly seen with the Optical microscope. Those showing thin colour layers, such as TA2, were stylistically classified as underglaze painted while those with thick colour layers, such as TA3, as slip-painted ware. Fig. 5 (B) shows a thin layer of a red fine clay (rich in Fe_2O_3) applied over the white slip corresponding to the red-light brown decoration of sample TA2. The dark brown decoration of sample TA3 appears as a thick coarse layer of a red clay mixed with quartz and feldspars as is shown in the polarised light image of the cross section (Fig. 5C). On the contrary, the black decorations of all samples were obtained with a pigment made of large iron oxide particles (Fig. 5D) applied over the white slip. Although all the black decorations contain mainly iron oxides, some of them contain also particles of manganese oxide (TA10, TA11, TA12, TA13 and TS2). Iron (and manganese) oxide particles applied under the glaze tend to soar in the lead glaze, as it is observed in Fig. 5D.

In particular, bowl TA12 (Fig. 6) has a black slip completely covering the inner surface. The black slip contains large grains of iron oxide, some grains of a spinel with chromium (Fig. 6B) and partly dissolved grains of manganese oxide (Fig. 6A). Moreover, TA11 has a black epigraphic band which contains also large particles of iron oxides, neoformed hematite crystals and melanotekite crystals. According to Di Febo and others (2017), the presence of melanotekite and neoformed crystals of hematite indicates a glaze firing temperature below 925ºC.

In the case of the vessels with *sgraffiato* decoration (TA4 and TA7), incisions were made through the white slip where crystallites of diopside grew at the bottom of the glaze (Fig. 7) over the lead feldspars crystals formed at the interface. The slips and pigments used for the splashed *sgraffiato* ceramics are the same as those of the painted specimens commented before (Tables 2 and 3).

TS2 shows slight differences comparing with the rest of slip-painted and underglaze painted samples from the alluvial plain. The glaze is poorer in PbO (45 wt% PbO) and the black pigment is manganese-richer.

In summary, although corresponding to productions stylistically different (slip-painted, underglaze/inglaze painted or splashed *sgraffiato* wares) all the ceramics were produced using the following technique:

1. The vessel was first covered with a white clayey slip with one exception (a black slip for TA12)
2. The *sgraffiato* was made after applying the slip and before it was completely dry
3. The red or brown painted decorations were applied over the slip as a thin fine red clay or a thick layer coarse red clay, respectively. When they are thin, the ceramics are considered underglaze painted, on the contrary when they are thick the decoration is labelled slip-painted.
4. Black decorations were obtained with a pigment made of large iron oxide particles applied over the white slip, some of them contain also particles of manganese oxide or chromite.
5. The glaze was applied and fired in a second firing.

A recent study on underglaze painted and splashed *sgraffiato* ceramics from the Khurasan region, more specifically from Affrasiyab in Uzbekistan (Hoolakey et al 2019), and dated to the

Samanid period (9th -10th AD) shows that these are also covered with a lead glaze over a white slip; red and brown painted decorations were also made of iron and manganese oxides. Nonetheless, as the samples of this study have been analysed by non-invasive techniques, quantitative chemical analysis of the glazes and slips has not been obtained and cannot be compared with our data.

Bowl TS3 represents a different ware within the first glazed group from Termez: it is a monochrome glazed vessel characterised by a green lead glaze applied directly over the surface (Table 2). The glaze composition is not very different from the lead glazes of the other ceramics from the alluvial plain, but it does not have slip. The glaze has 2.7 wt% of copper mainly dissolved into the glaze and also some copper containing pyroxenes formed into the glaze (dark little crystals in the image of Fig. 8)

4.2. Ceramics with Alkaline Glazes

The ceramic vessels found at *shahristan* (TS4, TS5, TS6, TS7, TS8) have alkaline glazes (Na_2O + K_2O > 10 wt%), with high silica content (about 70 wt% of SiO_2, 5 wt% of Al_2O_3, 4 wt% of CaO and 2 wt% of MgO) (Table 2). They show bubbles across the glaze and some unreacted quartz grains. The alkaline glazes are more weathered and less well preserved than previous lead glazes. The glazes are between 100 and 200 microns thick, and are also applied over a white slip, but in this case the slip contains large quartz grains (Fig. 9) and therefore is silica richer but also richer in alkalis than the lead-glazed vessels. A comparison between the alkaline and the lead glazes compositions and their related white slips is shown in Table 4.

Copper is found dissolved into the alkaline glazes of samples TS5, TS6, TS7. Copper in rich sodium alkaline glazes gives a turquoise colour instead of green colour, which is typical of lead glazes.

The glaze of TS8 has a transparent alkaline glaze decorated in turquoise and black; the slip is richer in SiO_2 than the earlier alkaline glazes as can be seen in Fig. 9 D-F. The black decoration is made of chromite grains with growing acicular yellow crystals around and which are identified as pyroxenes of Na-Ca-Fe-Cr.

Consequently, the ceramics of this period were also slipped, decorated and glazed, although the nature of the glazes and slips is different than the earliest local/regional productions.

4.3 Imported vessels

Three imported vessels have been recognised: TA1, TA6, and TS1. They show opaque tin glazes with a mixed alkaline-lead composition. The samples do not have slips.

Bowl TA1 has a ceramic body composition similar to the Abbasid production from Iraq (Molina et al 2014) and it has the same low lead alkali glaze composition. Therefore, the glaze analysis confirms a provenance of the lustre-painted bowl from the Iraqi regions.

Dishes TA6 and TS1 also have tin-opacified mixed-alkaline lead glazes (Table 2). The archaeological and stylistical study of these specimens has already identified strong resemblance with items from Iraq, but also from Iran and Syria (Martínez Ferreras et al., 2019a).

Discussion

The present study on the surface coatings of the selected glazed vessels from ancient Termez gives very interesting insights into the technology of the most widespread productions circulating at this site during the Islamic period.

