Early Islamic Ceramics and Glazes of Akhsiket, Uzbekistan

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Declaration

I, Christina Henshaw, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signed____

Abstract

The thesis examines the technical aspects of ceramics and glazes from Akhsiket, a regional capital in the early Islamic period, which was abandoned in the early 13th century.

Ceramics and glazes of the time period under discussion (9th - 13th century) in Uzbekistan are understudied, with minimal scientific analysis of the technological processes. These processes include the forming and firing of ceramic vessels, the origin of raw materials used in ceramics and glazes, and decoration methods such as slip painting and colored glazes.

A variety of commonly-seen ceramic types have been studied, giving a well-rounded picture of the ceramic assemblage at Akhsiket. Comparison between ceramics from different sites in Uzbekistan, and the development of the technology over four centuries, is possible with the use of chemical and petrographical data obtained with a variety of scientific techniques - primarily the scanning electron microscope. Contemporary glazed ceramics from Kuva and Tashkent, both in Uzbekistan, were also examined for comparison, and to shed light on the transfer of technological and artistic techniques through Central Asia.

Typological analysis of Islamic ceramics shows a progression of artistic and technological knowledge from the Middle East to Central Asia during the Arab expansion in the 8th – 9th centuries. Data from chemical and petrographical analysis has shown interesting similarities and differences between ceramic pastes and glazes used at Akhsiket, Kuva and Tashkent. These analyses are used as evidence for relationships in ceramic production and technology in Uzbekistan and by comparison with published data, to ceramics further afield.

Along with providing a clearer picture of ceramic production in Uzbekistan, this work

provides a new dimension to the discipline of Islamic ceramic studies, demonstrating the importance of archaeological ceramics of the eastern fringes to the understanding of the production of ceramics and the transmission of knowledge and cultural traditions within the Islamic caliphate.

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1. Introduction

The aim of this project is to produce a comprehensive primary investigation of the technology of Akhsiket's domestic ceramics, particularly the glazed tablewares. Specifically, the objective was to investigation how Akhsiket's ceramics and glazes fit into the technological context of Islamic ceramics both local, and in the wider Islamic world, using data on the chemical and petrographical characteristics of bodies, slips and glazes. Scientific analysis sheds light on the actions taken by early Islamic potters in creating the objects (the *chaîne opératoire*). The *chaîne opératoire* is a complex network of actions and influences comprising technical and aesthetic choices, transmission of knowledge and innovation, economics and other social forces, use and function, and cultural significance. This thesis provides some of the fundamental data necessary for reconstructing this *chaîne;* a full reconstruction is impossible within this limited project.

The archaeological site of Akhsiket consists of the remains of a large urban settlement in the Ferghana Valley, Uzbekistan dating from the 2nd/1st century BC to the early 13th century AD. The city has been shown, by both archaeological and historical sources, to be an important economic and political locus in the region during the early Islamic period of the late 8th to early 13th century. Akhsiket was a significant consumer of pottery during the early Islamic period, as shown by the large numbers of sherds found in annual excavations carried out by the Institute of Archaeology, Samarkand. Thousands of pottery sherds have been recovered from these excavations with a high percentage of glazed wares, although it is unclear where the pottery was in fact produced – there being no direct evidence for pottery production in the Ferghana Valley.

The glazed wares consist of both lead glazed tablewares – bowls, plates and cups as well as oil lamps; and alkali glazed tablewares and other closed forms. The unglazed wares include finewares such as jars and urns, large storage jars, and calcite-tempered cooking pots. The pottery assemblage is on the whole representative of typical Islamic ceramic types found across Central Asia during the 9th – 12th centuries.All Akhsiket sherds analysed in this thesis, although unprovenanced, were found at Akhsiket and can generally be dated. This thesis addresses the issue by working under the assumption that the pottery at Akhsiket is local to the Ferghana Valley (if not to Akhsiket).

Developments in glaze technology in the Middle East in the 8th century had spread east to the cultural centres of a newly Islamic Central Asia. Here, further innovations had a wide impact on the pottery of the region, introducing glazed wares as a fixture of pottery production by the 9th century, and the creation of a new industry. This new industry, with its specific stylistic characteristics, contributed significantly to the archaeological record of urban sites stretching from Iran to Kyrgyzstan. As one of the most prominent artefacts found at the site, the ceramics of Akhsiket are important in terms of demonstrating some level of affiliation with the culture of the Islamic centres further West, the affluence of the inhabitants in consuming such large numbers of vessels, and as a potential (albeit by no means proven) production and/or trade centre of these wares.

There are many questions surrounding these ceramics, including their technological origins, their provenance, depth of similarity with ceramics from other sites or regions, and their basic production technology, to name a few. Although many Central Asian pottery types have been described typologically (Anarbaev and Ilyasova 2000; Brusenko 1986; Bulliet, 1992; Ilyasova 1986, 1990 and 2000; Shishkina 1979, Shishkina and Pavchinskaja 1993; Simeon 2009) technological analyses are few and far between (Shishkina 1986 as a rare example). For the Ferghana Valley, technological studies are completely lacking. There is a need to better understand the technological characteristics of this pottery, in order to expand our picture of intra- and inter-regional connections in the Ferghana Valley, and further afield.

Building on existing work on the visible features – body shapes and sizes, fabric colour and texture, decoration colour and design – as well as the archaeological and historical contexts of the types of pottery found on the site, scientific analysis is able to answer many questions regarding the technology of pottery production. Such analysis also provides a quantifiable means for comparing Akhsiket's ceramics and glazes with those of other sites in the region, and with published data from many other types of ceramics in the Islamic world.

In order to approach the overarching question of this thesis: how Akhsiket's ceramics and glazes fit into the technological context of Islamic ceramics both local, and in the wider Islamic world, the following research questions were posed:

- What are the characteristics of the Akhsiket assemblages?
- What interpretations can be derived from the scientific evidence regarding technical and aesthetic style?
- What relationships can be seen between the different assemblages present at Akhsiket?
- Will the current research provide any evidence to indicate provenance of these ceramics?
- What relationships do Akhsiket's ceramics have to those from Kuva and Tashkent, and to the wider Islamic world?
- What insights do the technological and typological interpretations provide regarding the social and political influences on and role of pottery production and consumption at Akhsiket?

These questions required an investigation into the nature of the technology of the pottery – the character of and comparisons between microstructures of glazes, slips, mineral inclusions, and clay matrices. The information available from this study can address questions such as what raw materials were used and in what concentrations, what variations can be seen in craftsmanship such as the forming of vessels, application of decorations and firing in the kiln, and what relationships there are between production methods of different cities in the region and further afield. In particular, samples were obtained from two comparative sites that were near neighbours and had close trade links with Akhsiket: Chach (Tashkent) and Kuva. Both were areas of similar economic and political stature to Akhsiket in the early Islamic period, providing a good comparison in the rate of goods consumption and production, and the extent of trade.

The focus of this thesis has necessarily been on the technical aspects, which are approachable with the available evidence. Technical choices (or technical 'styles') are revealed by the formal and scientific characteristics of the artefacts. This allows the researcher to identify 'performance characteristics' (Shiffer and Skibo, 1987), and therefore priorities and compromises actioned by the potters. A comprehensive understanding of the microstructure and chemical characterisation of the bodies, slips and glazes is essential to determining technical choice – what is the 'standard' product, is there any variation and to what extent, and how does the technology fit into the wider context, are questions appropriate to this kind of investigation.

Similarity with wares from other sites provides useful indications of what to expect, technologically. For example, colourless lead glazes have been analysed in other parts of the Islamic world, outside Central Asia, and we have a good understanding of how these lead glazes were produced and applied. Alkali glazed wares have also been analysed – largely from the Middle East.

By working backward from the final product, the ceramic assemblage(s), we can begin to understand further the implication this technology, may have had on the society and culture of Akhsiket. Aesthetic choices are an important part of this and must be considered hand in hand with the technical choices – interacting but not necessarily co-dependent with technological know-how. Although this is a preliminary investigation of these specific pottery types, and much information is lacking such issues can be approached with the results gathered so far. The context of historical events in the local region and glazed pottery production in the wider Islamic world can also provide some direction. The interpretations set out here form a basis for further development, assessment (or re-assessment), and greater synthesis between art historical, archaeological, and scientific investigations.

Scanning electron microscopy proved to be the most efficient method for investigating pottery technology in the present case, due to flexibility in analysing to a high accuracy many different areas of each sample, such as glaze, inclusions, slips and body fabrics. Both bulk analysis and spot analyses were possible. Visual information could be captured in the form of backscatter electron photomicrographs. Smaller petrographical and X-ray fluorescence pilot studies were also carried out to provide specific information on particular aspects of the ceramic bodies. There are of course many other analytical methods which could have been used but the three mentioned above produced the data needed, were available on-site, and have a firm background of use in ceramics and glass research.

The main limitation of this work is the lack of direct evidence for the provenance of the sherds. This issue is related to a larger lack of research on local clay sources and other components. So far, no significant pottery kiln remains from the early Islamic period have been found in the Ferghana Valley. Small studies of potential local wares (coarse wares and brick) have been carried out to see if the finewares are generally consistent technologically – with a local origin - but it was not possible within the scope of this work to attempt a definitive provenance for any of the pottery samples.

These themes will be explored through the thesis.

Chapter 2 provides a historical and archaeological background to the site and the region, placing the research material in its geographical, political and economic context, with a discussion on Akhsiket as a city and the archaeological evidence for its development.

Chapter 3 presents the typological analyses of style and form, with discussion of previous and current work in detail.

Chapter 4 summarizes the extent of previous research in the field, and explains the practical methodologies used for excavation, sampling and scientific analysis.

Chapter 5 gives a detailed description of the analytical results for the Akhsiket ceramics, both glazed and unglazed, including SEM-EDS, petrographical and XRF analysis.

Chapter 6 gives, first, the background to the comparative sites of Kuva and Chach (Tashkent), then the results of analytical work done on samples from these areas.

Chapter 7 synthesises the analytical results and presents the evidence for 'technical choices' which give insight into specific methods used to produce the pottery. These are considered within the wider context of the comparative sites and published results from further afield. Preliminary indications regarding the role of pottery in Akhsiket's society and impacts on pottery production are also discussed.

Chapter 8 concludes the thesis with a summary of the main findings, contribution to the field, and suggested priorities for future research.

2. Background to the site of Akhsiket

Akhsiket[1] was located on the fringes of the eastern Islamic caliphate during the 9th to early 13th century AD. There is evidence for the existence of a settlement at Akhsiket from at least the 2nd century BC. Historical records throughout this time period are limited to observations and accounts from outsiders – there being none from Akhsiket itself. However, sub-surface remains of the city and its material culture provide a rich picture of the environment in which its inhabitants lived and worked. From the late 9th century strong links to areas further west, particularly Tashkent and Samarkand, had an impact on Akhsiket's cultural development as an important city in an Islamic territory.

This chapter describes the geographical, historical and archaeological setting, providing a backdrop for the analyses and interpretation of Akhsiket's ceramics, and the ceramics of its neighbours, Tashkent and Kuva.

2.1. Geographical setting

Central Asia encompasses the area between the Caspian Sea and China, bordered on the north by Russia and the south by India, Pakistan and Iran (Figure 2.1). Throughout history this region has acted as a bridge between the European and Semitic West, and the Chinese East. Alexander the Great reached the end of his conquests in Tajikistan, spreading Hellenism to Central Asia, while the Chinese and Tibetans moved west as far as Kyrgyzstan and Tajikistan. The Silk Road was a thoroughfare running primarily east-west, with trade flowing in both directions, and branches running south into India

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[1] The name 'Akhsiket' is the most recently used version of several from different texts. Other spellings include 'Akhsikent', 'Ahsiket' and 'Eski Akhsi' (the original version which means 'old clear water' (Ivanov 2003)).

and north into Siberia, bringing trade through and to Central Asia throughout the first half of the first millennium A.D. In the 8th century A.D., Silk Road trade was disrupted, and long-distance trade waned during the Islamic period, much of it moving north into Semirechye, to the north of the Tian Shan mountains in Kazakhstan (Baipakov 2000, 222).

The history of Uzbekistan as a modern nation begins in the late-19th century with the expansion of the Russian empire into Central Asia. Uzbekistan was fully incorporated as a Soviet Socialist Republic in 1924. The modern borders were not finalised until 1971, but these have remained intact beyond its declaration of independence in 1991. Uzbekistan’s location is in the middle of Central Asia, bordering the other former Central Asian SSRs and Afghanistan. It has possession of the fertile Ferghana Valley, a comparatively great number of large cities and industrial sites, a high population, and the cachet of its great ancient intellectual centres – Samarkand, Bukhara and others. This gives Uzbekistan a present geographical and political presence in Eurasia not unknown to its ancient provinces in the Islamic period.

Uzbekistan’s primary geographical feature is the Amu Darya (or Oxus river) which runs along its southern and western border. Another great river, the Syr Darya (or Jaxartes) runs through middle of the Ferghana Valley, and then turns north into Kazakhstan. Both rivers terminate at the Aral Sea on the northeastern border of Uzbekistan. Transoxania is a commonly used classical name for the region meaning “land beyond the Oxus”, while Mawarannahr is the Arabic name meaning much the same.

Now divided into six modern states of Turkmenistan, Uzbekistan, Kazakhstan, Tajikistan, Kyrgyzstan, and Afghanistan, in Islamic times Central Asia was divided into provinces governed by rulers appointed by the Islamic caliph: Khurasan, Khwarazm, Transoxania (or Mawarannahr) which included Tashkent, and the Ferghana Valley, and Bactria. The Ferghana Valley in Uzbekistan was the eastern limit of the Islamic Empire. The ancient provinces of Central Asia tended to be bound by geographical features. Khurasan was bordered on the east by the Kara Kum desert, while Khwarazm encompassed the lower Amu river delta and the Aral Sea, divided from Transoxania by the Kyzl Kum desert. Chach and lower Transoxania was made up largely of semi-desert, with Tashkent divided from the Ferghana Valley by the Chatkal mountain range. Fertile areas were concentrated in the Zarafshan river valley, in Sogd and the Ferghana Valley, while settlements tended to cluster along the major rivers (Knobloch 2001, 5-7).

Akhsiket lies in the northern part of the Ferghana Valley (commonly referred to as just 'Ferghana') (see Figure 2.2). Around 200 by 70 km in size, the valley is ringed by mountains: from the Tian Shan in the north to the Pamir-Alai in the south, and although it lies mainly in Uzbekistan, it overlaps geographically with northern Tajikistan and western Kyrgyzstan. From the mountains rivers flow toward the centre of the Valley and the Syr Darya, which runs east to west through the centre of the Valley. The middle of Ferghana contains arid semi-desert and true desert. There are few easy access points into Ferghana – the main one being the 'Khojend Gate' in the west, a wide river valley formed by the Syr Darya on its way westward to the Aral Sea. The mountains provide summer pasturage to nomadic herders, there are foothills with timber and mineral resources, and river valleys are well watered with irrigation systems - many dating from prehistoric times.

The major cities of the Ferghana Valley included Kokand, Pap, Akhsiket, Kuva, and Andijan in Uzbekistan, Osh and Uzgen in Tajikistan, and Khojend in Tajikistan. These cities were almost entirely destroyed by the Mongols in the 1220s A.D., but most have a modern successor – making use of strategic locations near rivers and existing thoroughfares. Near ancient Akhsiket is the largest city in the Ferghana Valley, Namangan; near Kuva is the modern capital of the region, Ferghana. Others have retained their ancient names. Remains for many of these cities remain visible today.

According to contemporary sources, a branch of the ancient Silk Road passed through the southern Ferghana Valley until the Islamic invasions, connecting Kuva, Andijan and Osh. This was located around 60km to the south of Akhsiket. Akhsiket was a regional capital during the Abbasid and Samanid caliphates according to historical and numismatic data. Another lesser trading route passed through Akhsiket from Kurkat and Samgar in the east (Baipakov 2000, 233), but it would seem that this was of lesser importance than the more southerly route through Kuva. Silver and gold mines near Akhsiket are historically documented, as well as many other commodities essential for craft working or as trade resources (Barthold 1977, 164).

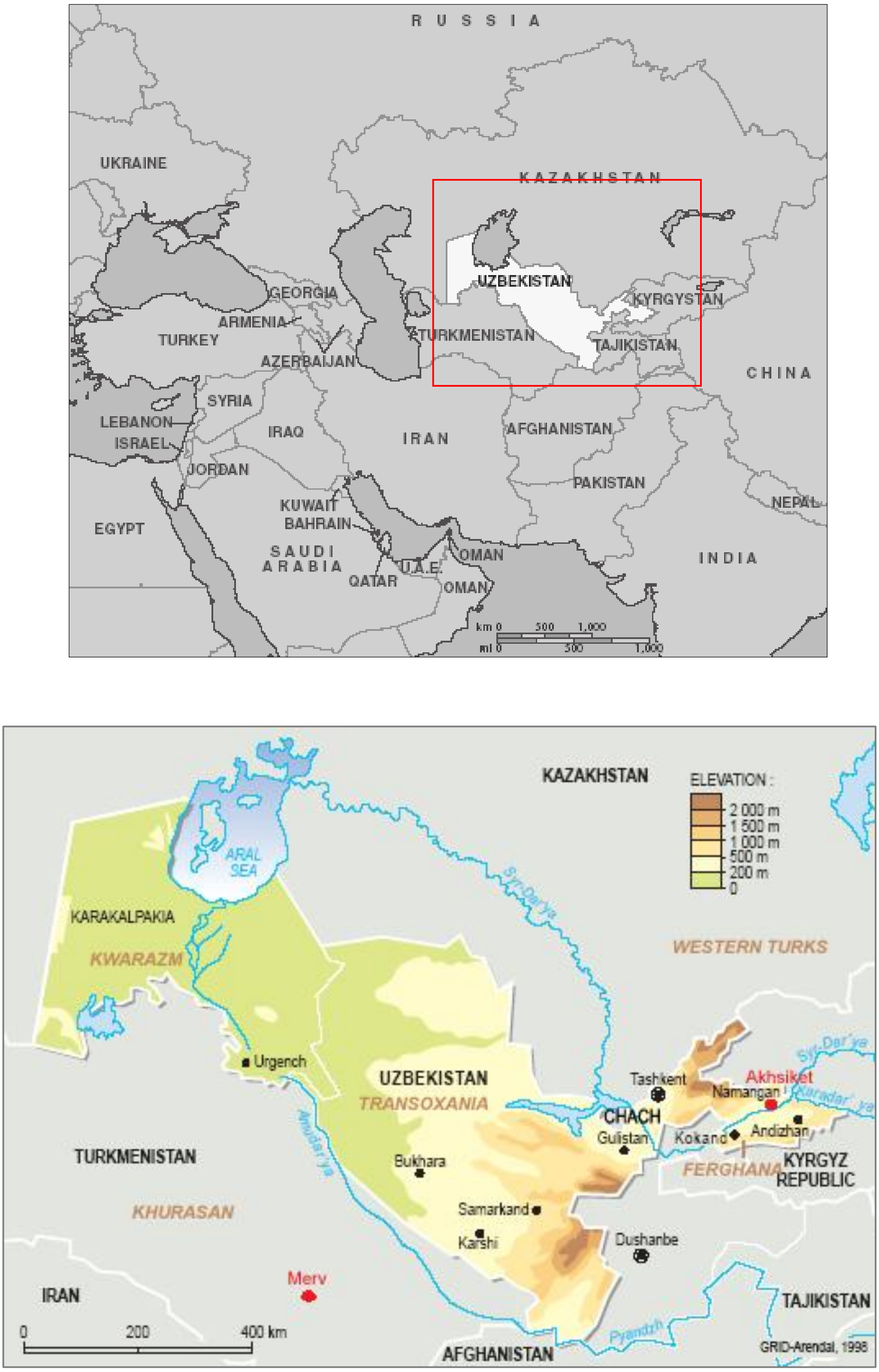

Figure 2.1 Maps of modern-day Uzbekistan, including ancient provinces (bottom) (UNEP/GRID-Arendal 1997).

Figure 2.2 Map of modern-day Ferghana Valley, showing the position of Akhsiket and Kuva (UNEP/GRID-Arendal 1997).

2.2. Historical setting

There are no extant historical sources originating from Central Asia on its pre-Islamic history. The earliest known sources are Chinese records, some contemporary, some retrospective, on diplomatic and military activities in Ferghana from the 2nd century BC. Up to the Arab invasions, many references to the geography and politics of Central Asia in the historical sources are ambiguous. There are references to geographical locations such as the Syr Darya in the classical sources primarily related to the conquests of Alexander the Great (Gorbunova 1986, 22), but little on the social or political environment. There are also mentions of pre-Islamic Central Asia in the Islamic-era histories and geographies written centuries after the fact. These are few and their historical basis unclear. Luckily, archaeological sites for this time period are numerous and rich. The study of artefacts and manuscripts from the Silk Road cities (such as the International Dunhuang Project[2], which looks at a wide range of sites, and in-depth excavations such as the International Merv Project[3] (Herrmann 1999; Herrmann et al 2001)) provide invaluable evidence of trade, economy, social structures, culture and the movement of people. Extensive numismatic evidence can be used to unravel the various political entities and succession of rulers in Central Asia using style and, most importantly, inscriptions (Cribb 2007; Fedorov 2004; Rtveladze 2007).

What can be gleaned from these sources is that Central Asia was closely aligned with the Iranian Sasanian empire in the early part of the 1st millennium A.D., although Transoxania itself was not necessarily under the direct control of the Sasanians. The political situation in pre-Islamic Central Asia was one of a combination of city-states based on market towns, and nomadic tribes – essentially fragmented and independent from the large empires surrounding the region (the Sasanians in Iran, the Kushans in Bactria, the Tibetans and the various Chinese dynasties).

During the 4th and 5th centuries A.D. Central Asia was dominated by various nomadic tribes refered to collectively as the Huns who had an Iranian culture, and originated from Central Asia. The Kidarites, Chionites and Hephthalites are examples of these, and they spread southward towards India and eastward into China (Frye 1983, 346-7). The Hephthalites in particular appear to have largely overtaken most of Central Asia, and during this time the city states flourished, with the merchant class holding sway in a similar fashion to the landowners in Iran and Afghanistan (*ibid*, 352). The most famous of these merchants were the Sogdians, and their most famous cities were Afrisiyab (ancient Samarkand) and Bukhara. The Sogdians and - by association and geographical location - the Ferghanans were eastward-oriented, having much contact with China (Frye 1983, 352; 1964, 245). The merchant classes were "willing to ally themselves or submit to the power which could enforce peace over the trade routes to the Far East and to Mongolia, the special areas of trade for the Sogdians" (Frye 1983, 353).

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[2] http://idp.bl.uk

[3] Now called the Ancient Merv Project (Williams, et al, 2002).

The Hephthalites were overcome in the early 6th century by new nomadic aggressors in Central Asia: the Turks (Frye 1983, 349). The Turks seem to have taken on the Iranian culture endemic to Central Asia, probably facilitated by the Iranian *lingua franca* and the importance of trading with Iranian merchants. The Turkish impact seems to have been mainly the renewed fragmentation of political power, with a multiplicity of rulers evidenced by coinage (*ibid*, 357). This was, however, also the height of the Silk Road trade through Central Asia. Fragmentation among city states and nomadic tribes and a strong trade economy was the political and economic situation facing the Arab invaders in Transoxania in the early 7th century.

The pre-Islamic political, cultural and economic climate is key to understanding how the peoples of Central Asia reacted and adapted to the coming of the Arabs and Islam. Factors such as the continued influence of the Persian Sasanian traditions, the dichotomy between nomadic tribalism and the market-driven city state, and the importance of the Silk Road in shaping the character and culture of the region, for example, had an impact on how history was played out in the latter half of the first millennium A.D.

Historical sources for the **early Islamic period**, the period under consideration here, consist of copies and translations of Arab geographers and explorers who were drawn to the progressive cities of Central Asia such as Merv and Nishapur in Khurasan and Samarkand in Transoxania. Their writings are travel documentaries and historical epics where they recorded impressions of the territories claimed by the caliphate and the events that shaped them. Key works include The History of Prophets and Kings by Al-Tabari (including the invaluable account of Abu'l-Hasan al-Mada'ini who wrote about the conquest of Central Asia); The Routes and Countries, by Ibn Khurdadhbah; The Face of the Earth [*Surat al-Ardh*] by Ibn Hawqal (Barthold 1977, 161); al-Muqaddasi's geographical work The Best Divisions of Knowledge of the Regions (translated by Collins in 1994);and the anonymous work The Regions of the World *[Hudud al alam]* (translated by Minorsky 1937); all of which describe the cities of Transoxania and the Ferghana Valley, often including Akhsiket.

Further contemporary information on the early Islamic period in Central Asia can be found in al-Athir's Perfect Book Concerning History, a 13th century history drawing heavily on al-Sallami's 10th century History of the Governors of Khurasan which was lost after the Mongol invasions (Bosworth 2000, 143). For the Samanid era there is the account of Al-Azdi in Information About the Vanished States *[Akhbar Al-Duwal Al-Munqati'a]* (translated by Treadwell 2005) and the History of Bukhara, by the Bukharan Narshakhi (Barthold 1977, 14). For the Karakhanid era, there is a fragment from a work by Hilal on the Karakhanid occupation of Bukhara, and a biography of Karakhanid rulers, Examples of Diplomacy in the Aims of Government by Samarqandi (Barthold 1977, 8, 18). The titles supplied here do not make up an exhaustive list, but these works are particularly well used and contemporary sources.

The early Islamic period began in the 7th century A.D. with the consolidation of power by Muhammad in Arabia, and the subsequent Arab expansion into the vacuum of power caused by the "collapse of the Persian Empire and the exhaustion of the Byzantine" (Holt et al, 1977, 55). The spread of Islam was almost immediately carried beyond the borders of the Arabian Peninsula by Muhammad's successors - the caliphs - after his death in 632. The caliph (*khalifa*) commanded the loyalty of the Muslim tribes of Arabia. Arabian armies had successfully invaded Syria, Palestine, Lebanon, Jazira (the area encompassing the Euphraties and Tigris river basins in Iraq), Armenia and Egypt within a decade of Muhammad's death. The Byzantines were ejected from these lands, and large swathes of North Africa and Persia subsequently fell to the Arabs.

This expansion was not without its difficulties, costs and compromises, and the caliphate had to maintain a large military force to contain various rebellions within their zone of influence. Internally, the caliphate was not stable, with divided loyalties creating various factions in the ruling classes. Civil war broke out in 656 between those who supported the current caliph, and those who supported Mu'awiya, governor of Syria. After months of siege warfare, attempts at arbitration, assassinations and general chaos, Mu'awiya was eventually named head of state (Holt et al, 1977, 72). Thus began the reign of the first great Muslim dynasty, the Umayyads.

Mu'awiya oversaw invasions into Khurasan as far as the Oxus in 664 (Holt et al, 1977, 79). In 689, a member of the Khurasani ruling family, Musa, took Termez, on the Oxus, and created a power base for himself in the area (Kennedy 2007, 246). This was the first real Islamic inroad into Transoxania, although Musa was working under his own authorisation, and was, in fact, not a friend of the Umayyads (*ibid*, 240-253). He was ousted by the governor of Khurasan in 704.

The Khurasan governor Qutayba ibn Muslim campaigned against Transoxania from the beginning of his investiture in 706 to his death in 715. He started with seasonal "diplomatic visits" (heavily backed by a strong military force) in which tribute was sought from towns such as Kish, Bukhara and Samarkand (Gibb 1923, 31). The Transoxanians were generally unwelcoming and eventually Qutayba was prompted to establish a permanent force in Bukhara (Kennedy 2007, 245). In 712 he took Samarkand, facilitating heavy settlement by Muslim Arabs there and in Bukhara (Barthold 1977, 185). In 713 he invaded Chach and Ferghana for the first time, but achieved little by doing so. The next year, he moved into Ferghana again, and travelled as far as Kashgar (Kennedy 2007, 271). Qutayba, however, died soon after this, killed by his own men in the aftermath of the appointment of a new caliph.

Transoxania was largely pacified during the 730s and 40s by Nasr ibn Sayyar, who reinstated Khurasani rule that had diminished after Qutayba's death. He also repulsed the Chinese who decided to take up the cause of the Ferghanan's (now the home of many exiled Sogdian merchants) and had invaded Chach (Gibb 1923, 99; Kennedy 2007, 291; de la Vaissière 2007, 54-58). Ferghana, however, was far from fully incorporated into the Islamic state – this would not be achieved until the end of the 8th century.

The Umayyads were distant overlords – as the Abbasids would be after them - leaving governance of the frontier provinces to the locals, and relying on the continuance of local structures such as systems of coinage and taxation. Without a strong imperial presence in Persia, politics saw the "re-assertion of local loyalties and provincialism" although the Iranians were generally co-operative with the Arab invaders (Frye 1964, 242-3). Arabic eventually became the new *lingua franca* for the educated classes, although Iranian was still widely spoken, and many Sasanian traditions persisted, including courtly practices which were taken up by the caliphs (Frye 1964, 243-4), and the style of coinage (Cribb 2007, 369).

The Umayyads, however, had serious rivals in the shape of the Abbasids. The Abbasid's claim to the caliphate rested primarily on their Hashemite status (members of the Prophet's family). Decades of political and religious propaganda on the part of the Abbasids combined with unrest and rebellious tendencies of the eastern populations in particular against the Umayyads, bolstered Abbasids influence (Holt et al 1977, 106; Kennedy 1981, 35-43). They gained a large amount of support in Iraq and Iran, and particularly in Khurasan, which also helped them rise above another rival, the Alid family, also descendents of the Prophet's family.

The Abbasid's success was largely due to the Central Asian commander Abu Muslim, who led a strong military force loyal to the Abbasids in Khurasan (the "Khurasaniyya"). In 747 he succeeded in capturing the city of Merv, one of the largest and most important cities in Central Asia (Kennedy 1981, 44). This was the beginning of the Abbasid military revolution. In late 749, the rebellion had succeeded and the Abbasid prince Abu'l-Abbas was appointed caliph in the place of Marwan, the Umayyad (Mottahedeh 1975, 57). In 750, Marwan was defeated in battle and fled to Egypt, where he was killed by the Abbasid army (Kennedy 2004, 115). The Abbasid armies routed all other remaining Umayyads with the sole exception of Spain, where members of the Umayyad family continued to rule for several hundred years (Kennedy 1981, 48).

Frye argues that strong support for the Abbasids in Khurasan was largely due to the economic interests in the region, to which the Abbasids were "sympathetic and liberal" (1964, 247). Beckwith echoes this in his summary of the Abbasid rebellion, emphasising the Central Asian focus of the rebellion, with its Central Asian battlefields, and the prominence of Abu Muslim and the Khurasaniyya (2009, 143). Kennedy emphasises the religious propaganda, particularly in the early days when the Abbasids were pushing a radical agenda of religious reform and resting heavily on their status as descendents of the Prophet (Kennedy 1981, 39-43). As the Abbasids gained influence, they simplified their religious agenda in order to gain support from a broader base (*ibid*, 41).

The Abbasid revolution brought significant changes to the Islamic world. As Kennedy states: "It was no *coup d'état* or palace intrigue but a massive social and political upheaval whose objectives went beyond the setting up of a new dynasty to the reforming and purifying of society according to the laws of Islam" (1981, 35). Their "ecumenical Islam" allowed Iranians and other non-Arab Muslims to "fully participate in the Islamic state, to influence and be influenced by in turn… The foundation for an Islamic renaissance in the 9th and 10th centuries was laid" (Golden, 1990, 346). In this way, and using their considerable military strength, the Abbasids solidified power and influence over the caliphate from their base in Baghdad, and continued its growth. Khurasan as a territory grew in importance through its political connections with the Abbasid caliph (Kennedy 2004, 135).

During the late 7th and early 8th century, the Abbasids firmly imposed their rule in Transoxania. There was patchy resistance in the region, and the Abbasids were also campaigning against the "Western" Turks to the north. The resistance was overcome via a combination of factors including accelerated Islamicisation (albeit often via unorthodox religious sects); the equal status now given to Arabs and non-Arab Muslims; and strict reprisals on local *dihqans* when they resisted (particularly after the rebellion of al-Muqanna in the 770s, which was taken up by both Samarkand and Bukhara) (Kennedy 2007, 291). 'One of the most important factors in the stabilization of the situation in Transoxania was the new attitude of the local *dihqans* (princes) toward the Muslim authorities,' (Bosworth & Bolshakov 1999, 33).

The Abbasid caliph al'Madhi initiated a successful campaign in Ferghana in 777 but in 792/3 the governor of Khurasan had to interfere militarily 'to subjugate the Farghanans who had fallen away from Islam again' (Fedorov 2004, 119). By 818, numismatic data shows that Ferghana was at least partly incorporated into the caliphate as an "appanage", or semi-autonomous principality[4] (*ibid*), although the extent of the adoption of Islam here is unknown.

It was during the early 9th century that Silk Road trade began to seriously decline. Beckwith argues that military action in Central Asia was probably not the cause, as military action had not seriously hampered trade during the previous several centuries. It appeared that a number of other factors lead to the decline and permanent collapse of major long distance trade via the Silk Road. The Chinese difficulties with the Tibetans, Uighurs to the east, unfriendly actions by the Chinese against Sogdian traders, the economic decline of the Tang government, and climate issues all contributing factors (2009, 157-8).

Great provincial dynasties arose under the Abbasids. In Central Asia, namely the Tahirids, the Saffarids, and – most importantly – the Samanids. These hereditary dynasties were official representations of caliphal rule over their territories, but became highly independent. Members of the Tahirid dynasty were heavily involved in the Abbasid civil war, and instrumental in securing the caliphate for al-Ma'muris, who appointed Tahir governor in Khurasan in 821 (Kennedy 2004, 148-9).

Already in the 820s Tahir was omitting the caliphs name from coinage, asserting his independence (Bosworth 1975, 95). This dynasty ruled large parts of eastern Iran until overcome by the Saffarids in 873 (Golden 1990, 347). The Saffarids added Khurasan to their existing territory in Afghanistan, and continued to expand their territory throughout Iran in the 9th century. Saffarid rule here was short: 'Amr bin Laith, the last Saffarid governor, fatally antagonised the Samanids, and his lands were assigned to the head of the Samanid dynasty by the caliph in 902 (Bosworth 1975, 121). This paved the way for the Samanids to become the most powerful ruling dynasty yet in Central Asia and beyond.

The Samanids were Iranian Central Asians, but their origins are not very clear. They

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[4] A number of terms for the political regions of Central Asia are used, both Arabic and Turkish as well as more familiar terms such as 'principality' and 'vassalage'. To what level regions such as Ferghana owed 'fealty' to the caliph is not completely clear, nor is the exact political structure within such regions, so some ambiguity is unavoidable.

could have originated in Samarkand, Termez, or Balkh (Frye 1975, 136; Golden 1990, 347). The Samanids come onto the political stage first in 819 when the governor of Khurasan rewarded four brothers of the Samanid family for their military actions by appointing them governors of four areas: Samarkand, Ferghana, Chach and Herat (Frye 1975, 136; Golden 1990, 347).

Ahmad ibn Asad, governor of Ferghana, became the head of the Samanid dynasty at the expense of his brothers. He maneovered his sons Nasr, Yaqub and Ismail into prime positions as rulers of Transoxania, with Ismail quickly taking the dominant role (Golden 1990, 347). Nasr had ruled from Samarkand, but Ismail moved the capital to Bukhara (Frye 1975, 137). Transoxania was officially invested to the Samanids in 875 by the caliph, creating a "Samanid state" (*ibid).*

Coins were minted in the name of the Samanids throughout Transoxania (including Akhsiket from as early as 822/3). During the reign of Nasr and Ismail Samanid coins ceased naming the caliph, demonstrating their independent status (Fedorov 2004, 121). In 898, 'Amr, the Saffarid governor, secured a decree investing him with Transoxania. In all opposition to the caliph (whose motives in doing this were unclear), Ismail defeated 'Amr in battle in 902 and was subsequently given the Saffarid territories – greatly enlarging the Samanid sphere of authority (Bosworth 1975, 121).

The Samanids were great patrons of Iranian culture, which re-emerged as a "new Islamic Persian culture" (Frye 1962, 254). At this time, Islam "had become a multi-national, multi-lingual universal culture and faith" (*ibid*, 255). During the height of Samanid power in the late 9th/ 10th century the Samarkand school of glazed ceramic decoration came into existence, based on techniques first developed in Egypt and Iraq during the previous century, having an impact on glazed pottery production in Transoxania and Khurasan, and exporting its wares throughout the eastern Islamic world. This is clearly mirrored to some degree at Akhsiket, where glazed ceramics fit firmly within the wider stylistic milieu found throughout Central Asia.

Throughout the early 10th century, "steppe" Turks hounded the Samanids with periodic invasions. The Samanids continued the Muslim *jihad* (Holy War) with short-term invasions to the north into the Turkish Karluk Kaghanate of Utrushana (southern Kazakhstan) (Golden 1990, 352). In 910, according to Al-Azdi, the Turks attacked Transoxania with 400,000 men on several fronts, including Chach (Treadwell 2005, 164). It may have been retaliation by the Karluks for previous invasions (Golden 1990, 352), but on this occasion proved unsuccessful, and the Samanids maintained control over the targeted cities. These military expeditions provided the Samanids with so many Turkish slaves that they monopolised the trade and caused the price of slaves to fall (Frye 1975, 150). This penchant for slaves – *ghulums* - training them and relying on them in high positions in government and in the military – would eventually contribute to the Samanid's downfall.

Whether the *jihad* was the cause or not, the sustained growth of Islamic conversion by the Karluks and other Turks in the area would have great significance: by the 920s, the Samanids were appointing governors in Ferghana which were local Turks who had converted to Islam (Fedorov 2004, 123; Golden 1990, 358). It is possible to surmise, on examination of the names and titles on the coins of the 940s-50s, that the Turks ruling Ferghana began to assert their independence from the Samanids at this time. As Fedorov points out, historical sources mention the execution of one of the members of the Turkish Malik family at Bukhara, and the Malik name disappears from coinage after 955/6 – possibly a backlash to their dynastic posturing (2004, 124). The ruling Turkish dynasty of Ferghana was based at Uzgen in the eastern end of the Ferghana Valley, and Akhsiket was under the control of a governor by the name of Bughra (*ibid*, 124).

In 965/6, control of Akhsiket was given to Ahmad ibn Ali, and later coins mention other names and titles that are not yet fully understood (*ibid,* 125). Ahmad was also named on coins at Kuva and Uzgen, evidence that he governed most if not all Ferghana (*ibid,* 126). It would appear that from the 980s Ahmad left Ferghana under the control of a Turkish vassel who in turn had a sub-vassal, who delegated power to some lower ranking official. The names all appear on the coins – visual confirmation of who was to profit from the taxes (*ibid*, 126). Coins of the late 980s and 90s mention the last two Samanid-era governors of Ferghana, both of whom allied with the

Karakhanids, another Turkish dynasty based in Uzgen, in 992. By 993 Karakhanid coins were already being minted in Ferghana, probably at Uzgen (Fedorov 2004, 127).

The Samanids downfall was, as with many in their position, a combination of internal struggle, incompetence, and a risky level of reliance on external military forces. The Samanids had built up a *ghulam* army of Turks, including the Ghaznavids who took advantage of the weakened Samanids in the late 10th century, vying for power with other Turks within the Samanid territories. They eventually allied with the Karakhanids and jointly conquered the Samanids once and for all (Golden 1990, 359). In 999 this Turkish partnership carved up the former Samanid state between them. The Ghaznavids took the lands to the south of the Oxus, and the Karakhanids to the north. The Karakhanids would retain their control here until the late 12th century. The Karakhanids were the first ethnically Turkish dynasty to gain "respectability within the Islamic orbit" (*ibid*, 360).

Over the next half century, the Karakhanids and the Ghaznavids maintained an uneasy balance of power, at times clashing, at times plagued by internal strife, and dealing with external problems including new Turkish migrations from the northeast (Golden 1990). At Merv in 1040 the Ghaznavids were defeated by military commanders they had recruited from the ranks of the Seljuks, ethnic Oghuz Turks that had recently converted to Islam (*ibid*, 364). The Seljuks had a major impact on Central Asia and the Middle East as they became more powerful even than the Samanids, essentially taking over the caliphate. However, the Seljuks had little impact on Transoxania and Ferghana itself, which remained under the Karakhanids for the remainder of the time period under discussion here. Ferghana was a geographical nexus for Karakhanid internal struggles, and this may have had some impact in the 11th century on stability in the region.

The Mongols invaded Ferghana in the 1220s (Knobloch 2001, 23), causing the permanent abandonment of Akhsiket and many other urban settlements. Our historical introduction ends here, as there was a long hiatus in the production of ceramics in the vicinity of Akhsiket after the arrival of the Mongols, and when it was again resumed in the 15th century, the styles and techniques had changed considerably.

The downfall of the Samanids and the rise of the Ghaznavids and Karakhanids seems to have had little impact on the material culture of Akhsiket. These dynasties were firmly part of the "new Islamic Persian culture" established in the 9th and 10th centuries by the Samainids, and clearly kept trade communications open. This is supported further by 11th century pottery production at Akhsiket, which, as we shall see, continues to follow shifts and changes seen in Central Asia and Iran. Throughout the time period, Akhsiket remained an economic success, with no interruption in the archaeological record of steel-making or ceramic consumption.

2.3. Archaeological setting

Akhsiket conformed to a three part city structure that typified Sasanian-era cities in the pre-Islamic period. It consisted of: 1. the *quhandiz* (or 'ark') – a citadel often on a hill or high area, 2. the *shahristan* – the main city usually enclosed by fortified walls, some with towers, and 3. the *rabad* – suburbs located outside the fortifications, which often contained the bulk of industrial activities. Ahksiket's citadel was located in the southwest corner, Akhsi 1A and 1B as the *shahristan* surrounded by fortifications and towers, and Akhsi II-IV comprising the existing area of *rabad* (see Figure 2.3, below, for a map of the site).

During the course of archaeological investigations from the 1950s onwards, the dimensions of Akhsiket have been determined in their present form: the citadel at its largest dimensions being 100 x 30 m, the 'inner' *shahristan* (Akhsi IA) being 8 ha, and the main *shahristan* (Akhsi IB) being over 20 ha (Anarbaev 1988 175-178). The remaining fortifications of Akhsi IB consist of the mounds of 20 'turrets'. Several 'Objects' or area excavations and sondages have been excavated in this area as well as in the areas of the *rabad* referred to as Akhsi II and III (see Figure 2.3). The earliest finds on the site were red-slipware sherds (possibly 2nd/1st century BC), in Akhsi II (*ibid,* 182). The shahristan areas appear to date from the 7th/8th century AD (*ibid,* 178). It would seem then, that in the so-called 'archaic' time period, when Akhsiket was under the control of the Turks, before the Arab's arrival, the town was located at Akhsi II, while in the 7th or 8th century – around the time of the Arab invasions of Ferghana - the centre moved to Akhsi I, the medieval fortified enclosure, with Akhsi II and III as its suburb (along with other possible areas not studied, or no longer existing due to river erosion).

Ibn Hawkal, writing in the latter half of the 10th century, refered to Akhsiket as the capital of Ferghana. According to Le Strange, Ibn Hawkal described Akhsiket as

> "a large city, with a castle, where stood the Friday Mosque, the governor's palace, and the prison; and outside the inner town was an extensive suburb. The inner city, which measured a mile across in every direction, was intersected by numerous water channels, all connected with a great tank; and there were markets both here and in the suburb, which latter was surrounded by a wall. The inner city had five gates, namely the Kasan Gate, the Mosque Gate (Bab-al-Jami'), the Rahanah Gate, next a gate with an uncertain name that may be read as Bakhtar, and finally the Gate of Al-Mardakshah. The place was entirely surrounded by gardens, which extended for a distance of a couple of leagues beyond thesuburb gates, and on the further, or south side of the Jaxartes were rich pasture grounds" (Le Strange 1905, 477).

Le Strange goes on to say that Akhsiket was apparently ruined in the wars with the Khwarazm Shah and the coming of the Mongols in the beginning of the 13th century, at which point the capital of Ferghana moved to Andijan. Akhsiket was called "Akhsikant or Akhsikat" during the time of Timur (in the 14th century), and "Akhsi" during Babur (late 14th to mid 15th century) (*ibid*, 477-8).

According to Barthold (1977, 161-2) Maqaddasi described Akhsiket as being 'half as large again as the famous town of Ramla in Palestine' – or more than a kilometre in length and breadth; the cities of Ferghana were considered remarkable in size in comparison to other regions in Transoxania, and Akhsiket was among the largest and most prosperous.

In the *Hudud al alam* Akhsiket is described as "the capital of Farghana and the residence of the amir and (his) lieutenants. It is a large town on the bank of the river Khashart (Jaxartes), at the foot of a mountain. In its mountains there are numerous mines of gold and silver. Its inhabitants are wine drinkers (*nabidh-khwara*)" (Minorsky 1937, 116, including his translator's comments). Ferghana the region was described in this work, as "a prosperous, large, and very pleasant region… Great numbers of Turkish slaves are brought here" mentioning again mines of silver, gold, copper and lead (*ibid*).

The site as it exists today is partly flat and partly undulating, with the citadel some meters higher than the surrounding *shahristan*. The entire site is raised in comparison to the surrounding land. Remains consist of the foundation levels of early Islamic structures including municipal buildings, domestic housing and craft workshops, with the entire area dominated by the remains of the fortification towers and the citadel. Other than the southern side of the city (which was heavily eroded by the Syr Darya) the towers, or "turrets" can be seen spaced along the outer perimeter. The fortifications were not used as such during the Islamic period – in some areas at least, the walls were repurposed as workshop areas, or other non-military urban structures (Object 9, one of the excavations carried out for this thesis, was located on what would have been the fortification wall). Excavations at the citadel have produced the remains of a barracks, including pottery dated by the archaeologists to the 10-12th century (Anarbaev 2002). See below for a series of images showing the citadel and other areas of the site. For detailed descriptions of the excavations carried out for this research, see Chapter 4.3.

Economic activity increased sharply in the 9th-10th centuries. The centralised control of the Samanids resulted in 'the growth of trade, and consequently that of the cities and their crafts' in Ferghana, and the militarization of the Samanid regime provided a vast market for products such as steel weaponry and armour (Papachristou, 1985, 123). Excavations show evidence of closely packed habitation within the *shahristan*, including houses of 4 to 6 rooms with personal storage chambers. A bathing complex dating to the 10th/11th century, and further disintegration of the fortifications to make room for industrial activity shows Akhsiket's increasing prosperity, a development which happened at the same time at Kuva (Ivanov 2003, 208). A mint in Akhsi II produced coins up to the Karakhanid period (Anarbaev 1988, 185). There was an organised city maintenance system, with underground water piping, waste-flow systems, underground storage chambers and cisterns. Industrial activity was extensive, with remains of steel-making crucibles in several areas across the site. There is also evidence of copper smelting and glass working. Glazed wares were introduced in the late 9th century and appear particularly abundant and diverse in the 10th and 11th centuries.

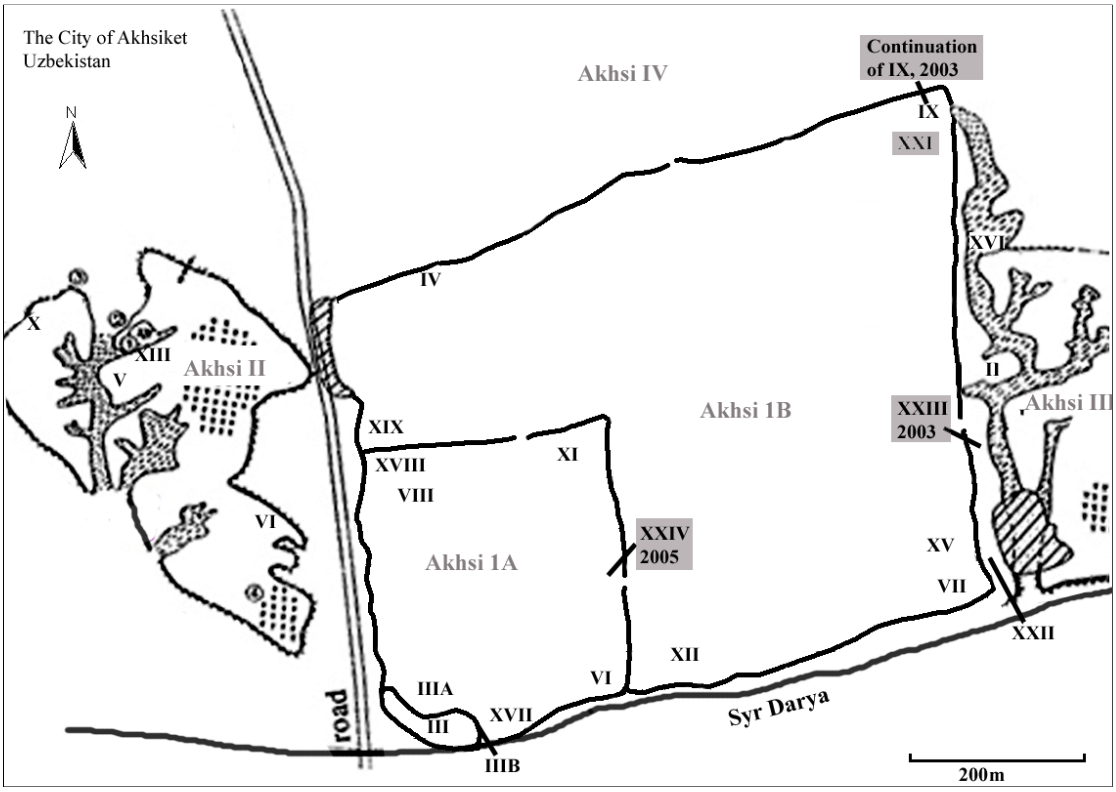


Figure 2.3 Map of Akhsiket showing the layout of the city, and previous excavations.

Figure 2.4. Object 3b, citadel.

Figure 2.5. The citadel (middle ground) from the northeast.

Figure 2.6. Eastern fortification towers, from the northwest.

Figure 2.7. Outside the eastern fortification towers, from the north (area of Object 23).

Figure 2.8. The western edge of the *shahristan*, containing visible remains (the arched cavern) of the underground waste or water system.

Figure 2.9. Remains of buried storage jars in the foundations of Object 24, a house.

For some reason, from the second half of the 11th century to the second half of the 12th century, the minting of Karakhanid coinage seems to have stopped (*ibid*). This may be related to the break from centralised control during the Karakhanid period in this region. Archaeologically, however, from the 11th century until the Mongol invasions, Akhsiket continued to prosper. Akhsiket's prosperity seems to have been due either in part, or in the main, to the extent of its steel-making industry throughout the 9th to 12th centuries, and that it was the main known production site of crucible steel in the Ferghana Valley (Rehren and Papakhristu 2000, 56). The large numbers of glazed pottery sherds on the site also indicate either a locally-based glazed pottery industry (of which there is no direct evidence, such as kiln remains or wasters), or a wealthy consumer base for the import of such goods.

Akhsiket was destroyed in the early 13th century, and after the Mongol invasions it was permanently abandoned. Another settlement, also called Akhsiket (now known as 'New Akhsiket') was established about 7 km downriver in the 15th century, but this town was abandoned in the 17th century and no known traces remain.

Akhsiket's excavation program continues, under the directorship of the Institute of Archaeology based in Samarkand, part of the Uzbek Academy of Sciences at Tashkent. This research has produced a number of reports and articles, nearly all of which are published locally in Russian. Abdulhamid Anarbaev, currently director of the Institute of Archaeology, has been managing the archaeological investigations of Akhsiket for many years, and personally oversaw the excavations and sampling for this research in 2003 and 2005. Analytical work on crucible and slag remains from Akhsiket and other sites in Uzbekistan has resulted in several papers and three MSc dissertations (at University College London) are available on the analysis of glass and glassworking remains from Akhsiket and Kuva (Cheng 2006; Jolley 2003; Osorio 2005; Papakhristu and Rehren 2002; Rehren and Papachristou 2003).

2.4. Summary

The incorporation of Ferghana into the Islamic caliphate was on the whole a slow, fragmented process. Historical and numismatic evidence shows that there was a continual shuffling of power between members of the Samanid family, and, from the 920s, a rather top-heavy hierarchy delegating government to Turkish officials based at Uzgen. It would seem that Akhsiket, at least, was minting Samanid coins from as early as the 820s, so perhaps it was a relatively early adopter of the Islamic regime. This may have helped to entrench its status as a regional capital. However, the late coming of glazed ceramics at Akhsiket, as discussed further in Chapter 3, may show that easy connections with the world outside of the Ferghana Valley were not established after the initial Arab invasions until the late 9th century when the Ferghana Valley was fully incorporated into the Samanid state.

Although Transoxania became a stable part of the Islamic hegemony that ranged from Spain to Madagascar by the 12th century, like Egypt and Khurasan the region was virtually independent of the caliphate under its successive dynastic governments. These successive regimes, from the Iranian influence of the Samanids, to the Turkish influence of the Uzgen-based overseers and eventually the Karakhanids, provides a background of political upheaval and cultural shift. This is the environment under which the crafts and industries of Akhsiket came about, and the consumption of material goods changed and developed. It also helps to inform consideration of Akhsiket's external links within and without the immediate region. Archaeological and stratigraphic evidence appears consistent with the historical sources. They show a large, prosperous urban centre with a strong industrial economy based on steel-making, high consumption of quality goods such as glazed finewares, and population growth during the Samanid and Karakhanid periods.

3. Islamic ceramics and glazes

3.1. Introduction

The purpose of this chapter is to give an introduction to Islamic ceramic and glaze technology, and present the typological characteristics of Akhsiket's pottery, its chronology, and its developmental history. This is particularly important in the case of glazed ceramics, as a particular phenomenon of the time period under discussion. Although incomplete and, in some cases, tentative, an understanding of this framework formed the basis for choosing samples for the microanalytical work presented in the following chapters, and the main focus of this thesis.

Ceramic typology is traditionally based on the study of the macro-morphology of ceramic vessels and sherds, such as vessel dimensions and shape, colour and texture of body fabrics, decoration methods, and decorative designs and colours. It is the foremost method for the classification of pottery, and helps the researcher to piece together information on type groupings, stylistic development over time (leading to relative chronologies), the flow of stylistic influences between lesser or greater distances or between cultures, and the rate of localised innovation in stylistic development.

Dating is a particular concern for early Islamic pottery, as pottery is ubiquitous, and datable diagnostic remains are invaluable for understanding archaeological contexts. Archaeological pottery has been found in datable contexts either through historically-attested events (such as the destruction of a site providing a *terminus ante quem* for a particular assemblage), or through association with other firmly datable artefacts such as coins, leading to a smattering of datable styles. However the chronology of Islamic pottery is very patchy, even for the glazed wares. Also, many pieces that make up the corpus of Islamic pottery in museums and other collections exist *ex situ*, in particular items in museum and private collections, with no known site of origin, and with no associated artefacts with which to accurately date them. Thus many date and origin attributions have been, and are, approximations often based on long-held assumptions concerning typological sequences.

Central Asian pottery is particularly problematic as there is little systematic typological information on the glazed ceramics, and less for the unglazed wares. Research has been published on a few stylistic types – such as rosette design found on polychrome slipwares (see section 3.4.1) (Anarbaev and Ilyasova 2000) – but the majority of serious work on stylistic development or the characterisation of assemblages from stratified contexts, is carried out as part of research degrees. These theses are long-term pieces of work, and tend to be either incomplete, or simply unavailable. It remains necessary to compare archaeological sherds with a few published catalogues or reports on finds from other areas of Central Asia including Chach (Brusenko 1982), Samarkand (Shishkina 1979), and Merv (Herrmann, et al 1997, 2001).

For the purposes of this study, the assemblages analysed can be fairly accurately dated to the scale of 100-150 years – and this serves the purpose for understanding broad developments in the early Islamic wares from a scientific point of view. Where date attributes can be linked to previous typological studies, or dated sherds of similar style, this is indicated in the text.

3.2. Introduction to glazed Islamic pottery

During the centuries under discussion (8th – 12th centuries AD), the foremost developments in ceramic technology were in glazed wares. These developments were centred in China, the Middle East and Central Asia.

The first known deliberate use of ceramic glazes began sometime in the middle of the 2nd millennium BC in the Middle East and in China (Harman 1973, 2). These were so-called alkali glazes, and this type of glaze continued in use to the 11th century AD in the Middle East. Glaze based on lead oxide was developed first in China in the latter half of the 1st millennium BC and in the West by the 1st century AD (Fehérvári 2000, 37, 38, 47; Kleinmann 1986, 73; Lane 1958, 3; Tite 1988, 30), and became the primary glazing method of choice during the early Islamic period, particularly for open 'tableware'.

During the Islamic period glazed wares became produced for export in their many varieties. Glazed wares form a small proportion of ceramic assemblages on the whole, but can be found in quantity in some urban areas where there has been production activity or high consumption (over 10% for urban sites in the Middle East according to Mason (2004,1)). Much glazed pottery studied over the decades exist as individual pieces in museum or private collections with little or no accompanying contextual information. Archaeological ceramics (those recovered as part of an archaeological excavation) are key to the study of these wares, with chronological frameworks built up from a combination of dated contexts (largely based on coins, inscriptions and "event horizons") and the application of typological seriation to assemblages found in quantity in undisturbed stratified contexts. However, due to the scattered and patchy nature of archaeological activity in the Middle East and Central Asia, the local character of some styles, and the rarity of other styles, archaeological research has not yet provided a comprehensive picture of the rise and fall of many styles, designs or technologies assigned to the early Islamic period.

It has long been accepted by art historians that although there was already a long history of glazing in Mesopotamia and Egypt, an influx of Chinese imports in the mid 8th century was the impetus behind the earliest glazing innovations in the Islamic world (Watson 2004, 14). However, there are many developments in Islamic ceramics that are unrelated to the Chinese imports, or pre-date the advent of Chinese imports. Arguments for early glazing development built on Sasanian or Roman techniques are based on excavated examples: for example the 'yellow wares' first discovered at Tell Aswad, Raqqa, in Syria. The field report for excavations at Hadir Qinnasrin, an early Islamic settlement in Syria, notes that excavated examples from similar sites in Syria 'have clearly demonstrated the transitional nature of this ware between Coptic glazed ware… and the introduction of Samarran wares…' showing an Egyptian antecedent. In their preliminary judgement, the 'yellow wares' are diagnostic of the 8th century (Whitcomb 2007). In Watson's opinion, these findings suggest that: '…this highly-developed industry was already in production by at least the late 8th century, thus undermining the traditional notion that the impetus for the sudden and widespread development of Islamic glazed pottery was the copying of Chinese wares in the Samarran period (post A.D. 836)' (Watson 2004, 14).

The early Mesopotamian glaze technology continued in use throughout the early Islamic period, being produced in monochromatic styles in yellow, green and turquoise. Kennet, working on wares in the United Arab Emirates has labelled this pre- and early Islamic type 'TURQ' class (Kennet 2004, 29). This glaze type never becomes mass produced as later Islamic ceramics would be, forming less than 1% of glazed ware assemblages after the 9th century (*ibid*, 30).

Mason discusses several early classes of glazed pottery in the Islamic world (2004). The earliest 'Islamic' glaze types – showing a departure from the ancient glazing methods - were developed in Iraq, particularly at Basra (Table 3.1 shows all the major ceramic types mentioned here in their general geographic and chronological context.). 'Blue-painted' ware, developed there in the 8th century, was an alkali glaze with blue painted decoration created by the use of cobalt pigments (*ibid*, 36). By the late 8th century some body types show a resemblance to imported Chinese wares of the 8th/9th century (*ibid,* 43), and it is evident from comparing imported Tang ceramics to some early Islamic wares that certain glazing styles in particular were indeed mimicked ('splashed' wares, for examples). However, the use of cobalt on the Blue-painted ware was a completely unique Islamic innovation as was the calligraphic design technique developed by these potters (Mason 2004, 24).

Iraqi production centres also developed the quartz-rich slip engobe – used to cover red or buff clay bodies with a smooth white surface (Mason 2004, 31), a technique heavily employed by later Central Asian potters.

The influence of this new Islamic style of pottery is shown by the wide adoption of the Blue-painted type, which was copied and traded in Egypt and Syria (*ibid,* 44). High-lead glaze (glaze with around 50% lead oxide) first appears in an Islamic context in Egypt in the 8th/early 9th century ('Semi-glazed' ware), but by the early 10th century Basra imports, copies of Basra wares and Chinese wares had become more common in Egypt (Mason 2004, 77). The calligraphic style first seen on the Blue-painted wares continue in use in Central Asia on the lead glazed slipwares, particularly "Samanid" ware of the 10th – early 11th centuries, and was used on lustre wares in the Middle East as well, demonstrating the wide-ranging and long-lived impact of Islamic innovations, and their transfer from one type of technology (or medium) to another.

Tin-opacified glaze was first developed in Iraq in the 8th century, and lustre-ware in the 9th century – both firmly Islamic inventions. Tin-opacification was used to render an alkali or lead-alkali glaze opaque white in colour by the suspension of tin-oxide particles in the glaze, scattering light far more effectively than gas bubbles and quartz inclusions alone can achieve (Caiger-Smith 1973; Mason and Tite 1997). Lustre wares - heavily studied for their interesting stylistic, chemical and physical properties - demonstrate a metallic sheen due to the reduction of silver, gold and copper oxides applied to the surface of an alkali or lead-based glaze (Pradell et al 2008; Borgia et al 2002; Caiger-Smith 1985; Watson 1985;).

Egypt picks up the lustre technique in the early 10th century just as the practice sharply declines in Iraq – possibly due to the transfer of knowledgeable potters to Fatimid Cairo around this time, and historically attested (Mason 2004, 78). Syria, starting out with lead-glazed moulded styles in the Romano-Byzantine tradition in the 8th century, quickly takes its cue from Iraq with Blue-painted, lustre and other Iraqi types produced here until the late 11th century (*ibid*, 108).

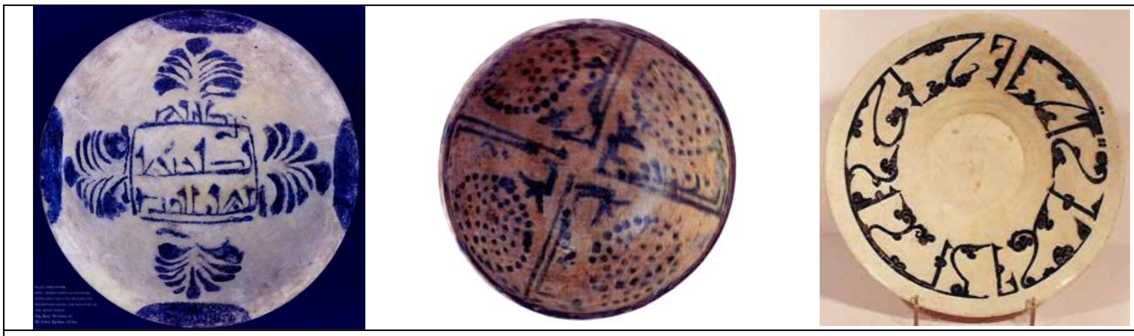
At some point during the 8th century Iraqi and Chinese/Pacific influences percolated into Central Asia. In Central Asia there is no evidence that glazing predates the Arab conquest, so it is a virtual certainty that glazing technology and design were derivative of the methods developed in Iraq that filtered through local interpretations in Iran (which had 'literally dozens of production centres, all with their unique style sequences' (Mason 2004, 78)). At this time Baghdad was the centre of the caliphate, with the Abbasids fully entrenched and making serious headway into Central Asia. The technology from these earlier glazing practices could have travelled with craftsmen immigrants patronised by the new governing classes to regional centres such as Rayy and Nishapur in Iran, Merv in Turkmenistan, and Samarkand and Chach in Transoxania. From here, it was a short distance to Ferghana.

During the Samanid period, in the 9th and 10th century, a distinct style arose in the eastern Islamic world commonly referred to as the "Samarkand" school. This school used a calligraphic style – usually black on white – created with coloured slips incised to create a sharp line. It was particularly endemic to Transoxania and Khurasan, and Samarkand and Nishapur are considered to be the main production areas (Fehérvári 1998, 13-14; Mason 2004, 122). The Nishapur wares also include the distinctive polychrome figural scenes, or 'Buff ware' (Bulliet 1992, 78; Wilkinson 1973). However, the style was traded throughout the eastern Islamic world, and copied widely (including in the Ferghana Valley, with many examples of this ware being discovered at Akhsiket – see Chapter 3.4.1 for further discussion of this type).

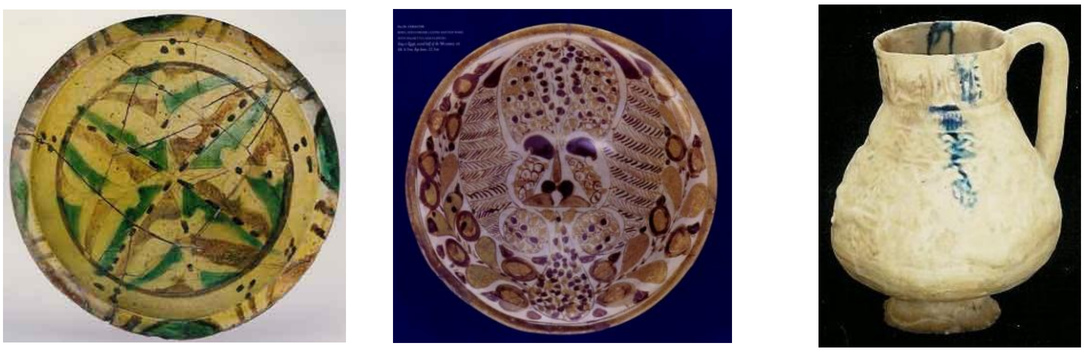
Towards the end of the Samanid period in the early 11th century, while Transoxania was in the hands of the Karakhanids, other parts of the caliphate were falling under the dominion of independent dynasties. The foremost of these prior to the Mongols were the Seljuks. The Seljuks were Turks who took Khurasan and Iran in the early 11th century and eventually the whole of the eastern caliphate (under whom the Karakhanids continued to govern Transoxania). They were based at Merv, one of the major Islamic silk road cities. The Fatimids, a dynasty based in Egypt, exercised control over the whole of Islamic north Africa and the Levant by the 11th century.

<table>
<tr><th></th><th>700</th><th>750</th><th>800</th><th>850</th><th>900</th><th>950</th><th>1000</th><th>1050</th><th>1100</th><th>1150</th><th>1200</th></tr>
<tr><td>Blue-painted wares</td><td colspan="4">Basra</td><td>Egypt</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Tin-opacified glazes</td><td>Basra</td><td colspan="5">"Samarran" (Baghdad?)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Yellow lead glazed wares</td><td colspan="4">Syria</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lead glazed moulded wares</td><td colspan="2">Syria</td><td colspan="2">Basra</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Tang imports</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>High lead "semi-glazed" ware</td><td></td><td colspan="5">Egypt</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lustre wares (early styles)</td><td></td><td></td><td colspan="2">Basra</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lustre wares (poly- and bi-chrome)</td><td></td><td></td><td></td><td></td><td>Basra</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lustre wares (monochrome)</td><td></td><td></td><td></td><td></td><td colspan="2">Basra</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lustre wares</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Egypt</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lustre wares</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Syria</td><td></td><td></td></tr>
<tr><td>Stonepaste bodies</td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Throughout Middle East</td><td></td><td></td></tr>
<tr><td>Incised wares</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Throughout Middle East</td><td></td></tr>
<tr><td>“Ishkor" wares</td><td></td><td></td><td colspan="5">Central Asia</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lead glazed slipwares</td><td></td><td></td><td></td><td></td><td colspan="6">Central Asia/Iran</td><td></td></tr>
<tr><td>Incised wares</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Central Asia/Iran</td><td></td></tr>
</table>

Table 3.1. General timeline for some major Islamic ceramic style groupings and technologies for the Middle East and Central Asia and their primary geographical association (please note that not every identified style or group is included here).



Tin-glaze blue-painted ware | Yellow-ware | Lead glazed slipware



Incised ware | Lustre ware | Stonepaste

Figure 3.1. Examples of some Islamic ceramic types (by courtesy of the Tareq Rajab Museum, Kuwait).

During this political realignment, the next – and last – pre-Mongol innovation was the widespread use of stonepaste technology. Also known as composite white fritware, this was a partially vitrified body made of a quartz-rich paste that mimicked porcelain to a much greater degree than slipwares (Fehérvári 1998, 23). This may have been developed in Iraq (Mason 2004, 170). Highly fired in comparison to earthenwares, this allowed the redevelopment of alkali glazes and became widely used for alkali glazed lustre wares and other wares in the Middle East from the early 11th century (*ibid*, 78).

By the 12th century, glaze technology in Central Asia - and indeed throughout the caliphate - is commonly regarded to have waned in excellence and innovation. So we see a reduction in the production of lustre wares and complicated slipwares, replaced by much simpler monochrome and incised styles throughout the region, including the Ferghana Valley. Incised wares fell into two main categories – monochrome green, and those with a yellow or white ground (depending on the presence or not of a white engobe) with green, red and yellow 'splashes', sparse decoration with little resemblance to the earlier precise motif-based polychrome styles (Herrmann et al 2001, 44-5; Kennet 2004, 35-6, 7).

The incised styles were picked up in Iran in the later 11th century, particularly the green-painted incised wares. This type was 'more often … largely undifferentiated across the entire Iranian region, apparently with numerous production centres' (Mason 2004, 122). In Central Asia, green incised wares also become ubiquitous in the 12th century, indicating yet again that glazing techniques were transferred – often with some time lag – from the Middle East through Iran and into Central Asia, even during the time of the Karakhanids.

Not all the styles in use in the Middle East were transferred, or adopted by the Central Asians. Tin-opacified glazes, lustre-wares, Blue-painted wares and stonepaste all required specialist techniques and ingredients, and none of these wares are found in any real quantity in Central Asia during the early Islamic period. It would seem that only stylistic changes based on already familiar practices were transferred to the fringe areas of the eastern Islamic world at this time. Incised styles did not employ a particularly different technology, but merely a variation in the application of already known methods. This is discussed further in Chapter 7 with reference to the analytical results and comparisons with the wider Islamic world.

The overall picture of the developments described here up to the 12th century is that there were a small number of major pottery types, which were possibly developed locally in the earliest period (8th century). Over time, particular styles grew popular enough to have an impact outside the immediate production area – by trade and the movement of specialist craftsmen. However, fully understanding the transfer of styles, and the waxing and waning of techniques requires a sound chronological and geographical basis – and for Central Asian ceramics, this is often lacking.

Akhsiket's ceramics are entirely dated by comparison to contemporary ceramics from excavations in Transoxania. This presents problems as the date ranges quoted for Transoxania in the literature are only partly based on clear evidence, such as numismatics. In some cases, ceramics can be roughly dated by comparison to more firmly dated examples from other parts of the Islamic empire. Often relative chronological sequences as a result of stratigraphical layering are the only basis for dating stylistic developments (Brusenko 1986; Shishkina 1986, 1979; Shishkina and Pavchinskaya 1993; Vishnevskaya 2001). Brusenko relies largely on excavations at a single site not far from Tashkent called Hanabad which contained coins dating from the 7th/ 8th centuries to the 12th/13th centuries (Brusenko 1986, 15-32).

Some Akhsiket glazed ceramics have been studied in greater detail and typological analysis carried out – for example, developments over time in certain floral designs on the medieval lead glazed wares (Anarbaev and Ilyasova 2000; Ilyasova 1986, 1990 and 2000). This is a case of using typological analysis to fill in the gaps, or to show a progression from one style to another which is consistent with the stratigraphical evidence. This chapter presents the stylistic and technological groupings of the styles and motifs found on Akhsiket ceramics, including date indicators for those styles that have some level of chronological seriation.

3.3. Introduction to ceramic and glaze technology

3.3.1. Clay bodies and production in Central Asia

Ceramic technology is the method of turning clay into durable, heat- and water-resistant objects. Raw clay is the product of weathered rock and may be sourced from primary deposits (those that remain at the location of the parent rock) or secondary deposits (those that have been transported by erosion or some other method to a distance from the parent rock). Primary deposits are more ‘pure’, containing mineral inclusions solely from the parent rock, while secondary clays include additional minerals picked up during contact with other rocks, clays or organic substances during transport and deposition (Rice 1987, 36).

Clay can be dried (freely present H_2O being evaporated), but without suitable heat molecules of H_2O will remain bonded to the silica-alumina structure. If heated to a high enough temperature (over c. 600° C), water which is chemically bonded to the silica-alumina clay particles evaporates, and the clay begins to 'sinter' – fuse into a fixed, ceramic structure (Lambert 1998, 48). Once this happens, water can no longer be chemically absorbed and the clay made pliable again. Clay for forming needs to be pliable, yet the wetter, and finer, the clay is, the less space for air to escape as water evaporates in the kiln. Impurities and inclusions can have an impact on the ability of the clay to remain intact during heating and cooling (Rice 1987, 94). A fine balance must be made between processing the clay (refining it, adding temper, etc.), forming it, drying it, and firing it. Clay shrinks during drying and firing due to the loss of water, and this must be taken into consideration, especially if glaze is to be applied before firing. Firing temperatures must be controlled, as clay which is heated or cooled too quickly may crack or explode – and this threshold will be different for different clays or grades of clay.

Evidence for firing techniques on Akhsiket's pottery are the marks on the inside of glazed bowls, which show that three-footed supports resembling little tripods were used to stack bowls on top of each other; and a single kiln rod with green glaze drops discovered in Object 23, indicating that in some cases pots were suspended either on the rods (which would have been mounted in the walls of the kiln) or above them.

The nearest examples of early Islamic pottery kilns are those from Samarkand (Afrisiab) and Chach (Khakha). Most detailed are the descriptions of kiln structures of Afrisiab in Shishkina and Pavchinskaja (1993, 35-44). Kilns used in the potter's quarter for glazed ceramics were circular in shape, with an open firebox situated in a pit in the centre which was accessible by a ramp. The kiln was made of fired brick with an arched ceiling, and pots could be placed on the ground, between the firebox and the walls, and hung on pegs attached to the walls of the kiln (using hooks) or placed on top of them (*ibid* 1993, 35-6). Three-footed tripods (as described above) were also used (called *pernettes*, specifically *sepâyé,* in Shishkina and Pavchinskaja 1993, 39). Once the kiln was charged, the access opening was bricked up leaving a peephole through which a lump of clay attached to the interior of the wall could be viewed, to determine when firing should be ceased (*ibid*, 39).

Unglazed wares were fired in a different type of kiln. The firebox was covered by a raised floor which was full of holes to allow the heat into the kiln chamber. The heat could be regulated both by the charge of the firebox and by plugging or unplugging the holes. From the 12th century onward, both glazed and unglazed pottery at Samarkand were fired in this type of kiln. Larger unglazed objects such as storage jars and irrigation pipes were fired in rectangular kilns with a bigger floor space over the firebox (*ibid*, 41).

The kilns discovered in Chach were located in the pottery district of Khakha, dating from the 6th – 8th century (Burjakov and Filanovich 1999). The construction of the kilns seem to be similar to those at Samarkand, with round chambers, with or without a raised floor (*ibid).* Presumably, at this date, these were for unglazed wares only. A two-chamber kiln from the 9th century was also found here (*ibid*), with slip-decorated wares and red-slipware still inside, but Buryakov admits that the pottery was dated to the 2nd half of the 8th to the beginning of the 9th century. So there is some discrepancy in the dating of these kiln sites. Kiln wasters – pottery that has not fired successfully and was immediately discarded – have been found in Binket, the ancient capital of Chach now encompassed by modern Chach. These can be dated to the 9th and beginning of the 10th century (*ibid).*

Kiln remains have also been found at Merv. The first kilns were discovered in the 1950s by YuTAKE, with two having been excavated more recently during the International Merv Project's 7th season (Herrmann et al 1999, 13-15). These appear to have been used for "plainwares" (unglazed wares) – to date, no definitive glazed ware kiln remains have been found at Merv. Kilns with both round and rectangular firepits have been found from the early Islamic period, and the assumption appears to be that the circular kilns are earlier (7th/8th century), and the rectangular kilns later (9th/10th century) (*ibid*, 15).

There is a strong argument that glazed pottery technology was initiated in Samarkand and then picked up in Chach and Akhsiket (see previous section). It is likely that firing techniques and kiln construction would also have derived from methods used at these other pottery production centres. Other evidence includes the kiln rod found during the Akshiket excavations that is identical in appearance to the rods used at Samarkand,

and the marks left on glazed bowls that show the use of similar tripod *pernettes* to those recorded from Samarkand.

3.3.2. Glaze technology and production in Central Asia

Glaze is a viscous glass that was developed as a compatible material for the decoration of earthenwares, porcelains and stonewares during the ancient and medieval period. The first glazes were developed in Egypt in the 12th-6th millennium BC on faience or pure quartz bodies, and in Mesopotamia in the 3rd millennium BC, applied to clay bodies by the middle of the 2nd millennium BC (Harman 1973, 2; Hedges and Moorey 1975, 25). These early glazes were made of silica (sand or crushed quartz) and ash, taking advantage of the fluxing properties of the alkalis present in plant ashes to bring silica down to a workable melting temperature (Hedges and Moorey 1975, 25).

Typically, this glaze was created by fritting silica and plant ash before applying it to the vessel surface – pre-melting the silica with ash and allowing it to vitrify, then grinding it, mixing with liquid into a slurry, and applying it by dipping, brushing or pouring (Tite et al 1988, 253).

This 'alkali' glaze was exclusively used in the west until sometime during the 1st centuries BC/AD when the Romans appear to have invented lead glaze (Tite et al 1988, 242). Lead oxide acts as a flux, lowering the melting temperature of the silica in the same way the alkalis do, but lead is also a good base glaze component. Lead oxide (PbO) (made from litharge, a by-product of silver smelting, or by burning lead metal) could be applied as a pre-prepared powder, suspended in liquid on its own or with crushed silica. Lead metal itself would have been obtained from ores such as galena (PbS), associated with silver mining (Newel 1995, 79).

Lead glaze was particularly suited to earthenware, having a close thermal expansion coefficient to clay (expanding and contracting at the same rate of the clay body during heating and cooling), minimizing flaking and crazing (Tite et al 1988, 253). Lead glaze also fuses more evenly at lower temperatures than alkali glaze, thereby producing a less viscous, more homogeneous, smoother glass than alkali glaze. Alkali glazes often fuse unevenly in earthenware kilns leaving relict unfused grains, gas bubbles and undiffused silica-rich areas affecting the visual appearance, and facilitating crazing and flaking decreasing the lifetime of use (Al-Saad 2002, 805; Tite et al 1988, 253).

While earthenware was used as the primary vessel-forming material, alkali glazes remained difficult to master for effective, flexible use. They were mainly used for coloured glazes, particularly the turquoise wares as described above, which made the most of the opacity-causing bubbles and unfused grains, with the viscosity allowing good separation of colours for basic designs. Lead glaze was more easily rendered virtually colourless and able to smooth over unevenness in the vessel surface, but was more difficult to create polychrome designs due to its runny consistency, and the raw materials may have been more complicated to obtain, requiring access to lead metals (assuming that for alkali glazes, the plants were freely available nearby). Therefore, glazing of ceramics needed something other than the knowledge of these basic techniques to become mass-producible and of flexible use for changing fashions and the mimicking of more advanced styles. The use of these techniques and the technical styles employed are discussed further in the next section, and with reference to the analytical results in Chapters 5 to 7.

