

Scientific Analysis on the Manufacturing Technique of Early Historic Pottery of Bangladesh: Application of Experimental Archaeology

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Abstract

The present study wants to identify the making technique of an early historic pottery type of Bangladesh and for this research potshard samples were collected from archaeological excavated site with documented stratigraphic data. The used method for analysis is known as ‘Polished thin-section’ which is now commonly using for petrographic analysis in modern world. Another important aspect for this archaeological analysis is experiment to reproduction of the same quality object, and present research did successful replication of an early historic pottery of Bangladesh known as ‘Northern Black Polished ware’ or NBPW. Archaeological pottery analysis with modern scientific method is still faces challenges in Bangladesh because lack of proper knowledge and absence of modern equipped laboratory. Prepared Thin-section petrography from collected samples shows that NBPW of Bangladesh has possess thin polished surface of multi-layered coating. The practical experiments were successful by achieving the reproduction of a black colored surface which is almost resembled with original potsherd of Northern Black Polished Ware. This research tells us a story of vigorous cultural aesthetic behavior as well as provides information on scientific sustainable technique of pottery decoration.

Keywords: Pottery, Tradition, Archaeology, Bangladesh, South Asia, Cultural Heritage, Microscope, Thin-section, Northern Black Polished Ware, Slip.

1. Introduction

Ancient pottery is one of the fundamental sources for historical reconstruction since it is closely related to the day-to-day life of the society. The significance of laboratory tests on pottery has been recognized in the early 20th century and only during the last few decades scientists have started specializing in this branch. The sophisticated scientific analyses of pottery have enabled archaeologists to evaluate the ancient people’s capability in technology specially to pottery making process. The presence of pottery tells us many stories; specially the possibility of trade and production. Pottery has provided us many information which is linked with technology, daily life house-hold objects, believe and religious practices, ancient burial system, their aesthetic ideology and many more.

Petrography is a scientific process to know details about organic and inorganic material. This micro analysis process has been used in the ceramic research since the 1930s and first used by Scottish geologist William Nicol in the late 18th century who prepared thin-section from fossilized wood to

identify the species of wood [1]. On the other hand, during the middle of the 19th century, geologist Henry Clifton Sorby was studied rocks and minerals in thin-section petrography and he also analysis ceramic objects in the same process. Today's ceramic petrographers are using many of his techniques and methodology employed within petrography. But if we want to talk about archaeological ceramic analysis, then we have to know about two scientists, named as Wayne Felts and Anna Shepard, who successfully applied petrography in the ceramic analysis in the early 1940s. One used this technique on New Mexican ceramic samples and the other one used ceramic sample from Turkey for petrographic analysis. In the case of early prehistoric ceramic petrology, David Peacock was first utilized this method by in the late 1960s in the UK [2]. In this research, a recently developed ceramic petrography has used which is known as 'Polished Thin-section method' and firstly introduced by Masahiro Nagashima of Japan. After few years, Prof. Dr. Okada Fumio developed this method with more accurate results in late 1980s.

Bangladesh is a South Asian country and has a rich historical and cultural past. Numerous types of potsherds have been excavated from here; e.g., 'Northern Black Polished Ware' (NBPW), 'Black Slipped Ware' (BSW), 'Black and Red Ware', 'Rouletted Ware', 'Glazed Ware', and 'Knobbed Ware' [3]. It is true that lots of research has been done on the shape and colour of these pottery in recent past but still there is no specific research regarding the surface coating analysis. The present study is undertaken to find out this gap in knowledge arena. Experimental archaeology is a part of practical archaeology where archaeological hypothesis has been testing by reproducing or replicating the object or approximating the feasibility of any ancient culture. The interpretation on pottery technology is necessary for our own purpose and that is the primary objective of this research. In this research paper, ceramic petrography is used as a basic method of technology analysis; and elaborate practical experiments also take place for reproduce the black polished pottery.

2. Types of Pottery: an integral part of the Bangladesh archaeology

In Bengal region, pottery was first introduced in around 1500 BCE. Because of the availability of fine clay, the ancient inhabitants naturally used this resource for making their numerous daily household potteries. We have numerous archaeological sites in the sub-continent, and all of these sites revealed numerous potsherds/potteries, commonly known as 'Black-and-red Ware'/(BRW), 'Northern Black Polished Ware'/(NBPW), 'Rouletted Ware', 'Amphorae', 'Black Slipped Ware'/(BSW), 'Knobbed Ware' etc. A brief discussion on this pottery art is as follows:

2.1 Northern Black Polished Ware or NBPW

From the point of production technique, NBPW occupies the highest position not only in the Indian subcontinent but also in the whole of South Asia. In fact, NBPW is one of the most excellent types of pottery of the ancient civilization. Many archaeologists and scientists are like to call this pottery as 'Table ware' as this pottery does not have large and heavy forms like storage jar or the globular pot. The initial recognition of Northern Black Polished Ware (NBPW) by Sir John Marshall (ASI-AR 1904-5) at Sarnath in 1904, it continued to occupy the attention of the archaeologists and consequently 570 NBPW sites have been discovered from Bangladesh, India, Pakistan, Nepal and Sri Lanka generally indicates the significance of this shards in the contemporary socio-economic life. The term 'NBPW' was first suggested by Sir Mortimer Wheeler and Krishna Deva in 1945. These two scholars also discarded the view of J. Marshall who regarded NBPW as a kind of 'Greek Black Ware' [4].

The spread of Mauryan imperialism, Buddhism, or the trade routes could be the main cause of the wide distribution of NBPW (5). Because NBPW was distributed from the North (Udegram, Pakistan) to South (Alagankulam, South India), and from Mahasthangarh (Bangladesh) to Anuradhapura (Sri Lanka). Again, the discovery of NBPW in Wari sites in North east Bangladesh has further extended the eastern limit which carries special significance for the NBPW Empire and related many factors.



Figure 1: Potsherds of NBPW, preserved in the Mahasthangarh Museum.