The two well-defined technological groups, identified through the archaeometric analysis of slips and glazes, are consistent with the groups of wares recognised by the archaeological research-work, according to the examination of their morphological and decorative features. They represent two main chronological phases of the local/regional pottery production. The data obtained so far show that the technological tradition related to the manufacture of glazed vessels, especially concerning the slip and glaze recipes, clearly changed from the late 12th-early 13th century. Indeed, the glazed wares produced before this moment, i.e. between the 9th and the 11th century, are characterized by clayey slips and high lead glazes, while the wares manufactured from the late 12th-early 13th century onwards show slips very rich in quartz sand and alkaline glazes. Moreover, differences in the colours palettes of their decorations follow the fashion spread in each historical period: a large polychromy, including white, yellow, green, red, brown, black, is typical of the first group of wares; the second group is mainly associated with a colour scheme using turquoise, blue and black.

It is probable that this change in technology and fashion could be related to the Mongols' conquest of Termez in 1220, which deeply affected its daily life, including the artisanal activities. The archaeological research-work of the IPAEB team and the archaeometric study of the ceramics from Termez have revealed some repercussions of this shocking event on the pottery manufacture. First, as the city shrank, the pottery workshops moved from the suburbs to the *shahristan*, an urban area previously densely inhabited. Second, different raw materials, new techniques, new forms, and new motifs were introduced in the local pottery manufacture, in order to respond to a new economic and social order.

Especially the changes in fashion of the glazed earthenware vessels produced in the area of Termez could be possibly explained with the growing circulation and popularity of new high-quality and more expensive ceramic items made of stonepaste, an artificial paste consisting in a mixture of crushed quartz, frit-glass, and white clay, that clearly imitates the porcelain body. Forms, colour palette, and decorative motifs of the vessels from Termez dated to the 12th/13th-17th century are strongly influenced by the features of these stonepaste vessels, spread in Central Asian and Iranian regions since the late 12th century. Therefore, it is possible to suggest that the slips rich in quartz sand were produced to imitate the stonepaste body, while the use of blue/turquoise and black was influenced by the underglaze painted decoration of the stonepaste vessels, such as the Blue and White ware, that became widespread especially from the Timurid period.

The fruitful combination of the archaeological study and the archaeometric examination of pastes and surface coatings of the glazed samples from ancient Termez also allow proposing the provenance of the imported items. At least two of them, i.e. the lustre-painted bowl TA1 and the opaque white glazed dish TA6, most probably came from manufacturing centres located in the Iraqi regions, thus testifying to the role of Termez as an important trading post along Central Asian routes. In some cases, the arrival of these imports at Termez seems to have influenced the local production, as suggested by the specimen TA3: its decoration, consisting of palmette motifs painted in different brown hues, recalls that of the lustre-painted vessels although it is obvious that the potters did not known the secret of lustre. Therefore, it is possible that some local potters, specialized in producing slip-painted ware, tried to imitate imported luxury items from Iraq by using raw materials and techniques at their disposals; they possibly ignored the secret of the glaze opacification, even if there exist tin sources in Uzbekistan (in the area of Karnab, at about 450 km north of Termez, see for example Kaniuth 2007).

Conclusions

The ceramic vessels, of local or regional provenance, found in the alluvial plain of Termez and dated from the 9th to the 11th century have lead transparent glaze over a clayey slip. Colour decorations were applied over the slip, forming thinner or thicker layers depending on the painting technique chosen. Green (copper), red (iron) and brown/black (iron and in some cases iron plus manganese) pigments were used for the decorations. The slips were made with a rich-alumina clay mixed with lead oxide.

Ceramics collected in the *shahristan* dating between the 12th and the 17th century were made with alkaline glazes over white slips which contained large quartz grains and feldspars.

It is probable that this change in technology and fashion could be related to the Mongols' conquest of Termez in 1220and the effects it had on the city life.

In conclusion, even if the vessels analysed represent a small sampling and more analysis are needed, the present study can be considered an important contribution to the technological characterisation of the Central Asian pottery productions of the Islamic period. From a stylistical point of view, the transformation to which the local/regional glazed manufacture from Termez underwent has been detected also in other Central Asian sites (e.g. Balkh, Ghazni, Samarqand); nonetheless, to date this phenomenon, and its technological aspects, has been insufficiently studied and discussed by using an archaeometric approach, with a few exceptions (see, for example, Fusaro 2014).

The preliminary hypotheses so far proposed are interesting starting points that will be further investigated and verified by the future researches and results of this study, which is still in progress.

Acknowledgments

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Tables

Table 1. Classification of the glazed vessels analysed according to the chemical (WD-XRF) and petrographic groups identified, with indication of their location, the proposed chronology and the estimated firing temperature of the body (EFT) determined through XRD (Martínez Ferreras et al., 2019a)

PROVENANCE	SITE	DATE	SAMPLES	EFT	WARE
LOCAL Group A	Alluvial plain and *shahristan*	9th- 11th c.	TA9	800-900ºC	Underglaze painted
			TS2	1000-1100°C	Slip-painted
		12th-13th c.	TS5	900-1000ºC	Monochrome (green & turquoise)
			TS3, TS6, TS7	1000-1100°C	
		14th-15th c.	TS4	1000-1100°C	Underglaze/inglaze painted
		16th-17th c.	TS8	1000-1100°C	
LOCAL Group B	Alluvial plain	9th- 11th c.	TA5, TA10	800-900ºC	Underglaze painted
			TA3, TA11	900-1000ºC	Slip-painted
			TA7	900-1000ºC	Splashed *sgraffiato*
LOCAL-REGIONAL Group C	Alluvial plain	9th- 11th c.	TA2	800-900ºC	Underglaze painted
			TA13	1000-1100°C	
			TA8	900-1000ºC	Slip-painted
			TA12	1000-1100°C	
			TA4	1000-1100°C	Splashed *sgraffiato*
IMPORTS	Alluvial plain and *shahristan*	9th-10th c.	TA1	1000-1100°C	Lustre painted
			TA6, TS1	1000-1100°C	Opaque white glazed

