A physicochemical study of Medieval and Post-Medieval ceramics from the Aegean

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CHAPTER 12 SUMMARY OF THE ANALYTICAL RESULTS OF THE SAMPLES

12. DISCUSSION

In this chapter the meaning and identity of the data presented in the previous chapters will be analysed, combined and explored. The focus will be on results that are directly connected to the general aims and scope of the entire research. The aspects examined in the 245 samples from the three different sites in Greece include provenance and technology construction (fabrics, glazes and slips) (Appendix X).

About the provenance

A large variety of ceramics were manufactured in **Chalcis,** among which A8A Amphora, Günsenin 2 Amphora, Günsenin 3 Amphora, Slip-Painted Ware, Green and Brown Painted Ware, Brown Painted Ware, Painted Fine Sgraffito Ware, Incised Sgraffito Ware, Champlevé Ware and Splashed Ware. Some ceramics found in the Ancient Agora were also constructed in Chalcis with local clay, in particular pieces of Incised Sgraffito Ware of Athens (AGBZY846) and Painted Ware (AAG44). Incised Sgraffito Ware was manufactured both in Chalcis and in Athens with local clays in each case. Furthermore, Chalcidiean potters attempted to imitate some characteristic, widespread pottery typologies that were produced in other regions of the Mediterranean, such as Roulette/Veneto Ware from North east Italy, Didymoteicho Ware from Dardanelles or Northern Greece, Zeuxippus Ware from Western Turkey.

Chalcis was in close trade contacts with Constantinople (Istanbul), West Turkey, Dardanelles or Northern Greece, Syria and Italy as indicated by the pottery from these areas that was found in Chalcis, namely Glazed White Ware II, Zeuxippus Ware, Didymoteicho Ware, Glazed Frit Ware and Maiolica. The imported original Zeuxippus Ware and Didymoteicho Ware found in Chalcis appeared separately than the imitations at the cluster analysis. The Painted Ware (AAG44) from Athens was made in Chalcis while the Painted Ware (CH104) from Chalcis was imported from Western Turkey. The physicochemical analysis of fabrics from Chalcis verified that these ceramics belong to the local production and were made, as in antiquity, from clay from the area of the Lelantine Plain, which is located to the southeast of the city of Chalcis. This provenance of the raw material is attested also in textual and material evidence (Waksman and Wartburg 2006; Waksman et al. 2014;2018; Skartzis and Vaxevanis 2017).

In the **Athenian Agora in Attica**, a large sample of pottery was made with local raw materials and two different types of clay were noticed. Specifically, the Polychrome Sgraffito Ware and the Polychrome Painted Ware/Maiolica were made with different clays than the Incised Sgraffito Ware, the Green and Brown Painted Ware and the Fine Sgraffito Ware. Imitations were also located, such as the Spanish Luster Ware (AAG68) from Spain. Furthermore, some imported wares like Maiolica, Spanish Lustre Ware and Zeuxippus Ware Subtype were found. The imitations of

Spanish Luster Ware had the same raw materials as those used for Polychrome Sgraffito Ware and Polychrome Painted Ware/Maiolica.

But the potters of the Ancient Agora mainly imitated Maiolica of Italy, creating a unique style with 'Polychrome Painted Ware/Maiolica'. Maiolica produced in Italy was widely used during that period. The Athenian potters, however, accomplished the successful imitation of this ware. For this, they utilized a different clay from another region a light-coloured pinkish clay, and secondly, they produced a unique pottery type: 'Polychrome Painted Ware/Maiolica'. The Athenians were very experienced and flexible potters as they relied on an age-long pottery tradition.

WD-XRF analysis proved that those two different sources of raw materials were used at the locally made pottery in the Ancient Agora of Athens. The primary clay source was identified as the typical red Attica clay used for many centuries, going back to Geometric or even Mycenaean times. It is a fine clay found mainly on Mt. Pentelikon and Mt. Parnitha.[6]

The second group consisted of a completely different clay. This clay has a pinkish colour and its potential provenance is the Municipality of Vari-Voula-Vouliagmeni at the Saronic Gulf in Attica, at a distance of about 15 kms from the Athenian Agora (Latsoudas, IGME, 1976,1977,1979,1991,1992). Another plausible provenance area of this light-coloured clay is Mesogaia in Attica which is a complex of municipalities of Eastern Attica that extend east of Mt. Hymettus but this region is located even farther away from the Athenian Agora, at a distance about 20-30 kms (Vogiatzoglou 2009).[7] It is not a usual distance for caring raw materials in the ancient world but it is possible for Middle Byzantine to Post-Medieval periods.