Slip is a fine suspension of clay which has a number of uses - from smoothing over a vessel surface to joining different clay pieces together. A slip “engobe” is a layer of slip that covers large areas of a vessel surface (sometimes the entire surface). Slips coloured with metallic oxides such as iron oxide, manganese oxide and others are used for painted designs, although pigments could also be used “neat” as it were. Slip paints, slip engobe and pigments became a popular decoration method for lead-glazed bi-chrome and polychrome wares throughout the Islamic world, but primarily in Central Asia and Iran. The systematic use of slip engobe and slip paint in conjunction with colourless lead glaze became a major characteristic of the eastern Islamic world during the 8th – 12th century (Mason 2004, 122).

A white slip engobe turns earthenware into pseudo-porcelain or pseudo-faience with a smooth surface for decoration. Slip paints and underglaze pigments bypassed the problem of runny glaze allowing clear, crisp designs including epigraphy, the new artistic motif unique to the Islamic world.

Alkali glazes continued to be useful for a limited range of coloured glaze motifs, but lead glazes proved more useful not only for colourless glazes, but for green, brown, yellow and black coloured 'opaque' glaze, used as a monochrome decoration. In the following sections the major classes of glazed ceramics and ceramic styles found at Akhsiket, which fall almost entirely within those two broad technological groups are described and discussed.

3.4. Typology of Akhsiket glazed ceramics

3.4.1. Lead glazed slipware

Slip-painting was the most widely used decoration technique on glazed ceramics in Central Asia in the early Islamic period as shown by the high prevalence in archaeological assemblages, and in collections attributed to the eastern Islamic world (Fehérvári 2000, 50). The lead glaze developed in the Roman west may have been the forerunner to the Islamic high-lead glazes used throughout the caliphate from the 8th century, while slip painting appears to have been developed by Islamic potters in Iran, Syria and Egypt (Mason 2004, 177). This technique became highly typical in particular of Khurasan and Transoxania in the 9th-11th century (the 'Samanid' and 'Buff ware' mentioned in the previous section). Its apex was in the 10th century, when the decoration style reached the height of sophistication and variability (*ibid*, 17). This technique – both the monochrome (black on white) and polychrome types – were very common at Akhsiket.

By far the most common vessel shape is the sectional bowl with a simple rim (Figure 3.2) (for examples of other drawings see Anarbaev 2002 including other glazed ware forms; Anarbaev and Ilyasova 2000; Ilyasova 2000). For comparative examples of vessel forms from Samarkand and Tashkent see Shishkina (1979, Table IV) and Brusenko (1986, Table 29); from the wider Islamic world see Mason (2004, 18-19). Occasionally other vessel shapes are seen such as conical and cono-segmental bowls, and flat plates.

Rim shapes are usually simple, but may occasionally be straight or out-curved. The most common type of base, known as ‘convex’ (not included in Mason’s catalogue but present at both Samarkand and Tashkent), is used throughout the time period.

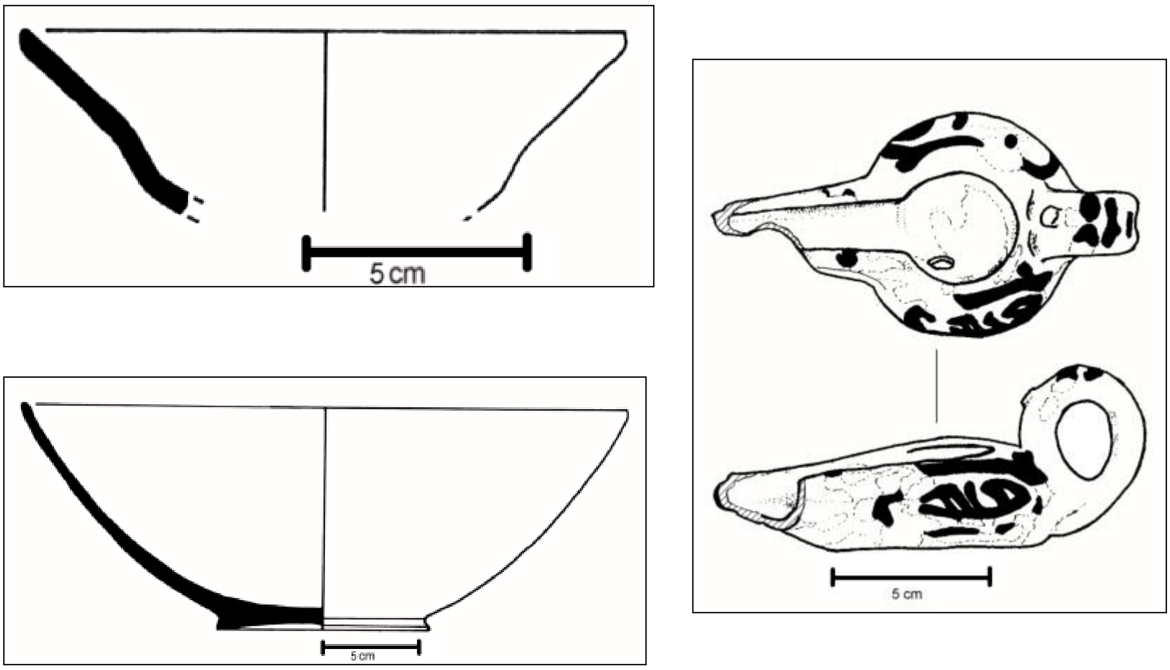


Figure 3.2 Example of conical and sectional bowl shapes, with simple rims and concave base; monochrome slipware lamp (*chirag*). Scale in all images is 5 cm.

Body shapes are not useful for dating purposes at Akhsiket, except for a few base shapes rarely seen. These include the flat base (10th century), and the incised base (12th century). 10th century bases may also tend toward a smaller diameter (Papchristou 2003, pers. comm.).

Another common vessel type for polychrome slipware designs is the oil lamp, or *chirag*. Examples from Objects 9 and 23 were found to be around 9-12 cm long and 3.5 cm high, with the handles rising to 5.5-6 cm high. The polychrome slipware body type has a lower, more streamlined body shape than the monochrome types (see below), with a teardrop-shaped, simple handle (see Shishkina 1979, Table XVII nos. 8 and 10; and Brusenko 1986, Table 31).

A white engobe was used to cover the surface of the vessels. Engobe is primarily associated with lead glazed slipware, and the main purpose is assumed to have been to render the decorated surface of a buff or red earthenware vessel white, in order to mimic the fashionable Chinese porcelains currently being imported. The same effect was gained in Iraq and Syria by the use of tin-opacified white glazes (Fehérvári 2000, 37). The engobe could be applied to just the 'face' of the vessel (the most visible part of the vessel, such as the inner surface of a bowl) or it could cover both sides. At Akhsiket engobe was usually applied to the inside of open shapes and just over the rim.

Quartz-rich engobe also helped bind the glaze to the vessel surface, providing a 'buffer zone' which minimises cracking or flaking from expansion of the body during firing. This appears to be an unintentional benefit, as lead glazes are already fairly well suited to earthenware bodies. The alkaline glazes are much less suited to the bodies, and yet engobe was not applied to these types (in Central Asia – however there is evidence of slip applied elsewhere in conjunction with alkali glazes: al-Saad 2002).

Slip paints in black, brown, red and olive were used for a wide variety of designs on the "Samanid" (so-called as this style became popular during the height of the Samand regime in Central Asia) and polychrome wares in Central Asia and Iran. Slip-paints allow for clear separation and overlaying of colours not possible with coloured lead glazes. Pigments can also be used instead of slip paints: the visual appearance often looks the same. At Akhsiket thin layers of coloured slips would be painted onto the engobe, and these could be (in order of usage from often to rare) black, dark brown, red, olive, green, orange, yellow and pink. It was found during analysis that black decorations may occasionally be painted on as pigments which partially or completely leached into the glaze (see Chapter 5 for analysis of coloured glaze on slipwares). The designs are variable, but fall under broad categories explained below, including **epigraphical** (and pseudo-epigraphical), **floral and vegetal**, and **miscellaneous** motifs which include **geometrical** and **figural**.

After the slip paints have been applied, the surface of the vessel is coated with a transparent glaze which uses lead oxide as a flux and base. This provides a hard, brilliant covering which protects the decoration from weathering and makes the vessel impermeable on firing. The glaze is applied to the interior (or exterior in the case of *chirags*) and just over the edge of the rim. Rarely, the glaze is also applied to the outside of the vessel.

The **epigraphical motif** is one of the most studied and interpreted of all the Islamic decorative elements (Figure 3.3). All epigraphical designs on Central Asian pottery of the early Islamic period use a particular style of Arabic lettering called *kufic*. This was the earliest form of Arabic script, and was used throughout the caliphate, although other, more complicated styles were developed for handwriting from the 10th century onward. See Watson (2004, Cat. D.12 and D.13) for examples of this style on the Middle Eastern and North African wares.

The first epigraphical ceramic style was produced at Samarkand and Nishapur, and has historically been called Samanid ware, as it was first developed during the height of the Samanid dynasty (mid 9th century). This was one of the first decorative styles which was truly 'Islamic', whereby Arabic words and phrases were applied in a black/dark brown or (less commonly) red slip painted on a white engobe. When this decorative style first appeared, it was an innovation not only of style but of technique. The slip painting allowed crisp, exact designs to be achieved, and the Samarkand 'school' appears to have been the first to master the technique for use with glazes. The style was produced throughout Central Asia and eastern Iran. 'Samanid' epigraphic designs similar to those from Akhsiket can be seen in Sishkina (1979, Table III no.2, XLII no.12, LIV nos.1 and 4); Brusenko (1986, Tables 5 no.4 and 13 nos. 4, 5 and 10); also Siméon (2008, Illustrations T and U and *Planche* 80-86) for several variations from Hulbuk, and Watson (2004, pp.206-218) for examples attributed to 'the eastern Iranian world'.

Kufic calligraphy can be divided into sub-styles including early kufic, eastern (or Iranian) kufic, floriate kufic, and knotted kufic. Early kufic was developed in the 7th century, while both eastern and floriate became widely used in the 10th century. Knotted kufic (and variations such as plaited) came into use in the 11th century, and this style could be highly ornamental, to the point of near illegibility (Shishkina 1979, 56). The sayings that are commonly seen on pottery are generally aphorisms – exhortations for good conduct, generosity towards strangers, and general wishes for well-being.

Many of Akhsiket's ceramics appear to utilize early kufic judging from the prevalence of this type found in the excavations. This is a simple, horizontally-aligned form that is usually inscribed either concentric with the rim of the vessel, or horizontally across the inside of the bowl. This style is characteristic of the 10th and 11th century (Brusenko 1986, several examples provided in the tables). Eastern kufic is angular, with long vertical elements, tags, and dots, and is also seen on Akhsiket's ceramics, as is knotted kufic. Of course, there were many regional variations on these.

As in many parts of the caliphate, the kufic used on Akhsiket's pottery became highly symbolic. This 'pseudo-kufic', which overlapped with the legible kufic, came to be used in two main ways, 1. as a series of dots or lines that marginally resemble early kufic styles, usually placed concentric to the rim edge next to a notched or crescent rim and often with a line below it, and 2. as repeating elements in a larger design such as a segmented band around a central rosette – usually in the form here labelled 'Q' pseudo-kufic, as it resembles an old fashioned latin Q (Figure 3.4). The same motif can be seen in Shishkina (1979, Table LXX nos. 26-28), but is not evident in Brusenko (1986).

Figure 3.3 Examples of kufic styles on Akhsiket pottery: early kufic (top left), eastern kufic (top right), knotted kufic (bottom).

Figure 3.4 Epigraphical motifs: ‘Q’ kufic design (top), miscellaneous pseudo-kufic (bottom).

The orientation of the lettering on open form vessels changed around the end of the 10th century: before this, the letters were orientated so that they were read from the rim; from the 11th century, they were read from the centre, outward (Brusenko 1976, 102-3). Not many of Akhsiket’s kufic sherds are possible to translate, due to their fragmentary nature (which also makes it difficult to estimate the percentage of illegible inscriptions or pseudo-kufic forms). A common saying *al-yumn* (‘good health’) is seen on samples from Binket dating from the second half of the 10th century to the beginning of the 11th century (Brusenko 1986, 57), and is likely to have been used on the Akhsiket ceramics as well.

This style category shows directly the link between the earliest glazed ceramics in Central Asia and the adopted Islamic culture. In a non-Arabic speaking region, this is particularly of symbolic, rather than literary or textual communication. The early forms with a stark black kufic style on a plain white background make the script the focus of the design – indeed, the *only* design – visible on the vessel, a bold statement at a time of still unsettled Islamic control. This is particularly true in the Ferghana Valley, which was the last to be subjugated.

Floral and vegetal motifs are some of the most common designs seen at Akhsiket, often combined with a variety of other motifs including pseudo-kufic. Two common types are the '**bouquet**' and the '**central rosette**'. In general, the earlier designs were simpler, with a limited palette. Over time, they both became more complicated and colourful, utilising greater expertise in polychrome techniques.

The **rosette** is the most common of the floral/vegetal motifs at Akhsiket (Figure 3.5 and Figure 3.6). It is often found in conjunction with other elements, and appears in several varieties. At Akhsiket, rosettes often have a 'vorticed' or 'pinwheel' effect, and occur in the middle of the bowl.

Figure 3.5. Drawings of rosette motifs from Akhsiket (not to scale).

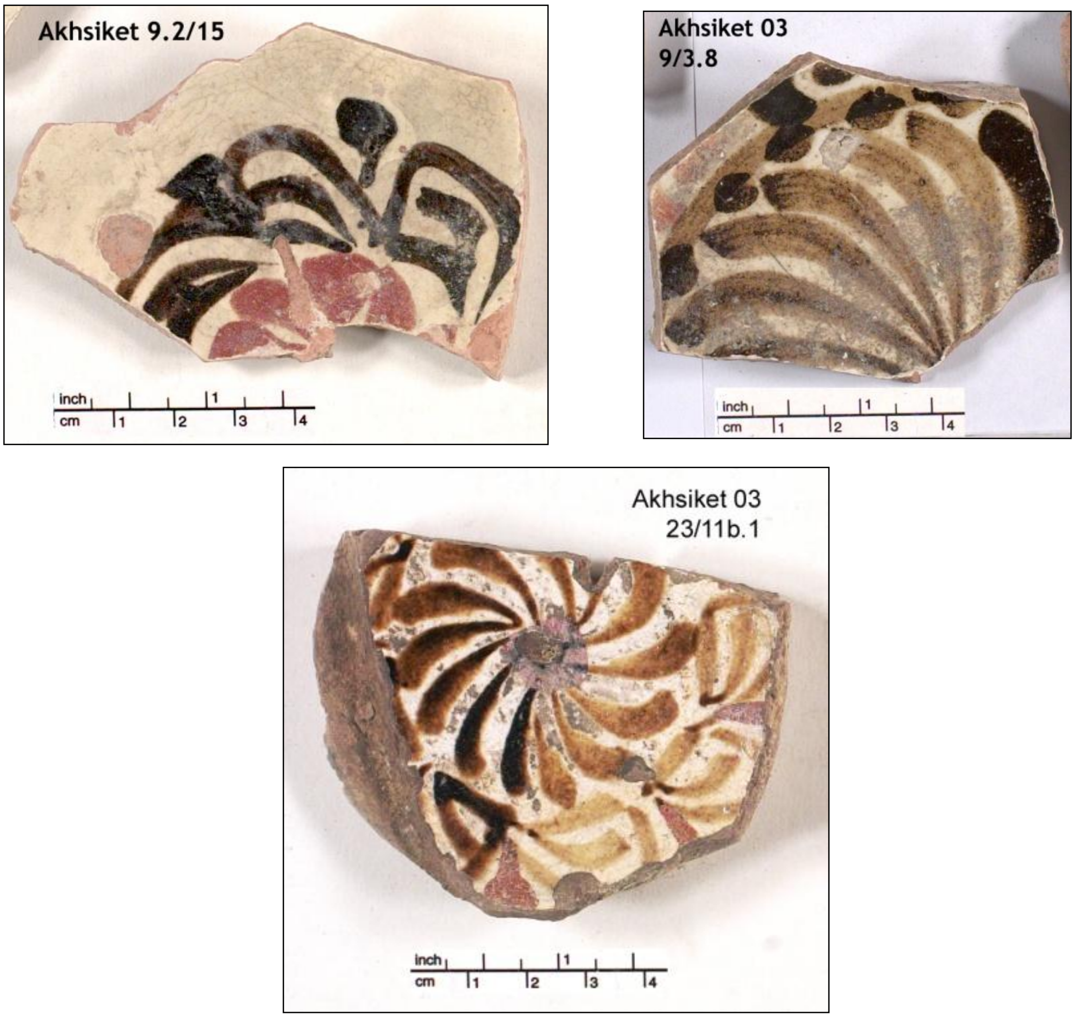


Figure 3.6 Images of rosette motifs.

There are two main divisions: 1. a rosette in a pinwheel shape with a crescent or notched rim, and 2. a pinwheel rosette with a second pinwheel border surrounded by floral figures and epigraphical design (Papachristou 2003, pers. comm.; Ilyasova 2005, pers. comm.). Until the end of the 10th century, a continuous single or double border to the pinwheel was used, in the first half of 11th century this was replaced by borders of simple motifs and pinwheel shapes. In the second half of the 11th century, the petals or leaves of the rosette became more complicated, more colourful, and bent more sharply to the left. This coincides with, or slightly post-dates, similar changes observed in Chach ceramics, and post-date similar Samarkand rosette motifs which are only seen up to the first half of the 11th century (Anarbaev and Ilyasova 2000, 213-15). Rosettes designs simiar to type 1 have also been found in 11th/12th century contexts at Merv (Herrmann et al 2000, 44-45). For further examples see Shishkina (1979, Tables I no. 15 and LXI no.1 for type 2 rosettes; LX no. 5, LXIV no. 4, and LXVII no.1 for type 1); and

Brusenko (1986, Table 47).

Another common floral motif, indicative of the 11th century, is the '**bouquet**' which is seen as a double, triple, or quadruple spray of flower or leaf 'lobes' radiating from a central dot or small flower at the centre of the bowl. I would suggest that there are two main styles, the monochrome bouquet and the polychrome bouquet (Figure 3.7). The monochrome bouquet is black on white, and has a particular decorative style, with lobes looping back towards the centre of the bowl, and lines incised through the black slip. Polychrome bouquets are painted with black or dark brown stems, and red, brown and olive elements representing leaves or flowers. For an example of the polychrome style at Samarkand see Shishkina (1979, Table LXII no.3); and from Tashkent see Brusenko (1986, Table 47). An Iranian version can be seen in Watson (2004, Cat. Gb. 4).

Figure 3.7 Bouquet designs: monochrome (left), polychrome (right).

The bouquet motifs have been classified by the number of sprays and the number of lobes in a spray. They are further subdivided according to the nature of the flower or leaf lobes: 1. simple buds without stems (not radiating from the centre), 2. bouquets with stems radiating from the centre, including extremely stylized forms of radiating stems without lobes, and 3. 'exaggerated' bouquets, with larger, more complex lobes (Brusenko 1976, 94). It is apparent that, as with rosettes, the designs became more complicated over time. The examples found in Objects 9 and 23 in the 2003 fieldwork season can be dated to the early 11th century, due to their somewhat simple style. This motif may be derived from pattern elements seen in Shishkina (1979, Table LXVIII nos.

7-12).

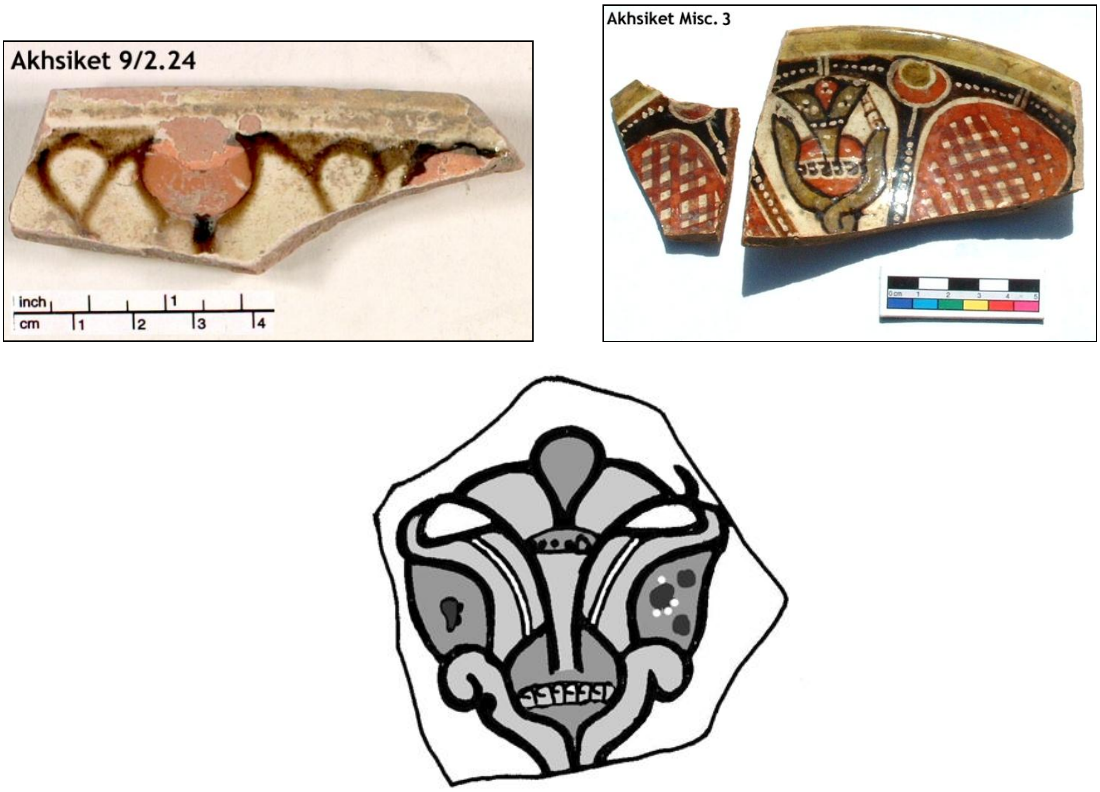


Figure 3.8 Pomegranate designs: buds (top left), flowers (top right and bottom).

Another floral motif is the **pomegranate** (Figure 3.8). At Akhsiket, this is found in the form of a pomegranate flower or as a bud. Pomegranate flowers are seen on glazed ceramics of Binket and Samarkand from the 10th century (Shishkina 1979, 59). The pomegranate flower motif at Akhsiket, however, may be characteristic of the 11th century, showing a time lag of some decades at least (Papachristou 2003, pers. comm.). Examples of what appears to be a similar motif can be seen on Sogdian pottery in Shishkina (1979, Table I nos. 3, 17, 20, 22, and 26 among others), and from Tashkent in Brusenko (1986, Table 11 nos. 4, 6, 8; 15 no.1; 16 no.4; 47 (**Error! Reference source not found.**)).

Variations of the **palmette** and other leafy designs are used, and these are seen on both lead glazed slipware and *ishkor* wares (Figure 3.9). The palmette is a simple single palm frond, depicted as a young, curled frond, or as a mature, open version. On slipware they are usually olive green or green. The form of the palmette can vary. This motif is a late arrival, seen in Binket and Samarkand only from the beginning of the 11th century (Ilyasova 1986). At Akhsiket, they are typically found in 12th century contexts (Ilyasova

1986).

Figure 3.9 Palmette designs.

It can be seen that these floral/vegetal motifs form a common tradition in this part of Central Asia, with similar designs applied across the region. Yet the styles are often seen earlier at Samarkand, and, in some cases, may have disappeared there while still in use further east.

Other motifs are seen, and these mainly fall under the 'miscellaneous' category, as they are one-off designs, or so variable that it is difficult to ascribe them to a particular type group (for a selection see Figure 3.10). This includes geometric patterns, usually simple linear bands; stylized versions of knots, ropes, and peacock eyes; and freeform designs. These can be either background elements, or, particularly in the case of knots, a central theme.

Other background patterns include crosshatching, dot-tracks, dot-field, v-field, s-tracks, and notched or crescent rims. See Mason (2004, 53, 82, 149) for similar motifs on various wares of Iraq (‘bulls-eye’, ‘v-field’, ‘running-crescent’, ‘double-L’), Egypt (Motifs FL. 2, FL. 5, Fl. 7, FL. 10, FL. 16, FL. 17) and Iran (Motifs KL. 1, KL. 40). Their similarities lie primarily in the simpler patterns, indicating a certain universality in the use of rim edging, dots, banding and eye-shapes. There are many examples to be seen in Shishkina (1979) and Brusenko (1986).

Figural designs are very rarely seen at Akhsiket (Figure 3.11). These are most often birds, more or less stylized in a range of colours, including red, olive and pink. Without enough examples of complete bowls, it is difficult to say whether these are usually a single motif in the centre, or whether they are associated with other elements such as notched rims or bands of epigraphy. Animal figures are rarer – during the 2003 season, three bird motifs were found, and only a single animal motif. Only part of the animal can be seen, so it is difficult to tell what it is. Unfortunately, the rarity of these types meant I was not able to analyse them. The particular brown of the animal was certainly an unusual colour for slipwares, and this piece may have been imported.

Figure 3.10 Miscellaneous patterns: a. ropes and knot, b. knot with ?eyes, c. medallion, d.vertical lines, e. notched rim with incised band, f. notched/crescent rim and segmented track with ‘clubs’, g. ?peacock eyes.

Figure 3.11 Figural designs: a. human, b. animal, c. bird

This also applies to the single human figure found in 2003 – only the second of its type ever found at Akhsiket (see Figure 3.11c). It is Iranian in style, a partial face of a musician with what appears to be part of a floriate-style letter. The execution was of a high quality, and very different in style to other designs at Akhsiket. Again, this sherd was too precious to be sampled. Along with the animal motif, this shows that figural representation at Akhsiket was very rare, and probably not locally made. It is unknown where this piece could have been imported from. Animals, birds and human depictions were not uncommon in 10th century lustre-wares of Iraq (Watson 2004, Cat. E.11-15) and some slip-painted wares in eastern Iran and elsewhere (*ibid*, 232-235; Cat. Gf.1). Birds and animal motifs can also be seen in Shishkina (1979, Table II nos.70-73 and LXII no.1) and Brusenko (1986, Tables 45 and 46); human figures in Sishkina (1979, Table LXXV) and Brusenko (1986, Table 45 no.10).

3.4.2. Lead glazed monochrome wares

Lead monochrome glazes found in the excavations were usually green or black, although a few examples of yellow and brown were also seen. The glazes are coloured, and may or may not be applied over white engobe. Monochrome green is a popular colour for glazed *chirags* in the 11th century, but is also used for tablewares, sometimes with different shades on the inside and outside of the vessel (Figure 3.12). Monochrome green *incised* wares become very common in the late 11th/12th century in the wider Islamic world (see below) (Kennet 2004, 35).

Black and yellow opaque glazes are not very common – in the sherds found in the 2003 season only a couple of each were found. Of the black glazes, one sherd had a white and red 'bulls-eye', and another had a white stroke that looked like part of a floriate kufic letter (Figure 3.13). It is the opinion of the local archaeologists that these were imported, probably from Samarkand. They were a high quality glaze – well preserved, glossy and smooth, and fully opaque. The only monochrome brown sherds were fragments of *chirags*, of a non-typical brightness and texture (Figure 3.14). Like the animal and human figural wares found, these sherds stand out very much visually from the rest of Akhsiket's assemblage.

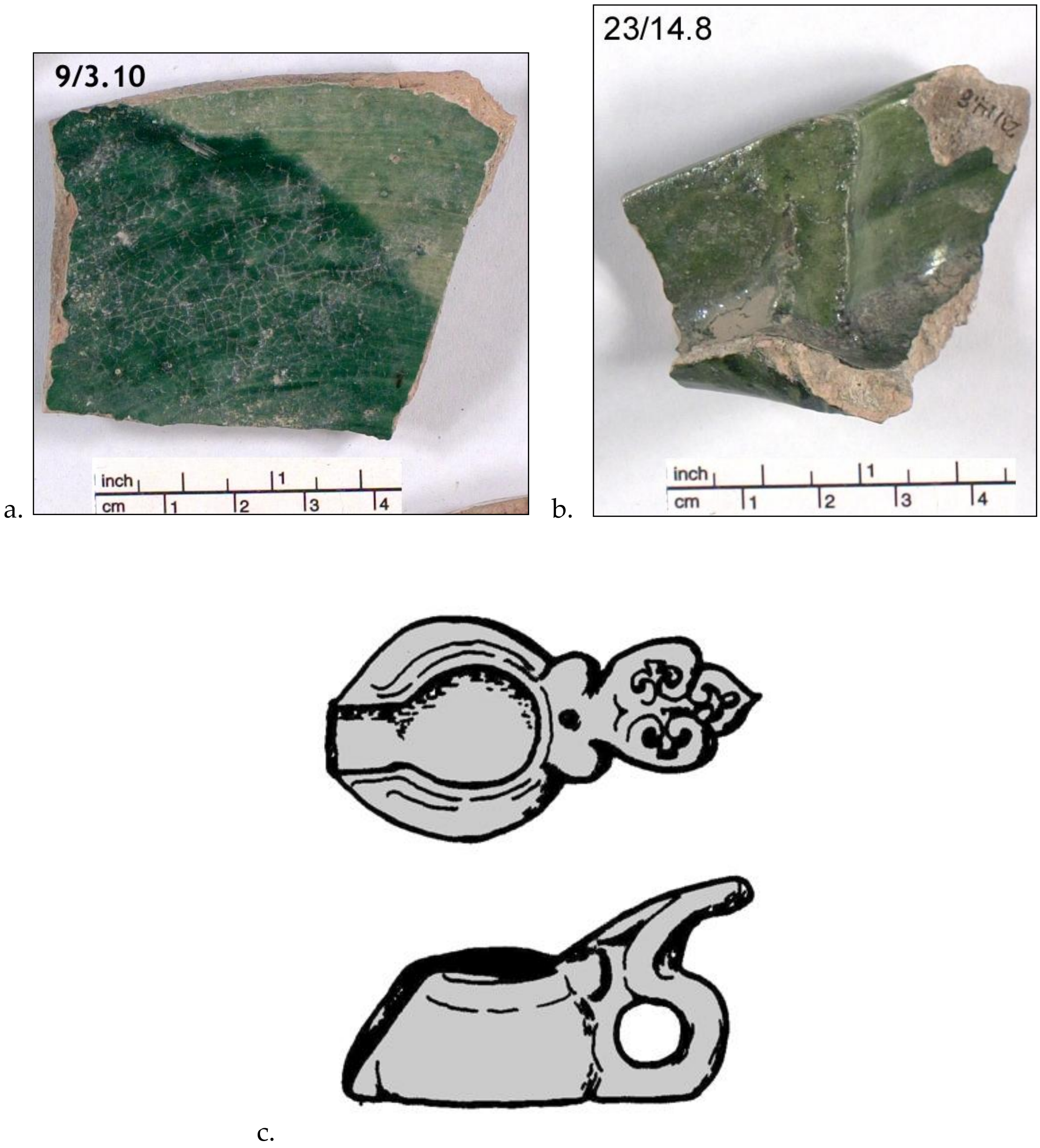


Figure 3.12 Monochrome Green: a. body sherd of bowl, b. nose of *chirag*, c. drawing of monochrome green *chirag* fragment (missing the 'nose').

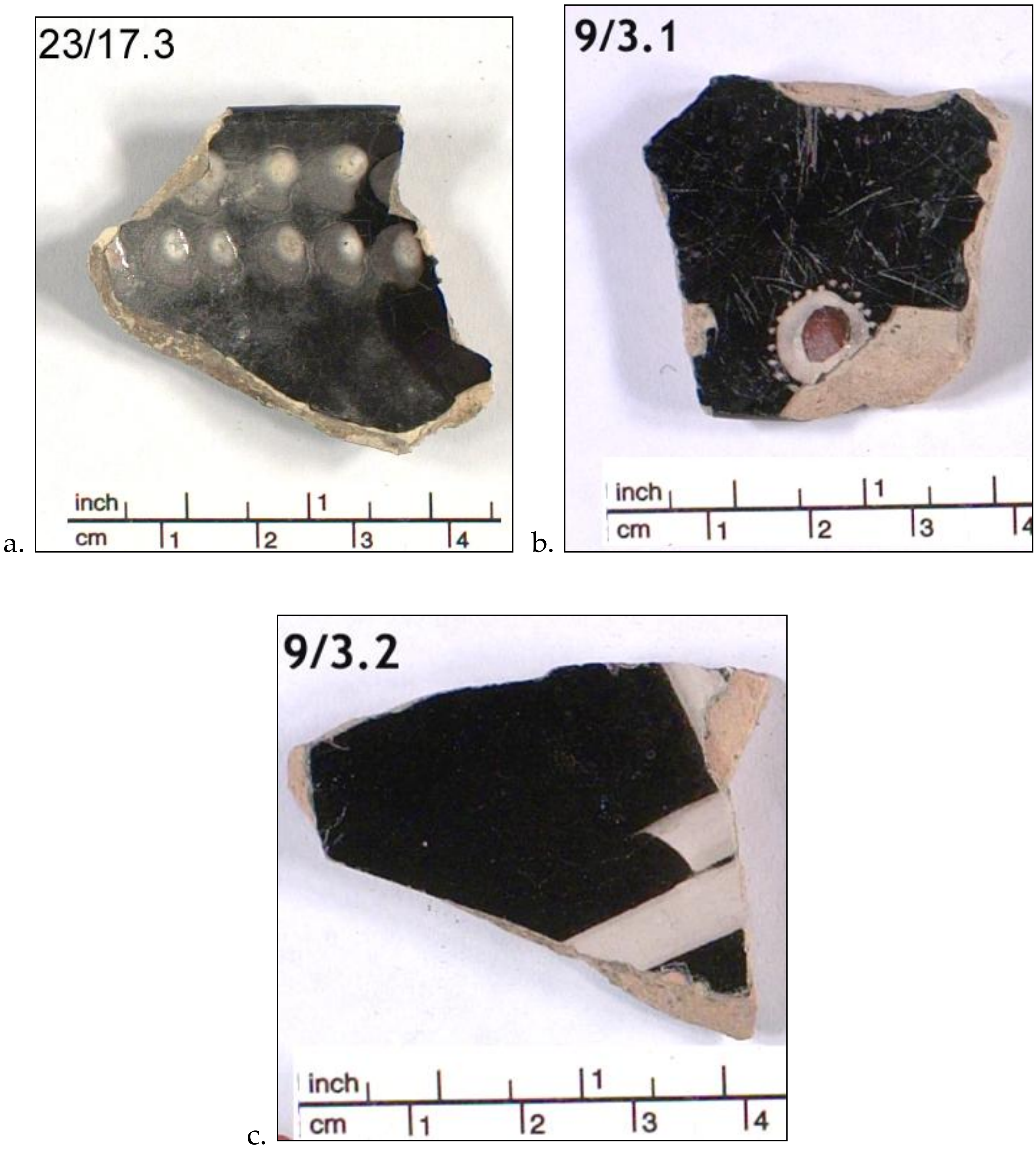


Figure 3.13 Black-glazed wares: a. dot-field, b. bulls-eye medallion, c. kufic or pseudo-kufic.

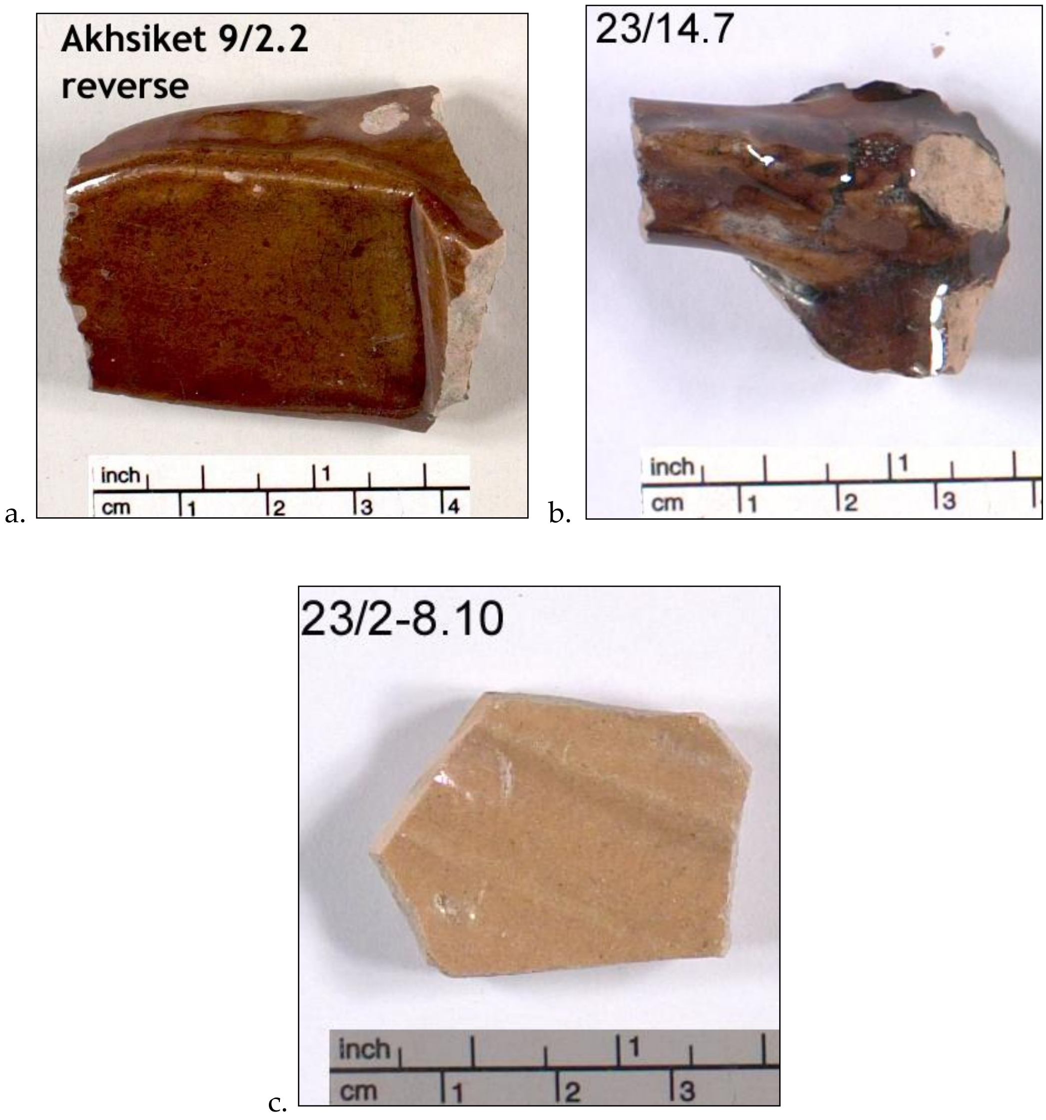


Figure 3.14 Brown *chirags* and yellow glazed ware.

3.4.3. Lead glazed incised wares

Incision was used to some extent on coloured slips as early as the 10th century at Akhsiket, usually on the monochrome bouquet designs, but also occasionally as small decorative additions to various abstract patterns. This technique really came into use in the 11th century, when many glazed wares had incised (*sgraffito*) patterns all over the Islamic world (Kennet 2004, 32-34), although it appears that these are most particularly associated with the 12th century at Akhsiket (Papachristou pers. comm.. 2003).

The two types were the monochrome green bowls, with careful, symmetrical *sgraffito* covering the glazed surface, and the white or yellow *sgraffito* wares, which had a variety of slip-painted brushwork designs in geometric shapes such as triangles, spots and stylistic floral patterns (Figure 3.15). Similar technique with different effects can be seen in Watson (2004, 252-271).

Figure 3.15 Green sgraffito and 12th century incised polychrome wares.

3.4.4. Alkali glazed wares

Akhsiket's alkali glazed wares fall under two categories: what is locally called '***ishkor***'[5] (Rakhimov 2000, 134), the traditional ceramic glazes with blue, green and lilac colours, and the '**skeuomorphic**' wares, which are generally limited to a simple vase shape with a dark purple/black monochrome glaze (Figure 3.16 and Figure 3.17). These ceramic types are highly understudied in the region, and there are therefore extremely few comparative examples to refer to, or to compare against. However, they are found across Central Asia as far as Merv (Herrmann et al 2005, 45, 46; Wang 2009), as discussed further in Chapter 7.1.4. The observations made in this section are based almost entirely on discussions with archaeologists in the field, and my own analysis of samples removed from the excavation sites carried out in 2003 and 2005.

Alkali glazes are generally produced by fritting an silica source (such as quartz pebbles or sand) with ash (either plant or wood) or a mineral alkali source such as natron (Jackson *et al* 2005; Mason 2004, 174; Brill 1970). As discussed in section 3.3.2, silica has a high melting temperature – too high for the clay bodies used – so the alkalis have to be added in order to reduce the firing temperature to an acceptable level. These alkali glazes (*ishkor* and skeuomorphic glaze) were usually coloured with oxides of manganese and copper to produce the rather limited range of colours found at the site. At other locations, lead oxide is also present, producing a bluish-green (see discussion of Chach *ishkor* in Chapter 6).

Ishkor glazes appear around the same time as the lead glazed wares at Akhsiket, The earliest alkaline glazes used in the region may date from as early as the 9th century – although few examples are known from such an early date and these have not been documented. Most *ishkor* at Akhsiket dates from the 10th century, although examples are also found in 11th century contexts. There is a greater variability in vessel forms than the other types of glazes. Smaller, thin-walled 'cups' are found, as well as the larger, typical, sectional and cono-segmental bowls. Closed forms such as jugs and jars

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[5] The exact etymology of *ishkor* is unclear although the term is widely used in Central Asia. It may derive from the name of a plant used as an ash source for the glaze recipe – for example, *shakhar* is the name of a plant mentioned by Abu 'l-Qasim in his c. 1300 treatise on ceramic and glaze technology (Allan 1973).

are also seen. Rims and bases are usually concave, except for the closed vessels which

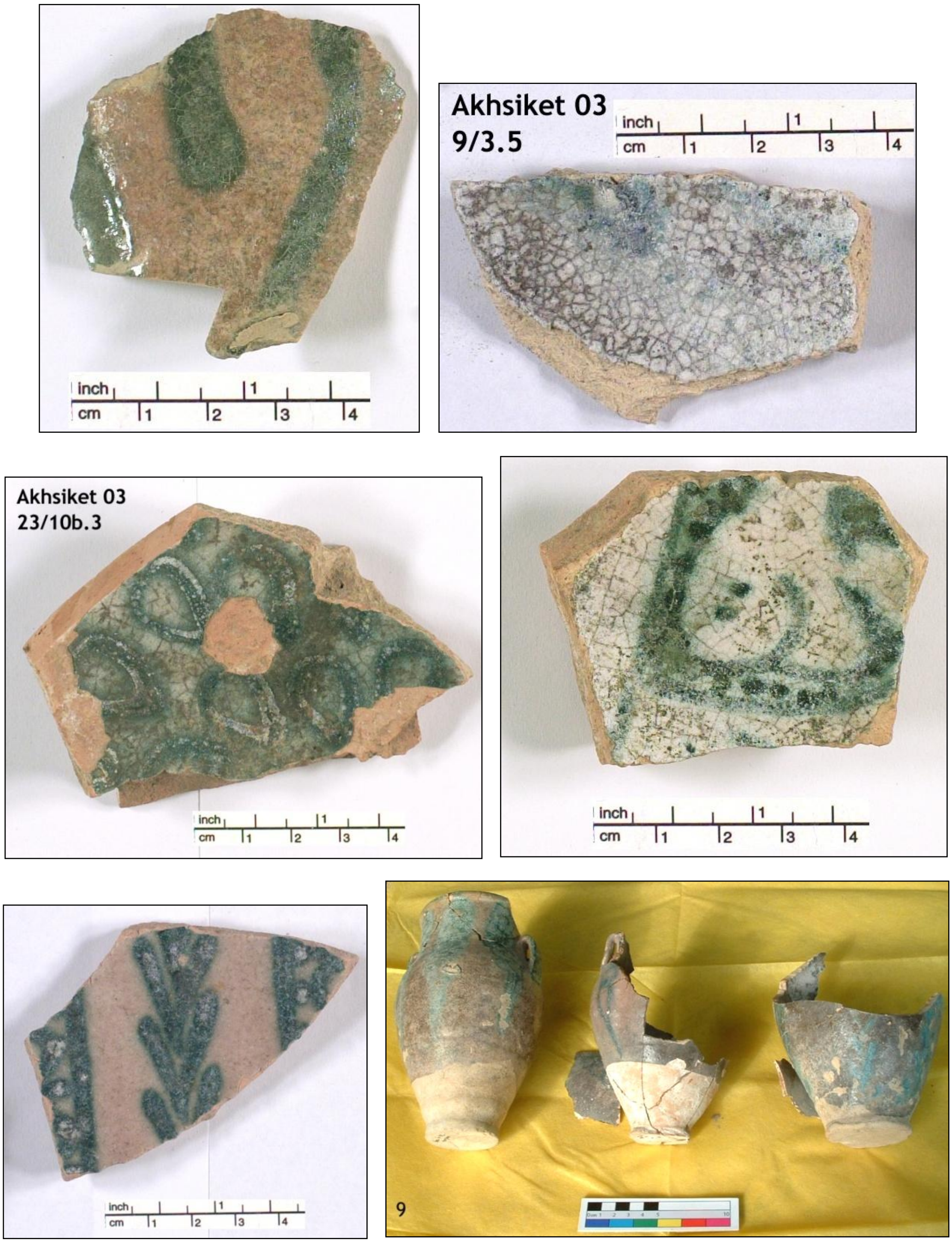

Figure 3.16 *Ishkor* wares in various states of preservation.

have flat bases like their unglazed counterparts.

Ishkor designs appear to be far less influenced by Islamic artistic traditions than the slipware of the same time period – perhaps because they were of a lower economic value, or because of their use (utilitarian rather than decorative). Raw materials for the glaze were easily obtainable without the need for special suppliers, and did not really suit the earthenware bodies they were used on – they were therefore cheaper to produce than the other types of glazed ware (albeit some examples, well preserved, show a brilliance, smoothness and decorative execution that would rival the best of the slipwares). The range of body types and thicknesses indicate that this was a less specialised ware. Decoration was applied using a small range of colours, easily obtained with varying quantities of one or two metallic oxides. Engobe and coloured slips were not used in conjunction with alkali glaze – the opacity of the glaze presumably negating their use as a visual decoration.

Typically decorations are abstract, although the palmette is seen (and in fact appears to pre-date the use of the palmette on the slipwares). Glaze was often applied to both sides of the vessel equally, and designs were painted on a relatively large scale. Whereas slipware designs were often confined to specific areas of the vessel with white space between, *ishkor* designs were more likely to cover the entire surface. Alkali glazes range from lightly to fully opaque. In the case of *ishkor* this depends on the colour and tone of the glaze (the darker the colour, the more opaque it appears), and on the quantity of bubbles and undissolved quartz grains remaining after firing.

A stylistic distinction is made between the earlier *ishkor* and later *ishkor* wares, with the latter referred to as 'pseudo-*ishkor*' (Papchristou 2003, pers. comm.; Ilyasova 2005, pers. comm.). Early *ishkor* is, apparently, simpler in design or monochrome, and has a green or greenish-blue hue. The early *ishkor* is very rare, and none of the *ishkor* samples from the excavations or comparative sites fell into this category. One possible early *ishkor* sherd was collected, but turned out on investigation to be a weathered green lead glaze.

Skeuomorphic wares get their name from the assumption that their appearance was designed to imitate vessels made from metals – whether by coloured glaze or slips. Akhsiket has a specific body type which uses a dark glaze such as this. The vessels are open form vases with simple rims and a flat base, no handles (Figure 3.17). There is some variation to be seen in size and shape. Bases can range from 4 cm to upwards of 6 cm. Body shapes are cono-segmental to a greater or lesser degree, and somewhat uneven. They are relatively roughly made, thick walled, with obvious hand or tool marks from turning or possibly coil building, on the interior face. Glaze covers the interior and the exterior of the vessels, stopping short of the base by a distance that may range from less than 1 cm to several cm. The glaze is always opaque monochrome – dark purple to black (Figure 3.18).

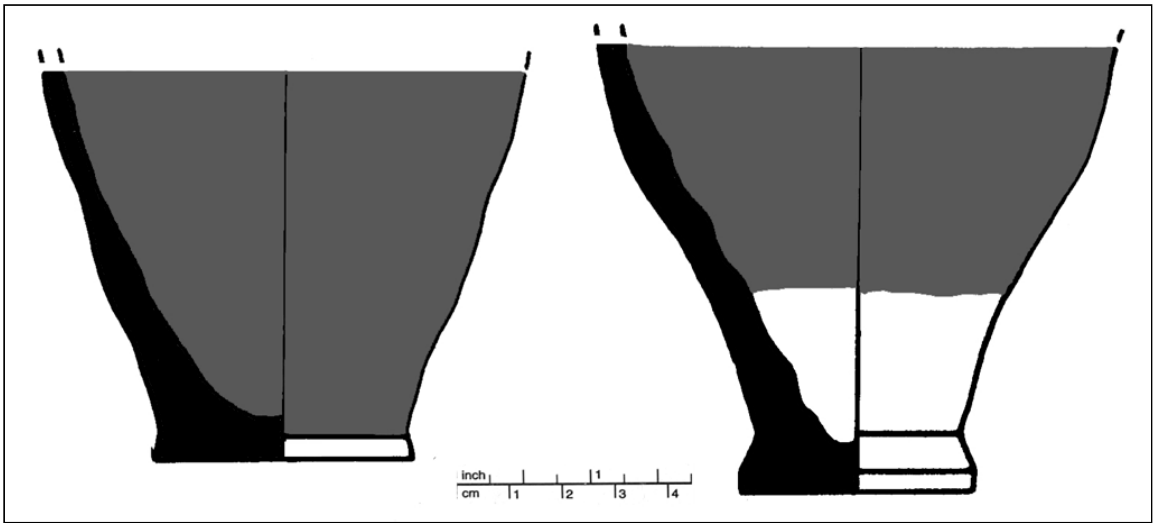

Figure 3.17 Drawings of skeuomorphic vessels.

Figure 3.18 Skeuomorphic sherd.

3.4.5. Summary of glazed ware typology

Glazed ceramics are found at Akhsiket dating from at least the early 10th century to the late 12th century. The ceramics fall into two main types – lead glazed wares which were in use throughout this time period, and alkali glazed wares which waned in use in the early 11th century, disappearing by the 12th century.

Lead glazed wares can be categorised by style, of which there are a range of different motifs that are used in a variety of ways. Some lead glazed styles show distinct changes over time. Alkali glazed wares have not (yet) been shown to change in design or form over time, with a simpler, less variable, and presumably more conservative artistic tradition.

As described at the beginning of this chapter, the dating of styles is largely based on sherds from Tashkent and Samarkand which have been dated using coins. Table 3.1 gives a summary of glazed pottery characteristics and the chronological developments known or assumed for each type found at Akhsiket, and Figure 3.19 shows the relationships between the main styles.

Style	Dates present at Akhsiket	Known chronological indicators
"Samanid" ware	Very common throughout 10th century, to early 11th century.	• Black on white early kufic is the earliest type. • Stylised Kufic script • Orientation of letters changed in the 11th century from inward-facing to outward facing.
Rosette	Common in second half of the 10th century and throughout the 11th century	• Early styles are simpler. • By 11th century, rosettes were "vorticed", and this became more prominent in 2nd half of the 11th century. • Continuous border around the rosette until end of the 10th century. • In 11th century bordered by simple motifs and pinwheels • 2nd half 11th century, rosettes were more colourful
Polychrome bouquet	Fairly common throughout 11th century	• Early 11th century simple, fewer lobes • Later 11th century, more elaborate, more lobes, and sometimes lacking stems.
Monochrome bouquet	Small numbers found throughout 11th century	As above, but black on white
Pomegranate	Occasional examples found in 11th century only (?)	No known changes. Appears in Chach and Samarkand in 10th century, but appears at Akhsiket in 11th.
Palmette	Occasional examples found in 12th century only (?)	No known changes. Appears in Chach and Samarkand from beginning of 11th century, but appears at Akhsiket in 12th century.
Miscellaneous motifs	Common throughout 10th – 11th century	A number of motifs appearing throughout the time period (bulls-eye, notched rims, stylised ropes and knots, eyes, etc.).
Figural (animals, birds, humans)	Extremely rare, 10th century	No known changes during the time period.
Other monochrome	Small numbers found in 11th century	Black, yellow, brown found with no known changes during the time period.
Monochrome green	Common throughout 10th – 12th century	• Most common in 11th-12th century. • Incised designs indicative of late 11th/12th century.
Polychrome incised	Common during 12th century	No known changes during the time period.
Ishkor	Small numbers found during 9th – 11th century	• 9th century examples very rare. • Most common in 10th century
Skeuomorphic	Small numbers found during 10th – 11th century	No known changes during the time period.

Table 3.2. Summary of glazed ware designs and chronology.

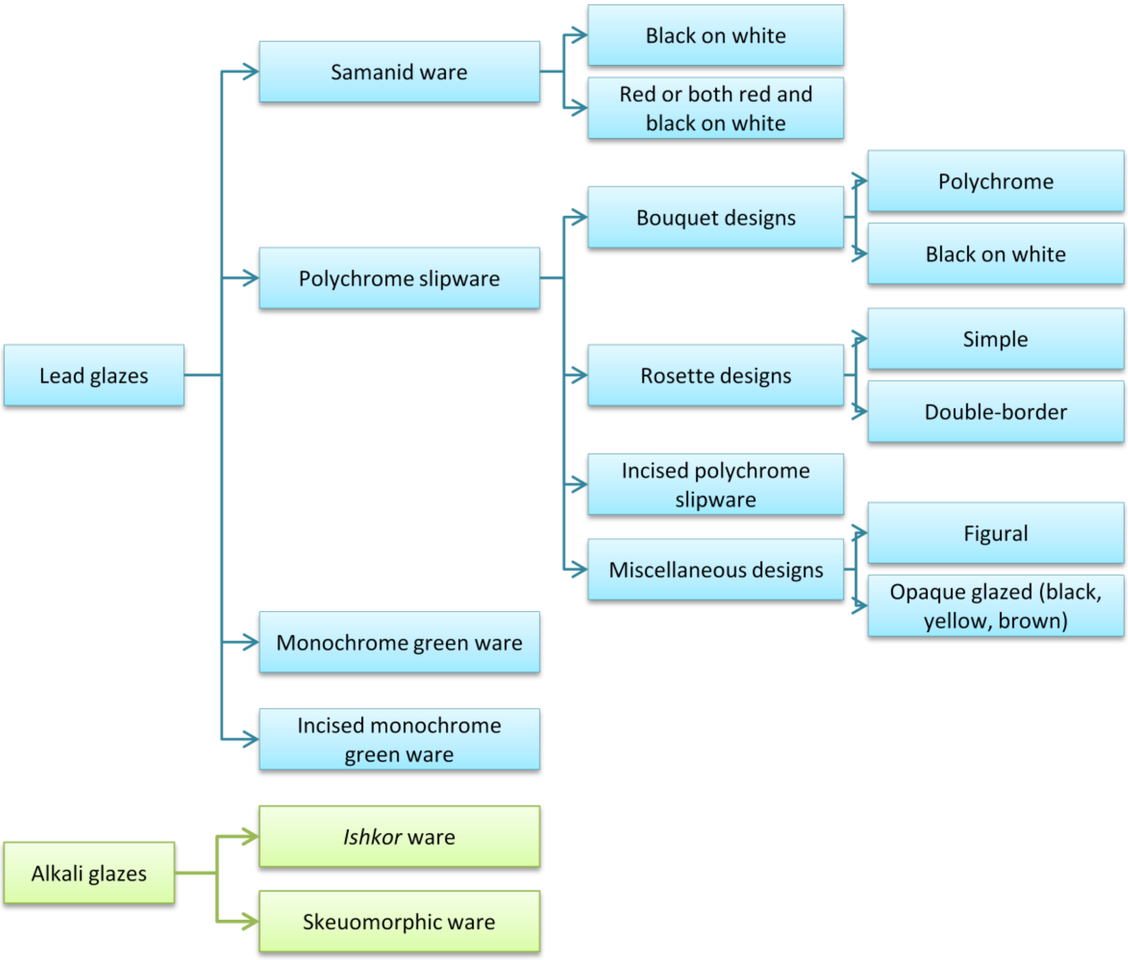

Figure 3.19. Flowchart showing the main lead glaze types present at Akhsiket (minor motifs are not shown, although they are described in the text).

3.5. Typology of Akhsiket unglazed ceramics

Although the focus of this thesis is the glazed wares found at Akhsiket, the unglazed wares form the majority of the ceramics found at the site, and are an important dimension of the ceramic production/consumption environment at Akhsiket. Samples from this group were analysed both to allow comparison with the glazed wares and to test the efficacy of trace element analysis on fabrics from the site (see Chapter 5). Unglazed wares – particularly the larger utilitarian vessels – were probably created fairly locally (if not at the site itself), and therefore likely link to local production practices. For the first time, this study presents the chemical and microstructural characteristics of a range of unglazed wares from the region.

The unglazed ceramics of Akhsiket can be categorised into three classes: the domestic ceramics, architectural ceramics and technical ceramics. The first class includes fineware vessels such as jars, urns, bowls, plates, sphero-conical vessels, and 'Khazak tables'; somewhat coarser, but still relatively fine, are storage jars in large sizes; and cooking pots which are coarse, tempered with limestone, and blackened by fire. The architectural ceramics include brick and tile. Technical ceramics (which are not examined in this paper) consist of steel or copper smelting crucibles, although some examples of burnt clay furnace wall and/or floor may be included in this category.

These types of ceramics are numerous and found across the site, as to be expected in an urban context. As with glazed ceramics, there is no direct evidence for the production of these wares at Akhsiket – although a brick kiln is visible in section in the ravine cutting through the eastern rabad. These vessels are bulky, used in large quantities, and have a short lifespan (especially in the case of crucibles and cooking vessels) due to the nature of their use. Generally, these vessels are not technologically difficult to manufacture, being made with easily available raw materials, and with less demanding shaping and firing techniques in comparison with glazed wares – thus specialist potteries are not necessarily required. It is likely that this type of pottery was made locally, using local materials.

There is little previous analysis on the unglazed vessels of Akhsiket. There is currently no established typological seriation for the early Islamic time period. It could be that the groundwork simply has not yet been done, but it is more likely that little chronological or developmental information would be forthcoming for this relatively short time period. Compared to the variation seen in the glazed wares, unglazed vessel forms are far more conservative. This is not to say that there may not be interesting and and revealing changes in body forms or decorations during the time period – but much further work is required before this can be established. Comparative work on early Islamic unglazed finewares is being carried out on wares from Merv throughout the time period (Herrmann et al 1999, 16-19) although complete results from this assemblage are not yet available.

Assuming that the unglazed ceramics, particularly the domestic ceramics, were produced in small potteries, what variations can be seen may not necessarily relate to any chronological development, but to the individual workshop or even potter. In that case, without kiln or waster evidence, it is impossible, based on typological analysis alone, to determine the number of workshops, or the output of any individual workshops. The following sections describe and illustrate the main unglazed ware types found during the excavations in 2003 and 2005.

3.5.1. Domestic Finewares

The term 'fineware' is here used to differentiate jars, urns, cups and other small forms from the coarser cooking wares and the large storage jars. At Akhsiket, these are made of a fine clay and are usually buff in colour. They are all wheel-thrown, and fired to a hard, evenly-coloured body. There is no temper in the clay (see Chapter 5.2 for analytical results).

The most common vessel type in this class is the single-handled jug, with a pear-shaped body, flat base, short spout and long strap handle (Figure 3.21). There is some variation in size and form while bases are always flat, ranging from around 4 cm to 11 cm. Open forms are occasionally seen. Many vessels are decorated with incised, stamped or pressed pattern, usually on the shoulders (Figure 3.20 and Figure 3.22).

There is a limited variety of motifs, the most common being incised bands and wavy lines, either continuous or in a broken wave pattern and impressed or stamped triangles and circles forming a band. More complicated patterns occur occasionally, such as the moulded fish motif in Figure 3.20.

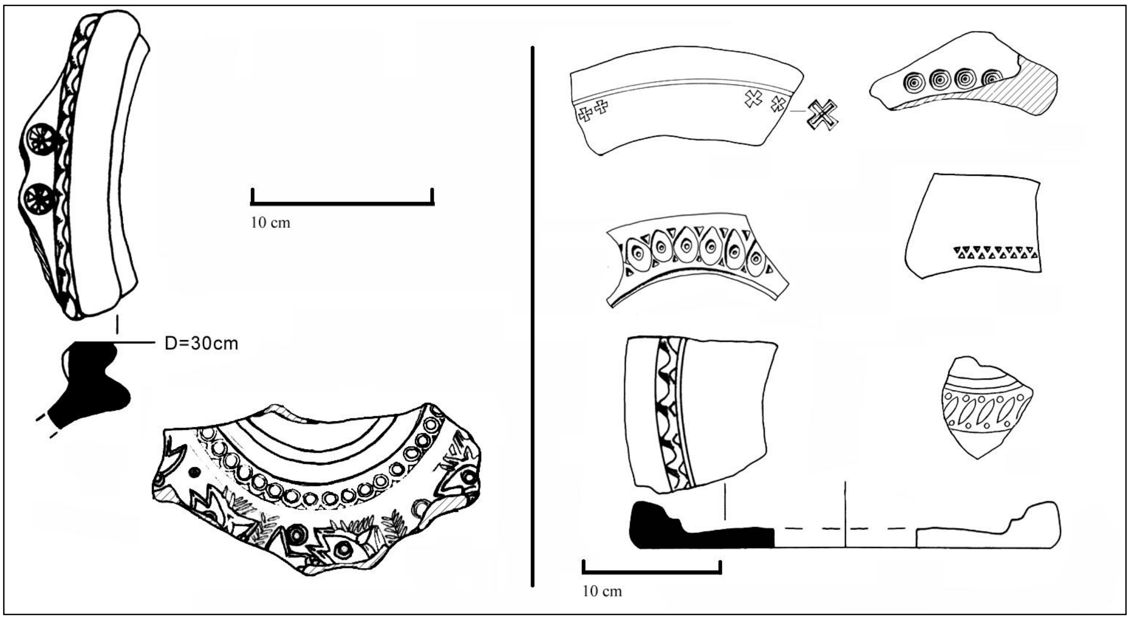

Figure 3.20 Decorated unglazed wares, including storage jar rim (far left).

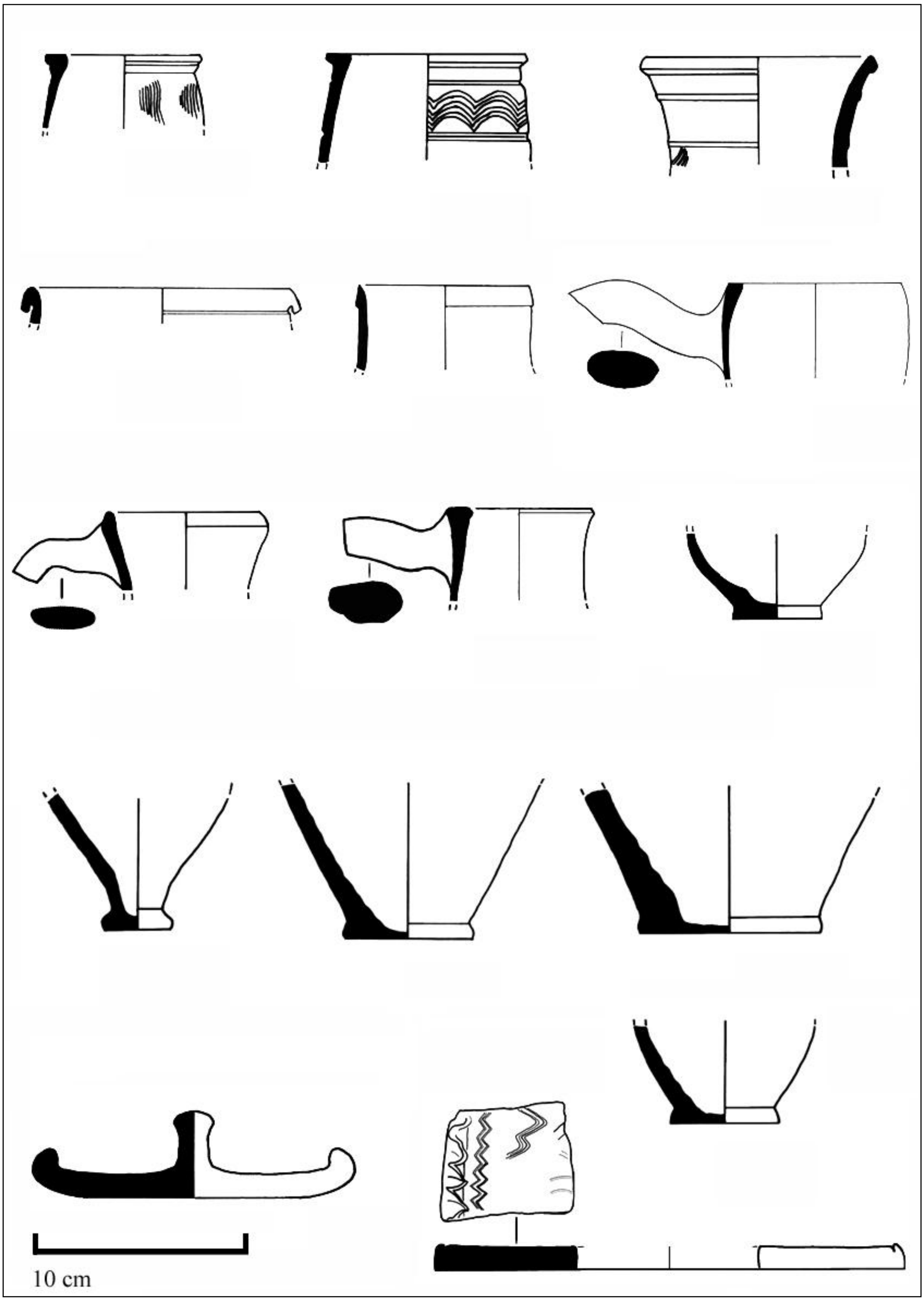

Figure 3.21 Unglazed fineware forms and decoration patterns.

Figure 3.22. Examples of decorated fineware sherds.

3.5.2. Cooking pots

The cooking pots have ball-shaped bodies with flattened bases, two handles and a slightly closed form (Figure 3.23). The bodies are made of somewhat coarser clay with calcite inclusions. The fabric is multicoloured – from buff to red to brown, with blackened areas from use. A dark buff/brown is the most common colour. The colouration variation on single vessels may be due to parts of the pots having more access to air in the kiln than other parts, causing the pots to oxidise or reduce unevenly. There is some variation in the rim shapes, and most have a ridge around the inner edge of the rim for a flat lid with central knob handle. The bodies are occasionally decorated with moulded designs. It appears that the same clay was used for these bodies as for the other types of ceramics – other than the calcite-rich inclusions, the chemical analysis shows a very similar matrix composition. The visual differences of the finished product show that these vessels were not fired in the same way, or probably even in the same kilns, as the finer wares.

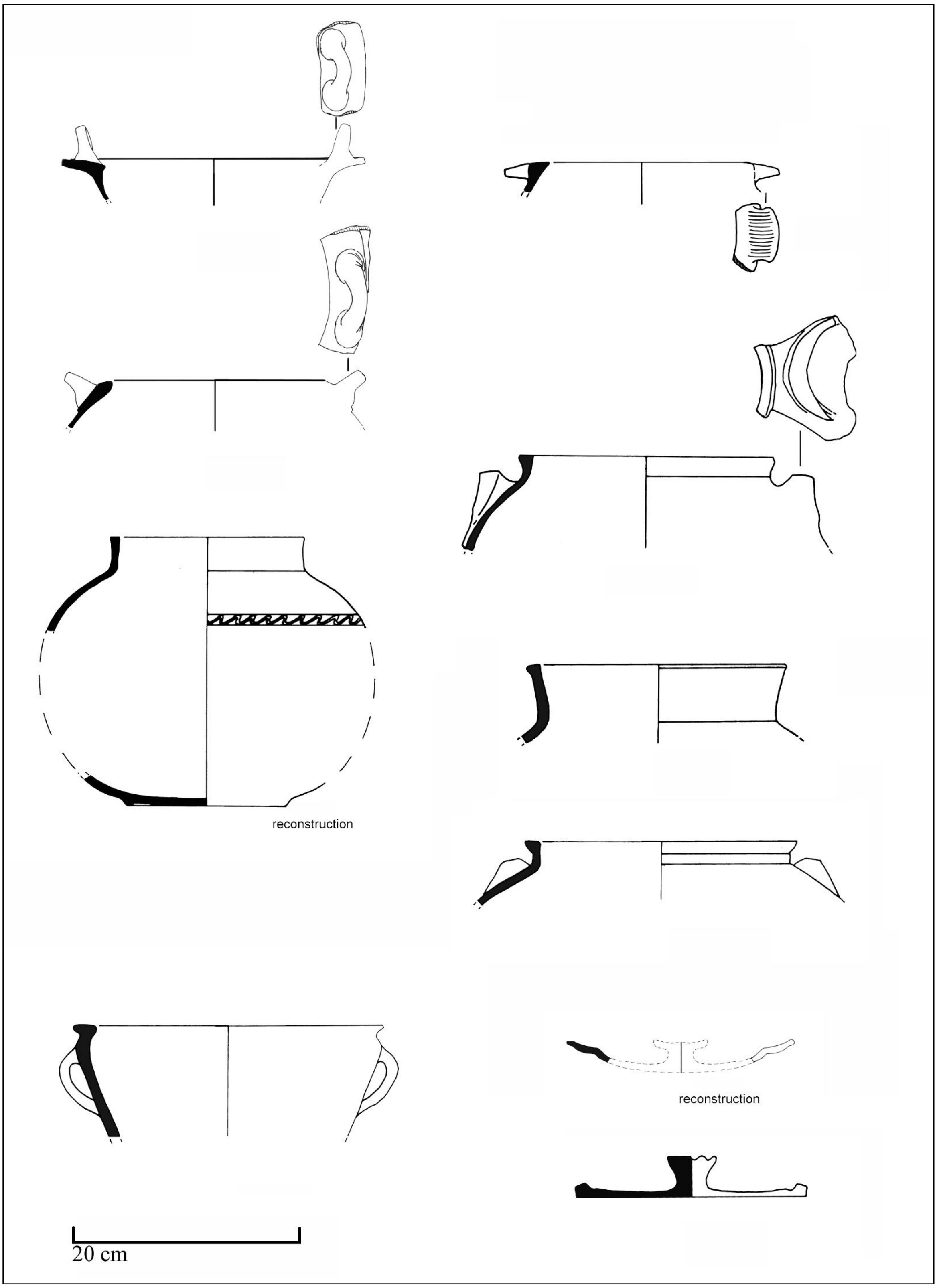

Figure 3.23 Cooking pot forms.

3.5.3. Storage jars

The storage jars are similar in fabric to the domestic finewares. The main difference is the size, as they are obviously used to store large quantities of food or water. Examples have been found *in situ* half buried in the floors of houses, evidently for use as permanent storage chambers (see Figure 3.25 below for an example of an *in situ* storage jar). They have thick rounded or squared-off rims and occasionally lids (Figure 3.24). These are usually buff-coloured clay like the kitchen ceramics, but often have a red-coloured area, which probably indicates that the air flow in the firing kiln was not very even, and with these larger vessels it has had an impact on the colour, oxidising some areas more than others in the same way as is seen with the cooking pots.

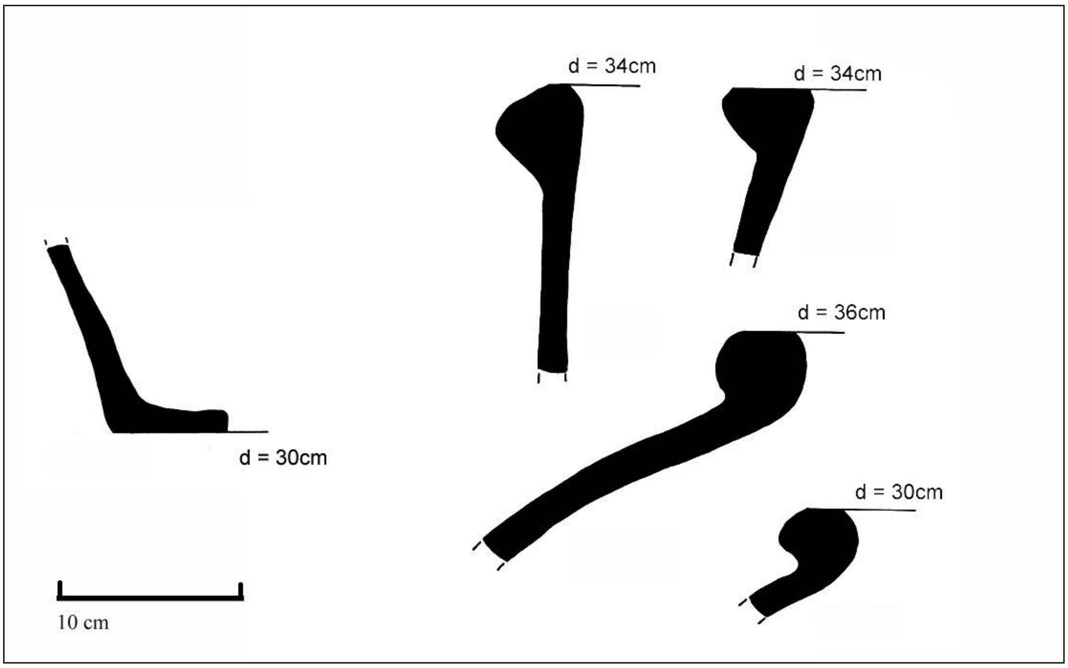

Figure 3.24. Storage jar rim and base shapes.

Figure 3.25. Storage jars in *situ*, Object 24, Akhsiket.

3.5.4. Slip-painted vessels

These vessels have a different range of forms than the domestic finewares, although in size, and perhaps use, are similar to them. They are closed forms, vases and jars, but with more adventurous body forms, such as long necks. The slip paints are in red, black and blue in simple cross-hatch and wavy-line patterns (Figure 3.26).

Figure 3.26 Unglazed slip-painted jug.

3.5.5. Architectural ceramics

There is, of course, a large quantity of architectural remains across the site of Akhsiket, and much of the building was done with fired brick, including the interior structures of the fortification walls. Tile is also seen, and may have been used for flooring. Several samples of brick were included in this study in order to compare with the bodies of the domestic ceramics. The brick fabrics can be either buff or red. Visual inspection shows that the bricks are more ‘powdery’ and friable in texture than the domestic finewares. There is evidence of a brick kiln to the east of the shahristan, although this has not been investigated.

3.5.6. Summary of unglazed ceramics

Unglazed ceramics are ubiquitous across the site and in many contexts at Akhsiket. They fall into a range of 6 basic types – domestic finewares, cooking pots, storage jars, slip-painted vessels, sphero-conical vessels and architectural ceramics. Forms are conservative, appearing to change little over this relatively short time period, but further work is required on the formal characteristics of these wares in order to understand any potential typological developments over time, and to compare assemblages with wares from other sites, and to look at continuity with earlier ceramic typologies (such as Puschnigg’s typological analyses of Sasanian wares at Merv (2006 and 2000)). Table 3.3 summarises the unglazed types and their main characteristics.

Type	Main characteristics
Domestic fineware	• Mostly losed forms such as jars and urns with pear-shaped bodies • Fine fabric, usually buff in colour, untempered • Usually decorated with simple impressed, incised or moulded designs • Highly common
Cooking pots	• Ball-shaped , slightly closed forms, with a ridge for the lid and two handles • Lids with central handle • Coarse fabric, usually brown with calcite inclusions • Occasionally decorated with moulded designs • Commonly found
Storage jars	• Closed forms with roughly pear-shaped bodies and thick rims • Tend to be much larger than "tablewares" – bases usually over 30 cm • Fine fabric, usually buff in colour but with red areas, untempered • Rarely decorated • Commonly found
Slip-painted wares	• Similar in body form to the domestic finewares, but more adventurous body forms are seen • Simple geometric or wavy designs in red, black and blue painted on as slips • Rarely found
Architectural ceramics	• Tile and brick • Fabrics are fairly fine and can be red or buff/yellow in colour • Found in large quantities

Table 3.3. Summary of unglazed ceramic types and their main characteristics.

3.6. Summary of Islamic ceramics and glazes

Akhsiket had a wide range of pottery types, falling under several classes. Glazed wares were popular from the early 10th century up to the Mongol invasion in the 1220s, and can be found in a number of contexts including household waste dumps, industrial waste dumps, in the remains of housing foundations, and on the surface, in many areas across the city. There is virtually no direct evidence that Akhsiket produced pottery. This would entail the remains of furnaces, kiln wasters, and kiln structures and furniture, none of which has been found. A single clay rod with green glaze on it, which must have come from a pottery kiln and would have been used for supporting pots on the walls of the kiln, was found in Object 23 – SEM-EDS results are discussed in Chapter 5.

Excavations are generally by trenches several meters in size - small areas compared to the size of the city and its surrounding inhabited areas. Samarkand had an extensive pottery 'quarter', and there may have been something similar in a city in Ferghana that supplied the region (as yet undiscovered), or was in a part of Akhsiket which has been eroded away. Alternatively, any individual workshops, scattered across the site, may simply be too difficult to find considering the size of the site. The consistency of the lead glazed wares, typologically, and, as will be shown in the next chapter, technologically, is consistent with a more centralised, controlled industry. The *ishkor* wares are less consistent than the lead glazed wares with greater variability in form, design and quality. Further discussion of this continues in Chapter 7.

As far as dating these assemblages is concerned, typological analyses of similar styles and forms from Samarkand and Tashkent, and the observations of Akhsiket's archaeologists over the years, have provided a rough framework for the glazed wares (if not for the unglazed wares). This requires much further refining, not only by the greater synthesis of typological studies (although this is in progress: see Simeon 2008), but also by the collation of stratigraphical evidence scattered throughout numerous archaeological reports.

It is clear that Akhsiket's inhabitants were consumers of glazed pottery on a large scale. Most examples found in the 2003 and 2005 excavations, as well as the sherds in storage from other excavations, show that the quality of production was generally high. It is already known from the written sources, as well as the archaeological investigations, that Akhsiket was a prosperous city, with administrative status as regional capital, a mint, and a highly developed steel-making industry. The presence of high-quality glazed ceramics further supports this picture of prosperity. The appearance of such ceramics in the early 10th century also shows that, although Akhsiket was minting Samanid coins from the 9th century, it took some time for the glazing technology to become known, or for the pottery to become a desirable commodity. The Ferghana Valley was not fully incorporated into the Samanid state until the early 10th century, so perhaps there were political factors involved in the uptake of these iconic ceramic types.