Table 2. Chemical analysis of the ceramic glazes (TA and TS) through SEM-EDS

Ref.	**Chronology**	**Na_2O**	**MgO**	**Al_2O_3**	**SiO_2**	**K_2O**	**CaO**	**MnO**	**FeO**	**CuO**	**SnO_2**	**PbO**	**Type**
TA1	9-10th	7.3	4.0	1.3	68.4	4.0	5.0	0.5	0.3	b.d	5.1	4.9	Tin glaze
TA6	9-11th	2.8	0.9	2.1	52.1	4.0	2.6	b.d	0.5	b.d	5.6	29.6	Tin glaze
TS1	9-10th	2.4	0.8	2.1	48.5	3.4	2.6	b.d	1.4	b.d	4.8	34.4	Tin glaze
TA5	9-10th	1.0	0.3	3.6	38.6	0.6	1.1	0.1	1.8	0.6	b.d	52.4	Lead Glaze
TA10	9-10th	0.8	0.4	2.0	36.9	0.5	1.3	0.8	1.7	b.d	b.d	55.8	Lead Glaze
TA11	9-10th	0.5	0.3	1.8	34.7	0.4	1.7	1.1	4.0	b.d	b.d	55.4	Lead Glaze
TA3	10-11th	0.7	0.2	2.4	38.1	0.5	1.1	0.3	0.5	0.4	b.d	53.1	Lead Glaze
TA7	10-11th	0.7	0.6	2.2	39.9	0.7	2.2	b.d	0.6	2.9	b.d	49.9	Lead Glaze
TA8	9-10th	1.3	0.4	1.6	36.4	2.0	1.3	0.3	5.3	b.d	b.d	51.6	Lead Glaze
TA2	9-11th	0.9	0.4	1.7	36.4	0.5	1.1	0.1	0.6	0.2	0.2	58.1	Lead Glaze
TA13	9-11th	1.3	0.8	3.1	50.5	2.7	2.0	0.0	0.9	0.0	b.d	38.8	Lead Glaze
TA12	10th	1.0	0.6	2.8	35.7	1.2	1.8	2.2	5.8	0.2	b.d	48.7	Lead Glaze
TA4	10-11th	1.1	0.6	2.4	39.1	1.0	1.7	b.d	0.9	1.0	b.d	52.2	Lead Glaze
TA9	9-11th	0.3	0.2	5.0	37.4	0.6	2.9	b.d	0.9	b.d	b.d	52.8	Lead Glaze
TS2	10-11th	1.4	0.6	3.7	41.1	1.8	1.8	0.8	3.4	0.2	b.d	45.3	Lead Glaze
TS3	11-12th	0.7	0.5	2.7	33.9	1.1	3.0	0.0	1.2	2.7	b.d	54.1	Lead Glaze
TS5	12-13th	12.3	2.2	3.4	67.7	4.4	3.7	0.0	0.8	5.1	b.d	0.1	Alkaline Glaze
TS6	12-13th	8.7	2.1	4.3	68.7	5.8	4.3	0.3	1.0	4.1	b.d	0.3	Alkaline Glaze
TS7	12-13th	7.1	2.5	4.5	74.2	5.4	4.8	b.d	0.5	b.d	b.d	0.2	Alkaline Glaze
TS4	14-15th	8.0	1.5	11.0	67.1	7.3	2.7	0.3	0.5	0.7	b.d	0.2	Alkaline Glaze
TS8	16-17th	7.2	2.9	2.7	68.2	3.8	5.0	b.d	7.9	1.6	b.d	0.0	Alkaline Glaze

Table 4. Mean and standard deviation of Alkaline and Lead glazes and their slips renormalizing the composition after removing the colourants (copper, iron and manganese).

Ref.	Chronology	Arch. Context	Na_2O	K_2O	Al_2O_3	SiO_2	MgO	CaO	PbO
Lead Glaze	**9-11th**	**alluvial plain**	0.9	1.0	2.7	39.8	0.5	1.7	53.7
		std	*0.3*	*0.7*	*1.0*	*3.9*	*0.2*	*0.6*	*5.1*
Alkaline Glaze	**12-17th**	**shahristan**	9.2	5.6	5.4	73.0	2.4	4.3	0.2
		std	*2.3*	*1.3*	*3.3*	*2.9*	*0.6*	*1.1*	*0.1*
Lead rich Slip	**9-11th**	**alluvial plain**	1.8	3.7	22.5	51.7	0.5	1.8	17.9
		std	*0.5*	*1.3*	*3.3*	*4.2*	*0.2*	*0.5*	*4.5*
Quartz rich Slip	**12-17th**	**shahristan**	4.0	4.5	11.2	78.2	0.6	1.5	-
		std	*1.3*	*1.9*	*5.2*	*8.5*	*0.3*	*1.2*	-

Table 3. Chemical analysis of slips (TA and TS) through SEM-EDS

Ref.	Chronology	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	MnO	FeO	CuO	PbO	Type
TA5	9-10th	2.8	0.3	24.0	51.2	2.8	1.4	b.d	0.9	0.1	16.2	Lead Glaze
TA10	9-10th	1.5	0.6	15.9	55.6	2.0	2.3	0.2	2.6	0.3	18.0	Lead Glaze
TA11	9-10th	1.1	0.7	19.0	53.0	2.2	1.1	0.1	1.1	b.d	21.9	Lead Glaze
TA3	10-11th	1.8	0.2	24.8	50.1	2.6	1.3	b.d	0.5	b.d	17.8	Lead Glaze
TA7	10-11th	2.0	0.4	18.7	50.3	2.6	1.9	b.d	1.0	0.5	22.2	Lead Glaze
TA8	9-10th	1.8	0.8	23.0	46.1	4.8	0.6	b.d	0.9	0.1	21.3	Lead Glaze
TA2	9-11th	1.6	0.4	25.2	56.7	5.6	1.5	b.d	0.4	b.d	8.2	Lead Glaze
TA13	9-11th	2.0	0.6	26.1	42.7	4.9	1.1	b.d	1.6	b.d	20.0	Lead Glaze
TA12	10th	1.3	0.5	17.5	44.5	4.2	1.3	2.3	10.1	b.d	17.5	Lead Glaze
TA4	10-11th	2.3	0.3	22.5	51.4	3.7	1.4	b.d	0.4	0.3	16.7	Lead Glaze
TA9	9-11th	0.9	1.0	24.5	50.8	3.8	5.6	b.d	1.3	b.d	11.2	Lead Glaze
TS2	10-11th	1.5	0.7	15.2	47.2	4.0	3.3	3.1	12.6	b.d	10.0	Lead Glaze
TS5	12-13th	3.6	0.8	14.3	73.5	3.3	3.1	b.d	1.3	b.d	0.0	Alkaline Glaze
TS6	12-13th	4.6	0.7	11.2	73.4	6.1	2.1	b.d	1.0	1.0	0.0	Alkaline Glaze
TS7	12-13th	3.7	0.2	12.5	79.1	4.0	0.3	b.d	0.2	b.d	0.0	Alkaline Glaze
TS4	14-15th	5.6	1.0	15.0	69.7	6.5	1.4	b.d	0.4	b.d	0.0	Alkaline Glaze
TS8	16-17th	2.1	0.3	2.3	89.8	2.1	0.5	b.d	2.9	0.1	0.0	Alkaline Glaze

