

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

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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 it 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 °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 °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 fluvial 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 fluvial 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 fluvatile 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 fluvatile 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 fluvatile 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 fluvial 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.

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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.

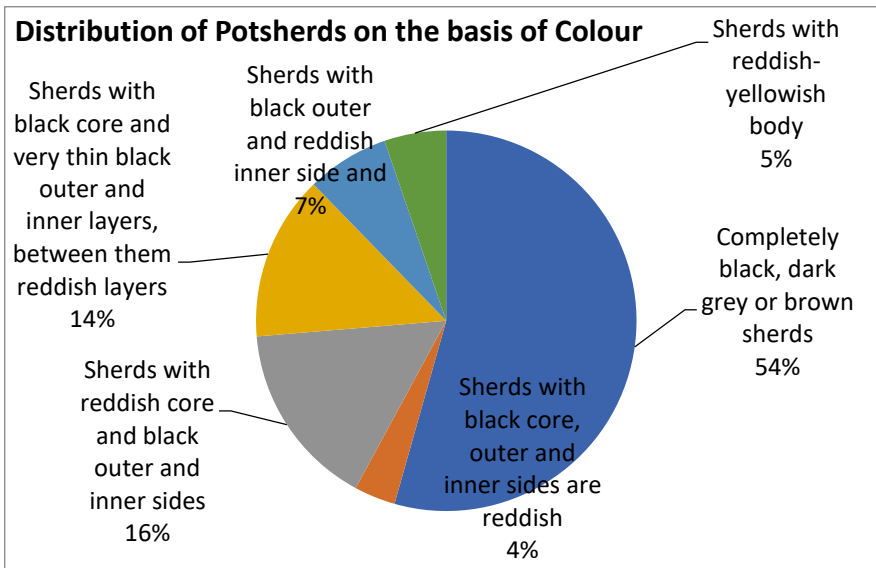


Fig. 1 - Distribution of Potsherds on the basis of Colour.

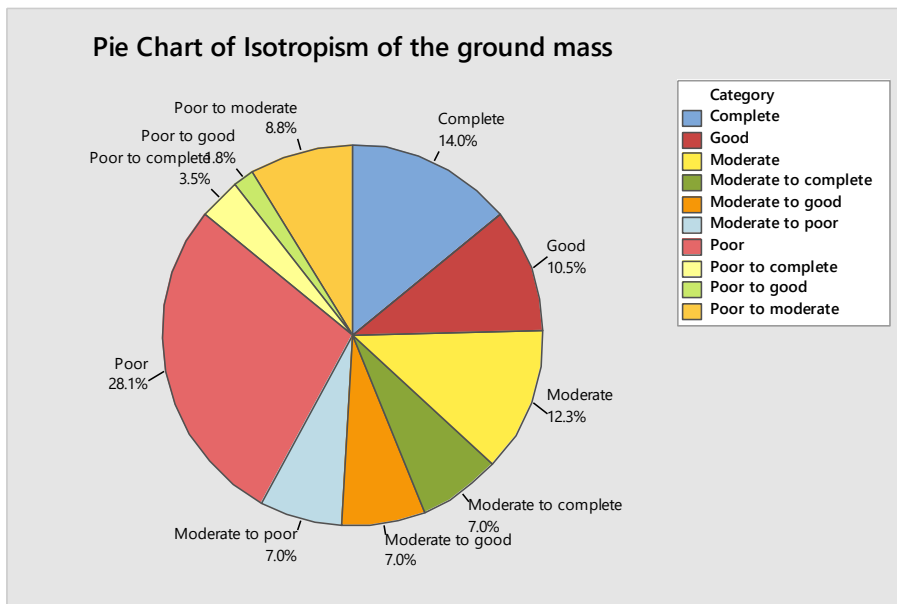


Fig. 2 - Pie chart of isotropism of the ground mass.

