CHAPTER 8

CONCLUSIONS

Pottery manufacture involves a number of stages such as collection of suitable clay, preparation of 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. The present study is an attempt to understand the salient features of these stages as practiced by the potters of Harappa Culture in Gujarat. For this work pottery samples recovered from stratified layers of the excavated sites at Vagad, Nageswar and Ratanpura were chosen. These pottery specimens were analysed using chemical and petrographic methods.

Chronologically Nageswar represents the mature Harappan phase, Vagad falls in the initial phase of the late Harappan and Ratanpura corresponds to the final phase of the late Harappan tradition in Gujarat. These sites are situated in different lithological regions (Figure 6.2). Vagad is on the bank of the Bhadar river and it falls in the alluvial track of central Gujarat. Nageswar is located on a coastal deposit on the Dwarka bed. Ratanpura is on the bank of the Rupen river in north Gujarat. A part of this site is located on a sand dune and the other part on the alluvium close to the river bank.
The provenance analysis has been carried out to understand the source of clay that was used for throwing pottery at each of these sites. For this the mineralogy of the non-plastic inclusions present in the pottery fabric, lithology and drainage pattern of the area and mineralogy of the non-plastic inclusions present in the clay collected from different deposits near the sites are taken into consideration. From this study it has been found that the potters of the Harappan period at Vagad, Nageswar and Ratanpura had exploited the clay deposits found within their vicinity. Excavators of Nageswar and Ratanpura have reported the presence of vitrified pot-sherds at these sites. This evidence further supports the observation that the pottery was manufactured locally.

The second stage in the manufacture of pottery is the preparation of clay paste. Thin-section studies and textural analysis have revealed that the clay paste used for throwing the wares was prepared by the laborious process of repeated elutriation of locally available clay. From the grain-size analysis it appears that the non-plastic inclusions in the pottery fabric were not deliberately added. They were all associated with the clay at its source. The quality of the clay paste varied according to the kind of pottery that was thrown. This was achieved by increasing or decreasing the number of elutriation processes (Chapter 5.4: 94). Thus coarser wares were
made using a less elutriated clay and finer wares were thrown from more elutriated clay. One generally notices that in the later phases of the Harappa Culture in Gujarat the quality of all pottery becomes poor. The thin-section studies and textural analysis of a variety of pottery specimens recovered in the excavations at the above three sites have revealed that in the later phases of the Harappa Culture, the pottery tended to be coarser (Figure C.6, C.7 and C.8). This was due to the reduced efforts on the part of the potter in elutriating the clay. In other words the number of elutriation processes decreased in the later phases of the Harappa Culture in Gujārat which resulted in poorer fabrics.

The clay paste prepared by the elutriation process was thrown on a wheel into pots of different shapes. The surface of the pottery was then dressed by applying a slip. A few of the pots were then decorated with certain pigments. In order to understand the composition of different pigments and the slips and to identify their raw materials, their chemical analysis was carried out.

The chemical analysis of the decorative pigments have revealed two types of pigments. They are: (1) manganese rich black pigment and (2) iron rich black pigment. The ratio of manganese to iron in manganese rich pigment is found to be 1:2, 1:3 and 1:4 (Table 6.3). The ratio of
manganese to iron in the undecorated slip portion of the same pottery is found to be 1:50. From these results it is possible to infer that manganese oxide present in the pigment contributed to the black colour of the decorations. The presence of other elements in the pigmented portion (Table 6.3) and the evidence of sintering on the pigmented portion (Figure D.2) indicate that the pigment was prepared by finely grinding the crushed colouring agents with well elutriated very fine quality clay which was free from non-plastic inclusions.

