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SOME ASPECTS OF PREHISTORIC TECHNOLOGY IN INDIA

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FOREWORD

One of the objectives of the National Commission for the Compilation of the History of Sciences in India is to publish studies on the History of Sciences in India, as and when ready, serially as well as in the form of monographs.

A Symposium on the History of Sciences in India was organized in Delhi during October 1968. When the proceedings were being published, it was discovered that there was a lacuna on the contribution to the study of Prehistoric technology. Professor H. D. Sankalia whose reputation as an authority in Indian Archaeology is widely recognized and who has published studies on Prehistory and Protohistory of India and on 'Stone Age Tools, their techniques and probable function', was invited by the National Commission to contribute a monograph on the subject. The Editorial Board takes this opportunity of expressing their appreciation to Professor Sankalia for his agreeing to contribute this monograph to the series. It is specially rich in the discussion of techniques employed in industries during the Protohistoric period. The problem of dating the age of different periods in Prehistory and Protohistory has been largely solved for the Protohistory period by the recently introduced method of carbon dating. For the Prehistoric period it has not yet been possible to introduce a similar technique.

How the archaeologists attempt to assign the sequence to the different types of tools belonging to the early Stone Age, has been discussed by B. and R. Allchin in the recent Penguin publication "The Birth of Indian Civilization". Beginners in the study of Indian archaeology who would like to supplement their reading of the present monograph may be recommended to read Allchin's book. It is hoped that Professor Sankalia would agree to contribute a more detailed monograph to the series on the subject of ancient Indian Archaeology.

D. M. Bose

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Preface

Prehistory in its true sense is a period before writing was known. Hence there cannot be any written records from which we might extract an account of the man's knowledge of the various techniques employed by him. No doubt in Egypt, Iraq, and Crete, there are some records of a very early period which fall on the borderland between history and prehistory. Though a majority of these records are not very useful in ascertaining the then prevalent techniques, for these records are essentially accounts of victories, or mythical accounts of the origin of the world, or accounts of temples, still some, for instance, deal with wound and accident surgery (Westendorf 1966).

In India we have only brief inscriptions on so-called seals of the Harappan or the Indus Civilization. These are so far unread, and hence we do not know if they refer to any techniques or technicians, such as the potter, mason, coppersmith. The rest of the material is purely archaeological.

However, there remains another source, the whole body of literature known as the Vedic. This was until the beginning of the Christian era unwritten and known only orally. There is no doubt that the Vedic literature coincides, if not wholly, at least towards its later part, with the Protohistoric Period, *c.* 1500 B.C. Should not, therefore, this source be used ? It could be, like the Egyptian papyrus and the Sumerian tablets, but the difficulty is that for a proper understanding of the techniques we should visualize the object, nay handle it. This we cannot do with all that is described in the Vedic and the post-Vedic literature. We are not even sure of the material used, whether it is copper or iron. We have to rest content, therefore with Schrader's *Real Lexikon* (1917-1923, 1929) and Macdonell and Keith's *Vedic Index* (1912). A glance at these works will at once show that in the Vedic Age, whatever be its exact period, lived architect-engineers, masons, carpenters, smiths, weavers, spinners, dyers and potters. Both copper and iron are mentioned and there are words for smelting copper/bronze, iron, silver and gold. No doubt Schrader has illustrated a few of the objects, such as sickle, sword, pottery, wagons and houses, but even this we cannot do for want of definite evidence. It is unfortunate that so far we have been unable to identify any habitation as Vedic and say from the study of its contents about the techniques during the Vedic Period.

Under the circumstances we have to rely solely on the archaeological evidence. Here too, our account cannot be exhaustive or detailed as one would expect. We have got to go a long way in this direction. So far little has been done to determine the iron or copper-bronze technology. Thus the objects from the Copper Hoards as well as the megaliths in South India are regarded as specimens, not to be desecrated by scientific examination!! Nor have these copper and iron objects been related to the raw materials (ores), and the polished stone tools to the rocks so that we can establish real contacts between Maharashtra and Mysore, for instance. So that besides discussing the forms of certain tools and weapons, our knowledge does not go beyond the forms of certain tools and the affinities suggested by these forms. The same is true of pottery, the most prolific prehistoric material found in any excavation in India. Under these circumstances, what one could do is to mention the various categories of objects, known so far, and summarize whatever is available about the techniques.

The various techniques employed by the Indus or the Harappan people have been admirably deduced by Mackay from the then available evidence and scientific examination by chemists and metallurgists. I have given the account in the words of Mackay himself, first because it was written after a very careful study. Secondly, I have had no occasion to study the finds of this civilization at first hand (except for a brief period far back in 1936), and also there was no opportunity, in the absence of the originals, to carry out further scientific experiments. However, wherever possible, this and other accounts have been brought up-to-date with the additional knowledge gained from recent excavations.

For the purpose of this monograph, I have summarized Mackay's account regarding the various categories of objects found in the Indus Civilization.

For pottery, my colleague Dr. G. G. Majumdar has carried out some scientific examination and this has been included in the relevant sections. On copper-bronze technology, a little more evidence is available, because of the discovery of copper slag in a hearth at Ahar, and its full study by Dr. K. N. T. Hegde. Similar study should have been done for the slag found at Lothal. Further welcome data are available from the studies of Dr. D. P. Agrawal. I am extremely grateful to these scholars for allowing me to use their works which are still unpublished.

Division of the Subject

The prehistoric period is divided broadly into two main periods.

I. Prehistoric, ranging from *c.* 2,00,000 B.C. to c. 3,000 B.C.

II. Protohistoric, from *c.* 3,000 B.C. to c. 500 B.C.

I. The Prehistoric Period includes the three or four Stone Ages:
   (*i*) The Early Stone Age;
   (*ii*) The Middle Stone Age and
   (*iii*) The Late Stone Age.

II. The Protohistoric Period includes all the Neolithic, Chalcolithic and Bronze Age cultures as well as the Early Iron Age ending in *c.* 500 B.C.

A word about the treatment or the method in presenting the techniques. Instead of merely mentioning the techniques, the objects, a study of which indicates the techniques, are also mentioned in every case. For so far our students at various levels are told only of the general features of the Indus Civilization; they do not know even at the M.A. stage, the reasons which have prompted these deductions. Hence our knowledge of technology is extremely weak. It is hoped that the method here followed will encourage a more detailed study both by average students and also by chemists, physicists and other experts.

H. D. SANKALIA

I

TECHNIQUES DURING THE PREHISTORIC PERIOD

The techniques prevalent during the Stone Age have been described in detail and also fully illustrated by me elsewhere (Sankalia 1964). It might be mentioned here that these techniques in no way differ from those observed elsewhere in the world, particularly in the Old World. Further their development chronologically is not different as witnessed elsewhere, though this would be true taxonomically and not in space and time. That is the technique, say the Stone Hammer or Block-on-Block, though the earliest in India, as well as in Africa and Europe, would not be necessarily of the same age.

A. Block-on-Block and Stone Hammer Technique

Though in India we have not a very clear-cut stratigraphical development in the flaking of stone tools, the earliest and the most widespread was the Stone Hammer and Block-on-Block or Anvil Technique. The latter is best witnessed in the middle Narbada at Hoshangabad and Maheshwar and in the East and West Panjab in the valleys of the Sohan, the Indus and the Banganga and in the Liddar Valley in Kashmir. Huge flakes with prominent bulbs of percussion were most probably the result of striking one large pebble or boulder against another. Their age is Early to Middle Pleistocene.

B. Stone Hammer Technique

In the Stone Hammer Technique, the artificer took one round or ovalish pebble and struck against the periphery of the other, kept in his right or left hand as the case may be. This was continued, often striking on alternate sides, until a sharp wavy edge, as desired (Fig. I, 1) was produced.

C. Controlled or Step-method technique

This was followed by the Controlled or Step-method of flaking. Briefly, the flake scars are smaller, shallower and leave a step-like mark, as the blows do not go much deeper, and are against the body of the tool. The longitudinal profile of many handaxes as well as cleavers are found trimmed in this way.