Source: author

The two most prominent archaeological site of Bangladesh for NBPW are Impwn as ‘Wari-Bateshwar’ and ‘Mahasthangarh’. The chronology for Wari-Bateshwar site has been fixed from c. 700 BCE ~100 BCE or 50 CE for the sub continental site [6]. Mahasthangarh NBPW is dated to c. 400 BCE – 100 CE [7]. Recent radiocarbon dates from *Ayodhya*, a site located in Uttar Pradesh of India suggests that the NBPW time period could possibly go back to as early as c. 1000 BCE [8].

All the NBPW is not top-graded, fine quality, not so highly lustrous and thin in section. It seems that, NBPW is not a single homogenous type of ware as defined earlier produced out of one single technique. The archaeologists like Dr. T.N. Roy suggest that, early phase of NBPW at Prahladpur site, India as the golden period for the slip decorative technique in the ceramic tradition of Ancient India [9].

NBPW have divided into five main group on the basis of fabric by T.N. Roy (1983) [10]. The group has been shown in the Table 1.

Table 1: NBPW Classification

Type A	Finest in condition, also hard and dense.
Type B	Thick and surface can be easily scratched. Core is gray, made from fine levigated clay and wheel throned.
Type C	Core is red to grey core, slip can be peels off more easily.
Type D	Variation of Black and Red ware.
Type E	Thick, surface color is usually dull black or grey, some are lustrous

The Shapes of NBPW of Mahasthangarh are represented by dish, cup bowl and Beaker. Majority of this NBPW are black though there are also red, silvery, and golden in color [11]. The NBPW from Wari-Bateshwar site are commonly dish, bowl and spouted jar which possess black and grey core, the surface is commonly black lustrous color, but light chocolate, light silver and light red shards are also found [12]. Excavated NBPW are found both in monochrome and biochrome. NBPW is normally found in without decoration though some potshards were found on painted designs [13]. As a decoration, painting, incised designs, and graffiti marks are occasionally found on NBPW [14].

Prof. Rahman said that, NBPW was highly valued deluxe ware which was probably made for elite class of those days and usually broken parts were repaired and reused. Such kind of repaired pieces have been also revealed from excavations [15].

Many researches have been presented regarding the black gloss of NBPW by many scientists in last 70 years. The story of NBPW was first started by the hand of Sir John Marshall at India in 1904. In-depth Research work of NBPW was started in 1946 by K.B.M Sanaullah (India). In the continuation, B.B. Lal in 1956; Dr. Karunakara Hegde in 1966; H.C. Bhardwaj in 1973; Mitchell in 1979; K.J.S. Gillies & D.S. Urch in 1983; Robert Harding in 2004; and lastly in 2012, research work was published by a young researcher Sharmin Dilruba [16].

2.2 Black Slipped Ware or BSW

BSW is look alike NBPW though the black luster is absent. Numerous BSW has been yielded in Mahasthangarh, Wari-Bateshwar, Bangarh and other sites related with NBPW culture [17]. B.B. Lal and B.K. Thapar were the first archaeologists who discovered specimens of black slipped ware or black polished ware from the PGW levels of Hastinapura, India [18]. The common shape of black-slipped wares was bowls of different types. Archaeologist suggested that the main source of black colored slip was a special kind of liquid clay which contains fine quality red ochre [19]. A proportional figure of the black slipped wares found in the recent excavation at Wari-Bateshwar includes 54.13% bowls, 30.28% small pots, 2.73% bowl on-stand, 1.13% basin, 9.17% plate, 0.92% dish on-stand [20]. A great number of shards of spouted-pots of NBPW and Black Slipped Wares have been discovered. This fact suggests that liquid foods were consumed more in quantity by the people of that time [21].

2.3 Black Ware

From the general view of this potsherd shows that it could be a variation or imperfectness production of the Black Slipped Ware. Some shard has impression of some kind of surface coating on their exterior surface. But whether the slip is completely peeled off or the ware is black in origin and without slip is difficult to ascertain. Bowls, dishes, drinking-cup and tumblers including a miniature goblet were the noteworthy forms. At Sonpur, India, Black Ware shards were found in the NBPW cultural period [22]. There is no identical information about this type of ware in Bangladesh as the analysis work is very inadequate.

2.4 Burnished Black (Black Polished) Ware

Burnished Black ware, referred to as 'Black Polished Ware' was found with Northern Black Polished Ware at Sravasti, India. The main shape in this ware is bowls and dishes. Some specimens of Burnished Black Ware in the Northern Black Polished Ware or NBPW strata are reported from Pataliputra, Vaisali and Champa, India [23]. Due to the lack of proper investigation and inadequate published report, enough

information is not available regarding the excavated black ware of Bangladesh.

2.5 Rauletted Ware

Rauletted Ware is known as classical ceramic type and has provided important information about the trade and exchange network about early historic period. This pottery type has excavated from numerous archaeological areas of West Bengal and Bangladesh and proven the growing trading network of the early historic period which connected many urban centers in South India and Southeast Asia. In characteristics, Rouletted Ware is a wheel-turned dish with thick incurved rim, contiguous body and base, and without any foot. It has a smooth lustrous surface, exhibiting a variety of color and indented concentric circular decoration on the interior surface of the base [24].

The art of terracotta of Bangladesh also has fascinated history. We can talk about the aesthetic terracotta art of 'Kantajeer temple' of Dinajpur, and 'Puthia temple complex' at Greater Rajshahi division. In modern days, terracotta and clay-made pottery is developing as an aesthetic art to mass people. For example; *Sakher Hanri*. It is one of the popular folk arts in the country; the Chinese traveler Ma Huen, who visited Bengal in 1406 CE, mentioned this art in his travel accounts. '*Sakher hanri*' is also known as 'sakher chukai' or 'jhanpi' [25]. Numerous types of motifs of fish, birds, half-blossomed lotus, combs, mirrors, daldam (a kind of aquatic grass) and floral creepers are usually paint on the surface for decoration purpose. This traditional art is highly praised, being popular from generation to generation for many centuries. As our country is believe in religious coalescence and we are enjoying numerous religious festive all over the year, so '*Sakher hanri*' is sold mostly on the occasions of religious festivals like Rathajatra (Hindu festive), Durga Puja (Hindu festive), Eid-ul-Fitr (Muslim festive), Eid ul-Azha (Muslim festive), and Muharram (Muslim Shia festive). At present, pottery is using as commercial product. Many folk and traditional ceremony is using multi color aesthetic pottery for multipurpose; for home décor or for daily use. Gradually this clay-art is achieving popularity among urban people.