Most of the ceramic fragments that were selected for physicochemical analysis from **the Castle of Mytilene** were imported as the results were represented by the initial sampling and were not a general conclusion of the local production. About the local pottery production, the Monochrome Painted Ware and the Polychrome Sgraffito Ware collections were locally made in Mytilene because one pottery waster and one tripod stilt were found in the same group within the cluster analysis diagram. It was very interesting that a Kütahya Ware sample (MYT218) was made in Mytilene as an imitation, since it has a red body fabric in contrast to original Kütahya Ware with white body fabrics. The rest of the samples at the cluster analyses were imported mainly from present-day Turkey but also from Italy. Specifically, Polychrome Marbled Ware, Iznik Ware, Kütahya Ware, Glazed White Ware, Miletus Ware, Painted Ware, Polychrome Sgraffito Ware, Elaborate Incised Ware, Zeuxippus Ware, Monochrome and one-colour Ware; Roulette/Veneto Ware and a tripod stilt were constructed in Western Turkey. Although the potters constructed similar or identical pottery types, these types were possibly manufactured in different pottery workshops (in nearby workshops that used slightly different raw materials or in workshops from other regions of Western Turkey) due to the difference in raw materials. The Turkish potters made also imitations of the authentic Polychrome Marbled Ware and Roulette/Veneto Ware from

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[7] Personal contact with Dr. Yannis Bassiakos, Researcher Emeritus at the Institute of Nanoscience and Nanotechnology, NCSR "Demokritos".

Northern Italy that were found in the Castle of Mytilene. In addition, Polychrome Painted Ware (MYT228) and Glazed Frit Ware (MYT182) found in Mytilene were constructed in Western Asia or Egypt. Moreover, the pieces of Maiolica (MYT227, MYT236) and Painted Ware (MYT187) were imported from Italy. Finally, Polychrome Sgraffito Ware (MYT217) is imported from an unknown location. Painted Ware, found in Mytilene, is a pottery type that was produced both in present-day Turkey and in Italy.

In conclusion, the geological map of Lesvos has variable geological features due to the complexity of the geology of the eastern part compared to the western part of Lesvos. On the east part of the island were presented mainly aphiolites in general, greenschists, limestones and metamorphic basement contrary to the west part that volcanic stones are existed. This study focuses on the east side of Lesvos due to the existence of clayey raw materials but also on the Castle of Mytilene located on the south-east coast of the island. The geological features of the east part of Lesvos are too close to these of the littoral of present-day Turkey on the opposite coast. The raw materials seemed to have come from the eastern part of the island and specifically from an area near the castle. Clay was found on the southeast coastal area and specifically in the region starting Mytilene, the capital of Lesvos, and extending to the airport and beyond, where an inaccessible military base exists today. Another area is at the southeast coastal area surrounding the village of 'Moria' about 6,5 km away. Unfortunately, the residential areas of ancient and medieval Mytilene are practically lost under later and modern buildings, surfacing only occasionally with salvage excavations, whereas in Moria, apart from the antique quarry and the Roman aqueduct little is preserved as well. Another area with good quality of clay is Thermi about 10 km to the north along the eastern coast, a region famous also for its thermal baths. According to the personal opinion of the Emeritus Researcher Dr. Yannis Bassiakos and the PhD candidate Katerina Pollatou who are geologists, this area has excellent raw material for ceramics and is 10-15 kms away from the castle.[8] These areas have quaternary undivided with grey and red clays, sands, gravels, coastal conglomerates continental deposits. Katerina Pollatou, started a survey in 2021 of clayey raw materials in Mytilene. For her survey, she interviewed the 3rd generation potter Mr Zachariadis Anastasios in Mytilene in August 2021, who told her that his grandfather was extracting clay from a coastal area north of Mytilene, but he did not remember exactly the name of the location. Judging from his descriptions, it could be either Moria or Thermi. Today, Mr Zachariadis Anastasios buys clay from abroad.

[8] Personal contact with Dr. Yannis Bassiakos, Researcher Emeritus at the Institute of Nanoscience and Nanotechnology, NCSR "Demokritos and Katerina Pollatou, PhD candidate of Geology.

