MYSTERY OF THE GLOSS ON THE EARLY HISTORIC NBP WARE

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The NBP (Northern Black Polished) Ware is an enigmatic ceramic and its very name is a bit anachronistic because it is neither northern, nor polished, nor even black! Its characteristic gloss has been the theme of various investigations though there is hardly any unanimity about it. Robert Harding of the Institute of Archaeology, London carried out some scanning electron microscopic work on this ceramic, a summary of which is given here. The recent investigations tend to show that they applied a very thin layer (about 1 micron) of iron oxide and some alkali and obtained the required gloss.

The manufacture of the NBPW begins in the early to mid-first millennium B.C. and continues until c. 200 B.C. As a luxury ware it constitutes a small percentage of assemblages in which it occurs. The most remarkable property of this ceramic of course is the remarkable sheen on its surface, distinguishing it from a black-slipped ware. From the gloss and dominant colour it does appear to be a deluxe ware. Typical shapes are dishes and bowls. Although the distribution area is the Ganga Plains, it has been found over a large area of India. Though mostly black it is also found in a number of colours like steel blue, bronze, pink, violet, silver and gold. Thus, it is not entirely northern or completely black; and whatever the method of production, its sheen is not a polish. Nor is it a glaze, since it does not involve the breakdown of the clay into an amorphous crystalline structure. The gloss is basically because of the treatment of the slip, using in particular, ferric oxide.

Earlier, T.N. Roy (1983) had divided the NBP fabric into five main groups. Type A is - thin in section, fine, hard and dense, and its surface is difficult to mark. It is found only in the form of corrugated or flanged bowls but never on dishes. Type B is thicker and its surface can be more easily scratched. Both dishes and bowls are found in this fabric. Both types are made of well-levigated clay, on a fast wheel and have a grey core. Type C has a red to grey core with a surface below the slip of red to buff matt colour. The slip itself peels off more easily than the other types. Type D is a variation of Black-and-Red Ware. Finally, Type E is thick in section, with the surface dull black or grey, and rarely lustrous. It appears to have been fired at a lower temperature than other types and its surface could be described as a wash or self-slip.

Probably , the NBP developed from the pre-NBP Black-Slipped Ware of Bihar in the seventh century B.C. According to Roy, from the fourth century B.C. there is a decline of NBP both in numbers and in quality and it is from this time that the coarser type E is mainly produced.

Previous Theories

Although a variety of hypotheses have been proposed about the technology of NBP, the two main theories proposed either iron or carbon as the main ingredients responsible for its surface gloss.

Iron was first proposed as the major colouring agent by Sana UlIah, who detected an oxide in the coating of a sample at the level of 13%. He identified it as a ferrous silicate. The lustre was imparted by the ferrous-lime and ferrous magnesia silicates that fused at a low temperature, and the blackness was increased by the addition of carbon and tar. Early tests at the British Museum concluded that an inorganic ferruginous material was responsible for the gloss, that a pot was dipped before firing, and then fired at a high temperature (800 °C) and cooled in a reducing atmosphere. In a series of papers Hegde also identified it as iron. Hegde found that oxides of iron and sodium were ten times greater on the surface than in the core, and that when heated in an open crucible at 800^0 C, the surface changed colour from black to orange to a bright shiny red. He proposed that the dressing was of magnetite; it was also found in the core of his samples, but in much smaller amounts. Hegde suggested that it was liquid clay, peptised with the addition of an alkali, possibly the common encrustation found on alluvial soils known as *sajjimatti*. A resultant chemical reaction would have produced black magnetic oxide of iron (Fe_3O_9) and the sodium compounds in the *sajjimatti* would have combined with aluminum and silica to create the glaze silicate. A number of samples showed crazing, and so he argued that pots were baked at 600^0-700^0 C; he had noted that when the surface layer was removed the pot was a red colour, so presumably he believed it was oxidised. A ferruginous slip was then applied, followed by firing at 800^0-900^0 C. The thermal expansion produced by a high percentage of sodium could have produced the crazing.