Figure 2: The '*sakher hanri*' or pot of passion
Source: author

3. Objective of the Research

This study focused on the pottery analysis of Bangladesh which is developed on the basis of collected samples from numerous archaeological surveys. Present Research has also aimed to introduce a modern scientific technique of thin-section petrography to the ceramic researcher of Bangladesh. This unique thin-section petrography has been originated from Japan. East Asian countries like Japan, China and Korea have modern technique to analysis archaeological ceramics. But in the case of Bangladesh, we still facing problem regarding the chronological interpretation of our archaeological pottery as well as lacks of technical methods which could identify the manufacturing technology. Our historical research and heritage preservation is now in a vulnerable condition because of proper research, inadequate excavation work and lacking of published report. This research was faced some challenges which effects on the results of the experiments; for example, collection of archaeological material from different site need government permission which was sometimes very difficult to get and absence of scientific laboratory for thin section petrography is a major problem for archaeological research in Bangladesh. For the purpose of scientific laboratory analysis, the thin-section petrography of the collected samples was done in the laboratory of Historical heritage department, Kyoto University of Art and Design, which was located in the Kitashirakawa Street in Kyoto of Japan. Another limitation for this research was inadequate research samples. More samples may provide more authentic results. The Core aim of this research can be outlined as follows:

- a. Clearly present the surface coating technique of archaeological ceramic of NBPW
- b. Reproduction of NBPW by using numerous experimental method

4. Methodology

This research can be titled as descriptive-qualitative research that includes surveys, literature study and qualitative analysis of acquired data which was gathered by laboratory experiments. To collect authentic data, plenty of surveys are done in Bangladesh and samples were collected from Bogura and Narshingdi district. Analytical study was carried out by microscopic analysis. Surface of the samples were observed in binocular (Olympus SZH10) with Fiber light FL-50 and scanning electron microscope (HITACHI, Miniscope TM-1000). All the laboratory analysis and experimental process has been completed in the laboratory of Kyoto University of Art and Design, Japan.

The core method used in this research is thin-section petrography. Thin section studies can be extremely useful in determining the methods of the surface coating technique of archaeological pottery and currently 'Polished thin section method' is very popular in East Asia in organic and inorganic research. Prepared thin sections were observed in a camera attached optical microscope and scanning electron microscope (SEM). Optical examination of thin sections is generally performed by methods of transmission microscopy. The technique of the 'polished thin section method' was first introduced by Masaharu Nagashima in Japan. He analyzed the structures of the layers of coating films under transmitted light by microscope on excavated Japanese lacquer ware. The method of prepared the 'polished thin section' which was used in this study, was invented by Dr. Fumio Okada [26]. This method (a) requires very little experience to follow; (b) is relatively inexpensive; (c) requires little variation in technique for different types of material; (d) and allows prepared thin sections to be preserved for many years at room temperature. Microscopic specimens of thin-sections can be used to identify the technique by which the pottery was made, the quality of the used clay, the characteristics of

the slip and coating that was applied.

The polished thin section method is efficient for researching different types of information. For example, the surface coating technique of pottery, characteristics of the clay used in the pottery, quality of the applied slip and coating, identification of different types of organic materials like fiber and wood used on the iron artifacts, the character of pigments used in the ancient wall painting, and many more. In this way, both the inorganic and organic material can be successfully analysis by this method.


The present research is divided into two parts; the first part has been laboratory oriented and observations were done by binocular, biological and scanning electron microscope. Initially all visual observation was done and then thin-sections were prepared by a recognized method named as ‘polished thin-section’. The second part is experimental; by which a prototype of NBPW will be reproduce.


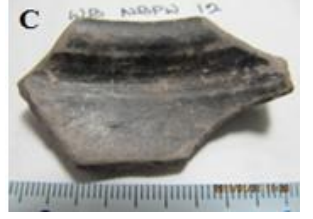



5. Research output

5.1 Study area and Location: For this research, samples were collected from two excavated sites of Bangladesh; 1) Wari-Bateshwar site situated in Narshingdi district, north-east of capital city Dhaka and 2) Mahasthangarh site situated in Northern Bangladesh. It is already established that all the artifacts excavated from Wari-Bateshwar site is clear evidence of the settlement of stone age culture, the Neolithic era settlement, the early historic life and historical settlement in the region (Rahman, 2000). Archaeologists has confirmed that Wari-Bateshwar had a great possibility of close connection with the contemporary other places of Indian subcontinent. Another very famous archaeological settlement of Bangladesh is ‘Mahasthangarh’, located in Bogura district of northern Bangladesh. Historians says that, Bogura district was a part of the kingdom of ‘*Pundravardharna*’ and a part of the ‘*Gauda*’ empire in c. 500 BCE to 1300 CE.

