# Estimation of Production Technology of Potsherds from Kaghan Valley (Mansehra) using their Physical Properties as Basic Parameters

**Naveed Usman / Shakirullah / Rashid Ahmad**

***Abstract***

*Physical characteristics such as colour of the potsherds, colour of the groundmass, isotropism, texture, grain size distribution, maximum grain size, roundness and sphericity of the non-plastic inclusions (clasts) may refer to the estimation of technology used in the pottery production. A total of fifty seven potsherds collected from the surface of seven different sites of the Kaghan Valley Mansehra have been studied for their above-mentioned physical properties. The study revealed that these characteristics have been proved as strong parameters for the estimation of firing environment (oxidative or reductive), production technology and the nature of tempering material used in the paste preparation for the pottery production. Moreover, these properties especially the colour reveals the presence of organic and inorganic materials in the paste and their current condition in the potsherds in addition the state of burning of these materials i.e. fully burnt or partially burnt.*

***Key Words*:** Colour, Oxidation, Reduction, Firing Atmosphere, Non-plastic inclusions

## 1. Introduction

Morphological and macroscopic analyses reveal important information regarding the macrofabrics of vessels/ potsherds which surely motivated the researchers to trace the links between various archaeological sites (Maritan et al. 2017: 712-725). The textural properties which can provide information about the type of raw materials used for pottery production, the technology of production, and post-depositional environment of the potsherds are (Orton et al. 1993: 69, 2013: 277-285; Szakmany 1996: 143-150, 1998: 77-83, Banning 2000: 160-242) the following:

1. Colour
2. Isotropism (optical activity of the groundmass)
3. Texture type
4. Grain size distribution (GSD)
5. Maximum grain size (MGS)
6. Roundness
7. Sphericity of the clasts

Pottery materials show remarkable variability in average grain size (AGS), the grain size distribution (GSD) of the non-plastic inclusions (clasts), and type of the texture i.e. hiatal, serial or hiatal to serial. One of the most important things in the microscopic analysis is to identify the intentionally/purposely added tempering material. It is very critical because it greatly influences the production technology (Maggetti 1994: 23-35, Szakmany 1998: 77-83)

Besides other parameters, the colour of groundmass also demonstrates the firing atmosphere at the time of production. The firing atmosphere affects the colour in different ways. For instance, if a vessel is fired in an oxidizing atmosphere, the resultant colour will be reddish to orange whereas if the process is done in the reducing environment, the end colour will be grayish to black.

The presence of organic materials and finely grained iron minerals also impart the characteristic colours to the vessel. For example, organic materials burn out when the vessels are fired in the reduction atmosphere and turn blackish. It will not be discharged from the vessel itself but rather will impart the dark colour to it. The firing in the reducing atmosphere in the absence of organic materials will convert the iron oriented minerals into iron (II) oxide or magnetite which itself is blackish and consequently imparts blackish colour to the vessel.

The firing temperature also affects the formation of iron based minerals. At very high temperature the firing process is fast which affects the complete burning of the organic material due to less firing time (Maggetti 1994: 23-35). Therefore, in many cases the potsherds contain black cores in their middle. Moreover, the oxidation state of iron also influences the resultant colour, for example, in the oxidizing atmosphere the oxidation state of iron is changed from iron (II) to iron (III) which impart reddish to orange colour to the resultant vessel (Rye 1981: 123-140, Sinopoli, 1991: 58).

## 2. Material and Methodology

A total number of fifty seven potsherds form seven different sites of the study area have been selected for the study, which are distributed as:

1. Ganool: 28 Sherds
2. Ratta Nulla: 1 Sherd
3. Shogran: 5 Sherds
4. Tarla Paror: 5 Sherds
5. Ashanra: 6 Sherds
6. Tarli Batta Kundi: 6 Sherds
7. Morad Vega: 6 Sherds

All of these potsherds are examined for the type, thickness, colour scheme, surface, isotropism, texture etc. in order to classify them in proper manner (Appendix 1 and 2). The type is examined visually with the help of an expert eye whereas the minimum and maximum thickness is measured with the help of a digital vernier caliper. The main thing to decide for the study was colour scheme.

Many systems of colour arrangement have been proposed, and at least three colour standards have been used by archaeologists for the description of pottery: Ridgway (1912), Maerz and Paul (1930), and Munsell (1942). The advantages of the Munsell system are so great that it is hardly necessary to argue its superiority. It is the only one of the three which has equal visual spacing of colour. As a standard for colour matching, it covers the range most uniformly in consequence of the fact that it is based on the way a human being sees the colour rather than on the way colourants are mixed or colour is calculated by laboratory or instrumental methods. One of the reasons why it has been widely adopted in scientific work is that is has been subject to the most exacting measurements, and optical constants have been determined with a degree of accuracy which ensures exact reproduction. Equal visual spacing and a convenient system of symbols facilitate interpolation in colour reading (Shepard 1956, Banning 2000: 241, Sinopoli 1991: 65, Orton et al. 2013: 157).

The cooling process also affects the outer colour of the vessel after the completion of firing process (Picon 1973: 1-135, Sinopoli 1991: 12-13) In the literature, archaeo-scientists have reported three modes of firing and cooling (Orton et al. 2013: 165)

Mode 1: firing in the reducing atmosphere while cooling in the oxidizing atmosphere
Mode 2: both firing and cooling in the reducing atmospheres
Mode 3: both firing and cooling in the oxidizing atmosphere.