Typological analysis shows clear evidence that Akhsiket's glazed ceramics, and probably those of the entire Ferghana Valley, were derived from those produced at Samarkand, possibly via Chach or other production sites. Samarkand, in turn, picked up glazing technology from further west. However, it is necessary to investigate these ceramics further to gain a deeper understanding of how the pottery was made so that the assemblage at Akhsiket can be more precisely characterised, and so comparisons can be made on a quantifiable level. Raw materials, decoration methods and firing habits are all important aspects of this pottery which instrumental analysis can more fully investigate. Technological similarities and differences on a microscopic scale between lead glazed and *ishkor* wares, between glazed and unglazed wares, between ceramics from different centuries, are the aspects discussed further in this thesis.

4. Research and Analytical Methods

4.1. Aims and objectives

This thesis approaches the question of how Akhsiket’s ceramics and glazes fit into the technological context of Islamic ceramics both local, and in the wider Islamic world.

The overarching research question is met by investigating in-depth technological characteristics using scientific methods. This allows a more complete characterisation of the assemblage, demonstrates relationships between different styles of glazed wares and unglazed wares, and provides evidence for relationships with glazed ceramics from other sites in the region and the wider Islamic world. Interpretation of the analytical results, combined with previous work on typology, contributes significantly towards understanding questions of technical choice such as the raw materials used and their concentrations, and variations in craftsmanship such as the forming of vessels, and application of decorations and firing.

The research questions set out in Chapter 1 are as follows:

- What are the characteristics of the Akhsiket assemblages?
- What interpretations can be derived from the scientific evidence regarding technical and aesthetic style, including production methods and transfer of technical knowledge?
- What relationships can be seen between the different assemblages present at Akhsiket?

- Will the current research provide any evidence to indicate provenance of these ceramics?
- What relationships do Akhsiket's ceramics have to those from Kuva and Tashkent, and to the wider Islamic world?
- What insights do the technological and typological interpretations provide regarding the social and political influences on and role of pottery production and consumption at Akhsiket?

4.2. Previous research

As discussed in Chapter 2, archaeological excavations have been ongoing at Akhsiket for over 50 years, the aim being to understand the nature of the city in the Islamic and pre-Islamic periods, including the extent of its craft industry (most recently Anarbaev 2004, 1999, 1988). The descriptions, research and comparisons carried out on the ceramics are largely limited to their usefulness as a date-range indicator for the archaeological contexts. The issues around dating Akhsiket's ceramics – and lack of typological seriation - have been discussed in 3.1 and 3.2.

Investigations into the socio-cultural context of Akhsiket's ceramics have not been carried out, or were not available. Site reports and research papers on Akhsiket's ceramics do not give details of the proportions of different types of ceramics found, or how these relate to different features or other finds. The raw data would be available in the excavation records, but no specific research has been published. From my own observations of the excavations carried out in 2003 and 2005, finds retained from other previous or ongoing excavations on the site, and even on the surface of the site, it was clear that lead glazed ceramics belonging to the main stylistic categories (slipwares, monochrome and incised wares) are common and form a significant proportion of artefacts found. Alkali glazed wares form less than 5% of the glazed ware assemblage.

Akhsiket ceramics have not been analysed technologically, and no relevant work has been published on any Central Asian ceramics, bar SEM analysis of two or three samples from Samarkand by Mason (1997a-e, 2004). There have, however, been numerous analytical studies on comparative glazed ceramics from other parts of the Islamic world (see al-Saad 2002; Benedetto 2004; Frierman 1975; Hill, Speakman and Glascock 2004; Kleinmann 1991, 1986; Lazzarini, Verita and Charola 1994; Mason, Farquhar and Smith 1992; Mason and Tite 1997; Mason et al 2001; Molera and Vendrell-Saz 2001; Molera et al 2001; Perez-Arantegui and Castillo 2002; Tite 1988; Tite et al 1998, Wolf et al 2003). These are invaluable in showing how the technology of the Islamic "centre" compares with that of the peripheral areas, such as the Ferghana Valley. These studies are highly technical, usually fairly limited in scope with a specific focus on a particular technological issue. A rare example of comprehensive synthesis of typological, petrographical and chemical analysis of Islamic ceramics is Mason 2004. Even here, however, there are occasions where archaeological sites, widely dispersed, are represented by less than five samples (and in the case of Central Asia, only one sample from Samarkand and two from Nishapur), and there is a lack of interpretive discussion regarding the differences between the different sites and the different types of pottery. For further discussion and comparison to previous research, see Chapters 5-7.

4.3. Excavations and sampling

From the start of this project it was clear that excavations at Akhsiket to obtain samples were needed. Although there were pottery sherds in storage from past excavations, they were limited to a few specific areas of the site, and it was necessary to have access to the full range of pottery found in archaeological context. In 2003 two excavations (Objects 9 and 23) were opened up in areas where large numbers of finds in a relatively simple stratigraphy could be removed and in 2005 further samples were taken from a new excavation (Object 24) and from storage. All of these excavations were directed by the Akhsiket archaeological team from the Institute of Archaeology in Samarkand. Appendix D contains field photographs of the sherds recovered from these excavations.

The aim of the excavations and subsequent sampling in the second season was to collect the most common types of pottery which thus appeared to be indigenous to the area, throughout the time that glazed wares were present at Akhsiket. The sampling strategy was primarily based on typological characteristics, such as form and style and visible decoration methods, as well as ensuring samples from the full chronological range. Both glazed and unglazed sherds were sampled, although around twice as many glazed as unglazed wares were collected. This was due to the greater variability in decoration methods, and the focus of this research on investigating the different glazed wares. The unglazed wares were sampled to get an idea of the range of variation in body fabrics alone. See Chapter 3 for further details of the range of types and styles of pottery found on the site. The knowledge of archaeologists and ceramics specialists who have worked on the site for many years was invaluable here – and during both fieldwork seasons, their opinions drove much of the specific examples chosen for analysis.

The archaeological methods currently employed in Central Asia generally follow the Soviet tradition established in the first half of the 20th century (Puschnigg, 2006, 6). In the case of Objects 9 and 23 trenches were excavated according to pre-defined depths of 25 cm or 50 cm deep, with an emphasis on the vertical, and less regard for horizontal features. Neither of these Objects contained distinct features. Object 9 as an area of building collapse mixed with discarded artefacts did not have a distinct stratigraphy, while Object 23 was a dumping area with successive layering as more and more discarded material was added over a period of 150-200 years. So although any subtle evidence for features would have been lost according to the excavation methods used, for the purposes of collecting material for analyses with broad time-spans, the methods were adequate.

During the first season, samples were chosen from the two excavations (Objects 9 and 23 as described below), with several examples from each style category. It was not a given that any future fieldwork would be possible, so a large sample (250 sherds in total) was taken from both glazed and unglazed assemblages, including examples of all the main glaze and slip colours and a wide variety of vessel types and decoration motifs. From such small excavations, it is not expected to have a statistically representative sample of finds from the site of Akhsiket – but every effort was made to collect examples from all the major groups that were discovered in the 2003 excavations.

The excavation of Object 9 was planned specifically for this project. This was an extension of an existing excavation from an earlier field season and was chosen as it has produced a large number of glazed sherds in the past. The trench was located on the northern fortification wall near the northeast corner (see Figure 2.3). The fortification wall, several meters wide, was reused in the early Islamic period for domestic housing and craft workshops. The new extension of Object 9 measured 3 m by 1.5 m, excavated by 50 cm spits to a depth of 1.5 m. The remains found consisted of brick and mortar mixed with pottery sherds, bones, broken tile, ceramic crucibles used to melt copper and steel, broken glass objects and a few iron objects. The entire area excavated was dated to the 10th and 11th century according to the local understanding of seriation of the glazed pottery sherds found, and these dates should be seen as provisional. Little stratification, in the end, could be seen. The bricks did not represent an in situ structure, and could have been either the remains of a demolished building or the fortification brickwork. Undisturbed soil was not reached, as there was not enough time to excavate the remaining two or three meters' worth of human activity as was visible in the earlier section.

The material remains indicate this was a domestic waste area, as pottery and animal bones far outnumbered crucibles. Object 9 extension produced a wide variety of glazed pottery, particularly noted for technically sophisticated wares. It was also here that most of the decorated unglazed wares were found, with incised, stamped, moulded and pressed patterns. Although there was not the same chronological scale as Object 23 the wide variation in patterns, colours, styles and decoration techniques, and the high quantities of these, meant that all the common (and some uncommon) types for the most prolific time-span could be sampled. A report on the ceramics of the original Object 9 was published in 1990 (Papachristou and Baratova), and the ceramics report from the extension excavated in 2003 was published in summary (Papachristu, Henshaw, and Nasriddinov 2004). Both reports listed the types of pottery styles found, (as well as other artefacts), in which layers, and the date ranges assigned to layers according to the glazed wares' rough typological seriation.

The second Object excavated in 2003 was primarily chosen to provide samples for a research project on Akhsiket's steel-working industry. However, a number of domestic ceramics, including glazed pottery, were also present. It was located just outside the eastern fortification wall, on a slope which terminated in a ravine post-dating the city's habitation (see Figure 2.3). This seems to have been an industrial dumping area, particularly for used crucibles and slag waste. Object 23 measured 5.5 m by 2.5 m, with a depth of 4 to 5 m. Natural soil was reached, and thirteen discrete 'cultural layers' with artefacts were visible (the other layers consisting of clean soil with no artifacts). Object 23 showed a range of material from the 10th and possibly 9th centuries for the lower layers, to late 11th, possibly early 12th century in the top levels. These dates are based on the glazed ceramic typology.

Object 23, in the end, had the clearest and widest chronological sequence of the two excavations, so has provided the bulk of the samples used for chemical analysis. The finds were dominated by ceramic crucibles and slag, but there were also bone, brick, tile and mortar, and iron objects. Of the domestic ceramics, glazed wares made up a good proportion (over 10%). The glazed and other fine wares indicate that although this was primarily an industrial waste dump, some domestic rubbish was also dumped here, perhaps from the households of families involved in the steel-working industry. An initial archaeological assessment of this Object was published (Anarbaev, Rehren, and Maksudov 2004). There is far more variation present in the glazed wares, so a higher proportion of these were sampled than the unglazed wares.

The second fieldwork season served to supplement the existing sample of glazed wares by extending the chronological representation to the 12th century and collecting further samples of common styles from other parts of the site. For this purpose 16 sherds were collected from Object 24 (described below), and 22 samples from storage collections (largely from Object 21, described below). Both slipware and *ishkor*[6] sherds were collected.

Object 24 was opened during the 2005 field season, just inside the eastern line of the 'inner' shahristan wall. There were far fewer ceramic remains compared to Objects 9 and 23, but the chronological sequence followed on from both of the previous field season's excavations, with a predominance of 12th century sherds – supplementing the sample collected in 2003. This trench bisected what appeared to be a glass-working area - there was a section filled solely with glass fragments, prills and cakes, and a couple of burnt areas - although it may also have been another waste site. The Object also contained bone, fired brick and mud brick. The excavation, and the glass finds, were recorded in a Master's thesis (Osorio 2005).

A small number of finds, mainly glazed and decorated pottery, are kept in storage, and during the 2005 season these were viewed and samples taken. Most of the glazed sherds collected in this way were from Object 21, an ongoing area excavation in the northeast part of the city which has uncovered building foundations, an underground water transport system, cisterns and embedded storage jars. The sherds collected date from the 11th and 12th century according to their decorative styles.

Kuva and Tashkent were both important cities (or, in the case of Tashkent, the area of Chach with its major city – Binket – and satellite towns) and contemporary with Akhsiket, and comparative samples were collected for analysis. Kuva was a trade and craft centre in the southern Ferghana Valley. The Kuva material was stored at the Ferghana Museum in the city of Ferghana. The sherds range in date from the 10th – 12th century. Modern Tashkent covers the remains of several towns including the ancient city of Binket, capital of Chach in the medieval period. The sherds made available to me came mainly from rescue archaeology. Only location descriptions were provided, but as with the Kuva sherds, the primary aim is to provide a comparison in manufacturing technology, for which this limited information is sufficient. Sherds collected ranged from late 9th century to 17th century, but post-Mongol sherds were not

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[6] *"Ishkor"* is the term locally used for glazes with an alkali flux in early Islamic Central Asia. See Chapter 3.4.4 for further information.

analysed. The Tashkent sherds were published in Brusenko (1986). Whether these sherds were indeed produced local to their findspots is uncertain – but they do at least provide a broader picture in the study of eastern Uzbek ceramics for the time period than those found at Akhsiket alone.

The selection of comparative samples not originating with excavations at Akhsiket was dictated by availability and limited to glazed wares which were diagnostic and contemporary with the Akhsiket sample (except those from New Akhsiket). Kuva had the most limited numbers, due to glazed wares being less abundant there. The sherds were provided by G. Ivanov, an archaeologist who has worked on Kuva for many years. The Tashkent sherds were also selected by archaeologists from the Uzbek Academy of Sciences, and 18 sherds were collected. There were no examples of New Akhsiket pottery in storage, so the samples used for petrographical studies were only those collected from the surface in the vicinity of New Akhsiket. The purpose was for comparison of the petrographical characteristics of post-Mongol ceramics, which were assumed to be locally produced, with the early Islamic ceramic bodies.

Finally, the last comparative sample taken was of clay from a hillside to the east of Akhsiket where two 15 cm sample bags were filled with undisturbed clay for experimental firing in order to examine similarities in chemical composition with the ancient wares. This clay is the closest known source to the site of Akhsiket, and would have been located just outside the eastern *rabad.* With the lack of any pottery production evidence in the region, much larger clay sampling will be required in future.

The following section describes the analytical methodologies employed during the course of this project and provides a more detailed look at the samples that were chosen for instrumental analysis.

4.4. Instrumental analysis

The **scanning electron microscope** (SEM) was used for the bulk of the micro-analytical data which forms the basis of this thesis (see Table 4.1 and 4.2 for a full list of samples analysed, and the techniques used). As an instrumental technique, the SEM is well established for use in the chemical analysis of ceramics and glass (see Tite 1999 for a summary of micro-analytical techniques and their contribution to the study of ceramics). The SEM is particularly suitable for the study of glazed pottery as there are several elements to each sherd that must be visually as well as chemically analysed. This is achieved with the use of backscattered images, which give a picture of the matrix, inclusions, slips and glaze according to their respective chemical composition, and which provide the flexibility of spot and area scans using energy-dispersive spectrometry (EDS) in user-defined polygonal shapes that can be easily used to pinpoint the exact areas to be scanned.

Glazed samples and the analytical methods used

Sample	SEM-EDS	Petrography	Sample	SEM-EDS	Petrography
9/2.3	X		NA 1		X
9/3.3	X		NA 3		X
15/1.1	X		NA 8		X
23/2-8.3	X		NA 10		X
23/2-8.5	X		Kv 1	X	X
23/2-8.10	X		Kv 2		X
23/2-8.11		X	Kv 6	X	X
23/2-8.15		X	Kv 9	X	
23/2-8.17	X		Kv 12	X	
23/11a.2	X		Kv 18	X	
23/11a.3	X		Kv 19	X	
23/11b.1		X	Kv 20	X	
23/11c.1		X	Tash.2	X	
23/11c.2		X	Tash.4	X	
23/12.9		X	Tash.10	X	
23/12.10	X		Tash.15	X	
23/12.15	X		Tash.18	X	X
23/13.1		X	Tash.24	X	
23/13.2		X	Tash.32	X	X
23/13.3	X		Tash.47		X
23/14.4	X				
23/14.16		X			
23/15.1	X	X			
23/15.5		X			
23.16.1	X				
23/16.3	X				
23/20.7	X				
24/26	X				
24/23	X				
24/29		X			
24/30		X			
24/33		X			
23/2-8.1	X				
23/10a.1	X				
23/10b.3	X				
23/11c.1	X				
23/14.1	X				
23/14.17	X				
23/15.2	X				
23/15.5		X			
23/16.2	X				
23/20.2	X				
23/20.6	x				

Table 4.1. Glazed samples and the analytical methods used. Left-most column are all Akhsiket samples. NA = New Akhsiket, Kv = Kuva and Tash = Tashkent.

Unglazed samples and the analytical methods used		
Unglazed	**SEM-EDS**	**XRF**
9/3.1	X	X
9/3.2	X	X
9/3.3	X	
28/2-8.1	X	
23/10a.1	X	
23/11c.1	X	
23/12.8	X	
23/13.1	X	
23/13.2	X	X
23/13.3	X	X
23/13.4	X	
23/15.1	X	X
23/15.5	X	X
23/17.1	X	
23/20.1	X	
Clay 1	X	X

Table 4.2. Unglazed samples and the analytical methods used. All samples originate from Akhsiket. Clay 1 sample was taken from a local clay source.

The SEM-EDS is a quantitative technique which can detect elements down to around 0.5%. However quantitative totals can often be low in comparison to the actual concentrations, largely due to the inevitable fact that the beam varies in intensity – reducing in intensity over time as analysis is carried out. Beam intensity is monitored and adjusted by regular analysis of a Co “standard”. For porous ceramic fabrics and slips, and glazes which may contain cracks and voids, this is compounded, and varies from sample to sample (or between scan areas of the same sample). Totals analysed were generally better than 50% for the unglazed fineware and glazed bodies, but this can go as low as 48/50% for bodies with a high proportion of pores. Glazes themselves were usually over 70%. However, all elements are equally affected by beam variability and porosity. Normalising the data to produce relative weight percent concentrations of elements (“semi-quantitative”) to 100% removes this affect. The analysis of standards also provides information on the general accuracy of the instrumentation and the settings used.

The level of detection achieved by the SEM-EDS of 0.5% was adequate for determining technological attributes of the bodies and glazes, general characterisation, and for comparison – present and in future – with other SEM studies on ceramics and ceramic coatings, both microstructural and chemical.

During the period of study, two **standard reference materials** (SRM) of similar composition to the ceramic bodies were repeatedly used to verify accuracy and precision (Table 4.4). Powdered Andesite AGV-2 (USGS Certificate of Analysis) and SARM 69 (selected from an ancient ceramic body and certified by the Department of Geology, University of the Free State in 2000) (Jacobson, Van der Westhuizen, and Oosthuysen 2002), were mixed with epoxy resin and allowed to set, then mounted and polished in the same way as the sherd samples. Each analysis was done at a relatively low magnification, between 100 and 250x – around the same as that used for bulk analysis of bodies of the archaeological samples, and compared to the published results. Total concentrations analysed were fairly low due to the light elements in the epoxy resin, which cannot be detected by SEM-EDS (scans below 30% total concentration were not used), but this effect was countered by normalising all results to 100%.

The accuracy values show how similar the SEM-EDS analyses were to the published results. This was calculated by the following formula:

$$\text{error} = \frac{\text{sample result} - \text{published result}}{\text{published result}} \times 100$$

This method normalises the error for easier comparison between values of varying concentrations. Precision values (relative standard deviation) show how tightly grouped the values are to the average – calculated by the following formula:

$$\text{relative standard deviation} = \frac{\text{standard deviation}}{\text{average sample result}} \times 100$$

There are two reasons for analysing SRMs: first, to establish the accuracy of the instrumental calibration against a rigorously analysed material with a certified analytical data set; and second, to track any changes in accuracy and precision over time. Establishing the accuracy of the instrument allows systematic errors in the data to be taken into account when comparing to data results from other instruments (Bishop *et al* 1990, 539). Over the course of the four years analysis was carried out slight changes in the instrument settings were inevitable.

Andesite										
Session	**Na**	**Mg**	**Al**	**Si**	**K**	**Ca**	**Ti**	**Fe**	**Date**	
1	2.4	1.1	8.1	29.9	2.3	3.5	0.5	5.6	Jan '04	n=3
2	2.6	0.7	8.3	29.4	2.6	3.5	0.8	4.5	Jan '04	n=2
3	2.7	1.1	8.0	30.7	2.7	3.6	0.0	4.4	Feb '04	n=2
4	2.6	0.8	8.3	29.4	2.5	3.6	0.7	4.4	Oct '04	n=4
5	2.4	0.2	8.4	30.5	2.9	4.1	0.2	4.4	Nov '05	n=3
6	3.0	0.2	8.8	31.0	2.6	3.8	0.0	3.3	Jan '06	n=4
7	2.8	0.7	8.7	31.0	2.2	3.5	0.3	3.1	Mar '06	n=5
8	2.3	0.6	8.1	30.0	2.6	4.2	0.3	4.9	Aug '07	n=2
Average	**2.6**	**0.7**	**8.3**	**30.2**	**2.6**	**3.7**	**0.4**	**4.3**		
St. Dev.	0.23	0.35	0.29	0.66	0.22	0.28	0.30	0.81		
Precision %	9.0	51.2	3.4	2.2	8.6	7.6	85.0	18.7		
Accuracy %	-16.1	-43.8	-7.4	+8.0	+6.3	+0.7	-41.7	-8.0		
Published	3.1	1.2	9.0	28.0	2.4	3.7	0.6	4.7		

Table 4.3. SEM-EDS results in wt. % for Andesite (as elements) compared against published results.

SARM 69										
Session	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**TiO2**	**Fe2O3**	**Date**	
1	0.5	1.4	17.1	67.3	3.1	2.6	0.8	7.5	Jan '04	n=3
2	0.0	1.7	16.1	66.3	2.5	2.7	0.7	10.1	Feb '04	n=2
3	0.8	1.3	14.0	72.5	2.1	2.6	0.4	6.0	Oct '04	n=4
4	0.5	1.9	14.3	70.8	2.8	2.3	0.6	6.8	Nov '04	n=3
5	0.0	1.8	13.3	72.7	2.0	2.7	0.5	6.9	Nov '04	n=3
6	0.6	1.4	13.8	72.3	2.1	2.3	0.6	6.5	Feb '05	n=4
7	0.0	1.6	14.9	71.2	2.1	2.8	0.4	7.0	July '05	n=3
8	0.0	1.4	14.3	71.0	2.3	2.9	0.5	7.7	Aug '07	n=2
Average	**0.3**	**1.6**	**14.7**	**70.5**	**2.4**	**2.6**	**0.6**	**7.3**		
St. Dev.	0.33	0.22	1.27	2.41	0.40	0.22	0.14	1.25		
Precision %	111.3	14.1	8.6	3.4	16.7	8.3	25.0	17.0		
Accuracy %	-62.5	-13.2	+2.3	+5.9	+21.2	+10.2	-27.9	+1.6		
Published	0.8	1.8	14.4	66.6	1.96	2.37	0.78	7.2		

Table 4.4 SEM-EDS results in wt. % for SARM 69 (as oxides), compared against published results.

These particular SRMs were used to demonstrate accuracy in particular for porous ceramic or ceramic-like material with pores and small, granular inclusions. This exercise shows that the SEM method employed was both accurate and precise within the known limits of the instrument, but any elements at those near-detection levels should be used with care, if at all, to differentiate samples or sample areas.

In the Andesite SRM, calcium was accurate to better than 1%, while aluminium, silicon, postassium and iron were accurate to better than 10%. Sodium was accurate to around 16%, while magnesium and titanium were accurate to just over 40% - all three of these being light elements (sodium) or very near the accurate detection limit of the SEM (magnesium and iron), as explained above. Precision is good for aluminium and silicon, both less than 5%. Sodium, potassium, and calcium are more variable but less than 10%. Iron is fairly variable at 18.7% - despite a relatively high concentration, this is probably due to the "nugget effect" of discrete iron-rich particles scattered irregularly throughout the sample (although powdered, small inclusions were still visible in the sample matrix). Magnesium and titanium being highly variable as expected being very close to accurate detection limits (51.2% and 85% respectively).

For SARM 69 alumina and iron oxide were accurate to better than 3%, silica just under 6%. Magnesia and lime were accurate to better than 15%. Potash and titanium oxide were accurate to 21.2% and 27.9% respectively, with soda the least accurate at 62.5%. Precision values also vary, with the highest precision for silica at less than 4% and alumina and lime at less than 9%. Magnesia, potash and iron oxide varied from 14% - 17%, with titanium oxide at 25%.

In interpreting these values, it is important to take into account the full context of the material, the limits of the instrument, and the relative proportions. It can be seen that in real terms both precision and accuracy levels relate to absolute variations of between 0.1% and 0.5% (with the exception of silica). The SEM accuracy limit being 0.5%, with a detection limit of 0.1%, these variations are as expected. When analysing the archaeological samples using SEM-EDS, elements between 0.5% and 0.1% were reported, but could not be used as significant indicators of variability between samples, sample areas, or over time.

The archaeological sample material was mounted in resin blocks containing around 1x2 cm of sherd cross-section and polished to 1 μm. Glazed sherds were then photographed using reflected light with crossed polarisers. This method produced the most realistic-looking photographs, where the glassy nature of the glaze, its coloration, and the grains in the slips and fabric could clearly be seen. All samples were then coated with carbon for SEM analysis, carbon facilitating electrical conductivity on the sample's surface. SEM analysis parameters remained consistent throughout the project. Cobalt was used with all samples as a standard calibration material during sessions. The current was set at 20 kV and the distance between the sample and the backscatter detector was 10 mm. Spot analysis was used for inclusions (minimum coverage of around 5 μm in diametre) with multiple area scans of varying dimensions for bulk analysis of bodies, slips and glaze matrices. Scans of glaze matrices were made both near the body and near the surface to determine the extent of any leaching of oxides from the body or slips into the glaze.

Forty-six sherds from Akhsiket were analysed with SEM-EDS – thirty glazed and sixteen unglazed. Of the glazed wares, twenty were assumed to be lead glazed and ten alkali glazed, the chosen lead glazed examples representing the primary glazed ware styles and colours, while the alkali glazed samples represented a range of colours, hues and qualities. Sherds also represent multiple excavation sites and layers within the stratigraphy of those sites. For comparison, seven Kuva and seven Tashkent wares were also analysed with SEM-EDS. Sherds analysed from Kuva and Tashkent chosen from the available set were those that most closely matched the Akhsiket samples in style and colour. Summary results of these analyses are described and discussed in Chapters 5-7, with full results provided in Appendices A-C.

The visual aspect of the SEM backscatter detector provides information on the boundaries between different areas, decorative or microstructural, and can highlight areas of chemical variation, particularly in glazes and mineral inclusions. The SEM-EDS results give a measure of relative chemical composition which indicates the type of material being scanned (lead-silica glaze, for example), with the ratios of different elements giving clues to clay characterisation and glaze recipes. This data can be compared to other ceramics to form groupings by similarity of chemical composition or production technology used. In this way the chemical data provides a means for the interpretation of Akhsiket's ceramics on a technological level which has not been possible, or was only partly possible, using visual characteristics alone.

Mason (2004) has shown that even for finewares, where there are few rock inclusions, characteristics visible under a polarising light microscope can be used in some cases to distinguish between pastes formed from different clay sources. In order to investigate the possibility of petrofabric characteristics as a determining factor in grouping fabrics (see Chapter 5.1 for further details) twelve glazed sherds from Akhsiket were thin sectioned for a **petrographic analysis pilot study**. Three or four sherds each from Kuva, Tashkent and New Akhsiket were also prepared to see what, if any, variation there might be between different assemblages. The Akhsiket sherds included three or four samples representing each of the three glazed ware Fabric Types (see Table 5.3 for further details). Petrofabrics were then compared to the visible fabric characteristics such as fabric colour, nature of inclusions and texture. A cross section of each sherd was mounted to a glass slide, polished to a thickness of 30 μm, and covered with a glass slipcover. At this thickness, it is possible for light to pass through the thin section, revealing specific properties of the matrix and mineral inclusions under a polarising microscope. This technique allows determination of such aspects as grain distribution, size, shape and light-affecting properties of individual particles to facilitate the identification of minerals and description of the fabric's structure.

The **X-ray fluorescence** (XRF) spectrometer (Spectro X-Lab 2000, using the Turboquant method) was used to analyse major, minor and trace elements of seven unglazed sherds as a small case study to investigate the efficacy of this technique on the finer fabric types. These included samples from both 2003 excavations, representing domestic fineware and brick. XRF produces compositional values for around 50 elements, 25 of which were present in the Akhsiket sherds above the detection limit. The XRF is sensitive to trace elements down to less than 1 μg/g, although accuracy levels vary depending on the element. Pellets were prepared by grinding and milling 6-8 grams of sample in agate vessels, mixing with a standard proportion of wax and then pressed into shape. The pottery and brick samples were analysed alongside two reference samples in 2003.

In 2008, an experimental fired brick sample (see Chapter 5.5 for further details) was fired alongside the same two reference samples and three of the original Akhsiket ceramic samples, to verify that the precision of the machine was acceptable. Each sample was run through the analytical process three times (see Appendix B for full results). Average totals were between 80 and 93 wt. %.

Any elements that fell below 10μg/g were discounted due to low accuracy levels below that concentration according to standard practice for the particular equipment and method used. Oxides above the detection limit were: Na_2O, MgO, Al_2O_3, SiO_2, P_2O_5, SO_3, K_2O, CaO, TiO_2, V_2O_5, Cr_2O_3, MnO, Fe_2O_3, Co_3O_4, NiO, ZnO, Ga_2O_3, As_2O_3, Rb_2O, SrO, Y_2O_3, ZrO_2, BaO, CeO_2 and PbO. Those elements that were analysed, but fell below the detection limit were Ge, Se, Br, Nb, Mo, Ag, Cd, In, Sn, Sb, Te, I, Cs, La, Hf, Ta, W, Hg, Tl, Bi, Th and U. Cl was also discounted as a contaminant from the wax used in the pressed pellets. Data processing consisted of converting all μg/g values into percentages to determine wt. % totals, and for meaningful comparison with the major and minor elements. All detected elements were then normalised to account for the slight range in variation in analytical totals between different samples. Original values are shown in Appendix B.

Certified reference standards SARM 69 and SRM 679 (brick clay, certified by the National Bureau of Standards, 1987) were used to verify the accuracy and precision of the XRF machine. The calculations as described above for the SEM standards demonstrate, in particular, the high precision of the XRF method employed (Turboquant). The XRF, however, showed variable accuracy levels that must be taken into account when comparing with analytic results carried out on any other instrument. Two analytical sessions are shown (see Table 4.5 and Table 4.6, below). SARM 69_2008 and SRM 679_2008 were analysed in 2008 and SARM 69_2003 and SRM 679_2003 were analysed in 2003 alongside the archaeological samples, which were also analysed in two sessions. Both sessions are compared to the certified results in the tables below. Values in italics are non-certified, preliminary results and blank cells indicate elements not detected or not analysed for.

SARM 69

Element	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	K2O	CaO	TiO2	V2O5
Dimension	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
SARM 69_2008	0.42	1.46	15.94	57.20	0.25	0.03	1.64	1.86	0.56	0.03
SARM 69_2003	0.64	1.32	15.25	61.57	0.27	0.00	2.01	2.42	0.73	0.03
Precision %	**28.8**	**6.9**	**3.1**	**5.2**	**4.3**		**14.4**	**18.8**	**18.6**	**17.8**
SARM 69_CRM	*0.79*	1.85	14.4	66.6	*0.28*		1.96	2.37	0.777	*0.03*
Accuracy % ‘08	**-46.4**	**-21.1**	**+13.2**	**-11.5**	**-10.1**		**-16.2**	**-21.7**	**-28.3**	**-15.3**
Accuracy % 03	**-19.0**	**-28.4**	**+8.4**	**-4.7**	**-4.5**		**+2.8**	**+2.3**	**-6.6**	**+9.1**

Element	Cr2O3	MnO	Fe2O3	Co3O4	NiO	CuO	ZnO	Ga2O3	As2O3	Rb2O	SrO	Y2O3
Dimension	**%**	**%**	**%**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**
SARM 69_2008	0.03	0.13	7.39	104	56	62	82	18	0.00	70	132	30
SARM 69_2003	0.03	0.13	7.39	107	56	64	83	17	0.00	69	129	29
Precision %	**11.0**	**1.2**	**0.0**	**2.0**	**0.0**	**2.2**	**0.9**	**4.0**	**0.00**	**1.0**	**1.6**	**2.4**
SARM 69_CRM	0.02	0.13	7.18	36		58	85			*72*	*129*	*37*
Accuracy % ‘08	**+33.9**	**-1.7**	**+2.9**	**+201.2**		**+7.7**	**-3.1**			**-3.0**	**+2.4**	**-18.5**
Accuracy % 03	**+14.5**	**+0.0**	**+3.0**	**+210.0**		**+11.1**	**-1.9**			**-4.4**	**+0.1**	**-21.3**

Element	ZrO2	BaO	CeO2	PbO	Sum
Dimension	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**%**
SARM 69_2008	244	465	31	14	91.9
SARM 69_2003	233	440	30	14	87.1
Precision %	**3.3**	**3.9**	**2.3**	**0.0**	
SARM 69_CRM		578	*82*	*16*	
Accuracy % ‘08		**-19.6**	**-62.3**	**-12.5**	
Accuracy % 03		**-23.9**	**-63.5**	**-12.5**	

Table 4.5. XRF results for SARM 69 in wt. % and µg/g standards as analysed and published.

Taking the major and minor elements first (those that are present above 0.1 wt.%), precision values are calculated for the two sessions (2008 and 2003). For SARM 69 all but soda, potash, lime and titanium are better than 10%, however the latter three fall between 14% and 19% while soda is just under 30%. Sulphur oxide may be an anomaly, being found in only 2008. Precision for brick clay SRM 679 is better than 7% for magnesia, alumina, silica and phosphorus oxide, and better than 20% for the rest (with titanium slightly over 20%).

Brick clay SRM 679

Element	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**P2O5**	**SO3**	**K2O**	**CaO**	**TiO2**	**V2O5**
Dimension	%	%	%	%	%	%	%	%	%	%
SRM 679_2008	0.33	1.13	20.77	46.70	0.12	0.11	2.27	0.18	0.71	0.03
SRM 679_2003	0.27	1.10	20.34	51.38	0.12	0.09	2.85	0.24	0.96	0.04
Precision %	**15.0**	**1.4**	**1.5**	**6.7**	**2.8**	**18.5**	**16.1**	**18.4**	**20.9**	**19.2**
679_CRM	0.18	1.26	20.80	52.07	0.17	n/a	2.93	0.23	0.96	
Accuracy % 08	**+88.4**	**-10.7**	**-0.1**	**-10.3**	**-31.6**		**-22.7**	**-19.7**	**-25.8**	
Accuracy % 03	**+52.2**	**-12.5**	**-2.2**	**-1.3**	**-28.8**		**-2.8**	**+4.2**	**0.0**	

Element	**Cr2O3**	**MnO**	**Fe2O3**	**Co3O4**	**NiO**	**CuO**	**ZnO**	**Ga2O3**	**As2O3**	**Rb2O**	**SrO**	**Y2O3**
Dimension	%	%	%	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
SRM 679_2008	0.01	0.22	13.06	165	47	44	143	38	18	192	81	47
SRM 679_2003	0.01	0.24	13.60	164	52	48	151	41	18	198	84	50
Precision %	**11.3**	**5.0**	**2.9**	**0.4**	**6.0**	**5.6**	**3.5**	**6.2**	**0.0**	**2.2**	**3.0**	**4.3**
679_CRM	0.01	0.22	12.94	33			187			208	86	
Accuracy % 08	**-3.6**	**-1.8**	**+0.9**	**+399.0**			**-23.4**			**-7.8**	**-6.3**	
Accuracy % 03	**-17.9**	**+5.5**	**+5.1**	**+396.0**			**-19.5**			**-4.9**	**-2.2**	

Element	**ZrO2**	**BaO**	**CeO2**	**PbO**	**Sum**
Dimension	µg/g	µg/g	µg/g	µg/g	%
SRM 679_2008	116	425	54	18	85.67
SRM 679_2003	110	445	73	17	91.37
Precision %	**3.7**	**3.3**	**21.0**	**3.5**	
679_CRM		482	12		
Accuracy % 08		**-11.8**	**+353.1**		
Accuracy % 03		**-7.6**	**+511.2**		

Table 4.6. XRF results for SRM 679 (brick clay) in wt. % and µg/g standards as analysed and published.

Accuracy levels are better in the earlier session (2003, or number 2 in the tables). It is possible that slight changes or contamination of the pellets in the intervening period has affected the results, or that the calibration of the instrumentation is slightly different. Looking at the 2003 session for SARM 69, silica, phosphorus oxide, potash, lime, manganese oxide and iron oxide are better than 5%, with alumina and titanium better than 9%. Soda and magnesia are less accurate at 19% and 28.4% respectively. SRM 679 2003 shows a similar picture with alumina, silica, potash and titanium better than 3%, lime better than 5%, manganese and iron oxide at just over 5%, and magnesia at 12.5%. Soda, again, is far less accurate at 52.2%, while phosphorus oxide is at 28.8%. Precision and accuracy levels for the XRF are, on the whole, better than the SEM, as are the detection limits, particularly for trace elements (10 ppm for XRF compared to c.

1,000 ppm for SEM-EDS). However, as with any analytical technique, elements which demonstrate low accuracy and/or precision levels should be used with care, if at all.

The XRF values for the trace elements are of particular interest as the focus of the XRF study, and the *raison d'être* of the instrument. Trace elements are those under 0.1%. Immediately it can be seen that between the two sessions – variations in major and minor elements aside – the XRF has been highly precise. Of the 15 trace elements analysed for SARM 69, only two elements show worse than 4% precision (vanadium and chromium at 17.8% and 11%). Similarly, for SRM 679 only three elements show worse than 10% precision (vanadium, chromium and cesium at 19.2%, 11.3% and 21%), the rest being around 6% or less.

Only 11 trace elements for SARM 69 and 7 for SRM 679 were certified (or published as preliminary), and these have been compared to the analysed results to determine accuracy levels. Using the 2003 values, for SARM 69 accuracy levels are better than 1% for strontium, 2% for zinc and 5% for rubidium. Vanadium is slightly under 10% and copper slightly over 10%. Both chromium and lead are better than 15%, ytterbium and barium better than 25%. The least accurate are cesium at 63.5% and cobalt at 210%. For SRM 679 there are fewer trace elements to compare to: both rubidium and strontium are accurate to better than 5%, barium better than 8%, and chromium and zinc better than 20%. However cobalt and cerium are far less accurate, at 396% and 511% respectively, both over-represented.

Comparing the XRF results with the certified values as published shows that the accuracy is not as good as the precision. For comparing results analysed on the same machine this method is adequate, but raises problems in comparing with other trace analytical data. Further, there may be problems with certain elements between sessions even on the same machine. Problematic elements to be aware of for this particular study where precision is concerned are the alkalis, lime and titanium for major and minor elements (these oxides are better analysed by SEM-EDS), while problematic trace elements are V_2O_5, Cr_2O_3 and possibly CeO_2.

In future, it may be necessary to develop the XRF method further for ceramics, to gain greater accuracy – although looking at tests carried out by Hein, et al on SRM 679 (2002), even with the combined force of 6 analytical sessions using XRF, ICP-MS, NAA, and ICP-OES, accuracy is an issue for all analytical techniques when it comes to trace element analysis. So whereas the mean for Co is far more accurate in the Hein et al test at 25.9 ppm, Ce , Zn, Rb and Sr are all less accurate. This paper shows that "in some cases significant differences between concentrations measured with different setups can be expected" (Hein et al 2002, 549), and that in order to compare data between setups correction factors must be applied. These correction factors are deduced by comparing the ratios between different setups, and/or by correcting to standards.

It was not within the scope of this thesis to conduct a comprehensive XRF analysis of glazed wares from Akhsiket, or from the comparative sites, considering the additionl focus on the decoration methods. As the unglazed coarse wares are more likely to have been made at or near their place of use, it was considered useful to target this initial assessment of trace element variability to these wares to test the range of variation at the site of Akhsiket. See Chapter 5 for detailed results from the analytical work, and Chapter 7 for further discussion on the results and the potential for future work.

4.5. Summary of research and analytical methods

The aims and objectives of this research are centred on the investigation of ceramic and glaze technology. The research questions required spectroscopic and micro-analytical methods with a high spatial analysis, in keeping with existing research on similar material from other regions. The paucity of previous analytical research on material from Central Asia, although limiting the potential for comparison of assemblages between sites, leaves a wide opportunity for primary analysis. Excavating *in-situ* material provided adequate contextual information, and was a good opportunity for well-balanced sampling, albeit from a very small proportion of the site itself. Common, and most likely indigenous wares, were the focus of the sampling strategy, although comparative sherds from other sites were also collected for comparison with the main glazed assemblage. The expertise of the archaeologists who work on the site was invaluable in understanding the site and its archaeological context, and the typological classification of its artefacts.

The analytical techniques well established and commonly used for glass and ceramic research. In future, the use of other methods for different research goals may be necessary (such as lead or strontium isotope analysis, or further trace analysis), but for general characterisation, grouping, and production technology, SEM-EDS analysist of major and minor elements, petrography and a small subset of trace analysis was perfectly adequate to meet the requirements of the research questions.

5. Results of instrumental analysis

This chapter presents the results of scientific data collection on Akhsiket sherds – focusing on the new data concerning technological aspects of the different types of pottery studied. Summaries of average chemical and petrographical data for practical reasons are given here. For the full analytical data, see Appendices A and B. This data provides the basis for the technological and social interpretations presented in Chapters 7.

All the bodies of the glazed wares will be described and discussed together, while the glazes, slips and pigments are treated in groupings according to class and type. Unglazed wares are described in groups according to class.

5.1. Glazed pottery bodies

Scientific analysis addresses questions regarding the characterisation of the fabrics by chemical and mineralogical composition, any differentiated groupings based on these characteristics, and the comparison of the bodies to those of other assemblages (such as the unglazed wares at Akhsiket, or pottery from other sites). This helps to place Akhsiket's pottery in context locally and regionally. At present, here is no evidence for pottery production in the Ferghana Valley, and no geological prospection has been carried out on clay sources and other raw material sources that could have been used in production. Therefore, the analysis of bodies from Akhsiket is an original, important and necessary contribution to the study of pottery production in the region – along with Kuva, allowing the creation of a scientifically-testable 'Ferghana' assemblage.

The fabrics were initially characterised by eye into several groups, taking texture, colour, density and colour of visible inclusions, and porosity into account. Bulk SEM analyses as well as spot analyses of a number of inclusions were carried out for major and minor elements in thirty-three glazed samples. Sixteen sherds were also thin-sectioned for petrographic analysis to test the potential of differentiating between Fabric Types by examining the clay inclusions more closely.

The clay matrix is calcareous and homogeneous, dense, with small, more or less evenly distributed inclusions. There is no evidence of any temper. Traces of organics appear to remain in some pores and as microscopic inclusions (such as seeds), although whether they were present in the raw clay, or added during preparation is unknown.

Within the SEM-EDS analyses of the glazed wares, it can be seen that there is little variation overall, although some samples show particularly low or high values in a number of components (see Table 5.1).

The standard deviation and standard error show that the greatest range in variation is in silica and lime at 1.6% and 1.8% standard deviation, respectively. Standard error is good, at 0.1-0.2% except for silica and lime at 0.29% and 0.32% respectively. Variations in silica and lime are not unexpected – this can be due to variations in the size and density of inclusions such as quartz, feldspars and calcite grains.

Overall, the bodies are highly calcareous and iron-rich. Alkalis and alkali earths make up 8 wt.% together, potash and magnesia being dominant. Alumina averages 12.6%. Of the other elements, titanium is present in all but a couple of samples, averaging 0.64%, sulphur in around half the sherds and highly variable, and phosphorus detectable in a mere two sherds. There is a correlation between silica and lime with the earlier wares more closely grouped (see Figure 5.1).

Akhsiket glazed ceramic bodies

Sample	Fabric Type	Style code	Na2O	MgO	Al2O3	SiO2	K2O	CaO	TiO2	Fe2O3	P2O5	SO3	
9/2.3	1	MG	1.0	3.0	12.2	54.9	3.7	17.4	0.7	7.3	0.0	0.0	n=4
9/3.3	1	PM	1.0	3.8	12.0	56.4	3.1	16.8	0.8	6.1	0.0	0.0	n=4
15/1.1	5	TP	1.2	3.3	14.1	56.9	4.5	11.8	0.7	7.6	0.0	0.0	n=4
23/2-8.3	1	SW	0.7	3.6	12.6	56.6	3.2	16.5	0.6	6.2	0.0	0.0	n=3
23/2-8.5	2	LG	0.8	5.2	12.4	58.3	2.6	13.8	0.7	6.0	0.0	0.9	n=3
23/2-8.10	1	Y	1.4	4.2	14.1	57.0	3.4	14.5	0.0	5.5	0.0	0.0	n=3
23/2-8.17	5	PM	1.0	4.1	13.6	59.6	3.8	11.2	0.6	5.8	0.0	0.6	n=2
23/11a.2	1	PM	0.9	3.8	12.7	54.3	3.1	16.2	0.9	7.0	0.0	0.8	n=2
23/11a.3	1	LG	0.8	3.3	12.7	55.5	3.6	17.9	0.4	5.4	0.0	0.4	n=4
23/12.10	2	MG	1.4	3.3	12.0	55.9	3.6	16.3	0.7	6.2	0.0	0.5	n=4
23/12.15	5	SW	1.2	3.5	12.6	54.4	3.6	17.9	0.7	5.8	0.0	0.0	n=4
23/13.3	5	LL	1.5	2.7	13.0	58.5	2.9	13.7	1.1	4.8	0.0	2.9	n=3
23/14.4	1	PM	1.1	3.9	13.2	59.8	2.8	13.0	0.8	5.3	0.0	0.0	n=2
23/15.1	1	SW	1.3	3.0	13.4	56.0	2.6	15.5	0.9	6.2	0.0	0.5	n=4
23.16.1	1	PM	1.1	3.3	12.5	56.8	3.8	15.5	0.7	6.3	0.0	0.0	n=4
23/16.3	2	SW	1.3	3.7	12.8	55.5	2.4	17.4	0.7	5.8	0.0	0.5	n=4
23/20.7	2	MG	1.1	3.4	12.6	54.7	4.1	15.7	0.6	6.1	0.3	1.1	n=4
24/26	5	PM	1.0	2.7	12.3	56.6	4.3	16.0	0.8	6.4	0.0	0.0	n=4
24/23	1	MG	5.2	2.7	10.9	54.9	4.0	14.9	0.3	6.7	0.0	0.4	n=3
23/2-8.1	1	I	1.3	3.9	13.3	57.6	2.5	15.9	0.0	5.5	0.0	0.0	n=4
23/10a.1	2	SM	0.9	3.0	12.8	58.6	3.6	15.0	0.7	5.3	0.0	0.0	n=4
23/10b.3	5	I	1.3	3.2	12.8	53.0	4.7	16.2	0.7	7.7	0.0	0.0	n=3
23/11c.1	1	I	1.8	3.7	13.4	59.0	2.8	14.2	0.4	4.7	0.0	0.0	N=3
23/14.1	1	I	1.1	3.4	12.0	56.7	3.4	16.3	0.7	5.8	0.0	0.0	n=4
23/14.17	2	I	1.9	4.0	12.3	57.8	2.1	15.4	0.6	5.3	0.0	0.2	n=4
23/15.2	5	I	1.3	3.0	12.2	55.5	3.8	17.5	0.5	6.2	0.0	0.0	n=2
23/16.2	5	I	0.2	1.5	9.4	55.6	5.4	18.7	0.9	7.9	0.0	0.3	n=2
23/20.2	2	I	1.0	3.2	12.2	56.1	3.8	17.6	0.6	5.3	0.0	0.3	n=4
23/20.6	1	I	1.0	3.4	13.0	55.1	3.6	17.3	0.8	5.9	0.0	0.0	n=4
average			**1.3**	**3.4**	**12.6**	**56.5**	**3.5**	**15.7**	**0.6**	**6.0**	**0.0**	**0.3**	
St. Deviation			0.8	0.6	0.9	1.6	0.7	1.8	0.2	0.8	0.1	0.6	
Max			5.2	5.2	14.1	59.8	5.4	18.7	1.1	7.9	0.6	2.9	
Min			0.2	1.5	9.4	53.0	2.1	11.2	0.0	4.7	0.0	0.0	
St. Error			0.1	0.1	0.2	0.3	0.1	0.3	0.0	0.1	0.0	0.1	

Table 5.1. SEM-EDS results in wt. % for 29 glazed bodies. See Table 5.2 for a style code key, and a detailed description of Fabric types 1, 2, and 5 in the text below.

I	*Ishkor*
LG	Lead glazed - unspecified
LL	Lead glazed - lamp
MG	Monochrome green lead glazed
PM	Polychrome lead glazed
SW	Samanid ware
SM	Skeuomorphic ware
TP	12th century polychrome lead glazed
Y	Yellow lead glazed

Table 5.2. Glazed wares style code key.

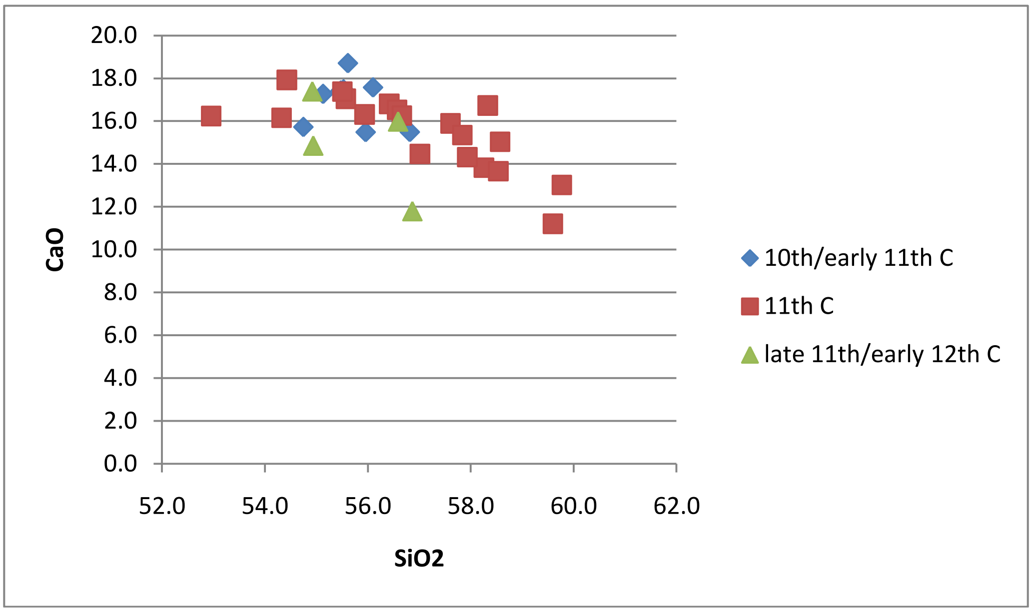


Figure 5.1. Chart showing correlation for lime and silica in Akhsiket glazed bodies.

SEM backscatter electron (BSE) images show the scale of the natural inclusions and pores visible in a cross section of body fabric. Figure 5.2 shows a typical clay matrix with small, well-evolved (less than 100 microns across) inclusions. The medium grey inclusions are quartz and the lighter grey are a silica-alumina-potassium mineral. The long lathe-like grains are mica, and the bright areas are heavy minerals such as iron or manganese oxide ingrown with quartz.

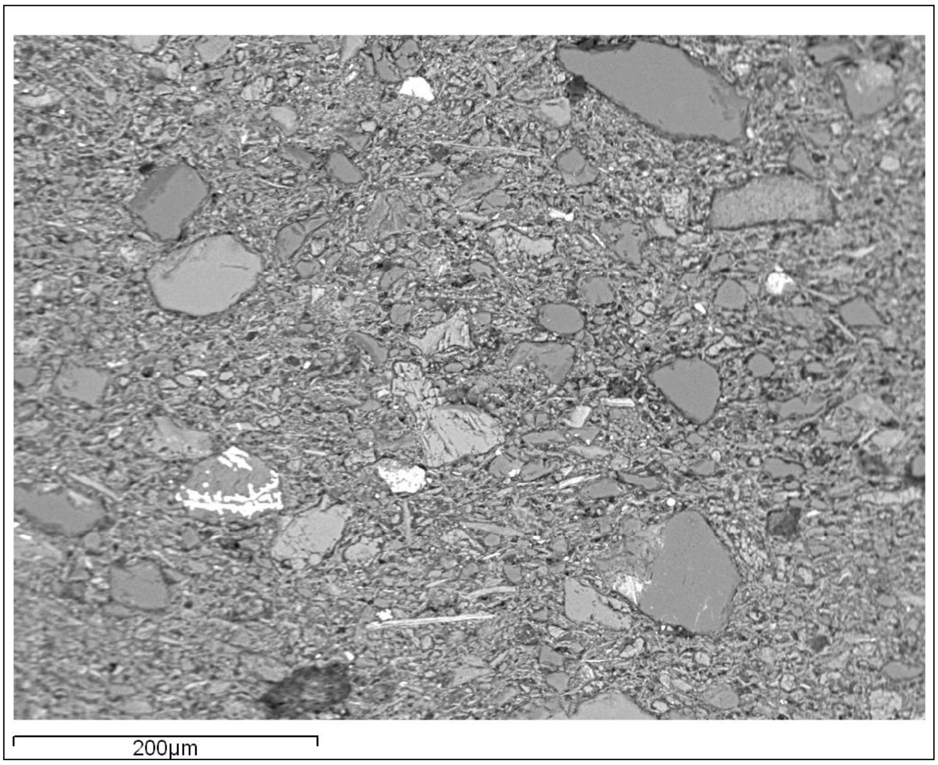


Figure 5.2. BSE image of Akhsiket 23/16.1 body fabric as an example of the inclusion characteristics typical of the Akhsiket finewares.

Petrography can reveal more information on the inclusions visible only as flat shapes in shades of grey in a BSE image. A small selection of 16 samples served as a case study to test whether petrographical analysis could provide further useful information on groupings, and to provide a set of data for comparison to other petrographic studies.

It is possible to differentiate three groups (Table 5.3). The three main groups are differentiated by slight variations in type and number of inclusions and matrix characteristics, subtle differences that may indicate different production processes – either in the clay sources, or in clay preparation. Monocrystalline quartz is the major inclusion type in these fabrics. In general they are all very fine and dense, with few pores. Fabric 3 consists of a single sherd (23/12.5) which is a red-slipware sherd in the Hellenistic style and Fabric 4 consists of sphero-conical wares. These were not thin-sectioned for petrographical analysis, so do not have a corresponding Petrofabric group.

This petrographical case study indicates that it could be useful to carry out a more widespread thin-section study in future to see a) if these groupings hold across a wider selection of samples, and b) if there are other groups which have not yet been discovered. The groups are not replicated in the SEM data, as the differences are too minor to be visible in bulk analytical results.

Fabric type 1 Pinkish red to pinkish buff, soft, very fine, tiny white, red and dark brown inclusions Samples in this group: 23/2-8.11 23/11c.1 23/13.1 23/15.1 24/33	Petrofabric 1 Inclusions: Size: ~10-15% 50-100μm, to ~40-50% 5-20μm Sorting: Moderate to well-sorted Shape: sub-angular and angular inclusions, smaller inclusions are sub-rounded to rounded Density: 15%, a couple examples 25-35% Well-evolved, except quartz Matrix The matrix is iron rich and shows some vitrification	95% monocrystalline quartz, 5% polycrystalline Some quartz ingrown with iron minerals or mica Some granite or schist grains in a few examples < 5% mica Many opaques Few feldspars
Fabric type 2 Buff, soft, with very fine, tiny white, red and dark brown inclusions. Slightly larger and more frequently occurring red inclusions than Fabric 1. Samples in this group: 23/2-8.8 23/11b.1 23/13.2 23/14.16 24/30	Petrofabric 2 Inclusions: Size: 5-20μm. Few 50-100μm Sorting: Very well sorted Shape: sub-angular and angular inclusions, smaller inclusions sub-rounded and rounded. Pores are long and thin. Density: mostly ~15% Well-evolved Matrix The matrix is iron-rich.	Mostly monocrystalline quartz, some polycrystalline in a few examples Many opaques Some calcite Few feldspars Trace mica
Fabric type 5 Red, medium hard to hard, tiny brown and white inclusions, less fine than Fabrics 1 and 2. Samples in this group: 23/2-8.17 23/11c.2 23/12.9 23/15.5 24/29	Petrofabric 3 Inclusions Size: 5-20μm Sorting: Poor to very well sorted Shape: sub-angular and (mostly) angular inclusions Density: 20-30% less well-evolved in comparison to other fabric types, and more variation in grain distribution and grain types. Matrix The matrix is iron-rich.	Mostly monocrystalline quartz, few polycrystalline Some calcite Some feldspars (crosshatch twinning) Some mica, also mixed with quartz possibly granite grains in some cases

Table 5.3. Fabric types and petrofabric groupings for Akhsiket thin-sectioned pottery.

5.2. Lead glazed wares: slips and glazes

5.2.1. Slipwares

The most common class of glazed pottery found at Akhsiket are the **slipwares**. These include polychrome slipware, incised wares, and 'Samanid' ware. Chapter 3.4.1 gives a detailed description of the typology of these styles. The term 'slipware' generally refers to the use of one or more coloured slips applied over a white slip ground, or engobe, which is then covered by a thin lead glaze. Some samples also utilise pigments. Samples chosen for analyses represent common styles found at Akhsiket, and were also selected to provide a wide range of slip and glaze colours commonly found.

Polychrome slipware fabric types and decoration styles		
Sample	**Fabric type**	**Style code**
15/1.1	5	TP
24/26	5	PM
24/35	1	TP
23/2-8.17	5	PM
23/11a.2	1	PR
23/12.2	1	PM
23/12.13	5	PM
9/3.3	1	PM
23/14.4	1	PM
23/15.1	1	SW
23/16.1	5	PM

Table 5.4. Polychrome slipware fabric type and decoration style for each sample with analysed glaze. See Table 5.2 for a key to the style codes.

Figure 5.3. Images of polychrome slipware sherds analysed by SEM-EDS.

Polychrome slipware

Sample population: Eleven polychrome slipware sherds were analysed (Figure 5.3; see Appendix A for full analytical results). All of these samples have a white engobe except for sample 23/2-8.17 which has a red slip ground.

Engobe characteristics: The engobe is generally between 100 and 200 microns thick, and usually finer in texture than the earthenware bodies. The engobe consists of mostly quartz and alumino-silicates, mixed with fine clay. Lead has leached into the engobe during firing to between 7% and 20% (Table 5.5). With PbO removed and the remaining elements normalised, the true composition of the engobe can be seen (Table 5.6). Silica is very high in comparison to the bodies (Table 5.1), at 72.4% on average for these samples, while alumina and potash are also higher at 15.9% and 5.8%. Lime and iron are very low – 3.1 and 0.8% respectively. Potash is higher than the body, and may be due to the use of felspathic sands as the quartz component. See Chapter 7 for further discussion of raw material sources.

Polychrome slipware engobe										
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**TiO2**	**PbO**	
9/3.3	0.9	0.7	10.7	70.8	6.5	1.2	0.6	0.7	7.9	n=3
15/1.1	0.2	0.0	8.9	73.4	3.0	1.1	0.3	1.1	11.9	n=2
23/11a.2	0.5	1.0	16.0	63.1	4.9	1.4	0.0	0.0	13.1	n=5
23/12.2	0.3	0.0	16.0	59.6	7.4	0.5	0.6	0.5	14.9	n=9
23/12.13	0.7	0.8	12.6	71.1	3.7	4.1	0.3	0.1	6.6	n=3
23/14.4	1.0	1.8	16.9	61.8	6.0	5.2	0.2	0.2	7.0	n=3
23/15.1	0.9	2.3	16.6	60.8	3.7	6.6	1.3	0.2	6.8	n=3
24/26	1.0	0.6	14.2	57.3	5.3	3.6	1.4	0.8	15.4	n=2
24/35	1.5	0.0	13.6	56.7	5.1	1.4	1.4	0.2	20.2	n=3
Average	**0.8**	**0.8**	**13.9**	**63.8**	**5.1**	**2.8**	**0.7**	**0.4**	**11.5**	
St. Deviation	0.4	0.8	2.8	6.3	1.4	2.2	0.5	0.4	4.8	
St. Error	0.1	0.3	0.9	2.1	0.5	0.7	0.2	0.1	1.6	

Table 5.5. SEM-EDS results in wt. % for polychrome engobe.

Polychrome slipware engobe (without PbO)								
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**TiO2**
15/1.1	0.2	0.0	9.9	81.9	3.4	1.3	0.3	1.3
24/26	1.2	0.7	17.0	68.7	6.3	4.3	1.7	1.0
24/35	1.8	0.0	17.1	71.2	6.5	1.7	1.7	0.3
23/11a.2	0.6	1.2	18.4	72.7	5.7	1.6	0.0	0.0
23/12.2	0.4	0.0	19.0	70.6	8.7	0.6	0.7	0.6
23/12.13	0.8	0.9	13.5	76.2	3.9	4.4	0.3	0.1
9/3.3	0.9	0.8	11.7	77.5	7.1	1.4	0.6	0.8
23/14.4	1.0	2.0	18.2	66.5	6.5	5.6	0.2	0.2
23/15.1	1.0	2.5	18.0	66.0	4.0	7.2	1.4	0.3
Average	**0.9**	**0.9**	**15.9**	**72.4**	**5.8**	**3.1**	**0.8**	**0.5**
St. Deviation	0.5	0.9	3.3	5.3	1.7	2.3	0.7	0.4
St. Error	0.2	0.3	1.1	1.8	0.6	0.8	0.2	0.1

Table 5.6. SEM-EDS results in wt. % for Akhsiket polychrome slipware engobe with PbO removed and normalized to 100%.

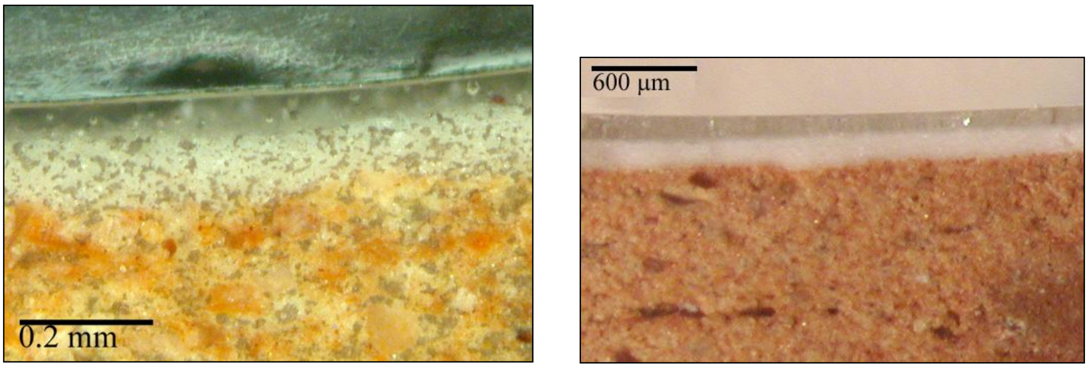
Glaze characteristics: The thickness of the **colourless glazes** ranges from 75 microns to ~ 200 microns. The glazes are usually fairly homogenous and fully fused, with the exception of occasional relict grains of quartz. The surface of the glaze, although normally smooth and straight, is sometimes marred by bubbles (sample 23/11a.2), chipped areas (sample 23/12.2) or flaking (sample 24/35). Much of this is probably due to post-depositional weathering.

Optical microscopy (OM) images (Figure 5.4 below) show that the line between glaze and engobe can be blurred – for example, in 9/3.3, the glaze is whiter at the interface with the engobe due to the higher concentration of digested and reacted quartz which comes about during firing. In some cases, the glaze is very clear (23/15.1), in others yellowish (23/12.13) or greenish (23/11a.2 and 23/12.2) when viewed as a cross section. Backscatter electron (BSE) images show most clearly the homogenous compositional nature of the colourless lead glazes, with occasional relict quartz or alumino-silicate grains, and the occasional gas bubble (Figure 5.5). The high lead content leads to a white appearance in the BSE images that is sharply defined along the intersection with the underlying engobe, and the engobe itself is to some extent brighter than the underlying body due to leached lead.

Table 5.7 shows that the colourless glazes contain an average of 53.8 wt.% lead, although this varies by up to 30%. The highest lead oxide concentration is from number 23/16.1 at 69.7%. However, even with the value for this sherd removed, the average changes little (to 52.2%) and the variation remains high at around 22%. The minor elements show some variation between samples. Soda and potash are positively correlated for the most part. Lime does not correlate very closely to the alkalis or with magnesia. Sample 24/35 has the highest concentration of minor elements – adding up in total to ~11%, or twice the average. The lowest is 23/16.1 which contains a total of 1.4% minor elements. The silica source is the likely source of minor elements and alumna, and variations in these could indicate different silica sources.

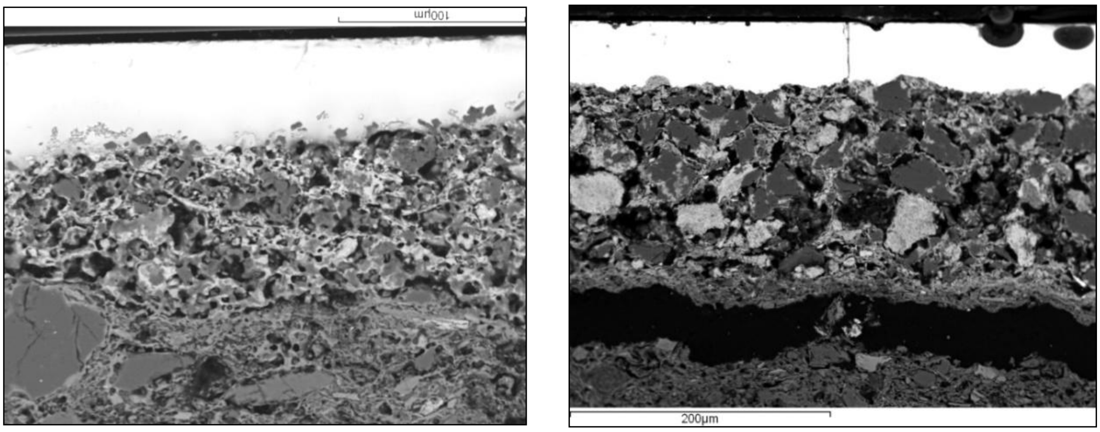
With PbO removed and renormalized to 100%, the remaining elements can be compared to the underlying engobe. Silica is now around 30% higher in the glaze than the engobe (Table 5.8), while all the other elements are lower than the engobe. This indicates that silica was part of the lead glaze slurry – a method of application discussed further in Chapter 7.

According to the differences seen in near-body (lower) areas and near-surface (upper) areas of the glazes (Table 5.9 – now including the lead oxide), the engobe was dissolved at varying rates from sample to sample. In one case silica is 1% *lower* near the body than at the surface; in another it is as much as 6% higher at the body. Alumina is always higher near the body, by 0.5% to 2%, with a similar pattern seen in potash concentrations, indicating absorption of clay from the engobe. Differences in soda, lime and iron concentrations do not appear to correlate to upper or lower areas of the glaze. All are present at < 1% and therefore any change in these may be too small to be detected (e.g. if the differences are less than 0.1%).

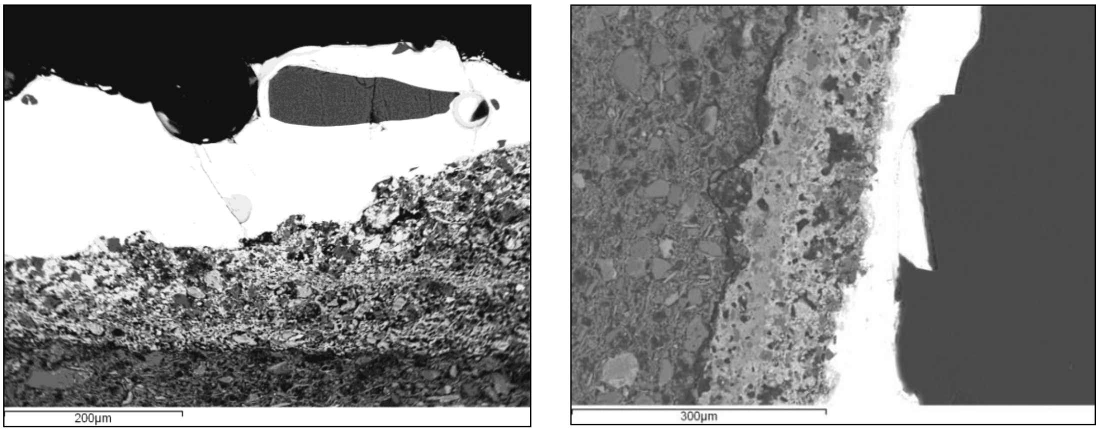


9/3.3 23/15.1

Figure 5.4. OM images of two Akhsiket polychrome colourless glazes showing in cross-section (from top to bottom): resin block, glaze, engobe, and body fabric.



9/3.3 (scale is 100 µm) 15/1.1 (scale is 200 µm)



23/11a.2 (scale is 200 µm) 23/12.2 (scale is 300 µm)

Figure 5.5. BSE images of Akhsiket polychrome colourless glazes showing in cross-section (from top to bottom or right to left): resin block, glaze, engobe, and body fabric.

Polychrome slipware colourless glazes

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	
9/3.3	0.7	0.1	3.8	50.9	3.2	0.3	0.2	40.9	n=6
15/1.1	0.0	0.0	1.4	35.2	0.0	0.8	0.4	62.2	n=2
23/2-8.17	0.0	0.0	3.7	35.7	0.8	0.7	0.9	57.9	n=2
23/11a.2	0.1	0.0	3.0	41.9	1.6	0.6	0.0	52.8	n=4
23/12.2	0.2	0.0	5.3	45.9	1.2	0.9	0.0	46.5	n=10
23/12.13	0.1	0.0	2.3	36.2	1.0	0.4	0.2	59.7	n=4
23/14.4	0.8	0.0	3.4	41.4	1.8	0.9	0.1	51.6	n=4
23/15.1	0.0	0.3	3.6	42.7	1.5	0.5	1.4	49.8	n=3
23/16.1	0.0	0.0	1.0	28.8	0.0	0.1	0.3	69.7	n=6
24/26	0.5	0.0	2.0	35.4	0.9	1.0	0.0	60.1	n=2
24/35	0.6	0.7	3.3	48.9	2.6	2.7	1.0	40.1	n=5
Average	**0.3**	**0.1**	**3.0**	**40.3**	**1.3**	**0.8**	**0.4**	**53.8**	
St. Deviation	0.3	0.2	1.2	6.7	1.0	0.7	0.5	9.2	
St. Error	0.1	0.1	0.4	2.0	0.3	0.2	0.1	2.8	

Table 5.7. SEM-EDS results in wt. % for Akhsiket polychrome colourless lead glazes.

Polychrome slipware colourless glazes (without PbO)

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3
9/3.3	1.1	0.1	6.4	86.0	5.4	0.5	0.3
15/1.1	0.0	0.0	3.7	93.2	0.0	2.0	1.1
23/11a.2	0.3	0.0	6.4	88.8	3.4	1.2	0.0
23/12.2	0.4	0.1	9.8	85.8	2.2	1.6	0.0
23/12.13	0.3	0.0	5.8	89.8	2.6	1.0	0.4
23/14.4	1.6	0.0	7.1	85.5	3.8	1.8	0.3
23/15.1	0.0	0.7	7.2	85.4	3.0	1.1	2.7
24/26	1.3	0.0	5.0	88.8	2.3	2.5	0.0
24/35	1.1	1.1	5.5	81.7	4.4	4.5	1.7
Average	**0.7**	**0.2**	**6.3**	**87.2**	**3.0**	**1.8**	**0.7**
St. Deviation	0.6	0.4	1.7	3.3	1.5	1.2	0.9
St. Error	0.2	0.1	0.6	1.1	0.5	0.4	0.3

Table 5.8. SEM-EDS results in wt. % for Akhsiket polychrome colourless lead glazes, PbO removed.

Polychrome slipware colourless glazes, upper v. lower values

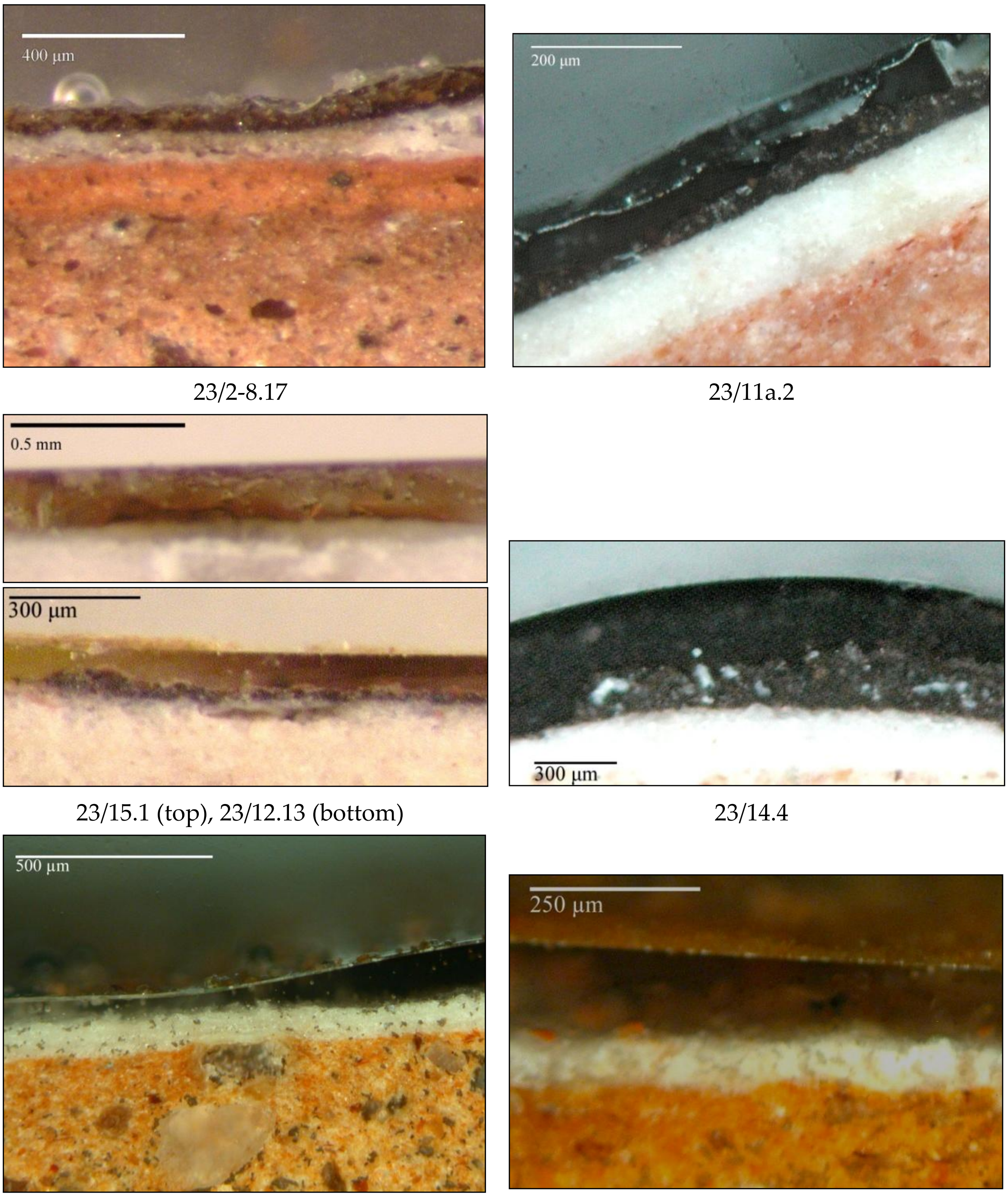
Sample	Area	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	
9/3.3	upper	0.7	0.0	3.4	50.7	3.1	0.4	0.3	41.6	n=4
	lower	0.8	0.0	6.0	56.4	4.6	0.0	0.0	32.2	n=1
23/11a.2	upper	0.2	0.0	2.3	39.5	1.2	0.6	0.0	56.2	n=2
	lower	0.0	0.0	3.7	44.4	2.0	0.5	0.0	49.4	n=2
23/12.2	upper	0.0	0.1	3.5	46.2	0.8	0.9	0.0	48.5	n=5
	lower	0.5	0.0	7.0	45.6	1.6	0.9	0.0	44.5	n=5
23/12.13	upper	0.0	0.0	2.1	35.2	0.9	0.3	0.0	61.5	n=2
	lower	0.2	0.0	2.6	37.2	1.2	0.5	0.3	58.0	n=2
23/14.4	upper	0.7	0.0	2.7	40.1	1.6	0.9	0.3	53.8	n=2
	lower	0.9	0.0	4.1	42.7	2.0	0.8	0.0	49.4	n=2
24/35	upper	0.7	0.6	3.2	49.3	2.7	2.8	1.0	39.8	n=3
	lower	0.6	0.7	3.5	48.4	2.6	2.6	1.1	40.5	n=2

Table 5.9. SEM-EDS results in wt% for Akhsiket polychrome colourless lead glazes, upper v. lower values.

Black coloured glazes on polychrome slipwares (as with the Samanid wares, below), are coloured with iron and/or manganese oxides originating from underlying black slips or pigments – not by the application of a pre-coloured glaze. In many cases these oxides have diffused more or less evenly throughout the glaze and, where pigments have been used, may leave no traces of the original pigment layer.

Sample 23/2-8.17 for example, has a black glaze with no visible slip. It is likely that a pigment was used in this case, which has fully reacted with the overlying glaze. Some colour has also leached into the underlying engobe (Figure 5.6). Sample 23/15.1 appears to show a dark brown layer at the bottom of the glaze which is probably the remains of a pigment, but could also be a very thin slip (which could also leach into the glaze). Sample 23/11a.2 (and possibly 23/12.13 and 23/14.4) show a black slip in use.

The BSE images clearly show that these glazes are more likely than the colourless glazes to have a crystalline interface (Figure 5.7). In the image of 9/3.3 the division between the colourless glaze (on the left side of the sherd, showing no crystalline interface) and the black (on the right, with a very thick crystalline layer) is clear. All the BSE images show some evidence of an interface in the black glazes except 23/11a.2. These interface layers range from < 50 microns to a maximum of 100 microns. Although difficult to analyse due to contamination from the surrounding glaze, these crystals are generally high in alumina and potash, indicating K-feldspar minerals.