Table 4. Mean and standard deviation of Alkaline and Lead glazes and their slips renormalizing the composition after removing the colourants (copper, iron and manganese).

Ref.	Chronology	Arch. Context	Na_2O	K_2O	Al_2O_3	SiO_2	MgO	CaO	PbO
Lead Glazes	**9-11th**	**alluvial plain**	0.9	1.0	2.7	39.8	0.5	1.7	53.7
		std	*0.3*	*0.7*	*1.0*	*3.9*	*0.2*	*0.6*	*5.1*
Slip under Lead Glazes	**9-11th**	**alluvial plain**	1.8	3.7	22.5	51.7	0.5	1.8	17.9
		std	*0.5*	*1.3*	*3.3*	*4.2*	*0.2*	*0.5*	*4.5*
Alkaline Glazes	**12-17th**	**shahristan**	9.2	5.6	5.4	73.0	2.4	4.3	0.2
		std	*2.3*	*1.3*	*3.3*	*2.9*	*0.6*	*1.1*	*0.1*
Slip under alkaline Glazes	**12-17th**	**shahristan**	4.0	4.5	11.2	78.2	0.6	1.5	-
		std	*1.3*	*1.9*	*5.2*	*8.5*	*0.3*	*1.2*	-

Figures

Fig.1

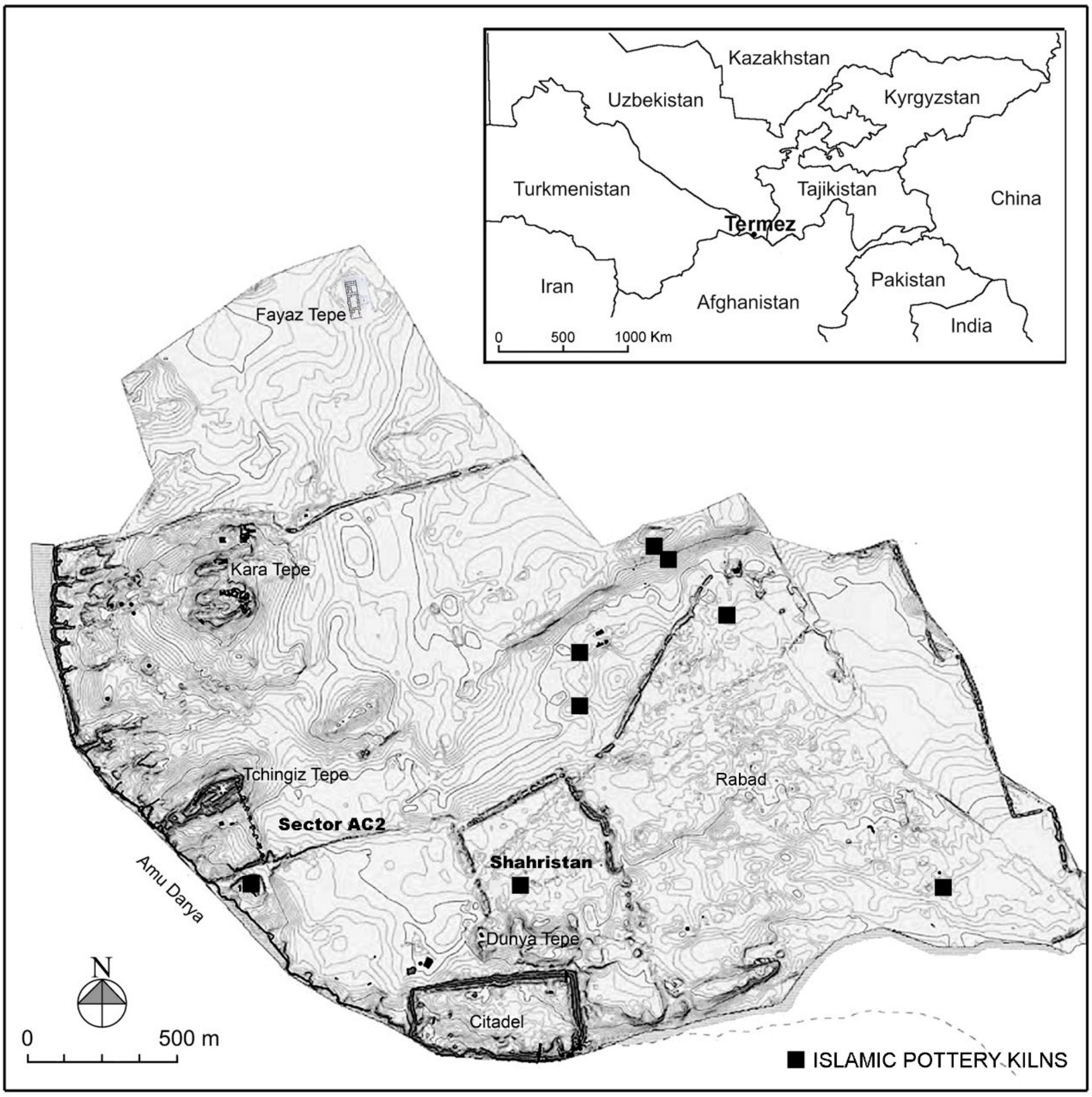

Fig. 1. The location and general layout of Ancient Termez (from Leriche and Pidaev 2007: 183, fig. 2), with the indication of the Islamic pottery workshops.