The crossed nicols method was used to determine the isotropism of the ground mass. In this method two nicols prisms were placed in front of each other and are oriented in such a way that their transmission of the plane polarized light are at the right angle. The predominant information that this method gives is the presence of finely grained content of the carbonate in the matrix which describes the following two facts:

a. The presence of the calcareous clay in the matrix will reveal that the firing temperature did not reach the level at which it would have been damaged i.e. 750 to 800 $^{o}$C. if it is found that the ground mass still have the optical properties then it is understood that the non-calcareous clay was used by the potter or the pottery was fired at a temperature where all the calcite content has been burnt out (Szakmany 1998: 77-83)
b. The ground mass showing the isotropism means that the firing temperature of pottery during the process was not less than 1050 $^{o}$C (Maggetti 1994: 23-35).

## 3. Discussion and Results

*Colour*

The potsherds can be divided in to several groups on the basis of colour and core layers which also refer to the firing conditions (Fig. 1, Appendix 1). These groups/types are as under:

1. Completely black, dark grey or brown potsherds (31 samples)
2. Potsherds with black core and reddish outer and inner sides (2 samples)
3. Potsherds with reddish core and black outer and inner sides (9 samples)
4. Potsherds with black core and thin outer and inner layers and reddish layers between them, also called sandwich structure (8 samples)

5. Potsherds with outer side black and inner side reddish (4 samples)
6. Potsherds having body reddish to yellowish colour (3 samples)

From colour of the cores, the following firing conditions and techniques can be concluded (Picon 1973: 53, Orton et al. 1993: 131-141, Orton et al. 2013: 211-219, Santacreu and Albero 2014: 101-108):

1. Potsherds found with black or dark gray colour were fired and cooled in reducing conditions
2. Potsherds with black core and red inner and outer sides were fired in reducing conditions and cooled in oxidizing conditions. There are some diffused black cores with sharp boundaries which suggest the rapid cooling process
3. Potsherds with red core were fired and cooled in reducing conditions. The reddish core also suggests that initially the process was started under oxidizing conditions and when the desired temperature was attained, the conditions suddenly changed to the reducing ones and end-firing and the whole cooling were taken place in the reducing atmospheres
4. Potsherds with sandwich structure i.e. black core and thin outer and inner layers and reddish layers between them were fired and cooled in the reducing conditions. Red layers suggest a sudden change of conditions from reducing to oxidizing. Probably, the door of the kiln suddenly became opened due to the mismanagement of potter and air entered the kiln which caused this sudden change. The door was then closed again and after consuming the air in firing, the conditions again became reducing. Margins of the cores are sharp which refer the rapid cooling
5. Potsherds with reddish inner surface and black outer surface were fired initially in oxidizing atmosphere, the conditions then became reducing later on and the cooling then took place in reducing atmosphere which refers the outer black colour. Probably, there was a small vessel placed inside the large vessel and the reducing conditions did not take place in the inner side of the ceramic which is evident from its reddish colour (Velde and Druc 1999: 123-124)

6. Potsherds with reddish body were fired, soaked and cooled in the oxidizing atmosphere.

*Isotropism of the Groundmass*

The type of raw material used for the production of pottery is attributed to the fabric analyses parameters such as colour and isotropism of the groundmass, texture type, grain size distribution, maximum grain size, roundness and sphericity of the non-plastic inclusions or clasts.

From all the fifty seven potsherds studied, thirty five were observed with the isotropic textural properties (brown to dark brown in colour) whereas twenty two were found with fully or partially anisotropic texture (yellow to orange colour) (Fig. 2, Appendix 2).

It shows the low firing atmospheres indicating the non-calcareous clays where the carbonatic material became vanished and did not exist anymore. Any of the calcite fragment artificially added may not be considered in the isotropism.

*Texture*

The artificial tempering was probably done by the potter during the paste preparation which is obvious from coarser size of the clasts and their hiatal texture, but mostly it has been observed that they were dependent on natural clay or sediment temper. This may be attributed to the materials present in the vicinity nearer to the place of production and for avoiding the transportation it may have been preferred which is supported by the presence of angular clasts in excess (Maggetti 1994: 23-35) (Fig. 3, Appendix 2). The artificial temper may also have been added from the fluviatile sources in order to improve the paste quality (Szakmany 1998: 55-60).

The unsorting of material, serial grain size and sub-angular to sub-rounded shapes of the clasts also support the inclusion of the fluviatile materials in the paste.

*Maximum Grain Size*

The histogram shows that the maximum grain size (MGS) of the clasts is between 1500 to 2000 microns which refer to very coarse sand (Fig. 4; Appendix 2). There are some samples which even show the grain sized more than 2 millimeters.From the above discussion, the paste production (by the potter using the available raw material) measures can be concluded as under (Maggetti 1994: 23-35):

1. Where the texture is fine, distribution is serial, grain size is comparatively larger, roundness is well, the clasts are carbonatic which belong to the clay pallets as found in case of the potsherd sample TBK-6
2. Where the texture is serial, clasts are sub-angular to rounded, maximum grain size is between 600 and 1000 microns, the sediments are fluviatile and the paste is not tempered artificially as observed in case of samples GNL-20 and ASN-3
3. Where the texture is more hiatal than serial, clasts are angular to sub-rounded, grain size is between 1000 to 4000 microns (granules), the sediments are fluviatile materials mixed with silty clays which consist of large grains or granules as observed in the case of samples GNL-14 and ASN-2

Where the texture is hiatal, clasts are angular to sub-rounded, grains size is between 4000 and 7000 microns, the sediments have fluviatile origin same as the non-plastic inclusions that were used as tempering material. So much grain size lead to the pebbles sorting which may have been crushed for the sake of preparing the tempering material which is obvious from partially rounded clasts.