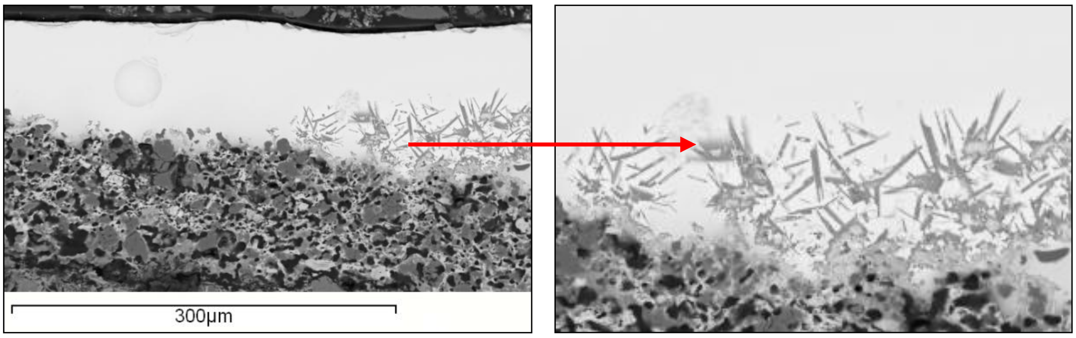


23/2-8.17 23/11a.2

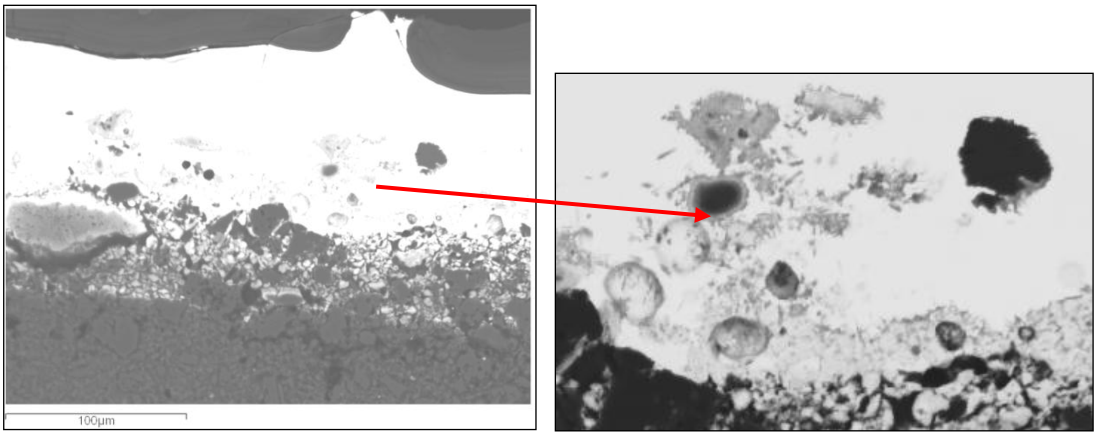
23/15.1 (top), 23/12.13 (bottom) 23/14.4

24/35 24/26

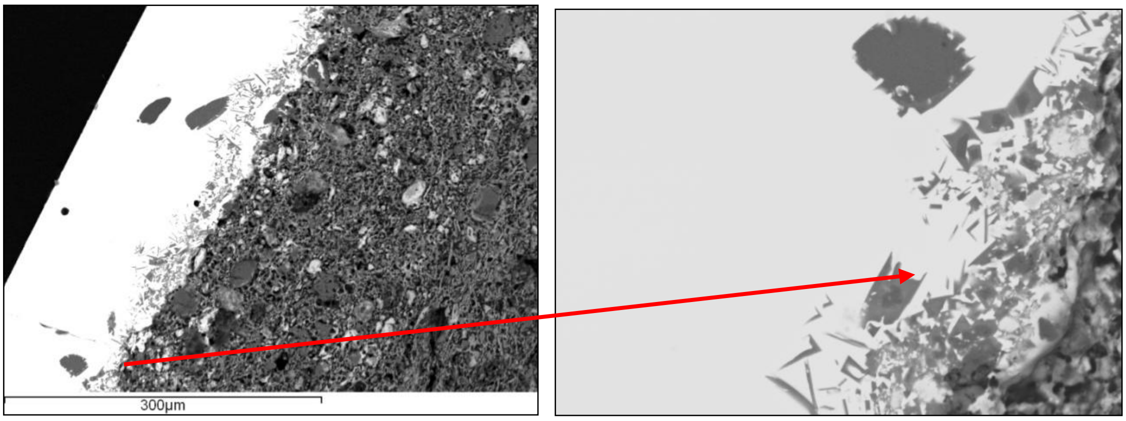
Figure 5.6. OM images of some Akhsiket polychrome black glazes showing (top to bottom): resin block, glaze, coloured slip (where it exists), engobe, and body fabric. Sample 23/208.17 shows a rather weathered glaze. Samples 23/11a.2 23/12.13 and 23/14.4 clearly use coloured slips for the black decoration. The others likely used a pigment, remains of which may be seen in 23/2-8.17 and 23/15.1 (staining of the engobe and lack of clay slip layer).



9/3.3 9/3.3



23/2-8.17 23/2-8.17



23/14.4 23/14.4

Figure 5.7. BSE images of some Akhsiket polychrome black glazes. The images on the left show (top to bottom or left to right): resin block, glaze, engobe and body fabric. Slip layers on 9/3.3 and 23/14.4 are not visible in BSE images. On the right are detail images of the interface areas showing the crystalline growth visible in cross-section.

The black glazes have an average of 2.4 wt.% Fe_2O_3 and 1.1% MnO in the body of the glaze (see Table 5.10). Values range from 1.0 to 5.6 for Fe_2O_3 and 0.1 to 3.6 for MnO, both clearly highly variable and not necessarily correlated. In some cases, these values are much higher at or near the interface, and where this is the case these areas have not been included in the averages seen below. The uptake of Fe_2O_3 and MnO from the pigments and slips is probably due to a number of factors, including the thickness and density of the pigment as well as the glaze overlying it, the temperature and duration of firing in the kiln, and the composition of the glaze recipe – discussed further in Chapter 7.

Alumina and potash are as expected higher near the body, while lead oxide is lower (Table 5.11). However, silica is not uniformly higher near the body, as seen in the colourless glazes. In samples 9/3.3, 23/11a.2, 23/12.2 and 24/35 silica is (on average) slightly higher near the surface of the glaze. The higher iron concentration near the body demonstrates the diffusion of iron oxide into the glaze from the underlying colouring minerals. This increase may have resulted in a lowering of the silica concentrations from the glaze slurry, whereas clay minerals have been diffused into the glaze as normal. MnO is less consistent and in most cases slightly higher at the surface.

The glaze/engobe interfaces are largely made up of K-feldspar and other alumino-silicate crystals formed during cooling after firing. Analysis of these inclusions (Table 5.12) shows high silica, alumina and potash. Occasional relict iron minerals are also seen at the interface, as in the case of 9/3.3. For further discussion of the interface layers and their significance with regards to ceramic production see Chapter 7.

Although the image of sample 23/14.4 shows a thick black layer at the top edge of the vessel rim (see Figure 5.6), this tapers out and disappears under an otherwise black-coloured slip. It is likely that this slip was unevenly applied and the thinner areas fully diffused into the glaze. In Figure 5.8, the red arrow indicates the location of an area scan of the engobe where there is no visible black slip, and which has low iron and undetectable manganese oxide (i.e. a normal engobe composition), while the green arrow indicates an interface scan where high iron and manganese oxides *were* present. The visible mineral crystals are not iron or manganese rich, however – they are K-feldspars, formed from the digestion of clay minerals during firing. See Table 5.13 for SEM-EDS results of analyses from the same area shown in Figure 5.8.

Polychrome slipware black glazes

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	MnO	
9/3.3	0.4	0.0	3.7	42.0	2.2	0.6	4.0	45.3	1.8	n=4
23/2-8.17	0.0	0.0	3.5	36.0	1.0	0.6	5.6	52.5	0.9	n=3
23/11a.2	0.2	0.0	2.9	43.7	1.8	0.7	1.3	49.3	0.1	n=8
23/12.2	0.1	0.1	4.9	41.8	1.0	0.8	2.6	47.7	0.9	n=8
23/14.4	1.1	0.1	4.2	43.4	2.6	2.2	1.0	45.4	0.1	n=5
23/15.1	0.3	0.0	3.6	44.1	1.7	0.5	2.2	47.0	0.6	n=2
24/26	0.5	0.1	2.5	36.2	1.1	1.1	1.0	56.8	0.6	n=3
24/35	0.4	0.7	4.1	45.6	2.8	2.0	1.9	38.8	3.6	n=8
Average	**0.4**	**0.1**	**3.7**	**41.6**	**1.8**	**1.1**	**2.4**	**47.8**	**1.1**	
St. Deviation	0.3	0.2	0.8	3.6	0.7	0.7	1.6	5.3	1.2	
St. Error	0.1	0.1	0.3	1.3	0.3	0.2	0.6	1.9	0.4	

Table 5.10. SEM-EDS results in wt. % for Akhsiket polychrome black glazes.

Polychrome slipware black glazes, upper v. lower values

Sample	Area	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	MnO	
9/3.3	upper	0.2	0.0	2.5	42.9	1.7	0.6	1.4	48.5	2.2	n=2
	lower	0.5	0.0	5.5	40.9	3.0	0.5	8.4	38.7	2.4	n=1
23/11a.2	upper	0.1	0.0	2.5	43.9	1.6	0.7	0.7	50.3	0.1	n=4
	lower	0.2	0.0	3.2	43.5	2.0	0.7	1.9	48.4	0.1	n=4
23/12.2	upper	0.0	0.2	3.0	42.9	0.8	0.8	1.3	49.8	1.1	n=4
	lower	0.1	0.0	6.8	40.7	1.3	0.8	3.9	45.5	0.8	n=4
23/14.4	upper	1.1	0.3	3.4	42.6	2.3	2.7	0.9	46.8	0.0	n=2
	lower	1.3	0.0	5.5	44.4	3.1	2.5	1.0	42.1	0.0	n=2
24/26	upper	0.4	0.2	2.0	35.8	0.9	1.2	0.9	57.8	0.7	n=2
	lower	0.7	0.0	3.5	37.0	1.3	1.1	1.2	54.6	0.5	n=1
24/35	upper	0.3	0.7	3.8	46.0	2.7	2.1	1.9	38.7	3.7	n=5
	lower	0.5	0.7	4.8	44.9	2.8	2.0	1.8	39.0	3.5	n=3

Table 5.11. SEM-EDS results in wt. % for Akhsiket polychrome black glazes, upper v. lower values.

Polychrome slipware black glazes, inclusions and interfaces

Sample	Area	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	MnO	
9/3.3	Inclusion	0.7	0.0	8.3	26.8	3.9	1.0	48.1	0.0	7.1	4.2	n=1
23/14.4	Inclusion	0.4	0.0	16.8	66.2	16.6	0.0	0.0	0.0	0.0	0.0	n=1
23/15.1	Inclusion	1.0	0.6	25.8	44.1	5.3	2.1	0.9	0.0	20.3	0.0	n=1
23/2-8.17	**Interface**	**0.8**	**0.0**	**18.4**	**39.4**	**3.1**	**0.0**	**1.9**	**0.0**	**35.6**	**0.8**	**n=2**
23/12.2	**Interface**	**0.0**	**0.0**	**9.4**	**35.4**	**5.2**	**1.0**	**16.0**	**0.6**	**31.6**	**0.9**	**n=1**
23/14.4	**Interface**	**1.0**	**0.0**	**10.5**	**47.9**	**7.3**	**0.0**	**10.0**	**0.0**	**22.9**	**0.4**	**n=2**

Table 5.12. SEM-EDS results in wt. % for Akhsiket polychrome black glazes, inclusions and (in bold) interfaces.

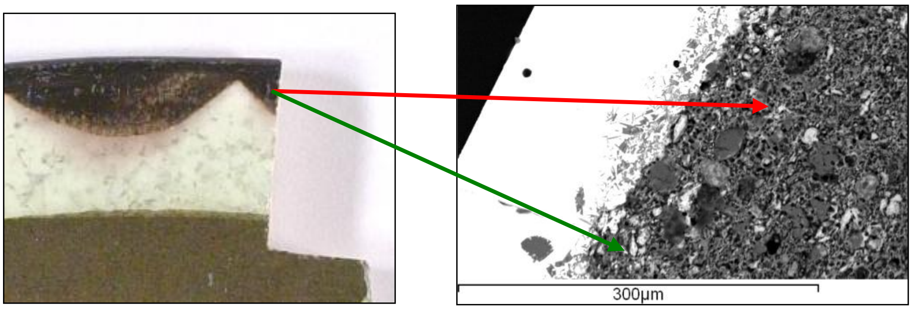


Figure 5.8. Sample 23/14.4 OM and BSE images. Here a black pigment was probably used to colour the glaze. The OM image on the left shows a top view of the sherd decoration – a scalloped rim and an olive horizontal band over white. The right BSE image shows (left to right): sample resin, glaze, and engobe. The arrows show approximately where, on the cut of the sherd, the analyses have been taken - referred to in the text above.

Akhsiket 23/14.4 black glaze, interface and engobe

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	MnO	
Glaze	0.7	0.0	3.1	43.0	2.1	0.6	1.0	49.0	0.7	n=1
Interface	1.0	0.0	10.5	47.9	7.3	0.0	10.0	22.9	0.4	n=2
Crystal	0.4	0.0	16.8	66.2	16.6	0.0	0.0	0.0	0.0	n=1
Engobe	0.9	2.0	17.1	60.5	6.1	5.5	0.3	7.6	0.0	n=2

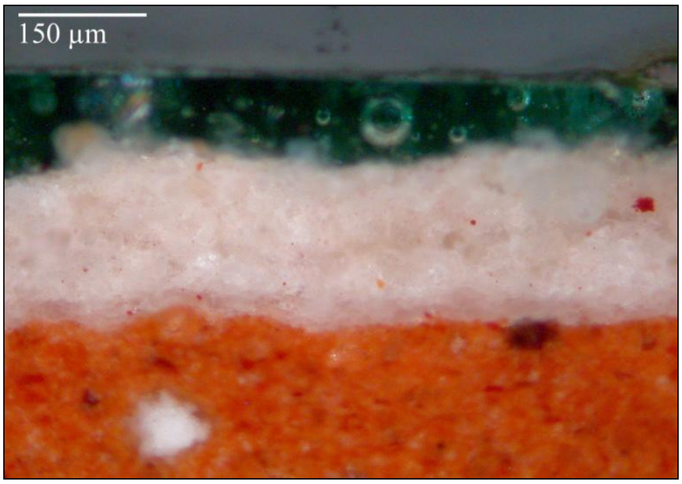
Table 5.13. SEM-EDS results in wt. % for sample 23/14.4 black glaze, interface and engobe.

Green coloured glaze: the 12th century polychrome incised wares – of which two have been analysed - usually include a green design element such as lines or dots. These are pre-coloured glazes, applied under or over the colourless glaze. The glazes are fairly diffuse, of a different colour temperature and hue to the typical olive green slip-painted decoration, and similar to the greens used on the monochrome green glazed wares (see below).

OM images show the glassy, dark glaze with bubbles, and some areas of less-well diffused silica (Figure 5.9) The BSE image for Akhsiket 15/1.1 shows a uniform glaze. In 24/35 the green glaze has a mottled appearance, with patches of darker grey distributed more or less evenly across the thickness of the glaze (Figure 5.10).

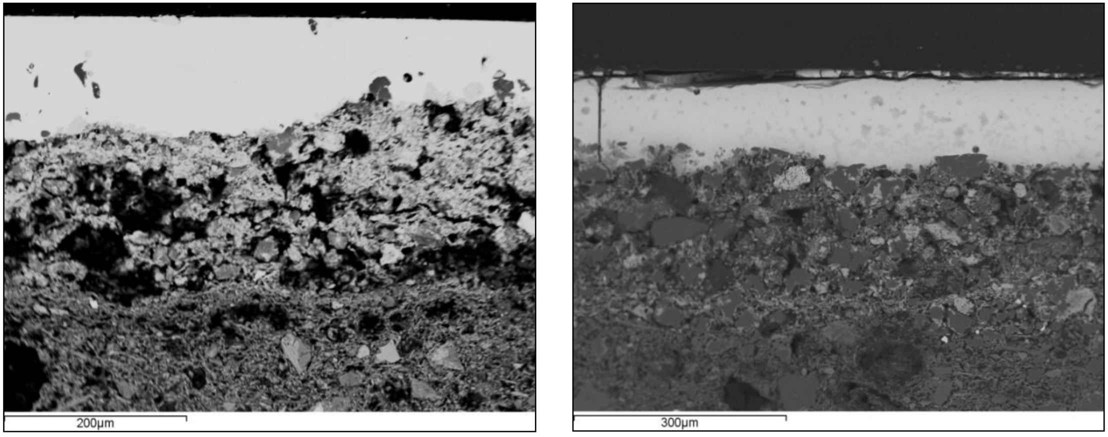
SEM-EDS analysis shows that these glazes have high amounts of lead oxide and 3.4%/1.9% copper oxide included as a colorant (Table 5.14). With copper oxide removed, the base glaze shows some differences between the two samples. 15/1.1 has a very high lead glaze, with 62% lead, and is only lightly contaminated with minor elements – 2.4% in total, with no soda, magnesia or iron oxide detected, and very low alumina at 1.6%. 24/35, on the other hand, has slightly less lead than silica (42%/47%), and 11.1% total minor elements, including all the typical alkalis, alkaline earths and iron oxide, and 4.4% alumina.

In comparison to the colourless glazes, it is clear that the green glazes were made from the same batch as the respective colourless glazes (see the colourless analyses in italics in Table 5.14). So the silica in 15/1.1 is 35.7% (copper removed) compared to the colourless glaze on the same sherd which is 35.2%, and so on.



15/1.1

Figure 5.9. OM image of Akhsiket polychrome green glazes.



15/1.1 24/35

Figure 5.10. BSE images of Akhsiket polychrome green glazes.

Polychrome slipware green glazes										
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**CuO**	
15/1.1	0.0	0.0	1.5	34.4	0.1	0.7	0.0	59.9	3.4	n=3
24/35	0.2	0.6	4.3	46.1	2.7	2.1	1.1	41.2	1.9	n=5
15/1.1[1]	**0.0**	**0.0**	**1.6**	**35.7**	**0.1**	**0.7**	**0.0**	**62.0**		
24/35	**0.2**	**0.6**	**4.4**	**47.0**	**2.7**	**2.1**	**1.1**	**42.0**		
15/1.1[2]	*0.0*	*0.0*	*1.4*	*35.2*	*0.0*	*0.8*	*0.4*	*62.2*		
24/35	*0.6*	*0.7*	*3.3*	*48.9*	*2.6*	*2.7*	*1.0*	*40.1*		

[1] Without CuO (in bold), [2] Colourless glazes (in italics)

Table 5.14. SEM-EDS results in wt. % for Akhsiket polychrome green glazes.

Slip paint characteristics: Sample 23/11a.2 uses a genuine slip-paint for its black decoration (Figure 5.6), which is rich in iron and manganese oxide, and as coarse as the underlying engobe (Table 5.15). The slip has high iron oxide (28.5%) and manganese oxide (12.3%). The glaze itself has low concentrations of these colorants. With the colorants (and barium oxide) removed, the black slip is nearly identical to the engobe. It is highly likely that the coloured slip was prepared from the same batch of clay as the white engobe.

Akhsiket 23/11a.2 black glaze, slip, and engobe												
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**TiO2**	**PbO**	**MnO**	**BaO**	
Glaze	0.2	0.0	2.9	43.7	1.8	0.7	1.3	0.0	49.3	0.1	0.0	n=8
Black slip	0.3	0.6	8.9	35.0	2.8	1.1	28.5	0.2	8.2	12.3	2.1	n=3
Black slip[1]	0.5	1.1	15.6	61.2	4.9	1.9	0.0	0.4	14.4	0.0	0.0	n=3
Engobe	0.5	1.0	16.0	63.1	4.9	1.4	0.0	0.0	13.1	0.0	0.0	n=5

[1] with Fe2O3, MnO and BaO removed for comparison with engobe

Table 5.15. SEM-EDS results in wt. % for Akhsiket 23/11a.2 black glaze, black slip and engobe.

Olive slips were used for the olive decorations on the four Akhsiket sherds sampled here. These slips are ~100 microns thick, and stain the glaze overlying them (Figure 5.11). The colorant occurs in the glaze due to digestion of the chromium-rich minerals used in the slip – such minerals can be seen as relict crystals in the glaze of sample 23/14.4, near the interface with the slip (see Figure 5.12). Analysis of this area, dominated by the chromium-rich inclusion, is shown in Table 5.19, below.

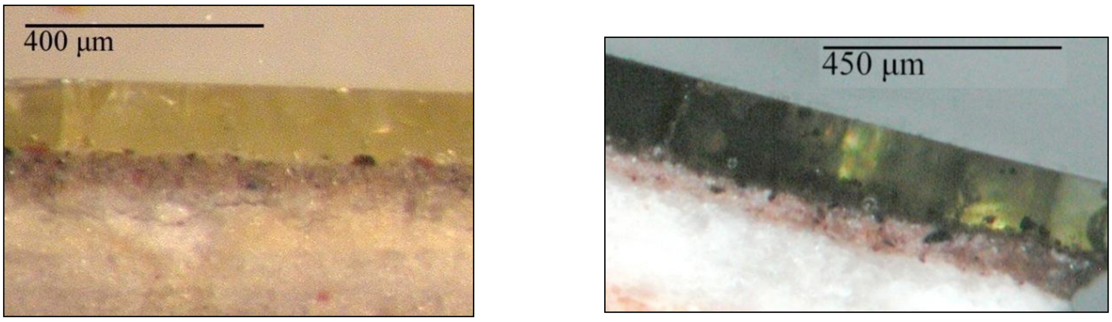
The slips themselves are similar in composition to the engobe as shown in Table 5.17 (renormalized without PbO, to show a more accurate comparison). Silica is almost identical, as are soda, magnesia and titanium oxide. Lime and potash are slightly lower. Alumina is several percent lower, possibly due to the increased iron (which ranges from 0.9 to 3.9) and chromium (1.2 to 4.1%). In the full results, there are familiar variable levels of leached PbO (5.1 to 12.9%) as shown in Table 5.16. The variations in iron and chromium (and the 0.8% MnO) are due to differences in size and density of colouring minerals in the slip.

Sample 23/12.13 shows an interface layer of some sort (Figure 5.12), but there is no detected chromium oxide in this layer, and only slightly higher iron oxide. It is otherwise characterised chemically only by a small increase of silica and alumina, as normal.

Sample 24/35, an example of 12th century polychrome decoration has olive slip painted on the engobe, with black pigment applied over it at certain points. Chromium is only detectable however in the slip under the black pigment (in two of the four scans – see Appendix A).

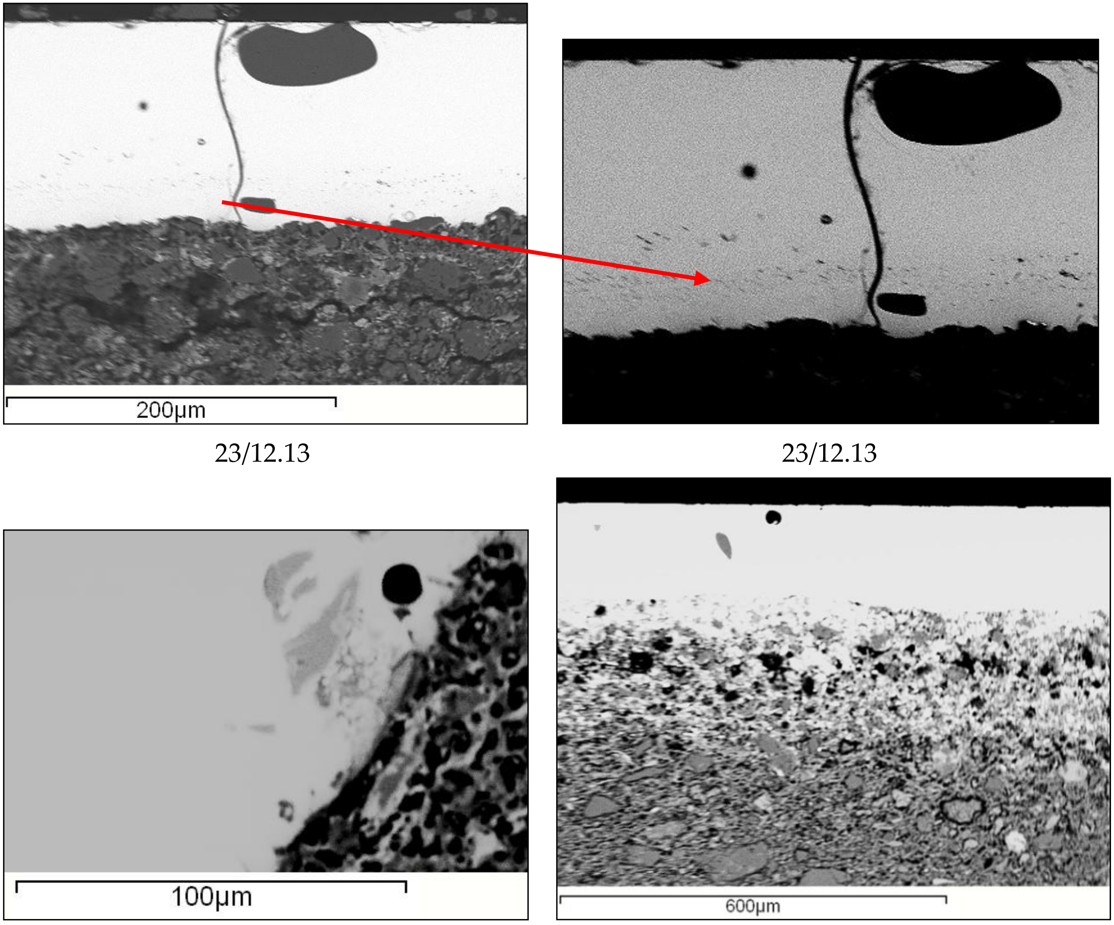
Chromium oxide, a strong colorant, may need to be present in only trace amounts in order to produce a slightly yellow stain to the glaze. Glazes over the olive slips show only small evidence of chromium oxide, with one scan near the body of 23/14.4 glaze containing 0.5% chromium oxide –due to relict mineral grains near the interface being included in the scan (Table 5.18). The glazes do appear slightly olive in cross section, although it is usual for otherwise colourless glazes to appear coloured from this angle.

The chromium-rich crystals seen at the interface between the slip and the glaze have been analysed in a single sample, where they were visible in the BSE image. This is an area scan of the glaze that includes a cluster of the relict minerals. This scan shows that Cr_2O_3 is high (27.6%), MgO, Al_2O_3 and Fe_2O_3 are elevated in comparison to the base glaze, and there is also 1.2% CuO (Table 5.19). The exact mineral is not completely clear, although it falls roughly within the expectations of chromite $(Mg, Fe)Cr_2O_4$ and appears dark as chromite should through the optical microscope. A similar composition is cited by Okyar for chromite minerals in glaze (2000, 201).



23/12.13 23/14.4

Figure 5.11. OM images of olive slips and glazes showing (from top to bottom): resin block, glaze, olive slip, and engobe. Dark chromium-rich minerals can be seen at the glaze interface and in the slips.



23/12.13 23/12.13

23/14.4 23/16.1

Figure 5.12. BSE images of olive slips and glazes showing (from top to bottom): resin block, glaze, slip and engobe (and body fabric in 23/16.1). The top right image is a detail view of the top left image with lowered contrast to show the small dark inclusions visible along bottom of the glaze cross-section. Sample 23/14.4 shows a detail view of the chromium-rich crystals in the glaze (in darker grey than the surrounding glaze). Sample 23/16.1 also shows grey chromium-rich inclusions in the glaze along the interface with the slip.

Polychrome slipware olive slips

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	Cr2O3	MnO	
23/12.13	0.2	1.0	10.4	71.7	2.9	1.7	0.8	1.3	8.7	1.2		n=2
23/14.4	0.9	1.9	14.2	63.7	5.4	4.1	1.1	0.8	5.1	2.9		n=2
23/16.1	0.2	1.3	10.0	63.9	2.7	1.2	3.4	0.0	13.8	3.5		n=4
Average	**0.4**	**1.4**	**11.5**	**66.5**	**3.7**	**2.3**	**1.8**	**0.7**	**9.2**	**2.5**		
St. Deviation	**0.4**	**0.4**	**2.3**	**4.6**	**1.5**	**1.6**	**1.4**	**0.6**	**4.4**	**1.2**		
St. Error	**0.2**	**0.3**	**1.3**	**2.6**	**0.9**	**0.9**	**0.8**	**0.4**	**2.5**	**0.7**		

Table 5.16. SEM-EDS results in wt. % for olive slip.

Polychrome slipware olive slips (without PbO)

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	Cr2O3	MnO
23/12.13	0.3	1.1	11.4	78.6	3.2	1.9	0.9	1.4	1.3	
23/14.4	1.0	2.0	14.9	67.1	5.6	4.3	1.1	0.8	3.1	
23/16.1	0.2	1.5	11.6	74.2	3.1	1.4	3.9	0.0	4.1	
Average	**0.5**	**1.5**	**12.7**	**73.3**	**4.0**	**2.5**	**2.0**	**0.7**	**2.8**	
St. Deviation	**0.4**	**0.4**	**2.0**	**5.8**	**1.4**	**1.6**	**1.7**	**0.7**	**1.4**	
St. Error	**0.3**	**0.3**	**1.1**	**3.3**	**0.8**	**0.9**	**1.0**	**0.4**	**0.8**	

Table 5.17. SEM-EDS results in wt. % for olive slip (without PbO).

Polychrome slipware glaze over olive slip and engobe

Sample		Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	Cr2O3	
23/12.13	over slip	0.0	0.0	2.5	36.8	0.8	0.7	0.1	59.1	0.0	n=4
	over engobe	0.1	0.0	2.3	36.2	1.0	0.4	0.2	59.7		n=4
23/14.4	over slip	0.7	0.3	3.1	42.7	1.9	0.9	0.2	50.1	0.1	n=6
	over engobe	0.8	0.0	3.4	41.4	1.8	0.9	0.1	51.6		n=4
23/16.1	over slip	0.0	0.0	1.1	28.7	0.0	0.2	0.4	69.6	0.0	n=3

Table 5.18. SEM-EDS results in wt. % of glazes over olive slip v. over engobe.

Polychrome slipware olive slip inclusion

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	Cr2O3	CuO
23/14.4	0.0	4.8	7.3	31.9	3.1	0.0	6.3	17.8	27.6	1.2

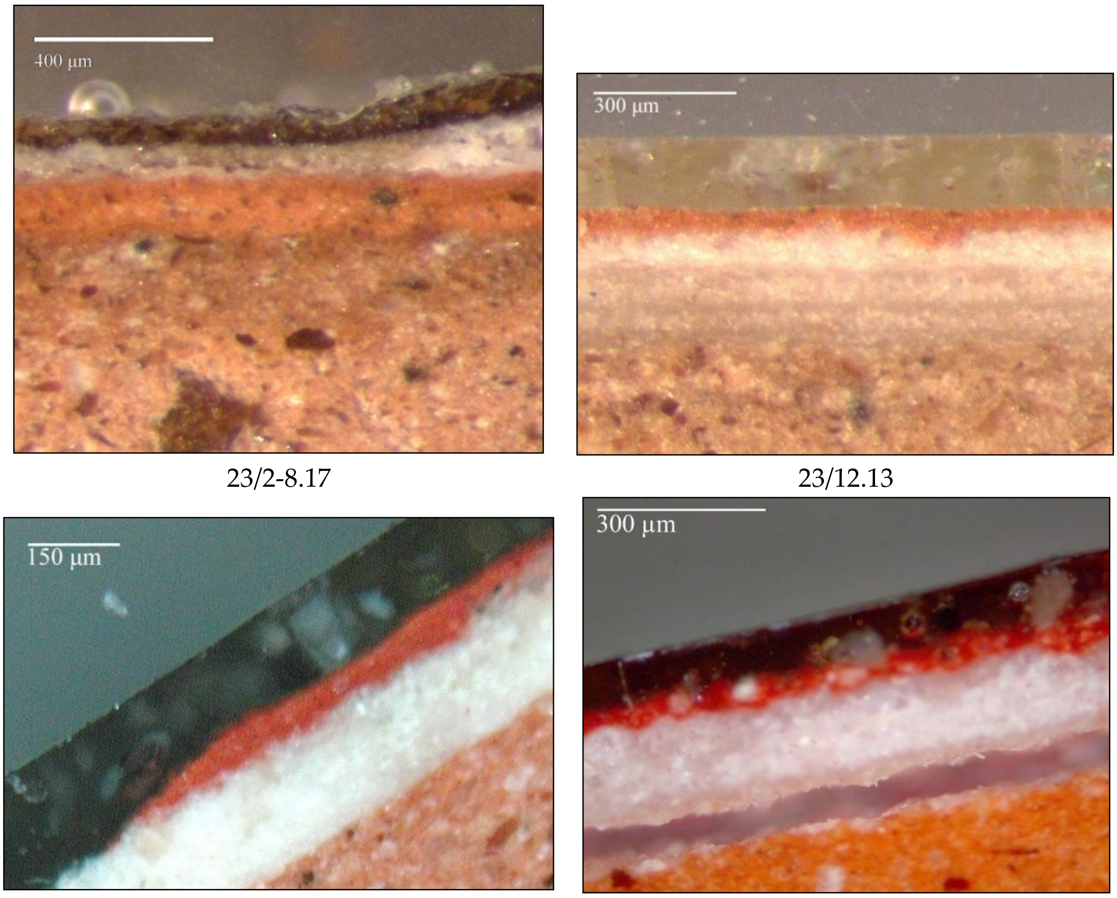
Table 5.19. SEM-EDS results in wt. % of olive slip inclusion in glaze.

Red slips were commonly used, and seven sherds with red slip have been analysed. Red decoration is normally applied as a slip. The iron-rich clay produces the red colour although iron minerals may have been added to this. Table 5.21 (slip concentrations with PbO removed) shows silica at an average of 62.1% and alumina at 17.5%. Lime is at 3.7% and the alkalies, magnesia and titanium are all present at just under 1%. Leached lead oxide ranges from not detected to 21.4% - depending on how close to the glaze the analyses were taken for the individual samples (Table 5.20). The slip has a similar composition to the engobe, but with a higher alumina concentration by 4%.

Glazes over the red slips show higher iron oxide due to digestion of iron minerals and clay minerals during firing, as expected, in comparison with glazes over white engobe

(Table 5.22). This varies due to differences in firing conditions and other production methods used, such as thickness of glaze, concentration of iron minerals in the slip, etc. The lowest level of difference is in sample 23/12.13 with 0.3% iron in glazes over the slip against 0.2% over engobe, which is very near the detection limit of the EDS. The largest differences are seen in 23/15.1 (7.6% and 1.4% respectively) and 23/16.1 (6.0% and 0.3%). The glazes can appear fairly dark over the red slips where digested iron is visibly colouring the glaze. In one case, (23/12.13) the glaze is completely colourless.

In samples 23/11a.2 and 24/26, some areas of the red slips contain MnO. In both these cases the decorations are of red slips next to black slips and/or pigments, so contamination or scanned areas accidently straying into the domain of the black slip (as it is very difficult to distinguish between black and red slips on an SEM image) may have been the cause. Contamination could have derived from the actual slip production or decoration process. Sample 23/12.13, which has a red slip with 0.8% Cr_2O_3 could not be due to contamination by olive slip during analysis, as the two colours are on opposite sides of the sherd, so it is probably due to contamination during production. However the red of this sherd is in fact slightly orange in comparison to the normal shades of pinkish-red and a dark ‘brick’ red – it could be that chromite was deliberately used to change the colour of the slip.



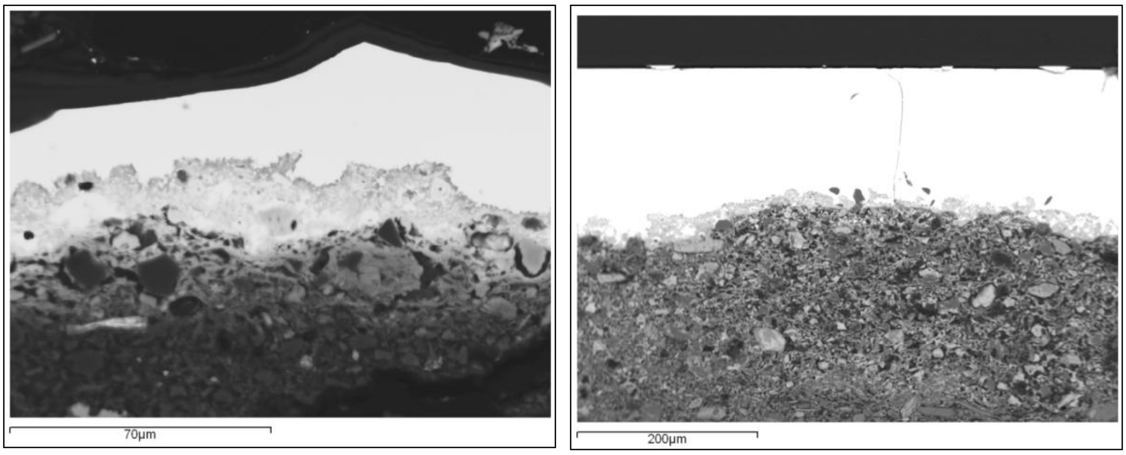
23/2-8.17

23/12.13

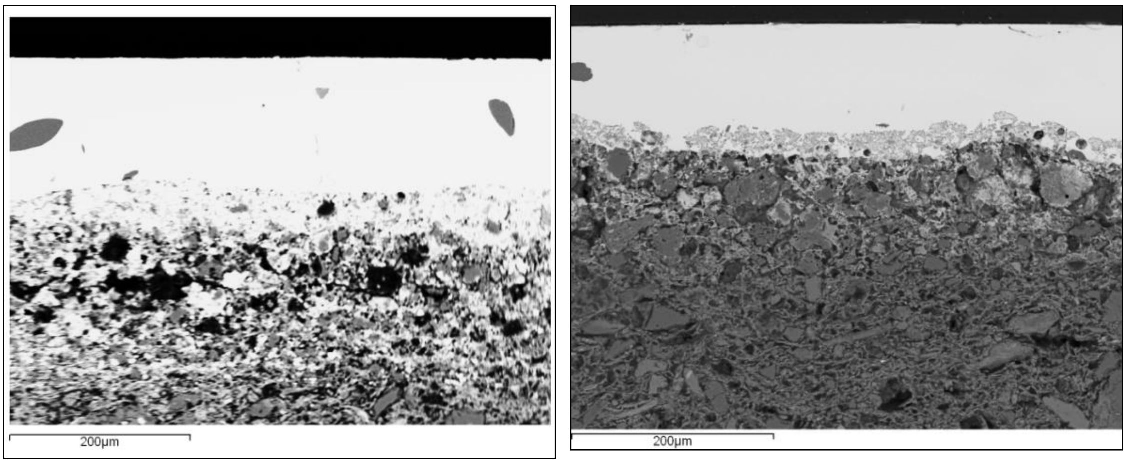
23/16.1

15/1.1

Figure 5.13. OM images of some examples of red slips.



23/2-8.17 23/15.1



23/16.1 24/26

Figure 5.14. BSE images of red slips.

Polychrome slipware red slips

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	MnO	Cr2O3	SO3	P2O5	
9/3.3	0.9	0.4	16.1	55.7	6.4	0.9	6.4	0.9	12.4					n=4
23/2-8.17	0.1	1.1	20.6	62.3	2.1	7.2	5.4	1.0	0.0			0.8		n=3
23/11a.2	0.0	0.9	13.6	48.2	3.9	1.1	14.2	1.1	13.7	3.3				n=2
23/12.13	0.7	0.5	16.2	63.2	5.0	1.0	5.4	0.7	6.8		0.8			n=2
23/15.1	0.9	2.4	17.4	56.7	3.9	5.7	2.5	0.2	9.6					n=3
23/16.1	0.7	0.0	13.1	42.8	2.5	1.2	17.0	0.5	21.4				0.5	n=2
24/26	1.2	0.6	12.8	61.3	5.3	6.6	0.7	0.5	9.3	0.2		0.8	0.6	n=4
Average	**0.6**	**0.8**	**15.7**	**55.7**	**4.2**	**3.4**	**7.4**	**0.7**	**10.5**					
St. Dev.	0.4	0.8	2.8	7.7	1.5	3.0	6.0	0.3	6.6					
St. Error	0.2	0.3	1.1	2.9	0.6	1.1	2.3	0.1	2.5					

Table 5.20. SEM-EDS results in wt. % for red slips.

Polychrome slipware red slips (without PbO)

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO	MnO	Cr2O3	SO3	P2O5
9/3.3	1.0	0.5	18.3	63.5	7.3	1.0	7.3	1.1				
23/2-8.17	0.1	1.1	20.6	62.3	2.1	7.2	5.4	1.0			0.8	
23/11a.2	0.0	1.0	15.7	55.8	4.5	1.3	16.4	1.3	3.8			
23/12.13	0.8	0.6	17.3	67.6	5.4	1.0	5.8	0.7		0.9		
23/15.1	1.0	2.7	19.5	63.2	4.4	6.4	2.8	0.2				
23/16.1	0.9	0.0	16.6	54.6	3.2	1.6	21.7	0.6				0.6
24/26	1.3	0.7	14.1	67.6	5.8	7.3	0.8	0.5	0.2		0.9	0.7
Average	**0.7**	**0.9**	**17.5**	**62.1**	**4.7**	**3.7**	**8.6**	**0.8**				
St. Deviation	0.5	0.9	2.2	5.2	1.7	3.1	7.6	0.4				
St. Error	0.2	0.3	0.8	1.9	0.6	1.2	2.9	0.1				

Table 5.21. SEM-EDS results in wt. % for red slips (without PbO).

Polychrome slipware glaze over red slip and engobe

Sample		Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	
9/3.3	over slip	0.7	0.0	2.9	44.3	2.7	0.6	0.8	48.1	n=5
	over engobe	0.7	0.1	3.8	50.9	3.2	0.3	0.2	40.9	
23/12.13	over slip	0.0	0.0	2.5	36.8	0.6	0.7	0.3	59.1	n=8
	over engobe	0.1	0.0	2.3	36.2	1.0	0.4	0.2	59.7	
23/15.1	over slip	0.4	0.0	9.4	42.1	3.5	0.1	7.6	36.7	n=4
	over engobe	0.0	0.3	3.6	42.7	1.5	0.5	1.4	49.8	
23/16.1	over slip	0.8	0.0	7.3	36.5	5.2	0.3	6.0	46.0	n=5
	over engobe	0.0	0.0	1.0	28.8	0.0	0.1	0.3	69.7	
24/26	over slip	0.6	0.1	2.6	35.6	1.0	1.3	0.7	58.2	n=6
	over engobe	0.5	0.0	2.0	35.4	0.9	1.0	0.0	60.1	

Table 5.22. SEM-EDS results in wt. % for glazes over red slip v. over engobe.

Samanid ware

Sample population: Five Samanid ware samples were analysed, two from *chirags* (lamps) (Figure 5.15). As with the polychrome wares, these are earthenware bodies, covered with a white slip, decorated with black slip or pigment and covered by a thin high lead glaze. None of the samples appear to use a black pigment.

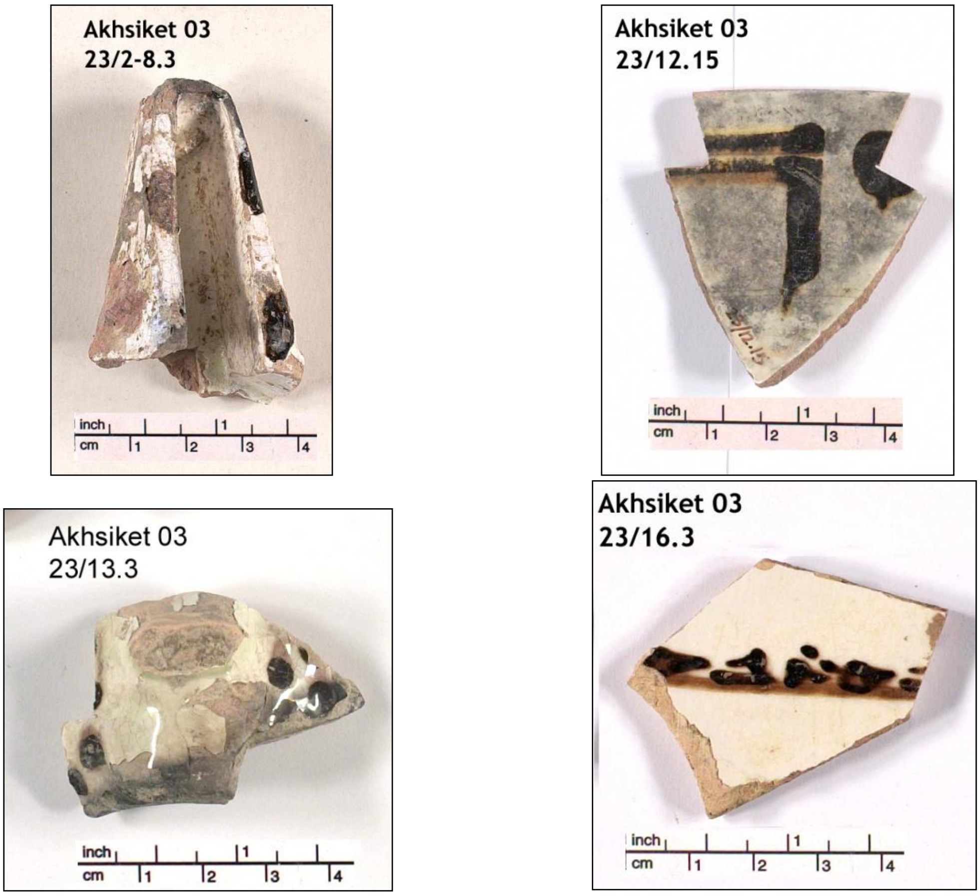


Figure 5.15. Images of Samanid slipware sherds analysed with SEM.

Engobe characteristics: The engobe of these sherds, 100 to 200 microns thick, is, as before, high in quartz with some alumino-silicates and a small amount of clay, generally finer in texture than the body fabric. In cross section optical microscopy shows a typical uniform, even white layer (Figure 5.16). BSE images show that in many cases the engobe appears as two layers, one finer than the other, or two similarly-fine layers but with a visible dividing line (Figure 5.17). Leached lead oxide ranges from 8.1% to 16.4% (Table 5.23). With lead oxide removed, silica, alumina and potash are all higher than the bodies, at 65.5%, 20.8% and 4.7% (Table 5.24).

Samanid engobe

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	Ti2O3	PbO	
23/2-8.3	0.5	0.8	15.6	63.3	3.9	1.5	0.7	0.2	13.5	n=3
23/12.15	0.4	1.4	20.6	50.5	3.1	7.7	0.4	1.2	14.6	n=4
23/13.3	1.5	1.8	18.8	60.5	4.2	4.5	0.3	0.0	8.1	n=4
23/16.3	0.8	0.5	18.4	57.4	5.5	0.4	0.5	0.0	16.4	n=2
Average	**0.8**	**1.1**	**18.4**	**57.9**	**4.2**	**3.6**	**0.5**	**0.3**	**13.2**	
St.Deviation	0.5	0.6	2.1	5.5	1.0	3.3	0.2	0.6	3.5	
St.Error	0.2	0.3	1.0	2.7	0.5	1.6	0.1	0.3	1.8	

Table 5.23. SEM-EDS results in wt.% for Samanid engobe.

Samanid engobe (without PbO)

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3
23/2-8.3	0.5	1.0	18.1	73.1	4.5	1.8	0.8
23/12.15	0.5	1.6	24.2	59.3	3.6	9.1	0.4
23/13.3	1.6	1.8	18.8	60.6	4.2	4.5	0.3
23/16.3	1.0	0.6	22.0	68.7	6.6	0.5	0.6
Average	**0.9**	**1.3**	**20.8**	**65.5**	**4.7**	**4.0**	**0.5**
St.Deviation	0.5	0.6	2.8	6.6	1.3	3.8	0.2
St.Error	0.3	0.3	1.4	3.3	0.6	1.9	0.1

Table 5.24. SEM-EDS results in wt.% for Samanid engobe (without PbO).

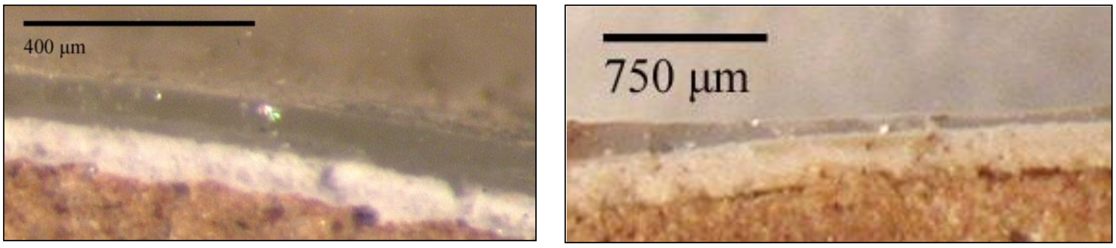
Glaze characteristics: The **colourless glazes** are 75-200 microns thick, homogenous with occasional relict quartz, alumino-silicates, and/or bubbles. The surfaces are fairly smooth although some unevenness is apparent in the greyish glaze, which appears to be badly fired (probably in reducing conditions).

Optical microscopy shows a more or less sharp division between glaze and engobe, where any clay minerals digested in the glaze have been fully dissolved (Figure 5.16). The glazes vary from clear to a strong green viewed in cross section. BSE images show a stark contrast between the heavy-element lead glazes and the lighter-element silica-rich engobe (Figure 5.17).

Lead oxide averages at 52.6%, silica at 41.6%, and the remaining minor elements add up to 5.8%, over half of this alumina (Table 5.25). Silica and lead oxide vary in the Samanid samples by up to 5%. The sherd with the highest proportion of minor elements is 23/12.15 at 6.6% and the lowest is 23/2-8.3 at 5.5%. None of the samples contain detectable magnesia and only one contains detectible iron oxide (23/12.15). Soda and potash correlate positively, while both correlate negatively with lime.

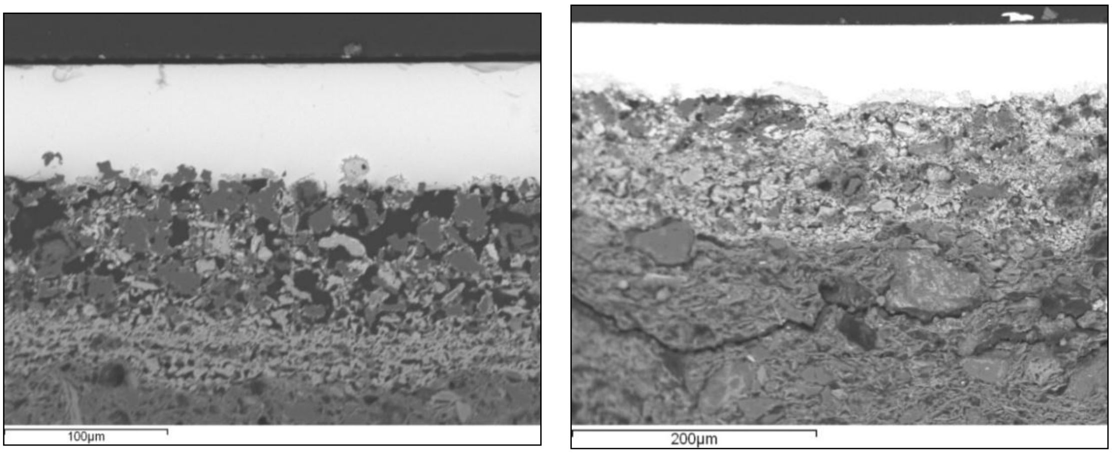
These glazes contain higher levels of silica in the glaze (with PbO removed) than the underlying engobe by ~ 20%, indicating the use of a lead-silica slurry rather than lead oxide on its own (Table 5.26). There are small differences in composition between areas of the glaze near the body and near the surface. In all cases, alumina is higher, as would be expected, near the interface, as is potash.

There is very little glaze/engobe interface layer visible on these colourless glazes, and where it is visible (samples 23/2-8.3 and 23/12.15) it is less than 50µm thick. Where an interface is visible, it is comprised of K-feldspar crystalline phases created by the digestion of clay minerals devitrifying on cooling after firing.



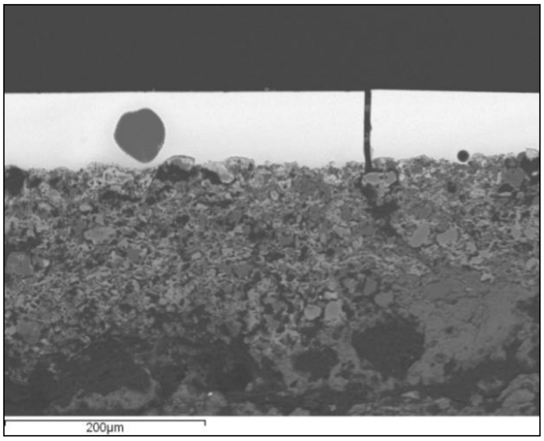
23/12.15 23/13.3

Figure 5.16. OM images of some Akhsiket Samanid colourless glazes showing (top to bottom): resin block, glaze, engobe, and body fabric.



23/2-8.3 (scale is 100 µm)

23/12.15



23/13.3 (scale is 200 µm)

Figure 5.17. BSE images of some Akhsiket Samanid colourless glazes showing (top to bottom): resin block, glaze, engobe and body fabric. All these samples excepet 23/12.15 show two layers of engobe, visible by slight changes in brightness (due to diffusion of lead from the glaze), and grain size.

Samanid colourless glazes									
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	
23/2-8.3	0.3	0.0	3.4	44.0	1.3	0.6	0.0	50.5	n=4
23/12.15	0.3	0.0	4.0	39.4	0.9	0.8	0.5	54.0	n=8
23/13.3	0.8	0.0	2.6	39.8	1.7	1.0	0.0	54.1	n=8
23/16.3	0.0	0.0	3.0	43.3	1.4	0.5	0.0	51.8	n=2
Average	**0.3**	**0.0**	**3.2**	**41.6**	**1.3**	**0.7**	**0.1**	**52.6**	
St. Deviation	0.3	0.0	0.6	2.4	0.3	0.2	0.3	1.8	
St. Error	0.2	0.0	0.3	1.2	0.2	0.1	0.1	0.9	

Table 5.25. SEM-EDS results in wt. % for Samanid colourless glazes

Samanid colourless glazes (without PbO)

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3
23/2-8.3	0.6	0.0	6.8	88.9	2.6	1.2	0.0
23/12.15	0.6	0.1	8.7	85.7	2.0	1.8	1.2
23/13.3	1.7	0.1	5.4	83.6	3.6	2.0	0.0
23/16.3	0.0	0.1	6.3	89.8	2.9	1.1	0.0
Average	**0.7**	**0.1**	**6.8**	**87.0**	**2.8**	**1.5**	**0.3**
St. Deviation	0.7	0.0	1.4	2.9	0.7	0.5	0.6
St. Error	0.4	0.0	0.7	1.4	0.3	0.2	0.3

Table 5.26. SEM-EDS results in wt. % for Akhsiket Samanid colourless glazes, PbO removed.

Samanid colourless glazes, upper v. lower values

Sample	Area	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	
23/12.15	upper	0.3	0.0	2.7	40.0	0.9	0.8	0.2	55.1	n=4
	lower	0.3	0.1	5.2	38.7	1.0	0.8	0.9	52.9	n=4

Table 5.27. SEM-EDS results in wt. % for Akhsiket Samanid colourless glaze (23/12.15), upper v. lower values.

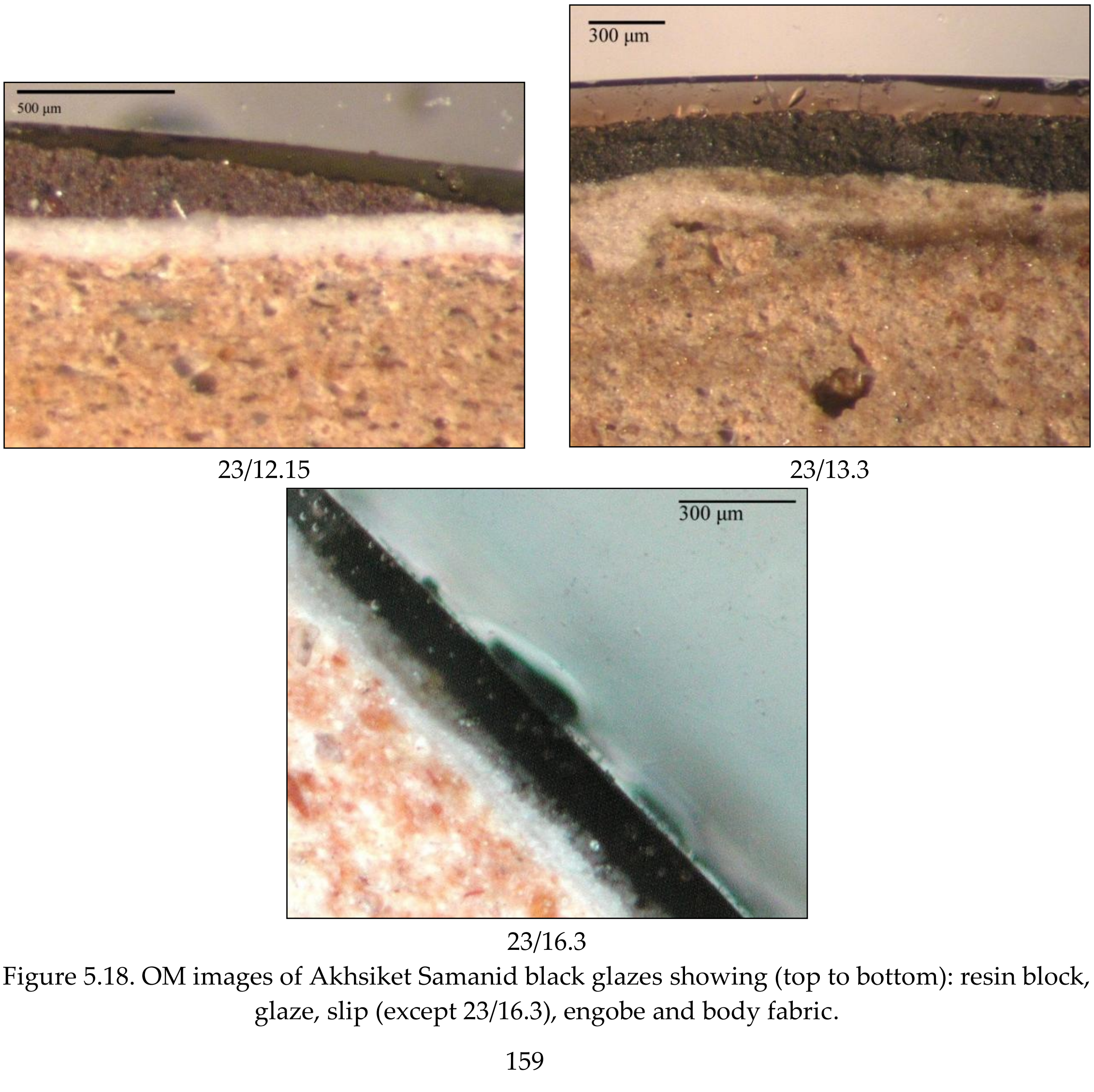
The **coloured glazes** on the Samanid wares, as with the polychrome wares, are coloured by diffusion of iron and manganese oxides digested by the glaze from underlying pigments or slips.

Minerals digested by the glaze have diffused more or less evenly throughout it, as can be seen in the optical microscopy images (Figure 5.18). The staining remains fairly localised above the origin of the minerals (slip or pigment). A pigment appears to have been used on 23/16.3. The slips have in some cases leached colour into the underlying engobe, and a similar discoloration can be seen in 23/16.3 as well.

BSE images show, as with the polychrome samples, that the black glazes are more likely to have a crystalline interface layer next to the engobe – although not in all cases (samples 23/12.15 and 23/13.3 for example have little to no visible interface layer) (Figure 5.19). In the case of 23/2-8.3 an interface layer of >50µm can be seen, with two different types of crystalline formation. There are both small rounded crystals and long, lathe-like crystals, often grouped around partially-reacted quartz grains at or near the glaze interface. The lathe-like crystals are K-feldspars, while the small round crystals are iron-rich crystals which have precipitated into the melt from the underlying colouring minerals.

The black glazes have an average of 4.4% Fe_2O_3 and 1.2% MnO (Table 5.28). These values vary from a minimum of 1.6% Fe_2O_3 and 0.4% MnO to a maximum of 11.2% Fe_2O_3 and 2.3% MnO. Both of these oxides are positively correlated. The base glaze composition fits well into the normal variation of colourless glazes. The typical pattern seen in the colourless glazes of higher silica in the lower section of the glaze is not consistent here – as with the polychrome black glazes, the digestion of iron oxide could be replacing some of the silica concentration present in the glaze slurry (Table 5.29). Only 23/13.3 shows higher silica near the body.

The interface areas analysed in 23/12.15 and 23/16.3 (in bold in Table 5.30) are dominated by feldspars. Iron oxide is very low in this area, and manganese oxide was not detected. Interface crystals in 23/2-8.15 include feldspars and iron-rich minerals with some manganese. One inclusion in particular shows just under 91% iron – most likely unreacted haematite.

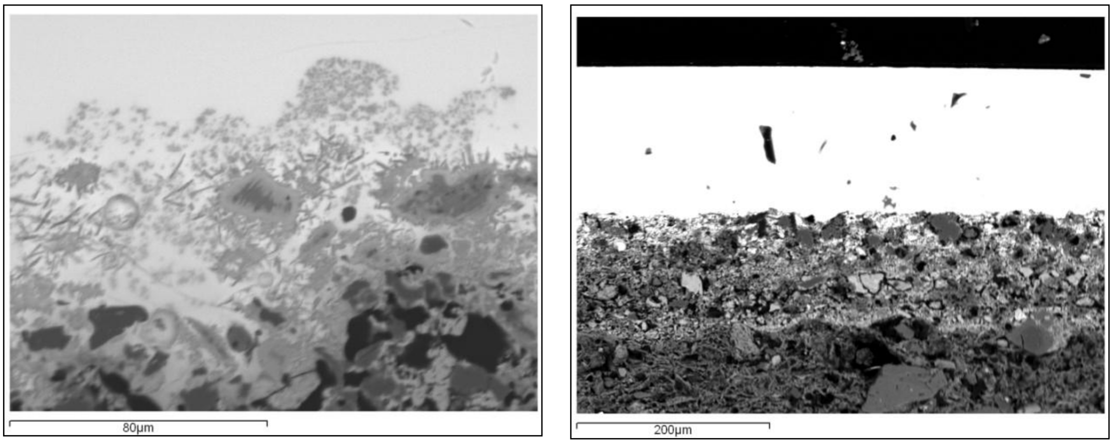


23/12.15

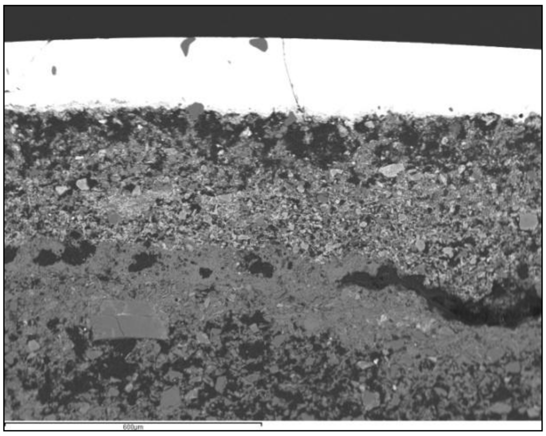
23/13.3

23/16.3

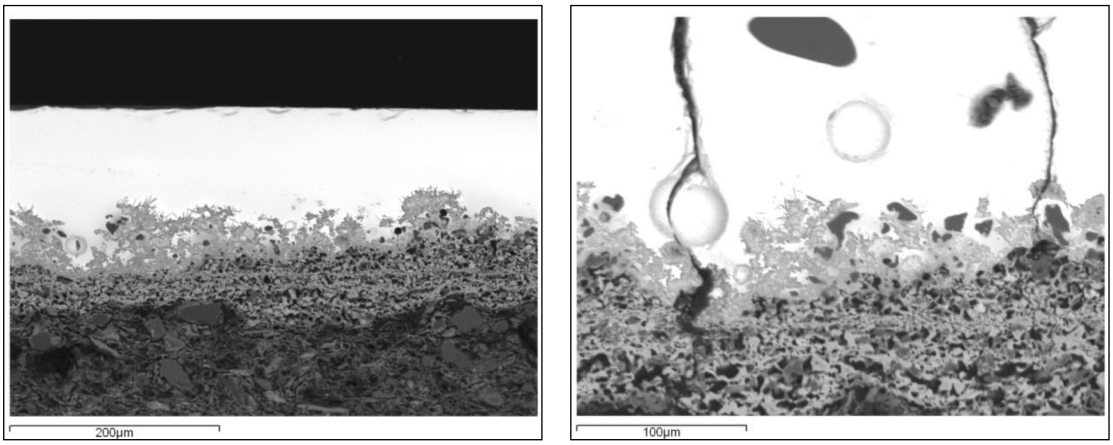
Figure 5.18. OM images of Akhsiket Samanid black glazes showing (top to bottom): resin block, glaze, slip (except 23/16.3), engobe and body fabric.



23/2-8.3 (scale is 80 µm) 23/12.15 (scale is 200 µm)



23/13.3 (scale is 400 µm)



23/16.3 (scale is 200 µm) 23/16.3 (scale is 100 µm)

Figure 5.19. BSE images of Akhsiket Samanid black glazes showing (from top to bottom): resin block (except detail images), glaze, slip where it exists, engobe, and body fabric (except detail images). Crystalline growth can be seen at the interface and in all but 23/12.15 and 23/13.1.

Samanid black glazes										
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**MnO**	
23/2-8.3	0.1	0.0	4.8	37.4	1.6	0.5	11.2	42.1	2.3	n=3
23/12.15	0.3	0.0	3.7	39.0	0.7	0.4	4.0	51.4	0.4	n=10
23/13.3	0.6	0.0	2.9	41.8	1.7	0.5	1.8	49.3	1.5	n=2
23/16.3	0.4	0.0	3.1	42.3	1.5	0.5	2.4	49.0	0.7	n=6
Average	**0.3**	**0.0**	**3.6**	**40.1**	**1.4**	**0.5**	**4.9**	**47.9**	**1.2**	
St. Deviation	0.2	0.0	0.9	2.3	0.5	0.1	4.3	4.0	0.8	
St. Error	0.1	0.0	0.4	1.2	0.2	0.0	2.2	2.0	0.4	

Table 5.28. SEM-EDS results in wt. % for Samanid black glazes.

Samanid black glazes, upper v. lower values											
Sample	**Area**	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**MnO**	
23/12.15	upper	0.4	0.1	2.3	40.6	0.5	0.4	2.0	53.2	0.5	n=5
	lower	0.3	0.0	5.1	37.3	0.9	0.4	6.1	49.6	0.3	n=5

Table 5.29. SEM-EDS results in wt. % for Samanid black glazes, upper v. lower values.

Samanid black glazes - inclusions and interface												
Sample		**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**TiO2**	**PbO**	**MnO**	
23/2-8.3	Inclusion	0.8	0.0	12.7	34.6	4.0	0.0	25.6	0.4	19.9	1.9	n=1
23/12.15	**Interface**	**1.1**	**1.4**	**24.4**	**39.5**	**3.4**	**2.9**	**0.2**	**1.2**	**25.5**	**0.0**	**n=3**

Table 5.30. SEM-EDS results in wt. % for Samanid black glaze inclusions and interfaces.

Coloured slip characteristics: Coloured slips were used on two of the sherds – 23/12.15 and 23/13.3. Unlike the olive and red slips, black slips tend to be thick - 300µm or more in these cases. Only one sample, 23/13.3, was analysed with SEM-EDS.

The black slip in this case was contaminated with 8.3% lead oxide. With lead oxide removed, the colorants are between 20.7% iron oxide and 7.4% manganese oxide –a ratio of around 3 parts iron to 1 part manganese (Table 5.31).

The slip on 23/13.3 is quite different from the underlying engobe – with much lower silica (57.3% compared with 65.1%), and alumina (16.5% compared with 20.8%) and far higher lime (15.1% compared with 5.3%). Further, higher soda, existence of titanium oxide, and lower magnesia and potash than the engobe shows that this may have been created from a different clay batch or clay source.

Samanid black slip, with and without PbO and colorants

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	MnO	
23/13.3	1.7	0.7	10.5	36.7	3.9	9.7	18.5	0.8	8.3	6.6	n=4
23/13.3[1]	**1.9**	**0.8**	**11.8**	**41.2**	**4.4**	**10.9**	**20.7**	**0.9**		**7.4**	
23/13.3[2]	*2.7*	*1.0*	*16.5*	*57.3*	*6.1*	*15.1*		*1.3*			

[1] Without PbO (in bold), [2] Without PbO, Fe2O3 and MnO (in italics)

Table 5.31. SEM-EDS results in wt. % for Samanid black slip (23/13.3), shown as analysed; without PbO; and without PbO and colorants.

5.2.2. Green monochrome wares

Three green monochrome glazed samples were analysed, all from the 10th to 11th century (no incised green wares were analysed). Visually, they are not completely uniform – sample 23/12.10 is a bluer, cooler hue than the other two, and 9/2.3 is the best preserved. 9/2.3, however is marred by bubbles and other flaws in the glaze that appear to be the result of firing conditions.

OM images show variation in shade, as expected, with a uniform colouring throughout the glaze (Figure 5.21). Sample 9/2.3 has numerous bubbles, the others very few, and both 9/2.3 and 23/20.7 show a layer of undiffused melted silica at the interface. BSE images show more significant differences between the three sherds (Figure 5.22): 9/2.3 has a thick glaze (>200 μm), with a deep interface layer of around 100 μm, evidence of devitrification scattered throughout the glaze, and large bubbles. Sample 23/12.10 is also quite thick, ~150 μm, with a dense but thinner interface and little sign of devitrification. The surface of the glaze is weathered (the dark grey areas indicate depleted PbO). Sample 23/20.7, the earliest sherd in this group, has a very thin glaze, in some cases less than 50 μm, and a correspondingly thin crystalline interface. This sherd also shows evidence of some degredation at the surface. In all of these samples, the glazes have been applied directly over the body.

The colorants in the glazes range from 1.3% to 3.3% copper oxide combined with 0.9% to 3% iron oxide. With these colorants removed, the base lead glaze can be seen. Sample 23/20.7 has the highest lead oxide concentration, at 54%, and correspondingly low silica concentration at 37.8%. Sample 9/2.3 has the lowest lead at only 36%, with silica 45.1% - unusual amongst the lead glazes. Sample 23/12.10 also has high lead, although not quite as high as 23/20.7. Minor elements are quite high in all these glazes, although highest in 9/2.3 at 18.8%. Lime in this glaze is unusually high at 7.7%, as is alumina at 6.4%. Alumina is very low in the other two sherds, whilst lime is higher than in the colourless lead glazes. Soda and potash are fairly average for the lead glaze on the whole, but the presence of MgO, especially in 9/2.3 with a high 1.3% is interesting, as magnesia is fairly rare in the colourless lead glazes studied so far (3 samples out of 18).

Silica, alumina and potash are more or less higher near the body than at the surface, indicating some digestion of clay minerals during firing (Table 5.35). Sample 23/12.10 is the exception with slightly higher silica at the surface, probably due to degredation and leaching of PbO from the surface of the glaze (although PbO is still higher at the surface than at the interface). 23/20.7 has the lowest range of differences, with alumina, silica and potash only 0.1%, 0.7% and 0.5% lower at the surface respectively. Copper oxide is generally higher at the surface with the exception of 23/20.7 where it is 0.1% lower, while iron oxide is lower at the surface – by 0.2% – 1.5%.

As already mentioned, 9/2.3 has a large quantity of inclusions, both crystalline interface inclusions, and devitrification in the main body of the glaze. The dark rounded crystals are high in lime and magnesia (see the first inclusion analysis in

Table 5.36). Low levels of lead in this analysis indicate a very minor amount of contamination in these scans, which means iron and copper oxide, silica and alumina are present to some degree in the inclusion itself, or the inclusion is a conglomerate of several smaller inclusions which have grouped together. The small square crystals at the interface are feldspars (second inclusion analysis in

Table 5.36). The third inclusion in the table is an analysis of a cluster of these which combines alumino-silicates and lime/magnesia-rich crystals.

The interface layer of 23/12.10, in the same table, indicates high concentration of K-feldspar and lime/magnesia crystals, as well as having minor amounts of titanium, copper and phosphorous oxides. 23/20.7 is fairly typical with the high Si-Al-K that indicates K-feldspar, somewhat elevated lime and magnesia, 0.5% titanium oxide and no copper.

Green monochrome fabric types and decoration styles		
Sample	**Fabric type**	**Style code**
9/2.3	1	MG
23/12.10	2	MG
23/20.7	2	MG

Table 5.32. Green monochrome fabric types and decoration styles. See Table 5.2 for a key to style codes.

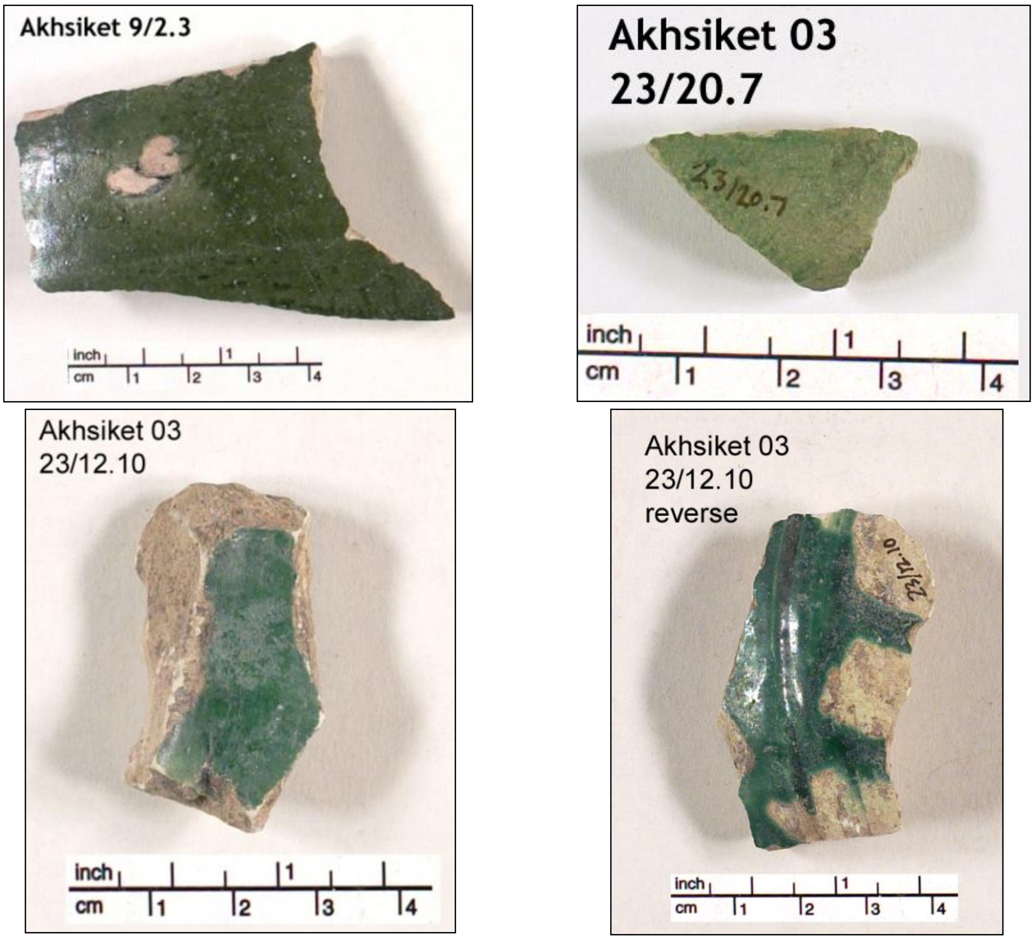
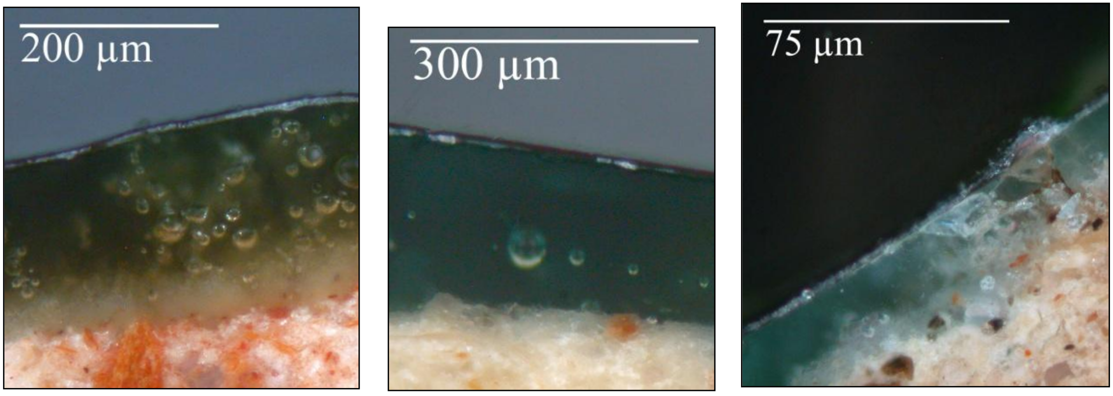
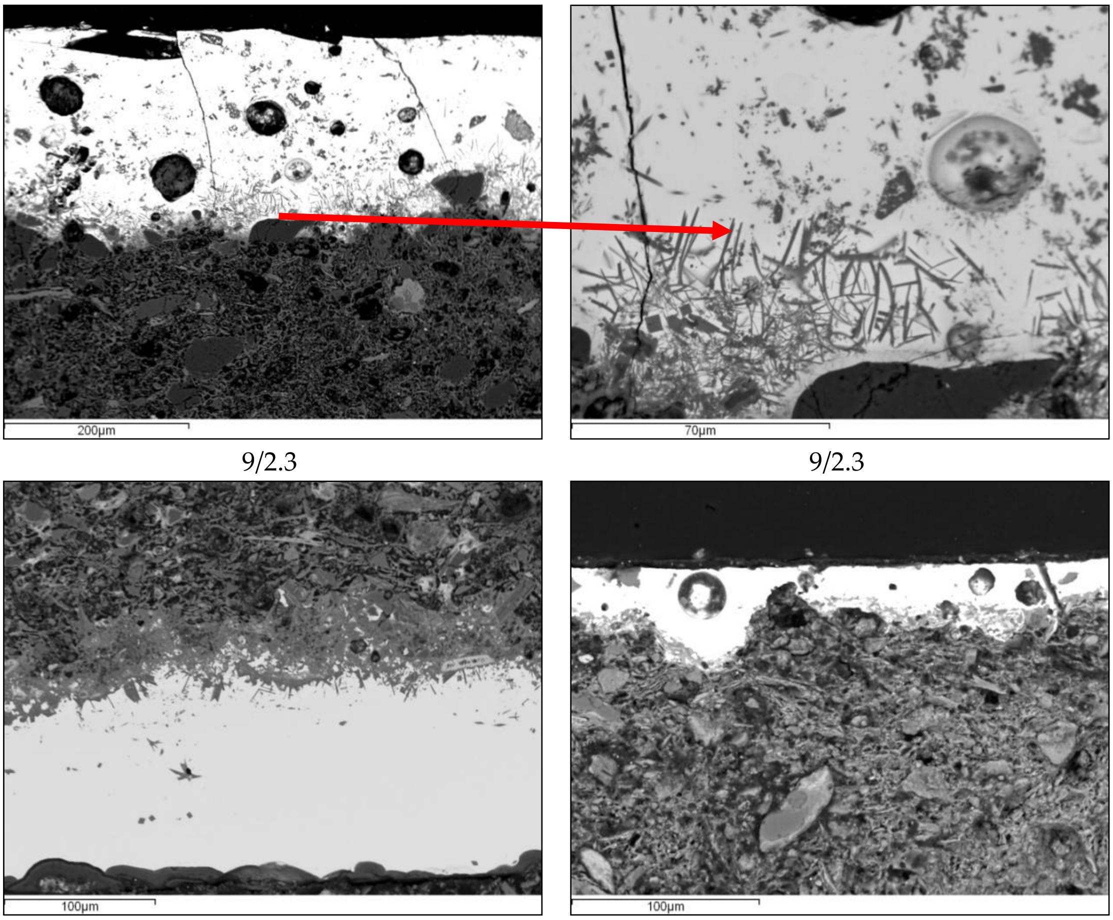


Figure 5.20. Images of green monochrome sherds analyses with SEM.



