SYNOPSIS

Pottery remains are one of the most important relics in archaeological records. Generally archaeological studies on pottery are much restricted to the typology of different wares and the decorative motifs seen on them. But, so far very few attempts have been made to study pottery remains with the help of scientific methods to reconstruct their production technology. The production of pottery involves various stages such as collection of clay, preparation of the clay paste, shaping of pots, application of slips over them, decorating them with different pigments, drying them under sunlight and finally baking them in a kiln. This thesis is an attempt to understand the salient features of these stages as practiced by the potters of Harappa Culture in Gujarat.

The thesis is based on the chemical analysis and petrographic study of the pottery specimens recovered from the stratified layers of the excavated Harappan sites, viz., Vagad, Nageswar and Ratanpura in Gujarat. These three sites are located on lithologically different regions.
The major objectives of this study are:

1. to identify the sources of the clay used for making the pottery and to understand whether these pots were locally made or imported,

2. to know the techniques involved in the preparation of different quality clay pastes used for throwing different wares,

3. to understand the composition of different decorative pigments and slips and thus to determine the raw materials that were used for decorating the wares,

4. to find out the techniques of kiln baking adopted in the production of wares,

and

5. to determine the baking temperature of the pottery.

Outline of the thesis

Chapter 1  Introduction:

General aspects of the Harappan Civilization;
Harappan Civilization in Gujarat; Harappan pottery;
previous work and objectives of the present study.

Chapter 2  Archaeological Background:

A brief summary of the published reports of the three excavated sites, namely, Vagad, Nageswar and
Ratanpura from where the samples were taken for the present investigation.

Chapter 3 Methodology

A description of various methods used in this study, namely, sampling; characterization of colour; thin-section microscopy; x-ray diffraction; energy dispersive x-ray microanalysis; scanning electron microscopy and differential thermal analysis.

Chapter 4 Petrography and Mineralogy

A description of the results obtained from thin-section studies, textural analysis and x-ray diffraction studies.

Chapter 5 Provenance of the clay and Preparation of the clay paste

Sources of the raw material (clay) used for throwing different wares and the techniques involved in the preparation of different quality clay paste.

Chapter 6 Chemical Analysis

Composition of different pigments; composition of different slips; discussion of the results obtained from the chemical analysis and the reconstruction of the techniques used in kiln baking of pottery.
Chapter 7 Thermal Analysis:

Differential thermal analysis of the Harappan pottery samples and a clay sample from Nageswar; discussion of the results and determination of the baking temperature of the fine wares.

Chapter 8 Conclusions:

Reconstruction of the different stages in the manufacture of pottery during the Harappa Culture period in Gujarat.
Statement I

(Statement showing the particulars on which the work is based, the discovery of new facts and of new relationships between facts observed by others and how the work tends to help the general advancement of knowledge.)

A detailed scientific study of the representative Harappan pottery specimens in order to understand their production technology has been attempted for the first time in India. A few quantitative chemical analyses carried out by Dr. Hamid, Mohammad Sana Ullah and Dr. B. B. Lal, on Harappan ceramics are restricted to indicating the percentage composition of the ceramic artifacts studied. A detailed study on production technology, consisting of thin-section microscopy, x-ray diffraction, energy dispersive x-ray microanalysis, scanning electron microscopy and differential thermal analysis, has not so far been attempted.

In order to reconstruct the various stages involved in the manufacture of Harappan pottery, a detailed scientific investigation of the representative pottery specimens of the Harappan period recovered from the stratified layers of excavations at Vagad, Nageswar and
Ratanpura in Gujarat state is attempted in this thesis. From the data obtained from the above analyses, the salient features of the pottery manufacturing stages of the Harappan period in Gujarat is reconstructed. The thesis, therefore, adds detailed information to our existing knowledge on the following aspects:

1. It indicates the probable sources of the raw material, viz., clay, the deposits from where it was collected for making the pottery at Vagad, Nageswar and Ratanpura during the Harappan period. This information is obtained by comparing the mineralogy of the non-plastic inclusions present in the pottery fabric with the lithology and drainage pattern of the area and the mineralogy of the non-plastic inclusions present in the clay collected from different deposits near the Harappan settlements.