## 4. Conclusions

The colour of raw clays is primarily due to two classes of impurities, organic matter and iron compounds. Clays that are relatively free from impurities are white. Organic matter makes clay gray to blackish, depending on its amount and condition. Hematite and the hydrated forms of ferric oxide produce reds, browns and yellow colours. These are compounds in which the iron is in its highest state of oxidation. Compounds in which the iron is not fully oxidized impart a gray colour to the clay.

The potsherds under study have been classified into six different groups on the basis of their colour determined by the Munsell Colour System. Each group represented the characteristic firing and cooling/soaking atmosphere as a characteristic colour tone which had been imparted due to the presence of different constituents (organic and inorganic) and the oxidation state of Iron (II and III). The isotropic properties show the low firing atmospheres indicating the non-calcareous clays where the carbonatic material became vanished and did not exist anymore.

It can be concluded from the color that some of the potsherds were fired and cooled in reducing conditions whereas some in oxidizing condition. Some of them were initially started under oxidizing conditions and when the desired temperature was attained, the conditions suddenly changed to the reducing ones and end-firing and the whole cooling were taken place in the reducing atmospheres. Some of them were fired and cooled in the reducing conditions while some potsherds were fired initially in oxidizing atmosphere, the conditions then became reducing later on and the cooling then took place in reducing atmosphere which refers the outer black colour.

In texture, the unsorting of material, serial grain size and sub-angular to sub-rounded shapes of the clasts support the inclusion of the fluviatile materials in the paste. The maximum grain size (MGS) of the clasts is between 1500 to 2000 microns which refer to very coarse sand and consequently to the coarse wares.

**Acknowledgements**

Authors are very thankful to the Ministry of Information, Broadcasting and National Heritage, Government of Pakistan which have funded the exploration of Kaghan Valley Mansehra from which the ceramics under study were taken and investigated in this research.The whole team of the project entitled "Archaeological Survey of Un-Explored Parts of Districts Mansehra and Haripur of Hazara Division" for conducting the field survey of the Kaghan Valley. Special thanks are extended to Prof. Dr. Luca Maria Olivieri, Director Italian Archaeological Mission in Swat (Pakistan) for facilitating the arrangement of a training seminar on ceramic petrology in collaboration with Taxila Institute of Asian Civilizations, Quaid-i-Azam University Islamabad and Hazara University Mansehra. The Seminar was held by Prof. Lara Maritan, Department of Geosciences, University of Padova, Italy, from 17 to 20 August 2020.

## References

Banning, E.B. (2000) *The archaeologist`s Laboratory: The analysis of archaeological data*. New York: Kluwer Academic Publishers.

Maggetti, M. (1994) Mineralogical and petrographical methods for the study of ancient pottery. In F. Burragato, O. Grubessi, and L. Lazzarini (eds.) *First European Workshop on Archaeological Ceramics*. Dipartimento Scienzedella Terra, Roma: Universitadeglistudi di Roma La Sapienza.

Maritan, L., F. Tourtet, G. Meneghin, C. Mazzoli, (2017) Technological Transfer? Comparative Analysis of 2nd – 3rd/4th century CE "Late Roman" Pottery form Tayma, Saudi Arabia, and Petra, Jordan. *Journal of Archaeological Science: Reports*,12: 712-725.

Orton, C., A.G. Vince and P. Tyers (1993) *Pottery in archaeology*. Cambridge: Cambridge University Press.

Orton., C., M. Hughes, (2013) Pottery in archaeology. *Cambridge Manuals in Archaeology*. Cambridge: Cambridge University Press.

Santacreu, D.A. and M.A. Cau Ontiveros (2016) Technological Choices in Hand-Made Indigenous Pottery from Western Mallorca (Balearic Islands, Spain) (C.1200–75 BC): An Archaeometric Approach. *Archaeometery*, 59 (4): 642-666.

Szakmany, G. (1996) Petrographical investigation in thin section of some potsherds. In J. Makkay, E. Starnini and M. Tulok (eds.) *Societa per la preistoria e protostoriadellaregione Friuli-Venezia giulia*, 6: 143-150.

Szakmany, G. (1998) Insight into the manufacturing technology and the workshops: Evidence from petrographic study of ancient ceramics. In L. Kolto and L. Bartosiewicz (eds.) *Archaeometrical research in Hungary*, II: 55-78

Peacock, D.P.S. (1969) The scientific analysis of ancient ceramics: A review. *World Archaeology*, 1: 375-389.

Picon, M. (1973) Introduction a letude technique des ceramiquessigillees de Lezoux. *Centre de recherchessur les techniques greco-romaines, Lyon*, pp. 1-135.

Rye, O.S. (1981) *Pottery technology: Principles and reconstructions*. Washington D.C.: Taraxacum.

Shepard, O.A. (1956) *Ceramics for the Archaeologists*. Washington, D.C.: Carnegie Institution.

Sinopoli, C.M. (1991) *Approaches to Archaeological Ceramics*. New York: Springer Science + Business Media.