9/2.3 23/12.10 23/20.7

Figure 5.21. OM images of Akhsiket green monochrome glazes showing (top to bottom): resin block, glaze, and body fabric.



9/2.3 9/2.3

23/12.10 23/20.7

Figure 5.22. BSE images of Akhsiket green monochrome glazes. The top two images of sample 9/2.3 shows a full cross-section on the left, and a detail view on the right – the red arrow indicates where the detail relates to. 9/2.3 shows extensive inclusions in the glaze as well as along the interface.

Monochrome green glazes											
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**TiO2**	**PbO**	**CuO**	
9/2.3[1]	0.4	1.3	6.0	42.5	2.9	7.3	3.0	0.0	34.0	2.7	n=8
23/12.10	0.9	0.6	1.9	37.3	2.3	3.1	0.9	0.0	49.6	3.3	n=10
23/20.7	0.9	0.2	1.6	36.8	2.5	2.8	1.2	0.1	52.6	1.3	n=7
Average	**0.7**	**0.7**	**3.2**	**38.9**	**2.6**	**4.4**	**1.7**	**0.0**	**45.4**	**2.4**	
St. Deviation	0.3	0.5	2.5	3.2	0.3	2.5	1.2	0.0	10.0	1.0	
St. Error	0.2	0.3	1.4	1.8	0.2	1.5	0.7	0.0	5.8	0.6	

[1] Face only

Table 5.33. SEM-EDS results in wt. % for Akhsiket green monochrome glazes.

Monochrome green glazes (without Fe2O3 and CuO)

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	TiO2	PbO
9/2.3	0.4	1.3	6.4	45.1	3.0	7.7	0.0	36.0
23/12.10	0.9	0.6	2.0	39.0	2.4	3.2	0.0	51.9
23/20.7	0.9	0.2	1.7	37.8	2.6	2.8	0.1	54.0
Average	**0.7**	**0.7**	**3.3**	**40.6**	**2.7**	**4.6**	**0.0**	**47.3**
St. Deviation	0.3	0.6	2.6	3.9	0.3	2.7	0.0	9.8
St. Error	0.2	0.3	1.5	2.3	0.2	1.6	0.0	5.7

Table 5.34. SEM-EDS results in wt. % for Akhsiket green monochrome glazes (without colorants).

Monochrome green glazes, upper v. lower values

Sample	Area	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	CuO	
9/2.3	upper	0.2	1.1	4.6	42.1	2.5	6.0	2.3	0.0	38.2	3.2	n=4
	lower	0.5	1.5	7.4	43.0	3.2	8.6	3.8	0.0	29.8	2.2	n=4
23/12.10	upper	0.9	0.4	1.7	38.2	2.5	3.0	0.8	0.0	49.2	3.4	n=2
	lower	1.0	0.4	2.6	37.7	2.7	2.8	1.0	0.0	48.9	2.8	n=2
23/20.7	upper	0.9	0.2	1.7	36.8	2.5	2.9	1.1	0.0	52.6	1.3	n=3
	lower	0.9	0.0	1.6	37.5	2.7	2.4	1.4	0.2	52.0	1.4	n=2

Table 5.35. SEM-EDS results in wt.% for Akhsiket green monochrome glazes, upper v. lower values.

Monochrome green glazes, inclusions and interfaces

Sample	Area	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	CuO	P2O5	
9/2.3	inclusion	0.0	12.5	2.7	50.5	0.2	26.2	4.1	0.0	2.3	1.4		n=1
9/2.3	inclusion	1.1	0.0	15.7	56.1	10.0	2.8	1.6	0.0	12.8	0.0		n=1
9/2.3	inclusion	0.8	1.9	16.6	45.2	2.1	16.2	5.5	0.7	10.0	0.9		n=1
23/12.10[1]	**interface**	**0.6**	**2.7**	**9.3**	**50.4**	**8.2**	**11.6**	**5.2**	**0.3**	**8.3**	**1.9**	**1.5**	**n=4**
23/20.7	**interface**	**0.6**	**1.3**	**14.1**	**53.1**	**11.2**	**3.0**	**2.7**	**0.5**	**13.4**	**0.0**		**n=2**

[1] Interface analysis (in bold)

Table 5.36. SEM-EDS results in wt.% for Akhsiket green monochrome glazes, inclusions and interfaces.

5.2.3. Kiln rod with green glaze

A single kiln rod with green glaze was recovered from the surface cleaning of Object 23 at Akhsiket. Its date is unknown, but the colour of the glaze is close to that of 11th century monochrome green wares and late 11th/12th century incised green wares. The shape and size of the kiln rod is similar to those found in Samarkand in the early Islamic period (Shishkina and Pavchinskaja 1993 , 35-36). The rod would have been used to hold glazed objects on the wall of the kiln during firing. It would appear that contact with the glazed pots during firing has deposited glaze and (possibly) engobe onto the rod. The presence of this object is by no means proof that pottery production was carried out on the site, but it was useful to investigate whether this artefact could be associated with the early Islamic pottery, and to examine its characteristics as the single piece of evidence from a kiln.

The remains of the rod is ~11 cm in length and 1.5 cm in diameter. It is tapered at one end; the other is flat. It may be the tip of a broken rod, or whole. The surface of the rod is heavily abraded due to its life on the surface of the site. The fabric is fine, and very similar to glazed Fabric 2. The glaze, dark green, is visible as patches from <0.5 cm to 1 cm in size.

All of the glaze spots are covered with a thin white layer, with another layer of dusty matter above that. Optical microscopy of the glaze shows a fairly thick (200 μm and more) layer of fully-fused glaze which has reacted strongly with the underlying clay, an iron rich, fine clay similar to the early Islamic glazed wares so far discussed (Figure 5.23). Digestion of clay minerals can be seen quite clearly as lighter areas in the margins of the glaze.

There is a quartz-rich white layer above this glaze, which appears similar to engobe under the optical microscope, but has in fact melted completely. It appears from the BSE image to be dissolved but undiffused quartz, with a lack of crystalline shapes to be seen. However, analysis shows this to be high in alumina and potash – i.e. alumino-silicates. It is very likely that these layers were deposited onto the rod by contact with a glazed vessel in the kiln, and during firing these contact points fused with the rod and broke away from the vessel when it was removed. This alumino-silica-rich layer is not an exact match to that used on the early Islamic lead glaze wares, being far higher in potash and lacking lime, iron or manganese, but it is a very similar type of material. It is, perhaps, an engobe produced using different raw sources – feldspars or a feldspar-rich quartz source. A third layer above this, very thin and dusty (and not possible to analyse due to extreme porosity) may be remains of ceramic body.

The glaze is lead-based (Table 5.37) and well within the range of variation seen in the early Islamic glazed wares. It has around 9.8% minor elements (not including copper oxide). The 1.1% iron and 1.7% copper oxide produces the dark green colour.

Although the glaze is consistent with the early Islamic lead glazes of the Akhsiket pottery, the apparent engobe is not. This is interesting on two points – first, that the rod was probably supporting a vessel different from those so far analysed at Akhsiket, and therefore originating from a later time period and/or a different geographical location; and secondly, that there is an alternative engobe technology present in the Ferghana Valley.

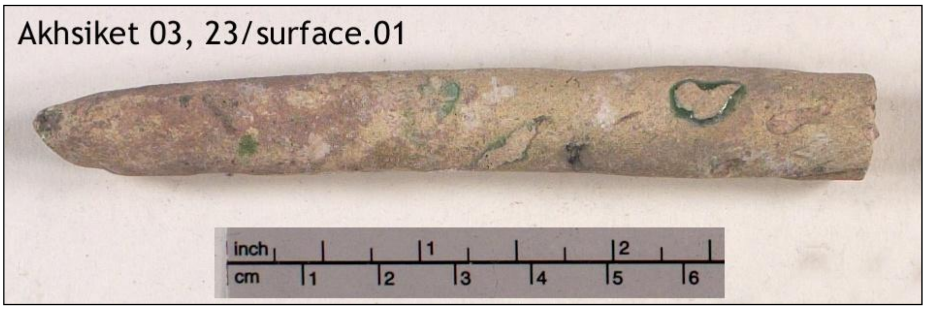


Figure 5.23. Image of Akhsiket green glazed kiln rod.

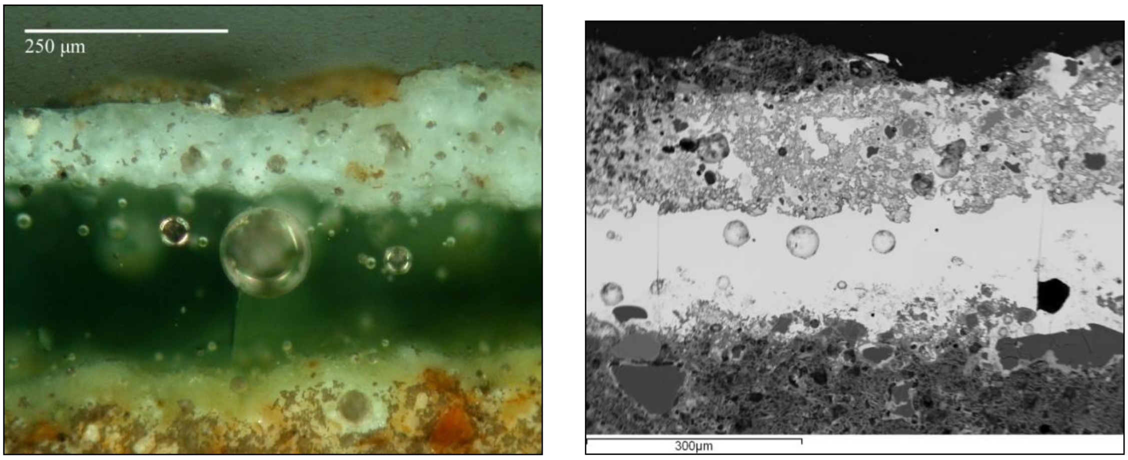


Figure 5.24. OM (left) and BSE (right) images of glaze on the kiln rod showing (from top to bottom): resin block, dusty top layer, "engobe" layer, glaze, interface, and body fabric.

Kiln rod with green glaze

Sample	Area	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	CuO	
Kiln rod	Glaze	0.2	0.5	3.2	40.3	1.8	3.0	1.1		48.1	1.7	n=6
	"Engobe"	1.1	0.0	18.9	48.8	8.2	0.0	0.0		23.1	0.0	n=2
	Body	0.8	3.1	11.0	55.8	3.1	18.9	6.9	0.5			n=3

Table 5.37. SEM-EDS results in wt.% of Akhsiket green glazed kiln rod.

5.3. Alkali glazed wares: slips and glazes

5.3.1. *Ishkor* wares

The alkali glazed wares in this part of Central Asia at this period in time consisted of two types – ishkor and skeuomorphic – and are found in 10th and early 11th century contexts. Chapter 3.4.4 gives a detailed typological description of these wares. Ishkor wares are fairly limited in design and motif in comparison with the lead glazed wares, but occur on a wider variety of body forms, including closed forms. The glazes were often applied to both sides of the vessel equally, and were applied directly to the body with no underlying slips. Coloured glazes were used, with a palette limited to turquoise hues, 'lilac', and occasional dark blue or greenish blue. The glazes are semi-opaque, depending on how strongly coloured they are or how many inclusions/bubbles there are in the matrix (Figure 5.25).

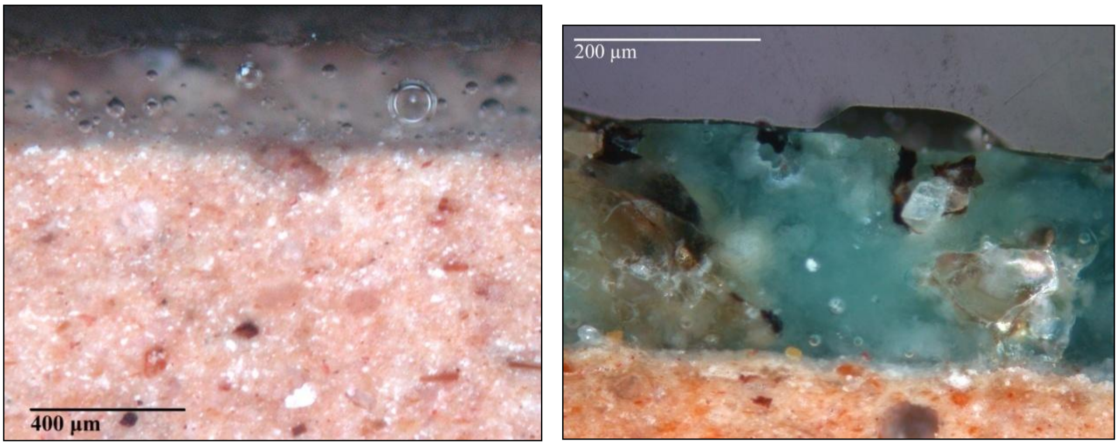
In cross section, it can be seen that these glazes are, on the whole, thick in comparison to the lead glazes – usually between 200 and 300 μm. The glazes are often riddled with bubbles and relict quartz grains left over from the glaze frit. Optical microscopy images show how heterogeneous these glazes are (Figure 5.26).

***Ishkor* fabric types and decoration styles**		
Sample	**Fabric type**	**Style code**
23/2-8.1	1	I
23/10b.3	5	I
23/11c.1	1	I
23/14.1	1	I
23/14.17	2	I
23/15.2	2	I
23/20.2	2	I
23/20.6	1	I

Table 5.38. *Ishkor* fabric types and decoration styles. See Table 5.2 for a key to style codes.

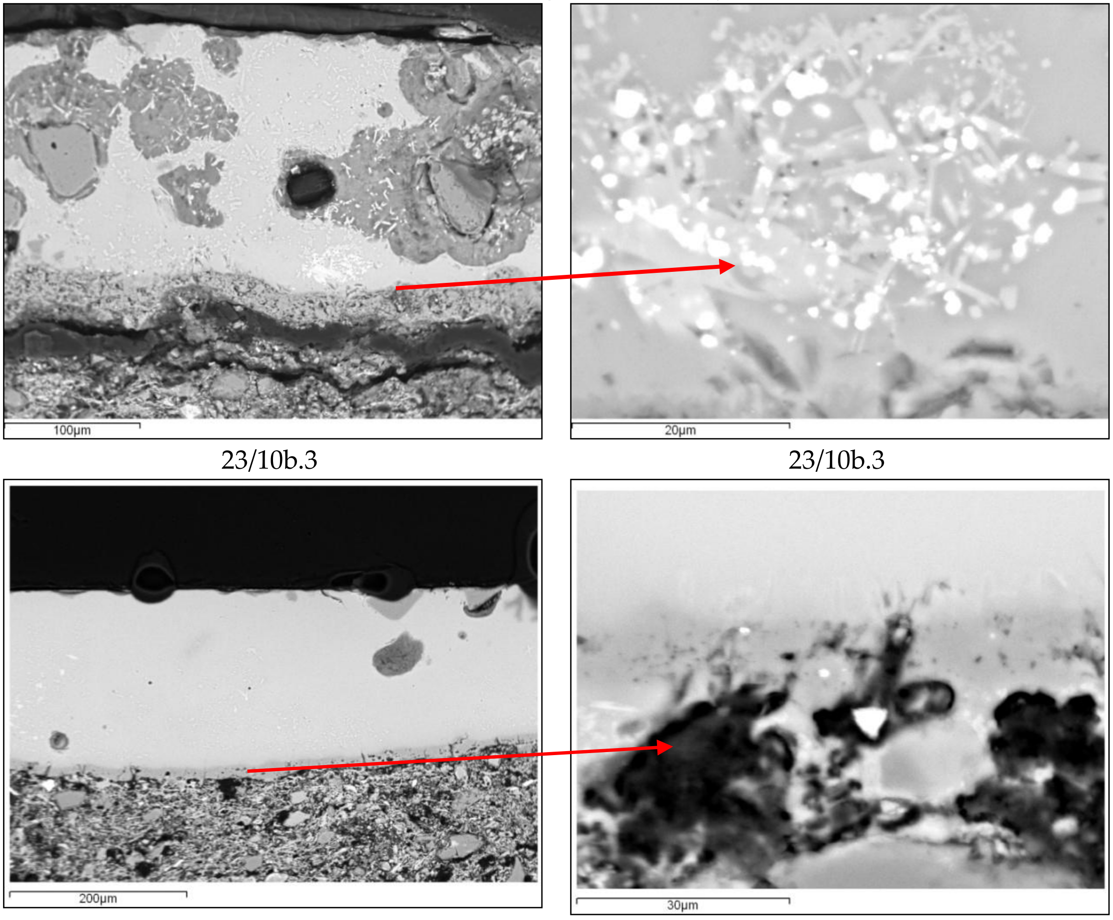
Ishkor glazes were not always fired at a high enough temperature and/or for long enough in the kiln to dissolve and disperse all the quartz grains in the frit. BSE images show partially reacted relict quartz grains and melted quartz that has not fully diffused through the glassy matrix (Figure 5.27 and Figure 5.28). Crystalline growth is also evident, but is more likely to be spread more or less evenly throughout the glaze, or clumped in locations in the body of the glaze. Both blue and lilac coloured glazes demonstrate this and in some cases show the tell-tale darker layers at the surface that indicates weathering – causing leaching of heavier metals from the glaze during the burial.

Figure 5.25. Images of *ishkor* sherds.



23/2-8.1 23/15.2

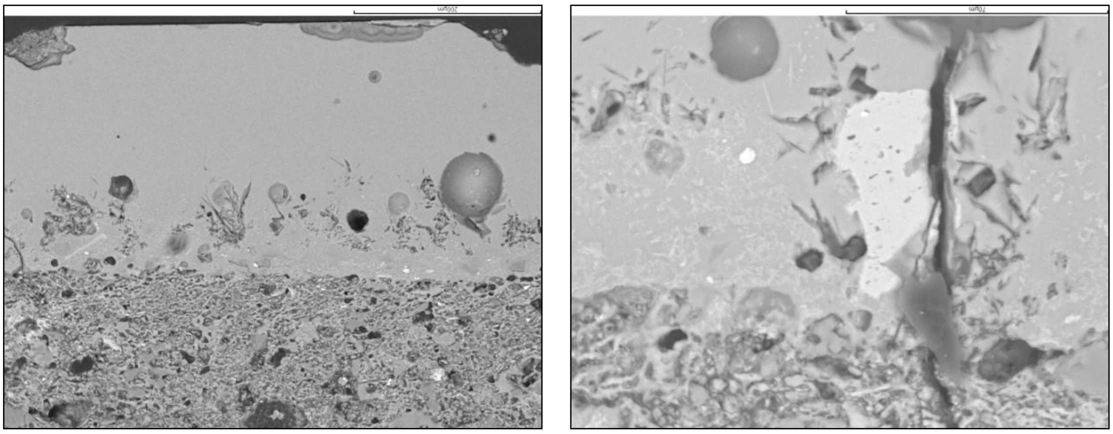
Figure 5.26. OM images of some *ishkor* sherds: lilac (left) and blue (right) showing (top to bottom): resin block, glaze, and body fabric.



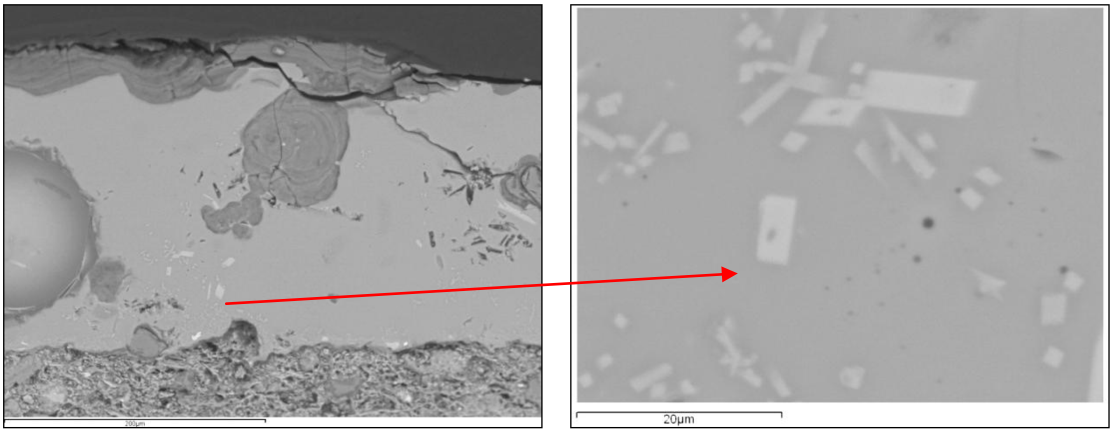
23/10b.3 23/10b.3

23/14.17 23/14.17

Figure 5.27. BSE images of some blue *ishkor* glazes showing full cross-section on the left, and detail views on the right. One the left (top to bottom): resin block, glaze, body fabric. 23/14.17 contrast has been increased to show the darker interface layer.



23/2-8.1 (scale is 200 µm) 23/2-8.1 (scale is 70 µm)



23/14.1 (scale is 200 µm) 23/14.1

Figure 5.28. BSE images of some lilac *ishkor* glazes showing full cross-section on the left, and detail views on the right. On the left (top to bottom): resin block, glaze, and body fabric.

SEM-EDS results present fairly consistent compositions for silica and alumina – an average across the board of 70.6% silica. This high level of silica requires a higher firing temperature than the lead glazes in order to fully melt (Table 5.39, Table 5.40 and **Error! Reference source not found.**). Silica varies across the population from a low of 67.8% to a high of 71.1%. Darker areas visible in the BSE images of the glaze are melted but undiffused quartz, and are higher in silica as a result. These areas have not been included in the tables referenced here (see Appendix A for the full results).

The alkalis - soda and potash - are the primary fluxing agents in these glazes. Soda is the most variable – ranging from 5.5% to 12.2%, while potash is slightly less so with a range of 3.7% to 9.4%. These two elements are roughly negatively correlated with each other (Figure 5.29), and together make up a fairly consistent total alkali contribution to the glaze recipe averaging ~13%. Potash and magnesia have a slight negative correlation (Figure 5.30). Lime has a general negative correlation with the alkalis combined (Figure 5.31). Differences in base glaze between the blue and lilac base glazes are not significant. The alkaline earths – magnesia and lime – are present as minor elements. Magnesia is relatively consistent, ranging from 1.5% to 3.5%. Lime is more variable, ranging from 2.6% for sample 23/2-8.1 to a high of 8% for 23/10b.3 blue glazes (Table 5.39).

The majority of the alkalis and alkaline earths will have originated from plant ashes used to lower the melting temperature of the silica frit. The significance of these values, and what they can tell us about glaze production, is discussed further in Chapter 7.

Alumina varies little across the population, although 23/2-8.1 has an unusually high quantity of 13.1% against an average of ~4% for the rest of the sherds. Other minor non-colouring elements include iron oxide at an overall average of 1.6%, and titanium oxide at very low concentrations (<0.5%) in the few cases where it was detectable. Phosphorus and sulphur oxides are present in a few cases at very low levels close to the detection limits of the SEM. Chlorine is present in all the samples, only missing from the blue glaze of sample 23/2-8.1. Chlorine is commonly found in low concentrations such as this (less than 1%) in alkali glasses, so it is no surprise to see it here.

There is much less variation in the glaze matrices between lower areas and upper areas than seen in the lead glazes – with silica, alumina and soda generally (but not always) a little higher near the surface, but not high enough to be very significant (Table 5.41). Potash shows no real pattern, while lime is slightly higher near the body. This is not surprising, as the high silica content of these glazes would have limited digestion from the body, and the viscosity would have inhibited diffusion of oxides into the glaze. It would appear that any digestion has been limited to the very shallow interface layers, as described below.

The colouring metals - manganese and copper oxide - produce a far different effect in alkali glazes than in lead glazes. Copper oxide produces a strong green in the lead glazes, while here it produces turquoise. The addition of MnO makes the turquoise a cooler, darker blue. MnO without a second colouring agent produces purple. In the case of *ishkor* wares, the low concentrations of MnO produces a light lilac shade. The darker blues usually contain between 5% and 7% CuO. MnO on average in the blue glazes is present at 1.3%, and varies between 0.5% to 1.8%.

Lilac glazes contain 1% or more MnO – no change from the concentrations contained in the blue glazes, on average. Without CuO, MnO results in the translucent purple-tinged 'background' colours of samples 23/2-8.1 and 23/14.1; higher amounts (2.0%) produce the richer lilac of 23/11c.1, and with nearly equal, but low, amounts MnO and CuO (plus high quantities of soda) a pale mauve that is almost white in appearance on sample 23/20.2. The grey glaze is in fact a very light, probably weathered, lilac glaze, with its 2.7% MnO and 2% Fe_2O_3 (**Error! Reference source not found.**).

Most of the *ishkor* glazes contain some mineral inclusions due to devitrification combined with relict minerals that have not fully reacted. Angular, rectangular-shaped crystals are high in lime, silica, and in some cases manganese (Table 5.42). In a few cases, small round inclusions (which show up very bright in the BSE images) occur, and these contain heavier elements such as antimony and tin. Tin oxide was often used to opacify glazes in Iran and Iraq at this time, but was not as commonly used in Central Asia – the significance of these inclusions is discussed further in Chapter 7. The inclusions are very small – many less than 5 µm across, although some are up to 20 µm in size – which means that it is impossible to analyse the crystals without some contamination from the surrounding glassy matrix of the glaze.

Some of the sherds show a thin interface layer, and these areas tend to be high in soda and alumina due to the alumino-silicate minerals that grew during firing as oxides leached into the glaze.

***Ishkor* blue glazes**

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	P2O5	SO3	Cl	MnO	CuO	
23/2-8.1	5.5	1.5	13.1	67.8	8.1	2.6	0.7	0.3	0.0	0.0	0.3	0.0	0.5	6.7	n=6
23/10b.3[1]	**8.4**	**2.1**	**4.1**	**73.6**	**4.0**	**5.4**	**1.4**	**0.0**	**0.0**	**0.0**	**0.2**	**1.0**	**1.4**	**7.1**	n=3
23/10b.3	*6.9*	*3.5*	*4.4*	*71.2*	*3.9*	*8.0*	*1.9*	*0.0*	*0.0*	*0.0*	*0.0*	*0.3*	*1.8*	*2.1*	n=2
23/14.1	5.7	2.9	4.0	72.3	6.2	6.8	1.3	0.0	0.0	0.2	0.0	0.4	1.5	6.6	n=6
23/14.17	**6.3**	**1.8**	**5.6**	**75.1**	**5.8**	**4.1**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.4**	**0.8**	**5.5**	n=5
23/14.17	*7.6*	*2.9*	*3.7*	*72.3*	*5.6*	*6.3*	*1.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.7*	*1.4*	*2.1*	n=5
23/15.2	**7.7**	**2.7**	**3.5**	**71.5**	**6.3**	**6.2**	**1.1**	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**	**1.6**	**3.0**	n=2
23/15.2	*7.1*	*2.9*	*3.6*	*70.7*	*6.5*	*7.1*	*1.1*	*0.0*	*0.0*	*0.0*	*0.0*	*1.0*	*1.8*	*0.5*	n=2
23/20.6	**10.2**	**2.8**	**3.2**	**72.1**	**4.2**	**5.2**	**1.2**	**0.0**	**0.0**	**0.1**	**0.0**	**0.9**	**1.1**	**3.0**	n=6
23/20.6	*8.4*	*2.9*	*3.4*	*72.0*	*6.0*	*5.0*	*1.3*	*0.1*	*0.0*	*0.1*	*0.0*	*0.8*	*1.2*	*0.6*	n=5
Average	**7.4**	**2.6**	**4.9**	**71.9**	**5.7**	**5.7**	**1.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.6**	**1.3**	**3.7**	
St. Deviation	1.4	0.6	3.0	1.9	1.3	1.6	0.3	0.1	0.0	0.1	0.1	0.3	0.4	2.5	
St. Error	0.5	0.2	0.9	0.6	0.4	0.5	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.8	

[1] **Dark blue in bold**, *Light blue in italics*

Table 5.39. SEM-EDS results in wt. % of blue *ishkor* glazes (non-colorants renormalised).

Ishkor lilac glazes

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	P2O5	SO3	Cl	MnO	CuO	
23/2-8.1	8.2	2.5	7.2	67.8	5.8	5.8	1.8	0.3	0.0	0.2	0.2	1.2	0.0	n=12
23/11c.1	6.2	3.0	5.1	69.1	9.4	4.9	1.7	0.0	0.0	0.0	0.6	2.0	0.0	n=4
23/14.1	6.7	2.6	4.0	71.1	6.6	6.9	1.6	0.1	0.0	0.0	0.7	1.6	0.0	n=6
23/20.2	12.2	3.1	3.4	69.7	3.7	6.4	0.8	0.0	0.1	0.1	0.5	1.0	1.3	n=6
Average	**8.3**	**2.8**	**4.9**	**69.4**	**6.4**	**6.0**	**1.5**	**0.1**	**0.0**	**0.1**	**0.5**	**1.5**	**0.3**	
St. Deviation	2.7	0.3	1.7	1.4	2.3	0.8	0.4	0.1	0.0	0.1	0.2	0.5	0.6	
St. Error	1.4	0.1	0.8	0.7	1.2	0.4	0.2	0.1	0.0	0.1	0.1	0.2	0.3	

Table 5.40. SEM-EDS results in wt. % of lilac *ishkor* glazes (non-colorants renormalised).

Ishkor blue glazes, upper v. lower values

Sample		Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	MnO	CuO	PbO	P2O5	S2O	Cl	
23/2-8.1	upper	5.4	1.3	10.5	62.6	7.1	2.7	0.6	0.3	0.6	8.6		0.0	0.2		n=3
	lower	4.8	1.5	13.7	63.3	7.9	2.2	0.7	0.3	0.3	4.9		0.0	0.3		n=3
23/10b.3	upper	7.7	1.9	3.9	66.9	3.8	4.8	1.3	0.0	1.5	7.2		0.0	0.0	1.0	n=1
	lower	7.0	2.4	3.6	68.9	3.7	5.1	1.5	0.0	1.3	5.4		0.0	0.6	0.7	n=1
23/20.6	upper	9.7	2.6	3.0	69.3	4.1	4.9	1.1	0.0	1.1	3.4		0.0	0.0	0.7	n=4
	lower	10.1	2.7	3.4	69.1	4.0	5.2	1.2	0.0	1.0	2.1		0.3	0.0	1.0	n=2

Table 5.41. SEM-EDS results in wt. % for blue *ishkor* glazes, upper v. lower values.

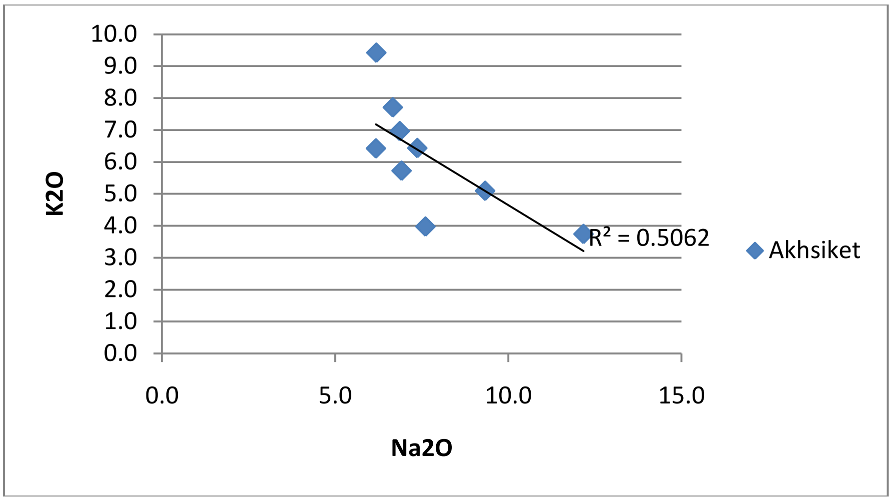


Figure 5.29. Scatter chart showing correlation of alkalis for *ishkor* base glaze in wt.%.

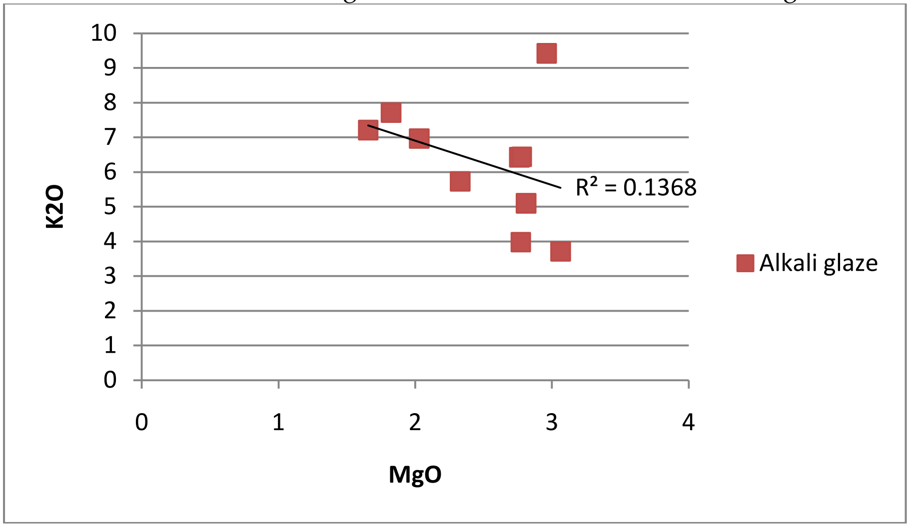


Figure 5.30. Scatter chart showing correlation of K2O and MgO for *ishkor* base glaze in wt.%.

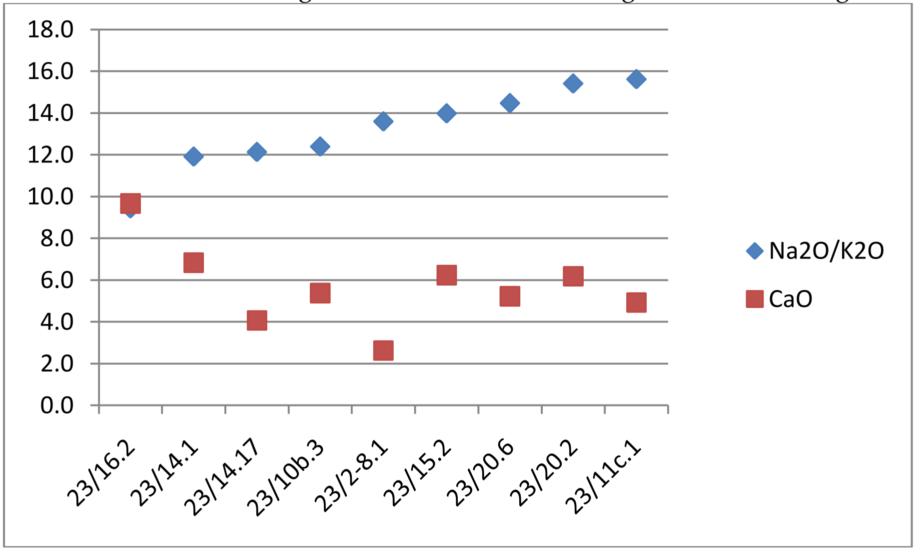


Figure 5.31. Chart (in wt.%) showing correlation of alkalis and lime for *ishkor* glaze.

Ishkor inclusions and interface areas

Sample	area	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	MnO	CuO	P2O5	SO3	Cl	Sb2O3	SnO2	
23/10b.3	inclusion	1.8	11.5	0.7	55.8	0.5	21.9	2.6	0.0	2.3	3.0	0.0	0.0	0.0			n=1
	inclusion	4.4	1.0	2.6	39.5	2.1	8.8	0.7	0.0	0.6	4.3	0.0	0.7	0.0	34.7		n=1
	inclusion	1.9	4.1	3.4	58.4	1.8	19.5	1.7	0.0	1.6	7.4	0.0	0.0	0.3			n=1
23/14.1	inclusion	0.4	1.0	0.0	52.0	0.4	44.6	0.0	0.0	1.8	0.0	0.0	0.0	0.0			n=1
23/20.2	inclusion	4.2	1.1	1.0	27.6	0.0	7.1	0.6	0.0	0.0	1.2	0.0	0.0	0.0		57.1	n=2
23/10b.3	interface(blue)	13.8	0.0	31.7	47.2	4.9	1.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0			n=1
	interface (lilac)	9.4	0.0	22.7	62.5	3.9	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0			n=1
23/11c.1	interface	11.2	0.5	30.8	48.8	5.6	2.8	0.0	0.3	0.0	0.0	0.0	0.0	0.0			n=2

[1] **Rectangular crystal in bold**, *Round crystal in italics*

Table 5.42. SEM-EDS results in wt. % for *ishkor* inclusions and interface areas.

5.3.2. Skeuomorphic wares

Skeuomorphic wares are a very specific type of pottery with an alkali glaze similar to the *ishkor* wares. The vessels conform to a very limited range of body shapes, covered with a uniform, monochrome, purplish black glaze. The glaze covers the inside of the vessel, and partly or fully covers the outside as well. One sherd was analysed, sample 23/10a.1, and due to the consistency in visual appearance, the assumption is that this sherd will be representative enough for the purposes of basic characterisation. However, further sherds should be analysed in future, to get a better idea of the range of variation present for this particular type. For detailed description of this type of vessel, see Chapter 3.4.4.

The sample is from a pear-shaped vessel with glaze on both sides, which was applied directly to the earthenware body. The visual appearance of the glaze is of a mottled black and purplish/brown due to the heterogeneity of the glaze, as seen in the optical microscopy image (Figure 5.32, top right). Like the *ishkor* wares, the glaze is fully fused, but silica is not always well diffused throughout the matrix. There are dark patches in the cross section of strongly coloured areas, visible in the OM images, although not so much in the BSE images.

This skeuomorphic glaze example has a lower silica content than the lowest of the *ishkor* glazes (66.5%) (Table 5.43). Alkali content is 15.5%, divided equally between soda and potassium. Lime is fairly typical at 6.6%, and titanium oxide was not detected. Iron oxide is a little high in comparison to the *ishkor* glazes at 1.6%, but only by 0.3% off the average. Manganese oxide is exactly the same concentration as the *ishkor* average, 1.4%.

Manganese oxide (and iron oxide) are not as high as one would expect, considering similar levels have produced far lighter colours in the *ishkor* glazes, and the base glaze composition is not significantly different from the *ishkor* wares (although further samples are required to gain a true picture of how this type compares to the wider *ishkor* assemblage). The key to the colour appearance is probably in the heterogeneity of the macrostructure of the glaze, which is difficult to pinpoint and analyse with the SEM. The OM image demonstrates well the scattered dark patches surrounded by a silica-rich matrix of a lighter colour. The former provides the somewhat patchy colouring while the latter scatters light and makes the glaze more opaque overall. These differences are invisible in the BSE images.

There is no visible interface layer between the glaze and the body, which is typical for the *ishkor* wares. There are small differences between upper and lower areas of the glaze, although the significance of these are not obvious (Table 5.44). Differences could be due as well to the general heterogeneity of the glaze components as to any interaction with the clay body.

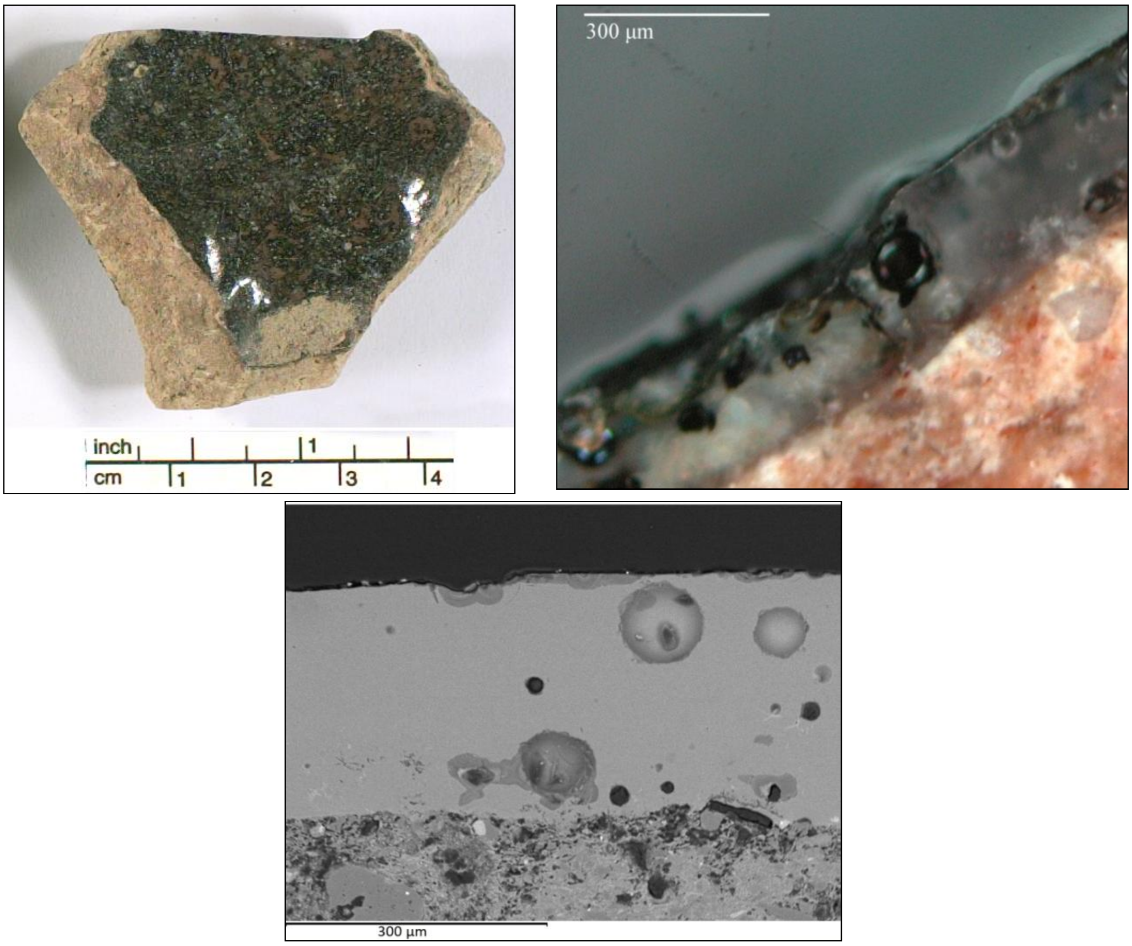


Figure 5.32. Images of Akhsiket 23/10b.1 skeuomorphic sherd, including OM (top right) and BSE (bottom) images of glaze. Microscopy images show (top to bottom): resin block, glaze, and body fabric.

Akhsiket 23/10a.1 skeuomorphic glaze												
Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	MnO	SO3	Cl	
23/10b.1	7.9	2.6	4.6	66.5	7.6	6.6	1.6	0.0	1.4	0.1	1.0	n=10

Table 5.43. SEM results in wt. % for Akhsiket 23/10b.1 skeuomorphic glaze.

Akhsiket 23/10b.1 skeuomorphic glaze, upper v. lower values													
Sample		Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	MnO	SO3	Cl	
23/10b.1	upper	8.0	2.6	4.7	66.5	7.7	6.4	1.4	0.1	1.5	0.1	1.0	n=8
	lower	7.6	2.5	4.5	66.5	7.4	7.3	2.2	0.0	1.1	0.0	1.0	n=2

Table 5.44. SEM-EDS results in wt.% for Akhsiket 23/10b.1 skeuomorphic glaze, upper v. lower values.

5.4. Unglazed pottery

The unglazed pottery at Akhsiket comes in a variety of forms (described in detail in Chapter 3.5). These include domestic fineware (water jars, tablewares, storage jars), cooking pots, and architectural ceramics such as brick and tile. A range of these were analysed to investigate the characteristics of the most commonly found wares at Akhsiket, and for comparison to the glazed wares. Samples were analysed with SEM-EDS, with a pilot study of XRF analysis. As the glazed wares were only analysed with SEM-EDS, the XRF results are not compared to the glazed sherds. No thin-section analysis was carried out, although SEM-EDS analysis of representative inclusions visible in the body fabrics were done, to compare with similar analysis on the glazed wares.

Analysis of unglazed ceramics from Akhsiket show a high degree of consistency across the seventeen bodies analysed via bulk SEM-EDS scans, and the seven samples chosen for the test XRF study. Several different vessel types were analysed with the SEM including fine kitchen wares; coarse cooking ware, usually of the two-handled ball-shaped variety; and brick. XRF analysis did not include cooking pots. For more information on the analytical methodology, refer to Chapter 4, and for full analytical results, refer to Appendix B.

5.4.1. Domestic fineware

Several types of 'domestic fineware' have been identified. The term 'domestic fineware' is here used to distinguishes untempered domestic pottery from the coarse cooking pottery and other types such as sphereo-conical wares, Kazakh tables, unglazed lamps, architectural ceramics, and so on. The most common forms of domestic fineware seen at Akhsiket are closed forms such as the pear shaped water jug with single handle and long spout and large storage jars without handles, although open form vessels such as bowls and vases are also seen. See Chapter 3.5.1 for further information on the typology of these wares.

SEM-EDS results show the fabric to be highly calcareous, with 14-16% lime (see Table 5.45). The paste is also iron-rich, with an average of 5.6% rising to 7.3% on one sherd. Alumina and magnesia concentrations vary little, with an average of 13.5% and 3.7% respectively. Soda and potash are more variable – soda ranging from 0.9% to 3.0%, and potash from 1.4% to 4.1%. Soda and potash are negatively. Titanium oxide is always less than 1%.

Inclusions are minerals, generally 25-50 microns in diameter with occasional inclusions of 100 microns or larger (see Figure 5.33 and Figure 5.34). SEM analysis of inclusions allowed identification of mineral types, or at least mineral groups. Most common is quartz with some alumino-silicates including feldspars. Iron-rich inclusions are common. Occasional calcite inclusions are also seen. SEM-EDS results of a range of common inclusions analysed in the fabrics are shown in Table 5.46.

Four domestic fineware sherds were included in a small XRF study of unglazed wares which also included brick. This study was carried out to test whether trace analysis would be useful for the Akhsiket sherds. Two sherds originated from Object 23 layer 15, and the other two from Object 9 layer 3. These sherds probably date to the late 10th/11th century according to associated glazed wares from these layers. All the fineware samples have typical buff fabrics, and are derived from closed kitchenware forms such as water jars.

Twenty-five elements were reliably detected by the XRF spectrometer. The elements presented in Table 5.47 are typical for ancient ceramic bodies. Trace elements, shown here as oxides in μg/g, are Co_3O_4, NiO, CuO, ZnO, Ga_2O_3, As_2O_3, Rb_2O, SrO, Y_2O_3, ZrO_2, BaO, CeO_2 and PbO. Results are shown in Table 5.47 as analysed (not normalised). The trace elements do not vary widely between these four samples. There are variations, however, particularly As_2O_3 (23/15.5 having more than double the concentration of the others), BaO, which varies from 669 - 736 μg/g, and PbO, where 23/15.5 – again – has twice as much as the others.

Akhsiket domestic fineware bodies

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	P2O5	SO3	
9/3.1	1.3	3.6	13.6	56.9	2.9	14.2	7.3	0.2	0.0	0.0	n=5
9/3.2	1.8	4.3	13.9	57.3	2.2	15.4	4.6	0.5	0.0	0.0	n=2
28/2-8.1	0.9	3.3	13.2	56.5	4.1	16.2	5.7	0.0	0.0	0.0	n=4
23/11c.1	3.0	4.3	14.4	56.9	1.4	14.3	5.3	0.7	0.0	0.0	n=2
23/12.8	1.7	3.6	12.6	56.7	2.5	16.4	5.9	0.1	0.0	0.6	n=5
23/15.1	1.5	3.6	13.5	58.4	2.8	13.8	5.7	0.6	0.0	0.0	n=5
23/15.5	1.4	3.3	13.1	56.7	3.8	15.8	5.0	0.8	0.0	0.0	n=3
Average	**1.7**	**3.7**	**13.5**	**57.1**	**2.8**	**15.1**	**5.6**	**0.4**	**0.0**	**0.1**	
St. Deviation	0.7	0.4	0.6	0.6	0.9	1.0	0.9	0.3	0.0	0.2	
St. Error	0.2	0.2	0.2	0.2	0.4	0.4	0.3	0.1	0.0	0.1	

Table 5.45. SEM-EDS results in wt. % for Akhsiket domestic fineware bodies.

Akhsiket domestic fineware inclusions

Inclusion type	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2
Alumino-silicate	1.0	0.0	16.8	66.5	14.0	0.8	0.8	0.1
Alumino-silicate	2.2	3.6	15.9	66.5	5.5	0.3	5.7	0.2
Alumino-silicate	4.5	0.3	18.8	66.7	9.1	0.3	0.0	0.4
Si-Ca-Al-Fe	0.1	2.1	16.2	51.9	0.3	17.6	11.6	0.2
Fe-Si	0.1	0.5	0.4	34.3	0.2	0.4	63.8	0.2
Fe-Si	0.4	0.3	6.1	33.3	0.7	1.5	57.6	0.1
Fe-Si	0.7	1.0	6.8	12.1	1.3	1.2	76.2	0.6
Calcite	0.4	0.4	0.2	0.3	0.0	98.6	0.1	0.0
Si-Al-Fe-Mg	1.1	17.8	21.1	35.3	3.1	3.0	18.4	0.0
Si-Fe-Al	1.5	3.2	20.2	41.2	3.5	2.9	27.2	0.5
Si-Al-Na	7.1	1.0	18.5	66.2	0.9	4.8	1.3	0.0

Table 5.46. SEM-EDS results in wt. % for Akhsiket domestic fineware inclusions.

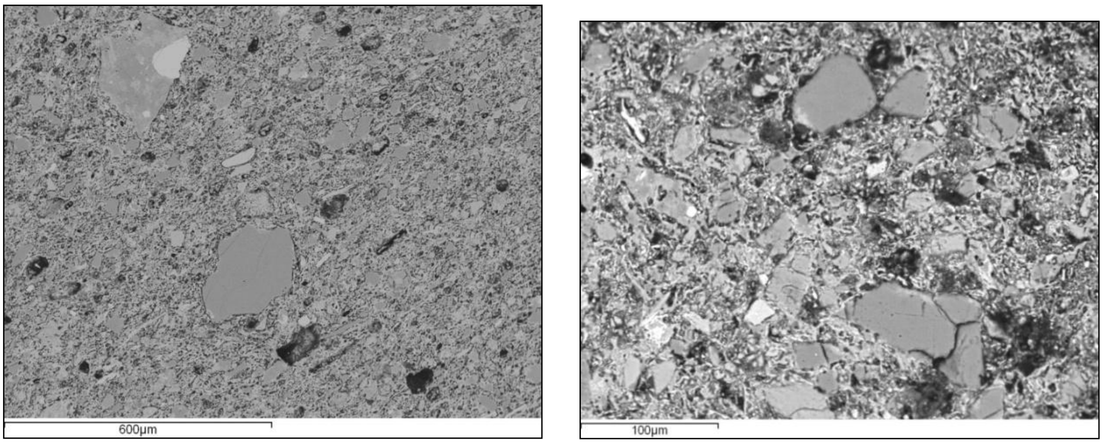
XRF analysis of finewares

Element	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	K2O	CaO	TiO2	V2O5	Cr2O3
Dimension	%	%	%	%	%	%	%	%	%	%	%
23/15.1	1.89	3.53	13.52	50.60	0.21	0.00	2.36	13.84	0.61	0.03	0.01
23/15.5	1.80	2.86	12.44	47.01	0.17	0.35	3.98	12.57	0.56	0.03	0.01
9/3.1	1.57	3.58	13.84	49.77	0.18	0.04	2.84	14.15	0.63	0.03	0.01
9/3.2	2.17	3.64	12.51	47.79	0.17	0.00	2.21	16.14	0.57	0.03	0.01
Average	**1.86**	**3.40**	**13.08**	**48.79**	**0.18**	**0.10**	**2.85**	**14.17**	**0.59**	**0.03**	**0.01**
St. Deviation	0.25	0.36	0.71	1.67	0.02	0.17	0.80	1.48	0.03	0.00	0.00
St. Error	0.12	0.18	0.35	0.84	0.01	0.08	0.40	0.74	0.01	0.00	0.00

Element	MnO	Fe2O3	Co3O4	NiO	CuO	ZnO	Ga2O3	As2O3	Rb2O	SrO	Y2O3	ZrO2
Dimension	%	%	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
23/15.1	0.11	5.70	63	46	71	110	27	10	103	324	32	133
23/15.5	0.11	5.25	50	45	64	121	24	35	114	384	27	125
9/3.1	0.12	5.97	75	52	88	127	26	14	111	355	31	111
9/3.2	0.11	5.56	65	46	92	120	23	13	97	395	29	111
Average	**0.11**	**5.62**	**63**	**47**	**79**	**119**	**19**	**18**	**106**	**364**	**23**	**120**
St. Deviation	0.00	0.30	10	3	13	7	2	11	8	32	2	11
St. Error	0.00	0.15	5	2	7	3	1	6	4	16	1	5

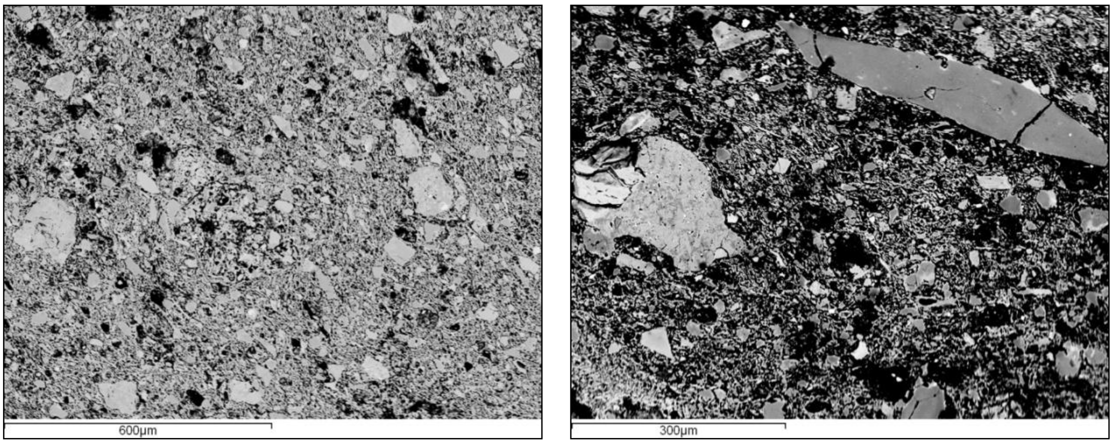
Element	BaO	CeO2	PbO
Dimension	µg/g	µg/g	µg/g
23/15.1	736	33	17
23/15.5	690	38	39
9/3.1	729	41	19
9/3.2	669	32	19
Average	**630**	**29**	**23**
St. Deviation	32	4	10
St. Error	16	2	5

Table 5.47. XRF trace analysis in wt. % and µg/g for Akhsiket domestic fineware bodies.



23/2-8.1

Figure 5.33. BSE images of an Akhsiket unglazed domestic fineware at magnifications of 100x and 320x. The large, medium grey crystals are quartz grains, while the small bright crystals are high in iron.



23/15.1
Figure 5.34. BSE images of an Akhsiket unglazed domestic fineware at magnification of 100x and 160x. The larger, medium grey crystals are quartz grains, and the lighter large crystal in the right image is a calcite grain.

5.4.2. Cooking pots

These utilitarian kitchen wares are usually ball-shaped with flattened bases (see Chapter 3.5.2 for detailed description of forms). Evidence for use over the fire is two-fold – they are often blackened from contact with flames or smoke, and the coarse, heavily tempered fabric was clearly designed to prevent the vessels from being damaged by the stresses of temperature variations.

The SEM-EDS was used for bulk analysis of the fabrics, and spot analysis of inclusions (Table 5.48, Table 5.49, and Table 5.50). Cooking pot samples were not analysed by XRF due to the high numbers of inclusions which would make comparison of trace element concentrations difficult. The fabrics are more variable than the other types, with their greater porosity and large temper inclusions, but are not exceptional, being calcareous and iron rich. Most variation can be seen in silica and lime, due to the temper. By reducing lime to the average seen in the domestic fineware bodies (15%) and re-normalising, these variations are greatly reduced (see Table 5.49), and the pots are not distinguishable in chemical composition from the other domestic types.

Large calcite grains are used as temper in these vessels, with occasional other inclusions such as quartz, feldspars or other rarer minerals (see Figure 5.35). These can be as large as 0.5 mm or greater, and are less evolved than the natural clay inclusions seen in the other wares, being angular in shape.

Akhsiket coarse cooking ware bodies

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	P2O5	SO3	
9/3.3	1.7	4.0	8.6	35.7	3.1	40.6	3.8	0.4	0.0	2.1	n=2
28/10a.1	0.9	5.5	9.0	38.8	3.3	35.1	4.5	0.0	1.1	1.8	n=2
23/17.1	1.4	6.3	9.1	36.1	2.7	37.5	3.3	0.0	0.6	2.4	n=2
23/20.1	0.9	5.2	11.9	45.7	3.3	26.1	4.6	0.4	1.2	0.9	n=2
Average	**1.2**	**5.2**	**9.7**	**39.1**	**3.1**	**34.8**	**4.1**	**0.2**	**0.7**	**1.8**	
St. Deviation	0.4	1.0	1.5	4.6	0.3	6.2	0.6	0.2	0.6	0.7	
St. Error	0.2	0.5	0.8	2.3	0.2	3.1	0.3	0.1	0.3	0.3	

Table 5.48. SEM-EDS results in wt. % for Akhsiket coarse cooking ware bodies.

Akhsiket coarse cooking ware bodies, CaO reduced to 15 wt. %

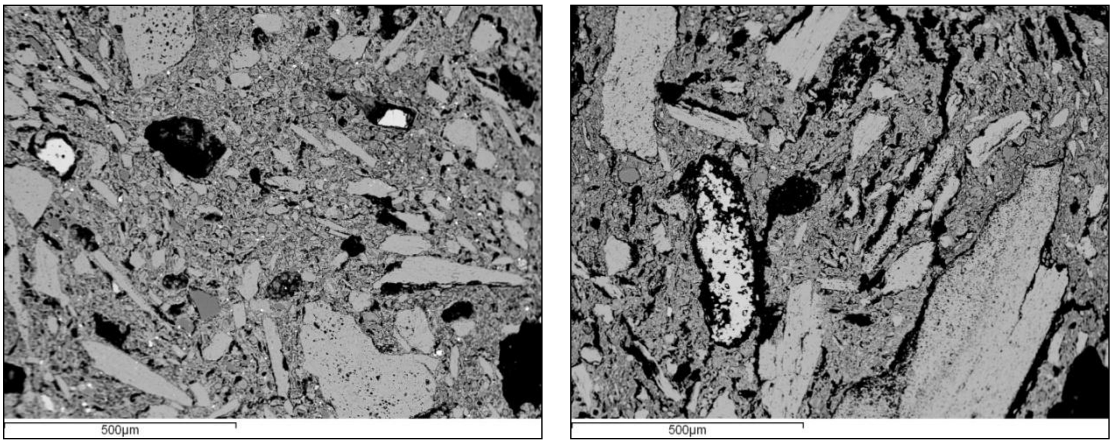
Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	P2O5	SO3	
9/3.3	2.4	5.7	12.4	51.1	4.4	15.0	5.5	0.5	0.0	3.0	n=2
28/10a.1	1.2	7.2	11.8	50.8	4.4	15.0	5.9	0.0	1.5	2.3	n=2
23/17.1	1.9	8.6	12.5	49.6	3.7	15.0	4.5	0.0	0.8	3.3	n=2
23/20.1	1.1	5.9	13.7	52.4	3.8	15.0	5.3	0.5	1.4	1.0	n=2
Average	**1.6**	**6.9**	**12.6**	**51.0**	**4.1**	**15.0**	**5.3**	**0.3**	**0.9**	**2.4**	
St. Deviation	0.6	1.3	0.8	1.1	0.4	0.0	0.6	0.3	0.7	1.0	
St. Error	0.3	0.7	0.4	0.6	0.2	0.0	0.3	0.1	0.3	0.5	

Table 5.49. SEM-EDS results in wt. % for Akhsiket coarse cooking ware bodies, with CaO values reduced to 15 wt. %, the average CaO composition in domestic fineware bodies.

Akhsiket coarse cooking ware inclusions

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	P2O5	SO3	MnO	Zr2O5
Ca-P	0.0	0.5	0.0	0.0	0.3	60.2	0.0	0.0	36.7	1.7		
Ca-P	0.0	0.8	0.0	0.0	0.0	56.0	0.0	0.0	38.2	4.9		
Calcite	0.0	0.4	0.0	0.0	0.1	98.2	0.0	0.0				
Iron mineral	1.1	3.3	0.9	17.4	1.2	4.9	70.4	0.0			0.8	
Iron mineral	0.0	6.9	6.5	13.1	1.1	11.1	61.4	0.0				
Zircon mineral	0.6	1.2	3.4	35.1	1.8	3.1	0.0	0.0	5.0	0.5		49.3

Table 5.50. SEM-EDS results in wt. % for a range of Akhsiket coarse cooking ware inclusions.



23/10a.1 23/20.1

Figure 5.35. BSE images of two Akhsiket cooking ware at a magnification of 100x showing calcite temper and iron mineral inclusion (the bright minerals – small in the left image and larger in the right image).

5.4.3. Brick

Of all the ceramics analysed, brick has the most claim to being produced locally using the nearest clay source. In comparison to the domestic pottery, brick was widespread - particularly in the fortification walls – easy to manufacture, of low value, and in the quantities used, would be far more efficient to produce locally rather than transporting over long distances. There are traces of brick kilns visible in cross-section in the ravine cutting through the western part of the city near Object 23 – including bricks remaining *in situ* in the kiln chambers (Papachristu 1999). These samples, therefore, are highly likely to demonstrate local clay characteristics. It is of course possible that clay was imported to create these bricks, but seems unlikely given that clay is available nearby (see section 5.4.3).

Four brick sherds recovered from Object 23 layer 13 were analysed with the SEM-EDS: two buff and two red coloured fabrics (Table 5.51). They are slightly coarser than the domestic fineware with a higher proportion of inclusions. The fabric is fairly soft and powdery. The macrostructure of these sherds, as seen in the BSE images below, shows dense but well-sorted clay (and possibly rock) inclusions (see Figure 5.36), mostly less than 50 microns in size, although the occasional larger inclusion is seen, and are generally angular or subangular. XRF analysis was carried out on two of these sherds (Table 5.52). The fabric is calcareous and iron-rich, and indistinguishable from the domestic fineware as far as major and minor elements are concerned.

Twenty-five elements were detected by the XRF. The trace element oxides are: Co_3O_4, NiO, CuO, ZnO, Ga_2O_3, As_2O_3, Rb_2O, SrO, Y_2O_3, ZrO_2, BaO, CeO_2 and PbO. The data is presented as analysed in Table 5.52 (not normalised). The trace elements are very similar between the two samples, the highest variation being seen in Rb_2O, with values of 114 and 92 µg/g. Many further samples are required, however, before a true picture of the variation can be seen.

Akhsiket brick

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	P2O5	SO3	
23/13.1	1.0	4.4	11.1	57.7	2.0	17.4	4.2	1.1	0.5	0.5	n=2
23/13.2	1.2	3.3	11.8	60.1	3.4	13.2	5.2	0.5	0.0	0.8	n=5
23/13.3	1.8	3.7	11.4	59.4	2.8	15.5	5.4	0.0	0.0	0.0	n=5
23/13.4	1.3	4.1	13.6	54.0	4.2	15.9	5.8	0.5	0.4	0.0	n=3
Average	**1.4**	**3.9**	**12.0**	**57.8**	**3.1**	**15.5**	**5.1**	**0.5**	**0.2**	**0.3**	
St. Deviation	0.3	0.5	1.1	2.7	1.0	1.7	0.7	0.4	0.3	0.4	
St. Error	0.2	0.2	0.6	1.4	0.5	0.9	0.3	0.2	0.1	0.2	

Table 5.51. SEM-EDS results in wt. % for Akhsiket brick samples.

XRF analysis of brick

Element	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	K2O	CaO	TiO2	V2O5	Cr2O3	MnO	Fe2O3	Co3O4	NiO	CuO	ZnO	Ga2O3	As2O3	Rb2O	SrO	Y2O3	ZrO2	BaO	CeO2	PbO
Dimension	%	%	%	%	%	%	%	%	%	%	%	%	%	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
23/13.2	1.43	3.49	11.55	46.49	0.28	0.09	2.96	14.28	0.57	0.03	0.01	0.11	5.15	54	42	74	118	21	27	114	385	29	147	938	33	35
23/13.3	1.59	4.07	10.47	47.91	0.15	0.00	1.83	17.11	0.57	0.03	0.01	0.09	4.91	62	39	69	104	21	17	92	368	31	142	934	29	25
Average	1.51	3.78	11.01	47.20	0.21	0.05	2.40	15.70	0.57	0.03	0.01	0.10	5.03	58	40	71	111	21	22	103	376	30	145	936	31	30
St. Dev.	0.11	0.41	0.76	1.01	0.09	0.06	0.80	2.00	0.00	0.00	0.00	0.01	0.17	5	2	4	9	0	8	15	12	1	3	3	3	7

Table 5.52. XRF results in wt. % and µg/g for Akhsiket brick trace elements.

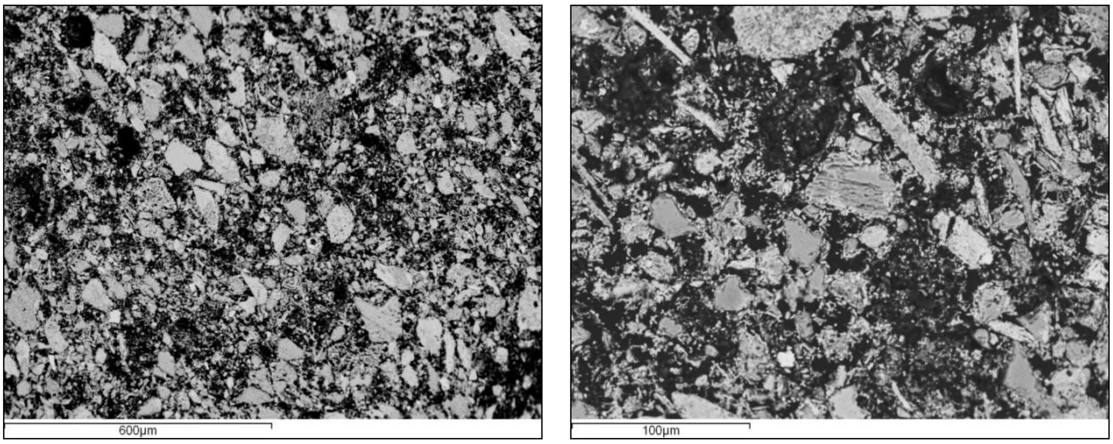


Figure 5.36. BSE images of Akhsiket brick sample 23/13.1 at magnifications of 100x and 400x.

5.5. Experimental firing exercise

During the 2005 fieldwork season at Akhsiket, a sample of clay was collected from an area to the east of Akhsiket on the outskirts of the town of Shaxand, across the gully from the eastern wall and Object 23. This area is a source of clay for the traditional bread ovens commonly used by households today. The clay, which was dry, was collected from unexposed layers of clay, reducing the chance of surface contamination.

As an experiment, a 3 cm x 2 cm x 1 cm briquette of this clay, without added sand or temper, was fired in a pottery kiln. It was fired once, at a maximum temperature of 850 degrees Celsius – close to the expected firing temperature of the domestic wares. In order to minimise cracking and shattering, the temperature was raised gradually by 100 degrees per hour to 600 degrees, when the gasses are fully driven off and the clay begins to fuse, then raised to 850 degrees at which point the briquette was allowed to cool naturally inside the closed kiln. The briquette survived the firing and was cut, mounted, and polished in the same manner as the ancient sherds.

The fabric of the fired briquette was dense, hard and red. SEM-EDS analysis shows that there is little noticeable difference in major and minor element concentration from the domestic fineware of Akhsiket. There are very small differences – around 1% – in alumina and lime. As a preliminary investigation, bulk analysis of this briquette is fully consistent with Akhsiket's early Islamic pottery.

This sample was also analysed with XRF. Twenty-five elements were detected including the trace element oxides Co_3O_4, NiO, CuO, ZnO, Ga_2O_3, As_2O_3, Rb_2O, SrO,

Y_2O_3, ZrO_2, BaO, CeO_2 and PbO. These results are discussed further in comparison to XRF results for the other samples in Chapter 7, where it is shown that the trace elements are very similar to some of the domestic sherds. Further research on clays from other areas would demonstrate what degree of variability in element concentrations exist in the Ferghana Valley, and therefore give a more accurate picture of how well Akhsiket's pottery fits in with this local clay source.

Akhsiket domestic fineware and experimental briquette

Sample	NaO2	MgO	Al2O3	Si2O	K2O	CaO	Fe2O3	TiO2	P2O5	SO3
domestic fine	1.7	3.7	13.5	57.1	2.8	15.2	5.6	0.4	0.0	0.1
briquette	1.0	3.3	11.8	56.1	3.7	17.0	6.0	0.8	0.2	0.0
St. Deviation	0.4	0.3	1.2	0.7	0.6	1.3	0.3	0.3	0.2	0.1

Table 5.53. SEM-EDS results in wt. % for Akhsiket domestic fineware (4 samples) and experimental briquette.

XRF analysis of fired clay

Element	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**P2O5**	**SO3**	**K2O**	**CaO**	**TiO2**	**V2O5**	**Cr2O3**
Dimension	%	%	%	%	%	%	%	%	%	%	%
Fired clay	0.83	4.53	13.15	47.20	0.14	0.16	2.40	13.60	0.47	0.03	0.01
MnO	**Fe2O3**	**Co3O4**	**NiO**	**CuO**	**ZnO**	**Ga2O3**	**As2O3**	**Rb2O**	**SrO**	**Y2O3**	**ZrO2**
%	%	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
0.10	5.31	57	44	49	124	22	25	120	344	31	132
BaO	**CeO2**	**PbO**									
µg/g	µg/g	µg/g									
1025	34	27									

Table 5.54. XRF results in wt. % and µg/g for fired clay experimental briquette.

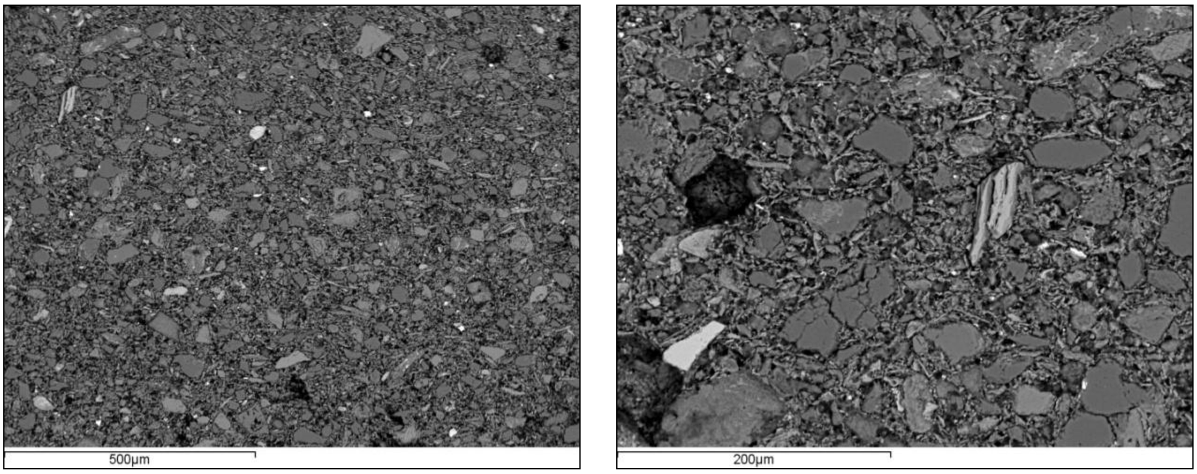


Figure 5.37. OM images of experimental briquette at 105x and 286x magnifications.

5.6. Summary of instrumental analysis

5.6.1. Bodies

Akhsiket's pottery clays are fine with no added temper (except for the cooking pots), uniform bulk compositions across the sample set (for oxides over 0.5 wt. %), and contain little in the way of polymineralic rock inclusions. The clay matrix is uniformly calcareous and iron rich, with on average 15.9 wt.% CaO and 6% Fe_2O_3. Petrographic analysis appears to show subtle groupings that may distinguish between different clays or preparation methods. Three possible groupings exist (Petrofabrics 1, 2 and 3), with differences in the clay mineral inclusions combined with the colour and texture of the fabrics leading to a preliminary estimate. As such a wide range of styles were analysed, it is difficult to match fabric types with styles. There is no obvious distinction between lead or alkali glazed wares within the Fabric Types. Further analysis would be required to confirm the presence of groupings, and should be done in combination with analysis of local clay sources.

XRF analysis was more revealing. With over 15 elements detectable by the XRF, there is a larger evidence set for comparison, providing a higher resolution of variation between what may be different clay sources originating from similar geologies. Generally, trace element concentrations are consistent between samples, although certain elements (such as lead, arsenic and barium) show high variation.

These analyses are discussed in greater detail in Chapter 7, where comparisons between different styles and assemblages are examined, and the implications of consistencies and variations in the analytical results are explored.

5.6.2. Glazed ware decoration methods

Lead glazed and alkali glazed wares were analysed, with a focus on obtaining a wide range of samples from the more common types and styles found at Akhsiket. The SEM-EDS was used for all compositional analyses. A range of interesting characteristics were analysed, and these are summarised below. Chapter 7 provides a more in-depth discussion of variations and interpretations, with reference to samples from comparative sites I the region and published results further afield.

A quartz-rich engobe was used for most of the polychrome and Samanid lead glazed wares, but was not present on monochrome lead glazed wares or alkali glazed wares. Engobe is far higher in silica and alumina and far lower in iron than the body clays used to form the vessels. This is fairly consistent across the assemblage, with some differences seen in alumina content for the Samanid wares. Coloured slips appear to have been made with similar components to the engobe present on the same sherd, only with added colorants. The higher alumina in the Samanid slips demonstrates this further. It is likely that both engobe and slips were created from a specific clay mixture – either using a different clay source altogether, or by preparing the clay in specific ways (mixing in kaolin clay, or crushed quartz, for example).

Slips are sometimes finer than the engobes, with smaller mineral inclusions, but not always. They were applied on the engobe, with the glaze applied over this. Colorants are limited to iron oxide, manganese oxide, copper oxide and chromium oxide/chromium grains. Iron oxide is used on its own to create red colours, in combination with manganese oxide for black or dark browns, copper oxide is used top produce green, and chromium is used for the olive green colours.

In some cases, it appears that pigments were used to create black or dark brown decorations – this is evidenced by the lack of a clay “carrier” slip present on the sherd, the presence of iron minerals at the interface between glaze and engobe, and the greater absorption of colorants into the lead glaze.

The lead glazes, which were normally applied over engobe and any slip or pigment decorations, were fairly typical high-lead glazes, with over 40% lead oxide in all cases. They have a smooth, homogeneous texture in general, with few cracks and bubbles. Well-fused to the underlying engobe or clay, a crystalline interaction layer can be seen in some, but not all, cases. The interaction layer seems to be particularly pronounced over black coloured slips or when glaze is directly applied to the body (as in the case of the monochrome green wares). Alkali glazes, on the other hand, show little to no interaction layer.

The alkali glazes contained no lead, have a silica base glaze, with roughly equal levels of soda and potash. Although the quantities of soda and potash are quite variable individually, together they represent a consistent total alkali concentration across the assemblage. This is likely to be a result of using different plants to produce the ashes, whilst maintaining a consistent ration of ash to silica in the recipe. Glazes are far more variable in quality than the lead glazes – there are often bubbles, cracks and unmelted or undiffused minerals (usually quartz). The glaze is always coloured, and ranges from nearly transparent for some of the lighter lilacs, to virtually opaque for very dark blues.

Colorants are limited to copper and manganese oxide. Manganese oxide is present in all the glaze colours at a fairly even quantity. Copper appears to be the colour "regulator". No copper present, and lilac is achieved; addition of a few percent copper gives a turquoise colour, while higher copper gives darker blues. The lilac colours are also affected by the colour of the underlying body, as there is no white slip to mask it. In the case of skeuomorphic wares, it appears from the single sample analysed, that the the quality of the glaze, and heterogeneity of the glaze colorants gives the dark purple affect which is achieved by otherwise similar levels of manganese oxide to the lilacs visible on the *ishkor* wares.

The following tables summarise the main characteristics for each type. The chronological framework for these can be seen in Table 3.2, above.