About the glazes

Studying the pigments through physicochemical analyses, we can understand the colourants, the physiology of human vision and the formation of chemical bonds. Only a small fraction of incident light is reflected on the surface. Most of it enters the glaze and is reflected back by the underlying body beneath a transparent glaze or scattered in all directions by particles of semiopaque or opaque glaze. For a clear glaze, visual effects are determined by the absorption of the glaze, the reflection of the underlying body, and any underglaze decoration. For bright glaze colours, the underlying fabric should be white or a slip layer needs to be applied on it in order to have a good reflectivity. For many glazes it is desirable to have good opacity or covering power, which requires that the light be diffusively reflected back to the surface before it reaches the underlying body; particles immersed in the glaze must scatter effectively and diffusely reflect the light.

A glossy glazed surface is smooth and reflective in contrast to a matte glazed surface that has crystals which disturb the surface smoothness resulting in a velvety texture. The potters from the studied areas had great experience and for the achievement of the desired result they used: a) Zink oxide, ZnO, which increases the brightness of the glasses in small quantities and in combination with Al2O3 increases the coverage and brightness of the enamels. ZnO below T 1160 ºC is giving the glass surface a characteristic matte finish. Glazed Frit Ware (CH106) contained ZnO in small quantity that increased the brightness of the glaze in contrast to Monochrome Glazed Ware (MYT200) that contained ZnO in a high concentration giving the glass surface a characteristic matte finish. b) Tin dioxide, SnO_2, which gives excellent coverage. Tin dioxide offers a good combination of effectiveness as an opacifier and insolubility in glazes, it forms the basis for a whole class of tin-opacified wares. This is due to the fact that it is suspended in the glassy mass with the form of well dispersed fine particles. The combination of the surface reflectance and microstructure-controlled internal scattering leads to reflectance patterns constituting a combination of specular and diffuse reflectance. The fragments of Lustre Ware (CH110), Glazed Frit Ware (CH106), Iznik Ware (MYT168, MYT170, MYT214) as well as Kütahya Ware (MYT184) contained SnO.; and c) Titanium dioxide, TiO_2, which gives whiteness and opacity in ceramics due to its tendency to crystallize during cooling. While titanium dioxide is used in glazes as an opacifier, it is not as effective and easy-to-use as tin oxide. In conclusion, the fragments of Didymoteicho Ware (CH135), Polychrome Sgraffito Ware (AGBZY860), Polychrome Painted Ware/Maiolica (AGBZY829, AAG30), Green and Brown Ware (AGBZY853), the pottery wasters (AGBZY827, AGBZY859, AGBZY868) and Porcelain (MYT186, MYT221, MYT222) contained TiO_2 <=1%. An exception constitutes the Monochrome Glazed Ware (MYT200) that in its turquoise colour contained TiO_2 57% and in its purple colour TiO_2 31% - maybe it was an experiment or it happened by accident.

Specifically, all the local pottery from Chalcis (Champlevé Ware, Incised Sgraffito Ware, Monochrome Glazed Ware, Splashed Ware, Slip-Painted Ware and Plain Glazed Ware) were typically lead glazes with a small amount of alkalis (CaO, K_2O, Na_2O) (Panagopoulou et al. 2021b,c). The same was observed at the imported glazes in Chalcis (Didymoteicho Ware, Zeuxippus Ware, Lustre Ware, Polychrome Marbled Ware, Roulette/Veneto Ware, Polychrome White Ware and Glazed Frit Ware). The difference appeared at the imported Maiolica sample (CH154) which has a lead glaze with a high amount of K_2O.

Regarding the local pottery from the Athenian Agora (Polychrome Painted Ware/Maiolica, Polychrome Sgraffito Ware, Incised Sgraffito Ware, Monochrome Glazed Ware, Green and Brown Painted Ware, Slip-Painted Ware and Zeuxippus Ware Subtype), all of the samples had characteristic lead glazes with a small amount of alkalis (CaO, K_2O, Na_2O) (Panagopoulou et al. 2019b). The difference appeared at the imported Maiolica sample which has a lead glaze with a higher amount of K_2O 6%. In general, the Maiolica sample (AAG70) has less amount of lead and higher amount of alkalis than the other imported pottery types.