Munsell Colour, (2009a) *Munsell washable soil colour charts* (Grand Rapids, Michigan: Munsell Colour X-Rite).

Velde, B., and I. Druc (1999) *Archaeological Ceramic Materials: Origin and Utilization*. Berlin: Springer.

Pl. I - (Kaghan Valley Mansehra): On-site Potsherd at Morad Vega.

Pl. II - (Kaghan Valley Mansehra): On-site Potsherd at Tarli Batta Kundi.

Pl. III - (Kaghan Valley Mansehra): Samples of Collected Potsherds.

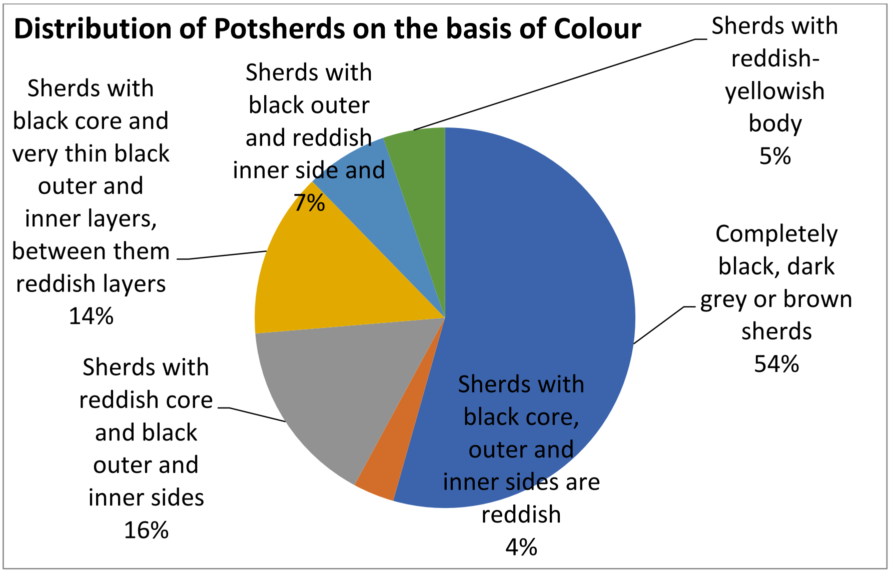


Fig. 1 - Distribution of Potsherds on the basis of Colour.

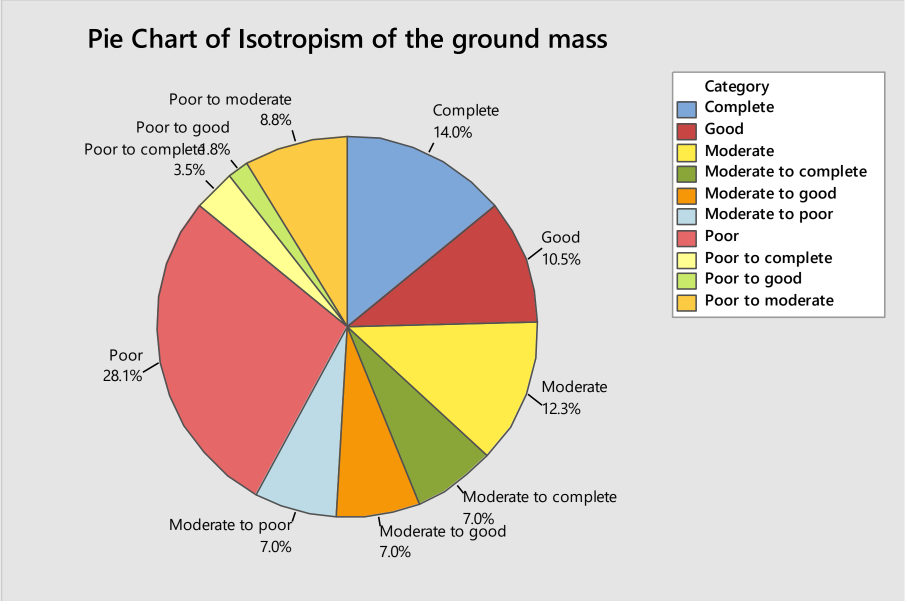


Fig. 2 - Pie chart of isotropism of the ground mass.

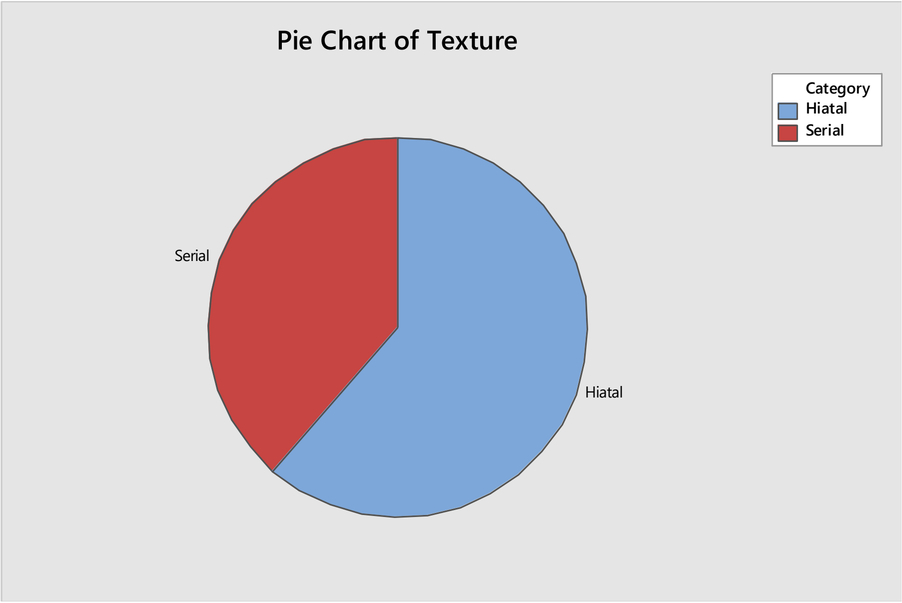


Fig. 3 - Pie chart for texture.