Lead glazed polychrome slipwares (all styles)		
Engobe		• 100-200 μm thick, usually on the thick side • More than one layer may be visible • Clay component is rich in quartz and other alumino-silicate minerals - similar to body clay, but difficult to compare due to added components • Includes PbO, leached from the glaze
Slips	**Black**	• Up to 100 μm thick, but highly variable • Applied on top of engobe • Similar clay composition to engobe • Iron and manganese minerals to produce the colour • Fe_2O_3 and MnO leaches into the glaze, staining it dark red/brown
	Olive	• As above, but the colorant is chromite • Chromite particles do not fully dissolve, but stain the glaze a greenish yellow colour
	Red	• As above, but the colorant is iron minerals • Clay used is iron rich, but iron minerals may have been added • Slightly higher alumina than other slips or engobe • Iron oxide may or may not be digested by the glaze
Black pigment		• Used often for black decoration • Coloured with iron and manganese minerals • Can be entirely diffused into the glaze, or traces of relict pigment minerals may be visible
Colourless glaze		• 75 – 100 μm thick – usually on the thin side • High lead, with an average of 53.8 wt.% PbO • Lead content highly variable, but usually over 50% • Alumina averages 3% • Minor elements low – less than 5% • Well fused, glassy, few bubbles or relict minerals • Silica was probably added to the glaze slurry before application • Little to no crystalline interface visible in cross-section
Black glaze		• Same composition as the colourless glaze on the same sherd • Increased iron and manganese oxide due to leaching from underlying pigments and/or slips (by 1 or 2 wt.%) • May have even colouring throughout the thickness, may have melted but undiffused patches of darker glaze, and/or may have relict minerals in the glaze • Tends to be a thicker glaze • Thick, dense crystalline interface layer (up to 100 μm) when pigment is used, comprising K-feldspars and other alumino-silicates
Green glaze		• On the polychrome wares, green glaze is a "cool", dark green • Same composition as the colourless glaze on the same sherd • Copper oxide of 2- 3.5 wt.% provides colorant

Lead glaze "Samanid" ware	
Engobe	• Composition and characteristics very similar to polychrome engobe, but with consistently higher alumina
Black slip	• Higher alumina than the black slip analysed for polychrome slipware • Higher iron and manganese oxide in comparison to polychrome slipware
Black pigment	• On one example, was used for black decoration • Coloured with iron and manganese minerals • Completely diffused into the glaze in this instance
Colourless glaze	• Composition and characteristics show no significant difference from the colourless lead glazes on polychrome slipwares
Black glaze	• As above, although one sherd shows significantly higher iron oxide in the glaze • As with polychrome slipwares, black glazes are coloured by the underlying pigment or slip
Lead glaze monochrome green ware	
Engobe	No engobe present
Green glaze	• Variation in thickness between samples (50 – 150 μm) • Variation in texture between samples)glassy and smooth, or can have bubbles and relict minerals) • All samples show an interface layer • Similar composition to colourless lead glazes, but higher CaO • Copper oxide averaging 2.4 wt.% provides the colorant (similar levels to polychrome slipware green glazes)
Kiln rod – green lead glaze	
Silica-rich layer	• Glassy layer high in undiffused, melted silica or alumino-silicate, overlying the spots of glaze (possible engobe transferred from contact with glazed vessel) • Not similar to the engobe used on polychrome slipwares – higher alumina and potash
Green glaze	Glaze very similar to monochrome green glazes on pottery
Alkali glazed *ishkor* ware	
Engobe	No engobe present
Blue glaze	• 200 – 300 μm thick • Sometimes smooth and glassy, more often riddled with bubbles, relict grains and undiffused melted silica • Crystalline growth often visible within the glaze • Thin interface layer sometimes seen • High alkali content – soda and potash roughly equal, with some variation (together totalling 13 wt.%) • Alumina averages around 4% • Roughly negative correlation between lime and soda+potash • Some visible change over time – soda decreases, but alkali content on the whole increases • Diffusion from the body less visible than the lead glazes • Blue colorant is up to 7% CuO and around 1.5% MnO
Lilac glaze	• Same composition as the blue glazes, but without the copper oxide • MnO is also the same as the blue glazes

Alkali glazed skeuomorphic ware	
Engobe	No engobe present
Black glaze	• Almost 300 μm thick • Heterogeneous glassy matrix with undiffused silica and colorant • Very similar composition to ishkor glaze • Similar levels of iron oxide and manganese oxide to the *ishkor* glaze • Colorants difficult to analyse – dispersed clumps not visible under SEM

Figure 5.38. Summary table providing the major microstructural characteristics of glazed ware decoration types.

6. Comparative analyses

Seven samples from the city of Kuva and seven samples from Chach (Tashkent) were analysed. This was to both examine the characteristics of sherds found at these sites, and to compliment the Akhsiket sample set - providing some comparative data for similar ceramics from elsewhere in the region. The analytical data for these sherds are presented and discussed here. For full results and images, refer to Appendix C.

6.1. Kuva

Kuva was an important trading oasis in the southern Ferghana Valley, located on a branch of the Silk Road (Figure 2.2). From the 8th century this route was superseded by a more northerly route through Semerichye (Kazakhstan). However, Kuva remained a major trading centre in the region and was known for its glass-working industry. Like Akhsiket, Kuva was an administrative centre with its own mint. An 8th century source states that 'Kubo [Kuva] was the seat of the governor-general appointed by the ruler of Ferghana' (Ivanov 2003, 206).

The fortified section of the city was smaller than Akhsiket's, but the city was widespread outside these borders. Similarly arranged to Akhsiket, Kuva also had a citadel (no longer existing), a fortified shahristan and a rabad. The mosque was on the citadel, while the bazaar, palace and prison were in the rabad (Ivanov 2003, 206). Excavations in many areas of the site have turned up glazed sherds of close similarity to Akhsiket's, but, as with Akhsiket, no direct evidence of pottery production has been found. It should be noted that this area (particularly Rishtan, a town nearby) is known for pottery production in the present day, and that traditional earthenwares are being manufactured there from local clays and glazes from indigenous plants (Komilov pers. comm. 2003). There are no publications relating to the glazed wares of Kuva.

Fifteen sherds were provided by G. Ivanov from excavations at Kuva, and seven were chosen for analysis. These sherds have been roughly dated according to loose stratigraphical and typological assumptions, but little other contextual information was available. Six lead glazed samples and two alkali samples (the only two available) were collected and analysed. These samples show some similarities in style and technology to the Akhsiket sherds. See Appendix C for images of all the sherds, including microphotographs.

6.1.1. Kuva Bodies

The bodies of the Kuva sherds are very fine with no added temper. They vary in colour from buff to red, are moderate to highly calcareous, and iron-rich. Geologically, the Kuva samples are fairly limited in variety. There is some variation across the seven sherds, particularly in silica and lime, but also in iron oxide concentrations. Summary results are presented in this section; for full analytical results see Appendix C. Full discussion of the implications of the results are in Chapter 7.

Petrographic analyses of three Kuva sherds are summarized in Table 6.1. Kuva 1 is a blue *ishkor* sherd, Kuva 2 monochrome green, and Kuva 6 is 12th century polychrome lead glazed ware (see following sections for images and further details of the glazes and slips). Each of these types relates to commonly found styles at Akhsiket, and span the full chronological range as far as is understood.

These particular samples fall into the red fabric types, with two similar to Fabric Type 1 and one similar to Fabric Type 5. The main division between these groups, petrographically, is the relative amounts of mono- and polycrystalline quartz in the bodies. The purpose of this small sample was to investigate comparisons with the Akhsiket samples, rather than to provide a comprehensive petrographic analysis of the Kuva assemblage.

Sample	Fabric characteristics	Grain characteristics	Mineral types
Kuva 1 **Kuva 2**	Red, some vitrification, very fine	Size: < 20 µm Sorting: Moderate Shape: Angular and rounded Density: 20% Few 50-100 µm grains	Mostly polycrystalline quartz Many opaques Few monocrystalline quartz Few calcite Few micas Few other minerals
Kuva 6	Dark red, some vitrification, very fine	Size: < 20 µm Sorting: Moderate Shape: Angular and rounded Density: 15% Few 50-100 µm grains	Mostly monocrystalline quartz Many opaques Some feldspars Few polycrystalline quartz (some ingrown with iron minerals) Few calcite Few horneblende

Table 6.1 Petrographic analyses of Kuva sherds.

Kuva bodies contain on average 59.1% silica, and roughly equal amounts of alumina and lime at 13% and 12% respectively (Table 6.2). Potash is the dominant alkali at 3.8%, while soda is 1.2%. Magnesia is 2.9%. Iron is fairly high at 6.3%, with a maximum of 8.4% for Kuva 6. Titanium oxide is 0.7%. Phosphorus and sulphur oxide are both present in some of the sherds, with sulphur the most common and with the highest levels, averaging 0.7% but as high as 2.4% for Kuva 18. The Kuva bulk averages are not completely homogeneous. The main differences are in quantities of silica and lime, which vary by up to 8% for both. There is a negative linear correlation between lime and silica. There are also differences in the iron oxide concentration, with two sherds having > 8%.

SEM-EDS analyses of inclusions show a range of mineral types, usually with a high silica content, such as quartz, feldspars, micas and other minerals normally associated with igneous rock origins (Table 6.3).

Sample	Fabric characteristics	Grain characteristics	Mineral types
Kuva 1 **Kuva 2**	Red, some vitrification, very fine	Size: < 20 µm Sorting: Moderate Shape: Angular and rounded Density: 20% Few 50-100 µm grains	Mostly polycrystalline quartz Many opaques Few monocrystalline quartz Few calcite Few micas Few other minerals
Kuva 6	Dark red, some vitrification, very fine	Size: < 20 µm Sorting: Moderate Shape: Angular and rounded Density: 15% Few 50-100 µm grains	Mostly monocrystalline quartz Many opaques Some feldspars Few polycrystalline quartz (some ingrown with iron minerals) Few calcite Few horneblende

Table 6.1. Petrofabric descriptions of 3 Kuva sherds.

Kuva bulk body averages											
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**TiO2**	**Fe2O3**	**P2O5**	**SO3**	
Kv1	1.8	3.1	12.0	63.2	3.5	9.8	0.8	5.2	0.6	0.0	n=4
Kv6	0.7	2.9	12.8	55.0	3.6	14.7	1.0	8.4	0.0	0.9	n=3
Kv9	1.1	2.7	13.6	60.8	5.0	8.3	0.6	8.0	0.0	0.0	n=2
Kv12	1.5	2.8	13.4	53.5	3.5	17.9	0.7	5.2	0.2	0.2	n=4
Kv18	1.2	2.8	12.9	60.6	4.3	9.1	0.8	5.5	0.4	2.4	n=3
Kv19	1.1	3.2	12.4	58.8	3.2	14.0	0.7	5.6	0.0	0.9	n=3
Kv20	0.9	2.9	13.8	61.5	3.5	10.6	0.5	5.8	0.2	0.4	n=5
Average	**1.2**	**2.9**	**13.0**	**59.1**	**3.8**	**12.0**	**0.7**	**6.3**	**0.2**	**0.7**	
St. Deviation	0.3	0.2	0.7	3.5	0.6	3.5	0.2	1.4	0.2	0.8	
St. Error	0.1	0.1	0.2	1.3	0.2	1.3	0.1	0.5	0.1	0.3	

Table 6.2. SEM results in wt. % for Kuva bodies.

Examples of inclusions in Kuva bodies											
Mineral	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**MnO**	**BaO**	**P2O5**	**SO3**
Diopside		10.2	0.7	53.2		21.8	13.9	0.4			
K-feldspar	1.9		17.9	65.3	13.4				1.5		
Fe mineral		1.2	0.8	3.9	0.4	0.8	91.9	0.9			
Apatite			0.6	1.2	0.5	54.4				43.2	
Calcite		1.9		5.1	0.6	87.9				3.2	1.4
Na-feldspar	10.1		18.2	71.0	0.4	0.3					

Table 6.3. SEM-EDS results in wt. % for Kuva fabric inclusions.

6.1.2. Kuva slips and glazes

This section describes each Kuva sherd analysed. As each sherd is quite different, and there are relatively few compared to the Akhsiket sherds, I have treated each sample in a separate section. For images of sherds, polished blocks, and SEM images, drawings of rims and base shapes, as well as the full results of analyses, refer to Appendix C.

Kuva 1 - *ishkor*

Sherd description: The *ishkor* glaze on this base sherd is abraded and weathered. However, the glaze was thick enough for analysis of unweathered glassy matrix. What remains of the visible colour is a light turquoise blue. The glaze was applied directly onto the body, which is red. This sherd has been dated to the 10th century according to its stratigraphical location and style (Ivanov pers. comm. 2005).

Glaze characteristics: This glaze is around 250 μm in depth and has a thin weathered layer at the surface but the main body of the glaze appears fairly uniform and clear of bubbles and relict inclusions. There is a thin layer of undiffused silica above a sort of interface layer consisting of 70-100 μm of partially-reacted glaze or body. The alkali content of the glaze is around 17%, divided between soda, potash and magnesia and with an addition of 6.9% lime (see Table 6.4). Soda is the dominant alkali at 10.2%, with potash and manganese at 3.1% and 3.9% respectively. The glaze at this point on the vessel is homogeneous, with few bubbles, although there are areas with crystalline growths formed during devitrification on cooling in the kiln. These crystals are rich in magnesia and lime, probably diopside. The light turquoise colour is produced by a small amount (1.18%) of copper oxide.

Kuva 1 Glaze													
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**TiO2**	**Fe2O3**	**CuO**	**P2O5**	**SO3**	**Cl**	
Glaze	10.2	3.9	3.4	69.1	3.1	7.0	0.1	1.0	1.2	0.5	0.4	0.1	n=8

Table 6.4. SEM-EDS results in wt. % for Kuva 1 glaze.

Kuva 6 – 12th century polychrome slipware

Sherd description: This sherd is the rim of a bowl or plate, polychrome slipware of a typically 12th century style. The pattern runs horizontally across the vessel and includes olive, black (or a very dark brown), red and green elements on a white engobe covered with a lead glaze. The olive pigment has stained the glaze yellow in places. The engobe covers both sides of the sherd, while the glaze overlaps the back of the rim by around 0.5 cm. The fabric is light red.

Glaze characteristics: The glaze is thin, at 75-80 μm, and the surface shows evidence of mild crazing. The body of the glaze is homogenous in texture, with a few relict inclusions and small bubbles. In some cases a thin, discontinuous crystalline interface exists. This is a high lead glaze with 63.4% lead oxide (see Table 6.5). The glaze on this sherd is very pure, showing little contamination by iron or alkalies. There is around 0.8% potash throughout the glaze. There are only slight differences throughout the thickness of the glaze, with alumina and silica around 0.5% higher near the body than the surface. Lead oxide is correspondingly lower, but K_2O and CaO are unchanging. No true interface crystals can be seen except small areas of unreacted quartz.

The olive pigment on this sherd has leached into the glaze, causing it to take on a yellowish hue. 0.28% iron can be seen in the glaze over the olive decoration itself. This is of a similar concentration to iron present in the green-coloured glaze (0.24%). There is no iron oxide in the black, yellow or colourless glaze over white engobe.

The black decoration was probably applied as a manganese-rich pigment over the engobe. The manganese does not vary in its concentration of around 1.46% through the thickness of the glaze. It is unusual for there to be no detectable iron oxide here.

Although the dark colorant is crisp and well contained, the same cannot be said for the green glaze. The green glaze shows a similar amount of iron oxide as the glaze over olive pigment, with the addition of 2.7% copper oxide as a colorant. The green glaze is otherwise identical to the rest of the glaze on the sherd, so must have been created from the same base glaze recipe. Areas with red decoration were not analysed.

Slip characteristics: The quartz-rich white engobe is fairly homogenous across the sherd, with some small variations in the silica and lead oxide concentrations (see Table 6.6). 17.5% lead oxide has leached into the slip from the glaze during firing; if removed, the actual composition of the engobe can be seen (see Table 6.7). Comparison of the engobe with the body, after subtracting silica and lead oxide, shows that there is quite a difference between the two. Alumina and potash are considerably higher in the engobe than the body as seen already on Akhsiket samples, indicating the use of feldspathic sands and/or kaolin clay, while lime and iron oxide are higher in the body (see Table 6.8).

Kuva 6 Glaze

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	CuO	MnO	
Colourless/Olive	0.0	0.1	2.6	31.8	0.8	0.7	0.3	63.7	0.0	0.0	n=6
Yellow	0.0	0.0	2.7	32.5	0.8	0.9	0.0	63.1	0.0	0.0	n=3
Black	0.0	0.0	2.5	32.0	0.8	0.9	0.0	62.3	0.0	1.5	n=3
Green	0.0	0.0	2.6	31.6	0.7	1.0	0.2	61.2	2.7	0.0	n=3
Colourless/White	0.0	0.0	2.7	32.3	0.9	0.7	0.0	63.4	0.0	0.0	n=3

Table 6.5. SEM-EDS results in wt.% for Kuva 6 glaze.

Kuva 6 Engobe

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	TiO2	Fe2O3	PbO	
Engobe	0.0	0.8	9.0	66.9	3.4	1.3	0.1	1.0	17.5	n=10

Table 6.6. SEM-EDS results in wt.% of Kuva 6 engobe.

Kuva 6 Engobe (PbO removed)

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	TiO2	Fe2O3	
Engobe	0.0	0.9	10.9	81.0	4.2	1.6	0.1	1.3	n=10

Table 6.7. SEM-EDS results in wt. % of Kuva 6 engobe without PbO.

Kuva 6 Engobe v. Body (SiO2 and PbO removed)

Area 1	Na2O	MgO	Al2O3	K2O	CaO	TiO2	Fe2O3
Engobe	0.0	5.0	57.9	22.1	8.3	0.0	6.6
Body	1.7	6.5	28.3	8.0	32.7	2.2	18.8

Table 6.8. SEM-EDS results in wt. % of Kuva 6 engobe and body, with silica and lead removed.

Kuva 9 – alkali glaze

Sherd description: This rim sherd has an alkali glaze and is greyish-blue in colour. The glaze is somewhat patchily coloured, and, unusually for an alkali glaze, lies over a quartz-rich engobe. The body is dark red. The use of an engobe and the colour indicates that this vessel was not of the *ishkor* type. This sherd has been dated to the 11th century according to context and style (Ivanov pers. comm. 2005).

Glaze characteristics: The glaze ranges from 80-140 μm in thickness. The matrix appears quite cloudy in the XPL image and this is caused by the heterogeneity of the silica diffusion during the molten stage. Otherwise, the chemical composition appears homogenous in the BSE image. Scattered throughout the thickness are devitrifcation inclusions, a few metal-rich inclusions of almost pure copper oxide, and some bubbles.

The basic glaze is 65.7% silica, with alkalis making up just over 11% (soda at 6.6%, potash at 4.4%), lime 7.2%, magnesia 3.2%, alumina 4.3%, and iron oxide at 1.9%. The remaining components are the colorants: copper (4.5%) and manganese (1.6%), and very minor amounts of other detectable elements (~ 0.5%) (see Table 6.9). There is around 2% higher concentration near the body of soda, magnesia, silica and potash, while lime is considerably lower near the body (averaging just under 5% as opposed to 9% near the surface), and slightly lower CuO and MnO. There is no discernable interface layer.

Slip characteristics: Kuva 9 engobe, ranging from 110 to 135 μm thick, is fairly consistent across the areas analysed, although it is coarser than the body; silica is high at 77.8%, with 9.4% alumina and 4.4% lime (see Table 6.10). Alkalis are divided between soda at 2.8% and potash at 3.7%; iron is fairly typical at 1.2%, as is manganese at 0.7%. With silica removed, and the remaining components renormalized, it can be seen that the engobe and body are not well matched. However, the engobe does demonstrate a high concentration of lime, indicating the use of more highly calcareous, low-iron clay component than the lead glazed engobes (see Table 6.11).

Kuva 9 Glaze

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	TiO2	Fe2O3	CuO	MnO	P2O5	SO3	Cl	
Glaze	6.6	3.2	4.3	65.7	4.4	7.2	0.1	1.9	4.5	1.6	0.1	0.2	0.2	n=8

Table 6.9. SEM-EDS results in wt. % of Kuva 9 glaze.

Kuva 9 Engobe

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	TiO2	Fe2O3	
Engobe	2.8	0.8	9.4	77.8	3.7	4.4	0.0	1.2	n=3

Table 6.10. SEM-EDS results in wt % of Kuva 9 engobe.

Kuva 9 Engobe v. Body (PbO and SiO2 removed)

Area 1	Na2O	MgO	Al2O3	K2O	CaO	TiO2	Fe2O3
Engobe	12.6	3.4	42.3	16.6	19.6	0.0	5.4
Body	1.9	7.3	34.7	12.8	21.1	2.0	20.3

Table 6.11. SEM-EDS results in wt. % for Kuva 9 engobe and body, with lead and silica removed.

Kuva 12 – 12th century polychrome

Sherd description: This body sherd is a 12th century lead glazed polychrome ware in a similar style to Kuva 6, but without a white engobe. In this case the decoration that was analysed was a dark brown spot and a line of olive/yellow with staining. The body is buff in colour.

Glaze characteristics: The glaze thickness ranges from 75-110 µm, and although the glassy matrix is fairly homogeneous, the glaze is pitted at the surface, and contains bubbles, relict inclusions and other imperfections. The coloured glazes contain a high quantity of inclusions both from colouring minerals and those normally seen only at the interface with the body, but here near the middle or upper areas of the glaze.

This is a high-lead glaze with 55% lead/39% silica and around 2% alkalis. 2.6% alumina, 1.4% lime and 0.5% iron make up the remaining uncoloured glaze composition (see Table 6.12). The dark brown glaze includes manganese of 3.4% as the primary colorant, with slightly higher iron oxide and lime concentrations. Alumina and potash are 1-1.5 % higher near the body than the surface. Silica ranges from 4-6% higher near the body with a corresponding increase in lead near the surface. The higher than usual rate of uptake of silica into the glaze could be due to the fact that the glaze was applied directly to the body, rather than over an engobe, with silica in the clay matrix reacting more easily.

Slips were not used on this sherd. Pigments may have been applied to the body which diffused through the glaze thickness during firing. Both the dark and light-appearing crystals in BSE images of the glaze are high in manganese with small amounts of copper, and some with small amounts of chromium (see Figure 6.1 and Table 6.13).

Kuva 12 Glaze										
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**MnO**	
Colourless	0.0	0.5	2.6	38.8	1.0	1.4	0.5	55.3	0.0	n=4
Dark Brown	0.0	0.6	2.6	36.5	0.8	2.3	0.7	53.0	3.4	n=6
Olive/yellow	0.0	0.3	2.7	37.9	1.1	1.3	0.5	56.3	0.0	n=6

Table 6.12. SEM-EDS results in wt. % of Kuva 12 glaze.

Kuva 12 Glaze inclusions												
Area 1	**Area 2**	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**CuO**	**MnO**	**Cr2O3**
Light 1	Spot	0.0	0.0	0.0	18.5	0.0	0.0	0.0	16.6	3.0	61.2	0.7
Light 2	Spot	0.0	0.0	0.0	20.7	0.0	0.0	0.6	18.3	2.7	57.8	0.0
Dark 3	Spot	0.0	7.7	0.0	45.8	0.0	0.0	12.9	7.1	0.9	25.2	0.5
Dark 4	Spot	0.0	2.7	0.0	39.6	0.0	0.6	5.1	3.3	1.2	47.5	0.0
Dark 5	Spot	0.0	1.0	1.5	16.2	0.0	0.0	1.1	68.9	1.7	9.8	0.0

Table 6.13. SEM-EDS results in wt. % of Kuva 12 glaze inclusion, as seen in Figure 6.1.

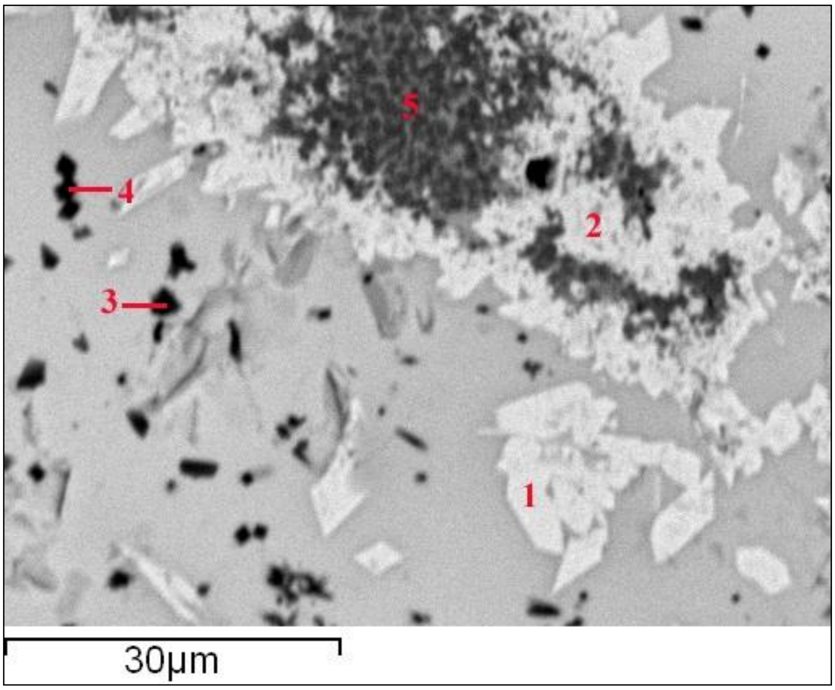


Figure 6.1. BSE image of Kuva 12 dark brown glaze showing the spot analyses.

Kuva 18 – Samanid ware

Sherd description: Kuva 18 is a lead glazed slipware sherd in the ‘Samanid’ style. It is a rim of a small bowl or cup, decorated on the inside only, with the glaze overlapping the back of the rim by an uneven 1.5 - 4.5 cm. The vessel is covered with a white engobe, back and front, with a discontinuous band of black pseudo-kufic over a black line, concentric with and about 2 cm below the rim. The body fabric is red. This sherd probably dates to the 10th century.

Glaze characteristics: The glaze is thin – around 80 µm – with some heterogeneity in the coloured glazes, but fairly homogenous colourless glazes. BSE images show a uniform chemical composition with occasional bubbles and a few small undiffused quartz grains, and there is little to no crystalline interface to be seen. It is high lead, at 57.6%, with around 1% potash as the alkali content (see Table 6.14). Lime is present at 1.4% and alumina at 1.9%. Leaching of chemicals from the body is unknown, as the analysis for this glaze was taken only at the mid-point.

The black decoration is glaze coloured with a manganese and iron-rich pigment, with slightly higher alumina, potash and iron than the colourless glaze. Under the optical microscope it can be seen that the glassy matrix is not completely homogenous. Although the glaze matrix is fairly evenly dark-coloured, there are reddish areas. The pigment was probably applied over the engobe, and has leached throughout the glaze without fully diffusing.

Engobe characteristics: The engobe is quartz-rich, and 200-250 microns in depth. Lead has leached into the engobe from the glaze during firing (see Table 6.15). With the lead removed, it can be seen that the engobe is fairly homogenous across the sherd (see Table 6.16). Compared with the body (lead and silica removed and the remaining components re-normalised) the clay component of the engobe is different from the body (see Table 6.16).

Kuva 18 Glaze										
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**MnO**	
Black	0.0	0.6	2.8	37.6	1.3	1.5	1.0	53.2	2.0	n=2
Colourless	0.0	0.3	1.9	37.7	0.8	1.4	0.3	57.6	0.0	n=6

Table 6.14. SEM-EDS results in wt. % for Kuva 18 glaze.

Kuva 18 Engobe											
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**TiO2**	**Fe2O3**	**PbO**	**SO3**	
Engobe	0.1	0.7	6.0	79.7	1.8	1.6	0.0	0.7	8.3	1.1	n=8

Table 6.15. SEM-EDS results in wt. % for Kuva 18 engobe under both black and colourless glaze.

Kuva 18 Engobe (without PbO)										
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**TiO2**	**Fe2O3**	**SO3**	
Engobe	0.0	0.8	6.3	76.6	2.0	2.0	0.0	0.8	10.5	n=8

Table 6.16. SEM-EDS results in wt. % of Kuva 18 engobe without PbO.

Kuva 18 Engobe v. Body (without SiO2 and PbO)								
Area 1	**Na2O**	**MgO**	**Al2O3**	**K2O**	**CaO**	**Ti2O3**	**Fe2O3**	**SO3**
Engobe	1.0	5.7	49.7	15.4	13.2	0.0	6.1	8.8
Body	3.2	7.2	33.0	10.9	23.2	2.1	14.1	6.2

Table 6.17. SEM-EDS results in wt. % for Kuva 18 engobe and body with SiO_2 and PbO removed.

Kuva 19 – monochrome green

Sherd description: Kuva 19 is a rim sherd of a bowl or plate, monochrome green in colour. The glaze was applied over an engobe which covers both sides of the sherd. The glaze overlaps the back of the rim by 0.5 cm. The fabric is pink. This sherd probably dates from the 11th century according to its design.

Glaze characteristics: Around 70 μm thick, with a uniform, homogeneous texture, this is a high lead glaze, with around 50% PbO. The glaze is very pure, with potash at 1%, no detectable soda, iron oxide 0.6% and lime at 1% (see Table 6.18). The colourant is produced with 5.6% copper oxide. There is no visible interface layer. Occasional relict grains of what appears to be K-feldspar remain in the glaze body and along the interface (high in silica, potassium and alumina).

Kuva 19 Glaze										
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**CuO**	
Glaze	0.0	0.2	3.9	37.8	1.0	1.2	0.7	50.1	5.2	n=8

Table 6.18. SEM-EDS results in wt. % of Kuva 19 glaze.

Kuva 20 – polychrome ware

Sherd description: This body sherd is lead glazed polychrome ware, with a band of pseudo-kufic in light olive on white engobe. The slip and the glaze cover both sides of the sherd. The olive pigment appears as dark green specks in a yellow-stained glaze, slightly raised. The result produces an olive green effect. The body is red. This sherd probably dates to the 10th century.

Glaze characteristics: This very thin (~50 µm) high lead glaze (57%) is pure and uniform, with around 1% alkalies and lime (see Table 6.19). There is no interface layer on this glaze. Iron is detectible in the yellow-stained glaze only, in minor amounts (average 0.3%), otherwise it is the same as the colourless glaze.

Slip characteristics: A 250 micron-thick quartz-rich engobe covers the surface of the sherd. Remaining quartz grains are small, mainly around 25-50 microns across. The takeup of lead oxide from the glaze is highly variable (see Table 6.20), but with PbO removed, and the remaining components re-normalised, the engobe is fairly uniform (see Table 6.21). The olive colour was achieved with the use of a pigment, applied on the surface of the engobe. Chromium-rich particles – probably chromite – can be seen at the interface layer – these are very dark in the OM images, and light grey in the BSE image (see Table 6.22).

Kuva 20 Glaze									
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	
Yellow-stained	0.0	0.0	1.7	38.1	0.5	0.7	0.3	58.6	n=5
Colourless	0.0	0.0	1.9	39.9	0.7	0.3	0.0	57.3	n=6

Table 6.19. SEM-EDS results in wt. % of Kuva 20 glaze.

Kuva 20 Engobe under colourless glaze									
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	
Engobe	0.0	0.2	5.5	83.0	1.5	0.2	0.2	9.4	n=3

Table 6.20. SEM-EDS results in wt. % for Kuva 20 engobe under colourless glaze.

Kuva 20 Engobe under colourless glaze (without PbO)							
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**
Engobe	0.0	0.2	6.1	91.6	1.6	0.2	0.3

Table 6.21. SEM-EDS results in wt. % for Kuva 20 colourless glaze, PbO removed.

Kuva 20 Chromite grain										
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**CuO**	**Cr2O3**
Chromite grain	0.0	16.0	10.4	0.7	0.0	0.0	9.1	0.0	1.4	62.3

Table 6.22 SEM-EDS results in wt. % for Kuva 20 chromite grains at interface of glaze and slip.

6.2. Chach (Tashkent)

The seven sherds chosen for analysis come from a small sample made available to me by the Academy of Sciences of Uzbekistan. All of these sherds were collected during excavations in the environs of modern Tashkent. Most of these sherds correlate well in style and date with Akhsiket's ceramics, or show a slightly wider range of styles using similar techniques. The sherds analysed for this thesis all date from the 9th – 11th century so fit within the chronological range present at Akhsiket.

The area currently occupied by the modern city of Tashkent was an important location for comparative material, as the nearest known pottery production centre. Tashkent currently occupies the area of a number of ancient towns, including the city of Binket, the regional capital of Chach (Figure 2.2). Binket and its surrounding market towns had direct and convenient access to the eastern caliphate, and would have been one of the most important links between the Ferghana Valley and the rest of Transoxania, serving as a funnel for new technologies from the West.

If the Ferghana Valley borrowed its glazed ceramic technology from Chach, it would be expected to find many similarities in style and production. It is already obvious from visual analysis and typological seriation that Akhsiket ceramics have many similarities in style and type to those at Chach – both being part of a larger, common artistic and technological tradition.

6.2.1. Tashkent bodies

Tashkent glazed bodies are fine, without added temper, and range from buff to red (red being the most common). They are on the whole more geologically diverse than the Kuva or Akhsiket bodies, with a greater proportion of inclusions (up to 75%). Iron-rich and moderate to highly calcareous, there is great uniformity across the nine sherds analysed with SEM-EDS (Table 6.39). Summary results are presented in this section; for full analytical results see Appendix C.

A small petrographic study of three sherds was carried out to enable some comparison with the Akhsiket sherds, and provides a very preliminary petrofabric analysis of the

Tashkent wares. Tash.18 is polychrome slipware miscellaneous design assigned to the 10th century, Tash.32 is polychrome slipware in a floral design also assigned to the 10th century, and Tash.47 is polychrome slipware yellow with olive bulls-eye design assigned to the 12th century (Brusenko 1986, Tables 11, 42).

Petrographical evidence shows that the Tashkent petrofabrics correspond fairly closely to the Akhsiket petrofabrics. The Tashkent sherds tend to have a well-evolved matrix but with a high proportion of angular grains (Table 6.23). Monocrystalline quartz is predominant, and in that respect seems to mirror the mono- v. polychrystalline divide seen in the Akhsiket and Kuva bodies.

The bodies contain 60.3% silica on average, with around 12.2% alumina (Table 6.24). Lime is fairly high at 13.6%, iron averaging 5.7%. The alkalis are dominated by potash at 3.2% against soda at 0.8%, magnesia falling in between at 2.3%. Titanium is 0.5% and not at all present in Tashkent 2. Phosphorus is present in most of the sherds, up to 3.9% for Tashkent 32.

Inclusions are typically dominated by quartz, and SEM-EDS analysis shows that there are a high number of calcium-rich silicate inclusions, often in conjunction with iron and alumina. Si-Al-K minerals are also abundant (feldspars or micas). There are also a few cases of Ca-P minerals – probably apatite.

For further discussion and comparison with Kuva, see section 6.3 below, and for comparison with Akhsiket, see Chapter 7.

Sample	Fabric characteristics	Grain characteristics	Mineral types
Tash.32	Fabric type 1 (closest) Red, some vitrification, very fine	Size: mostly < 20 µm Sorting: Moderate Shape: Angular and sub-angular Density: 20-25% Few >50 µm	Mostly monocrystalline quartz Many opaques Few calcite Few micas (<5%) Few other minerals
Tash.18 Tash.47	Fabric type 5 (closest) Dark red, some vitrification, very fine	Size: mostly <20 µm, some 20-50 µm Sorting: Well sorted Shape: Angular and subangular Density: 40-75% Few >50 µm	Mostly monocrystalline quartz Many opaques Many mica Some calcite Some feldspars Few polycrystalline quartz (some ingrown with iron minerals) Few other minerals

Table 6.23. Petrofabric descriptions of Tashkent sherds.

Tashkent bodies											
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**TiO2**	**SO3**	**P2O5**	
Tash.2	0.9	2.3	11.8	63.7	3.1	13.3	5.1	0.0	0.0	0.0	n=3
Tash.4	0.9	2.2	11.5	62.4	3.2	13.7	5.4	0.8	0.0	0.0	n=3
Tash.10	0.6	2.2	11.9	58.4	3.2	15.7	6.0	0.5	0.0	1.6	n=4
Tash.15	0.8	2.4	12.5	57.1	3.1	14.1	7.5	0.6	0.0	1.9	n=4
Tash.18	0.8	2.6	12.0	63.0	3.9	10.9	6.6	0.3	0.0	0.0	n=4
Tash.24	0.8	2.1	12.0	60.0	3.2	14.5	4.9	0.8	0.0	1.4	n=3
Tash.32	0.8	2.6	14.1	57.5	2.5	12.8	4.7	0.5	0.0	3.9	n=4
Average	**0.8**	**2.3**	**12.2**	**60.3**	**3.2**	**13.6**	**5.7**	**0.5**	**0.0**	**1.3**	
St. Deviation	0.1	0.2	0.9	2.7	0.4	1.5	1.0	0.3	0.0	1.4	
St. Error	0.0	0.1	0.3	1.0	0.2	0.6	0.4	0.1	0.0	0.5	

Table 6.24. SEM-EDS results in wt. % for Tashkent bodies.

Tashkent inclusions											
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**TiO2**	**MnO**	**P2O5**	**SO3**
Pyroxene		2.7	26.9	41.8		23.9	4.8				
Pyroxene	0.7	2.0	11.3	33.9	0.3	18.7	8.0	25.1			
Pyroxene	0.5	12.1	19.3	36.2	0.6	12.8	18.1		0.5		
Pyroxene			1.4	31.9		27.3	2.0	37.4			
Pyroxene		0.4	1.5	5.0		51.2	1.1			39.4	1.1
Diopside	0.5	10.5	24.5	34.3	0.7	14.1	14.8	0.6			
K-feldspar	1.6		15.2	70.6	11.4	0.9		0.4			
K-feldspar	1.8		16.4	67.0	13.2	0.6	1.0				
Diopside	0.5	12.6	18.8	33.0	1.2	11.0	20.8		0.4	0.7	1.0

Table 6.25. SEM-EDS results in wt. % for some Tashkent fabric inclusions.

6.2.2. Tashkent slips and glazes

This section describes each Tashkent sherd analysed. Most of the sherds are treated individually as they are relatively few in number, and are quite different from each other (except for Tashkent 2 and 4, the *ishkor* sherds). For images of sherds, polished blocks, and SEM images, drawings of rims and base shapes, as well as the full results of analyses, refer to Appendix C.

Tashkent 2 and 4: *Ishkor*

Sherd descriptions: Both of these samples are fragments of rim from an *ishkor* vessel, with a green amorphous decoration on a fairly transparent lilac background. The green glaze on these sherds is fairly intense and may be described as teal. Tashkent 1 has a buff fabric, while Tashkent 4 is pink. The glaze was applied directly to the body in both cases. Tashkent 2 originates from Binket and comes from surface collection of a 1981 excavation by the Tashkent Archaeological Expedition (TAE), while Tashkent 2 comes from a rubbish pit in the area of the Institute of Sport in Tashkent excavated in 2001. These sherds have been ascribed a date of mid 9th to mid 10th century by the local archaeologists, however this is based purely on its typological characteristics which for *ishkor* wares is not well established, and could indeed date from any time from roughly 850 – 1000. See Brusenko (1986, Tables 8.9 and 10) for similar sherds ascribed this date.

Glaze characteristics: The glazes thickness ranges from 400 - 600 μm thick, with the green glaze thicker – particularly where the green is darkest. Both samples are distinctive by the masses of bubbles contained in the glaze body, although the green glaze does have an upper layer of fairly pure glassy matrix; this area is also a deeper green than the underlying bubble-filled layer. It would appear that the green glaze was applied on top of the otherwise colourless or lightly lilac-coloured ‘background’ glaze. BSE images show that there are also inclusions in this glaze, the lilac glaze showing inclusions throughout the thickness, while the green glaze has inclusions only in the lower two thirds or so of the glaze – it would appear that the green glaze has vitrified fully in contrast to the underlying lilac glaze and remains suspended above the inclusion rich lilac glaze layer.

The two colours are essentially identical in composition as shown by removing PbO and CuO and renormalizing the remaining oxides. The green glaze is around 2% higher in silica, up to 1% lower in potash, 0.5% - 1% higher in soda, and 0.5% - 1% higher in lime than the lilac. The rest of the elements are within a few tenths of a percent in similarity. Silica is very high, at an average of 77.5% for Tashkent 2 and 79% for Tashkent 4. Alumina is just under 6%. The alkali fluxes are divided almost equally between soda and potash, with potash slightly higher.

Colorants are lead and copper oxides for the green glazes. Tashkent 2, with 16.4% lead oxide, and Tashket 4 dark green glaze at 16.5% are identical, while the light green in Tashkent 4 has a few percent less lead oxide present. Copper is quite low in Tashkent 2 (2.5%) compared with Tashkent 4, which has 9.5% in the dark green, and 5.2% in the lighter green. Copper oxide in a lead glaze solution produces green; copper oxide in an alkali solution at these firing ranges produces blue or turquoise, so the mixture of the two is as expected a bluish green.

The 'lilac' background colour is very lightly coloured with dispersed amounts of MnO. Of the 9 analyses of lilac glaze in Tashkent 2, only two had detectable MnO – at 0.6% and 0.5%, while Tashkent 4 contained 0.4% in only one of 6 analyses (too little to show up in the averaged total). There is also 8.4% lead oxide in Tashkent 4 lilac glaze, while Tashkent 2 has 1.4%. Without the copper oxide, the lead in this part of the glaze will not contribute to the colour. The lilac glaze is fairly transparent, so the underlying body colours are contributing to the effect more, perhaps, than any actual colorant in the glaze.

Tashkent 2 glaze with and without colorants

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	MnO	CuO	Cl	
Green	3.7	0.9	4.6	63.6	4.4	3.3	0.3	0.0	16.4	0.0	2.5	0.1	n=9
Lilac	4.9	1.5	5.9	75.3	6.4	3.5	0.8	0.1	1.4	0.1	0.0	0.2	n=9
Green*	4.6	1.2	5.7	78.5	5.5	4.1	0.4	0.0				0.1	
Lilac*	5.0	1.5	6.0	76.4	6.5	3.5	0.8	0.1				0.2	

*Without PbO, MnO and CuO

Tashkent 4 glaze with and without colorants

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	CuO	P2O5	
Dark green	3.1	1.0	3.8	59.1	3.6	3.6	0.0	0.0	16.5	9.4	0.0	n=3
Green	3.5	1.2	3.7	63.0	3.7	3.9	0.5	0.0	14.4	6.1	0.0	n=6
Lilac	4.3	1.5	3.8	73.4	4.1	3.7	0.6	0.0	8.4	0.0	0.0	n=6
Dark green*	4.4	1.5	4.7	79.3	4.6	4.9	0.7	0.0			0.0	
Green*	3.8	1.5	5.8	77.0	4.3	5.6	1.3	0.2			0.2	
Lilac*	4.7	1.6	4.1	80.3	4.5	4.1	0.7	0.0			0.0	

*Without PbO and CuO

Table 6.26. SEM-EDS results in wt. % for Tashkent *ishkor* glazes with and without colorants.

Tashkent 10 – polychrome slipware

Sherd description: A polychrome slipware sherd, rim of a bowl or plate with notched black pattern along the rim, pseudo-rope in red with incisions and black (possibly pseudo-kufic) lines. The black decoration shows some bleeding which is yellowish brown. The fabric is red in colour. This sherd originates from the 'rabad', rubbish pit 6, excavated by the TAE in 1989. According to the typology of this decoration type, it is dated to the 10th century (Brusenko 1986, Table 33).

Glaze characteristics: The thickness of the glaze ranges from ~85 μm for the colourless to 130 μm or more for the black coloured glaze. The OM images show the coloured glazes to be fairly evenly coloured, with the black glaze colour fading out to brownish red in the bleeding areas. 'Colourless' glaze over the red slip is actually fairly yellow in cross-section. This glaze is somewhat crazed, and the cracking can be seen clearly in the images. BSE images show little variation in the bulk chemical makeup, with a very thin crystalline interface in the black glaze.

The glaze is high lead, with an average of 54% PbO against 41 % silica and 5.3% minor elements (Table 6.27). Of this 3% is alumina, while potash (1.2%), soda (0.1%) and iron oxide (0.8%) make up the remainder. Magnesia was not detected, and lime is present in only one analysis of colourless glaze (0.7%). Considering the strong colour of the decoration, colourants in this glaze are surprisingly low – the black glaze having only 1.8% Fe_2O_3 and 0.4% MnO for the black glazes on average. However this is due to the heterogeneity of the glaze – in some analyses Fe_2O_3 rises to 2.1% and MnO is present in only two areas, but as 0.9% and 1.3%. The red glazes have 0.6% Fe_2O_3, not uncommon amounts for some colourless lead glazes. However some analysis of red coloured glaze have up to 1.7% Fe_2O_3.

Engobe and slip characteristics: There is no detected black slip on this sherd, so the colorant must have been produced by a pigment. Red slip was used, as is clear from the decoration motif with its incised lines. The red slip is high in Fe_2O_3 (6.5%) and has Cr_2O_5 in one analysis, at 1.7% (Table 6.28). Lead has leached into the red slip by 17.3% on average.

With the colorants and PbO removed and the remaining elements renormalized, it can be seen that the base slip composition is very similar to the engobe composition – with high silica and alumina (72.9% and 20%), and potash of 6%. Lime, soda and magnesia are all present at less than 1%.

Tashkent 10 glaze										
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**MnO**	
Red	0.0	0.0	4.1	40.2	0.7	0.0	0.6	54.4	0.0	n=5
Black	0.0	0.0	2.4	39.6	1.0	0.0	1.8	54.9	0.4	n=4
Colourless	0.4	0.0	2.5	42.6	1.9	0.1	0.0	52.5	0.0	n=5

Table 6.27. SEM-EDS results in wt. % for Tashkent 10 glaze.

Tashkent 10 slip and engobe											
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**TiO2**	**PbO**	**Cr2O5**	
Red slip	0.2	0.2	15.2	55.9	4.3	0.0	6.5	0.0	17.3	0.4	n=4
Engobe	0.5	0.3	17.3	62.4	5.3	1.0	0.0	0.1	13.3	0.0	n=10
Red slip*	0.2	0.3	20.0	73.8	5.7	0.0		0.0			
Engobe*	0.6	0.3	19.9	72.0	6.1	1.1		0.1			

*Without Fe2o3, PbO and Cr2O5

Table 6.28. SEM-EDS results in wt. % for Tashkent 10 slip and engobe, with and without colorants and PbO.

Tashkent 15 – monochrome green

Sherd description: This sample is a body sherd covered with a semi-transparent green glaze, applied directly to the body except for a couple of large (~2 cm in diameter) spots of white slip under the glaze. The effect of the glaze over the pink body appears opaque, but over the white slip it is obvious that it is somewhat patchily semi-transparent. This sherd originates from the 'rabad', rubbish pit 1, excavated by the TAE in 1979. It probably dates to the late 9th or early 10th century according to its style.

Glaze characteristics: Glaze thickness is around 110 μm. BSE images show the glaze to be largely uniform in composition, with a thin crystalline interface in the green glaze over the body (there is none apparent over the white slip). The glaze is high lead (50.1%) and coloured with 2.9% copper oxide (Table 6.29). Over the fourteen analyses, the lowest copper oxide is at 2.5% and the highest at 4.9% so there is some variation that explains the somewhat patchy effect visible over the white slip. Non-colouring minor elements make up 9.3% of the glaze, with alumina in the majority and all the typical minor elements present except for soda, which is not detected.

This sample exhibits a crystalline interface which is rich in silica, alumina and potash, as expected, and also rich in iron oxide (5.2%) (Table 6.29). Lime is also high, at 10.2%. Analysis consists of only one scan, but it may be the case that both lime and potassium feldspars have formed here. Copper oxide was not detected at the interface.

Slip characteristics: This sample does not utilise a covering engobe, but a white slip decoration as described above. 12.5% PbO has leached into this slip, and without this contamination it is clear that it is a very high silica slip, with 79.3%, with a good amount of alumina and potash as well (Table 6.30). 1% lime and <1% of the other typical elements make up the rest of the composition. It would appear that this slip is even more quartz-rich than the typical Tashkent engobe, probably indicating either a purer quartz source, or the relative lack of other alumino-silicate minerals.

Tashkent 15 glaze										
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**CuO**	
Glaze	0.0	0.5	3.6	37.6	1.7	2.4	1.1	50.1	2.9	n=14
Interface	0.6	3.4	9.5	58.2	6.9	10.2	5.2	6.0	0.0	n=1

Table 6.29. SEM-EDS results in wt. % for Tashkent 15 glaze.

Tashkent 15 slip										
Area 1	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**TiO2**	**PbO**	
White	0.3	0.5	11.7	69.4	4.3	0.9	0.1	0.2	12.5	n=8
White*	0.4	0.6	13.4	79.3	4.9	1.0	0.1	0.2		

*Without PbO

Table 6.30. SEM-EDS results in wt. % for Tashkent 15 slip.

Tashkent 18 – polychrome slipware

Sherd description. This sample is a body sherd with slip paints and coloured glaze on a white engobe background. The pattern is a miscellaneous polychrome slipware. The green glaze spots are normally seen on 12th century incised polychrome wares only, but this sherd is considered to be 10th century. The fabric is dark red. This sherd originates from Binket excavations, found in surface collection, so the date assigned (10th century) is based purely on its decorative appearance, which resembles early 10th century designs shown in Brusenko (1986) Table 33.

Glaze characteristics: Glaze thickness varies across the sherd but mainly falls within 150-200 μm. The glazes are fairly heterogenous in cross section, cloudy with undiffused silica, and, in the black glaze, the colorants are not evenly dissolved in the glaze matrix. BSE images are more homogenous in appearance, with the major elements fairly evenly distributed and occasional relict grains in the black glaze. There is minimal crystalline interface visible on the black glaze.

Only the black and colourless glazes were analysed, and these are high lead glazes, coloured by digestion of the underlying slip minerals. The colourless glaze contains 62.3% PbO and 34.8% silica, with very low alkalis (0.6% potash only), and trace amounts of lime. Magnesia is not detected in the colourless glazes, although one analysis of the black glaze shows 0.5%. Alumina is 2.2%. The black glazes include colorants only detected in analyses of the lower areas of the glaze, and these show iron in the range of 3.6% and manganese at 1.2%. Soda was not detected in any of the analyses.

Slip and engobe characteristics: The black slip contains 13% iron oxide and 1.1% manganese oxide, and this produces a very clean, precise decoration without the bleeding seen in the other Tashkent samples with black decoration. Immediate differences can be seen between the black slip and the engobe – the black slip is far lower in alumina (11.2% as compared to 20.1%) and far higher in lime (13.5% as compared to 4.5%). Phosphorus is also higher in the slip, and this could be linked to the lime – such as increased apatite minerals. Potash and soda are higher in the slip, and silica correspondingly lower. The engobe itself is fairly typical when compared to some other Tashkent engobe samples.

Tashkent 18 glaze

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	MnO	
Black	0.0	0.1	2.0	34.6	0.8	0.2	1.7	60.1	0.5	n=7
Colourless	0.0	0.0	2.2	34.8	0.6	0.1	0.0	62.3	0.0	n=6

Table 6.31. SEM-EDS results in wt. % for Tashkent 18 glaze.

Tashkent 18 slip and engobe

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	MnO	P2O5	
Black slip	0.3	0.3	8.6	51.3	3.8	10.3	13.0	0.0	9.4	1.1	1.9	n=2
Engobe	0.0	0.7	18.5	64.8	3.5	4.2	0.3	0.3	7.6	0.0	0.1	n=13
Black slip*	0.4	0.4	11.2	67.1	5.0	13.5		0.0			2.5	
Engobe*	0.0	0.7	20.1	70.3	3.8	4.5		0.3			0.1	

*Without Fe2O3, PbO and MnO

Table 6.32. SEM-EDS results in wt. % for Tashkent 18 slip and engobe.

Tashkent 24 – black slipware

Sherd description. This sample has a black engobe with white slip decoration painted over it, all covered with a high lead glaze. The decoration, which covers the face of this body sherd, consists of a bulls-eye track with horizontal lines and a possible band of pseudo-kufic. The fabric is dark red. This sherd originates from the same area as Tashkent 18 (surface collection at Binket), and has been dated to the 10th or 11th century based on its decorative characteristics, resembling similar 10th century black-background motifs in Brusenko (1986) Tables 4 and 32 in particular.

Glaze characteristics: The glaze is fairly thick at 200 μm and more. OM images show the glaze matrix to be a little patchy in the colour intensity in places – with the 'colourless' glaze over the white engobe appearing only slightly less coloured that that over the black engobe. BSE images show no variation in major chemical composition in the glassy matrix, and rare relict quartz grains or bubbles. There is some crystalline interface in the glaze over black engobe, but none over the white slip.

These are high-lead glazes, with 59.5% PbO (colourless glaze), and 37.3% silica, the remainder consisting of 2.1% alumina and < 1% potash and lime (Table 6.33). Glaze over the black engobe has taken up some of the colouring minerals in the lower areas of the glaze only, with averages for this area of 1.8% iron oxide and 1.1% manganese oxide.

Slip and engobe characteristics: The engobe is black, and applied as a background layer on the inner surface of the vessel. It contains iron oxide (13.4%) and high quantities of manganese oxide (4.3%) (Table 6.34). The effect is a uniform, opaque black over which white slip is applied. The black engobe with colorants and lead oxide removed contains 62.5% silica and 14.7% alumina. Lime is high at 8.7% and phosphorus very high at 7.2% - again indicating the presence of apatite minerals in the slip. Alkalis consist of mainly potash (3.8%) and 1% soda, and there is 1% magnesia and 0.5% sulphur oxide.

Comparing the slips with iron, lead and manganese oxides removed, it can be seen that although the white slip is high in silica, it contains less than the black engobe and also has higher alumina. Lime and phosphorus are present at lower levels than the black engobe (5.9% and 4.8%). Soda is around the same, potash about 1% higher and magnesia 0.5% lower than the black slip. This indicates a different clay mixture may have been used for the two different colours.

Tashkent 24 glaze

Area1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	MnO	
Black	0.2	0.0	2.4	37.3	1.0	0.4	0.7	57.4	0.6	n=8
Colourless	0.0	0.0	2.1	37.3	0.7	0.3	0.0	59.5	0.0	n=6

Table 6.33. SEM-EDS results in wt. % for Tashkent 24 glaze.

Tashkent 24 slip and engobe

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	MnO	P2O5	SO3	
Black engobe	0.8	0.8	11.4	48.6	2.9	6.8	13.4	0.5	4.5	4.3	5.6	0.4	n=12
White slip	1.0	0.4	23.7	43.2	3.9	4.8	5.8	0.0	11.6	1.8	3.9	0.0	n=6
Black engobe*	1.0	1.0	14.7	62.5	3.8	8.7		0.6			7.2	0.5	
White slip*	1.2	0.5	29.3	53.5	4.8	5.9		0.0			4.8	0.0	

*Without Fe2O3, PbO and MnO

Table 6.34. SEM-EDS results in wt. % for Tashkent slip and engobe.

Tashkent 32 – polychrome slipware

Sherd description: This is a very well preserved body sherd with sophisticated green and red floral designs, including palm fronds and broad leaves on a white background. The technique is polychrome slipware on a pink body. This is another sherd from surface collection at Binket, and dated by its decoration style to the 10th century (this sherd is recorded in Brusenko 1986, Table 11).

Glaze characteristics: The glaze is around 90 µm thick for colourless glazes, and 20 µm thinner for the glaze over green areas. The glaze is coloured from underlying slips, but the base 'colourless' glaze is a light green in cross section. In spite of the glossy, well preserved look of the glaze from the surface, in cross section it is fairly chipped and scratched, with cracks running through the glaze – especially over the green slip. The colours in the glaze over coloured slips is not completely homogenous and there are a number of inclusions, both relict minerals (most in the middle or near the surface), and other crystals near but not in the interface which are either relict or the product of devitrification. This is visible in all the glaze areas analysed. There is also a more typical crystalline interface thinly spread along the junction between the glaze and slip.

The glaze is high lead (57%) with a very small minor element contingent totalling a mere 3.1% with 2.4% alumina, 0.5% potash and 0.2% lime. There is a crystalline interface over the red slip decoration, and this is rich in alumina (16.9%) and potash

(4.1%), but only 0.2% higher in silica. Lime is about 0.5% higher, and iron oxide is present at 5.2% - presumably originating from the red slip. An inclusion at the interface with the green slip is consistent with chromite, having 62.3% chromium, 18.2% magnesium and iron at 4.2% (some of the iron expected appears to be replaced by the 14.5% alumina).

Slip and engobe characteristics: The engobe is white, quartz-rich and thus high in silica as usual (74.5%), with the expected range of other elements such as 15.8% alumina, 4% potash, a few percent lime, and < 1% soda and magnesia. Phosphorus is 1.2%. The full composition shows contamination of 12.4% lead oxide and 0.1% chromium oxide (actually 0.6% in a single analysis of the engobe).

There are some differences in the base slip of the three areas (red and green slips and white engobe). With PbO removed, the engobe is fairly average in composition with 74.5% silica, 15.8% alumina and 4% potash. Lime is 2.9% and potassium 1.2%. The other elements, soda, magnesia and titanium oxide are <1%. The red slip is lower in silica by around 8% and higher in alumina by the same amount. Otherwise there are only small differences (slightly more titanium oxide and potash, slightly less lime). The green slip by contrast has higher silica than the engobe by around 10%, and 8% less alumina. There are some differences in the other elements as well, being lower in all the minor elements except magnesia which is around 1% higher. Perhaps the green slip contained more silica in the mix, while the red slip contained more iron-rich clay.

Colorants in the slips are 6.3% iron oxide and 0.5% chromium oxide in the red slip and 1.6% iron oxide and 5.3% chromium oxide in the green. Chromium is quite high in comparison with the slip/pigments seen for the olive decorations, and in this case produces a brighter green. An inclusion in the green slip mirrors that found at the interface – what appears to be a chromite mineral with a high alumina and low iron content.

Tashkent 32 glaze, interface and inclusion

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	CuO	Cr2O3	
Glaze	0.0	0.0	2.4	39.9	0.5	0.2	0.0	56.9	0.0	0.0	n=4
Interface	0.5	0.0	16.9	40.5	4.1	1.1	5.2	31.6	0.0	0.0	n=1
Inclusion	0.0	18.2	14.5	0.0	0.0	0.0	4.2	0.0	0.9	62.3	n=1

Table 6.35. SEM-EDS results in wt. % for Tashkent 32 glaze, interface and inclusion.

Tashkent 32 engobe, slip and inclusion

Area 1	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	PbO	P2O5	Cr2O3	MnO	
Engobe	0.3	0.5	13.8	64.8	3.5	2.5	0.6	0.7	12.4	1.0	0.1	0.0	n=10
Red slip	0.1	0.6	16.1	48.9	4.0	1.0	6.3	1.4	20.0	1.2	0.5	0.0	n=4
Green slip	0.0	1.6	6.8	72.5	2.1	0.6	1.6	0.0	8.9	0.5	5.3	0.0	n=4
Engobe*	0.3	0.6	15.8	74.5	4.0	2.9		0.8		1.2			
Red slip*	0.2	0.8	22.0	66.8	5.5	1.3		1.9		1.6			
Green slip*	0.0	1.9	8.0	86.1	2.5	0.7		0.0		0.7			
Green slip inclusion	0.0	18.7	14.4	0.0	0.0	0.0	6.1	0.0	0.0	0.0	60.1	0.7	n=10

*Without Fe2O3, PbO, Cr2O3 and MnO

Table 6.36. SEM-EDS results in wt. % for Tashkent engobe, slip and inclusion.

6.3. Discussion

The Kuva and Tashkent sherds were chosen primarily for their usefulness as comparatively similar decoration types, colours and techniques to the Akhsiket sherds – although the polychrome slipwares do not have identical styles and motifs. As we have seen, this technique lends itself to variation and a certain amount of originality in the combination of a series of fairly common motifs and colours. It is not known whether these particular samples were actually produced at or near Kuva and Tashkent. There is currently no evidence for glazed pottery production at Kuva, while early kilns excavated in the Tashkent area have so far shown evidence of unglazed wares and slip-painted wares only (Burjakov and Filanovich 1999; for detailed discussion see section 3.3.1 above). Each of these areas requires a major study into their assemblages. For the purposes of this thesis, it was enough to see whether there was any technological coherence between samples found at each site or any significant differences or patterns to tease out from the analytical data.

In order to put the Akhsiket sherds into context, it was necessary to investigate how similar effects were produced in other pottery consuming areas. As no previous scientific work had been carried out on sherds from these areas, this chapter also serves as a preliminary pilot study of early Islamic wares from Kuva and Tashkent, testing assumptions concerning techniques employed to produce these wares. This section briefly summarises and highlights some of the interesting technological characteristics of the samples analysed, to be further discussed in Chapter 7, below.

Both Kuva and Tashkent assemblages have body compositions showing little variation within the sites (Table 6.37). Silica and lime are the most variable and demonstrate a negative correlation (Figure 6.1 for Kuva, Figure 6.2 for Tashkent). Comparing the averages of all the body analyses for the two sites shows that there is surprisingly little difference between the two. In fact there is around the same difference between Kuva and Tashkent as there is within the sherds from each area – the two sites almost completely overlapping. For silica and lime there is greater variation *within* the Kuva population. The only notable differences are in the volatiles where Kuva bodies contain sulphur while the Tashkent bodies do not, and Tashkent bodies tend to contain higher phosphorus than the Kuva bodies.

The petrographic studies are very preliminary for both populations, and serve mainly as a point of comparison with Akhsiket. Here we look some of these characteristics, to be discussed in relation to Akhsiket in Chapter 7. Only red fabrics were analysed, and there is little difference between the two Kuva 'petrofabrics' – divided almost purely on the basis of the relative dominance of polycrystalline or monocrystalline quartz. Tashkent bodies under XPL do show some notable characteristics - for example the fact that nearly all the mineral grains are angular and two of the three sherds from Tashkent, although well sorted, have a very high density of inclusions.

Kuva and Tashkent bodies											
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**Ti2O**	**SO3**	**P2O5**	
Kuva	1.2	2.9	12.9	58.9	3.8	12.1	6.3	0.7	0.8	0.2	n=7
St.Dev.	*0.3*	*0.1*	*0.7*	*3.6*	*0.6*	*3.5*	*1.4*	*0.2*	*1.0*	*0.2*	
Tashkent	0.8	2.3	12.2	60.3	3.2	13.6	5.7	0.5	0.0	1.3	n=7
St.Dev.	*0.1*	*0.2*	*0.9*	*2.7*	*0.4*	*1.5*	*1.0*	*0.3*	*0.0*	*1.4*	

Table 6.37. SEM-EDS results in wt. % for Kuva and Tashkent bodies.

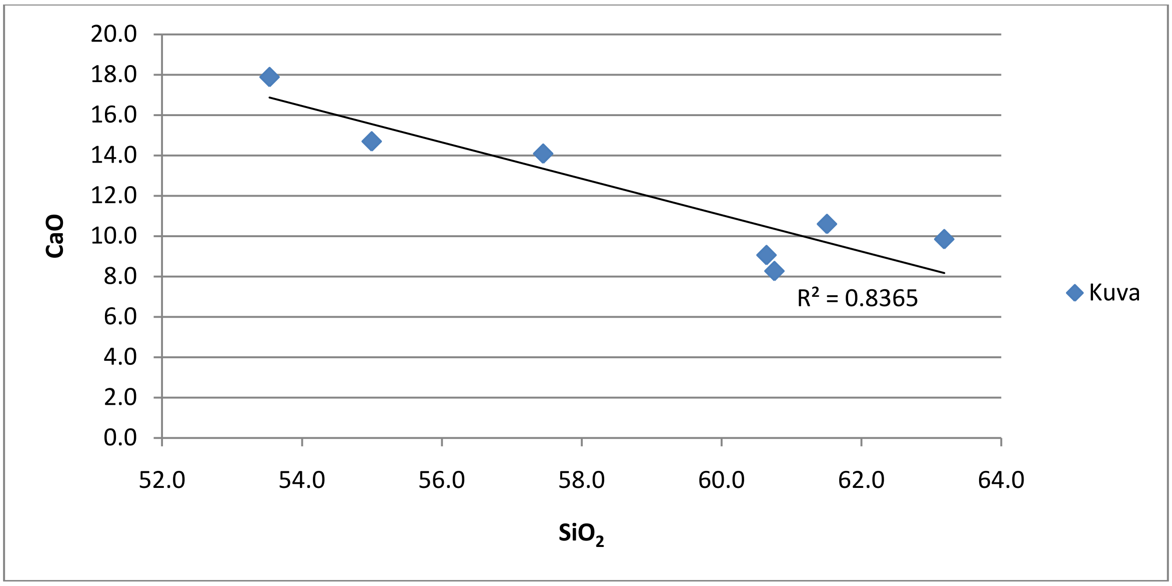


Figure 6.2. Line chart showing correlation of silica and lime for Kuva bodies.

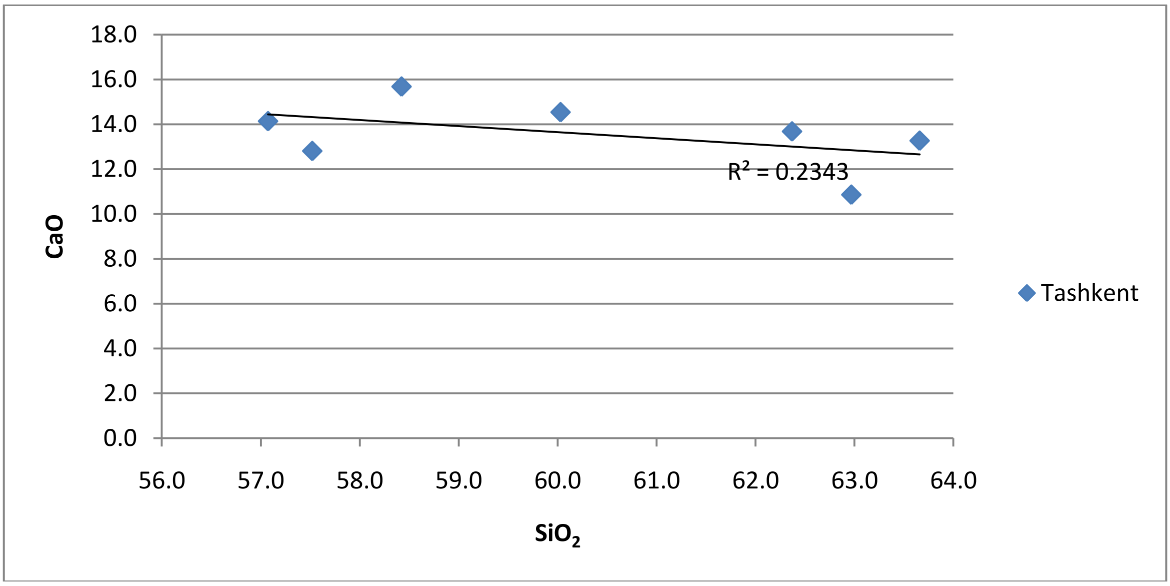


Figure 6.3. Line chart showing correlation of silica and lime for Tashkent bodies.

If PbO is removed from the **engobe** analyses, and silica from both engobe and body analyses, the remaining components can be compared. The degree of similarity between the engobe and body can show whether the engobe was a quartz-enriched version of the same clay used for the bodies. In the case of Kuva, it would appear that three of the four samples used a different, low-calcium clay source which also had very low levels of iron oxide and higher alumina (Table 6.38). Kuva 9 is different with only about 1% difference in lime concentrations between body and engobe, 4% difference in potash and around 6% difference in alumina. However it also has far lower iron (5.4% compared with 20.5% in the body) and far higher soda (unlike the rest of the sherds which have no soda detected). The key seems to be in the uniformly low iron oxide across all the engobe samples, which do not appear to correlate with iron levels in the respective bodies. A different low-iron, high alumina, white-firing clay such as kaolin could have been used as standard, with the added quartz containing more or less impurities depending on the source.

The Tashkent engobes show a similar pattern (Table 6.39) but are more consistent across the population of five sherds. Lime is lower in the engobe than the bodies by ~ 13% - 20%, with the engobe showing more variability between samples than the bodies. Alumina is also higher by twice the amount in the bodies or greater. Potash is higher in the engobe by around 2% - 9%, again with the variability all in the engobes. Iron is either non-existent or far lower in the engobe than the bodies. Soda is a little higher in three samples and lower in two samples compared to the bodies. As with the Kuva samples, the engobe appears to use a clay source which is exceptionally low in iron and lime and high in alumina, such as kaolin.

There is further discussion on this in the next Chapter in relation to Akhsiket engobe and kaolin clay samples from published sources.

Kuva engobe and body analyses

Sample		Na2O	MgO	Al2O3	K2O	CaO	Fe2O3	TiO2	SO3	P2O5
Kuva 6	engobe	0.0	5.0	57.9	22.1	8.3	6.6	0.0	0.0	0.0
	body	1.7	6.5	28.3	8.0	32.7	18.8	2.2	1.9	0.0
Kuva 9	engobe	12.6	3.4	42.4	16.7	19.7	5.4	0.0	0.0	0.0
	body	2.8	7.0	34.6	12.7	21.1	20.5	1.4	0.0	0.0
Kuva 18	engobe	0.0	8.4	66.4	18.7	1.9	4.7	0.0	0.0	0.0
	body	3.1	7.1	32.6	10.8	23.0	14.0	2.1	6.1	1.0
Kuva 20	engobe	0.0	3.5	76.0	15.5	1.4	3.5	0.0	0.0	0.0
	body	2.3	7.6	35.8	9.1	27.5	14.9	1.2	1.0	0.5

Table 6.38. SEM-EDS results in wt.% of Kuva white engobe and body analyses, PbO and silica removed.

Tashkent engobe and body analyses

Sample		Na2O	MgO	Al2O3	K2O	CaO	Fe2O3	TiO2	P2O5
Tash.10	engobe	1.7	1.2	51.0	16.7	6.0	0.0	0.7	0.0
	body	0.9	3.6	19.7	5.3	26.0	9.9	0.8	2.7
Tash.15	engobe	1.4	2.1	50.5	18.7	3.7	0.4	0.8	0.0
	body	1.3	4.1	20.7	5.1	23.5	12.5	1.1	3.1
Tash.18	engobe	0.0	2.1	46.7	9.4	15.6	0.3	0.9	0.0
	body	1.5	5.0	23.1	7.6	21.0	12.8	0.6	0.0
Tash.32	engobe	0.9	1.7	47.8	12.0	8.8	2.0	2.3	3.6
	body	1.4	4.9	26.4	4.8	24.0	8.9	0.9	0.0

Table 6.39. SEM-EDS results in wt. % of Tashkent white engobe and body analyses, PbO and silica removed.

Coloured slips are not in evidence on the Kuva sherds. Tashkent sherds had a few examples, with two red slips, a black slip (and engobe) and a green slip (Table 6.40). The red slips are similar to each other in that they have just under 8% iron oxide present as a colorant, and occasional minor quantities of Cr_2O_5 – perhaps a deliberate addition in order to alter the colour tone. In the case of Tashkent 32 the chromite could be contamination from the adjoining and overlapping green slip. The two red slips are more similar to each other than to their respective engobe or bodies. Where they differ, there is no correlation with the underlying engobe or bodies – for example, Tashkent 32 red slip contains lime and titanium oxide although these elements are not higher in the engobe or body than Tashkent 10 which does not have these elements present in the red slip.

The black slip example and the black engobe share similar characteristics, with almost identical iron oxide levels. Manganese is higher in Tashkent 24 at 4.5% against 2.1% in the black slip of Tashkent 18. Silica is relatively low in both being 7-11% lower than in the bodies. Otherwise it is difficult to fit the variations between the black slips, engobe and bodies into any kind of pattern.

The single green slip example is a slightly greener version of the typical olive seen on Akhsiket and Kuva polychrome slipwares. It has a very high silica content and low alumina, making it markedly different from the other clays on this sherd. Like the Kuva olive decoration, it is coloured with chromium oxide, which in this case is contained within the slip itself.

The chemical characteristics of the coloured slips are consistent with the idea that slips were made using specific raw materials – including specific clays – according to the colour and purposes required.

Tashkent slip, engobe and body analysis (without PbO)

Sample		Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	P2O5	MnO	Cr2O5
Tash.10	red slip	0.2	0.2	18.4	67.6	5.2	0.0	7.9	0.0	0.0	0.0	0.5
	engobe	0.7	0.5	19.6	70.4	6.4	2.3	0.0	0.3	0.0	0.0	0.0
	body	0.6	2.2	11.9	58.4	3.2	15.7	6.0	0.5	1.6	0.0	0.0
Tash.18	black slip	0.3	0.3	9.5	56.7	4.2	11.4	14.4	0.0	1.2	2.1	0.0
	engobe	0.0	0.8	18.4	70.4	3.7	6.1	0.1	0.4	0.0	0.0	0.0
	body	0.8	2.6	12.0	63.0	3.9	10.9	6.6	0.3	0.0	0.0	0.0
Tash.24	black engobe	0.8	0.8	12.0	51.1	3.1	7.1	14.1	0.5	5.9	4.5	0.0
	body	0.8	2.1	12.0	60.0	3.2	14.5	4.9	0.8	1.4	0.0	0.0
Tash.32	red slip	0.1	0.8	20.1	61.1	5.0	1.2	7.8	1.7	1.5	0.0	0.7
	green slip	0.0	1.9	8.4	77.1	2.3	0.9	2.1	0.0	1.2	0.0	6.0
	engobe	0.3	0.6	15.7	73.9	4.0	2.9	0.7	0.8	1.2	0.0	0.0
	body	0.8	2.6	14.1	57.5	2.5	12.8	4.7	0.5	3.9	0.0	0.0

Table 6.40. SEM-EDS results in wt. % for Tashkent slip, engobe and body analysis, with PbO contamination removed.

The Kuva **colourless lead glazes**, are, on the whole, fairly uniform in chemical composition. A couple examples include < 1% iron oxide, and these are also slightly higher in lime and magnesia (Table 6.41). Kuva 6 and 20 are purer in comparison with very low quantities of minor elements. A proportion of the composition is due to digestion of clay minerals during firing, as can be seen in the higher concentration of certain elements near the body, and the corresponding lowering of lead in the same area. Alumina, silica, and potash are concentrated more near the body by minor percentages (see Table 6.42), while lime is unaffected, and iron oxide does not follow a pattern. Lead oxide is around 3.5% higher near the surface than the body. All the glazes contain significantly higher silica than the underlying engobe when PbO is removed, as is obvious from the low minor element percentages in the glaze. This provides evidence that silica was added to the lead oxide before application (more on this in the next Chapter).

Tashkent glazes have a very slightly higher PbO content on average than in Kuva (Table 6.43), but the amounts of PbO overlap to a large degree. Kuva's are more closely grouped. Alumina is highly consistent ranging from 2.1% to 2.5%, and potash from 0.6% to 1.9%. However, there is no iron in the Tashkent glazes, unlike Kuva which has small amounts in two samples. The two samples analysed separately for lower and upper areas of the glaze demonstrate some digestion of clay minerals from the underlying engobe (Table 6.42 and Table 6.44).

Kuva colourless glazes									
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	
Kv6	0.0	0.0	2.7	32.3	0.9	0.7	0.0	63.4	n=3
Kv12	0.0	0.5	2.6	38.8	1.0	1.4	0.5	55.3	n=4
Kv18	0.0	0.3	1.9	37.7	0.8	1.4	0.3	57.6	n=6
Kv20	0.0	0.0	1.9	39.9	0.7	0.3	0.0	57.3	n=6
Average	**0.0**	**0.2**	**2.3**	**37.2**	**0.8**	**1.0**	**0.2**	**58.4**	
St. Deviation	0.0	0.3	0.4	3.4	0.2	0.5	0.2	3.5	
St. Error	0.0	0.1	0.2	1.7	0.1	0.3	0.1	1.7	

Table 6.41. SEM-EDS results in wt. % for Kuva colourless glazes.

Kuva colourless lead glazes, upper v. lower values										
Sample		**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	
Kuva 6	upper	0.0	0.0	2.5	31.8	0.8	0.8	0.1	64.0	n=8
	lower	0.0	0.1	3.0	32.7	0.9	0.7	0.2	62.4	n=4
Kuva 12	upper	0.0	0.5	2.1	37.5	0.9	1.3	0.4	57.4	n=7
	lower	0.0	0.2	3.9	40.1	1.5	1.3	0.7	52.4	n=3

Table 6.42. SEM-EDS results in wt. % of Kuva colourless glazes, upper v. lower values.

Tashkent colourless lead glazes									
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	
Tash.10	0.4	0.0	2.5	42.6	1.9	0.1	0.0	52.5	n=4
Tash.18	0.0	0.0	2.2	34.8	0.6	0.1	0.0	62.3	n=6
Tash.24	0.0	0.0	2.1	37.3	0.7	0.3	0.0	59.5	n=6
Tash.32	0.0	0.0	2.5	40.3	0.6	0.5	0.0	56.2	n=8
Average	**0.1**	**0.0**	**2.3**	**38.8**	**1.0**	**0.3**	**0.0**	**57.6**	
St. Deviation	0.2	0.0	0.2	3.4	0.6	0.2	0.0	4.2	
St. Error	0.1	0.0	0.1	1.7	0.3	0.1	0.0	2.1	

Table 6.43. SEM-EDS results in wt. % for Tashkent colourless glazes.

Tashkent colourless lead glazes, upper v. lower values										
Sample		**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	
Tash.10	upper	0.3	0.0	2.2	41.4	1.7	0.2	0.0	54.1	n=4
	lower	0.5	0.0	3.5	47.5	2.8	0.0	0.0	45.7	n=1
Tash.18	upper	0.0	0.0	1.9	34.7	0.4	0.2	0.0	62.8	n=4
	lower	0.0	0.0	2.9	34.9	0.9	0.0	0.0	61.3	n=2

Table 6.44. SEM-EDS results in wt. % for Tashkent colourless glazes, upper v. lower values.

The **coloured glazes** on polychrome wares have already been shown to be the same as the base, colourless glaze with colour produced by the leaching of minerals from pigments or slips. In many cases, pigments have completely dissolved into the glaze. Kuva black coloured glazes are coloured mainly with diffused MnO of 1.5% to 3.4%. Kuva 6 does not have any iron oxide at all, and the other two are at or just under 1%. The Kuva glazes do not show much of a crystalline interface.

Tashkent black glazes are lower in MnO, but on the whole higher in Fe_2O_3, ranging from 0.7% to 1.8%. These do have a crystalline interface at the point where the glaze meets the underlying engobe and/or slip. These interface layers are usually a mixture of reacted, but undiffused quartz from the body, and (probably) K-feldspar crystals. These are compared to Akhsiket, with further discussion, in Chapter 7.

Kuva black glazes

Sherd no.	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	MnO
Kuva 6	0.0	0.0	2.5	32.0	0.8	0.9	0.0	62.3	1.5
Kuva 12	0.0	0.6	2.6	36.5	0.8	2.3	0.7	53.0	3.4
Kuva 18	0.0	0.6	2.8	37.6	1.3	1.5	1.0	53.2	2.0
Average	**0.0**	**0.4**	**2.6**	**35.4**	**1.0**	**1.6**	**0.6**	**56.2**	**2.3**
St. Deviation	0.0	0.4	0.1	3.0	0.3	0.7	0.5	5.3	1.0
St. Error	0.0	0.2	0.1	1.7	0.2	0.4	0.3	3.1	0.6

Table 6.45. SEM-EDS results in wt. % for Kuva black glazes.

Tashkent black glazes

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	PbO	MnO
Tash.10	0.0	0.0	2.4	39.6	1.0	0.0	1.8	54.9	0.4
Tash.18	0.0	0.1	2.0	34.6	0.8	0.2	1.7	60.1	0.5
Tash.24	0.2	0.0	2.4	37.3	1.0	0.4	0.7	57.4	0.6
Average	**0.1**	**0.0**	**2.3**	**37.2**	**0.9**	**0.2**	**1.4**	**57.5**	**0.5**
St. Deviation	0.1	0.1	0.2	2.5	0.1	0.2	0.6	2.6	0.1
St. Error	0.1	0.0	0.1	1.4	0.1	0.1	0.4	1.5	0.1

Table 6.46. SEM-EDS results in wt. % for Tashkent black glazes.