The local analysed glazes from Mytilene were mainly lead glaze and sometimes they had a small amount of alkalis. The glazes of Polychrome Sgraffito Ware and Polychrome Marbled Ware are lead glazes, whereas, Polychrome Painted Ware is a soda lead glaze. A wonderful variation was noticed in the imported glaze recipes. Specifically, the pieces of Kütahya Ware are marked by a lead alkali glaze apart from one sample (MYT183) with a simple alkali glaze; is the latter one constitutes an imitation of the authentic one which was produced in Mytilene (Panagopoulou et al. 2019; 2021a). The pieces of Iznik Wares have lead alkali glaze; Miletus Ware has soda alkali glazes; Glazed Frit Ware has lead alkali glaze; Maiolica has a lead alkali glaze; Porcelain has an alkali glaze; Overfired Stoneware has an alkali glaze which is a high calcium glaze; the two Monochrome Glazed samples (MYT200, MYT201) have also alkali glazes; and Roulette/Veneto Ware has a high concentration lead calcium glaze. Moreover, the percentage of lead is quite lower in the imported ceramics than in the local ceramics. For the alkali glazes, about 5% of the incident light is reflected; for the high-lead glazes, the specular reflectance almost doubles and greatly increases the glaze brilliance.

About the pigments

For the glazes it is desired to be lightly opacified or translucent; particles immersed in the glaze should be fewer, or less effective at scattering and diffusely reflecting the light. The opacity given by pigment particles depends on their concentration, relative index of refraction, and size. For maximum light scattering and opacifying power, the particles should have a refractive index far different from that of the matrix material and a particle size close to the wavelength of light, that is, about half a micrometer -a fairly small size. The colour of the light reflected through the glaze surface by the body or by the particles within the glaze depends on the presence of ions that absorb energy in the visible spectrum. The principal ions responsible for colour are transition elements such as titanium, chromium, manganese, iron, cobalt, nickel and copper. In the transition elements, it is the outer electrons that absorb light and these electrons are much affected by the surroundings. As a result, copper in an alkaline glaze is blue, in a lead glaze is green, and in a lead-alkali glaze is turquoise in colour. Iron ions may have either two or three outer electrons, are usually surrounded by six negatively charged neighbors, and may have many different colours. When iron is surrounded by oxygen ions in red ocher, hematite (Fe_2O_3), the colour is a deep red. The mixed iron oxide, magnetite (Fe_3O_4), is a deep black. The potters from the three studied areas were apparently very experienced, as we notice a high diversity of pigments and different glaze recipes in their work.

Regarding the analyzed pigments of the **Chalcis pottery collection,** analysis attested to some specific recipes. The colourants of the **green colour** of Splashed Ware are Cu and Fe. The colourant of the **yellow colours** of Maiolica, Splashed Ware and Lustre Ware is Fe. The colourant of the **brown colour** of Didymoteicho Ware is Fe. The colourants of the **blue colour** of Maiolica are Fe, Co and Ni. The colourants of the **turquoise colour** of Glazed Frit Ware are Cu, Fe and Sn. The colourant of the **dark colour** of Didymoteicho Ware is Fe. Furthermore, the addition of Zn is noticed in Lustre Ware and Glazed Frit Ware (Panagopoulou et al. 2021b,c).