D. Cylinder Hammer Technique

Slightly later perhaps seems to have been developed the method known as Cylinder Hammer. The later might be of bone, wood or even stone. But it has been shown by actual experiments that such technique could have given a flat, symmetrical surface to the hand-axes, first found at St. Acheul in France and hence known as Acheulian. The flake-scars are very shallow and small. (Fig. I, 3)

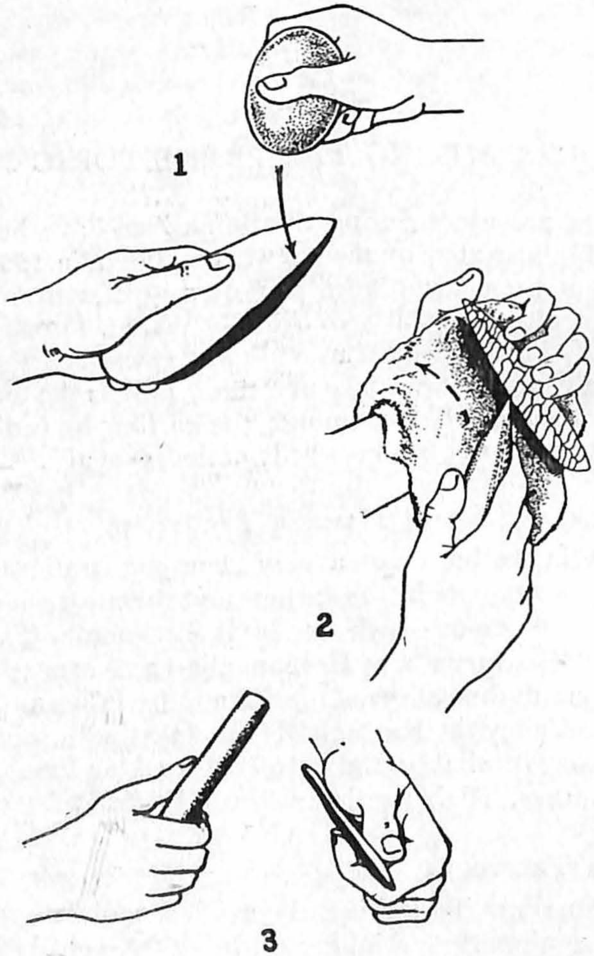

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Fig. I

1. Flaking with a hammer stone or Direct Percussion.
2. Pressure Flaking with a pointed tool.
3. Cylinder Hammer or Soft Hammer Technique.

(After Bordes, *The Old Stone Age*, *p.* 25.)

E. Prepared Core and Platform Technique

Then came a highly ingenious technique. It is called Prepared core and Platform technique or the Levalloisian technique after the type-site in France. This technique was certainly practised in the closing stage of the Early Stone Age and throughout the Middle Stone Age, more or less all over India, though for some reason its use seems to be infrequent.

In this technique a single, comparatively thin flake—round, oval or triangular—was removed after carefully working on the core, and preparing the platform where the blow was to be given. This blow was usually at an angle of 90°. Though it must be emphasized that the prepared platform is not the criterion for inferring the use of Levallois technique. The result was that a

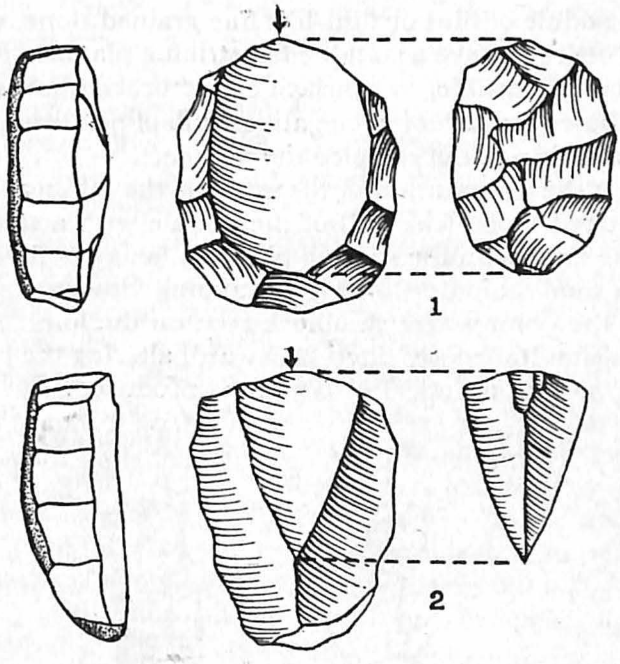

FIG. II
1. Levallois flake core with the flake beside it. (After Bordes, *The Old Stone Age, p.* 30.)
2. Special Levallois core for the production of Levallois points.

fine, symmetrical, fairly thin flake was produced. This required no further trimming. It must be emphasized here that all flakes and cores do not show all these characteristics, nor is it the case in the classic site of "Levallois Perret in France". The resultant core looks like a tortoise shell, particularly the back. Hence the name "tortoise core"· (Fig. II, 1-2)

F. Blade-Flake, Pressure and Crested Ridge Technique

These techniques are in a sense related because the main aim was to produce a thin flake, the length of which was more than its breadth, and known as blade. However, in practice, we can distinguish not only between the various types of blades, but the respective techniques employed in their production.

Probably the earliest to be discovered was the blade-flake technique. The characteristic blade-flake is long and comparatively narrow with more or less parallel edges. Such blade-flakes are occasionally found in Early and Middle Stone Age cultures, but regularly in the Upper Palaeolithic culture or the true blade-flake cultures. It was at this time, it is believed, that the proper technique for obtaining blade-flakes was discovered.

The technique employed for obtaining such long, narrow flakes with parallel edges is as follows:

First, the nodule of flint or flint-like fine grained stone, such as chert, is halved in order to have a suitable flat striking platform for a blade-flake core. As far as possible, the surface of the broken half should be even, without the concavity of a negative bulb of percussion. This is today called quartering of the stone or the nodule.

Next, starts the preparation of the core for the removal of blade-flakes. The quartered block (the half of the nodule with a smooth surface) is held on the knee with the striking platform facing obliquely upwards.

Then with a small hammerstone, light tapping blows are struck along the edge, just above the point where the block rests on the knee. As each blow is struck, the core is simultaneously tilted backward, altering the point of pressure against the knee, so that an effect of peeling is produced. The blows must be

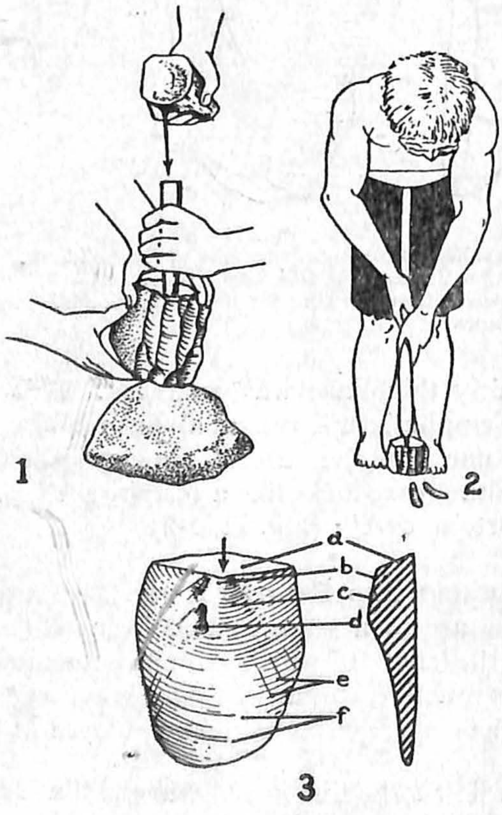

Fig. III

1. Indirect percussion (punch) technique for obtaining blades.
2. Chest-pressuse technique foɪ obtaining blades.
3. Features of the underside of the flake.
   a. Striking platform
   b. Cone of percussion
   c. Bulb of percussion
   d. Splinter
   e. Striations
   f. Undulations, the concavity of which is always towards the percussion cone. (*After Bordes.*)

struck at an angle of about 45° to the surface of the striking platform. After each flake has been struck, the block is slightly rotated about its own axis (keeping the striking platform always facing the same way) so that successive flakes can be removed round the edge of the core. Thus irregularities on the block are removed and since, all the flakes are removed in the same direction, a fluted appearance results, due to the parallel negative flake scars.