5.2 Research Samples: In this study, samples of NBPW were collected from Wari-Bateshwar and Mahasthangarh archaeological site. Collected potshards measurement, quality and site information are as follows:

Table 2: Collected potsherds and details

Potshard Samples	Site, Measurement and Excavated details	Types	Visual Characteristics	Image
NBPW A	Wari-Bateshwar, 2005, approx. 3×5 cm and 4.6 mm thick; Trench-2, Dig-30, Q-north, Depth-152 cm.	Broken rim part of a bowl	Surface is coated in both side and smooth, Core is deep ash color; gray color body surface is visible where the coating was damaged	

NBPW B	Wari-Bateshwar site, 2009, approx. 3×3 cm and 3.8 mm in thickness, Trench-RT ₁ , Dig-18, northeast (pit), Depth-176 cm.	Broken neck part of a Bowl	surface was coated, very smooth, glossy and black in color. Simple circular band was present in the neck area.	
NBPW C	Wari-Bateshwar site, 2005, approx. 4×6 cm and 5.1 mm in thickness, Trench-7, Dig-27, Q-north, Depth-163 cm.	broken rim part of a bowl	coated in both side, smooth, core is deep ash; gray color body surface is visible where the coating is damaged.	
NBPW D	Wari-Bateshwar, 2009, approx. 3.5×5 cm and 7mm in thickness, Trench-RT ₁ , Dig-22, Depth-156 cm.	Thick potsherd was a broken rim part of a dish	Same B, damaged	
NBPW E	Wari-Bateshwar, 2009, Trench-2, Dig-33, Q-north-west, Depth-152 cm. approx. 5×5.5 cm and 5.58 mm thick.	Lower part of a NBPW dish on stand	Same as A and C	
MAH A	Mahasthangarh, 2003, approx. 4.7×5.1 cm and 3.0 mm in thickness.	Broken body part of a NBPW dish	Core is deep ash color, Both the surface is coated, smooth, glossy and black in color.	

5.3 Surface Interpretation:

All the collected potsherds were initially observed in the binocular and scanning electron microscope (SEM). Observation found that potsherd contains polished body surface and a fragile top coating [Figure 3]. Figure [a and b] is the binocular image and [c and d] are from SEM observation. Both the observation has found the surface coat.

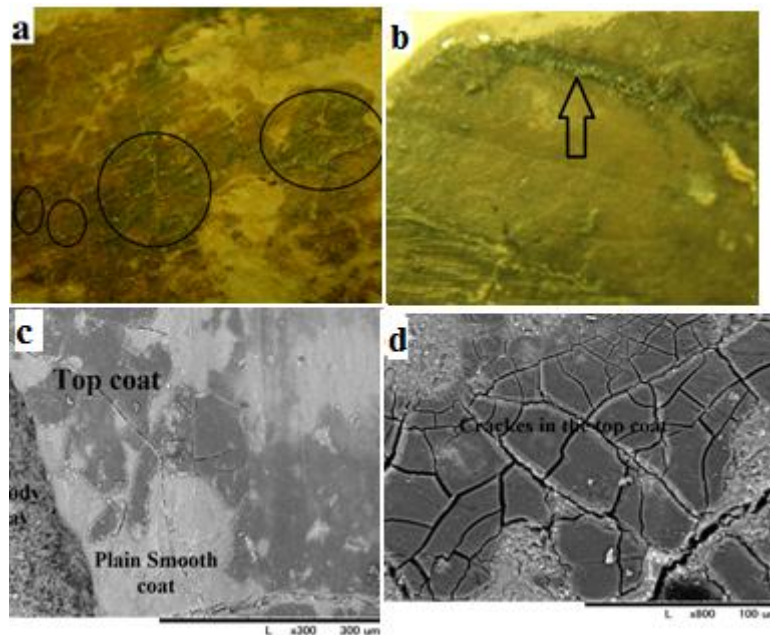


Figure 3: Binocular and SEM observation of NBPW potsherds; Surface coat detected.

5.4 Thin-section Analysis:

Polished thin-sections were prepared and observed under the polarized light microscope. In order to interpret deep aspects of the surface coating, scanning electron microscope (SEM) observations were also done. Information recovered from NBPW samples can be presented in this way:

- Well refined body clay is present; small mineral particles are approximately 10~20 μm and large one is approximately 50~60 μm
- The void for organic dirt is absent, usually small parts of husk, grass or shell are present as dirt in clay which are not identified here.
- clayey thick ground/base coating is present on the surface which is usually known as 'slip'.
- This slip is approximately 25~30 μm thick.
- Observation said that, slip was made from refined clay as there is no big dirt was present and the slip is brownish in color.
- This clayey coating/slip was applied on the both surface of the pottery uniformly.
- There is a top or upper coat is present which is very thin and measured as approximately 2~4 μm in thickness.
- SEM observation suggested that, ground coat/slip was thick and made from refined clay and possessed many horizontal cracks in it.
- Many vertical cracks are present in the thin-top coating.

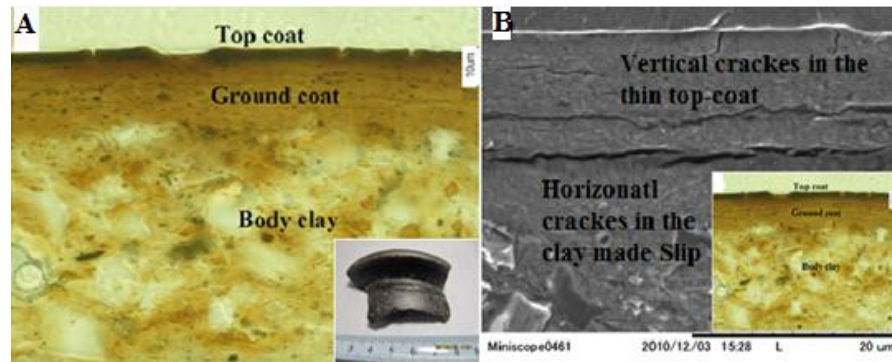


Figure 4: Thin-section observation; (A) clay body, base coating/slip and top/upper coat is identified; (B) scanning electron microscope observation shows horizontal cracks in the clay-made slip, upper/top coat possesses many vertical cracks.

6. Experimental Analysis

In the present research, experiment of replication is a vital method of study. Several types of experiments were performed to understand the coating technique of black colored potsherds. Before the core discussion of experiments, the previous view of the scientists should be discussed. Varied colors noticed in the cores of the NBPW. Scholars contend that the ancient potter`s did not able to control the temperature always perfectly while baking them. Besides it was not always possible to take the specific measurement of the iron present in clay. Some scholars suggested the cause of the black gloss of NBPW may have resulted from some post-firing techniques in which the nearly kiln-hot pottery was coated with some organic liquids after had been taken away from the kiln. The chemical reports indicate that the black was the result of the use of some specific chemicals over the black-slipped surface of the pottery. This black-coloring material was prepared from magnetite. Grinded red ‘*girimati*’ was mix with semi-liquid clay and baked in a very mild temperature to bring the black gloss. It has been speculated that silver and gold-dust were mixed with the clay to produce the silver-colored and golden NBPWs respectively. It must be, however, mentioned that in spite of scientific analyses from multiple perspective, the production process of NBPW is yet unclear [27]. Some other researcher stated in this way that, glossy black surface finish on Northern Black Polished ware was produced by the application of liquid clay containing finely ground, red ochre and peptized by an alkaline material called ‘*Sajjimatti*’.