Fig.2

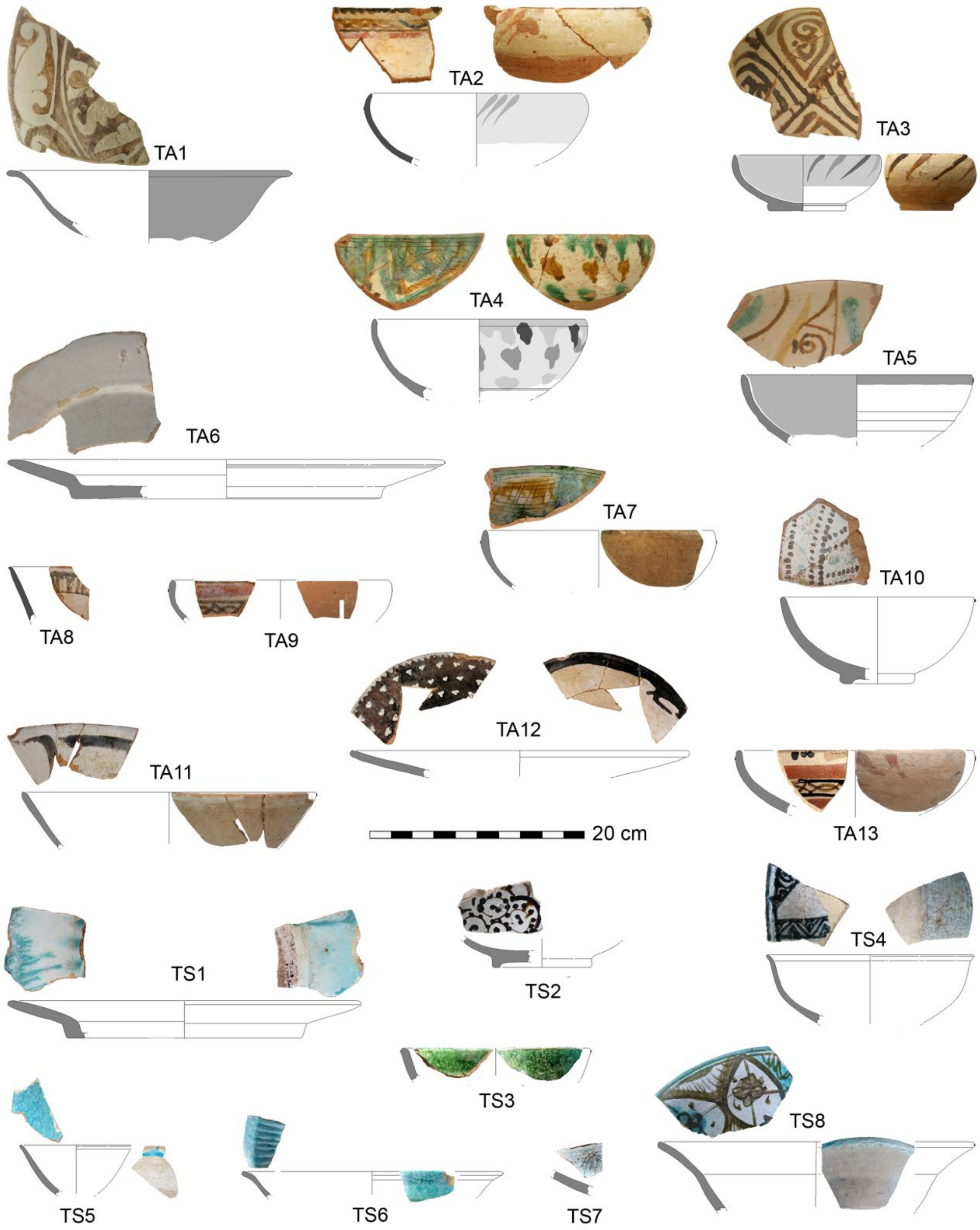

Fig. 2. Glazed vessels analysed from the rubbish dump in the alluvial plain (coded TA) and from the pottery workshop in the *shahristan* (coded TS)

Figure 3

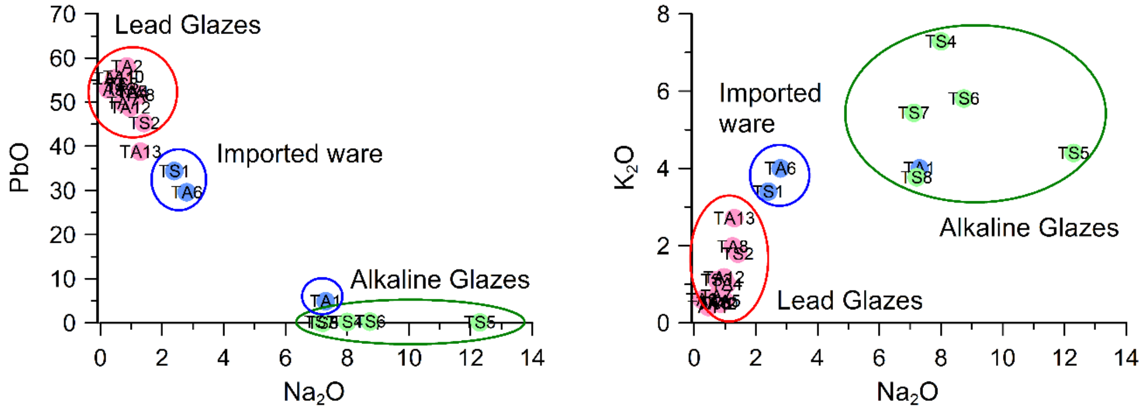

Fig. 3. Bivariant plots of chemical analysis of the ceramic glazes (TA and TS) from SEM-EDS data. Red circle: lead glazes; blue circle: imported wares; green circle: alkaline glazes