The whole of the circumference of the core having been thus prepared, it is ready for the removal of the blade-flakes. To achieve this, it is held as for the preliminary trimming. Each blow is now, however, struck about an intersection of two earlier negative flake scars, so that the ridge formed by their intersection will form a more or less central keel on the flake knocked off. As a variant, the blow may be struck so as to detach a wider blade-flake with both parallel keels on its upper face. (Leakey in Singer *et al.* 1956, pp. 134-36).

The method described by Leakey is still practised by the flint knappers of Brandon (England), and Turkey. And probably this was one of the principal techniques employed by the Chalcolithic people of India and Western Asia. For among the large number of cores only some show the crested ridge (see below), whereas others show flaking around as described by Leakey. Secondly, at all these sites, particularly at Navdatoli and Inamgaon, the writer has seen numerous small flattish pebbles which could have served as hammer-stones. For every one of them has pittings on one or both ends of the pebble, or sometimes around the periphery. These pittings were evidently the results of striking or tapping slowly against the chalcedony nodule.

In the method employed by the French scholars, a short wood punch was placed on the core, having a small platform, and a blow was given by a mallet (For details *see* Sankalia 1964, p. 38.) (Fig. III, 1)

G. Crested Ridge Technique

Such blade-flakes were also removed in Chalcolithic and Bronze Age Cultures by what is known as the "crested ridge or the guiding flake" technique. In this technique, all the irregularities or whatever could be easily removed from a chalcedony nodule were first removed by a round stone hammer. Secondly, a ridge was prepared along the length of the prepared core by alternate flaking. This ridge is supposed either to guide the regular removal of parallel-edged flakes or it creates a line of weakness which makes it easy for the removal of the first series of flakes.

Such crested ridge flakes and cores still having a ridge on them are found in the Harappan and later Chalcolithic cultures. And it is believed that for the mass production of blades this was a very convenient technique. (Subbarao in Sankalia *et al.* 1958).

H. Pressure Flake Technique

Thin, long, slender blades were also removed by a pressure technique. This is described in detail by the writer (Sankalia 1964, pp. 34-47). (See Fig. III, 2)

But there was another method as well. Man had invented what Leakey calls "the pressure-fabricator". It was not specialized in form, but a rough flake on which there was somewhere a thick, more or less rectangular, edge. By holding the fabricator in one hand and placing its end against the edge of the blade which was to be blunted, and exerting pressure, little flakes could be pushed off very rapidly and with practically no risk of snapping the blade.

It was by a kind of pressure-flaking again that very thin, flat flakes were removed from the surface of a blade in order to trim it into a lance-head or arrow-head. Two methods by which such pressure flaking was done has been described by the writer (Sankalia 1964).

Finally, according to Leakey for making a lunate, or a small crescentic stone blade, a type of fabricator was invented called *lame e'caille e*. With a few movements of this tool a whole series of tiny flakes could be simultaneously pushed off, thereby transforming a narrow blade-flake into a lunate.

I. Grinding and Polishing Technique

Lastly we have the technique called "Grinding and Polishing". In this a pebble or nodule or a block of stone, preferably dyke basalt, or diorite, was first flaked by the Stone Hammer, Control and Pressure techniques, if necessary. A fairly uniform surface was achieved. Then followed pecking by which all uneven surfaces were removed with a chisel-like tool. Then, this partly finished tool was ground in boat-shaped sandstone or rough-surfaced querns, with a little water and abrasives, though these are not quite necessary, if the surface is rough. Gradually the surface was smoothed. Since the man at this time was more particular about the edge part, this was further ground, until it became perfectly smooth, and perhaps with a little addition of some oily substance, the surface was made glistening. Thus were made the pointed butt axes (or celts), chisels and other wood-working tools of the New Stone Age. In India its principal home was Andhra, Mysore, Madras, then South Eastern U.P., Assam and Burzahom in Kashmir and now found in the East and West Punjab at a number of sites. In the latter, the stone used is not so hard as in the South. They are made on soft stone, like shale.

In Eastern India, Assam particularly, shouldered celts were made by wire-cutting (Dani 1960).

II

TECHNIQUES DURING THE PROTOHISTORIC PERIOD

A. Pottery

This is the most prolific object found in any excavation in India. Though detailed studies have not yet been made in a large number of cases, the following methods or techniques in the preparation of pottery have been deduced or inferred.

1. Handmade
   - (*i*) moulded in
     - (*a*) a basket, or
     - (*b*) a pot.
   - (*ii*) coiled.
2. Partly handmade and partly wheelmade.
3. Made on a turn-table.
4. Wheelmade.

There is a tendency among archaeologists to regard the handmade pottery as early and the wheelmade late. This presumption is, on the whole, true, though it must be emphasized at once that this is not a general rule. For it depends also upon the function and shape of the pot. Very large vessels, like storage pots, have to be made by hand; very often by the coiling as well as ring technique. So also other vessels, either for very ordinary use, or for some specialized function are found to be made by hand. All handmade pottery is thus not necessarily early. Before giving the details regionwise, some idea should be had about:

1. The two kinds of wheels;
2. The preparation of the clay; and
3. Firing.

(a) Potter's Wheel (Hand)

The potter's hand-wheel in India somewhat resembles a cartwheel. It is made of wood, and its rim plentifully daubed with clay to balance it. The middle of the upper surface of the wheel is flat to take the clay. The centre of the lower surface usually has a hard stone fitted to it with a small depression in the middle, which houses the wooden pivot set in the ground. The wheel revolves at a height of a few inches above the ground, and it is set in motion by a stick inserted between the spokes. A properly balanced wheel shows remarkably little wobble, but great care is necessary to obtain this desideratum.

The primitive potter's wheel was merely a round piece of wood with a pivothole in its underside which was not spun, but turned continually with one hand, while the clay was manipulated with the other.

(b) Foot-Wheel

All Mohenjo-daro pottery is wheel-made. Mackay thinks that looking to the evenness of the forms, and the regularity of the striations, these might have been made on a foot-wheel (which is faster than hand-wheel).

The foot-wheel is at present confined to Sind, Baluchistan and the Panjab, and it is likely this was introduced by the Harappans. Further this foot-wheel is of the same pattern as used in the Baherin Islands, Iraq, Syria, Palestine and Egypt.

The foot-wheel is regarded as the true potter's wheel. But it is indeed strange that it is practically unknown outside Sind and the Panjab, though as Mackay has shown, it has several advantages over a hand-spun wheel. The latter is very heavy, has a larger diameter to prevent it from wobbling, which prevents the potter from getting close to the clay in the centre. Thirdly, the wheel has to be constantly kept moving, and it is difficult to regulate its speed. "Despite all these disadvantages" admits Mackay, "the potter of India can and does produce very creditable work."

A pot made with finely levigated clay has a smooth, uniform texture, free from impurities, and is capable of equally fine baking. But such clay is not always available, for it depends upon the source of clay and these are conditioned by surface geology. It will be shown later that pottery from the Indo-Gangetic regions is generally finer (and is so even today) than the pottery from the Peninsular India, because of the fine river alluvium. And even here good potters select clay from ponds where fine clay has settled down. It is in this region that the art of potting and baking had reached a high degree of excellence, and has remained so till today, with a series of improvements, by later developments.

Good baking of pots is again dependent on two factors:

(1) The kind of kiln; and

(2) The availability and nature of the fuel.

In both these the Indo-Gangetic region seems to have achieved considerable progress, and fortunately for the Indus or Harappan Civilization we have also a few relics of kilns from Mohenjo-daro and Lothal. So we know how such excellent, uniformly baked pottery was made (though Mackay has observed equally good results in modern Sind without a kiln).

With this introduction we shall sketch briefly the development of pottery techniques in each major region of this sub-continent. We cannot take Indo-Pakistan as a whole. For various reasons, the development was not uniform all over this sub-continent.

Baluchistan

(*i*) Pottery. Earliest pottery (about 4000 B.C.) handmade either in a basket mould, or built up either by the ring or the coil method.

K. G. Mohamed II Period I, (Fairservis 1956, 262).

Burj basket marked (*Ibid.*, 262. 269).