For the replication of NBPW, eight pieces of test samples were prepared from the collected soil of Wari-Bateshwar archaeological site, Narsindhi district, Bangladesh. Soil sample was collected from the trench number-DT, Q-G-E1, Dig-2, Depth 171 cm. After refining, eight pieces of potsherd were prepared for study of the NBPW coating technology.

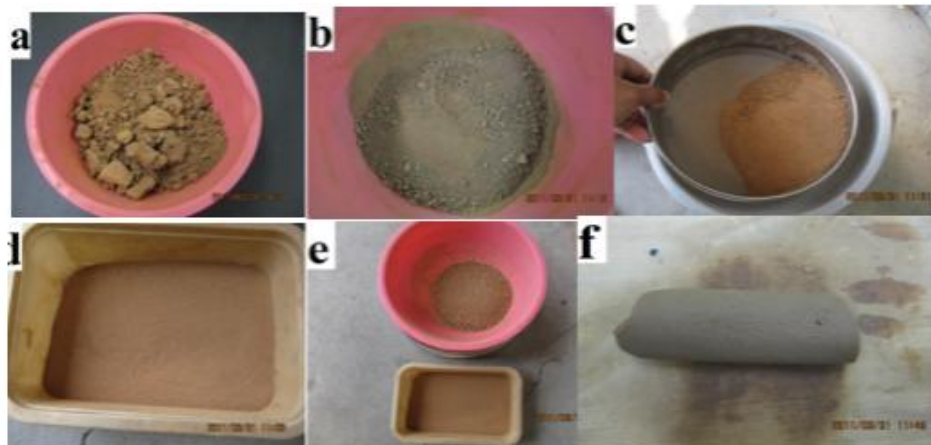


Figure 5: NBPW Test pieces preparation;(a) Collected clay from the excavated site; (b) Refining the clay; (c) refining the clay; (d) Refined clay; (e) Refined clay and separated minerals; (f) preparation of the test pieces.

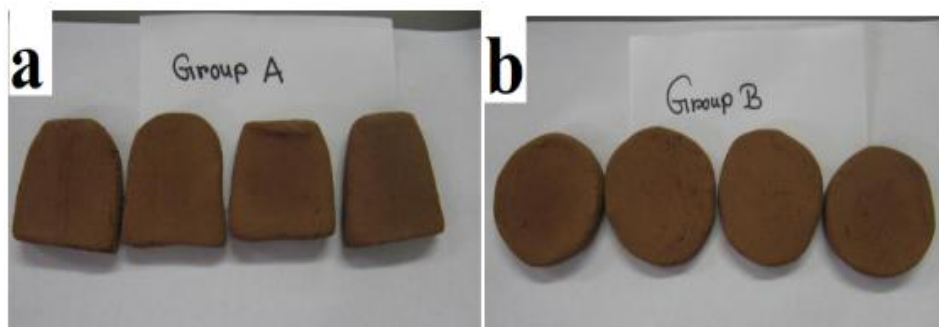


Figure 6: (a) Test pieces of group A; (b) test pieces of group B.

6.1 Preparation of the slip

The Slip coating is made from raw and powdered clay. In pottery making, Slip is used on the surface for diverse reasons, e.g., to suppress or hide joints or any scratch. Even slip can use to change the color of a pottery. In this experiment, clay was assembled from the Wari-Bateshwar archaeological site for the slip preparation. Applied slip was prepared by using several methods;

- (a) Collected soil (from Wari-Bateshwar site) was put in a container and adds water. The admixture was then Stir throughout with a wooden chopstick and then placed the mixture in that condition for 6-7 days. Next, after 6-7 days, mixed clay solution was put in the open sunlight and after 2-3 hour, a layer of fine clay was easy detachable from the surface of the mixed solution. This detached layer was then mixed with small amount of water and applied to the surface of the test piece.
- (b) Fine clay and *Bengara* powder mixed solution was applied on the surface of the dried test pieces as a slip. Four kind of solution was prepared by mixing the *Bengara* powder with fine clay in different amount. 60 gm. fine clay was mix with 20 gm., 15 gm., 10, and 4/5 gm. *Bengara* powder.
- (c) ‘*Sajimatti*’ was prepared and applied on the dried test pieces as a slip. The raw material for the

glaze of NBPW is ‘*Sajimatti*’, variously called ‘Reh’ or ‘Khari’ is an alkaline natural efflorescence profusely found in the Ganga. It is found to contain 15%–20% of Sodium carbonate, 10%–15% of Sodium Bicarbonate, silica 50%~70% and lime up to 5%. All the material was collected and mix with appropriate ratio as the previous research describe. This mixture was used on the test pieces as ‘slip of *Sajimatti*’.



Figure 7: Fine clay and *Bengara* mixture slip; (a) Fine clay and *Bengara* powder; (b) Fine clay and *Bengara* was mixed into different ratio; (c) Prepared slip and applied on the surface of the test piece.