2. This study further suggests that the pottery was manufactured locally at these three sites.

3. The textural analysis of the non-plastic inclusions has brought to light that laborious repeated elutriation of the clay was carried out for preparing different quality clay pastes.

4. The grain-size analysis of the non-plastic inclusions indicate that in the later phases of the
Harappan Culture the pottery tended to be coarser. This was due to the reduced number of elutriation processes in preparing the clay paste.

(5) The quantitative chemical analysis of the decorative pigments has revealed two types of pigments: (1) manganese rich black pigment and (2) iron rich black pigment.

(6) In the case of manganese rich black pigment it is observed that manganese oxide contributed to the black colour of the pigment.

(7) In the case of iron rich black pigment, reduction induced ferrous oxide phase and carbon particles are responsible for the black colour.

(8) Manganiferrous iron ore was the raw material that was used for preparing the decorative pigment.

(9) The crushed manganiferrous iron ore was finely ground with well elutriated very fine clay and this mixture was applied as the pigment.

(10) While baking inside the kiln this pigmented portion was sintered and sealed.

(11) The undecorated slip portion of the same pottery did not undergo sintering because this clay was
The pots of the Harappa culture were baked either in a vertical up-draught kiln or open-fire baking kiln.

The atmosphere within the kiln was kept well under control and the firing of the pots consisted of an oxidising-reducing-re-oxidising cycle.

Since the baking of the pots was done in an oxidising-reducing-re-oxidising cycle the simultaneous formation of black colour in the pigmented portion and red colour in the slip portion took place.

The factors responsible for the pigmented portion becoming black and slip portion red were the difference in porosity, variation in the degree of sintering, fineness of the clay and different conditions inside the kiln.

This study has revealed that the Chocolate Slipped Ware was also fired in an oxidising-reducing-re-oxidising cycle. Its surface colour was found to be equalvalent to 5 YR of the Munsell Chart for Ceramic Colour Designations. The same colour was observed for some of the black pigments decorating the Red ware.
(17) The colour of the Chocolate Slipped Ware is due to the formation of reduction induced ferrous oxide phases and carbon particles.

(18) The Red Ware obtain their red colour due to the ferric oxide in the clay.

(19) The factors responsible for the formation of various shades of red on Red ware are the baking temperature of the pottery, amount of organic matter present in the clay, amount of lime present in the clay and the amount of iron oxide available.

(20) It is pointed out that well heated pottery with high amounts of iron will have a bright red colour.

(21) If the percentage of iron decreases and that of lime increases, the pottery will obtain lighter shades of red colour.

(22) The Buff ware pottery contained less percentage of iron and appreciable amount of lime. The baking of this ware was done in an oxidising atmosphere while baking in a kiln, since the pottery was rich in lime it turned buff.

(23) The buff slip was also prepared by the addition of further quantities of lime.
(24) The baking temperature of the fine wares (Red Ware, Buff Ware and Chocolate Slipped Ware) was also determined. The baking temperature of these wares was found to be above 800°C.
Statement II

(Statement indicating the sources of information and the extent to which the thesis is based on the works of others and the portion of the thesis claimed as original)

The chief sources of information for this study are reports of the excavations of three Harappan sites, viz., Vagad, Nageswar and Ratanpura and the excavation reports of all other Harappan sites. Published chemical analysis data of the Harappan pottery specimens are noted in this study. For thin-section microscopy, x-ray diffraction, energy dispersive x-ray microanalysis, scanning electron microscopy, differential thermal analysis and general information regarding the ceramic technology, the following standard reference books were consulted:

The Petrology of Archaeological Artifacts.

(5) Kingery, W.D., Bowen, H.K., and Uhlmann, D.R.
(1976) Introduction to Ceramics. John Wiley and
Sons, New York.

Press, London.

London.


Chemistry and Physics of Clays. Earnest Bonn Ltd.,
London.

Carnegie Institute of Washington.

Application and results in Mineralogy. Springer-
Verlag Berlin Heidelberg, New York.

The portions of the thesis claimed as original are the reconstruction of the salient features of various stages of manufacture of pottery by the Harappa Culture potters of Gujarat; the identification of the provenance of the clay; preparation of the clay paste; identification of the decorative pigments; identification of the raw material of the pigments used; application of the pigments; techniques of baking of the pottery in the kiln and determination of the baking temperature of the pottery. These are the contributions of this thesis.