Nazim Hard-clay temper, Wheelmade From about 2,800 B.C (*ii*) Firing. No evidence for the method of firing but pots on the whole were well fired.

(*iii*) Clay. Well levigated.

Sind

(*i*) Pottery. (*a*) Earliest Handmade. Details not available. Amri *c.* 2,600 B.C. (*b*) Wheelmade (from 2,600 B.C.) Kot Diji.

(*ii*) Firing. (*a*) No evidence, but well fired. (*b*) Later fired in kilns, Mohenjo-daro and by implication everywhere in the Indus Civilization.

(*iii*) Clay. Well levigated. Fine river alluvium without salt preferred.

(*iv*) All the ancillary techniques such as luting known and practised.

Details given by Mackay (in Marshall 1931, I, pp. 287-335) are as follows:

(c) CLAY

Bricks, pottery, and miscellaneous terracotta objects have been found in abundance at the Indus Valley sites, and the local alluvial clay was employed for their making. It is found to contain sand or lime or both. This is particularly so in the painted pottery. But this mixture seems to be natural and not deliberate. The prevailing colours of these products are light red or salmon; black and grey are uncommon. These colours are due to the presence of iron compounds in the clay, which develop the red shades in the oxidizing atmosphere of the kiln, while black or grey ones are formed when a reducing or smoky atmosphere prevails in the course of burning. The pottery is sometimes covered with a slip of bright red colour, due to ferric oxide; or painted with designs in black or chocolate, which owe their colour to manganese oxide. The identity of the colouring materials with those employed by the Indian potter of the present day, as well as the simplicity of the latter's methods, leaves no doubt that the ancient technique has been handed down to him without any material alteration. He prepares the red slip by levigating red ochre or *Multani matti* (a yellow ochreous earth) with water, and employs a manganiferous haematite for the black or chocolate shades. The manganese ores which are frequently associated with ferric oxide, impart a black colour when rich in manganese, but chocolate, when the proportion of iro increases.

(d) RED WARE

Smaller jars were made out of a special paste. This has very close texture and contained no sand or lime. This was quite sensible, because there was little danger of these small vessels warping or cracking while drying or baking. Most of the red ware to be covered with a slip which varied from a thin wash to a thick coating were coloured either red or cream or white. Some vessels bore two slips, dark red above, and light red below. A slip of red oxide was used for most of the better-class pottery, rarely a chocolate-coloured one or a purplish one. These chocolate and purple slips derived their colour from manganese oxide mixed with a little red oxide. It is thought that these rendered the vessels waterproof. But in no case was the base of vessel slipped and polished. (Mackay 1938, I, p. 178).

(e) Grey Ware

In a further study of this ware, Mackay thought, since the pottery varied considerably in tint, something was added in varying proportions with the purpose of darkening it. The outer surface was fully or partly polished, which produced a soapy feeling.

(f) Black Ware

The black or black-coloured slips can be produced by adding lamp-black or powdered charcoal, or by smothering the vessel when red hot in coarse sawdust, corn-cobs or some kind of resin, gum or soot mixed with oil or the juice of *Tuthi* (*Abution indicum*) (Mackay 1938, p. 175).

Mackay has also noticed a third kind of clay in the Mohenjo-daro pottery. It is found used mostly for jars of unusual shape and thin fabric. This clay was never tempered with any other material and vessel when broken showed a clean fracture (Mackay 1938).

(g) Tempering Agents

As tempering materials like mica, lime and sand are found to be added to the clay. Mica when properly mixed facilitates the handling of the clay on the wheel, as well as the drying of the pottery without cracking.

What particular use was served by the addition of lime to the clay has not yet been scientifically determined (Mackay 1938, p. 176).

(h) Decorated Pottery

The Mohenjo-daro pottery was decorated, besides painting by (1) cord, (2) incised work, (3) scoring, (4) perforation, (5) graffiti, (6) impression.

(1) *Corded.* A cord is wound around a vessel while it is being revolved slowly on the wheel, or even when the jar is stationary.

(2) *Incised.* Incised decoration was usually confined to the bases of pans, and always inside. The specimens are said to be rare. But now it is found that this was a favourite device with the pre-Harappans as evidenced from Amri, Kot Diji and Kalibangan. And it is quite possible that the few examples noticed by Mackay at Mohenjo-daro are the survivals from an earlier period or in truth belong to the pre-Harappan phase at Mohenjo-daro. (Fig. IV, 1-2).

(3) *Scoring.* This was done with a very sharp tool, which was perhaps a metal comb (Mackay 1938, I, p. 179).

(4) *Perforated.* Beside the cylindrical perforated vessels of various sizes, a few pieces of perforated ware have been reported. These seem to be parts of square or rectangular bases or stands. These perforations were made by first scratching out the design on the unbaked clay to guide the work of the cutter. Perforations of this kind are also found in the later Chalcolithic cultures,

usually on stand, and were probably useful in reducing the weight of the jar-stand. But at times they were merely of decorative value.

(5) *Graffiti*. Pot-marks and graffiti were supposed to be rare at Mohenjo-daro. But subsequent excavations by Mackay have produced a fairly good number. Graffiti is usually a roughly incised mark or decoration after the pottery is baked. Of such marks the most interesting is the representation of a boat. The latter has a sharply upturned prow and stern and seems to be controlled by a single oar. The mast, may possibly be a tripod, while a line represents a furled sail. Very similar boats still ply in the Indus. And though the high prow and stern would be specially suitable to a river-boat so that cargo could be safely landed on a shelving bank. Similar boats were also used elsewhere for sea traffic. (Mackay 1938, I, p. 183).

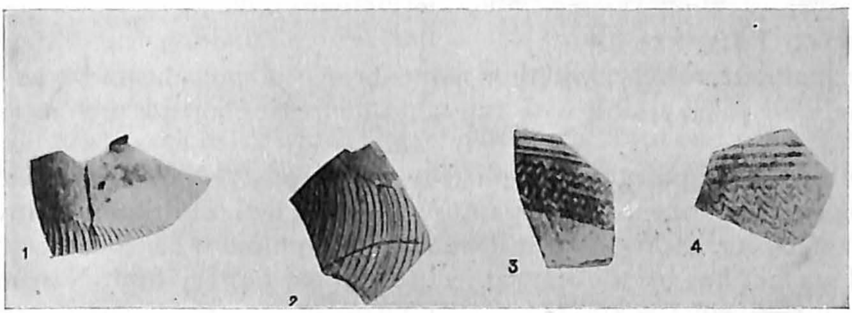

FIG. IV. Incised (1-2) and Reserved (3-4) slip ware. Mohenjodaro. Mackay, *Mohenjo-daro*, 1938. pl. lxvii.

Later excavations again revealed such incised specimens from the lower levels. Mackay illustrates and describes in detail a few typical ones. A slipless, grey ware of medium thickness was decorated with long curved lines by means of an edged tool which slightly raised one side of each cut, rather like the clods turned up by a plough. The same tool was then lightly run at right angles across the ridges thus produced, so as to give a toothed effect. Several patterns recall shells, and some of these were actually made with a shell as a tool (Mackay 1938, I, pp. 184-86).

(6) *Impressed Decoration*. This is included by Mackay under incised decoration. The former consists of motifs or designs which were first prepared in a wooden stamp, and this was impressed on the clay before baking.

(i) GLAZED WARE

This kind of pottery which is a characteristic of early Islamic Period (*c*. 900-1400 A.D.) is found as early as the lowest levels of Mohenjo-daro, Lothal and occurs on surface at several Harappan sites in Kutch. These are all of a light grey ware, covered with a dark purplish slip which had been carefully burnished. A glaze was then applied to the surface, but before being fired, a portion of glaze and slip were removed with a comb so as to form straight or wavy lines as a decorative pattern. Such pottery has been compared with the reserved slip ware from the Mesopotamian sites.

(j) Reserved Slip

A few sherds of the "reserved" ware were found in the lower layers of Mohenjo-daro. Later also at Lothal, Desalpur and other sites. (Fig. IV, 3-4)

In the so called "reserved slip" five processes or stages are involved.