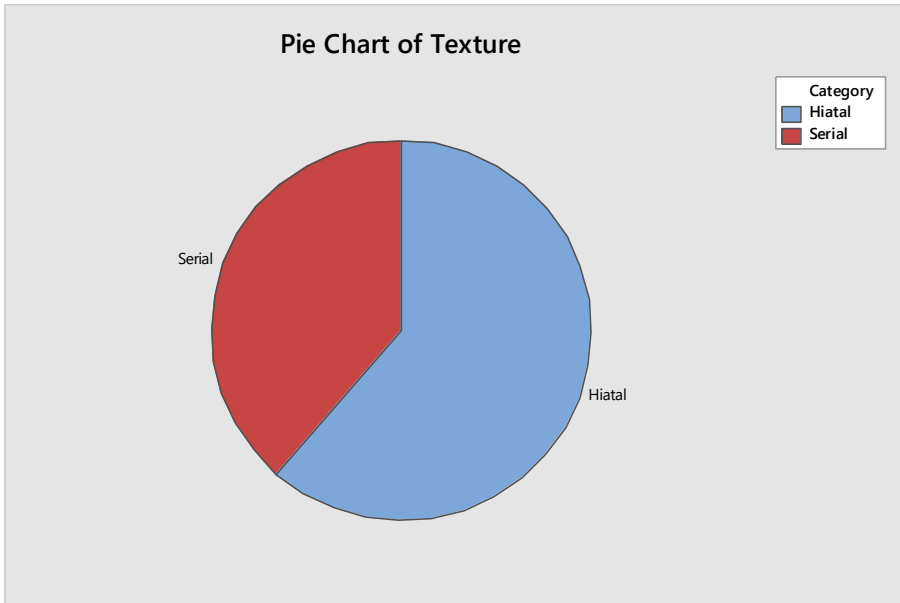


Fig. 3 - Pie chart for texture.

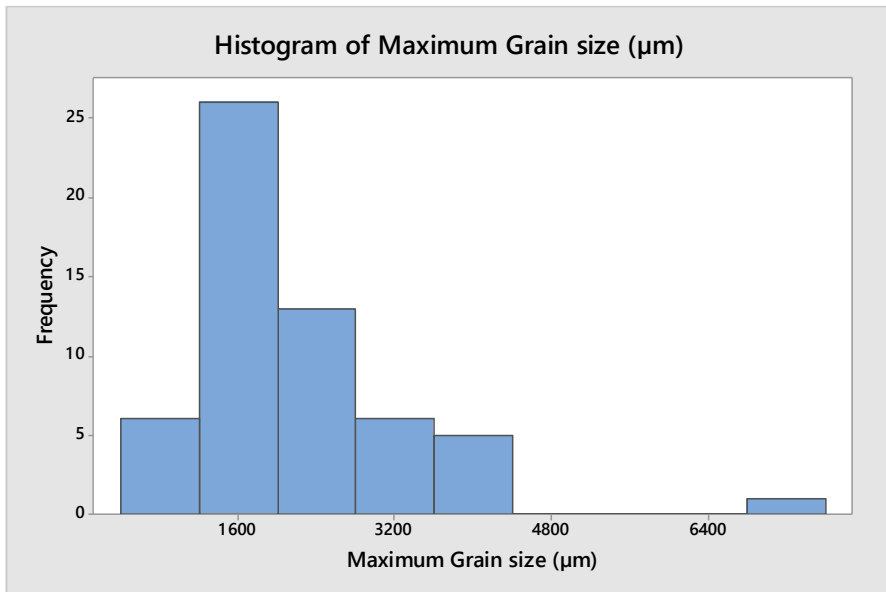


Fig. 4 - Histogram of maximum grain size.

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 Fragment	13	15	GLE Y 1 2.5/N black	GLE Y 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 yellowish 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	GLE Y 1 2.5/N black	GLE Y 1 2.5/N black	Burnished
18.	GNL-18	Ganool	Body sherd	7	8	GLE Y 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	GLE Y 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	GLE Y 1 2.5/N black	GLE Y 1 2.5/N black	Burnished
26.	GNL-26	Ganool	Base Frag	16	33	BD: GLE Y 1 2.5/N	GLE Y 1 2.5/N	Burnished

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			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	13	BD: 64 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	19	BD: 64 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 yellowish 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 yellowish 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

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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

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							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