The iron rich pigments contain high percentage of iron and negligible amount of manganese. The ratio of manganese to iron in these pigments are found to be 1:39, 1:28, 1:23 and 1:48 (Table 6.4). This very small quantity of manganese did not contribute to the black colour of the decoration on the pottery. This black colour was due to iron oxide. Iron oxide can impart black colour if fired in a reducing atmosphere. But in the case of Harappan Red ware the undecorated slip portion of the same pottery containing iron oxide is red in colour and the decorated portion is black. It is interesting to see here that iron oxide is responsible for both red and black colours. The presence of other elements in the pigmented portion (Table 6.4) and the evidence of sintering (Figure D.7 and D.8) on the pigmented portion indicate that the pigment was prepared as stated above by grinding crushed colouring
agents with well elutriated very fine clay (Chapter 6.3.2:117). But the undecorated slip portion of the same pottery is porous and does not show any sintering marks (Figure D.10). This is because the clay that was used to prepare the slip was not as fine as that clay which was used for mixing with the pigment (Chapter 6.3.2:118). From the chemical composition of the pigment and the slip and their surface morphology from SEM, it appears that the difference in porosity, variation in the degree of sintering and different conditions inside the kiln were responsible for the formation of black pigment and red slip from iron oxide. It appears that while baking these pots the potter changed the kiln atmosphere from oxidising to reducing and finally oxidising (re-oxidising). The baking of pottery in an oxidising-reducing-re-oxidising cycle is possible in a vertical up-draught or open-fire kiln (Chapter 6.3.2:119-120). Both these kilns have openings at the top which act like a chimney. The fuel feeding inlets are at the bottom (ground level). In the first instance of baking the hot gases rise up through the chimney resulting in a natural draught of air which produces the oxidising atmosphere within the kiln. The temperature within the kiln slowly rises to 800°C or more. After baking is completed the chimney and the ground level fuel feeding inlets of the kiln are closed. This is for beginning the cooling cycle by extinguishing the fire. But since some fuel is still inside the kiln the burning process continues in the absence
of fresh oxygen. This leads to the domination of carbon monoxide within the kiln atmosphere creating a reducing atmosphere. During this reduction process the pottery get darkened. After this stage the potter slowly opens all the vents and allow air to enter. This recreates the oxidising atmosphere inside the kiln. At this stage since the iron rich pigment is sintered and sealed it does not undergo oxidation. Thus the reduction induced ferrous oxide phases and carbon particles are retained on the decorated parts giving a black colour, whereas the porous red slip of the pottery gets oxidised and turns into red ferric oxide.

From the chemical composition of the pigmented portion it appears that manganiferrous iron ore was used as the colouring agent. In this ore the amount of manganese and iron vary over a wide range. Sometimes the amount of manganese in this ore is so small that it is lower than one per cent and the maximum percentage of manganese in this could go up to thirty.

The colour of the Chocolate Slipped Ware was found to be equivalent to 5 YR 3/4 of the Munsell Chart for ceramic colour Designations. The same colour was observed for some of the black pigments decorating the Red Ware. Different shades of black colour has been observed for the black pigment. Hence chocolate colour of this slip can be
considered as one of the shades of black. The ratio of manganese to iron in this slip has been found to be 1:48. Its scanning electron micrograph shows evidence of sintering on the slip surface. It appears that this pottery also obtained this colour because of its baking in an oxidising-reducing-re-oxidising atmosphere.

The red colour of the pottery (Red Ware) is due to the ferric oxide on it. Various shades of red occur among the red wares (Chapter 6.3.2:124). The colour of the pottery is influenced by factors like 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 present. Hence a well heated pottery sherd with high amount of iron will have a bright red colour. If the percentage of iron decreases and that of lime increases the pottery will have lighter shades of red colour.

The Buff Ware pottery is made of clay which is highly calcareous. The percentage of iron oxide is less in this ware. The baking of this ware was also done in an oxidising atmosphere. But since the pottery contained an appreciable amount of lime while baking it turned buff in colour. The buff slip is prepared by adding more amount of lime into the clay. Because of this higher percentage of lime, on heating the pottery turned to be buff in colour in its surface dressing.
The baking temperature of the fine wares (Sturdy Red Ware, Buff Ware and Chocolate Slipped Ware) were found to be above 800°C. This was determined by studying the various changes that took place in the clay while heating (Chapter 7, 133-134). When clay is fired, dehydration and decomposition reactions take place at a range of 300-800°C. Grim and Bradley have proved that clays fired at a temperature of less than 800°C gradually become rehydrated and regain a measure of its original structure over a period of time. But the clays fired above 800°C do not undergo these changes because the clay minerals have got irreversibly altered. From the differential thermal analysis of the fine wares it has been found that their dehydration and decomposition peaks were missing. The x-ray diffraction analysis of the potsherds also revealed that the clay minerals were permanently altered. This is possible only if the pots were fired at above 800°C. It is possible to attain this temperature in a pottery baking kiln. The temperature inside even in an open-fire pottery baking kiln has been found to be reaching 1000°C (Chapter 6.3.2; 123).

Even though the study is restricted to three sites, it appears that the same technology was adopted in all other sites to produce Red Ware, Buff Ware, Chocolate Slipped Ware and other wares. I hope to carry out further
work on the pottery specimens from all the Harappan sites of Gujarat to throw more light on the various aspects of this technology. However, it may be worth mentioning that the potters of the Harappan period were well aware of the peculiarities of clay and knew how to control the baking of their wares in a kiln. With this knowledge they could make a variety of good quality pottery.