(1) Coating of the pot, after modelling with a coloured clay.
(2) Burnishing of the coated surface with a blunt instrument.
(3) Application of a slip and drying of the pot in the sun.
(4) Removal of a part of the slip by a comb-like tool, thus creating a pattern or design.
(5) Firing of the pot at a high temperature.

(k) Painted Pottery

The painted pottery, whether monochrome or polychrome, was made of the same kind of clay, and with the same tempering agents such as sand and lime.

Normally, the paint was applied to an already polished slip; that is, the polishing was not done after the painting of the design. For the paint invariably has a mat surface, and whenever it was thickly applied it has a distinctly raised effect. This fact has been observed in the painted pottery from Navdatoli and Nevasa, Jorwe, etc.

(l) Paints

The pigment commonly used was a manganiferous haematite which burns into a warm or purplish black, according to the iron contained in it. The same pigment is used for the painted pottery in Sind today. For the polychrome ware a red ocher was also used and sometimes a green pigment, *terre verte*.

(m) Brushes

The slips were probably applied with mops and hair brushes of varying fineness for painting the designs. For certain details, as for example to hatch the leaves, Mackay thinks that a reed pen was used (Mackay 1938, I, p. 315).

(n) Painted Designs

Of all the painted designs, a favourite design of the Mohenjo-daro artist was the "intersecting circle". And this required probably some knowledge of geometry, and instruments for drawing it.

The design was first set out by means of a pointed tool whose marks are still to be seen. A number of vertical lines were first drawn dividing the surface of the jar into more or less equal panels; there are three of these lines on the sherd at distances of 2·69 and 2·58 inches. apart. With their centres on these lines, intersecting circles were scratched, apparently with a pair of dividers. There are no horizontal lines, as all that was necessary to set out the pattern was to mark off the centres of the circles on the vertical lines. By bisecting the distance between them, the levels of the centres of the circles to be placed between the lines were easily fixed. The diameters of the circles are not uniform, suggesting that the instrument used to scratch was not a templet*, and probably loose at the points (Mackay 1938, I, p. 221).

The pots of various shapes and sizes were made as follows:

Majority of the vessels have a flat base, so that these could be placed easily on flat brick-paved floors. These flat bases show a focussed grooving which is due to the cutting-off the jar from the wheel with a string. This was done when the jar was slowly revolving. The string was either held between the two hands or one end was tied to the little finger of the potter and the other stuck against the base of the vessel to be removed. As the jar was turned on the wheel, it was automatically cut off.

Vessels with carinated (angular) shoulders, were made in two pieces, which were fitted together when wet and placed on the wheel for a final trimming up. Sometimes the neck of the jar was also made separately.

Likewise censers or offering stands (dishes-on-stand) were made on the wheel, and in two sections, of which the stem and base form one and the pan the other. The joints were carefully luted, and Mackay surmises that the stand was placed on the wheel for a final trimming up.

These offering stands are coated with a thick slip, which was beautifully polished that it looks like lacquer.

These offering stands are of various sizes, varying from a height of 3 in. to over 2 ft. Some have an elaborate stem, with a ball-like moulding at the top of the stem. This might have been devised, conjectures Mackay, to prevent the hand coming into contact with the hot pan. Or, as we think, to facilitate handling, specially when the pan above contains some offering.

(o) Kilns

Out of the two kilns, noticed so far at Mohenjo-daro, the more intact one (found in DK Area, Block 2, House III) was elliptical on plan (though it is felt that the shape was not intentional). It measured 6 ft. by 4 ft. 9 in. inside. The height is unknown. Mackay reconstructs it working as follows: "A pit for the wood or reed fuel was prepared. Over this was a domed compartment to hold the vessels to be baked. Communication between the two was effected by round holes in the floor of the upper chamber (see the more intact kiln from Lothal (Figs. V-VII).

These kilns worked on the principle of a closed oven. Its advantage over an open oven or kiln was that after concentrating the heat it could be graduated by flues according to the needs, with a corresponding saving in the fuel, and the avoidance of smoke stains. The result was that all the pots, even the largest with a thick wall over an inch in thickness is fully baked.

It is therefore surprising as Mackay observes that the Sind potters today use an open kiln but produce equally good pots. He therefore concludes that the

* Pattern or gauge in the form of a thin board or metal plate used to guide in cutting or drilling.

successful baking of pottery does not always depend upon the type of furnace, though the more elaborate the furnace, the less the fuel needed and the fewer the cracked and misshapen vessels (and he adds that nobody has ascertained

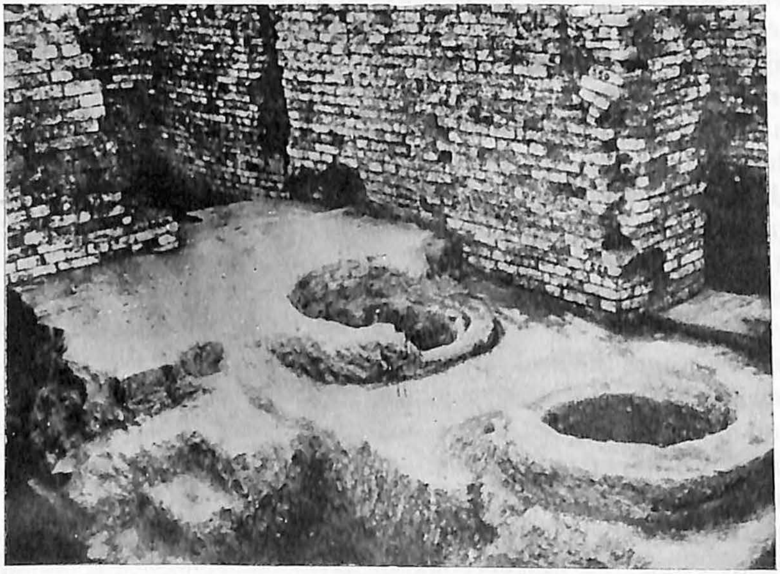

FIG. V. Kilns from Mohenjodaro. Mackay 1938, pl. xxxv (a).

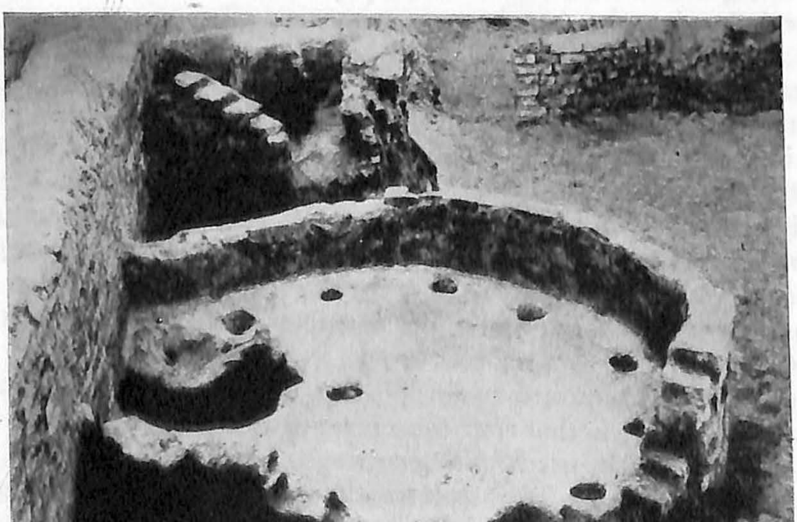

FIG. VI. Kiln from Mohenjodaro. Mackay *Mohenjodaro*, 1938. pl. xxxv (d).

how many vessels were spoiled in an open furnace) (Mackay 1938, I, pp. 176-78).

It is interesting to note that an identical type of kiln is at present current in a potter's village known as Gauf Kral in Kashmir.

FIG. VII. Kiln for baking earthenware. Lothal. (After S. R. Rao)
(Identical Kiln is still being used at Gauf Kral (Potter's village) near Srinagar, Kashmir)

(p) Pottery from other regions

Panjab

The same stages as known in Sind, are also available for the Panjab, but the earliest stage is not yet well documented.

Rajasthan

This should be viewed separately:

(*a*) Northern Rajasthan.

(*b*) South-eastern Rajasthan.