Monochrome green glazes are here included with green glazes found on certain types of polychrome slipwares. Kuva 6 green glaze was applied as part of a polychrome slipware design, while Kuva 19 is a typical monochrome green glaze which covers the surface of the vessel. They are different in composition, with the cool green of Kuva 6 having lower copper oxide (2.7% compared with 5.2% for the monochrome green glaze) (Table 6.47a). There is also slightly less iron oxide. As far as the base glaze, there are lower quantities of all the non-Pb elements than the monochrome green, being a purer, higher-lead glaze. Both glazes lack soda, and in magnesia is undetected in Kuva 6 and near detection limits for Kuva 19. Lime levels are within the normal range of variation as seen in the Kuva colourless glazes, and except for the presence of iron and copper oxides, Kuva 6 green glaze is virtually identical to its colourless and black counterparts.

Only one Tashkent monochrome green glaze was analysed. (Table 6.48). Lead oxide content is the same as Kuva 19, as is the proportion of minor elements, including the lack of soda.

Kuva green glazes									
Sherd no.	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**CuO**
Kuva 6	0.0	0.0	2.6	31.6	0.7	1.0	0.2	61.2	2.7
Kuva 19	0.0	0.2	3.9	37.8	1.0	1.2	0.7	50.1	5.2
Average	**0.0**	**0.1**	**3.2**	**34.7**	**0.9**	**1.1**	**0.5**	**55.6**	**3.9**
St. Deviation	0.0	0.1	0.9	4.4	0.2	0.2	0.3	7.8	1.7

Table 6.47. SEM-EDS results in wt. % for Kuva green glazes.

Tashkent green glazes									
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**PbO**	**CuO**
Tash.15	0.0	0.5	3.6	37.6	1.7	2.4	1.1	50.1	2.9

Table 6.48. SEM-EDS results in wt. % for Tashkent green glazes.

The **alkali glazes** analysed are all *ishkor* glazes, or something similar. The actual definition of *ishkor* is difficult to pin down, with both stylistic and technological implications. Of the Kuva samples, Kuva 1 falls within the technological *ishkor* category with soda as the dominant alkali, applied directly onto the body (Table 6.49 – these tables show non colouring elements and are renormalized to show basic glaze recipe). Its exact colour and decoration motif is not possible to determine however, as the glaze surface is weathered. According to the copper oxide concentrations and the lack of manganese, the original colour was probably a fairly light blue, although probably more turquoise than the light 'sky blue' as it appears now.

Kuva 9, on the other hand, is a dark greyish blue, applied over a white engobe (unseen in the more typical *ishkor* wares). Both the colour and the presence of engobe rules it out as an *ishkor* type, but it is still an alkali glaze, soda dominant, and similar in many ways to Kuva 1 chemical composition. The colorants are higher, producing the darker, more opaque colour; but without the colourants, the two glazes achieve a good parity on silica, alumina, lime, manganese and iron oxide, and only minor differences in the sulphur, phosphorus and chlorine. Potash is slightly higher in Kuva 9 (by 1.5%) and soda somewhat lower (by 3.3%). This is not exactly significant, as the Akhsiket *ishkor* examples are also variable in their alkali content.

Tashkent alkali glazes resemble the *ishkor* type more closely, in that there are dichromate motifs applied as coloured glazes directly to the body. Instead of turquoise or blue, the sherds analysed here are a strong bluish green on a light background. The background is a lighter version of the lilac seen at Akhsiket, and in fact the colouring element is so faint as to hardly exist at all. Comparing the chemical composition of the two sherds shows that they are very similar, as they are in visual appearance (Table 6.50 and Table 6.51). Potash is higher than soda in all these analyses except Tashkent 4 lilac which has 0.2% higher soda. The green glazes are more similar, although Tashkent 2 has a third the amount of copper oxide as Tashkent 4. Lead is fairly high in both (16.4% and 15.1%) and has produced the greenish hue – Tashkent 2 may be a deeper green as a result of the higher ratio of lead to copper.

The lilac or colourless glaze is slightly more variable, perhaps due to the heterogeneous nature of this glaze as seen in the optical microscopy images, with numerous bubbles and areas of undiffused silica. The variability is very small and not significant. The colorants consist of lead, copper and manganese oxide for Tashkent 2, while Tashkent 4 does not include copper. The copper and manganese are very low in concentration, and as described in the previous section for the relevant sherds, were not detected in every scan by the SEM. This explains the very slight colouring of this glaze. The lead oxide is more interesting, as there is only 1.4% in Tashkent 2, which has a slightly pinkish glaze and is fairly transparent, whereas Tashkent 4 has 8.4% PbO and is the same colour, but less transparent and appears lighter from the surface. In cross section, both of these glazes look light grey and fairly opaque.

These optical images show quite clearly that the green glaze was applied over a lilac background glaze. This is particularly apparent for Tashkent 2, where the green glaze rests as a glassy layer above the bubble-filled layer into which some of the green colorant has dissolved. BSE images are also clear in delineating the homogeneous glassy upper layer from the inclusion-filled lower layer. It is probable that the higher lead oxide content of the green glaze, particularly in the case of Tashkent 2, acted as a flux to the extent that this area of the glaze became fully molten while the underlying, higher-silica glaze did not. These techniques will be further discussed in the Chapter 7 below.

Kuva *ishkor* glaze

Sherd no.	Na2O	MgO	Al2O3	SiO2	K2O	CaO	TiO2	Fe2O3	P2O5	SO3	Cl	CuO	MnO
Kv1	10.3	3.9	3.4	70.0	3.1	7.1	0.1	1.1	0.5	0.4	0.1	1.2	0.0
Kv9	7.0	3.4	4.6	70.0	4.6	7.7	0.1	2.0	0.1	0.2	0.2	4.5	1.6

Table 6.49. SEM-EDS results in wt. % for Kuva *ishkor* glazes (CuO and MnO as analysed, the other oxides are normalised).

Tashkent green *ishkor* glazes

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	P2O5	Cl	PbO	CuO
Tash.2	4.6	1.2	5.7	78.5	5.5	4.1	0.4	0.0	0.0	0.1	16.4	2.5
Tash.4	3.3	1.1	3.7	61.7	3.6	3.8	0.3	0.0	0.0	0.1	15.1	7.2
Average	**4.0**	**1.2**	**4.7**	**70.1**	**4.6**	**3.9**	**0.4**	**0.0**	**0.0**	**0.1**	**15.8**	**4.9**

Table 6.50. SEM-EDS results in wt. % for Tashkent green *ishkor* glazes (PbO and CuO as analysed, the other oxides are normalised).

Tashkent lilac/colourless *ishkor* glazes

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	Cl	PbO	CuO	MnO
Tash.2	5.0	1.5	6.0	76.5	6.5	3.5	0.8	0.1	0.2	1.4	0.1	0.1
Tash.4	4.7	1.6	4.1	80.2	4.5	4.1	0.7	0.0	0.1	8.4	0.0	0.1
Average	**4.8**	**1.6**	**5.1**	**78.3**	**5.5**	**3.8**	**0.7**	**0.0**	**0.1**	**4.9**	**0.0**	**0.1**

Table 6.51. SEM-EDS results in wt. % for Tashkent lilac/colourless *ishkor* glazes (PbO, CuO and MnO as analysed, the other oxides are normalised)..

7. Production and consumption of Akhsiket's ceramics

7.1. Technological interpretations

'Technological practices are obviously constrained by the laws of physics and chemistry and by their geological, ecological and historical settings' (Killick 2004, 572). In interpreting the technological aspects of pottery, there are some very obvious constraints on how the finished item can be successfully produced. Clay, water, air, heat, silica and fluxes for glazes, etc. present a fairly limited range of choices, although of course there are alternatives to almost everything. These aspects can be observed, measured, and described, and their occurrence explained on a technological level using scientific knowledge and archaeological context.

Aesthetic choices - and, therefore, their technological implications - are less straightforward. For example: the vessel must (usually) be made out of clay, while the shape of that vessel is constrained partly by its ability to fully mature in the kiln without cracking or crumbling and partly by its function as a finished product - although of course socio-cultural context is also relevant. The decorations applied to the vessel are technologically constrained by availability of colouring minerals and the existing constraints of vessel formation, but are also highly constrained by socio-cultural context as well. For example, as we shall see, techniques that *could* have been used on both the lead glazed and alkali glazed wares were often specifically associated with one or the other. Technological expedience, or even ability, does not mean that other forces are not at play in directing the choices made.

The following sections try to interpret these technological choices by looking at the results of the final product – the bodies and their coatings – and determining what the standard criteria are, and where they differ. Differences can show that different choices are being made, and even where the exact actions behind the choices are unknown (for example, exact raw material source), they can provide valuable evidence for continuity and change in production processes. Table 7.1 gives a summary table of the major styles of glazed wares, and their defining characteristics.

Major type	Sub-types	Styles	Glaze composition	Glaze colours	Decoration methods
Polychrome slipware	Bouquet	-Polychrome -Black on white	High lead	-Colourless -Black	-Engobe -Painted slips -Pigments -Incised design (black on white only)
	Rosette	-Simple -Double-border -Misc motifs	High lead	-Colourless -Black	-Engobe -Painted slips -Pigments -Small incised designs
	Incised polychrome ware		High lead	Colourless	-Painted slips -Pigments(?) -Incised designs
	Miscellaneous	-Figural -Opaque -Other motifs	High lead	-Colourless -Black -Other colours	-Sometimes engobe -Painted slips -Pigments -Coloured glazes -Small incised designs
Samanid ware		-Black on white -Red on white -Black and red on white -Various epigraphical styles	High lead	-Colourless -Black	-Engobe -Painted slips -Pigments

Monochrome green			High lead	Green	Coloured glaze
Incised monochrome green			High lead (not analysed)	Green	Coloured glaze Incised designs
***Ishkor* ware**		Miscellaneous designs	Alkali	-Blue (turquoise, greenish blue, dark blue) -Lilac	Coloured glaze
Skeuomorphic ware			Alkali	-Black (dark purple)	Coloured glaze

Table 7.1. Summary table of major styles and their decoration characteristics.

7.1.1. Bodies

The bodies of the Akhsiket wares, and those of Tashkent and Kuva, are all formed from the same type of clay. The clays are characterised as highly calcareous, iron-rich, with a lack of additional temper, well evolved clay minerals, and less well evolved quartz inclusions. The source of this clay is unknown but is most likely derived from the loess that is widespread across Central Asia. It is very likely that the loess of north-eastern Uzbekistan is homogenous, and this would make differentiating samples across the region difficult. The major and minor chemical elements of the bodies are very similar (Table 7.2 and Table 7.3). However for both chemical and petrographical analysis some tantalising, albeit subtle, differences are apparent.

The glazed and unglazed bodies of Akhsiket show very minor differences in chemical composition. The averages for the two assemblages are extremely similar (discounting the high lime content of the cooking wares due to large numbers of calcite inclusions). Their forms are not at all similar, although both were made with the use of the wheel, and were expertly finished. While the unglazed wares consisted of 'kitchenwares' and storage jars and the like, the glazed wares were almost exclusively (in the case of lead glazed wares) limited to open forms – usually bowls, usually hemispherical sectional forms, and usually with a simple rim and concave base (as shown in Chapter 5). A second class of glazed ware is the *chirag* (oil lamp), which is most commonly found in two specific types (monochrome with thumb-guard, and black/brown on white without thumb-guard). The *ishkor* wares were less limited in form, and commonly included closed forms. Fewer samples were available to view from Kuva and Tashkent, but the published vessel types in Brusenko (1986) indicate that while simple hemispherical bowls with concave bases were common, many other forms were glazed including a variety of closed forms. The hemispherical bowls were easier to produce, flowing easily in shape from the motion of the wheel. Angular shapes, the addition of handles, the glazing of the outsides of closed forms – all would have been more difficult to produce, but not all necessarily requiring specialist skills.

As far as bulk analysis is concerned, the Akhsiket assemblage can possibly be distinguished from those of Kuva by the calcareousness of the clay. Kuva has a bimodal division between medium and highly calcareous samples (see Chapter 6.1.1) while the Akhsiket glazed bodies are more consistent along a gradual continuum and on average more highly calcareous. Tashkent is also slightly lower in lime than Akhsiket, with higher silica than both Akhsiket and Kuva.

Comparing soda and magnesia, it is clear that Tashkent and Kuva bodies are both tightly grouped (both showing less than 1% variation in MgO and only slightly more variation in Na_2O) and do not overlap with each other, although Kuva overlaps completely with the lower-MgO end of the Akhsiket pottery samples (see Figure 7.1 below). It may be that further analysis of Tashkent and Kuva wares will show greater variation than seen here, but early indications are that Tashkent samples at least may be able to be differentiated from Kuva and Akhsiket by SEM-EDS analysis.

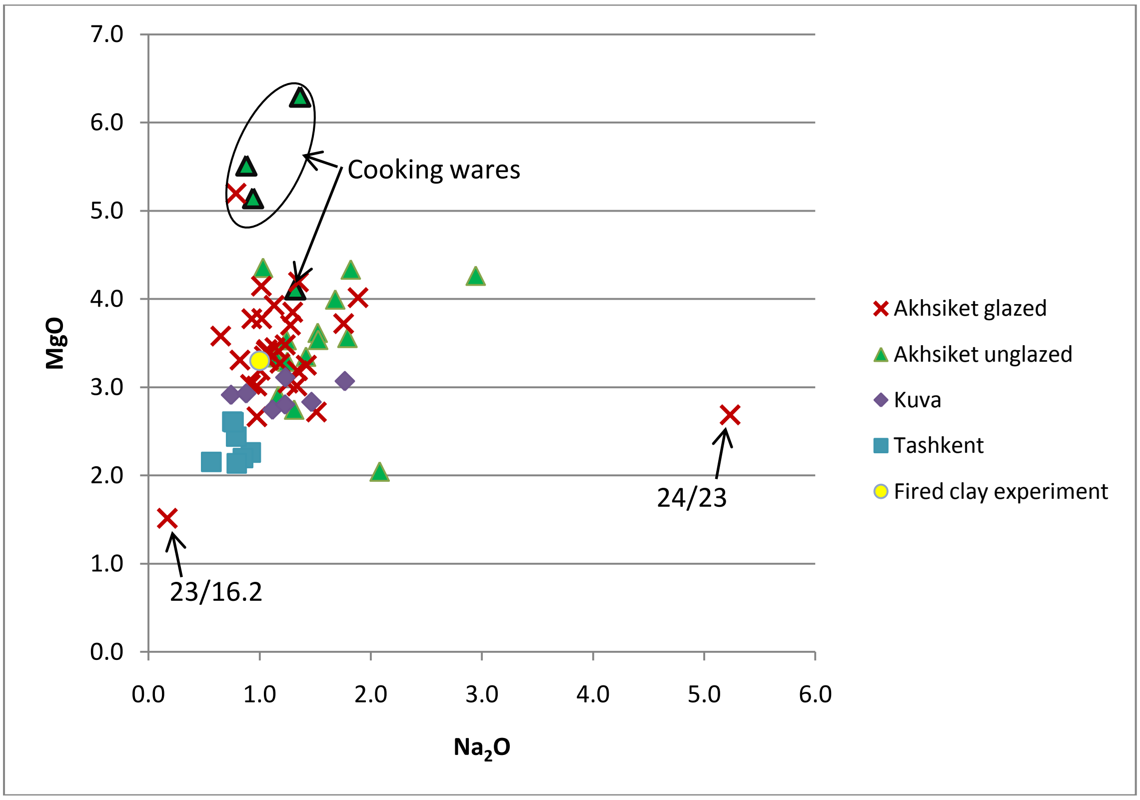


Figure 7.1. Scatter chart comparing MgO and Na_2O for all Akhsiket, Kuva and Tashkent bodies and fired clay. Akhsiket cooking wares are shown with black outline.

It is also possible to see differences between the site assemblages by looking at variability within the assemblages. Variations between samples from Akhsiket are greater than between the averages of the three sites – for example, maximum and minimum values for alumina in the Akhsiket glazed bodies are 14.1% and 9.4%, while on average the alumina contents of the three sites only differ by 0.5%. However, there is some difference between the sites in intra-assemblage variability. Plotting standard deviations on a chart (Figure 7.2) shows relative variability across the assemblages (major elements appear much more variable as they are present in much higher quantities). Cooking wares are excluded.

Akhsiket glazed and unglazed wares have a similar rate of variability, with unglazed bodies of Akhsiket only very slightly more variable than the glazed wares. Their pattern of similarity is striking when compared with Kuva, and - although not so strikingly - are different to Tashkent as well, which has slightly higher variability in silica and sulphur oxide, and particularly low variability in the alkalis and magnesia. The Kuva wares contain the highest variability in general – silica, lime, iron and phosphorus oxide – *and* the lowest or very low variability in the alkalis, magnesia, titanium, and sulphur oxide. Whether this variability is evidence for different clay sources is impossible to say – but it does show that different processing methods may have been used, particularly in the purification of the clays, with Tashkent the most pure (and having fewer large inclusions as explained below), with Kuva the least purified.

Characterisation and analysis of the petrofabrics, carried out as a test on Akhsiket, Kuva and Tashkent glazed wares, have proved of some use in distinguishing between the different sites, although there are inherent problems with characterising fineware petrofabrics – namely, the lack of a coarse fraction with very few rocky inclusions to indicate parent geological source and provide evidence for differentiation between sites. As Tite says of fine-textured pottery, 'the polymineralic rock fragment inclusions which provide the best evidence for source geology do not generally survive. Therefore, minor and trace element analysis is… normally the favoured technique' (1999, 196). Petrography is likely to be of most use in a geographically complex, non-standard production situation (Jones 1994, 17).

Mason (2004) addresses this problem in the context of homogenous siliceous stonewares. He has demonstrated the usefulness in distinguishing macro- and micro-crystalline quartz, and poly- and monocrystalline quartz in the absence of other distinguishing minerals. As already shown in the previous chapters, most of the clays analysed here are dominated by monocrystalline quartz, with the exception of two of the three Kuva samples. Without a good understanding of the clay sources in Ferghana and Tashkent, it is not possible to put this knowledge to use for provenancing the wares, but it does provide an important characteristic of the clays, and highlights those, like the Kuva examples, which are different and therefore likely to derive from a different source than the others.

The thin-sectioned samples can be arranged according to relative fineness of the clay inclusions within the three main petrofabrics (Figure 7.3). On average, the Tashkent samples are finest, the Akhsiket samples next finest, and Kuva samples slightly coarser. Of the Akhsiket samples, there is no chronological pattern in Object 23, but Object 24 (late 11th/12th century) tends to be coarser than the others. Although this does not necessarily indicate major differences in clay sources, it does show that different processing methods may have been used for these particular samples.

Although there is a high quantity of non-quartz aplastics in all the bodies analysed, these are very small (usually < 50 μm, rarely over 150 μm), highly evolved common rock-forming minerals. SEM-EDS analysis of the glazed ware fabric inclusions provided a good picture of the mineral phases present in the bodies, while petrography allowed further definition of specific minerals. We see from the analysis of many inclusions that similar phases are present in both glazed and unglazed wares – largely rock-forming minerals, but with a good number of Ca-rich minerals as well. The primary rock-forming minerals are silicates and alumino-silicates of course – (quartz, mica, and some feldspar), iron-bearing minerals, and other rare traces of titanium oxide or other metallic minerals. The Ca-rich minerals fall into three categories – calcite (limestone or secondary calcite), dolomite and apatite, with apatite the least common of the three. Many of these Ca-rich minerals are too small to adequately identify in thin section. Quartz ingrown with other minerals, usually mica, is also commonly seen. Other minerals and rock grains such as granite are present, but are rare (and seem to be more characteristic of Tashkent than Akhsiket or Kuva). These are the minerals that are best served by petrography with a better geological background for context, and may in future provide some interesting research avenues with regard to provenance.

There is data available on some of the clays of Chach and Samarkand - gathered as part of a project to attempt the recreation of Timurid architectural tiles (Rakhimov 2000). This shows that some Chach loess clays, with around 11.5% alumina, match the bodies analysed here, while the Samarkand clays have a higher alumina concentration (15.5%) (*ibid*, 138 and 142). Iron concentrations are exactly the same for both. The first Chach loess deposit includes a fine clay with quartzite, feldspar, calcite, dolomite, mica and kaolinite. Chach loess clay from the 'Parkent deposit' is different, with higher alumina (13.7%) and iron oxide (5%) (*ibid*, 143). However, these clays include significant amounts of some other minerals: hydromica (potassium rich type of muscovite), nephelite (associated with schist, alters into muscovite), haematite, and goethite (common iron-bearing mineral). These minerals are not inconsistent with the Tashkent fabrics studied (or the other fabrics). Further petrographic analysis of Tashkent wares may distinguish between different clay sources such as these. Rakhimov also mentions a clay source near Pap (in the Ferghana Valley to the west of Akhsiket) (Rakhimov 2000, 152) (there is currently a clay quarry at Pap for a modern brick factory).

Kaolin clays were also available in the region (Rakhimov 2000, 136), and were used for the creation of crucibles used in the steelworking industry at Akhsiket (Papakhristu and Rehren 2002; Rehren and Papachristou 2003; Rehren and Papakhristu 2000). High concentrations of silica and alumina made the fired paste highly refractory for use in the furnace. This clay was used for a specific purpose and it was not chosen for domestic ceramics. Earthenwares are more suitable for table and kitchenwares, large storage jars, and other types of ceramics such as brick and tile, because of their plasticity, ability to mature at relatively low temperatures (and therefore more efficient to produce), and their durability. This is standard across Central Asia. Earthenwares were the choice material for centuries before glazes came into use, and as a result the glazes and associated slips were made to 'fit' the earthenware bodies – not the other way around. The close similarity of the glazed and the unglazed vessels at Akhsiket demonstrates this very clearly.

In comparison to wares from other areas, there are the analyses carried out on Merv earthenwares by Wang (2009) for an MSc thesis. Merv, as a major oasis city on the trading routes between East and West throughout the early and later Islamic period would have seen the import of ceramics from many different areas. Wang's earthenware samples are all calcareous and iron rich, with two having particularly high magnesia and iron, and one of these also having extremely high lime (> 21%, normalised). The other two samples are closer in composition to the Ferghana/Tashkent wares – within the range of variation if slightly more calcareous in general, and having slightly higher silica and soda. These samples are discussed again later on when discussing alkali glazes.

The Ferghana/Tashkent bodies (both glazed and unglazed) are not very different from those analysed by Lazzarini from Nishapur, Iran, which include similar inclusions and are similarly fine with a high quantity of quartz (although largely polycrystalline). Without more information, and unable to examine the sherds themselves, it is difficult to compare the petrofabrics. Bulk analysis (using EPMA) was also carried out (Lazzarini 1994, 507). The Nishapur bodies have a couple percent higher alumina on average and around 4% lower lime than the Ferghana/Tashkent wares, so may be differentiated based on calcareousness.

Mason's analysis of clay bodies from Iran includes Gurgan, Sirjan, 'Garrus', Nishapur and Samarkand wares (2004, 133). Using SEM-EDS, Mason's two Nishapur sherds are similar to Lazzarini's results. Mason's Samarkand analysis (unfortunately only a single sherd) has around 8% higher silica on average and 7% lower lime than Ferghana/Tashkent, but how representative this is of Samarkand fabric is key to determining systematic differences in bulk analysis. The other Iranian clay bodies are all of a similar calcareous, iron-rich character, with varying amounts of silica and lime, somewhat distinguishable from the Ferghana/Tashkent wares. The important point to bring out here is that major and minor elements of fine earthenware bodies in the wide region of the eastern Islamic world can be differentiated only by minor differences in calcareousness and siliceousness. Larger sample sets *may* demonstrate significant differences in other elements revealed by bulk analysis, but it would be more useful rather to carry out XRF or other trace analysis studies, as demonstrated below.

Akhsiket bodies

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	P2O5	SO3	
Akhsiket glazed	1.3	3.4	12.6	56.5	3.4	15.7	6.1	0.6	0.0	0.3	n=31
St. Deviation	0.8	0.6	0.9	1.6	0.8	1.8	0.8	0.2	0.1	0.6	
Max	5.2	5.2	14.1	59.8	5.4	18.7	7.9	1.1	0.6	2.9	
Min	0.2	1.5	9.4	53.0	2.1	11.2	4.8	0.0	0.0	0.0	
Akhsiket unglazed	1.5	3.9	12.3	53.7	3.0	19.2	5.1	0.4	0.3	0.5	n=18
St. Deviation	0.5	1.0	1.8	8.4	0.7	9.4	1.6	0.4	0.5	0.8	
Max	2.9	6.3	14.4	62.5	4.2	42.3	7.2	1.1	1.4	2.4	
Min	0.9	2.0	8.7	36.1	1.4	10.1	0.0	0.0	0.0	0.0	
Akhsiket all	1.3	3.6	12.5	55.4	3.2	17.1	5.7	0.6	0.1	0.4	
St. Deviation	0.7	0.8	1.3	5.3	0.8	6.0	1.2	0.3	0.3	0.7	
Max	5.2	6.3	14.4	62.5	5.4	42.3	7.9	1.1	1.4	2.9	
Min	0.2	1.5	8.7	36.1	1.4	10.1	0.0	0.0	0.0	0.0	

Table 7.2. SEM-EDS results in wt. % for all Akhsiket bodies.

Akhsiket, Kuva, and Tashkent glazed bodies

Sample	Na2O	MgO	Al2O3	SiO2	K2O	CaO	Fe2O3	TiO2	P2O5	SO3	
Akhsiket glazed	1.3	3.4	12.6	56.5	3.5	15.7	6.1	0.6	0.0	0.3	n=30
Kuva glazed	1.2	2.9	12.9	58.9	3.8	12.1	6.3	0.7	0.2	0.8	n=7
Tashkent glazed	0.8	2.3	12.2	60.3	3.2	13.6	5.7	0.5	0.0	1.3	n=7

Table 7.3. SEM-EDS results in wt. % for Akhsiket, Kuva and Tashkent glazed bodies.

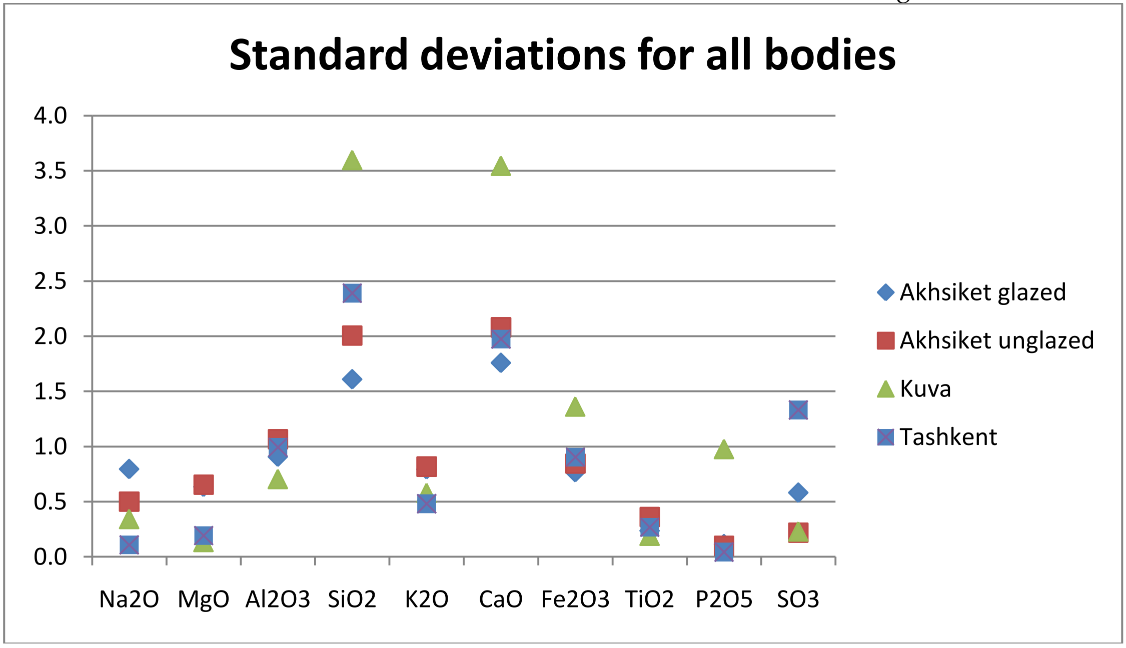


Figure 7.2. Line chart showing standard deviation for major and minor elements for all bodies.

Finest	**Petrofabric 1**	**Petrofabric 2**	**Petrofabric 3**
	24/33	23/13.2	Tash. 32
	Kuva6	23/14.16	Tash. 47
	23/2-8.11	23/11b.1	Tash. 18
	23/11c.1	24/30	23/11c.2
	23/13.1		23/15.5
	23/15.1		23/12.9
			Kuva 1
			23/2-8.15
			Kuva 2
			24/29
Coarsest			

Figure 7.3. Samples in the three main petrofabric groups according to coarseness ('NA' = New Akhsiket).

XRF analysis was carried out on seven unglazed samples from Akhsiket Objects 9 and 23, as well as the experimental briquette fired from local clay. Although Akhsiket's unglazed wares are not the focus of this thesis, they are a large and important part of Akhsiket's ceramic assemblage. Samples analysed here fall into the broad categories of fine kitchenware and storage vessels (collectively referred to as 'finewares'), cooking pots, sphero-conical wares and architectural ceramics – all of which have distinctive typologies, uses and histories of production. Unfortunately, there is little typological analysis to work from, but the XRF study has shown that there is much potential to provenancing these samples, and, by analogy, the glazed ware bodies as well.

We have already seen that the bulk chemical composition of the glazed and unglazed bodies of Akhsiket are nearly identical, and have determined that they are likely to derive from the same clay source, or from clay sources that derive from a similar geology. The unglazed domestic wares of Akhsiket are largely finewares – although not as fine as the glazed wares, they do not as a rule include a coarse fraction such as added temper. The exception to this is the cooking wares which contain large quantities of calcite temper.

The XRF case study of seven unglazed samples supports the theory of common origins, although until further analyses are carried out of both local clays, and samples from other parts of the region, it is not possible to confidently assign these samples as definitively local. There are some differences which may – with further research on a much larger population – show that more than one clay source was in fact in use. It is apparent that while the bulk chemistry of the bodies indicates this common clay source, the 'source' may be largely comprised of clay derived from homogenous loess abundant in this part of the world, the trace elements (and, possibly, petrographic studies of rare rock inclusions) may lead to more specific clay sources of clay, where the local geology has left its imprint.

Bulk SEM-EDS analysis shows small variations in silica and lime compositions, as discussed in Chapter 5, and also may indicate some distinctions between Akhsiket, Tashkent and Kuva bodies in general by relative MgO and Na2O concentrations (see above). Major and minor oxide analyses is, it has to be said, fairly limited however – and there may be little reason to continue analysis on the Akhsiket wares, at least. The XRF data is much better suited to grouping ceramic bodies once a general picture has been gathered from bulk analysis and/or petrography.

The XRF chemical 'fingerprints' revealed by the case study show some variations and interesting patterns that will be worth following up with further research in the future. The trace analysis data referred to here is the averaged, normalised results which have been converted from μg/g to percentages in order to compare with the major and minor elements. The elements are shown in charts below in groups for ease of references as follows: between 0.001 – 0.005% (detection limit to 50 μg/g), between 0.005% - 0.050% (50 μg/g to 500 μg/g), and between 0.050% - 0.500% (500 μg/g to 5,000 μg/g). PbO and As_2O_3 should be considered together, as the peaks overlap and may not have been accurately separated by the XRF analytical method.

First, comparing the brick, domestic fineware and experimental sample, we can see from the following charts that there are few elements that show major variations. There is a level of background variation, which, until many further samples are analysed, may be natural to a single clay source as much as indicating a variety of clay sources. The samples which appear to have the least typical compositions is 23/15.5, one of the fineware samples. Two groups may be identified from the trace analysis, with Group 2 having no widely varying elements (Table 7.4).

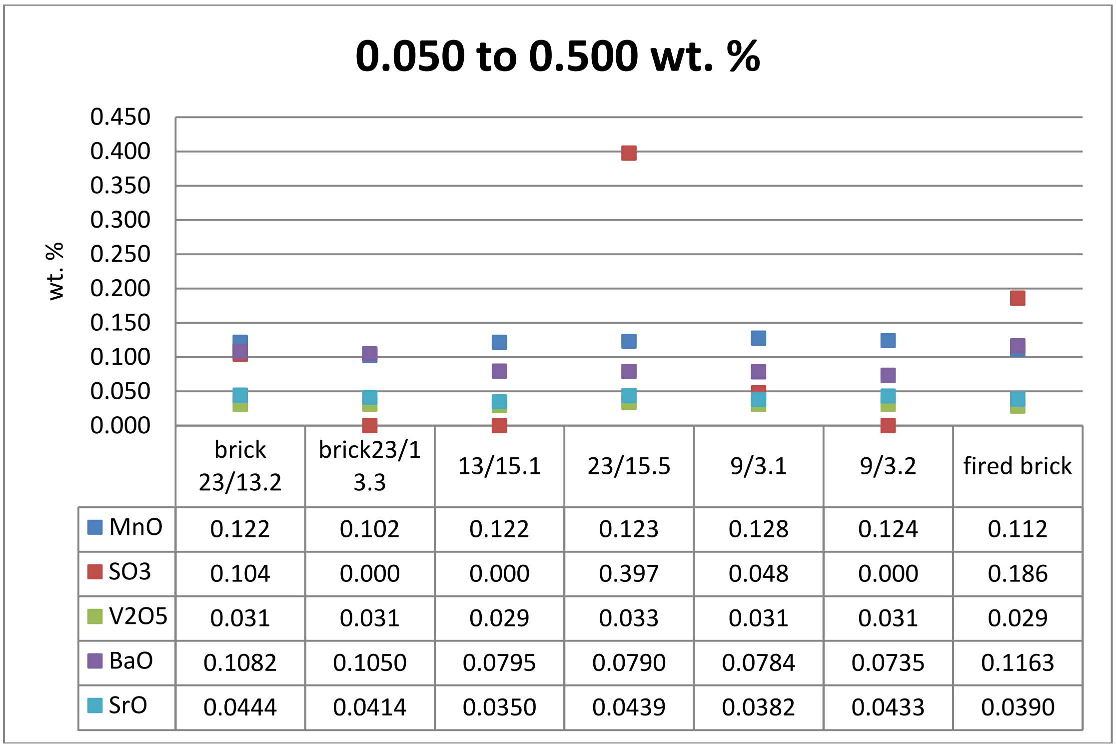
Group no.	Trace element characteristics	Sample
1	high BaO high $PbO+As_2O_3$ > 0.1% SO_3	Brick 23/13.2 Fineware 23/15.5 Experimental fired brick
2	< 0.1% SO_3	Brick 23/13.3 Fineware 13/15.1 Fineware 9/3.1 Fineware 9/3.2

Table 7.4. Table of groups by trace element analysis.

Figure 7.5 shows a greater amount of variation, as we are looking at elements at a finer 'resolution' in a sense, so minor variations are showing up as more dramatic than they really are. CuO and ZnO are fairly variable. There is a positive linear correlation between ZnO and Rb_2O, which also show small variation here, and may be a significant characteristic for comparison (Figure 7.7). The rest are generally within 0.002% of each other. Figure 7.6 shows elements between the detection limit up to about 0.005%. PbO + As_2O_3 are relatively highly variable here, although it is very difficult to say if this level of variation is in fact, significant. All the other elements are largely within 0.001% of each other – at the XRF detection limit so the little variation showing up here is not significant.

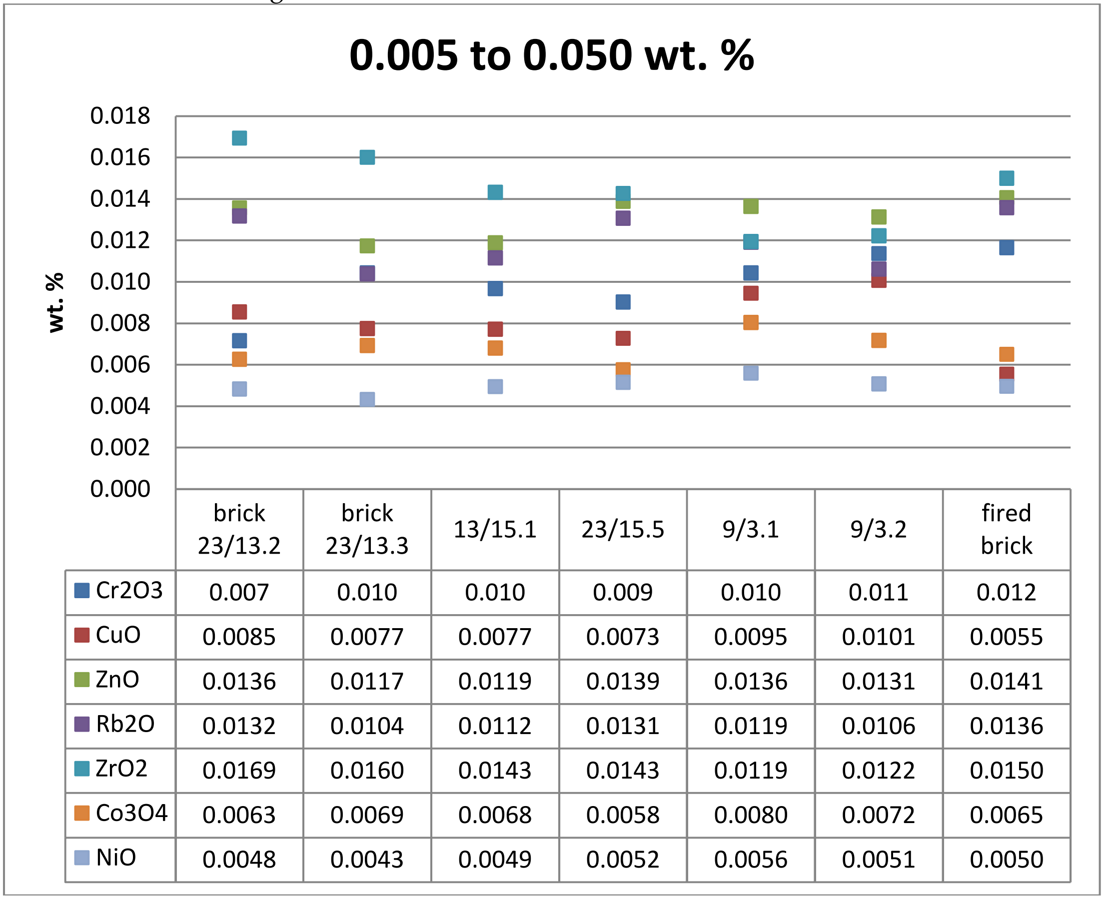
The interpretation of 'typical' variation v. potential outliers is extremely preliminary – a much larger body of data is needed to work out whether these differences are in fact significant, and which of these are indeed markers for different ceramic groupings – whether based on clay source or preparation. The two fineware and brick "outliers", 23/13.2 and 23/15.5, have been allocated to Group 1 along with the experimental fired brick due to consistently high BaO, $PbO+As_2O_3$ and SO_3. Whether these are significant or not is unknown, but the fact that a brick sample and a local clay source both demonstrate these characteristics shows that this 'fingerprint' is probably local. Group 2, which includes the rest of the finewares and the other brick sample, are as close as possible to a 'control group' containing the highest number of sherds, and a brick sample, which is probably local.

The next obvious step is to carry out trace analysis of the glazed ceramic bodies on a scale equal to that carried out by SEM-EDS; then to use petrographic analysis of the unglazed sherds to determine if there are more interesting inclusions in these slightly coarser wares. A comprehensive survey of the local region is also necessary in order to gain a better understanding of the trace elements inherent to the local clay sources.



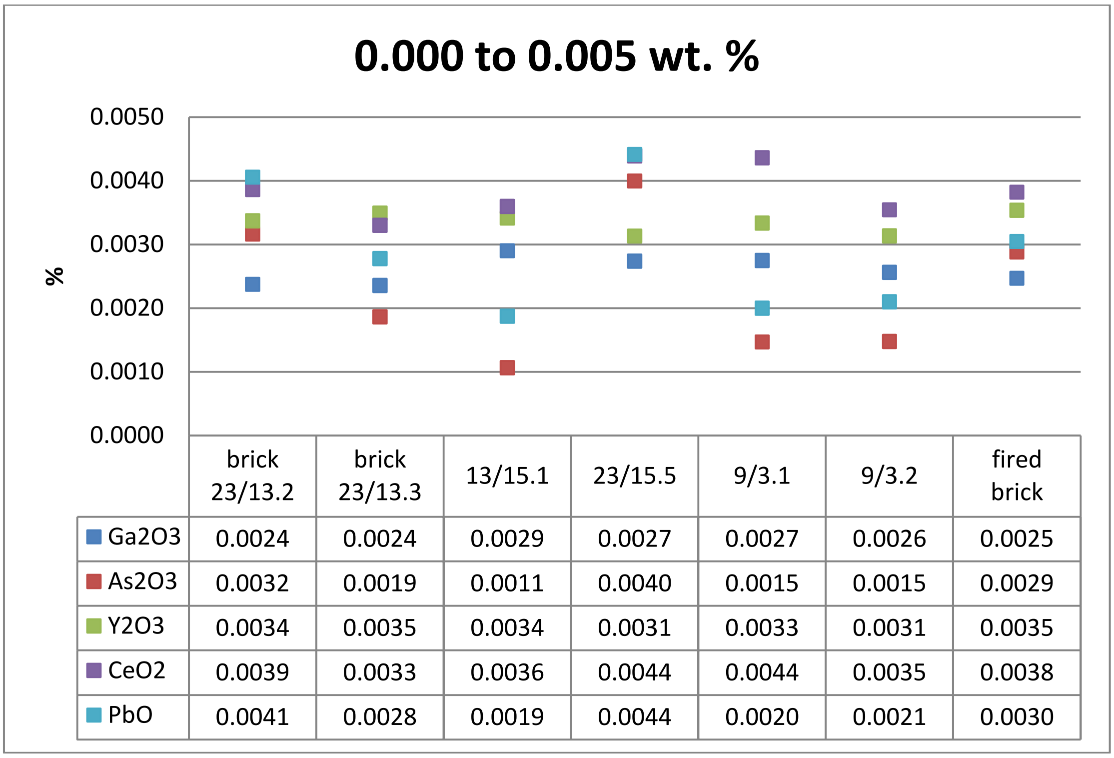
	brick 23/13.2	brick23/13.3	13/15.1	23/15.5	9/3.1	9/3.2	fired brick
🟦 MnO	0.122	0.102	0.122	0.123	0.128	0.124	0.112
🟥 SO3	0.104	0.000	0.000	0.397	0.048	0.000	0.186
🟩 V2O5	0.031	0.031	0.029	0.033	0.031	0.031	0.029
🟪 BaO	0.1082	0.1050	0.0795	0.0790	0.0784	0.0735	0.1163
🟦 SrO	0.0444	0.0414	0.0350	0.0439	0.0382	0.0433	0.0390

Figure 7.4. XRF data between 0.050 and 0.500 wt. %.



	brick 23/13.2	brick 23/13.3	13/15.1	23/15.5	9/3.1	9/3.2	fired brick
🟦 Cr2O3	0.007	0.010	0.010	0.009	0.010	0.011	0.012
🟥 CuO	0.0085	0.0077	0.0077	0.0073	0.0095	0.0101	0.0055
🟩 ZnO	0.0136	0.0117	0.0119	0.0139	0.0136	0.0131	0.0141
🟪 Rb2O	0.0132	0.0104	0.0112	0.0131	0.0119	0.0106	0.0136
🟦 ZrO2	0.0169	0.0160	0.0143	0.0143	0.0119	0.0122	0.0150
🟧 Co3O4	0.0063	0.0069	0.0068	0.0058	0.0080	0.0072	0.0065
🟦 NiO	0.0048	0.0043	0.0049	0.0052	0.0056	0.0051	0.0050

Figure 7.5. XRF data between 0.005 and 0.050 wt. %



	brick 23/13.2	brick 23/13.3	13/15.1	23/15.5	9/3.1	9/3.2	fired brick
🟦 Ga2O3	0.0024	0.0024	0.0029	0.0027	0.0027	0.0026	0.0025
🟥 As2O3	0.0032	0.0019	0.0011	0.0040	0.0015	0.0015	0.0029
🟩 Y2O3	0.0034	0.0035	0.0034	0.0031	0.0033	0.0031	0.0035
🟪 CeO2	0.0039	0.0033	0.0036	0.0044	0.0044	0.0035	0.0038
🟦 PbO	0.0041	0.0028	0.0019	0.0044	0.0020	0.0021	0.0030

Figure 7.6. XRF data between 0.005 and 0.050 wt. %.

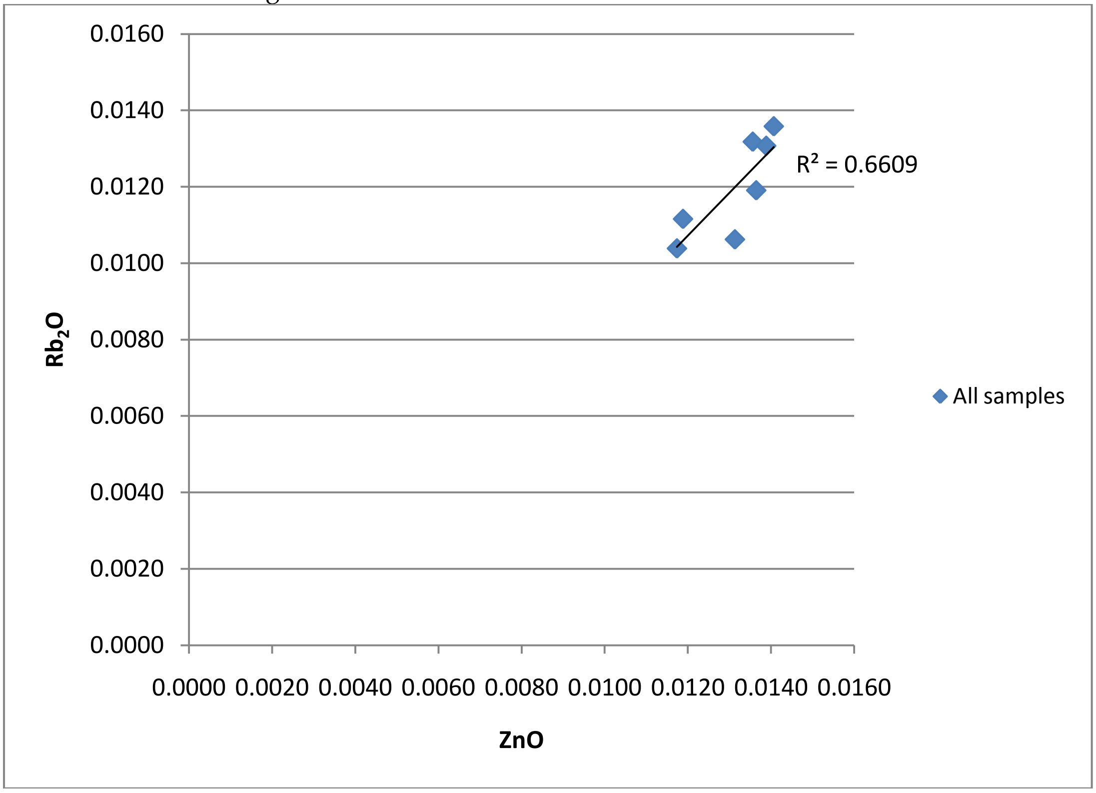


Figure 7.7. Scatter chart showing positive linear correlation between Rb2O and ZnO.

7.1.2. Slips and pigments

The lead glazed slipwares use a siliceous engobe for all 10th and 11th century polychrome and Samanid wares, usually white in colour although red and black are also seen. First used on 9th century wares in Iraq and possibly based on Egyptian faience technology (see discussion of this in Chapter 3.4), it was used to its best effect first by the Samarkand/Nishapur Samanid wares, with their minimalist black on white epigraphical designs.

Akhsiket's engobe was probably made using crushed feldspathic sands and/or kaolinitic clay – resulting in high silica and alumina values, and raised potash levels. This was added to a small amount of clay binder, the result producing a slurry which was liquid enough to be poured onto the vessel and would dry and fire at the same rate as the earthenwares. There is some variation in the silica and alumina values in the engobes used on Akhsiket wares – perhaps due to different sources of sand and/or the use of pure quartz in a few cases (see Chapter 5.2.1 for the results of polychrome and Samanid ware engobes). The Tashkent and Kuva wares are more tightly grouped, although Tashkent is within the mid-range of the Akhsiket variation. Kuva samples are higher in silica relative to alumina, indicating a relatively pure quartz source with fewer feldspathic inclusions. Once fired, all these engobes produced a white even covering over the surface of the vessel. This greatly changed the appearance of decorations, as the earthenware bodies tended to be red or at the lightest a yellowish-buff. It would appear that the white engobe was applied solely for the purpose of its visual properties. It was not applied to monochrome coloured glazed wares or to the semi-transparent alkali glazed wares where it would have improved the 'fit', durability and adhesion (i.e. quality) of the glaze.

The Akhsiket samples are grouped together in the 16%-22% alumina and 60%-75% silica range (with PbO contamination removed) (Figure 7.8). The quartz could have originated from a number of sources in the mountains to the north (a very pure silica was available, for example, at Chor Kesar in the Ferghana Valley (Rakhimov 2000, 141), but the high alumina and potash levels indicate the use of a feldspathic source such as immature kaolinitic clay, as the clay fraction of the engobe varies from the clay bodies. This would need to be verified by adequate sampling of local deposits. The engobe could probably not have been made entirely of kaolin, as kaolin used for the steel-melting crucibles of Central Asia, including those at Akhsiket, contain far higher alumina – between 28 and 32 wt. % for Uzbek crucibles (combination of EPMA and ICP analysis) (Rehren and Papachristou 2003, 396). Due to the added components, not just silica but also alumina and potash, it is difficult to compare the original clay of the engobe with the clay of the bodies. However, by removing all the elements which were probably largely introduced by the addition of silica-rich materials or leaching from the body or glaze (silica, potash, alumina and lead oxide) and renormalizing the remaining elements to view them in relative terms, it is possible to get a general idea of how well they group together.

Figure 7.9 shows that while the bodies are tightly clustered even in the context of exaggerated compositional differences (due to removing so many elements), the engobe for both polychrome and Samanid engobe is comparatively widely variable. Comparing iron and titanium oxide shows a similar pattern, with bodies tightly clustered and engobe values highly variable. In the latter case, there is a noticeable difference between the Samanid engobe, with its consistently low titanium oxide, and the polychrome engobe with high variation in both titanium and iron. The patterns shown here demonstrate that there are clear differences between the engobe and bodies for these elements. The variability in the engobe could be due to a number of scenarios: impurities in the silica source(s) which means that the values are not in fact solely down to the clay component; the use of different clays; or effects of firing having an impact on diffusion from the body and/or glazes. The engobes would have gone through more preparation than the clay for the bodies, and this brings in a higher possibility of variation due to human actions.

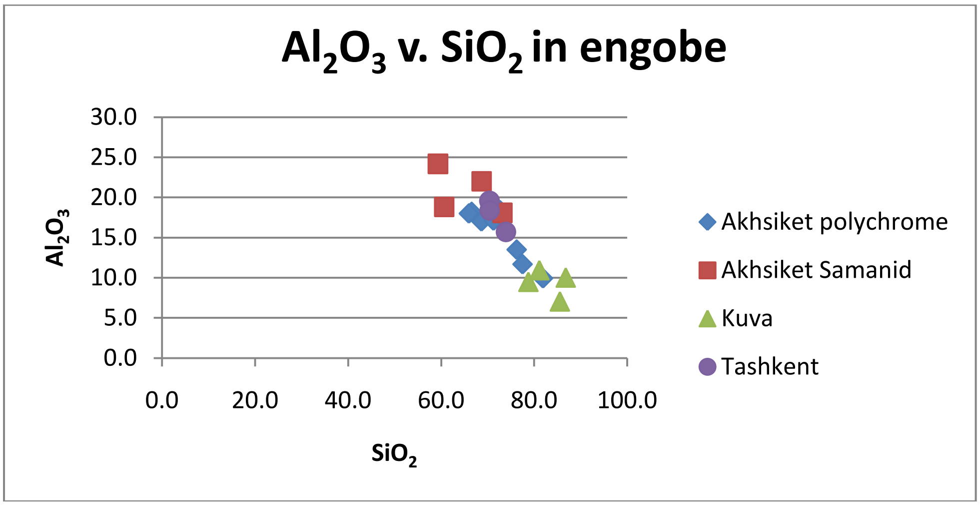


Figure 7.8. Scatter chart showing silica and alumina values for Akhsiket polychrome and Samanid wares, Tashkent (both) and Kuva (both) wares, with PbO removed.

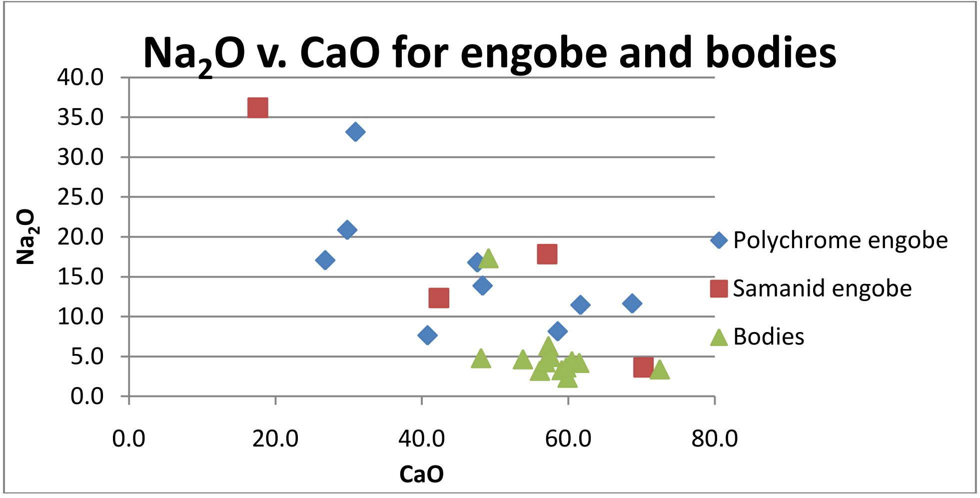


Figure 7.9. Scatter chart showing relative soda and lime values for engobe and body average (silica, alumina, potash and lead oxide removed).

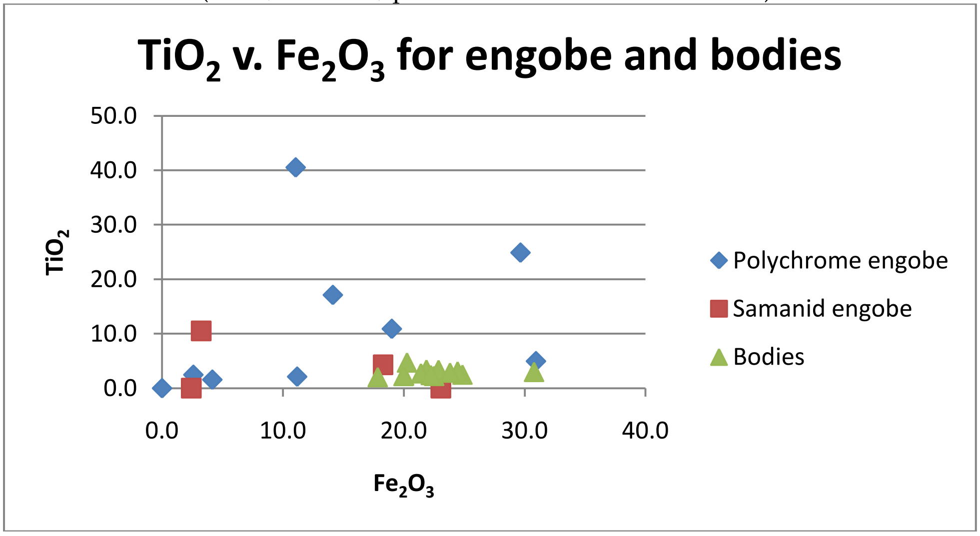


Figure 7.10. Scatter chart showing relative titanium and iron oxide values for engobe and body average (silica, alumina, potash and lead oxide removed).

As the purpose of the engobe was to provide a white background to the painted decorations, the use of typical earthenware paste, with its high iron content would have resulted in yellow, pink, or red areas that would have been difficult to mask, or control. The difference in iron/titanium oxide concentrations between polychrome and Samanid engobe is interesting – perhaps due to a more controlled production and therefore raw material source, and/or the difference in preparation methods used by different workshops. Further samples would increase confidence that these differences were in fact systematic.

The colours applied as decorative elements to the lead glazed slipwares had a limited palette and fell under one of two different techniques – 1. clay-based coloured slips and 2. mineral pigments. Akhsiket wares used slips for the red decoration, both slips and pigments for black or dark brown decoration, and slips for olive green decoration. Red slips were used on the Kuva samples, but black and olive were applied as pigments. Tashkent samples also used red slips, black slips, and green slips as well as black pigments.

The difference between coloured slips and pigments is essentially the presence or not of a slip 'carrier' for the colouring oxides. Slips are similar siliceous clays to the white engobe with added colouring oxides. Pigments use the same colouring minerals, but these are painted on without a clay carrier. The slips retain their shape and texture during firing, although some oxides leach into the glaze, and lead leaches into the slip from the glaze. The pigments, however, are incorporated into the glaze during firing, and, in some cases, leach into the underlying engobe. Relict colouring minerals – usually iron oxide (haematite) grains and chromite – may remain visible at the interface. The iron oxide (in its ferric state) is a strong colorant, and probably provides the bulk of the colour in the black glazes (and in the black slip where this is present), in oxidised conditions (Weyl 1951, 92). Manganese is most likely present as Mn 3+, which produces deeper colours than its divalent equivalent (*ibid*, 125).

The important characteristic of slips is their visual appearance. Presumably then, there is a compromise to be made between the availability of raw materials, ease of application, number of colours and shades possible, and the ability to create opaque colours that remain clean and precise. Lead glazes can easily be coloured green, black, brown and yellow, but as lead glaze is fairly fluid in the melt, the coloured glazes could not be controlled to the same degree as slips and pigments applied under the glazes. Early lead glazes in the Middle East did use coloured glazes – the 'splashed' wares, for example – where the colours were fairly freely applied and did not adhere to a clean, precise (or legible) decoration. Notwithstanding the desirability of this style, the use of slips quickly changed the face of ceramic decoration and allowed decorative motifs which were as precise as those on textiles or literary works.

The question here is not the aesthetic choice of one motif over another, but of the visual appearances that determined the technical manipulation of the raw materials. The difference between slips and pigments, for example, is important – as there is little visual difference to be seen from the surface. Presumably pigments were easier to apply and prepare, and the raw materials no more difficult to procure. Why, if the appearance is the same, and their use more complicated, would slips be used at all for these colours?

A few cases of black or brown decorated sherds were analysed with 'bleeding' of colour at the edges – in some cases only by a few millimetres, in others by as much as a centimetre. So far, these have used pigments rather than slips, and something about the raw material preparation, application method, or firing conditions, caused the colorants in the pigments to run. Under the assumption this was not a desirable effect (considering they are not often seen), it may be that the use of pigments is in fact more technologically demanding than it appears at first sight. Perhaps the use of pigments requires a bisque firing, before the application of the covering glaze, or perhaps the firing conditions – temperature, duration, rate of cooling, etc. – requires a more precise control than if slips are used. It may be that some workshops had the expertise to use pigments effectively, while others were restricted to the slightly more time-consuming - but more predictable - coloured slips. Only one Akhsiket sherd with colour bleed was analysed (23/12.2), and it shows differences in other aspects too: the body fabric is not as tightly consistent with the average as the rest of the bodies, and could be seen as an outlier, with higher lime and potash, and lower magnesia, alumina and silica. The engobe also does not fit well with the steep correlation line seen in Figure 7.8, with 15.4% alumina and 58% silica, and is the sample with the highest lime in Figure 7.9. The glaze itself, however, does not stand out from the other slipwares. Tashkent 10 demonstrates some pigment bleeding, albeit to a lesser extent, and with little or no variation from the rest of the Tashkent bodies.

Table 7.5 shows how the different coloured slips compare to the engobe and bodies. There is variation between the slips in all the elements, with the lowest variability in magnesia, potash and titanium. Iron has been removed due to its increased concentration in the red and black slips. Some variation can probably be explained by the use of feldspathic sands, as with the engobe, and reinforces the idea that the slips were made using the basic engobe recipe rather than body clay. Magnesia and potash are more similar to the engobe for all slip samples, while red and olive slips are closer to engobe in silica and lime. The average of the two black slips is closer to the body for silica, but far lower in lime. It is difficult to accurately judge similarities between the coloured slips, as it is not known to what extent the colouring minerals are affecting the minor elements in the clay.

The raw materials used to produce these colours would have been easy to obtain, and probably local. Iron, manganese and chromite could be obtained from a number of sources. Colours produced from these raw materials are also determined by the chemical reactions of lead in the glaze with the oxidised atmosphere in the kilns. For example, iron leaching into the glaze causes a range of colours including green, yellow, red and black, depending on quantity and the degree of oxidation. Manganese oxide produces dark brown to black in the same conditions. Chromite does not appear to be dissolved by the glaze, or not to any great extent, but glaze over chromite-rich slips tends to be yellow, probably from the iron included in the chromite source and in the slip itself, combined perhaps with trace levels of chromium and copper not detectible by the SEM-EDS. A similar technique was used in later Iznik wares in Turkey where chromite particles were visible at the glaze-slip interaction layer. These particles have higher copper than those analysed at Akhsiket and Kuva and appear to have produced a greener colour (Okyar 2000, 21). Copper oxide produces a strong green with no hint of blue (see below) when added to lead glazes, but as there are no cases of it being used in a slip or as an underglaze pigment, it simply may not produce sufficient colour in that way.

Iron oxide could have been sourced either from haematite mineral sources, iron ores such as goethite, or iron rich 'red earths'. Using current analytical techniques it is not possible to determine the exact origin of the iron oxide. Manganese oxide could have come from manganese ores such as pyrolusite or as a component of the red earth burnt umber. Chromium oxide used in the olive green colours, both slip and pigments, was derived from chromite, a source of both chromium and iron. Copper was mined in northeastern Uzbekistan at one location at least (Rakhimov 2000, 153), and there is evidence of copper working at the site of Akhsiket, so it would have been available in its processed form (as copper metal).

Colorants not widely used in Central Asia – and not found in Ferghana at all – are those that are largely used further west for colouring glazes rather than underglaze painting. This includes cobalt blue, chromium black, antimony yellow, and tin-oxide used to opacify white glazes. Lustre glaze effects using copper and gold were also not produced there. These colours and effects were the height of fashion from the 10th century onward in the Middle East – coming into use on a large scale after the Samanid styles had already been established in the Eastern territories. The techniques required the use of either expensive and limited raw materials (cobalt, gold, tin), advanced glazing techniques (in-glaze decoration, the triple firing and reduction of metals for lustre-ware), or were not adopted because other techniques existed which were considered sufficiently acceptable (use of iron and manganese minerals in pigments/slips rather than chromium black glaze).

Red slip, engobe and body averages (without PbO)								
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**TiO2**	
Red slip	0.7	1.1	20.2	68.6	5.0	3.6	0.9	n=6
Black slip	2.2	0.6	18.1	64.6	4.8	8.3	1.3	n=2
Olive slip	1.2	1.2	12.5	77.3	4.6	2.5	0.8	n=4
Engobe	0.9	0.9	16.0	72.8	5.8	3.1	0.5	n=14
Body	1.4	3.6	13.5	60.4	3.6	16.8	0.7	n=30

Table 7.5. SEM-EDS results in wt.% for coloured slip, engobe and body samples, PbO and colorants removed.

7.1.3. Lead glazes

Lead glaze technology is fairly simple and straightforward, and relatively predictable. At Akhsiket, the lead glazes were applied over the engobe and slip paints or, if coloured, directly onto the vessel body as the final stage of the decoration process. It is not possible to determine from the finished product alone whether glazes were applied to a 'bisque' fired body, or a green body. The glaze sealed in the colours in slips and pigments, rendered the surface impermeable to liquids and gave it a smooth, glassy surface that was durable. The discovery of lead glaze and its reasons for use have already been discussed in Chapter 3.3.2. Its use in Central Asia was widespread and its technology fairly uniform.

The primary source of lead as used by ancient glass and glaze makers would have been galena, a common lead ore comprised of lead sulphide (PbS). Heating the ore, and in the process oxidising the lead component and driving off sulphur and other volatile chemicals, creates litharge, or PbO. This crystallises and can be powdered and then melted again at relatively low temperatures (its pure form having a melting temperature of 888 ˚C). The PbO powder, in our case, was then mixed with silica – probably crushed quartz– and fritted (roasted in a kiln until the two have begun to fuse, then rapidly cooled and ground). Lead and silica do not need to be fritted together in order to be used – lead oxide can be applied to the vessel directly, where it will react with silica present on the vessel surface, or the two could be mixed together prior to glazing without pre-fritting. We know that silica was added to the lead glaze because removing lead and renormalizing the remaining elements produces differing compositions to the underlying engobe (Tite et al 1998, 249). Also, the low concentration of minor elements shows that body clay was not mixed with the lead. The exceedingly thin glaze covering and its homogenous level of fusion between lead and silica producing a clear glassy matrix, indicates pre-fritting was carried out. The low levels of other minor elements in the lead glazes indicate a very pure source of silica such as quartz pebbles.

PbO is a strong flux and lowers the melting temperature of the silica. The minor elements present in the glazes (alkalis, alkaline earths, and alumina) are consistent and probably introduced as contaminants from a single, fairly uniform, source of quartz. Potash, alumina and silica all leach into the lead glaze from the underlying slip at an unknown rate and depth – it is not possible to determine to what extent these derive from the original glaze materials. It is accepted that end-result lead glaze consists of a composition different from the original recipe – volatilization of PbO during firing, leaching of lead out of the surface of the glaze during burial, as well as the digestion of body minerals, means that bulk analysis of glazes are not always useful for classifying glazed wares (Harman 1973, 128; Vandiver and Kingery 1985, 217), but where there are noticeable changes between lead concentrations and/or minor element concentrations, these are indicators of different methods of application and firing techniques, and possibly raw material source, if not of original glaze recipe with exact ratios of silica and lead oxide.

The base glaze recipe (or as close as we can get to it) discussed here includes averages from the entire body of the glaze, as lead and silica levels are only a few percent different throughout the thicknesss. The Akhsiket, Kuva and Tashkent lead glazes fall along a gradual negative correlation line with little to distinguish the different sites from each other except that Kuva samples are more tightly clustered (Figure 7.11). This correlation is to be expected, as lead and silica combined make up near the entire composition of the glaze. Any increase in lead added to the glaze mixture will lead to a corresponding decrease in silica, and vice versa. As already indicated, it is not possible to relate the minor elements digested from the body in any way to the existing glaze components. Silica, potash and alumina are all digested and therefore all correlate positively with each other. Lime, soda, manganese and iron would have been included as random contaminants, although exactly how is not clear. The primary characteristic of the glazes are their high-lead composition, with low minor elements. This is uniform enough that any sherds found with mixed lead-alkali glazes would be considered imports from outside the Ferghana/Tashkent area. Lead-silica ratios have also been found to show inter-site differences in Spain (Molera, Vendrell-Saz, and Perez-Arantegui 2001).

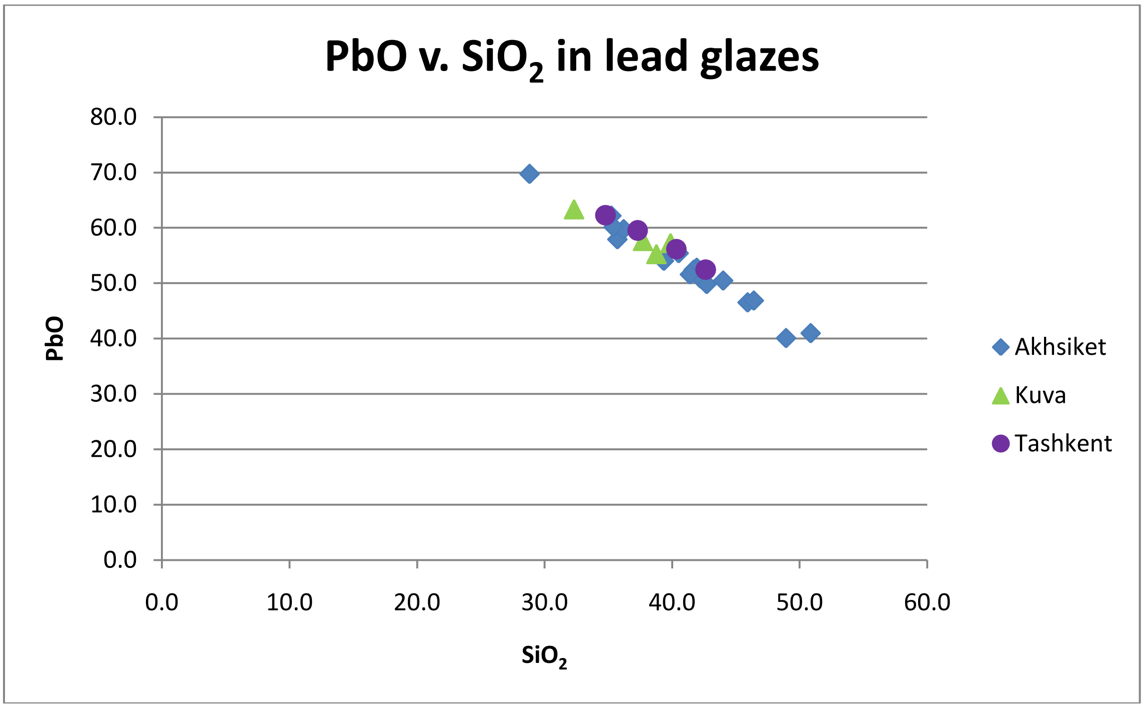


Figure 7.11. Scatter chart showing correlation between lead oxide and silica for colorless lead glazes – Akhsiket, Kuva and Tashkent. With a two-component mixture, a linear regression is to be expected. But this shows how the three sites compare along this line.

Green glazes are the most common coloured lead glaze found at Akhsiket, coloured with copper oxide. Green glazes come in two forms – the monochrome green wares, which are commonly seen in 11th and 12th century contexts, and as 'splashed' design elements on 12th century polychrome slipwares. These glazes were made in a similar fashion to the colourless glazes, with a pre-fritted lead-silica slurry to which was added copper oxide. The lead/silica concentrations fit well within the typical range seen for the Akhsiket colourless glazes (

Figure 7.12). Kuva and Tashkent green glazes fit into this range as well (

Figure 7.13). The green glazes include higher lime concentrations than the colourless glazes, and demonstrate positive linear correlations between potash and lime (Figure 7.14) and magnesia and lime (Figure 7.15), indicating that lime is also leaching into the glaze from the body without a silica-rich buffer slip

The sample with the highest lime content is 9/3.3 and this is probably due to accelerated migration of calcium from the body into the glaze which recrystallised as Ca-rich minerals on cooling (see below) – the high lime in the interface crystals demonstrates the level of reaction these glazes generated with calcium from the calcareous body. The green glaze on the kiln rod shows a different picture - although the rod itself is very high in lime at 18.9%, lime has not leached into the silica-rich layers that sandwich the glassy matrix, while the glaze itself has 3% lime – higher than the polychrome green glazes, but similar to the monochrome green glazes (and lower than 9/3.3). This may indicate that lime was in fact a component of a green glaze recipe (albeit not necessarily the early Islamic green lead glazes).

The colorants – copper and possibly iron oxide – were probably added into the glaze frit to be powdered along with the silica and lead oxide into the final glaze mixture. The colorants do not correlate with each other (see chapter 5.2.2). It seems surprising at first glance that these were not as carefully measured out as the lead oxide and silica materials, but then they are in small quantities, with differences of a few percent. This could also show that as long as it was green, the colour was acceptable – whether it was a slightly lighter, darker, or yellower green. Either way, we can see that all but one of the green glazes from the three different sites are indistinguishable from each other: one of the Akhsiket monochrome wares has a dramatically higher iron content than all the others. More samples need to be analysed before a true measure of variation can be taken.

The other major characteristic of these glazes besides their colour is their opacity. In the case of the monochrome greens, this is of course partly related to the intensity of the colour, and therefore the concentration of copper and, it would appear, iron (as in 9/2.3). However the devitrification and extensive interface layers visible in some of the sherds would have also increased opacity. The painted green glazes on the polychrome wares are less opaque due to their thinness in comparison to the monochrome wares.

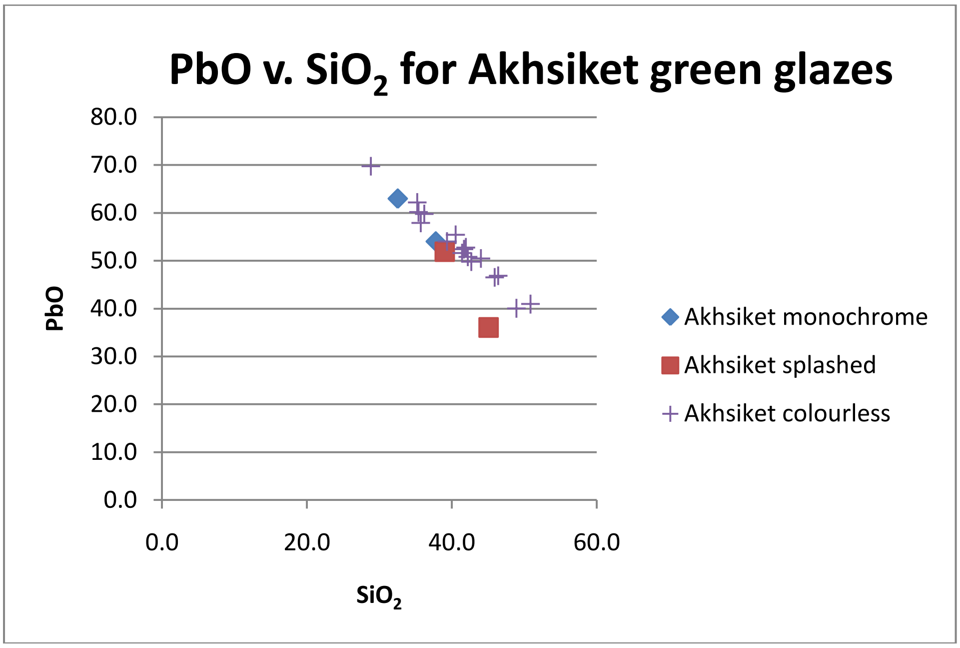


Figure 7.12. Scatter chart of PbO and SiO_2 for green and colourless lead glazes – Akhsiket.

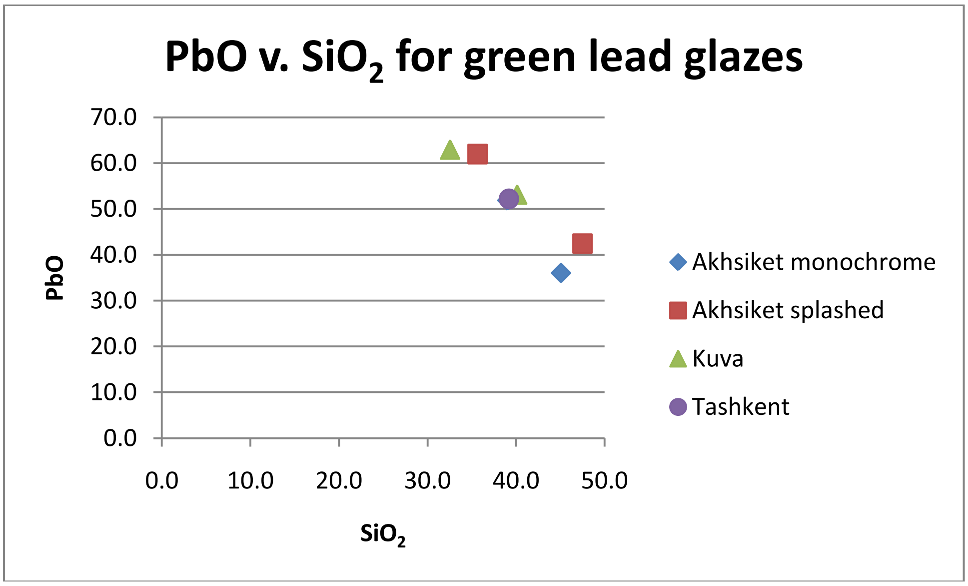


Figure 7.13. Scatter chart of PbO and SiO_2 for green glazes – Akhsiket, Kuva and Tashkent.