Carbon was first suggested as the key variable by B.B. Lal (1955-56: 56) who suggested that an organic liquid had been applied after firing, although he did not rule out ferruginous material altogether. More recent testing on two sherds from Kausambi and Rajgir has been carried out by Gillies and Urch. The first was black on one side, bronze on the other; the second bronze on both sides. Testing showed that firing had been in a reducing atmosphere, and that self-slipping was possible. They reported that there was a higher iron content in the black surface than in the body, and higher still in the bronze, whereas carbon was at the same level in both slip and body. They also found that the bronze only represented an outer layer and that a black surface lay underneath. They found no trace of iron oxides or spinels; instead they attributed the coloration to an iron-rich biotite or a related form of mica (e.g. muscovite). They explained that the "glazed" appearance under the microscope was due to the destruction of clay minerals by a sintering of the slip, and the characteristic NBP gloss was a product of mica platelets aligning themselves parallel to the surface of the slip. The bronze colour was due to the deliberate or accidental oxidising of the same material. However, again the analysis failed to take into consideration the full range of coloration.

Roy detected both carbon and metal in the slip and suggested that the latter was added as a fusible material, possibly in the form of borax; and a colouring agent such as iron or copper or both, was also added. An experimental firing was done using these elements and *kabiz,* an organic mixture derived from plants, was also applied. The pots were then fired in a reducing atmosphere and the results were close to NBP. He concluded that the gloss resulted from reduction of iron oxide and organic liquids together with the temperature level. It was the temperature that determined whether the firing was glossy or matt, and also the degree of hardness.

Though unpublished, the analyses carried out at the British Museum and the University of Baroda, on a larger scale than any previous research, have supported the theory of ferruginous material being of greatest importance, and have also detected double- and triple-slipping.

SEM Analysis

Harding took a set of samples from the pieces found at Rajgir together with their constituent elements and analysed them using a Scanning Electron Microscope (SEM) at the Department of Materials Science at Cambridge University. This work was jointly carried out with Colin Shell of the Department of Archaeology at Cambridge.

Sample 1 was a bichrome sherd (a dish with gold and silver coating) found near the northern wall of the Inner Fortification. The microscopic examination confirmed that the slip had not coalesced with the body, and was in fact partly detached from it. It was also very thin, in total about 10- 14 microns across. However, closer examination of the edges showed a doubleslip, with the top layer about a micron in thickness. Below it, a cross-section showed the fabric to have a compaction layer, demonstrating the pot had been burnished prior to the application of the slip, presumably to give a smooth, even surface.

Elemental analysis of the sherd indicated a high proportion of iron, representing 11.74% of the silver surface and 10.16% of the gold. This was in marked contrast to the fabric, which recorded only 2.15%.

Sample 2 was from the same area, and was a bronze colour on both sides. The results were very similar, showing a very thin slip on top of a thicker one. The elemental analysis showed iron at 18.94%, with the fabric at 6.33%.

Sample 3 was a so-called "degraded NBP" sherd, i.e. grey with dull red splotches, from the centre of the valley, in the area traditionally known as Old Rajgir. The grey area gave a reading of 5.39%; but the red was even lower, at 4.46%. This suggests the redness is possibly due to light refraction, the red areas simply being rougher than the grey. It also raised the question of whether the degraded form could have resulted from water action or was a waster.

Sample 4 was a thicker or "coarse" sample of NBP, the rim of a small bowl, again taken from the Old Rajgir area, and silvery in colour; the measurements were 12.91 % and 4.15% for the slip and fabric respectively.

Carbon does not appear to be the key variable. The level of oxide was high in all the samples, though it was not possible to determine how much of it had combined with the iron to produce ferric oxide.

Conclusions

Harding's preliminary conclusions are: Firstly, all the samples examined had two slips, with the upper surface being about a micron in width. The thinness of the upper coating was seen where an edge was available, and it was also shown by the presence of air bubbles on the sherd surface. The extreme thinness of the top coat implies either a very fine suspension in liquid that was either wiped on or into which the pot was dipped. Since a single layer of clay platelets would automatically arrange itself in a single alignment, light would reflect brightly and thus the presence of mica is not required to explain the surface gloss. Secondly, iron is present at significantly high levels in all the sherds, no matter what the colour, and at higher levels than the underlying fabric. Thirdly, evidence of oxidisation after the application of the slips opens up the possibility of a three-fold process of oxidisation, reduction and re-oxidisation. This would have helped in the creation of the colour and possibly control of this process could have created the colour variations. Harding concludes that more work needs to be done to confirm some of these conclusions, but a number of useful leads have been established.

Source:

Harding, Robert.2004. Report on Scanning Electron Microscope Analysis of NBP Sherds. Man and Environment. XXIX (2): 30-36.

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