Figure 4

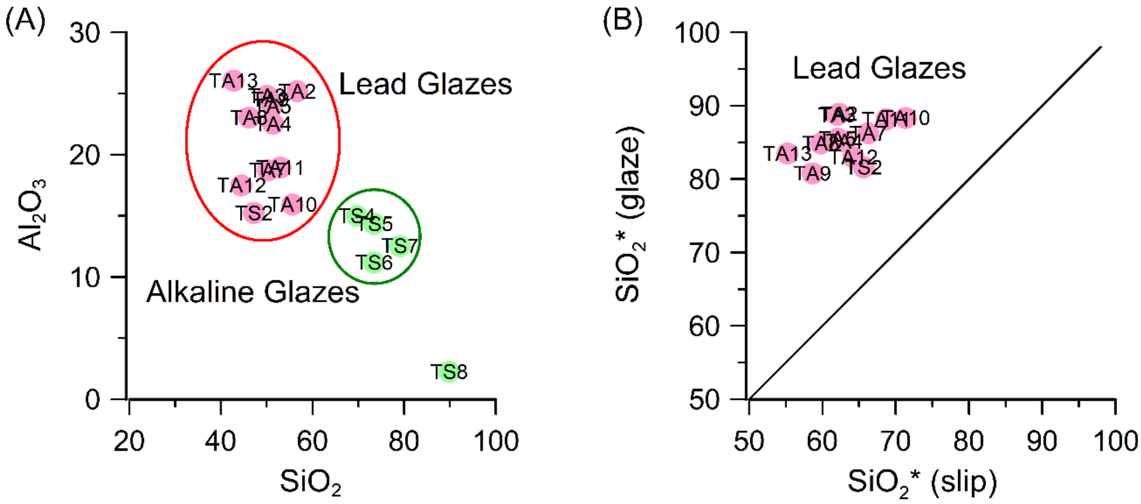

Fig. 4. (A) Bivariant plot of chemical analysis of the slips (TA and TS) from SEM-EDS data. Red circle: lead glazes; green circle: alkaline glazes (B) comparison between the SiO_2* of the glaze and of the slip after subtracting PbO and data normalizasion

Fig.5

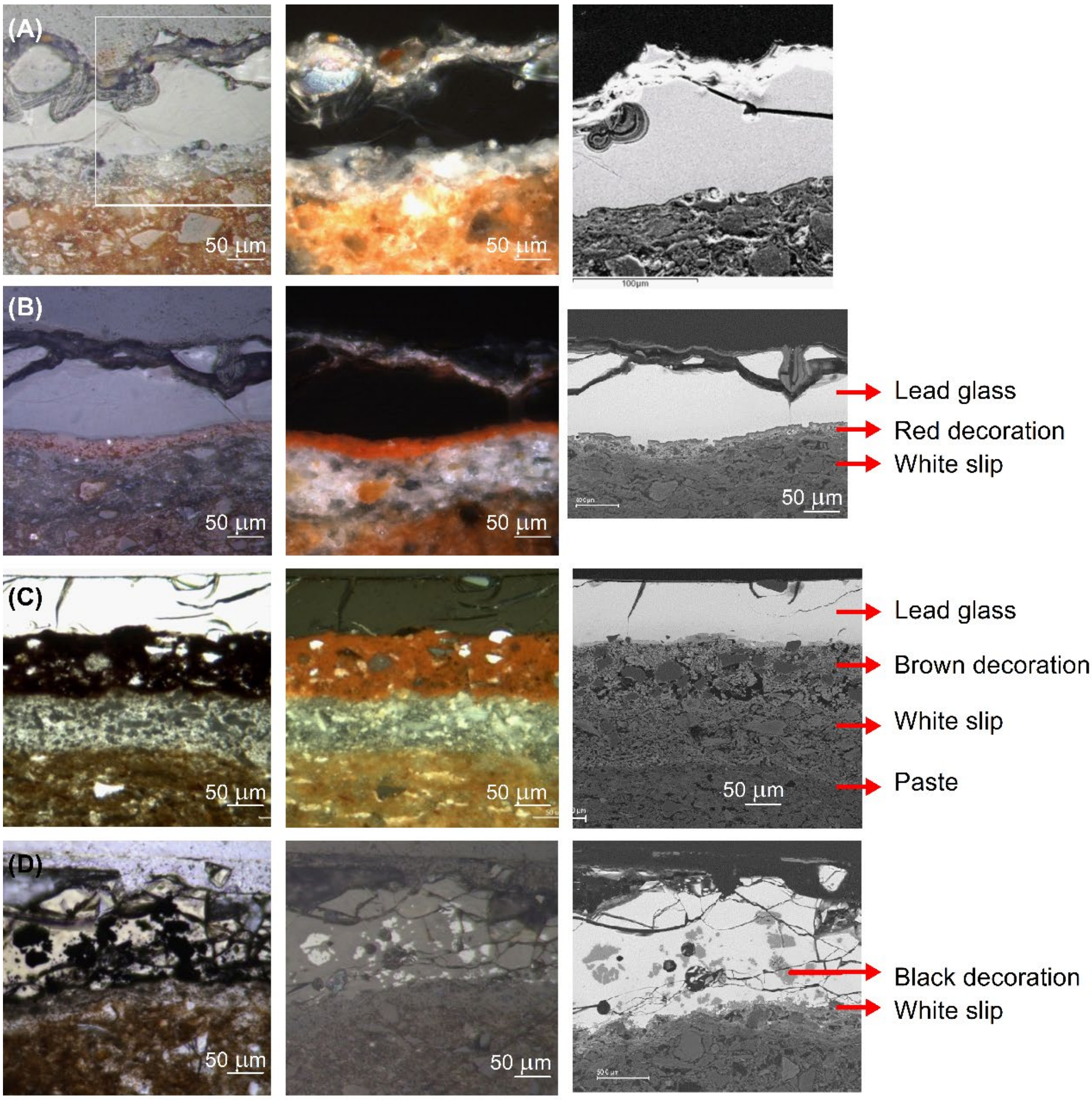

Fig. 5 From left to right optical microscope images in reflected light, polarised light, and BSE-SEM image from thin cross sections of (A) white slip and (B) red decoration of TA2, (C) brown decoration of TA3 and (D) black decoration of TA2 corresponding to iron oxides.