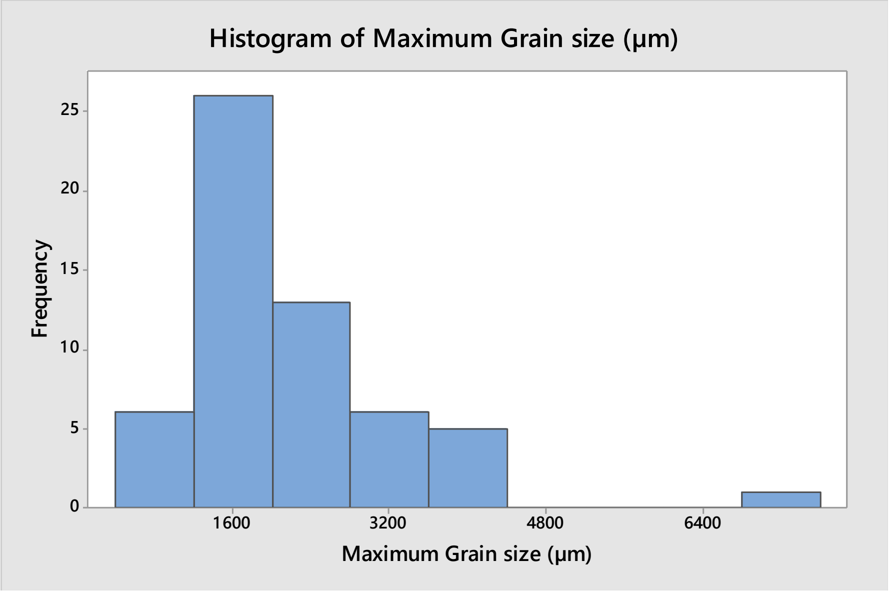


Fig. 4 - Histogram of maximum grain size.