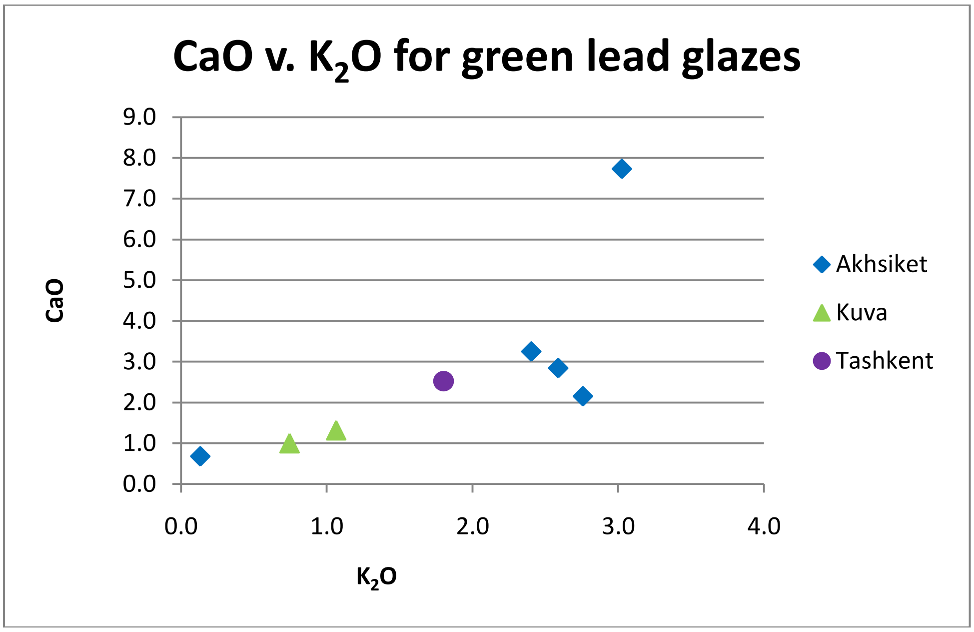


Figure 7.14. Scatter chart of CaO and K2O for green lead base glazes (colorants removed) – Akhsiket, Kuva and Tashkent

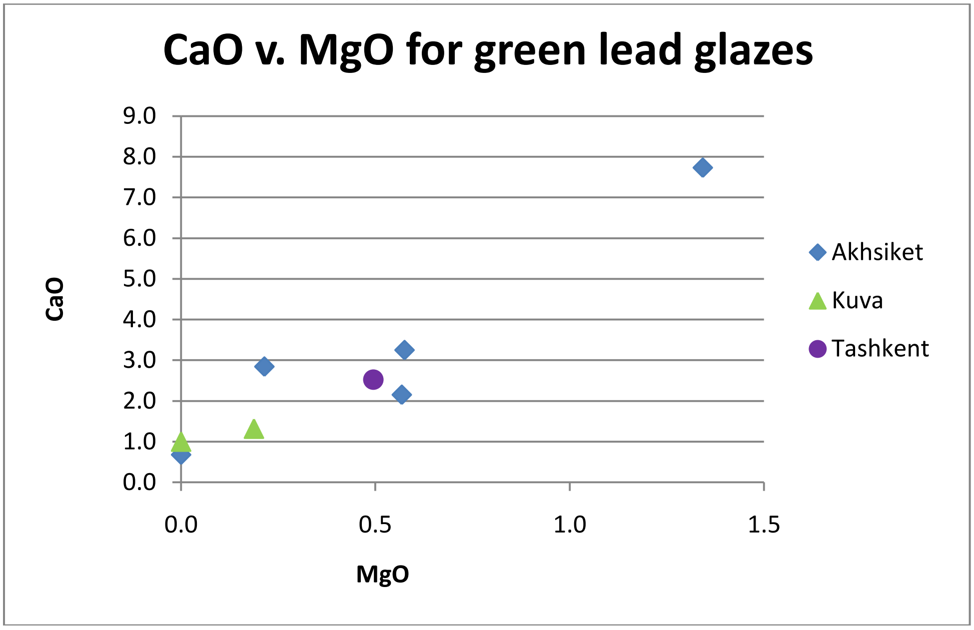


Figure 7.15. Scatter chart of CaO and MgO for green glazes – Akhsiket, Kuva and Tashkent

Once the lead glazes were applied, the vessels were fired in an oxidising atmosphere until melting point was reached – high enough to melt the lead and silica suspended in the slurry, and produce a bonding reaction with the underlying clay (the maturation point), but not so high that the glaze became excessively runny. This would be within the region of 820 - 1030 ˚C (Tite *et al* 1988, 247). A reasonable assumption for the present case would be at least 950 ˚C as it would allow firing of lead and alkali glazed wares together (Mason 2004, 176-77). The duration would have been long enough to cause the gasses in the body to escape through the fluid glaze coating and for some oxidation to occur, producing the red hue most of the body fabrics have, and to oxidise the iron in the red slips. The expansion of the raw materials during firing must be well matched – meaning that all the components (body, slip, and glaze) reach maturity at the same point and shrink on cooling at a similar rate. The exact duration is unknown, and not possible to estimate as there are many factors involved in producing the final glaze microstructure as we see it in the finished product. During cooling the viscous glaze solidifies but remains amorphous with occasional in-glaze or interface devitrification forming as it reaches freezing point.

Leaching of lead oxide into the underlying clay binds the lead glaze to the surface of the vessel. Along the interface with the underlying clay some devitrification may occur as alumina-silica-potassium crystals grow along the interface. We cannot know the precise amount of silica in the original recipe, and are unable to quantify the amount and depth of silica/alumina/potash digestion. It is the opinion of Tite *et al* that firing and cooling times for lead glazes are long enough for there to be an even distribution of digested elements through the glaze thickness up to 100-150 μm (1998, 251), although it is obvious from the analyses carried out of upper and lower areas of glaze that there is in fact a few percent difference in silica, alumina and potash, with a corresponding difference in lead oxide. Colourless glazes rarely show any crystalline interface layer, while glazes over coloured slip or pigment are very likely to. As we have seen in previous chapters coloured areas also have a high rate of digestion of the pigment minerals which are present throughout the thickness of the glaze. Dissolved pigments or colouring oxides may introduce more clay minerals into the melt than the engobe alone.

The effects of firing are fairly standard across the lead glazed wares analysed in this study. Most of the glazes are of a high standard – fully vitrified, few bubbles or relict minerals in the body of the glaze, with a smooth surface resistant to acids or weathering during use and burial. On cross-section the lead and trace iron in the glazes make the colourless glaze look coloured – light yellow to dark green depending on the intensity of the oxidation and the relative quantities of iron and lead oxide – although they are completely colourless from the surface.

Little colouring element is required to make the glazes appear coloured when viewed as a cross-section through the thickness of the glaze. For coloured glazes over white engobe (where a pigment has been completely digested by the glaze) only small amounts of iron and manganese oxide is required to make the glaze dark. This opaque effect is due to three properties: 1. manganese is a strong colorant and tends to diffuse evenly throughout the glassy matrix, 2. heterogeneity in the diffusion of iron oxide, even at low amounts, serves to scatter light and gives the glaze an opaque effect, 3. the crystalline interface layer of K-feldspars scatters light as well, and prevents the underlying engobe from being seen. In cases of olive green decoration, unfused chromite grains, although black in cross-section, produce an interesting effect which is the combination of dark green crystals along the interface, and yellowish-green transparent glaze from the oxidised lead and iron oxides.

The monochrome green glazes are also the product of firing in an oxidised atmosphere, with copper, lead and variable concentrations of iron reacting together producing medium to dark green shades. For the green decoration on the 12th century polychrome slipwares, this is a cooler hue, perhaps due to lower iron content. The monochrome green glazes have an extensive crystalline interface layer. The reaction may be stronger due to the ease of silica digestion from clay minerals as opposed to silica-rich engobe inclusions, although they are no higher in silica than the colourless lead glazes.

The crystalline layer has been used by others to determine whether the glazes were applied over a previously fired (bisque) body, or onto a green (or leather hard) body in a single firing (Molera *et al* 2001; Tite *et al* 1998). The assumptions, and some of the tests, show that a lead glaze tends to react more extensively on an unfired body, producing a thicker layer of interface crystals. Results of experimentation are mixed, however, and due to the various factors involved in the formation of such an interface layer (including composition of the underlying clay, firing conditions, and application methods), there is no straightforward one-to-one relationship. In the present case it would certainly appear that coloured slips and glazes and the (bare) body fabrics facilitate the formation of crystalline layers to at least some degree, while the siliceous engobe does not. However, on some of the Kuva examples, both colourless and green lead glazes applied directly to the body also show no evidence of crystalline interface.

Tashkent samples tend to lack crystalline interfaces as well, although evidence of digestion of clay minerals dissolved into the body of the glaze is unequivocal. It may well be that this interaction layer is due to variations in the production method – longer or shorter cooling times, brushing versus pouring glaze onto the vessel, etc. Or, it may be the case that Tashkent and Kuva pots were in fact fired before application of the glaze, while Akhsiket pots were not.

In order to consider whether single or double firing may have been used, for our interpretation of the *chaîne opératoire* it is useful to examine their respective merits. Bisque firing has a specific purpose – gasses produced by the clay can escape without fear of creating bubbles or blisters in the glaze; the body will not expand as much in the second firing, allowing a better glaze 'fit' and the glaze slurry will soak into the body without causing it to oversoften (Tite *et al* 1998, 24). However, a bisque firing was not absolutely necessary for the typical lead glazed wares studied here. Lead glaze is runny enough and thin enough that escaping gas does not get trapped during firing and the glaze will fill any gaps created by escaping gasses; lead glazes have a thermal expansion coefficient close to that of the bodies, and the engobe improves this by acting as a buffer, and a fine, dense, siliceous slip would resist too much seepage before firing. Indeed, any reaction with the body only provides further stability and glaze 'fit' by the formation of an interaction layer that binds the slip and surface of the engobe or body together.

Of course, the ancient potter could not have known many of these side effects which are only apparent under microscopy and with a modern scientific knowledge, and the production process is not always based on the most efficient methods. It is reasonable to assume that double-firing is less efficient and more expensive and economic reasons may well have had an impact here. Although not proven, the weight of evidence would suggest a single firing was carried out for most, if not all, of Akhsiket's lead glazed wares.

In comparison to other published slipware studies, it can be seen that the techniques described and explained here were commonly used throughout the Islamic world. Merv analyses of two green lead glazed wares (Henshaw 2001, Appendix A) shows an average, after removal of iron and copper oxide colorants, of 57.7% lead, higher in general than the Uzbek green glazes, but within their range of variation (both Kuva and Tashkent having samples with > 60% PbO). Although there is some variation between the two Merv samples, they both have identical total amounts of minor elements (10.6% for M2/6 and 10.5% for M2/9).

High lead Iranian glazes analysed by Mason (2004, 135) of Gurgan, Sirjan, 'Garrus', Nishapur and Samarkand are useful comparisons. As we have seen, the bulk of the lead glazed wares of Ferghana/Tashkent range from around 47% to 64% PbO, with three samples from Akhsiket outside this range. The glazes analysed by Mason from all the wares mentioned above range from 52% to 65%, on average having higher PbO concentration, but generally falling along the same range as the Kuva grouping. The 'Central Asian' wares (Nishapur is here included due to its stylistic similarities with Samarkand) are only represented by two samples from Nishapur and one from Samarkand. The Nishapur samples have higher PbO by around 6.5%, and extremely low alumina (in one case, no alumina, the other 0.3%). Samarkand is much more similar to Akhsiket with 54.4% PbO and 2.7% alumina. Other than slightly lower potash (but within the range of variation from Akhsiket) Samarkand is virtually identical to the Akhsiket average. Mason also shows results for lustre and *Mina'i* glazes (tin-opacified glaze types not seen in Central Asia) which are far lower in lead, and include high quantities of soda (up to 12.3%).

Al-Saad's work on lead glazed slipwares of later medieval Jordan shows that 'unfused' coloured minerals were used as underglaze paints for both black and blue colours (2002, 804). The glazes themselves have a similar level of lead, but much higher alumina (6.7% compared with an average of 2.4% for Ferghana/Tashkent). The alkalis are very low at < 1% in total (*ibid,* 807) indicating a purer source of silica. It is al-Saad's opinion that alumina was deliberately added in order to increase viscosity, although he does not explain how it could have been added (*ibid,* 808). Spanish lead glazed Islamic wares have a lower lead concentration, with between 33.5% and 47.9%, while lime is high ranging from 6.6% to 13.1% (compared to < 1% in the Ferghana/Tashkent glazes) along with other differences (no soda, slightly higher alumina) (Perez-Arantegui and Castillo 2002, 638). The Ferghana/Tashkent lead glazes analysed here are very close to the original lead glazes used in Roman times – 45-60% lead oxide, less than 2% alkalis, and 2-7% alumina (Tite *et al* 1998, 242).

The lead glazed wares exhibit a degree of uniformity that is partly determined by the limited choices available to creating successful lead glazed wares (the use of high quantities of lead, the use of slips and pigments rather than coloured glazes for polychrome decorations, firing in an oxidised atmosphere, for example), while other choices are clearly made as a result of other factors such as limited technical know-how, imposed aesthetic limitations, or lack of certain raw materials. In this latter category are cobalt, antimony and tin-oxide colourants, lustre-styles, closed-form vessels, and wider use of pigments. These choices appear to reflect a certain level of specialisation – possibly under some kind of centralised control, whether it was Ferghana-wide or local to Akhsiket. Similarities with Kuva would indicate the former, as well as the somewhat wider range of variation in the Akhsiket wares in comparison to the Kuva wares.

The production methods were certainly conservative, hardly changing over a period of some six or seven generations, but with minor – and therefore probably not deliberate – changes that lead to the variety that is seen in lead concentrations. Tashkent is also fairly evenly spread along a small range of PbO variation, and it is already accepted that there were a number of production sites in the Chach area, even if primary evidence is yet to be incontrovertibly shown. Vessel forms used at Akhsiket are far less adventurous than those from Chach published in Brusenko (1982) as described – perhaps due to greater cultural conservatism on the part of Ferghana potters and/or consumers.

7.1.4. Alkali glazes

Alkali glazes were used at Akhsiket during the 9th – 11th centuries. The alkali glazes were applied directly to buff and red-coloured bodies, and always coloured. Colours include various blue hues, turquoise and lilac, and range from opaque to nearly transparent. Alkali glazes are difficult to control due to variations in components of the ashes used, and with high concentrations of silica in the recipes used, alkali glazes do not fire as easily at low temperatures, often containing bubbles, relict minerals, and heterogeneous matrices in the final product. Even if such effects are desirable, they are not easy to control. So while the glaze was, in theory, easy and inexpensive to source, in practice it was more difficult to produce a consistent effect than using lead glazes.

As with the lead glazes, crushed quartz pebbles may have been used for the alkali glazes. Plant ashes were procured by harvesting and burning large quantities of specific plants. Either plants (collectively), or the ash product of the burnt plants, is called *ishkor* in Uzbekistan and include varieties called *kirk bugin* and *gulak* (Rakhimov 2000, 134) – probably halophytic plants common to arid and semi-arid environments which were commonly used for glaze and glass making (Barkoudah and Henderson 2006, 297). Ground silica and ash would then be roasted together until 'fritted' - fused, cooled rapidly in water, the resulting glassy product then finely ground. This process bonds the alkalis and alkaline earths in the ashes as insoluble glass and inert salts – reducing adverse reactions and facilitating a homogenous matrix.

Rakhimov describes a traditional practice carried out by modern potters in Uzbekistan attempting to recreate the Timurid alkali glazes. 70% *ishkor* was mixed with 30% crushed 'quartzite' [*sic*]. This was fired to 1200 ˚C two or three times, then cleaned, crushed, milled and sieved to create a powder ((2000, 134). Quartzite, found in several locations in the region of Chach and in the Ferghana Valley, is an extremely hard rock and would have been difficult to process using ancient techniques – it is therefore not seriously considered here as a silica source for early Islamic artefacts although without more evidence it cannot be discounted entirely. Quartz pebbles, on the other hand, are easily crushed and much more likely to have been the silica source.

Contemporary potters in Ferghana who create 'traditional' alkali glazes in the white, blue and green colours typical of the region use the same local plants mentioned by Rakhimov (above), but the ratio of ash to quartz is 3:1. 15 kg of ash and ground quartz are placed onto a sand base between a square of four bricks, and this is fired for 10 hours at 1200 ˚C. Smoke is reduced as much as possible as it is thought to harm the quality of the resulting glassy frit (Komilov 2003, pers. comm.). Figure 7.12 is an image of the glaze-making workshop of Ibragim Komilov in Rishtan, showing the preparation area where raw materials were crushed, ground and mixed.

Figure 7.16. Glaze-making workshop in Rishtan.

There is a single historical source for the creation of a *glass* frit which is relevant here: that of Abu 'l-Qasim who wrote about Persian glass-making practices in c. 1300. He mentioned some specific plant species – particularly '*ushnan*' (translated as *Salsola soda*) used in the creation of a glass frit. The ratio of ash (*shakhar*) to quartz (*shukar-i sang*) is given as 100 parts ash to 105 parts quartz, with the quartz crushed and ground and the ash included as 'lumps the size of hazelnuts or walnuts'. The ratio of ash to quartz depended on where the ash came from – more was needed if it came from Tabriz than

Baghdad, for example (Allan 1973, 113). This is a significantly higher quantity of quartz than that used by the Timurid tile recreation project.

Researchers studying ash use in glass recipes, including experimental recreations, have attempted to find chemical relationships between ashes and the final product (Barkoudah and Henderson 2006; Brill 1970; Jackson *et al* 2005; Rehren 2008; Tanimoto and Rehren 2008). These experiments have shown that whilst the chemical composition of the ash has an effect on the final alkali composition of the glass, there is no one-to-one relationship between, for example, soda and potash levels in the ash and that in the final product. This is due to both the loss of alkalis during the preparation of the ash and the amount of alkalis contained in the form of chlorides - limiting how much alkali concentration is actually rendered inert and how much is dissolved in the frit melt. Speaking of experimental glass-making using ashes, Jackson *et al* concluded that "it is possible to broadly predict the glass composition from an analysis of the raw materials. However, it is *more difficult* to deduce the specific raw materials used for glass production from the analysis of the finished glass' (2005, 793).

Relative amounts of alkalis and alkaline earths are, however, important indicators not only of plant ash v. wood ash or mineral alkali sources (first demonstrated from experiments by Brill 1970), but also provide the basic characteristics of the glazes which tend to fall either in the high soda type (nearly all previously analysed Islamic glasses and glazes), the high lime type (some Chinese and Turkish glazes), the high potash type (medieval European wood-ash glazes), or the mixed-alkali type similar to that seen in the Ferghana/Tashkent alkali glazes and some Merv glazes (Wang 2009).

An underlying slip was not used on any of the alkali glazes analysed. The use of a slip in conjunction with alkali glaze is not unheard of in the Middle East, being seen in other parts of the Islamic world (al-Saad 2002, 807). Although widely used on the lead glazed wares, it apparently did not fulfil the potters' criteria of a necessary addition to the alkali wares. Technologically, a siliceous engobe would have improved the fit of the glaze to earthenware bodies, but engobes are consistently associated with uses where their intrinsic aesthetic, not technical, properties are desired.

The alkali glazes at Akhsiket always included colouring oxides of manganese and copper. Depending on the relative amounts of these the glaze maker could produce batches of coloured frits – turquoise, dark blue, lilac, purple, black. The colouring ingredients did not need to be fritted, and could have been added after the fritting process, using the silica-alkali frit as a base to which the colouring ingredients could be added. It is not possible to determine this, as alkali glaze-making materials have never been found *in situ*.

Variation across the sample population is higher than for the lead glazes, but tend toward outliers and occasional fluctuations on concentration, while the majority of sherds are closely related. The correlations between the alkalis and the alkaline earths (see Chapter 5) are probably due to environmental and/or species characteristics – differences in soil chemistry and salinity, absorption of chemicals at different times of year, differences between species or even parts of plants. The removal of chemicals during burning, washing and fritting will also have an effect if carried out differently. The chlorine content, not detected in the lead glazes, derives from the ashes and is due to chlorides in the soil being enriched in the plants and their ashes.

Alumina appears to change over time, becoming slightly more concentrated. The earlier wares (from layers 23/15, 23/16 and 23/20) average 3.3%, while samples from layers 23/10, 23/11 and 23/14 average 4.7% with the most recent sample, 23/2-8.1 at 10.2% (Figure 7.17). Alumina also becomes more variable in the later samples (layers 23/14 to 23/2-8). Alumina is present due to absorption of clay minerals and/or from the silica source. Chronological changes in alumina concentrations could be due to a change in silica raw materials at some point in the 11th century, or a change in preparation or firing methods.

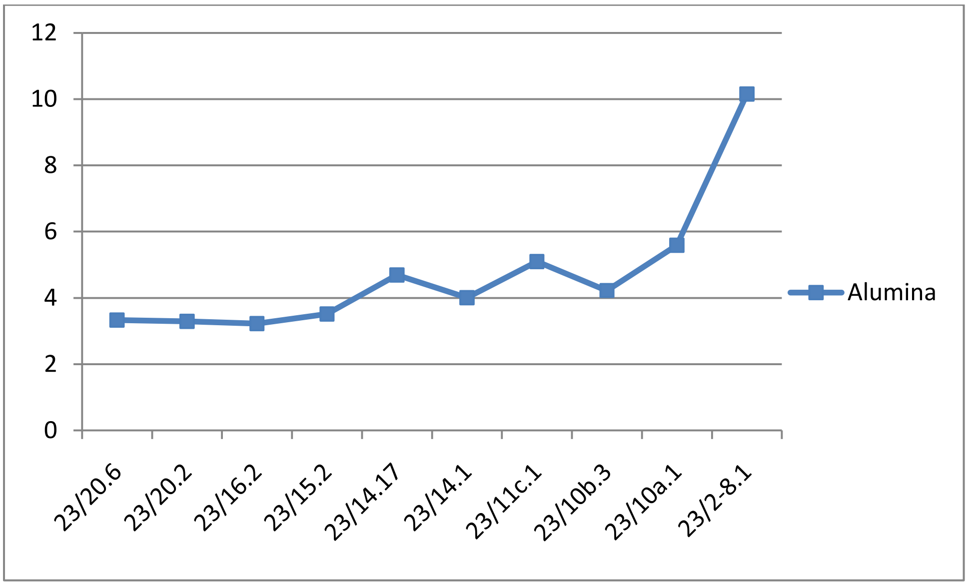


Figure 7.17. *Ishkor* base glaze samples, showing alumina concentrations in wt.% with sherds arranged according to stratigraphical context (left to right from the bottom to top layers).

Kuva and Tashkent *ishkor* wares are visibly different from Akhsiket in texture and colour. Akhsiket has closer chemical similarity with Kuva (Table 7.6). Kuva fits well within the range of variation seen in the Akhsiket sample population. Tashkent is clearly different across the elements, with lower soda, magnesia and iron, higher silica by 8% and slightly higher alumina than the other sites, with potash levels in-between Akhsiket and Kuva.

Kuva appears to use the same ratio of silica to alkali as Akhsiket, with a silica source having similar levels of contaminants, but the alkalis showing some variation. The Tashkent glazes, although clearly plant ashes, do show some differences which can be attributed to other plant ash sources – either the use of different species, or the same species growing in different geological environments. A comparison of the alkalis and lime concentrations for the three sites is shown in Figure 7.18. This shows that both Tashkent and Kuva overlap with Akhsiket samples, so distinctions are not so clear cut as they may seem when looking at overall averages of such small sample sets.

Akhsiket, Kuva and Tashkent alkali base glazes												
Sample	**Na2O**	**MgO**	**Al2O3**	**SiO2**	**K2O**	**CaO**	**Fe2O3**	**TiO2**	**P2O5**	**SO3**	**Cl**	
Akhsiket	**7.7**	**2.6**	**4.9**	**70.8**	**6.2**	**5.6**	**1.3**	**0.0**	**0.0**	**0.1**	**0.3**	n=9
St. Deviation	2.4	0.5	2.1	1.8	1.7	1.7	0.4	0.2	0.1	0.1	0.3	
Kuva	**8.7**	**3.7**	**4.0**	**70.0**	**3.9**	**7.4**	**1.5**	**0.1**	**0.3**	**0.3**	**0.2**	n=2
St. Deviation	2.3	0.4	0.8	0.0	1.1	0.5	0.7	0.0	0.3	0.1	0.1	
Tashkent	**4.5**	**1.5**	**5.4**	**78.2**	**5.2**	**4.3**	**0.7**	**0.1**	**0.1**	**0.0**	**0.1**	n=2
St. Deviation	0.4	0.2	0.8	1.5	1.0	0.8	0.2	0.1	0.1	0.0	0.0	

Table 7.6. SEM-EDS results in wt. % for Akhsiket, Kuva and Tashkent alkali base glazes.

The use of colorants on the Akhsiket samples is limited to copper and manganese oxide. Lead oxide, although not used in the Akhsiket samples, is seen on the Tashkent *ishkor* sherds. It is obvious from the results given in Chapters 5 and 6 that higher concentrations of copper, manganese, and lead produce darker, more opaque colours. Hue and shade are also dependent on the firing atmosphere (discussed below).

Typical colorants seen in the lead glazed slipware decorations that are not used for *ishkor* wares include iron (to any significant degree) and chromium. Iron in alkali glazes, if highly oxidised, tends to produce a yellow or brown colour, and can also produce red, but if reduced it will act as a flux rather than a colorant, possibly making it difficult to control as a glaze colorant in these thick, viscous glazes. Technologically, however, iron could have been used to expand the range of colours used. As already demonstrated chromite was used in the slipware slips and pigments for olive green colours. The use of chromium with alkali glazes came late, with 12th century Iranian alkali-glazed wares using chromium pigments to produce a rich black (Mason *et al* 2001). Chromite in the lead glazes does not dissolve at these low temperatures, so the chromite crystals themselves may have produced little effect in heterogenous, semi-opaqe alkali glazes. The *ishkor* wares produced black with the use of manganese and copper, so it was probably simply unnecessary to use chromite for this purpose even if it were possible. The range of colours appears then to have been limited both for aesthetic and technological reasons.

Manganese oxide is present in similar concentration across the total Akhsiket population, with a variation of around 1%. Copper varies much more greatly, and is not normally present in the lilac glazes. It would appear that perhaps manganese is included as a primary ingredient during fritting, while copper is the colour 'regulator'.

Copper oxide concentrations range widely from 0.5% to 7.1% for the blue and turquoise coloured glazes.

There is no copper present in the skeuomorphic glaze, and manganese is within the range seen in the *ishkor* glazes, as is iron. What makes the glaze appear so dark is difficult to determine. The mottled appearance of the BSE images (Figure 3.18), as with the *ishkor* glazes is due to the heterogeneity of chemicals in the glaze – darker areas indicating higher silica content. In the case of the skeuomorphic example, these darker areas have higher iron oxide – averaging 2.2% in comparison with 1.7% for the lighter areas – and lower manganese oxide. As seen in the lead glazes, manganese tends to dissolve more easily into the glaze melt, while iron often remains in localised high-concentration areas throughout the thickness. The same appears to be happening here, but with the different colour effects made possible by the high alkali content of the glaze, the opacifying effects of the undiffused silica, combined with the oxidising firing atmosphere used.

Kuva and Tashkent *ishkor* glazes contain manganese, lead and copper oxides. Of the four sherds only one fits the same chemical pattern as Akhsiket (Kuva 9 which is nonetheless quite different in colour from the typical Akhsiket *ishkor* range, probably due to different firing atmosphere). The other Kuva sample (Kuva 1) has no manganese oxide present and low copper (and is a pale blue as a result). Tashkent colours are divided between green and a 'lilac/white' colour which has only the slightest lilac hue, and is virtually opaque. The green glaze contains a mixture of copper and lead oxide as colorants. We return again to the question of Akhsiket's limited palette, with copper-only blues and copper-lead greens missing from the repertoire of samples available. In this case it would appear that aesthetic considerations have determined the use (or not) of colorants as they are not necessarily more demanding to produce.

The alkali glazed wares were fired in an oxidising atmosphere, probably around the same temperature as the lead glazed wares. To reach maturity they should be fired to at least 950 ˚C (Tite *et al* 1998, 253). Alkali glazes are most successfully fired at 1000 ˚C or higher – thus their renewed use in the Middle East and Iran in the early 11th century with quartz-based stonepastes. At lower earthenware temperatures, the silica does not always fuse evenly; bubbles can be trapped in the viscous slurry during the melt; devitrification is common where the melt becomes unevenly runny; the glaze expands more slowly than the body and to a lesser degree and therefore crazes on cooling, putting the glaze at risk of flaking off (*ibid*). Because the glaze does not always fit the body well, and because the glaze ingredients do not always fuse together fully and evenly, these glazes are more prone to damage and weathering over time and, of course, during burial. However, the bubbles, heterogeneity, devitrification and/or relict minerals all serve to increase the opacity of the glaze, which may well have been necessary to create the desired visual effect.

A comparison of the chemical compositions between these and other sites shows that the mixed alkali glazes found at Akhsiket, Kuva and Tashkent are most likely unique to the Eastern Islamic world. Middle Eastern and Iranian alkali base glaze compositions are significantly different in three ways.

- Soda to potash ratio is higher
- Alkali content in total tends to be higher
- Alumina is lower

Samples of both eastern and western alkali glazed wares have been found in excavations in Merv (Wang 2009). As a major Central Asian political centre, having strong trading networks with both the western/central and eastern Islamic worlds, Merv's assemblage would be strongly affected by imports. Alkali glazed stonepaste bodies, in particular, have a Middle Eastern/Iranian glazing technology, while the earthenwares general utilise the Central Asian glazing technology (Henshaw 2001; Wang 2009) – although two sherds analysed by Wang show characteristics of the former on earthenware bodies.

The Merv analyses available for comparison were taken by myself from 11th/12 century sherds for an MA dissertation (Henshaw 2001)[7], and by Kuan-Wen Wang from 12th –

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[7] M1/14, M1/19 and M1/28

14th century sherds for an MSc dissertation (Wang 2009)[8]. Thirteen samples in total are relevant to this research, and include blue, greenish-blue, turquoise, grey, and black coloured glazes, and range from the 11th to the mid 14th century. Most of these are monochrome, but a few samples demonstrate painted decorations. Analyses in Henshaw (2001) were taken with SEM-EDS, and Wang (2009) with EPMA (electron probe microanalyser). Averaged, normalised results are used for comparison, although there may be slight differences in the results from the two different analytical techniques (for example, soda is less likely to diffuse when analysed with EPMA, and therefore a higher value is detected).

The ternary diagram plotting soda, potash and lime (Figure 7.19) shows that whilst the stonepaste samples are grouped in a similar area to the Iranian samples (discussed below, and shown in Figure 7.20), the earthenwares are within the range of variation of the Akhsiket wares. Slight differences in soda concentration between sherds analysed by Henshaw and those analysed by Wang are likely due to the lower soda levels detected by the SEM-EDS method used for the earlier samples[9] – however, there is a clear overlap with Akhsiket, Kuva and Tashkent glazes. Looking at the alkalis separately, Akhsiket samples seem quite variable in comparison to the later Merv samples, but the situation changes once the total alkali content is taken into consideration (Figure 7.21).

Here, the Merv samples show greater variation on the whole. Of the earthenware Merv samples, around half fall into the Akhsiket grouping, while half have lower alumina and/or higher levels of alkalis and lime. This latter half groups well here with the stonepaste samples, although one of the stonepaste samples overlaps with Akhsiket and Kuva. Akhsiket and Kuva together (barring a single outlier) form a relatively tight grouping. We can surmise that the Ferghana potters used a consistent recipe for the *ishkor* glazes – whether followed by a single workshop, or multiple workshops. Whereas Merv seems to show a wider range of recipes – some samples having significantly higher silica, others significantly lower alumina, still others significantly

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[8] 1001, 1002, 1005, 1006, 1007, 1024, 1067, 1101, 1104

[9] Wang analysed a few samples with EMPA that had been analysed by SEM-EDS for this thesis. Wang's analyses show around 0.5% to 3% higher soda levels (2009, 74).

higher total alkali concentration. Tashkent, as discussed above, had a different recipe entirely from the other samples (higher silica, lower alkalis).

There were close links between Nishapur and Samarkand we already know, due to the common Samarkand school tradition that was followed in both cities. However, the alkali glazes at Nishapur conform to what appears to be a typical Iranian/Middle Eastern alkali composition with high soda and low alumina. Analytical results from Nishapur have been published by Lazzarini *et al (*1994). The samples date from the 11th – 12th century, and have moderately calcareous earthenware bodies (*ibid*, 509). The colours are blue, turquoise and white, and dark blue contains the colorant cobalt, which has so far not been seen in Central Asian glazes of this time period (*ibid*, 510). Lead oxide is also used on some of the Nishapur samples, and although the authors suggest these are therefore 'mixed alkaline-lead glazes' (*ibid*), perhaps there is an argument that the lead, in fact, was added as a colorant, as in the case of the Tashkent wares. It may be that the differences are largely due to raw material availability, and do not preclude the possibility that the general know-how could not have been shared between Nishapur and the pottery workshops of Central Asia.

Mason (2004, 135) has analysed a number of alkali glazes from Iran, all from stonepaste bodies (SEM-EDS with one WDS). See Figure 7.20 and Figure 7.21 which shows the obvious differences between the Iranian alkali glazes and the Central Asian glazes. High soda and low alumina are the distinguishing characteristics. Further afield, Syrian alkali glazes also contain extremely high soda (up to 21.7%) and virtually no alumina (Mason 2002, 102). 12th/13th century Jordanian alkali glazed earthenwares analysed by al-Saad (2002) contain – again – high soda (~16%), and had incised decorations under the glaze (not seen on the samples analysed in this study), and an underlying siliceous slip (this was added to facilitate the effects of the sgraffito) (*ibid* 804-7). Around the same time as the Jordanian wares, alkali glazes were used on Turkish calcareous fritware bodies. These are notably different from the present study due to their very high lime content – over 10% in most cases (Blackman and Redford 1994, 31). All of these samples used copper and manganese as colorants to produce turquoise, blue and purple.

Mason also analysed four pre-Islamic alkali glazes (using SEM-WDS and one EDS) from Nippur, Iraq. These contained an average of 65% silica, 12.5% soda, 4.7% potash, 7.9% lime, 3.4% alumina, 3.8% magnesia and 2.5% iron oxide (2004, 35). Variation between these sherds was small, except for soda, which ranged from 9.6% to 16.2%, and iron oxide which ranged from 0.8% to 5.2%. In the early Islamic period it appears raw material use was more varied – perhaps due to individual workshops creating wares with little centralised organisation. It is clear that at some point in the early Islamic period, glaze recipes in the Middle East and Iran began incorporating plants with *consistently* higher soda levels than their pre-Islamic predecessors – possibly due to greater control and organisation. It is unknown to what extent the glaze look and feel is affected by the differing amounts of alkalis and alumina (a much more intensive study of the colours and visual effects would be required); whether decisions on raw material source and preparation methods were linked to purely economic or aesthetic reasons, or why there is a difference between the eastern and central/western areas within the Islamic world.

It should be noted that the alkali glaze chemical make up is similar in technology to glass fragments found in archaeological contexts at Akhsiket and Kuva (Osorio 2005; Jolley 2003), with a silica base and high alkali composition. However the glasses are much closer in composition the typical soda-lime-silica Islamic period glasses than the Central Asian alkali glazes, and will not be investigated in this thesis.

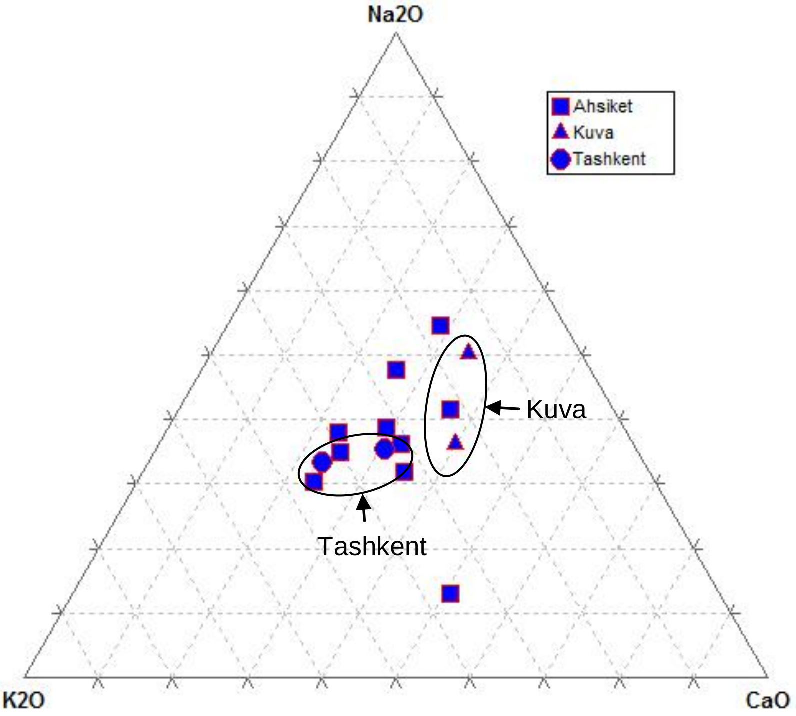

Figure 7.18. Ternary diagram showing Akhsiket, Tashkent and Kuva alkali glazes.

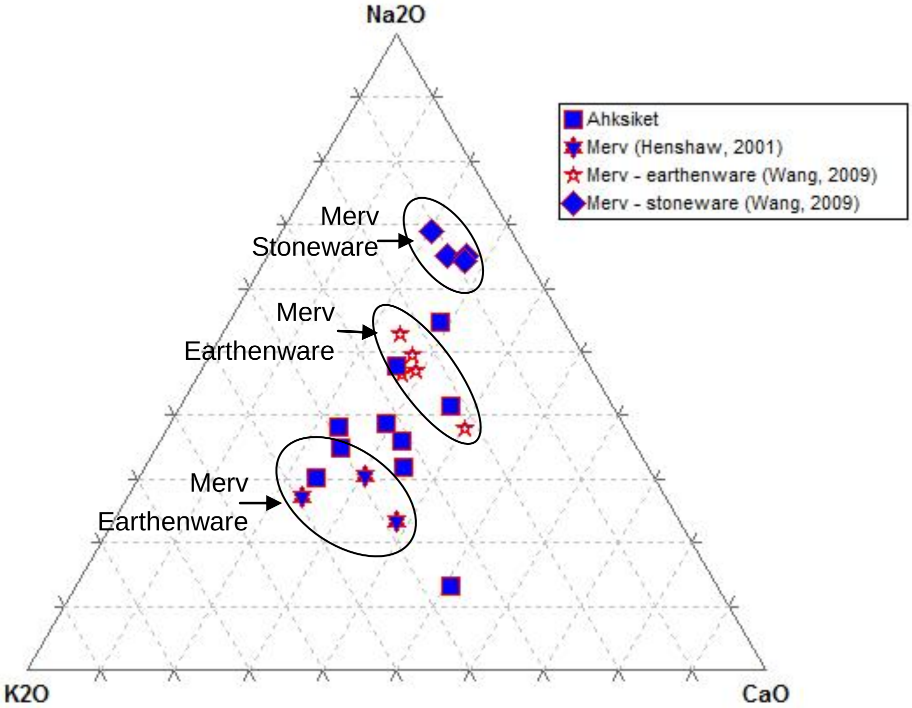

Figure 7.19. Ternary diagram showing Akhsiket and Merv alkali glazes.

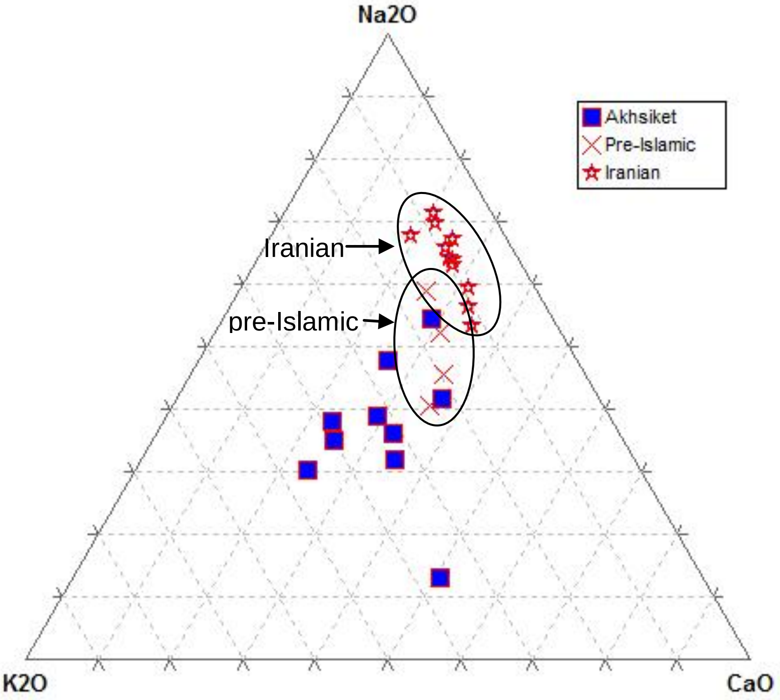

Figure 7.20. Ternary diagram showing Akhsiket, pre-Islamic and Iranian alkali glazes.

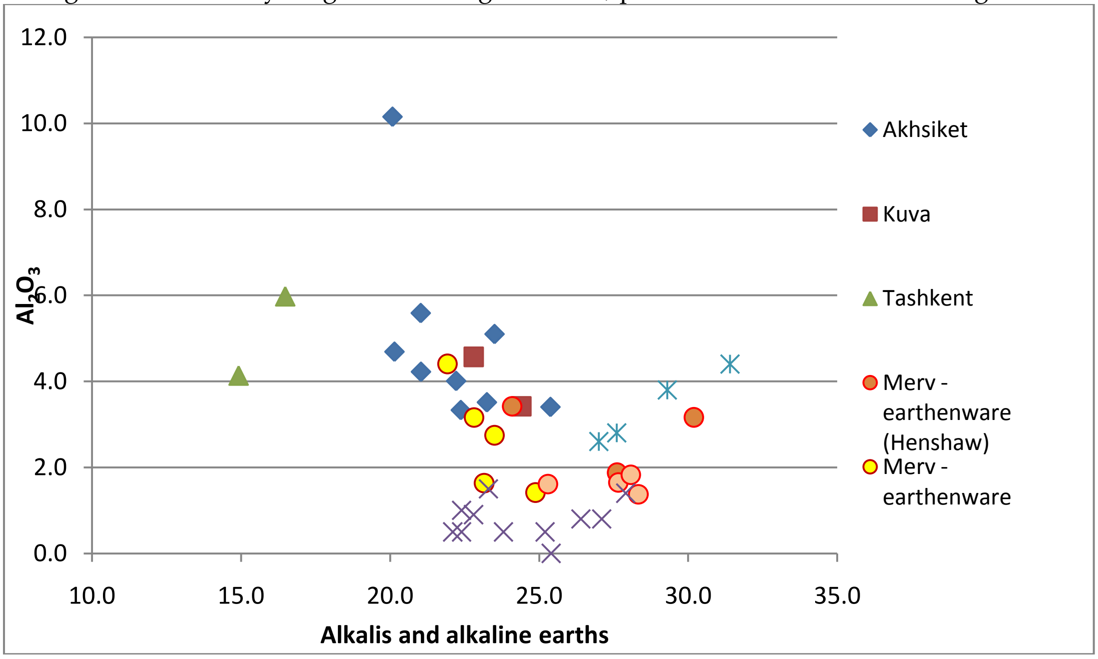

Figure 7.21. Scatter chart showing alkalis and alkaline earths v. alumina for Central Asian, Iranian and pre-Islamic (Iraq) alkali glazes. The Akhsiket outlier with high alumina is 23/2-8.1.

The technique of alkali glazing came to Ferghana from the early glaze-making practices of the Middle East, which, as with the lead glazes, was in use long before the Islamic period but was only taken up on a large scale and disseminated by the Islamic immigrants during the political and economic expansion of the caliphate. Technological similarities between the Ferghana/Tashkent glazes and those from the Islamic 'centre' are apparent and provide evidence for this transmission of knowledge, but more interesting are the differences that show localised preferences and/or abilities. These indicate the use of different raw materials, different ratio of silica to ash and different use of colorants. These properties allow not only the differentiation between sites for future possible provenancing of alkali glazed wares, but are also a window into differing socio-economic practices. The *chaîne opératoire* has distinct localised variations - an important discovery in the light of regional homogeneity in the lead glaze and ceramic body technology.

7.2. Technical and aesthetic choice

There are a number of general conclusions that can be made about Akhsiket's pottery, and the scientific analysis roots this in a new interpretive foundation. There were a series of major changes in Akhsiket's ceramics prior to the Mongol invasions which can be broken down thus:

No glazed pottery → glazed pottery

Early Islamic motifs → later Islamic motifs

Alkali glaze in use → alkali glaze falls out of use

At some point in the late 9th/ early 10th century glazed wares suddenly appear at Akhsiket and quickly become available *en masse* and to a high technical standard. This phenomenon stems from developments in technology throughout the Islamic world, starting with southern Iraq, moving into Iran and the Levant, spreading further east into Khurasan/Transoxania, and finally Ferghana – as shown by comparisons with Mason's work (2004) and others. Iraqi and Iranian pottery provide the early developmental evidence for Islamic ceramics as they appear in the eastern Islamic world – building on earlier technologies, with some influences perhaps from Chinese imports (see Chapter 3.4).

The ascendancy of glazed pottery in Samarkand as well as Nishapur coincided with two strong dynasties with high aims and pretentions – the Samanids in Transoxania and the Tahirids in Khurasan. It is possible that glazed pottery began as a more economical substitute for precious metal objects - painted decoration used in lieu of precious and semi-precious stones. The development of lustre wares at the height of glazed pottery production in the Middle East bears this out, with its hard-won imitation of silver and copper/bronze. Great artistic wares were created as glazing technology became more developed, and as potters gained ever more control over their raw materials. Eventually these glazed wares became *de rigeur* as elite decorative items throughout large areas of the Islamic world and spread, eventually, to Europe.

It is relatively easy to identify and describe changes in aesthetic and technical style - it is not so easy to interpret the decisions and processes that caused them. The 'trickle down' effect of elite stylistic preferences as applied to consumer products seems obvious from the typological and archaeological evidence (namely glazing technologies being brought from Egypt and Iraq to Central Asia, and stylistic similarities between Samarkand, Chach and Ferghana). How this translates to the technological development is now becoming clearer with the evidence from the microstructural and chemical analysis of the glazed wares. Unfortunately, it was not possible to analyse any wares from Samarkand, and only one or two comparable analytical results have been published. In order to complete the picture of technological development in Uzbekistan it will be necessary to address this omission.

We know that lead glazed polychrome wares were the most common type at Akhsiket, and therefore the most in-demand, until sometime in the later 11th century when monochrome green wares with sgraffito decorations became highly popular and the polychrome wares changed in line with stylistic shifts in the eastern Islamic world in the 12th century. Whatever links prompted the Ferghanans to take up the early Islamic glazed types appear to have affected them again two centuries or so later when styles shifted.

Trade routes criss-crossed this region, leading into the Ferghana Valley from east and west, and across the Valley from north to south. Glazed pottery, having risen to a certain prominence in Transoxania whereby it was produced within certain 'accepted' stylistic schools and widely traded, was probably imported to Ferghana from Chach and possibly Samarkand. This is assumed to have been the method by which the Ferghanans were first exposed to the glazed wares.

Schiffer and Skibo defined the term 'techno-science' as the technology of production, and made the important observation that 'an understanding of the techno-science content of a technology is a prerequisite for explaining technological variability and change' (1987, 597-8). This variability, they later explained, 'is caused, in a proximate fashion, by artisans executing different sequences of material procurement and manufacture activities, including materials preparation.' It is further influenced by 'externalities' such as the behavioural and social environment (1997, 28, 33). The artisans and externalities determine the available choices – both explicit and unconscious – for employing techno-science (Killick 2004, 571). Changes in these choices reveal which technologies are conservative, traditional technologies (standardised methods for which the original reason for adoption may be lost), and which are innovative (derived from experimentation or adaptation to new technologies) (Hill, Speakman, and Glascock 2004, 586).

It can safely be assumed that the appearance of glazed wares at Akhsiket was a major innovation in terms of consumption. The glazed wares are very different from the unglazed wares, and even if made from local, well-known materials, they utilised them in different ways that would have meant a serious shift in mindset for any pre-existing local producers and consumers. Was glazed pottery indeed produced by existing, local potters (in the first instance at least)? Unless there is a major gap in the archaeological record, filled with the 'missing links' of unglazed to glazed pottery transitional wares, the technology arrived fully-formed. We have seen in previous sections that there are a number of crucial differences between the unglazed and glazed wares (most obviously, the presence or not of glaze, but also body shapes and oxidisation of fabrics), and between the lead glazed and alkali wares (body shapes, decoration methods) – often for no other reason than purely aesthetic preference. Cross-fertilisation of technique, as far as visual effects are concerned, provides clues to the extent of specialisation in the industry. The Akhsiket ceramics, particularly the lead glazed wares, are highly specialised, defined by Tite (1999, 192) as having a high degree of standardisation, complex technology requiring a high level of skill, greater labour requirements, and specific facilities and equipment. Only the extent of distribution is in doubt as there has not been wide enough sampling from the region.

The degree of similarity between wares at Akhsiket, Kuva and Tashkent, and even further afield such as Samarkand, Merv and Nishapur, provides evidence for a familiarity with standardised techniques that were widely used across the eastern Islamic world. This is highly unlikely to have arisen by accident. Some Middle Eastern Islamic wares were copies of 12th century Chinese porcelain using a completely different technology (siliceous stonepaste) – obviously an innovative use of known material (Lane 1958, Mason 2004). The Akhsiket glazed wares, however, do not show this level of materials adaption.

Van der Leeuw, an influential theorist regarding innovation and technical choice in material culture, calls the methods of production and use a 'syntax' which must be recreated by studying the 'categorical and relational boundaries as defined by the ways in which they were transgressed' (1990, 94). Innovation, in his view, can be interpreted then by the choices which were available, but *not* chosen – narrowed down by experimentation and/or by comparing with other archaeologically-attested ways of making the same or similar objects (*ibid*, 100). Akhsiket's glazed ware 'syntax' is revealed by the typological and scientific observations described here, and there is no evidence that innovative choices had been made to the extent they would have, had the potters not had some previous knowledge and experience in 'traditional' production methods. The evidence leads towards a new influx of potters with specialist skills gained in Transoxanian workshops, or the deliberate apprenticeship of Ferghanan potters at these workshops. Lane raised this possibility when he reasoned that the movements of itinerant craftsmen between centres of power as dynasties rose and fell, could explain the 'surprising unity of style' seen in early Islamic ceramics (1958, 2).

Proceeding under this assumption, we then needed to determine which differences *are* visible, which deliberate choices were *not* taken, and which aesthetic possibilities *not* preferred in comparison to other exemplars. These are important as they are based on deliberate choices, not on lack of know-how, and therefore reveal something about the production and consumption process, not just the individual skills of the potter. Using typological and scientific analysis to characterise Akhsiket's pottery works to improve our understanding of what makes Akhsiket's pottery unique, and confirms the technological/typological *chaîne opératoire* as outlined in Figure 7.22.

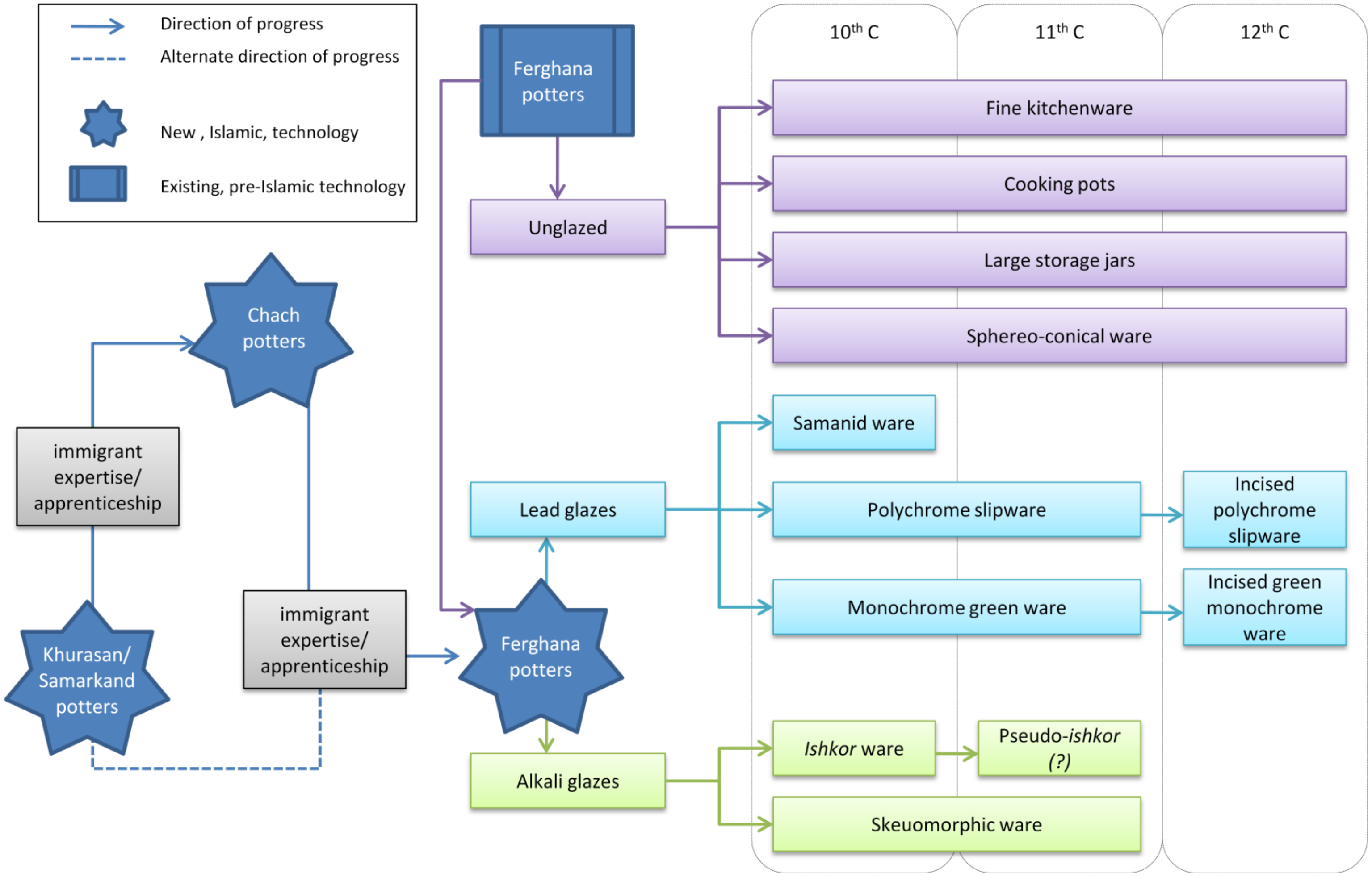

Figure 7.22. Diagram of the *chaîne opératoire* for Ferghana ceramic types.

Differences are apparent in the ceramic bodies. Whether these are significant or not, has yet to be determined, but initial indications are that the Tashkent and Kuva glazed wares used more homogenous clays and/or more standardised, repeatable methods in purifying the clays. Slight differences in calcareousness may differentiate between actual clay sources used at the three sites. If these are systematic differences, the assumption that Akhsiket's (and Kuva's) wares were not imported in the main from Tashkent are confirmed. Kuva bodies are slightly less calcareous on average than Akhsiket's, again indicating there could be different clay sources involved, and that the clays of Ferghana are not entirely homogenous in their bulk chemistry. Potential markers for differing sources may also be visible in the quartz inclusions.

Within the Akhsiket assemblage, bulk chemistry of the glazed and unglazed bodies show what appears to be a low level of variation, with some potential groupings. It is usually accepted that coarser wares are made locally in most contexts. The fired clay test shows that there is clay on site which is suitable for forming and firing up to 850 ˚C without temper and without purifying, and that the bulk and trace element analysis is consistent with the ancient pottery. The big question that remains is whether these characteristics are unique to Akhsiket's pottery and therefore useful for provenancing these and other ceramic samples.

The lead glazing technology is highly standardised across the region, including as far afield as Iran, and the Akhsiket wares fit comfortably into the typical high-lead glaze type. As with other lead glazes that have been studied, the Akhsiket wares demonstrate good quality, transparent glazes with or without crystalline interfaces depending on whether there was a siliceous engobe under the glaze. The use of siliceous engobe and slips, made from a different clay to the bodies, shows that some effort was made to procure and produce these decorative coatings, and although there are few analytical results to compare to, so far there is no evidence that these are anything out of the ordinary as far as standardised production goes.

The styles used on the lead glazed wares are more useful for studying their development, which is only evident in the artistic motifs, not in the technologies employed. Many of the designs follow on from developments at Chach, which, in turn, follow on from Samarkand. This was due to the flow of goods and information along the trade routes, and, presumably, what was desirable in Samarkand was desirable in the provinces as well. That is not to say that there were not local developments, independent from Samarkand, Chach, or anywhere else, that could have been influential in developing artistic style. The motifs could be used in many different configurations; it would be a very large project indeed to map every single variation to its origin production site. Similarly, there were probably many styles which did not make it into the repertoire of Akhsiket.

The impression from the evidence so far is that the lead-glazed wares were highly specialised and probably produced in a limited number of workshops. Variations in decoration are closely aligned to the prevailing trends seen in the central urban centres, and homogeneity in chemical composition, application technique, and body typologies does not show a great deal of individual expression regarding the technology.

If the lead glazes are highly standardised and traditional, the alkali glazed wares by contrast are to some extent less so. Significant differences can be seen in the alkali wares of Central Asia in comparison with areas further west – namely the lower soda levels and correspondingly higher potash and alumina.

Alkali glazed wares came into use around the same time as the lead glazed wares (some believe slightly before), having many features in common with wares from further west as well. This technology developed in Mesopotamia and Egypt, so it makes sense that these areas would have continued this already-traditional technology. However, it does not explain why take up of this technique was widespread in Central Asia, where the technology was fresh. Although apparently less popular, being in the minority, this technique was available from the late 9th to early 11th century at Akhsiket and changed very little over this time even as lead glazed wares underwent continual stylistic development. Then, inexplicably, this technique becomes far less common – possibly even extinct - well before the Mongol invasions and abandonment of Akhsiket, while lead glazed wares continued in use. Timing-wise, this seems to coincide with several developments in lead glazed wares. During the 11th century, polychrome wares saw the flourishing and continued development – usually increased embellishment and more confident use of multiple colours – of 'traditional' motifs (within the context of the relatively short timescale) as well as new motifs coming into play such as the monochrome bouquet motifs, the pomegranate flower, and, in the late 11th century, the palmette. The 11th century appears to have seen the end of faunal depictions, matching the trend seen at Chach and Samarkand. At a time of burgeoning artistic licence and confidence in lead glazed wares, the alkali glazes and their specific decorative styles were largely dropped. By the late 11th century, of course, lead glazed wares become much less variable, with the rise of incised wares and the 12th century polychrome wares.

Overall, the alkali glaze composition of the Akhsiket wares is fairly variable in alkalis, but all the ash components together show a consistent ratio in relation to silica across the sample population. The alkali variability is put into context when compared to the glass finds from Akhsiket. Kiln glass found in a specific location (Object 24) is highly homogenous, with little variability in soda or potash (Osorio 2005). Assuming these samples could not possibly have been from the same batch, due to the high quantities found in what appears to be a waste site from a glass workshop, the similarity is striking in comparison to both the glazes and the glass vessels found at Akhsiket (and Kuva). What we may be seeing here is a single workshop, having a specific method to produce glass vessels and perhaps coloured glasses for later use, while the finished products we find come from a variety of workshops that have slightly different methods producing slightly different chemical compositions. If variations in alkalis in glass can then be linked to an economy utilising multiple workshops, the same could be assumed for the alkali glazed wares. Bulliet (1992), one of the few researchers to make interesting links between pottery and Islamic social structures, argued that glazed pottery of Khurasan was stratified into popular v. elite wares. Although his argument does not utilise technological aspects, and he does not take alkali glazed wares into account, there may be some parallels with this in the Ferghana context.

The ash variability is mostly limited to the alkalis, not the alkaline earths, so differences in take-up of chlorides from the soil must be the discriminating factor here, and may make it possible to identify plant sources used for the glass and glazing techniques.

The glazes are all similar in colour, look and 'feel'. The use of different plants for the ash would have little to do with aesthetics or quality, and would not have been determined by consumer demand, but by technological preference and/or ease of procurement. This again is consistent with the idea that multiple workshops could have made these vessels. Ease of raw material procurement and preparation, application and the ability to create coloured decorations with ease would have enabled a greater number of potters or even pot-making households to create their own wares – constrained to some degree by cultural preference regarding colour and texture.

If the alkali wares were produced in this way, then how do they relate to the lead glazed wares? There may have been workshops that exclusively made alkali glazed wares (and, perhaps, unglazed wares, to which there are some similarities in body shapes). This does not mean that the lead glaze workshops did not also produce alkali glazes – and there may be clues in the variable quality and preservation rates of alkali wares in the archaeological record, and the range of difficulty of decoration. Perhaps there were specialist glazed ware workshops that produced lead glazed wares *and* high-quality alkali glazed wares, while others produced only lower-quality alkali glazed wares and, possibly, unglazed wares.

It appears that the glass working was probably carried out separately, using different techniques with the more typical high soda levels seen in Middle Eastern and Iranian soda-lime-silica glasses (Cheng 2006, Jolley 2003, Osorio 2005). Another craft industry at Akhsiket was steel-making, and this required a specific ceramic vessel type, which has been studied in detail as described earlier (Rehren and Papachristou 2003; Papakhristu and Rehren 2002,). There is no reason to link these particular vessels with the domestic wares, as they utilised different raw materials, firing conditions and end use. However, the occurrence of large numbers of these indirectly indicates, as with the domestic wares, that there was a local production supply.

If the technology was learned from areas further west – including decoration techniques, vessel types and forms, and colours – other aspects of production would have been transferred as well. Raw source preferences (quartz pebbles v. siliceous sands, red earths v. goethite, etc.) may also have formed part of the transmission 'package'. Or, raw material sources could have been adapted to existing knowledge and local availability. Further analysis of local geology will help to determine which is the case, and when, at Akhsiket. Firing is another technique that would have been learned along with the glaze technology, as it is so crucial to the successful production of the final product - not only kilns for fritting glaze materials, but also the firing of the pots themselves. They required kilns with particular adaptations and space-saving innovations for mass production. Marks indicating the use of identical *pernettes* to stack bowls and plates, and the use of rods in the kiln walls as found in Samarkand and elsewhere, points toward a common production method. If this is the case, then we can use other evidence from Samarkand (see Chapter 3.5) to inform our understanding of how the workshops may have looked at Akhsiket. By analogy, then, the organisation of Akhsiket's pottery industry may have been similar to that in Samarkand, with a defined potters' 'quarter', both for living and working.

Whether the pottery was in fact produced at Akhsiket or not, it remains true that there were large quantities of glazed wares present at the site. It seems obvious that glazed wares had a huge impact on the material culture of Akhsiket throughout the early Islamic period. The fact these are all end products, not wasters, indicates that Akhsiket was a great *consumer* of these wares, whether produced locally or not.

The appearance of glazed pottery in Ferghana happened during a time of significant political developments in Ferghana. First, there was the rise of emphasised self-importance of the Samanid dynasty around the late 9th century (as evidenced by the dropping of the Caliph's name from Samanid coinage), then the early 10th century appointment of Turkish overseers in Ferghana. It is not possible to come to any firm conclusions about how pottery may have played a role in this, but culture serves to articulate social belonging and identification. The use of such blatantly Islamic, Samanid-patronised, aesthetic traditions may have served to reinforce the link between the provincial cities and the more powerful centres of power – either emphasising Turkish overseers' connections with this power, or helping to retain the identity of Western-looking and/or Iranian residents in the face of growing Turkish influence in the region. The possible local production of the lead glazed wares in particular reinforces this as an embedded facet of Akhsiket's society.

8. Conclusion

This thesis has provided extensive technological insights into the production of Akhsiket’s pottery, touching on a number of issues within Central Asian archaeological research. The chosen research methods – SEM-EDS with pilot studies for XRF and petrographical analysis – resulted in enhanced understanding and the development of new interpretations concerning the pottery of Akhsiket and its neighbours Kuva and Chach (Tashkent). The focus of the thesis has been to build a wide-ranging dataset of chemical compositions revealing the nature of Akhsiket’s clays, slips and glazes in order to understand how these artefacts were produced – including both deliberate actions such as applying an engobe to a clay body to make the surface white and smooth, and the non deliberate effects of these actions, such as the engobe facilitating adherence of the glaze to the body. As the first scientific characterisation study for pottery from this region, the dataset also provides a basis for comparison to other ceramic assemblages, both intra-site (glazed and unglazed) and inter-site (Akhsiket and Kuva, Tashkent, Merv, and so on). This helps to place Akhsiket’s ceramics within the wider context – into a network of cultural and economic traditions that spanned the eastern Islamic empire during the early Islamic period.

Greater understanding of the ceramics also leads toward a better understanding of Akhsiket as a city; its culture, economy, perhaps even a local industry. It provides further evidence for the strong connections between Ferghana and Transoxania during the early years of consolidation of Samanid influence in the region, and for the continued success of Akhsiket as an urban centre during the Turkish governorship, the downfall of the Samanids and the rise of the Karakhanids.

The research questions set out at the beginning of this thesis are addressed in the following pages.

What are the characteristics of the Akhsiket assemblages – both glazed and unglazed?

This question was addressed by synthesising previous typological research and undertaking new scientific research on Akhsiket's glazes, slips and clays. This revealed information on technical choices including raw material selection, forming processes, decoration methods, colorants and firing conditions as well as aesthetic priorities and compromises. Typological analysis has shown that Akhsiket's pottery consisted of four main assemblages: unglazed fine domestic wares, unglazed coarse domestic wares, sphero-conical wares, and glazed wares. The glazed wares fall into two groups: lead glazed wares and alkali glazed wares. Samples from all assemblages were analysed. Comparative samples from Kuva and Tashkent consisted of lead and alkali glazed wares.

Samples were collected primarily from excavations carried out during the course of this thesis, although a few came from previous excavations. The sherds were typical of what is found on the site, but are not tied to any particular feature or location. Far more excavation is needed to understand in any detail the spatial significance of ceramic finds at Akhsiket. Akhsiket's sherds are largely dated by stylistic comparison to a very limited set of datable published wares.

The lead glazed wares consisted of polychrome slipwares, Samanid wares, green monochrome wares, 12th century polychrome incised wares, and green monochrome incised wares. All of these have a typical, high-lead glaze with 40 to 70 wt% PbO, colourless except for the green glazes. The glazes are thin and smooth, with few bubbles or relict grains and are generally well-preserved. In some cases, colouring metal oxides from underlying slips and pigments have diffused through the glaze, colouring it.

The polychrome and Samanid wares all utilised a siliceous white slip engobe until the 12th century when the new polychrome incised style was sometimes applied to the bare vessel. The chemical compositions of the engobes are not as uniform as the bodies, but are all similar to each other and made from a low-lime and low-iron type of clay, with a large proportion of crushed quartz. Coloured slips have similar compositions to the engobes, indicating a similar clay source. Red (iron oxide), black/brown (iron and manganese oxide) and olive green (unfused chromite particles combined with diffused iron oxide) formed the typical palette of colours. Pigments of iron and manganese oxide were used instead of slips for some of the black painted decorations, diffusing throughout the glaze.

Crystalline interaction layers are commonly seen, which formed during cooling in the kiln. These crystals are long, angular alumino-silica-potassium minerals – probably feldspars. These are normally seen in glazes overlying coloured slips and pigments or clay bodies, and not in glazes over white siliceous engobes.

Green lead glazes, coloured with copper and iron oxide, were applied directly to the vessel with no underlying engobe, and have slightly higher lime content than the colourless glazes, probably due to greater take-up of lime from the calcareous bodies. Green glazes were also applied to 12th century polychrome incised wares as design elements.

The alkali glazes at Akhsiket consist of *ishkor* wares and skeuomorphic wares, and were produced using a consistent ratio of ash to silica, with high soda and potash concentrations (averaging 7.2 and 6.3 wt% respectively). Silica concentrations average 71.7 wt% with low variability in comparison to the lead glazed wares. Manganese and copper oxides were added to produce lilac and blue/turquoise colours, with manganese oxide remaining fairly consistent in all colours at around 1 wt%, and copper oxide fluctuating widely according to the strength of the colour required or achieved. There is no crystalline interface on these samples, and take-up of minerals from the body appears to be less than for the lead glazes. The alkali glazes were probably viscous during firing, as they were not fired high enough to fuse as fully as the lead glazed wares, indicating a lower-than-optimal firing temperature. Bubbles, undiffused silica-rich areas, devitrification and the presence of relict quartz minerals are all very common in these relatively thick glazes, but this did enhance the opacity and colour-separating effects of the glaze. The alkali glazes did not preserve as well as the lead glazes, being more likely to flake off and become degraded.

The body fabrics underwent bulk SEM-EDS analysis at relatively low magnifications with inclusions analysed at higher magnifications. A small petrographic study was also carried out on several glazed samples. The Akhsiket bodies are calcareous and iron-rich, with small inclusions of quartz, calcite, micas and feldspars – quartz by far in the majority, making up 90% or so of all inclusions present. The fabrics are very fine, with inclusions usually less than 20 µm with occasional quartz inclusions as large as 100 µm or more. Non-quartz inclusions are well evolved while the harder quartz inclusions are generally sub-angular to angular. A small petrographic study shows that the quartz in these fabrics is almost entirely monocrystalline. Chemically, the fabrics are very similar across all sampled glazed and unglazed wares. The coarse cooking wares have large calcite (probably limestone) inclusions to improve thermal resistance, but none of the other wares analysed showed any evidence of temper.

What new interpretations can be derived from the scientific evidence regarding technical and aesthetic style?

The scientific evidence provided clues to the process used by the potters of these wares, although in some cases these are masked by alteration caused by firing and/or burial. The high rate of digestion of clay minerals from the engobe or body by the lead glazes made it impossible to accurately determine ratios of lead to silica in the original glaze recipe. The high silica content, however, indicates that the glaze was applied as a lead-silica slurry, possibly pre-fritted to create these thin, glassy glazes. The engobe's unique clay composition indicates a kaolin-rich source that is different to the clay bodies (and also to the kaolin ceramic steel-making crucibles). The use of siliceous engobe appears to be designed for aesthetic purposes, rather than the improvements it gives to glaze 'fit' and durability, as it is not used in cases where it is not visible. The use of pigments instead of slips is interesting, as the visual effect is little different. It is possible that pigments decorations are more difficult to fire successfully (as evidence by examples with 'staining'), but are probably quicker and easier to apply. One possible interpretation is that the preference of slips or pigments may distinguish between different workshops.

The high soda present in the alkali glazes clearly indicates that plant ashes were used. Although the standard deviations are low for the alkalis across the selection, there are a few outliers. These may have been produced using different types of ashes, whether different plant species, or some other variation in ash-making practices. The silica source may also have changed, as shown by changes in alumina concentrations and variability over time.

All the sherds were fired in an oxidised atmosphere, although there are differences between the glazed and unglazed wares that indicate different firing methods. The unglazed wares are not as highly oxidised as the glazed wares, and are more likely to show variations in oxidation from one side of the vessel to the other. The lead and alkali glazed wares may have been fired in the same kilns, together, at the same temperature and heating/cooling rate as the lead glazes are well-fired and the alkali glazes somewhat underfired.

A small XRF study carried out on fine unglazed wares and brick shows some interesting trace element patterns that could indicate three different clay sources and/or preparation methods used. These subtle variations may show that the clays of NE Uzbekistan are not compositionally identical, and therefore are likely to be useful to provenance the ancient pottery.

What relationships can be seen between the different assemblages present at Akhsiket?

Bulk analysis of body fabrics show that all of Akhsiket's ceramics could have been made from similar clay sources, but the trace analysis of the unglazed pilot study shows that there may be multiple sources. This question is closely linked with the previous question regarding technical and aesthetic choices – both demonstrating a sharp divide between the assemblages studied here. Cross-over is apparent in the body forms of the alkali glazed wares, where bowl shapes in the same style as lead glazed wares and closed forms similar to the unglazed kitchenwares are apparent. As far as glazing and decoration is concerned, there is little technological overlap, except for the possibility that all the glazed wares could, in theory, have been fired in the same kilns at the same temperature. Within the lead glazed wares there is one possible differentiator between the polychrome and Samanid styles – the Samanid engobes having higher alumina on average than those on polychrome wares, indicating a different raw material source and therefore a different production method.

Motifs used on the alkali wares (although far less understood and studied) are very different to the lead glazed wares, while decorations such as incision and moulding commonly found on unglazed finewares are very rarely seen on the glazed wares. Incised polychrome and monochrome green wares bear little or no relation to incised decorations on unglazed pottery.

Will the current research provide any evidence to indicate provenance of these ceramics?

Bulk chemical analysis of body fabrics showing subtle differences with those of Tashkent and Kuva indicates that differences between the three sites exist, although this is a very rough indicator. Comparison to a test sample of local fired clay is not inconsistent with the analyses of Akhsiket unglazed wares and brick. There is significant indirect evidence for local production in the form of thousands of glazed sherds being discovered at the site. As a large, well-organised city, with a very probable unglazed pottery industry and a prominent steel-working industry – the latter carried out on site – it is not outside the bounds of reason to assume that controlled glazed ware production would have easily fit into Akhsiket's industrious, economic-minded society. However, there is no direct evidence for pottery production at Akhsiket, or indeed anywhere in the Ferghana Valley, and this is a major drawback in the comparison of wares found at different locations in the region.

The Akhsiket data provides an initial step in this direction, providing not only a dataset for future comparison, but also showing that the sherds are not homogeneous between the three sites. It shows that XRF analysis could prove very useful in picking up variation within the Ferghana Valley, and that there are potential markers for differentiating assemblages – even within the finewares (such as calcareousness of clay bodies and the characteristics of quartz in the clays).

What relationships do Akhsiket's ceramics have to those from Kuva and Tashkent, and how do they compare to those from the wider Islamic world?

The glazed wares were the focus of the thesis as the glazes and decoration methods demonstrated a variety of interesting cultural and technical similarities with and influences from the wider Islamic world. The lead glazed wares, in particular, not only had close similarities stylistically with examples from further afield in Tashkent and Samarkand, but were technologically very similar as well. Several samples from Kuva and Tashkent were analysed in the same way as the Akhsiket sherds, including a small petrographic study. Analysis of these wares provided some context for the Akhsiket wares, otherwise completely isolated except for a few sherds analysed (with comparable methods) by Mason (2004) from Samarkand. There are close similarities between Akhsiket samples and those from Kuva and Tashkent, with lead glazes being all but indistinguishable, but alkali glazes, slips and bodies show interesting differences. This comparison provides an idea of the range of variation in the region, and showing that the ceramics from these different sites can, in fact, be differentiated to some degree in a meaningful way.

Akhsiket's glazes, in comparison to the wider Islamic world, show that lead glaze – again – is extremely similar in composition, texture and use. The alkali glazes are based on plant ashes the same as those from Iraq and Iran, but have much higher potash and much lower soda averages. The glass remains from Akhsiket are a typical high soda glass, so an interesting question remains as to why the glazes are different. This is true for glazes from Kuva, Tashkent, and as far away as Merv, at least, so is a phenomenon of the Central Asia region, not just of Akhsiket.

What insights do the technological and typological interpretations provide regarding the social and political influences on and role of pottery production and consumption at Akhsiket?

Pottery production probably began as a direct result of potters relocating to Ferghana at the behest of local leadership, or due to the economies of local demand. There is evidence for a separation of not only glazed and unglazed pottery production, but lead and alkali glazed production, with the lead glazed wares continuing a semblance of a well-controlled conservative technology. This technology was closely aligned with its antecedents further west, to the extent that changes in the west prompted changes in Ferghana as well – possibly by the continued movement of potters with new specialist knowledge, or a system of apprenticeship with other workshops closer to the cutting edge of glazed ware development.

The alkali glazed wares seem to fill a niche of locally-adapted methods and styles, having an affinity with the unglazed wares, and may have been less controlled and more widely produced (albeit in smaller numbers). This is reinforced by the differences apparent in typology and technology with Tashkent and Kuva wares. The decline of alkali glazed ware coincides with new developments in lead glazing, and this type of pottery becomes virtually extinct by the time the new phase of lead glaze decoration comes in in the late 11th century. Samanid wares and figural designs also fall out of use in the 11th century. This appears more closely aligned with changes outside Ferghana in the wider world of Islamic ceramics, as described in Chapter 3, than to any social or political changes at home in the form of increased Turkish influence, for example, and the rise of the Karakhanids.

Priorities for future research.

In order to investigate further economic, political and social implications of the pottery industry in Akhsiket, and the rest of Ferghana, further work is needed regarding the provenance of the wares. The first step to realising this is to gain a better idea of the geological context of the region. Clays in the Akhsiket and Kuva area – at a minimum –

must be analysed, as well as any obvious silica sources. Much larger sample sets must be subjected to XRF, NAA or ICP analysis, on all types of ceramic wares from the two sites, and those of New Akhsiket and later wares from Akhsiket (post-Mongol). Analysis of some of the major production areas in Transoxania and other surrounding areas is also required, particularly 9th and 10th century wares in Samarkand, but also early Islamic sites in surrounding regions.

Pinning down provenance as closely as possible will bring new avenues to the study of pottery in the region. Density, distribution and exchange all come into play at this point, and may reveal differences between cities regarding their material culture in ways typological analysis cannot. To this end, samples from each prioritised location must undergo trace element analysis for statistical analysis. Once general groupings have been identified, further investigation of the production methods for comparison will indicate how uniform the technical style of this pottery really is. All forms of pottery should be included – not only lead glazed ware but, even more importantly, the alkali wares, which may show greater variation between locations. Typological analysis should also be brought into the investigation, and there is likely to be considerable information ready to draw on from previous research efforts. Large data sets can then be cross-checked against technical variations to look for any coordinated patterns of development over time.

There is little knowledge of how the early Islamic wares relate to those that came before and after them. What pre-Islamic motifs and forms were carried over into the new technologies, particularly the alkali glazed wares? This is important as it could shed light on techniques which were indigenous, and where the technology is particularly conservative. After the Mongols, when the region was back to producing glazed pottery in large numbers, there was a significant shift in glazed ware styles. Blue and black wares, as seen from New Akhsiket, for example, become popular and petrographic analysis has shown that the body fabrics are coarser than the pre-Mongol bodies. There may be links to previous technology, or it could be completely new to the post-Mongol populations to the same extent as the advent of glazed wares in the late 9th century. What links do these wares have to other production areas, and are these the same as before the Mongols? There are many interesting avenues of research to be carried out that will lead to ever greater understanding of the Islamic societies of eastern Central Asia.

The usefulness of scientific analysis does not have to be argued in the case of understanding ceramic and glaze technology. It is well established, and the invaluable data it reveals has fuelled many interesting and influential interpretations worldwide, from all periods. However, there is an argument to be made for making good use of these techniques within the field of 'Islamic ceramics'. Notwithstanding the scientific investigations on many different types of Islamic ceramics by Mason, Perez-Arantegui, Molera, Tite and several others, there is a distinct gap between the scientific and typological research and socio-cultural interpretations. The fascinating details of the technology itself are not the final story, but rather the processes that drove its creation, development, and extinction. Too often exemplars of the pottery that typifies specific periods of time, and specific areas, are museum pieces with at best vague origins and assumed date, and representing a limited range of locations – rarely including Central Asian ceramics in the traditional 'Islamic corpus' bar a few Samanid wares from Samarkand. Archaeological glazed ceramics are the single most important material evidence of the spread and development of Islamic influence during and after the caliphate.

The former Soviet states of Central Asia have a long history of well-organised excavation, and large numbers of archaeological pottery from the Islamic period are kept in storage and added to every year. There is a wealth of information to be gained but research in these areas tends to have a largely Central Asian/Russian audience due to language barriers and other barriers to the exchange of information. Hopefully this project helps to bridge the gap and demonstrate that this region has a lot to offer the field of Islamic ceramics and the study of the early Islamic period, particularly regarding the social processes behind the development and distribution of ceramics under the aegis of Islamic governors.

Limitations to this study are primarily that of scale - due to the highly detailed nature of the analysis on the glazed wares and their decorative aspects, which was time consuming and required a great deal of careful reporting, it was not possible to take advantage of larger data sets such as comprehensive XRF studies. It was also not possible to explore the full range of Central Asian/Russian literature or site reports mainly due to language barriers, and also due to limits of access opportunities within the time available.

However, as a first study, the aim to collect enough data to provide a sound basis for the characterisation of the Akhsiket assemblages and to set this in context in the region and within the Islamic ceramic corpus was achieved. It was also important to demonstrate that socio-cultural interpretations based on technical and aesthetic choice *can* be approached with the methods used here. This research resulted in the identification of coherent lines of inquiry based on solid evidence – such as the degree of glaze standardisation, regional differences in technical choice, and the potential for provenance investigation using the bodies. As a bonus, the evidence provided a good case for pottery being produced locally to Akhsiket.

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