Fig.6

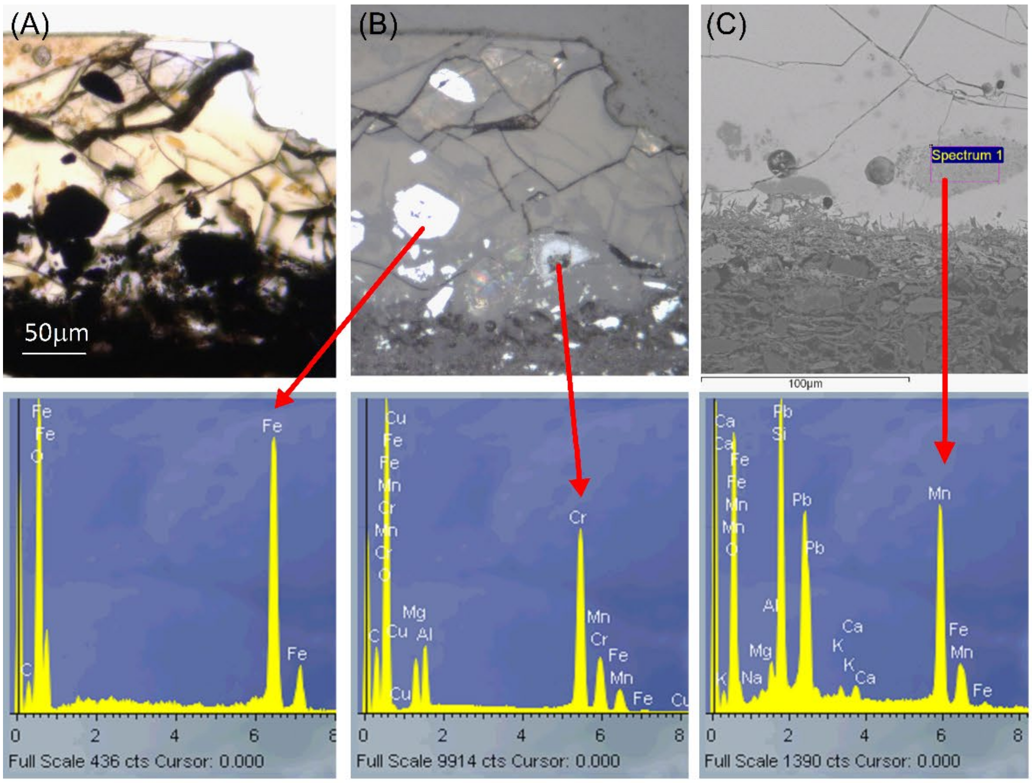

Fig. 6. (A) optical microscope images in transmission light, (B) reflected light, and (C) BSE-SEM image from thin cross sections from TA12. The black slip contains large particles of iron oxide, some particles of chromium spinel and partially dissolved manganese oxide particles.

Fig. 7

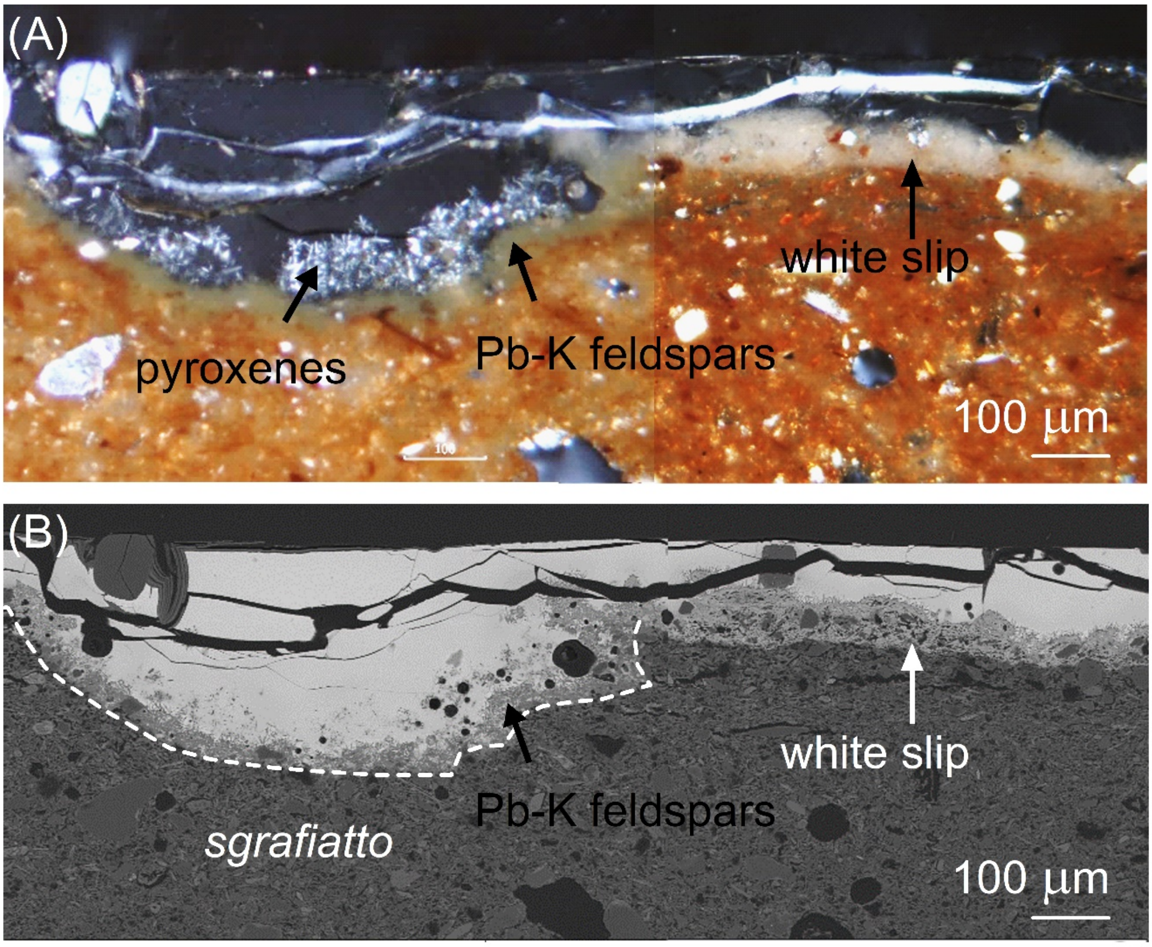

Fig. 7. (A) Optical image in reflected light and (B) BSE-SEM image of a thin cross section from sample TA7 showing the *sgraffiato* area.