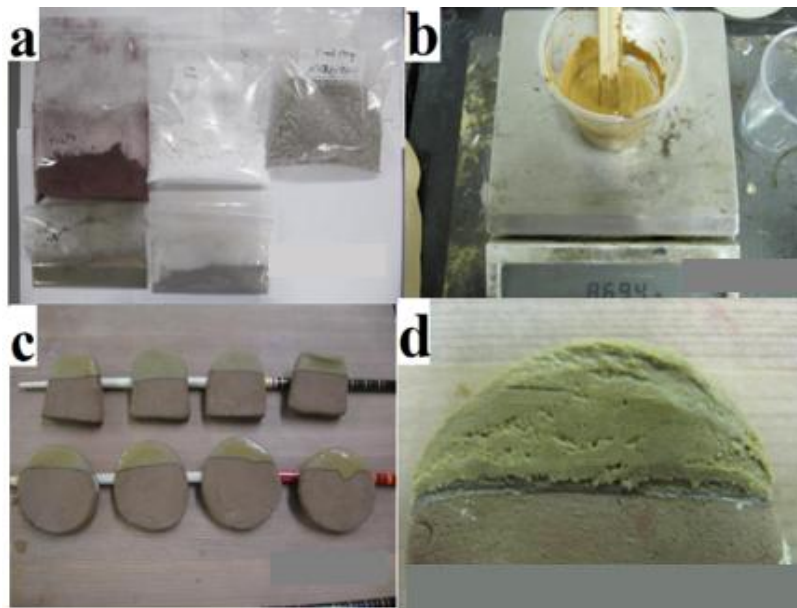


Figure 8: *Sajimatti* slip; (a) Material for the preparation of ‘*Sajimatti*’; (b) Mixing the material in different ratio; (c) *Sajimatti* applied test pieces (d) Test piece. *Source: author*

6.2 Applying the slip

Test pieces were dipped into the slip (½ in ‘*Sajimatti*’ and ½ in the prepared slip of *Bengara*) and polished by a spoon when the test pieces were in the touchable condition. For understanding the effect of the color after firing, prepared test pieces were classified in three groups: A, B and C; and then applying the top coating.

Firing: All eight pieces are fired in an electric kiln in high temperature (800°-1000° C). After completing the firing, four pieces of test pieces were taken out on the kiln hot condition (Group A). Then test pieces are dipped into a bowl full of husk for impregnation. The other four test pieces were taken out from the

kiln when those were getting cool [Group B]. Four test pieces of Group A, which was dipped into husk, is carbon black color. The other four pieces of Group B was dark brown color after firing and without impregnation.

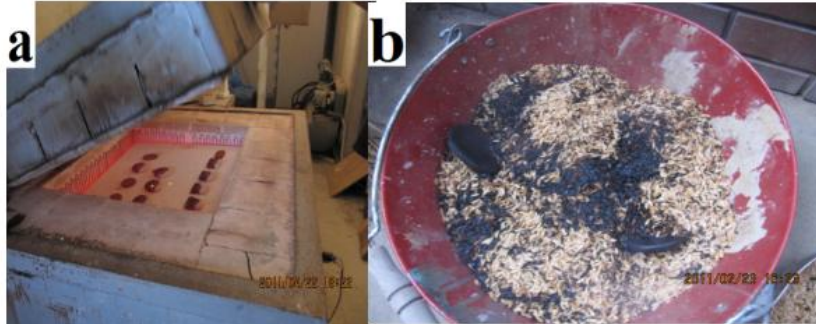


Figure 9: Firing the test pieces; (a) An electric kiln and the test pieces; (b) Test piece was dipped in husk.

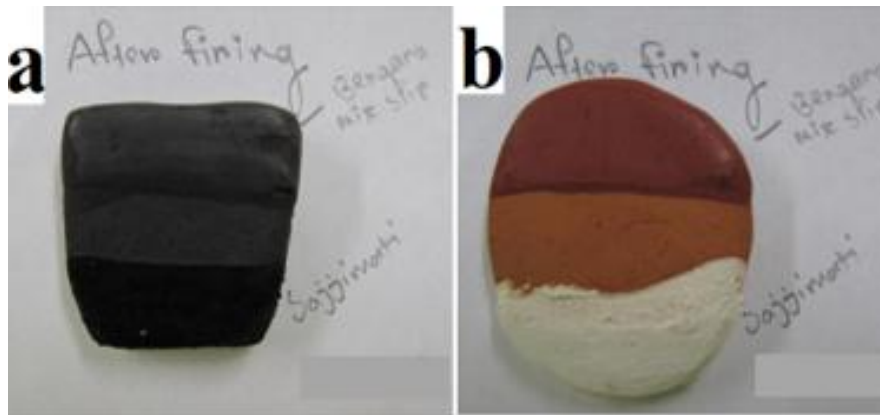


Figure 10: Test pieces after impregnation; (a) Group A, test piece that was dipped into husk; (b) Group B, Test piece that was not dipped into husk.

6.3 Applying the organic material as a top coating:

Prepared test pieces were coated with several types of organic oil to understand the coating technique of NBPW and to compare with the results of the chemical analysis.

- (a) Pine tar mixed with vegetable oil (perilla oil)
- (b) Tung oil
- (c) Only vegetable oil (Perilla oil)

The technique of the applying the organic materials are describes below:

Pine tar mixed with vegetable oil was first heated at 100°C for 3-5 minute; and then implement on the test pieces. Next, test piece was observed for 1 week in room temperature. Observation shows that, vegetable oil mix pine tar could make a coating on the test piece surface.

Tung oil was heated in a heater for 24 hours at 120°C and then applied on the surface of the test pieces. Result suggests that, Tung oil penetrates into the surface and could not make any coating to the surface.

Perilla oil was boiled in a hot plate for 3-5 minute and then applies on the surface of the test pieces.

Observation found that Perilla oil is penetrating into the surface quickly without left any mark. Decision could be made from this experiment that; mixture of oil and pine tar could make a coating when surface slip was made from refined clay as well as polished after apply the slip. When surface slip was prepared from non-refined clay and surface was not polished after applying the slip, then drying oil penetrated into the surface and could not make a coating.