## Appendix 1: Type, Thickness, Colour Scheme and Surface of the Selected Potsherds

| S.NO | No. | Site | Type | Thickness (mm) | | Colour (Munsell Colour System) | | | Surface |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | In | Core | Out | |
| **1.** | GNL-1 | Ganool | Body Sherd | 10 | 20 | 10YR 5/2 greyish brown | | 10YR 5/1 grey | Unburnished |
| **2.** | GNL-2 | Ganool | Body Sherd | 12 | 14 | 5YR 6/6 reddish yellow | GLEY 1 2.5/N: black | 5YR 6/6 reddish yellow | Burnished |
| **3.** | GNL-3 | Ganool | Body Sherd | 10 | 11 | 10YR 5/3 brown | | 10YR 2/1 black | Burnished |
| **4.** | GNL-4 | Ganool | Body Sherd | 10 | 10 | 10YR 5/1 grey | | 10YR 4/1 dark grey | Burnished |
| **5.** | GNL-5 | Ganool | Body Sherd | 9 | 9 | 7.5YR 6/3 light brown | GLEY 1 2.5/N: black | 7.5 YR 5/5 brown | Burnished |
| **6.** | GNL-6 | Ganool | Body Sherd | 11 | 11.5 | 10YR 4/1 dark grey | | 10YR 3/1 highly dark grey | Burnished |
| **7.** | GNL-7 | Ganool | Base fragment | 23 | 27 | GLEY 1 2.5/N black | | GLEY 1 2.5/N black | Burnished |
| | | | | Base dia. 78mm | | | | | |
| **8.** | GNL-8 | Ganool | Body Sherd | 6 | 8 | 10YR 4/1 dark grey | | 10YR 5/2 greyish brown | Burnished |
| **9.** | GNL-9 | Ganool | Body Sherd | 7 | 7 | 10YR 4/1 dark grey | | 10YR 3/1 very dark grey | Burnished |
| **10.** | GNL-10 | Ganool | Body sherd | 9 | 11 | 10YR 2/2 highly dark brown | | 10YR 2/2 highly dark brown | Burnished |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **11.** | GNL-11 | Ganool | Body sherd | 10 | 11 | 10YR 5/2 greyish brown | 10YR 4/2 dark greyish brown | Burnished |
| **12.** | GNL-12 | Ganool | Body sherd | 8 | 10 | 10YR 4/1 dark grey | 10 YR 3/1 very dark grey | Burnished |
| **13.** | GNL-13 | Ganool | Body sherd | 12 | 12 | 10YR 4/1 dark grey | 10YR 4/1 dark grey | Burnished |
| **14.** | GNL-14 | Ganool | Rim Frag ment | 13 | 15 | GLEY 1 2.5/N black | GLEY 1 2.5/N black | Burnished |
| **15.** | GNL-15 | Ganool | Body Sherd | 11 | 25 | 10YR 3/2 very dark greyish brown | 10YR 6/4 light yellowis h brown | Burnished |
| **16.** | GNL-16 | Ganool | Body Sherd | 9 | 22 | 10YR 6/1 grey | 10YR 4/1 dark grey | Burnished |
| **17.** | GNL-17 | Ganool | Body sherd | 8 | 9 | GLEY 1 2.5/N black | GLEY 1 2.5/N black | Burnished |
| **18.** | GNL-18 | Ganool | Body sherd | 7 | 8 | GLEY 1 4/N dark grey | 10YR 5/3 brown | Burnished |
| **19.** | GNL-19 | Ganool | Body sherd | 10 | 11 | 10YR 4/1 dark grey | 10YR 3/1 very dark grey | Burnished |
| **20.** | GNL-20 | Ganool | Body sherd | 10 | 10 | GLEY 1 2.5/N black | 10/YR 4/1 dark grey | Burnished |
| **21.** | GNL-21 | Ganool | Body Sherd | 10 | 10 | 10YR 5/3 brown | 10YR 4/2 dark greyish brown | Burnished |
| **22.** | GNL-22 | Ganool | Body Sherd | 10 | 11 | 10YR 4/1 dark grey | 10YR 4/1 dark grey | Burnished |
| **23.** | GNL-23 | Ganool | Body Sherd | 7 | 8 | 10YR 4/1 dark grey | 10YR 4/1 dark grey | Burnished |
| **24.** | GNL-24 | Ganool | Body Sherd | 12 | 12 | 10YR 5/1 grey | 10YR 5/1 grey | Burnished |
| **25.** | GNL-25 | Ganool | Body Sherd | 8 | 11 | GLEY 1 2.5/N black | GLEY 1 2.5/N black | Burnished |
| **26.** | GNL-26 | Ganool | Base Frag | 16 BD: | 33 | GLEY 1 2.5/N | GLEY 1 2.5/N | Burnished |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | ment | 56 | | black | black | |
| **27.** | GNL-27 | Ganool | Body Sherd | 6 | 7 | 10YR 5/1 grey | 10YR 6/1 grey | Burnished |
| **28.** | GNL-28 | Ganool | Body Sherd | 8 | 9 | 10YR 6/3 pale brown | 10YR 4/1 dark grey | Burnished |