In (*a*) Northern Rajasthan, the same stages as seen in Sind and the Panjab are witnessed, though the earliest so far known—Kalibangan—does not have hand-made pottery as in Sind and Baluchistan, but fine wheel-made pottery only. This is indeed strange, for at least some large storage jars should have been made by hand.

(*b*) South-Eastern Rajasthan.

Here at Ahar a very interesting and instructive evidence of pottery technique is witnessed. Not only the deluxe table-wares, the white-painted black-and-red ware and red ware with its various shades, but the medium-sized storage jars were made on the wheel, at least the portion above the shoulder and the neck. The lower portion, almost uniformly is rusticated with sand, so that it is not possible to say confidently whether this was fully hand-made, or first made on the wheel, and later roughened by hand, obliterating all evidence of pottery on the wheel. This feature is seen in the later black-painted red ware with their highly contrasting surfaces: the upper smooth and red, the lower coarse and light brown or earth coloured. However, some of the large basins were handmade, though other—a fine grey and black—one was wheel-made throughout.

The details regarding the white-painted black-and-red ware are as under (Personal communication from Majumdar):

1. Ware: Black and red (white-painted)
2. Locality: Ahar
3. Period: Chalcolithic
4. Colour: Upper Black and Red, Reddish Yellow 10 R, 2·5 YR: 5 YR; 7·5 YR.
   : Under: Black and Dark Grey
   : Section: Black Grey
5. Hardness: 4/5, Moh's scale
6. Temper: Very fine sandy material, no plant material seen
7. Slip: Thick slip
8. Wheel marks: Seen
9. Polishing: Present, semi-lustrous
10. Painting: White painting mainly on the black surface
11. Firing: Either single, or double redox firing; not so perfect.

For further details see Sankalia *et al.* 1969, pp. 18-28.

E. Panjab and W.U.P.

The earliest pottery, as revealed by excavations at three or four sites, is the OCP (Ochre Coloured Pottery), associated with the

(*a*) Harappans;
(*b*) Incised Ware of Bara type;
(*c*) Red Ware with evanescent slip;
(*d*) Cemetery-H-like pottery
(Krishna Deva, *Pottery Seminar Paper*, Patna, 1968 *Ed.* Sinha 1969).

Fabric:

The OCP has generally:

(*i*) a thick fabric (common)
(*ii*) a thinner fabric (rare).

Clay: Well levigated.

Firing: Well fired at high temperature, only the core grey.

Weathering: This appears to be due *not* to rolling in water or water-logging, but due to prolonged exposure, and deposition over it of wind-borne silty sand. (Lal, *Pottery Seminar Paper*, Patna, 1968, *Ed.* Sinha 1969).

Madhya Pradesh

Here now there are several wares. In the chronological order we have:

(*i*) the Kayatha;
(*ii*) white-painted Black-and-Red Ware;
(*iii*) the Malwa Ware and its associates,
(*iv*) the Jorwe Ware;
(*v*) and the Painted Grey Ware, the NBP and its associates. Here some details regarding three wares (*i*) Kayatha, (*ii*) Malwa and its associates and (*iii*) White-slipped ware, are given (Majumdar, personal communication).

(i) Kayatha Ware

1. Ware: Kayatha ware
2. Locality: Kayatha (M.P.)
3. Period: Chalcolithic
4. Hardness: 4/5 Moh's scale.
5. Colour: Upper (slip) surface:
Reddish brown/dark grey/very dark grey/Black; 5 YR, 2·5 YR, 7·5 YR.
Under. Reddish Yellow/5 YR, 7·5 YR.
Section. Yellowish Red 5 YR.
6. Temper: Plant material probable; little grass seen
7. Slip. Thick slip (reddish brown/dark grey/very dark grey/Black) Munsell 5 YR, 2·5 YR, 7·5 YR.
8. Wheel-marks. Seen
9. Polishing: Feeble marks, non-lustrous
10. Painting: Red painting on slipped surface
11. Firing: Oxidizing perfect, fairly good metallic ring.

(ii) MALWA WARE

1. Ware: Malwa
2. Locality: Navdatoli (NVT)
3. Period: Chacolithic
4. Colour:
   (*a*) Upper: Varying: 5 YR/2·5 YR
   (*b*) Under: Varying: 5 YR/7·5 YR
   (*c*) Core: Black/Grey.
5. Hardness: 4/5, Moh's scale
6. Skip: Medium thick slip
7. Wheel marks: Seen
8. Polishing: Present, semi-lustrous
9. Firing: Oxidizing, not so perfect, no good metallic ring
10. Painting: Blackish Brown
11. Temper: Plant material mainly grasses.

(For further detail *see* Sankalia *et al.* 1958 and 1970-71).

(iii) CREAM SLIPPED MALWA WARE

1. Ware: Cream-slipped Painted Malwa
2. Locality: Navdatoli.
3. Period: Chalcolithic
4. Hardness: 3/4 Moh's scale
5. Colour: Upper:
   Reddish Yellow (sometimes grey)
   with Black/Brown painting; 5YR: 7·5 YR, 10 YR
   Under: Same without painting
   Section: More red than both the surfaces
   5YR: Many times greyish core
6. Temper: Plant material mainly grasses
7. Slip: Thick slip (white/reddish yellow). Probably this difference is due to the varied thickness of a kaolin-based slip.
8. Wheel-marks: Seen
9. Polishing: Feeble marks
10. Painting: Black/Brown-painting on upper surface
11. Firing: Oxidizing, not so perfect. No good metallic ring.

Uttar Pradesh

1. The next important pottery group is the Painted Grey Ware. Though wheel-made and having thin walls, with finely levigated clay, "possibly without any degraissant," the technique by which it was so uniformly fired grey (and at places reddish) has not been understood (Lal 1954-55, p. 32). Though firing under reducing conditions is obvious, still there must have been perfect control. How this control was achieved is not yet known. Ballabh Saran (1968) has tentatively suggested that

(*i*) the pot was twice on the wheel; or first on the wheel, then removed when it was leather hard, and then attached to the lathe of some kind, and its walls reduced with a scraper. Such "Open type" vessels with egg-shell thickness are made at Azamgarh.

(*ii*) the colour of the pottery as inferred by Sana Ullah (1934-35, p. 88) is due to the black ferrous oxide produced by the action of reducing gases in the kiln.

Kausambi

Period I (*c.* 1300 B.C.-1000 B.C.)

The earliest pottery falls into five sub-groups:

(IA) Red (most common), occasionally painted in black pigment
(IB) Sturdy grey-buff ware (small percentage)
(IC) Coarse black-and-red ware
(ID) Incised ware
(IE) Coarse black ware.

IA Type

(*a*) Sturdy red ware
(*b*) Wheel-made
(*c*) Clay mixed with straw, sand and lime
(*d*) Well fired, with orange core
(*e*) Occasionally painted in black
(*f*) Bowls (various types), dishes, basins with ridges, goblets, beakers, storage jars.

IB Sturdy grey-buff ware

(*a*) Wheelmade
(*b*) Black slip on a smooth surface
(*c*) Paring technique on the surface.

IC-IE Coarse black and black-and-red ware

Only fragments—shapeless.

(*a*) Made on a slow wheel (?)
(*b*) Very coarse clay with rough organic material including stone pieces
(*c*) Inverted firing at a low temperature
(*d*) Traces of black slip
(*e*) Occasionally white paint on a black slip.

Period II with three sub-groups (*c.* 1000 B.C.-900 B.C.)

IIA Type

(*a*) Red Ware
(*b*) Made on a fast wheel
(*c*) Micaceous ocherous slip on both sides
(*d*) Occasionally painted in black or white, usually on the exterior, but at times on the interior
(*e*) Bowls, dishes, bowls-on-stand, dishes-on-stand, basin, rimless and neckless vessels, storage jars, carinated cooking vessels.

IIB Black-and-Red Ware
(*a*) Well-levigated clay
(*b*) Inverted firing.

IIC Incised Ware
Affinities: Late Harappan and Central Indian etc.

Period III
There are four sub-groups.
IIIA Painted Grey Ware.
IIIB Black-slipped Grey Ware
(*a*) Made on a fast wheel
(*b*) Smooth black slip and perhaps burnished
(*c*) Pervious texture
(*d*) Bowls and dishes
(*e*) Ancestor of the NBP (?)
(*f*) Many sites in Western U.P.