Many different recipe pigments were also found in the **Athenian Agora pottery collection**. The colourants of the **green colours** of Polychrome Painted Ware/Maiolica, Polychrome Sgraffito Ware, Green and Brown Painted Ware and Monochrome Glazed Ware are Cu and Fe. Only two greens have different recipes and specifically Polychrome Painted Ware/Maiolica (AAG29) with Fe, Cu, Co and Green and Brown Painted Ware (AGBZY854) with Fe, Cu, Mn. The dark greens have a high amount of Cu. To summarize, three different green colour recipes were observed in the Athenian Agora pottery collection and specifically the combination of Cu and Fe for light to dark greens or the combination of Fe, Cu, Co for bluish greens or Fe, Cu, Mn for brownish green colours. The colourant of the **yellow colours** of Polychrome Painted Ware/Maiolica, Maiolica, Green and Brown Painted Ware, Monochrome Glazed Ware and within a pottery waster is Fe. Two different recipes were noticed in the fragments of Polychrome Painted Ware/Maiolica (AGBZY862) with Fe, Cu, Mn and in Polychrome Painted Ware/Maiolica (AGBZY863) with Cu, Fe. As a result, three different yellow colour recipes were noticed in the Athenian Agora pottery collection and specifically Fe or Fe, Cu, Mn dark greenish yellow or Fe, Cu for greenish yellow colours. The colourant of the **orange colour** of Maiolica (AAG70) is Fe. The colourant of the **brown colours** of Polychrome Painted Ware/Maiolica, Polychrome Sgraffito Ware, Monochrome Glazed Ware, Maiolica and within a pottery waster is also Fe in high amount. Another different recipe was noticed in the sherds of Polychrome Sgraffito Ware (AGBZY828) and (AAG37) with Fe and Cu. The second one presents a darker brown colour than the first one as it has a higher amount of Fe. Finally, the **brown line** of the Maiolica (AAG70) is due to Mn and Fe. In short, two different brown colour recipes were noticed Fe and Fe, Cu for greenish brown colours and one recipe for brown lines with Mn, Fe in the Athenian Agora pottery collection. The high amount of Fe or Mn produces dark colours. The colourants of the **blue colours** of Polychrome Painted Ware/Maiolica, Spanish Lustre Ware and Maiolica are Co and Fe. Another different recipe was presented in Polychrome Painted Ware/Maiolica (AAG29) with Fe, Co and Cu. To summarize, two different recipes for blue colour as Fe, Co and Fe, Co, Cu for greenish blue colours were noticed in the Athenian Agora pottery collection. In addition, the colourants of the **turquoise colour** of Maiolica (AAG70) are Cu and Fe. The colourants of the **dark colour** of Green and Brown Painted Ware (AGBZY847) are Mn, Fe or only Fe at a high amount 2.4%. In short, two different recipes for dark colour were noticed in the Athenian Agora pottery collection (Panagopoulou et al. 2019b).

A high diversity of pigments was also noticed in the **Mytilene pottery collection**. The colourants of the **green colours** of Polychrome Sgraffito Ware, Polychrome Marbled Ware, Kütahya Ware, Iznik Ware, Maiolica and Porcelain are Cu and Fe. The Iznik Ware (MYT168) contains also Sn. The dark green pigments have a high amount of Cu. Accordingly, the potters followed the same recipe for the green colour. The colourant of the **yellow colours** of the fragments of Kütahya Ware is Fe. The colourant of the **red colours** of Polychrome Marbled Ware, Monochrome Glazed Ware, Kütahya Ware, Iznik Ware and Porcelain is Fe. But in Kütahya Ware (MYT183) Fe, Mn and in Iznik Ware (MYT214) Fe, Cu, Sn were observed. Consequently, three different recipes for red colour were noticed and specifically Fe, or Fe, Mn for brownish red or Fe, Cu, Sn for greenish red colours in the Athenian Agora pottery collection. Regarding the **brown colour**, three recipes were noticed in Polychrome Sgraffito Ware, Maiolica, Kütahya Ware and Porcelain. In the first recipe, the main colourant is Fe. The second recipe was noticed in Polychrome Sgraffito Ware with Fe, Mn for reddish brown colours. Finally, the third recipe was noticed in Kütahya Ware and in Porcelain with Co, Fe, Mn for bluish dark brown colours. Furthermore, four **blue colour** recipes were noticed in Polychrome Painted Ware, Kütahya Ware, Miletus Ware, Iznik Ware, Maiolica, Porcelain and Glazed Frit Ware. The first blue colour recipe with Co, Fe was observed in Polychrome Painted Ware, Kütahya Ware, Iznik Ware, Maiolica and Porcelain. In Porcelain, two different blue hues are noticeable; light blue with Co, Fe and dark blue with Co, Fe in a higher amount than light blue. The second recipe for blue colour is the use of Cu with Sn for a light blue to turquoise colour as it was observed in Iznik Ware. The third blue colour recipe is the combination of Co, Cu, Fe, as it was observed in Kütahya Ware and in Glazed Frit Ware. Kütahya Ware contains also Sn. The fourth blue colour recipe is the sample Porcelain that contains Co, Mn for a light blue colour. Furthermore, three different recipes were noticed for the **dark blue lines**. The dark blue line of Polychrome Painted Ware has Co, Mn, Cr and Fe. The second recipe is the dark blue line of Kütahya Ware which has Cu, Mn, Cr, Fe. The third one was observed in Miletus Ware sample with Co, Cu, Fe. Two recipes for **turquoise colour** were noticed in the Mytilene pottery collection. The colourants of the turquoise colours of the fragments of Kütahya Ware and Monochrome Glazed Ware are Cu, Fe. Both of them are based on the same recipe but the turquoise colour of the Monochrome Glazed Ware contains also Ti, Zn and as a result the hue of this colour is more intense than the other one. The second recipe is Kütahya Ware with Cu, Co and Fe. The colourants of the **dark colour** of Miletus Ware are Fe, Mn and Cr. The **dark lines** came from four different recipes. In the first recipe, the colourants of the dark line of Kütahya Ware are Fe, MnO, Cu, Cr. The second recipe was used for the dark line of Kütahya Ware with Fe, Cu, Cr and Co. In the third recipe, the colourants of the dark line of Miletus Ware are Fe and Cr. Finally, the fourth recipe of the dark line of Iznik Ware is due to Fe, Co, Cr and Sn. Three recipes are also noticed for **purple colours**. The first recipe was noticed in Monochrome Glazed Ware with Fe, Cu, Co, Zn and Ti. The second one was observed in the Kütahya Ware with Fe, Mn, Co and Cr. Finally, the third one in Kütahya Ware with Fe, Mn, Co and Cu (Panagopoulou et al. 2019; 2021a).