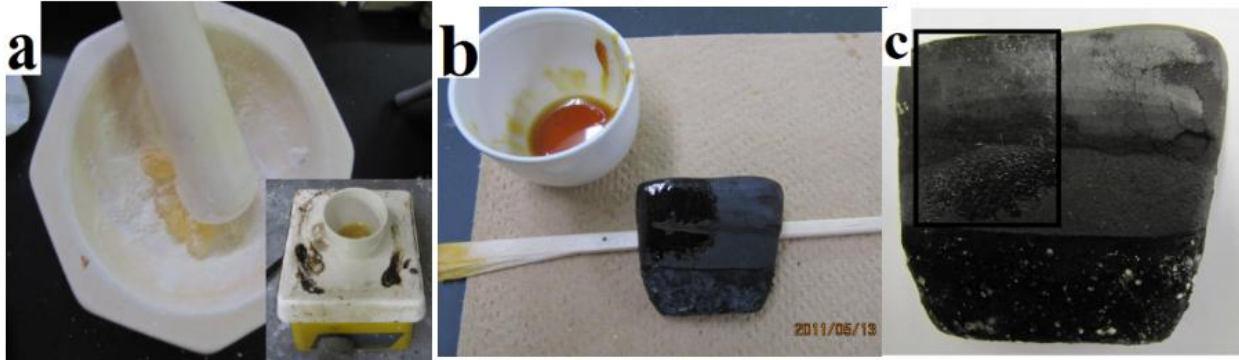


Figure 11: Applying the oil mixed pine tar as top coating; (a) Pine tar was smashed and heated on a hot plate; (b) applying the tar on the test piece; (c) a coating on the surface.



Figure 12: Applying the tung oil as top coating; (a) Tung oil was heating an oven for 24 hours at 120°C; (b) After take out from the oven, oil was applied on the test piece by using a cloth; (c) Applying the Tung oil on the surface of the test piece.

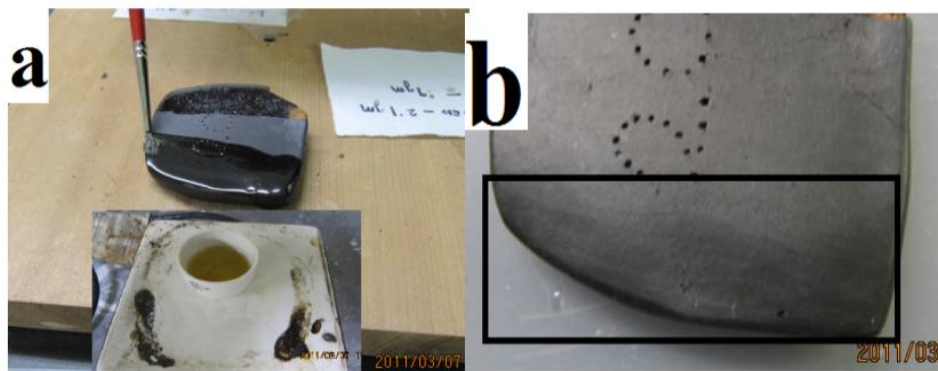


Figure 13: Applying the Perilla oil as top coating; (a) Perilla oil was heated on a hot plate and applied on the surface of the test piece; (b) After 10~20 minutes, perilla oil was penetrated into the surface.

6.4 Impregnation after firing

Another experiment was attempted to reproduce the NBPW. Test piece was prepared by the collected clay of Wari-Bateshwar site and applied slip was also prepared from the same clay with refinement. Clay was first mixed with water and kept for 15 days for preparing the fine layer of clay slip over the mixture. After 15 days, very fine layer was found on the upper portion of the clay mixture and that layer was carefully collected and applied on the surface of the test piece. Next, surface was polished with a smooth stone. Test piece was then kept for natural dry for 5-7 days and then fired in an electric kiln at 850°C. Then, the dry leaves of maple tree (*Acer*) were heated in a kiln and test piece was placed on the open hole over the kiln. The dried leaves of maple tree were fired and smoke was come out from the hole of the electric kiln. After 10-12 minutes the test piece was found impregnated with smoke and black surface of the test piece was alike the NBPW.

Thin section analysis prepared from the impregnated test pieces:

- (1) Thin and reddish color surface coat was identified on the surface which was similar with the top coat of NBPW.
- (2) From this experiment a possible technique of the NBPW surface coating may be suggested in this way that, NBPW was first coated with a fine-grained clay made slip and then polished the surface with wooden or bone spatula, smooth stones while it still is in a leathery state before firing. By the result of this polishing is, the surface is extremely shiny. After firing, pottery was impregnated with some resinous tree leaves or coated with some kind of drying oil for achieving the surface luster.

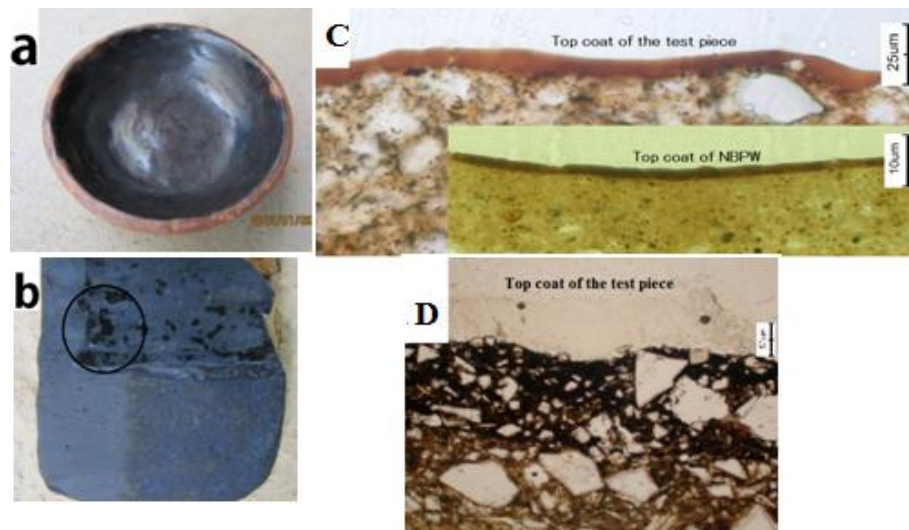


Figure 14: Impregnated and organic substance applied test pieces and observation: (a) oil applied impregnated test piece; (b) oil applied experimental test piece; (c) prepared thin-section from both test piece and NBPW; and microscopic observation. Similar type of thin top coating is visible on the both surface observation; (d) thin section observation which was prepared from oil applied impregnated test piece; carbon penetrated surface can identify on the surface which is not similar with NBPW.