| **29.** | RTN-1 | Ratta Nulla | Base Frag ment | 7 BD: 64 | 13 | GLEY 1 2.5/N black | GLEY 1 2.5/N black | Burnished |
| **30.** | SGN-1 | Shogran | Body Sherd | 13 | 14 | GLEY 1 2.5/N black | GLEY 1 2.5/N black | Burnished |
| **31.** | SGN-2 | Shogran | Body Sherd | 9 | 9 | 10YR 1 6/2 light brownish grey | GLEY 1 4/1 dark greenish grey | Burnished |
| **32.** | SGN-3 | Shogran | Body Sherd | 10 | 12 | 10YR grayish brown | 10YR 4/1 dark grey | Burnished |
| **33.** | SGN-4 | Shogran | Base Frag ment | 17 BD: 64 | 19 | 10YR grayish brown | 10YR 4/1 dark grey | Burnished |
| **34.** | SGN-5 | Shogran | Body sherd | 7 | 8 | 10YR 6/2 light brownish grey | GLEY 1 2.5/N black | Burnished |
| **35.** | TRP-1 | Tarla Paror | Rim Frag ment | 10 | 10 | GLEY 1 2.5/N black | GLEY 1 2.5/N black | Burnished |
| **36.** | TRP-2 | Tarla Paror | Body sherd | 5 | 6 | 10YR 5/8 yellowish brown | 10YR 5/8 yellowis h brown | Burnished |
| **37.** | TRP-3 | Tarla Paror | Rim Frag ment | 6 | 6 | 10YR 4/3 brown | 10YR 6/3 pale brown | Burnished |
| **38.** | TRP-4 | Tarla Paror | Body sherd | 5 | 6 | 10YR 3/2 very dark grayish brown | 10YR 2/1 black | Burnished |
| **39.** | TRP-5 | Tarla Paror | Body sherd | 9 | 11 | 10YR 4/4 dark yellowish brown | 10YR 5/6 yellowis h brown | Burnished |
| **40.** | ASN-1 | Ashanra | Body sherd | 12 | 13 | 10YR 4/1 dark grey | GLEY 1 2.5/N black | Unburnished |
| **41.** | ASN-2 | Ashanra | Body Sherd | 13 | 14 | 10YR 5/3 brown | GLEY 1 2.5/N black | Unburnished |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **42.** | ASN-3 | Ashanra | Body Sherd | 7 | 7 | 10YR 3/2 very dark greyish brown | | 10YR 2/1 black | Unburnished |
| **43.** | ASN-4 | Ashanra | Body Sherd | 9 | 15 | 10YR 5/1 grey | | GLEY 1 2.5/N black | Burnished |
| **44.** | ASN-5 | Ashanra | Body Sherd | 7 | 8 | 10YR 5/3 brown | | GLEY 1 2.5/N black | Unburnished |
| **45.** | ASN-6 | Ashanra | Body Sherd | 7 | 8 | GLEY 1 3/N very dark grey | | GLEY 1 3/N very dark grey | Burnished |
| **46.** | TBK-1 | Tarli Batta kundi | Body sherd | 7 | 7 | GLEY 1 3/N very dark grey | | GLEY 1 3/N very dark grey | Unburnished |
| **47.** | TBK-2 | Tarli Batta kundi | Body Sherd | 14 | 15 | 7.5YR 6/4 light brown | | 7.5YR 4/4 brown | Burnished |
| **48.** | TBK-3 | Tarli Batta kundi | Body Sherd | 5 | 7 | GLEY 1 3/N very dark grey | | GLEY 1 3/N very dark grey | Burnished |
| **49.** | TBK-4 | Tarli Batta kundi | Rim fragment | 7 | 8 | 10YR 4/2 dark greyish brown | | 10YR 4/2 dark greyish brown | Unburnished |
| **50.** | TBK-5 | Tarli Batta kundi | Body sherd | 13 | 15 | 10YR 5/2 greyish brown | 10YR 2/1 black | 10YR 6/4 light yellowish brown | Unburnished |
| **51.** | TBK-6 | Tarli Batta kundi | Body Sherd | 8 | 10 | 10YR 2/1 black | | 10YR 2/1 black | Unburnished |
| **52.** | MVG-1 | Morad Vega | Body Sherd | 11 | 12 | 10YR 5/4 yellowish brown | | 10YR 3/1 very dark grey | Unburnished |
| **53.** | MVG-2 | Morad Vega | Body sherd | 10 | 10 | 10YR 3/1 very dark grey | | 10YR 3/1 very dark grey | Unburnished |
| **54.** | MVG-3 | Morad Vega | Body sherd | 8 | 9 | 10YR 4/3 brown | | 10YR 3/1 very dark grey | Unburnished |
| **55.** | MVG-4 | Morad Vega | Body Sherd | 11 | 13 | 10YR 3/1 brown | | 10YR 3/1 very dark | Unburnished |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | grey | |
| **56.** | MVG-5 | Morad Vega | Body sherd | 8 | 9 | 10YR 4/1 dark grey | | 10YR 3/1 very dark grey | Unburnished |
| **57.** | MVG-6 | Morad Vega | Body Sherd | 7 | 9 | 10YR 6/3 pale brown | | 10YR 3/1 very dark grey | Burnished |