Finally, all the pottery typologies have underglaze decoration in Chalcis except for Champlevé Ware, Frit Ware, Monochrome Glazed Ware, Incised Sgraffito Ware, Roulette/Veneto Ware and Plain Ware in which pigment oxides were added in the glaze. Furthermore, all the pottery types in the Athenian Agora have underglaze decoration and pigment oxides were added in the glaze in the Monochrome Glazed Ware, Frit Ware, Porcelain and the Zeuxippus Ware Subtype. In Mytilene, all the other pottery types have underglaze decoration and in some cases a combination of underglaze decoration with a brush or similar tool on slip and also a red coloured slip at some points was observed. Consequently, artists looked for colour recipes from ancient times. For instance, Theophrastus in his book 'De Lapidibus' mentioned 'When the pots are thoroughly exposed to fire, they cause the ochre to be baked, and the more they are burnt, the darker and more glowing the ochre becomes' (Theophrastus 1965, p.79) and he mentioned that different recipes with Cu were applied for green colours (Theophrastus 1965, pp. 78-81). Finally, Theophrastus mentioned that 'Colours of every kind are derived from them owing to the nature of the substances themselves, and also to differences in their manufacture' (Theophrastus 1965, p.81). This means that potters used some of the ancient recipes of colours.

About the ceramic fabrics

The firing transformations of minerals was studied in the sampled pottery. Two groups of clays were distinguished according to the type of neoformed high-temperature minerals: mainly calcareous clays and some non-calcareous clays. Cristobalite and mullite were formed at temperatures in excess of T 1000 ºC from clays that contain illite and kaolinite. Firing of calcareous clays at temperatures T>950 ºC yielded Ca-silicates (diopside, gehlenite and wollastonite), cristobalite, hematite, and feldspars. Mullite may also form in the calcareous clay products when the carbonate content exceeds 10%.

The clay fabrics of the samples from **Chalcis** are quite chemically homogeneous and have an intense red colour as it was observed in Champlevé Ware, Incised Sgraffito Ware, Monochrome Glazed Ware, Splashed Ware, Slip-Painted Ware, Plain Glazed Ware, Unglazed Plain Ware, A8A Amphora, Günsenin 2 Amphora and Günsenin 3 Amphora (Panagopoulou et al. 2021b,c). According to the imported pottery, mainly two types of fabrics were observed. Specifically, imported Didymoteicho Ware, Polychrome Marbled Ware, Roulette/Veneto Ware, Zeuxippus Ware, Lustre Ware have a red fabric with a higher amount of Fe than Maiolica, Polychrome White Ware, Glazed White Ware II, Glazed Frit Ware, Frit Ware that have a white fabric with a lower amount of Fe. Concerning imported ceramics, some fabric recipes are of great interest in Chalcis. Specifically, Frit Ware (CH147), is an alkali fritware in contrast to Glazed Frit Ware (CH106), which is a lead alkali fritware. The first fabric recipe was an Iranian alkali frit recipe and the second one was an Ottoman lead alkali frit recipe that was well-known to be used in the Aegean.