7. Summary and Conclusion

The discovery of pottery on an archaeological site is a discovery of great importance. Pottery tells many stories of how it was made and who made it in what context. So, research on pottery is very important for a nation to establish its own deep-rooted history. There is no research work available to understand the chronological phase that establishes the pottery sequence of Bangladesh pottery. The traditional clay-made pottery of Bangladesh is dated as early as 300 BCE on the basis of the excavation report of Wari-Bateshwar and Mahasthangarh). Pottery was produced enormously in Mughal period also. Still our village artisan makes numerous varieties of clay utensils for daily use and commercial purpose. Our village women like to cook in clay pots named as 'Hari', they use clay made 'kolshi' or water pitcher to store water, and different types of dry food are usually stored in clay pots. We decorate our home and other public place with clay pots, during festivals, like Pohela Boishakh- the first day of Bengali year, presents different types of decorative mask and pots for visitors. The traditional pot called 'Shakher Hanri' needs proper support from all sectors so that it could survive for future generation. Because in modern days, people are fond of using many types of aluminium, iron and stainless-steel utensils. We should start to preserve the practice of this cultural product, by displaying this item in many shows room of the country for artistic interest as well as for selling purpose; government could give subsidy to this artisan so that they do not leave this occupation; and this element could nominate for the inclusion of national inventory and finally it may be nominated by UNESCO for world intangible cultural heritage in future.

Prof. Dr. S.S.M Mostafizur Rahman who's contribution in Bangladesh archaeology is enormous, said that, we already research about the characteristics of Chalcolithic and the early historic pottery of Bangladesh, while the potteries from the early medieval, medieval and late medieval are still neglected. He also said that, metal utensils of later days replaced traditional potteries. From this statement it is clear that, we should prepare a chronological chart for pottery genera of Bangladesh from ancient to modern times by authentic and laboratory-based research and published documents; so that distinct identity of our cultural past and present could proudly estimate by future generation. This type of research could provide detailed and clear information on the medieval pottery industry and its immediate progress in Bangladesh region. This could have been compiled from the results of archaeological excavations, documentary research and a study of published works. The pottery type of 10th to 19th centuries needs immediate concern for future preservation and sociological perspective.

In Bangladesh context, the most important task at present is to establish some laboratory equipped with all scientific features related to the technological analysis of pottery; for example, different types of microscopes for ceramic petrographical analysis, x-ray diffraction machineries, machineries for Pyrolysis-gas chromatography/mass spectrometric (Py-GC/MS) analysis, ATR (attenuated total reflection) Mapping Analysis & Infrared spectroscopy analysis. Without the scientific analysis of the traditional item, we will not be able to participate in the global trend.

Present research work initially tries to present the surface coating technique of the archaeological black colored pottery of Bangladesh which was also linked with the Indian subcontinent and basic method for data analysis was 'Polished Thin-section Method'. In this research, both the laboratory test and experiment prove that Northern black polished ware or NBPW was prepared with fine clay technology and slipped with clay as well as finally impregnated with dry leaves or husk or animal droppings. Clay-made thick surface coating was observed on the thin-section observation and a thin and solid top-coating

was identified.

Once upon a time, researcher H.C. Bhardwaj (1979) and Dr. B.B. Lal (1959-60) suggested that the main source of NBPW slip was fine clay and oil or plant juice which could make the pottery surface shiny [28]. Another suggestion came from the research result of Robert Harding (2004); where he said that 'examined potsherd possessed two layers of slip, and the upper surface possessed a slip which is approximately one micron in width' [29]. This study shows a partial similarity with the research of Harding; where base coating which can be called 'slip' is made from clay and approximately 25~30 μm in thickness. On the contrary, 2~4 μm in thick top coating does not have clay. Present research also suggested the post firing application of the top coating is possible, as B.B Lal suggested in his research. It is natural that organic substance has not survive if it applied to the surface before firing. It is proved in the present research where oil was applied before kiln firing and it was vanished after heating the pottery. The comment of H.C. Bhardwaj shows contradiction in this case; he said that the organic material present in the slip will be carbonized after firing, without burning out, and resulting a uniform black lustrous pottery surface' [30]. It can be said that different types of oil or tree juice can make a solid shiny surface of the pottery which has happened in the case of NBPW.

This scientific investigation boldly establishes the truth of coating process of the historic ware called NBPW clearly; the pottery was firstly coated with fine grained clay slip and then fired with dry leaves which contains oil or it can be used cow dung as firing material. As the SEM analysis found a solid and crack layer on the clayey slip; so, it is not possible of the clay-made double slip. Clay-made slip does not have solid characteristics as SEM analysis found in the research work [Figure 4].

An experimental data was strongly establishing the thin-section analysis. The preparation of fine-grained clay-slip, application of the slip, then kiln firing with dry maple-leaves which reproduce a shiny black test piece just like original NBPW (Figure 14 A). The archaeological analysis is always taking a long stage of experiments and the results are not always satisfactory and also authentic. Any kind of experiment is depending of time, resource and scientific laboratory. To establish the past history of many aesthetic pottery of Bangladesh we have to use modern methods and technologies like present research did. Also, we should concentrate the preservation and conservation of the archaeological site as well as the excavated pottery items and also focus on the proper scientific research in the country.

8. Biography of the Author:

My research has considered the role of scientist which inspired me to introduce with many disciplines of Social Sciences and Humanities as history, archaeology, anthropology, art history, world civilization, and Islamic history. Basically, I am a microscopic thin-section analyst in the field of traditional Ceramic. I am interested in the history of preservation and conservation of Asian cultural heritage in global perspective. Prehistoric ceramics of Japan, China and Korea and compare between the Far East and South Asian cultural tradition is my primary research interest. I have a keen interest in the field of Intangible Cultural Heritage also. By working in the field of cultural heritage, my research aims to technological analysis of the archaeological ceramics of Bangladesh so that this field could get concentration from government and other civic society.

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