## Appendix 2: Colour of the Groundmass, Isotropism, Texture, Grain Size, Roundness and Sphericity of the Clasts of the Selected Sherds

| S.NO | No. | Colour of the ground mass | Isotropism of the ground mass | Texture | Grain size distribution | Maximum Grain size (μm) | Roundness of the clasts | Sphericity of the clasts |
|---|---|---|---|---|---|---|---|---|
| **1.** | GNL-1 | Brown to dark brown | moderate-complete | hiatal | Poor | 3900 | Very angular to sub rounded | 1 to 4 |
| **2.** | GNL-2 | Orange to brown | poor-moderate | serial (hiatal) | Very poor | 2500 | Very angular to sub angular | 1 to 4 |
| **3.** | GNL-3 | Brown to dark brown | poor-complete | hiatal | Poor | 2600 | Very angular to sub rounded | 1 to 5 |
| **4.** | GNL-4 | dark brown | complete | hiatal | Poor | 3000 | Very angular to sub rounded | 1 to 4 |
| **5.** | GNL-5 | brown | poor-moderate | hiatal | Poor | 4000 | Very angular to rounded | 1 to 4 |
| **6.** | GNL-6 | brown-dark brown | moderate-complete | serial | Poor | 1400 | Very angular to sub angular | 1 to 3 |
| **7.** | GNL-7 | black | complete | serial (hiatal) | Poor | 2200 | Very angular to sub rounded | 1 to 4 |
| **8.** | GNL-8 | (dark) brown | moderate-complete | hiatal | Poor | 7000 | angular to sub rounded | 2 to 4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **9.** | GNL-9 | brown | poor | hiatal | Poor | 1700 | Very angular to sub angular | 1 to 3 |
| **10.** | GNL-10 | brown-dark brown | moderate-complete | Hiatal (serial) | Poor | 1800 | Sub angular to sub rounded | 1 to 4 |
| **11.** | GNL-11 | Brown | Poor to good | Serial | Poor | 1400 | Very angular to round | 1 to 3 |
| **12.** | GNL-12 | Brown | poor | hiatal | Poor | 1800 | Very angular to sub angular | 1 to 2 |
| **13.** | GNL-13 | Brown | Poor to moderate | hiatal | Poor | 2400 | Sub angular to sub rounded | 1 to 4 |
| **14.** | GNL-14 | Brown | Good | hiatal | Poor | 3700 | Sub angular to sub rounded | 1 to 3 |
| **15.** | GNL-15 | Brown | Good | hiatal | Poor | 3800 | Sub angular to sub rounded | 1 to 3 |
| **16.** | GNL-16 | Dark brown | Complete | hiatal | Poor | 2700 | Angular to round | 1 to 3 |
| **17.** | GNL-17 | Dark brown | Poor | hiatal | Poor | 2900 | Angular to sub rounded | 1 to 4 |
| **18.** | GNL-18 | Brown | Complete | hiatal | Poor | 1700 | Sub angular to sub rounded | 1 to 4 |
| **19.** | GNL-19 | Orange | Poor | Serial | Moderate to Poor | 1300 | Very angular to sub angular | 1 to 3 |
| **20.** | GNL-20 | Brown | Moderate | serial (hiatal) | Moderate to Poor | 2000 | Angular to sub rounded | 1 to 4 |
| **21.** | GNL-21 | Brown | Moderate | hiatal | Poor | 3000 | Angular to sub rounded | 1 to 3 |
| **22.** | GNL-22 | Brown | Moderate to good | serial (hiatal) | Poor | 1900 | Angular to sub rounded | 1 to 4 |
| **23.** | GNL-23 | Brown | Poor | hiatal | Poor | 2200 | Angular to rounded | 1 to 4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **24.** | GNL-24 | Brown | Poor | hiatal | Poor | 1800 | Angular to rounded | 1 to 4 |
| **25.** | GNL-25 | Brown | Poor | Serial | Poor | 1500 | Very angular to sub rounded | 1 to 5 |
| **26.** | GNL-26 | Brown | Poor | Serial | Poor | 1600 | Very angular to sub rounded | 1 to 3 |
| **27.** | GNL-27 | Brown | Good | hiatal | Poor | 2200 | Very angular to sub rounded | 1 to 3 |
| **28.** | GNL-28 | Brown | Poor | hiatal | Poor | 1600 | Very angular to sub rounded | 1 to 5 |
| **29.** | RTN-1 | Dark brown | Good | Serial | Poor | 1800 | Very angular to sub rounded | 1 to 3 |
| **30.** | SGN-1 | brown | Moderate to poor | Serial | Moderate to good | 1200 | Very angular to sub rounded | 1 to 4 |
| **31.** | SGN-2 | Yellowish brown | Poor | hiatal | Poor | 1800 | Very angular to sub angular | 1 to 2 |
| **32.** | SGN-3 | brown | Moderate to poor | Serial | Moderate | 650 | Very angular to sub angular | 1 to 4 |
| **33.** | SGN-4 | brown | Moderate to poor | hiatal | Poor | 1600 | Angular to sub angular | 1 to 2 |
| **34.** | SGN-5 | brown | Poor | Serial | Moderate | 1100 | Very angular to sub rounded | 1 to 2 |
| **35.** | TRP-1 | brown | Good | hiatal | Poor | 3400 | Very angular to sub rounded | 1 to 4 |
| **36.** | TRP-2 | Brown | Poor to moderate | Serial (hiatal) | Moderate to poor | 1400 | Angular to round | 1 to 3 |
| **37.** | TRP-3 | Brown | Moderate to good | Serial | Moderate | 1000 | Very angular to sub rounded | 1 to 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **38.** | TRP-4 | Dark brown | Complete | Hiatal | Poor | 2500 | Very angular to sub rounded | 1 to 4 |
| **39.** | TRP-5 | Dark brown | Moderate to good | Serial (hiatal) | Moderate to poor | 1000 | Very angular to sub rounded | 2 to 3 |
| **40.** | ASN-1 | Dark brown | Complete | Hiatal | Moderate | 2200 | Very angular to sub angular | 1 to 3 |
| **41.** | ASN-2 | Dark brown, black | Good | Hiatal | Poor to moderate | 2800 | Very angular to sub angular | 1 to 4 |
| **42.** | ASN-3 | Yellowish brown | Poor | Serial | poor | 1600 | Very angular to sub angular | 1 to 3 |
| **43.** | ASN-4 | Yellow | Poor | Hiatal | Moderate | 1800 | Very angular to sub angular | 1 to 2 |
| **44.** | ASN-5 | Yellowish brown | Poor to moderate | Serial | Moderate to poor | 2000 | Angular to round | 1 to 4 |
| **45.** | ASN-6 | Brown, dark brown | Poor | Serial | Moderate to poor | 1900 | Very angular to sub rounded | 1 to 3 |
| **46.** | TBK-1 | Brown | Moderate | Hiatal | Poor | 2700 | Very angular to sub angular | 1 to 3 |
| **47.** | TBK-2 | Yellow | poor | Hiatal | Poor | 3400 | Very angular to sub angular | 1 to 3 |
| **48.** | TBK-3 | Brown | Moderate to good | Hiatal | Poor | 3600 | Very angular to sub rounded | 1 to 3 |
| **49.** | TBK-4 | Brown | moderate | Serial | Good | 1000 | Very angular to round | 1 to 5 |
| **50.** | TBK-5 | Brown | Complete | Serial | Moderate | 1800 | Angular to round | 2 to 4 |
| **51.** | TBK-6 | Brown | Moderate | Serial | Moderate/good | 700 | Angular to round | 1 to 4 |
| **52.** | MVG-1 | Yellow brown | Moderate | Serial | Poor | 1900 | Very angular to | 1 to 3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | sub rounded | |
| **53.** | MVG-2 | Brown | Complete | Hiatal/serial | Poor | 1600 | Very angular to sub angular | 1 to 3 |
| **54.** | MVG-3 | brown | Poor | Serial/hiatal | Moderate | 1700 | Very angular to angular | 1 to 4 |
| **55.** | MVG-4 | Dark brown | Moderate to poor | Hiatal | Poor | 1900 | Very angular to sub rounded | 1 to 4 |
| **56.** | MVG-5 | Yellow brown | Poor to complete | Hiatal | Poor | 2000 | Very angular to sub angular | 1 to 3 |
| **57.** | MVG-6 | Brown | Moderate | Serial/Hiatal | Moderate to poor | 1400 | Very angular to sub angular | 1 to 3 |