During Early Byzantine to Middle Byzantine times, the fragments of Plain Glazed Ware were fired mainly at T 850-1050 ºC (Extensive Vitrification), apart from, some samples with higher temperature T>1000 ºC. During the Middle Byzantine/Frankish period, in A8A Amphora, potters used a lower temperature T 800-900 ºC (Initial Vitrification to Extensive Vitrification) than in Günsenin 2 and the Günsenin 3 Amphorae with T 850-1050 ºC (Extensive Vitrification). The temperature and kiln conditions depended on the typology of amphorae. Also, the fragments of Slip-Painted Ware and of Monochrome Glazed Ware with T 850-1150 ºC have Extensive to Intermediate Vitrification. Finally, imported Polychrome White Ware and Glazed White Ware II from Western Turkey, with T about 800-850 ºC have Initial Vitrification.

During the Middle Byzantine to Late Byzantine/Frankish periods, Champlevé Ware was fired at T 1050-1150 ºC (Intermediate to Total Vitrification). Also, potters used a lower temperature about T 850-950 ºC for Incised Sgraffito Ware pieces during the Middle Byzantine period and a higher T>950->1150 ºC during the Late Byzantine/Frankish period with Intermediate to Total

Vitrification. During the Late Byzantine/Frankish period, the Splashed Ware pieces were fired either at a low temperature about T 850-950 ºC or at a higher temperature T-1150 ºC (Extensive to Intermediate Vitrification). Moreover, imported Zeuxippus Ware from Western Turkey was fired at a high temperature T 1050-1150 ºC (Intermediate Vitrification) and imported Roulette/Veneto Ware pieces from Italy were fired at T 850-950 ºC (Initial Vitrification to Extensive Vitrification). During the Turkish/Venetian period, the imported Maiolica from Italy were fired at about T 950-1050 ºC (Extensive Vitrification) whereas Polychrome Marbled Ware pieces were fired at T 1050-1150 ºC (Intermediate Vitrification). Imported Lustre Ware from Egypt was fired at a high temperature T 950-1050 ºC (Extensive Vitrification). Glazed Frit Ware and Frit Ware were fired at a high temperature T>1050 ºC (Intermediate to Total Vitrification). All these typologies probably came from Syria or Egypt. During the Early Modern period, Didymoteicho Ware with T>1050 ºC have Intermediate to Total Vitrification (Panagopoulou et al. 2021b,c).

The samples from **the Athenian Agora** have a red colour or pinkish clay fabrics and specifically Polychrome Painted Ware/Maiolica, Polychrome Sgraffito Ware, Incised Sgraffito Ware, Green and Brown Painted Ware, Monochrome Glazed Ware, Zeuxippus Ware Subtype, Slip-Painted Ware and Pottery wasters. Regarding imported wares, Spanish Lustre Ware has a red clay matrix whereas Maiolica has a white clay matrix. Similar clay raw materials were used but a different fabric construction technology regarding temperature and kiln conditions was followed by the potters in Athens.

During the Middle Byzantine/Frankish period, the Green and Brown Painted Ware pieces from Athens were fired at a high temperature T 1000-1150 ºC (Extensive Vitrification to Intermediate Vitrification). During the Middle Byzantine to Late Byzantine/Frankish periods, Incised Sgraffito Ware from Athens was fired at a high Temperature with T 850-1050 ºC (Extensive Vitrification). During the Late Byzantine/Frankish period, the Zeuxippus Ware Subtype pieces from Athens were fired at a low temperature T 800-950 ºC (Initial Vitrification); the Slip-Painted Ware pieces were fired at T 850-1050 ºC (Extensive Vitrification). During the Late Byzantine/Frankish to Turkish/Venetian periods, the Monochrome Glazed Ware pieces from Athens were fired at T 1000-1150 ºC (Extensive Vitrification to Intermediate Vitrification). Only one sample (AAG54) was fired at a lower temperature T 800-950 ºC.

During the Turkish/Venetian period, the Polychrome Painted Ware/Maiolica pieces from Athens were fired at a high temperature with T 850-1050 ºC (Extensive Vitrification). The Polychrome Sgraffito Ware pieces from Athens were fired at a high temperature with T 850-1050 ºC (Extensive Vitrification). Spanish Lustre Ware from Spain was fired at high temperature T 850-1050 ºC (Extensive Vitrification). The imported Maiolica fragments from Italy were fired at a high temperature with T 850-1050 ºC (Extensive Vitrification).