Fig. 8

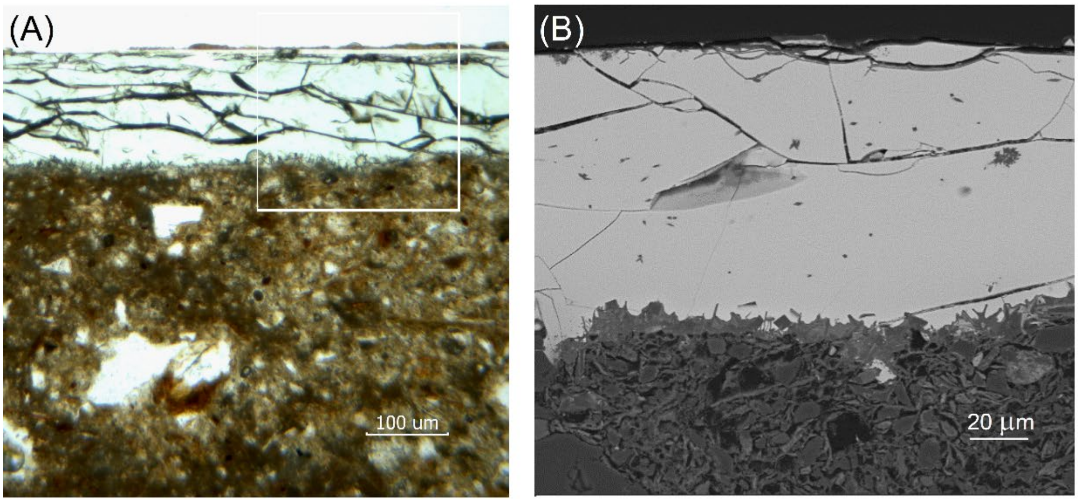

Fig. 8. (A) Optical image in reflected light and (B) BSE-SEM image of a thin cross section from sample TS3.

Fig. 9

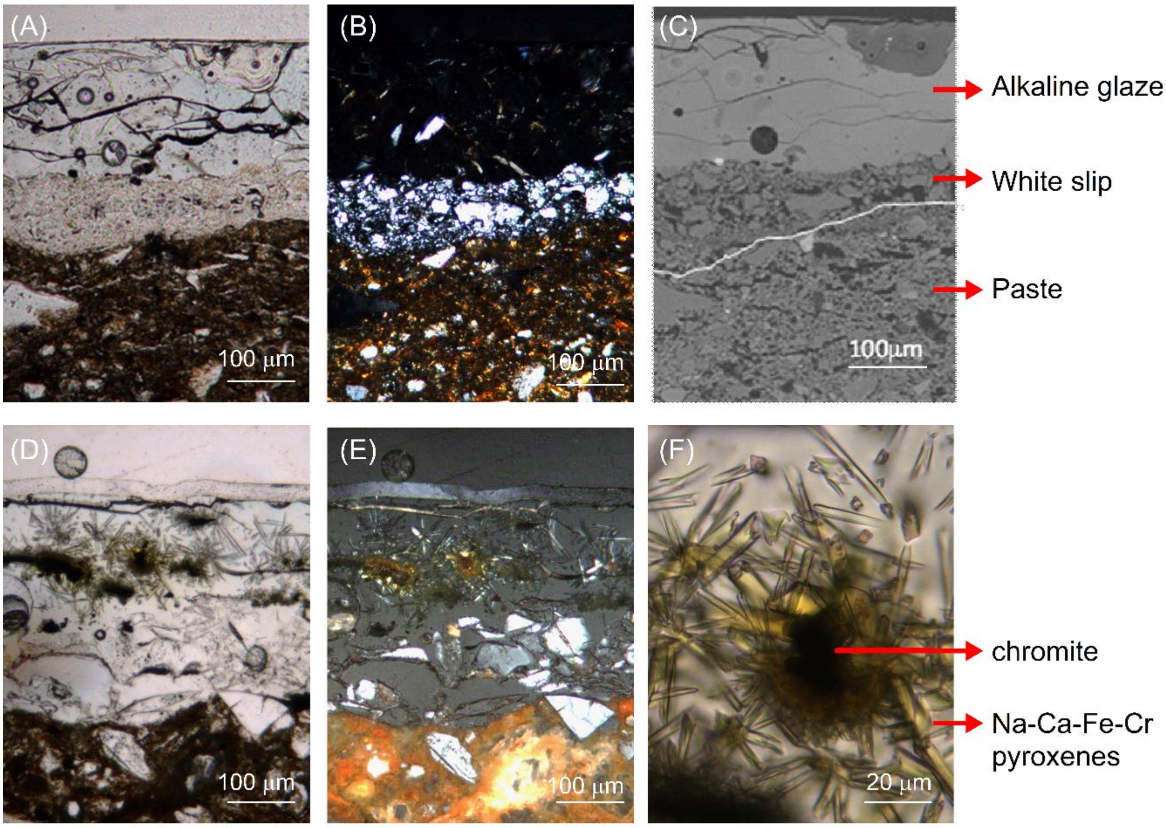

Fig. 9 (A) Optical image in transmission mode PPL (B), in reflection mode XPL, and (C) BSE-SEM image of a thin cross section from sample TS5. (E) Optical image in transmission mode, PPL (F) in reflection mode XPL of a thin cross section from sample TS8; (G) Optical image in transmission mode PPL of the black chromite and acicular yellow Ca-Fe-Na-Cr pyroxenes of the decoration of sample TS8.