IIIC Plain Grey Ware
IIID Black-and-Red Ware
Similar to Period II
IIIE Red Ware with two fabrics
(*a*) Coarse Red
(*b*) Bright slipped Red Ware

IIIF (*a*) Partly handmade
(*i*) Rims wheelmade and luted, which bears dabber-marks
(*ii*) Clay mixed with husk and mica
(*iii*) Well-fired
(*b*) Wheel-made
(*i*) Well levigated clay
(*ii*) Well fired
(*iii*) Bowls, dishes, basins, large storage jars.

Additional details of these wares as worked out by Majumdar at the Deccan College are as follows:

1. Ware: Painted Grey Ware
2. Locality: Atranjikhera (U.P.)
3. Period: Earlier than NBP (Chalcolithic ?)
4. Colour: Upper surface has uniform shades of grey, occasionally blackish stains
   Painting: Black
   Under: Same with painting in black
   Section: Same colour
5. Hardness: Same as that of NBP
6. Temper:

7. Wheelmarks: Same as that of NBP
8. Polishing: Feeble
9. Painting: Black painting on either surface
10. Firing: Reducing, with a perfect control of the kiln to stop at uniform grey
11. Slip: Thin self-slip.

3. The so-called Northern Black Polished ware (NBP) with its main sub-variations, the golden, silvery and steel grey succeeded the Painted Grey Ware. The NBP has undoubtedly evolved and reached its final culmination from the PGW or the Black Polished (as at Kausambi, Hastinapur etc.) Ware. Though some notable experiments have been made in understanding the technique by which this exquisite pottery was made, still its technique of manufacture remains a mystery. Bharadwaj (1968) seems to agree with the previous views of Sana Ullah and Lal that (*i*) the black colour in the case of the true NBP is due to the addition of carbon, (*ii*) whatever the substance, it is neither ferrous nor magnetic as inferred by Hegde. (For references *see* Bharadwaj 1968).

In addition, the analysis made by Majumdar has been given below:

1. Ware: NBP
2. Locality: Kausambi, Masaon etc. (U.P.)
3. Period: Borderland of Chalcolithic and early historic (Iron Age)
4. Colour: Upper: Varying, mainly black, silver, golden, steel-blue, coppery metallic shades occasionally
   Under: Same
   Section: Grey/dark grey
5. Hardness: 3/4 Moh's scale
6. Temper: No purposeful addition of any material (except what may be present in the natural clay used) apparent
7. Wheelmarks: Seen
8. Polishing: Lustre so uniform as not to leave any marks
9. Painting: Occasionally painted NBP (black & red) encountered
10. Firing: Reducing, fairly good
11. Slip: Thick slip present.

Bihar

Here the sequence is different from that known from U.P. So far, no clear instances of the OCP or the Indus-like pottery have been known. A Black-and-Red ware is said to precede the NBP. This is mostly wheelmade. Though there are a few instances of handmade ware, there is also the simple black-slipped or polished ware. Both these are again table wares, consisting of bowls and dishes, probably wheelmade. But whether the colour effect is due to its being fired in reducing conditions, or double firing, remains to be ascertained. There are coarse red, black and black-and-red ware. But none is scientifically examined yet (Sinha 1968).

West Bengal

Pandu Rajar Dhibi and several other sites. Of these, a brief report of the first site is available. Here out of four periods, the first three are called protohistoric.

Period I

(1) Coarse grey or red ware, sandy fabric with paddy-husks in the core. Handmade.
(2) Pale red ware with hatched cord designs.
(3) Black-and-red ware, rolled. Bowls and vases.

Period II

(1) Finer black-and-red ware with varied painted motifs.
(2) Lustrous red ware, often painted in black.
(3) Painted and plain red slipped ware, sometimes painted in white or cream.
(4) Painted chocolate ware.
The shapes include bowls of various types, basins, channel-spouted bowls, tulip-shaped vases with perforated bases, dishes-on-stand, high-necked and storage jars.

Period III

Most of the fabrics and forms of Period II continue in this period. A noteworthy new shape is:
(1) Bottle-shaped flasks with a bulbous body (Dasgupta 1966).

Andhra, Madras, Mysore

Phase I.

The earliest pottery falls into five sub-groups.
(*a*) Pale grey
(*b*) Grey ware
(*c*) Grey ware, with ochre painting after firing
(*d*) Brown ware
(*e*) Buff- slipped ware.

All these wares were potted on the hand, without a wheel or a turn-table. The clay is fairly well-levigated, and must have been collected from the nearby pools, as observed by us at Tekkalkota. To this was added quartz powder, which might have been specially made by crushing quartz pebbles which are easily available, or by mixing finely sifted sand. There is mica too. Both these give a glittering surface to the vessels. (Nagaraja Rao and Malhotra 1965, p. 36).

The whole of the outer and a part of the inner surfaces (as far as the hand could reach) were burnished with stone or bone. This burnishing becomes infrequent in Phase II.

Some sort of slip was applied in the case of pale grey and the buff ware, though its exact nature has not been ascertained. As at Ahar the surfaces of coarse brown, grey and dull red wares were rusticated or roughened. This seems to have been made with a rag or grass and some abrasive, such as quartz powder or very fine sand.

The technique of luting tubular or recurved spouts was mastered, so that no sign is left on the surface.

Handles and lugs were made in a peculiar way. These were not specially made and luted to the vessel, but when a rim of a pot partially broke, the sides and edges were ground to make a sort of a lug or a handle. (Nagaraja Rao and Malhotra 1965, p. 36, fig. 201).

Large storage jars (burial urns) were probably made on date-palm mats by the building method. This is also witnessed at Nevasa.

Phase II

In Phase II appears a black-and-red ware, usually associated with burials. And this is inferred to be made on a turn-table (Allchin 1960). In rare cases, it is found painted in white on the inside. A reference should also be made to legged and perforated vessels. The perforation was done when the pot was still green, so that the clay has come out on the other side, and the holes are not uniform.

The legs seem to have been carefully luted.

Recently a painted pottery from Patpadu, Andhra has been claimed to be handmade. This awaits a fuller scientific study (Sarma 1967 and Rao 1968).

Later, by about the fifth century B.C., if not earlier, a beautiful black-and-red ware or a pottery with black top and red body or bottom came into existence with the introduction of iron. This black-and-red ware is so far believed to be due to the technique of inverted firing in the usual potter's kiln.

However, experiments by Majumdar (1968), show that the idea of the inverted firing technique is purely theoretical. Three methods have been found to produce such a pottery. These are:

(1) *Single firing:* In this the inner surface and the rim portion of the outer surface is subjected to reducing conditions, rendering both black, and the rest of the portion to the oxidizing condition making the outer surface red, in one and the same kiln.

(2) *Double firing:* (*a*) First, the entire pot is subjected to firing in oxidizing kiln in the usual way, thus the whole pot turns out red. After cooling, it is again subjected to second firing in which a part of the surface (inner and part of the outer surface) is made to face reducing conditions, and the red of the pot to oxidizing conditions: (*b*) This time the entire pot is made black in the reducing kiln and during the second firing a part of the surface is subjected to reducing conditions, and the rest of the portion, to the oxidizing conditions.

Such a black-and-red pottery is an integral part of all the early historic cultures of peninsular India, and not only of South India. Further, a black-and-red ware occurs as antecedent to, or contemporary with, the PGW in the whole of northern Rajasthan and western U.P. and Bihar and West Bengal.

But still earlier a black-and-red ware painted in white is found at Ahar, S. E. Rajasthan; Kayatha, M.P. and Lothal and Rangpur (Saurashtra). Without a detailed scientific examination of each of these wares it is difficult to say what particular technique was followed in each case.

So far the pottery types have been pressed into service for drawing inferences regarding cultural affinities, but these too are inadequate, and cannot serve the place of true scientific investigations.

Maharashtra

Perhaps the earliest pottery found in this region is at Daimabad, Ahmadnagar District. This is not yet fully published, but appears to be related to that of Andhra-Mysore. If so, it is likely to be made by a similar technique.