The clay fabrics of the samples from **the Castle of Mytilene** have a red colour, and specifically Polychrome Sgraffito Ware, Polychrome Marbled Ware, Polychrome Painted Ware, Painted Ware and Monochrome Glazed Ware. Regarding imported pottery, Glazed White Ware IV, Iznik Ware, Porcelain, Overfired, Glazed Frit Ware, Maiolica are made with white clays, whereas imported Kütahya Ware, Miletus Ware, Roulette/Veneto Ware are made with red clays. Concerning imported ceramics, some fabric composition is of great interest. Specifically, all Porcelain and fritware fabrics of Iznik Ware are made with a high quality pure white clay fabric. The Iznik Ware pieces are alkali fritwares. The fabric recipe was the standard Iranian soda-alkali frit recipe due to the type of alkali used and specifically almost equal parts of pounded quartz stone and calcined soda plant. In addition, Glazed Frit Ware (MYT182) is an alkali fritware fabric. Furthermore, one Kütahya Ware sample and one Monochrome Glazed Ware sample seemed to have a fritware fabric. Only the fragments of Iznik Ware, Kütahya Ware (apart from MYT184), Porcelain and Monochrome Glazed Ware (MYT200) have less amount of CaO. The fabric construction technology presents variety in temperature, kiln conditions, and size of inclusions at fragments from Mytilene.

During the Late Byzantine/Frankish period, the Roulette/Veneto Ware pieces from Northern Italy were fired at T 850-950 ^oC (Extensive Vitrification); Glazed White Ware IV, that came from Western Turkey, was fired at a low temperature about T 800-850 ^oC (Initial Vitrification). During the Turkish/Venetian period, the Polychrome Sgraffito Ware pieces were fired at a high temperature T 1050- >1150 ^oC (Intermediate to Total Vitrification); The Iznik Ware pieces, that came from Western Turkey were fired at a high T 1050-1100 ^oC (Intermediate Vitrification); the Kütahya Ware pieces, that came from Western Turkey were fired at a high temperature T 1000-1050 ^oC (Extensive Vitrification); Miletus Ware pieces, that came from Western Turkey were fired at a low temperature T 800-950 ^oC (Initial Vitrification to Extensive Vitrification); Polychrome Marbled Ware, that came from Italy, was fired at T 950-1050 ^oC (Extensive Vitrification). Apart from sample (MYT165) that was fired at a lower temperature about T 800-850 ^oC; Monochrome Glazed Ware pieces were fired at T 1050-1150 ^oC (Intermediate Vitrification), apart from one sample from Mytilene which is no Calcareous and was fired at a higher temperature T>1000 ^oC; Polychrome Painted Ware was fired at a high temperature T>1000 ^oC; Unglazed Painted Ware was fired at a low temperature T 800-850 ^oC; Glazed Frit Ware, that came from Syria or Egypt was fired at a high temperature T>950 ^oC. Finally, Porcelain and Overfired Stoneware with T>1100 ^oC have Total Vitrification. During the Turkish/Venetian to Early Modern periods, the Painted Ware pieces were fired at a high temperature T>1100 ^oC (Intermediate to Total Vitrification).

About the slips

The layer of slip was observed in all types of pottery apart from Polychrome White Ware, Glazed White Ware II, Glazed White Ware IV, Glazed Frit Wares, Porcelain and Overfired Stoneware which do not have this layer as they have a white body fabric. Furthermore, a glaze diffusion is extant on some slip layers. Finally, a significant difference was observed in the slip layers of Iznik and Kütahya Ware as both of them have a fine, white slip of a quartz-frit type which is used as a ground for the painted decoration. Slip is a very compact structure with no voids and a greater degree of sintering compared to the body in all the samples. This indicates that the slips were applied to body surfaces in order to make a uniform slip layer. These data clearly indicate that a finer slip, with or no colourant and more fluxes, was used in the production of the slip than was utilized for the body. The iron content of the slip is less than for the bodies; therefore, it is reasonable to think that additional iron-bearing minerals were avoided in the slip. The optical microscopic images of the slip obtained from all samples indicated that a very compact and uniform structure, with a larger degree of sintering compared to the body, was formed over the vessels. The difference between the colours of these layers and of the bodies clearly indicates that finer clay fluxes were used in the production of the slip than for the bodies.