Later this was followed by a pottery which is called Jorwe-Nevasa, after the type sites in the same district. Its distribution now encompasses the whole of Western Maharashtra, with outliers in M.P. and Mysore.

This characteristic pottery has normally matt surface, with generally a few geometrical motifs painted in black round the shoulder. Occasionally, the surfaces might be more smoothly burnished, and the slip brighter, or thicker. It is wheelmade, and from the uniformity of the striations seems to have been made on a fast wheel (though it is impossible to say whether this was hand or foot-turned). The clay was well levigated, and mixed with a little lime and sand. But above all it was well fired, how we do not know, so that there are no blotches on the outer surface. The core is uniformly red (though not as in the Harappan) and the pot rings when struck. A kiln was discovered in the excavations (1968-69) at Inamgaon, Poona District. This belongs to the Late Jorwe phase. The kiln is made, as so often noticed in the modern potter's house, with broken pots stacked over one another. The intervening spaces are filled with ash.

Another feature of the Jorwe-Nevasa pottery is the predominance of a vessel type—usually a *lota*—with almost a vertical tubular spout. These spouts were separately made and inserted into the cavity on the body or the belly and carefully luted.

Scientific analysis of the Jorwe fabric (Majumdar 1968) is as under:

1. Ware: Jorwe
2. Locality: Nevasa
3. Period: Chalcolithic
4. Colour (*a*) Upper: Dominant shade
   (*b*) Under: Weak red to red
   (*c*) Core: Munsell card IOR
5. Hardness: 4/5, Moh's scale, for major area
6. Slip: Thin slip
7. Wheel marks: Seen
8. Polishing: Present, non-lustrous
9. Firing: Oxidising, perfect, metallic ring
10. Painting: Present, black/brown/purple shades
11. Temper: Sandy material, no plant remains (For details *see* Naik in

Sankalia and Deo, 1955, and Deo and Ansari in Sankalia *et al.* 1960).

Gujarat

In Gujarat, including Kutch, the earliest pottery is the Indus or the Harappan, though the lower layers at Lothal are said to have yielded a "micaceous Ware." No detailed study of this ware is available. The Indus Ware was baked in closed kilns and shows the same features as in Sind. With it is also associated a black-and-red ware, but with Indus shapes. No scientific study of this seems to have been made.

(q) THE LUSTROUS RED WARE

Later at Rangpur in Periods II B-C and III occurs a distinctive pottery known for its peculiar surface treatment and graceful forms. It is wheelmade and characterized by a lustrous slip showing shades of deep- and orange-red. The clay is not well levigated and comprises grits, so that the fractured surface is straight but rough. Fired at medium temperature, the core is often smoky. The smooth burnished shiny surface carries painted designs in black colour which shows no fusion with the body. The paintings are geometric as well as those of stylized animals.

The shapes include concave-sided bowl, stud-handled bowl, dish-on-stand, dish with carinated shoulders, high-necked jar.

According to the Archaeological Chemist in India, the lustrous surface was the result of fine, smooth burnishing, which was given a slip of finely-levigated red ochre. Probably in the green state, the pot was subjected to burnishing with pebbles of haematite, which left a fine powder of iron oxide securely adhering to the surfaces. The pot was then fired in oxidizing atmosphere. The decoration in black was evidently post-firing, as the black pigment does not show any evidence of sintering and does not stick firmly to the red surface. (Dr. B. B. Lal in Rao 1963, p. 136 and Fig. 34 and Pl. XXII).

A few sherds of the Lustrous Red Ware are found as far south as Poona, and north as Udaipur.

(r) SUMMARY

In summarizing the evidence from eleven major divisions of India, we might say that all the known techniques of making pottery were known in prehistoric India, between *c.* 4000 B.C. and 500 B.C., though the art of glazing known in the Harappan times, was for some reason not developed.

We broadly see the same stages of development; (1) the two or three methods of making handmade pottery, viz. (*a*) basket mould, (*b*) coil technique, or ring technique; (2) use of a primitive wheel, such as tournette or turntable, and (3) then the use of the wheel, slow as well as fast.

The art of potmaking had reached a high degree of excellence for, besides simple bowls and dishes and small or large storage jars, highly sophisticated types of vessels, such as offering stands of various sizes and shapes, handled and legged bowls, double pots, compartmental vessels and vessels with spouts, some exactly like our present day teapots, with careful luting of separately made parts, were also made. However, the near absence of vessels with handles and spoons so commonly seen in the Western Asiatic pottery might be noted.

The various methods of applying slips or washes, even the highly specialized art of reserved slip, were known, though the latter is seen but rarely in the Indus pottery only.

Some of this pottery, particularly the Baluch, the Indus, the Cemetery-H, and the Malwa and even the Deccan were painted, mostly before firing, so that the paintings have survived till today. A careful analysis of these paintings would throw light on the art of painting—the use of various kinds of brushes and the paints used (even their preparation). One may also distinguish the various styles, such as realistic, impressionistic, ritualistic or hieratic.

Earthen pots were also decorated besides painting by (*i*) incisions, (*ii*) applique, (*iii*) cutting, (*iv*) puncturing and (*v*) paring.

While all these methods were used before firing, only one, known as graffiti was used primarily after the pot was fired, though there are instances of pre-firing graffiti. The techniques of incision and graffiti may be traced to the earliest times (*c.* 3500 B.C.), its finest examples in the pre-Harappan of Sothi; all the rest are best witnessed at Ahar in Rajasthan by 1800 B.C.

The highwater mark of firing technique was reached during the Indus Valley Civilization, irrespective of the fact whether it was at Rupar in the Panjab, or Rangpur in Saurashtra. The control of firing seen in the Painted Grey Ware is also remarkable. Unfortunately we do not know whether these fine wares were the products of a specialized kiln, two roughly built samples of which were later found. The more complete was elliptical. It measured 6 ft. by 4 ft. 9 in. inside. Around the edge of its floor there were a number of flue-holes with an average diameter of 3·65 in. These are open-air kilns, as inferred by Mackay in the case of the Indus; and some control over the circulation of air in the case of the Painted Grey Ware is apparent. Both these pale into insignificance when we think of the Northern Black Polished Ware, which remains inimitable, as the precise techniques by which it was made still elude us.

B. Terracotta

The baked clay objects should go with pottery. Usually small objects—such as figures of animals, mostly bull, ram, and women—are found in many prehistoric cultures. For our purpose, we shall broadly group them into:

(1) The Indus or the Harappan; and
(2) Non-Harappan, including both (*i*) the Pre-Harappan and (*ii*) Post-Harappan.

As a rule all non-Harappan terracottas found from North Baluchistan as well as South Baluchistan and datable to a period between *c.* 2600 B.C.-*c.* 2000 B.C. are solid cast in a single-mould and then finished manually, or ***possibly completely handmade***. The same is true of those found from India proper, including the largest terracotta female figurine from Nevasa as well as smaller ones—

male and female, and animals from Inamgaon (1200 B.C.). These are all hand modelled (Sankalia 1963, Fig. 1).

(a) HARAPPAN TERRACOTTA

Modelling Technique

Unlike the human figures, many of the larger animal figures are hollow inside. Some of them must have been made on a core, but of what material the core was, it is as yet impossible to say, for the inner surfaces of the broken figures are uniformly smooth, though uneven. The core was clearly combustible, since it leaves no trace behind. There are always vent-holes in the unbroken figures, evidently made to permit the escape of the gases formed in burning the material of the core. Other figurines were made in a mould. It is easier to press a thin sheet than a thick mass of clay into the crevices of a mould.

With the exception of the mask-like faces and the fine bull which were certainly all made in a mould, the pottery figures of both humans and animals were entirely modelled by hand (Mackay in Marshall 1931, I, p. 349).

In the more elaborate models the details were added in various ways. Wrinkles in the skin are portrayed by means of incised lines, and heavy folds by the addition of strips of clay. The model animals are commonly painted and there is one spirited figure of a small dog covered with red spots and lines which recalls the modern Dalmatian dog.

Practically all the terracotta models were made of a clay that burned to a light-red colour, and only the better specimens were improved with a slip which was either cream-coloured or washed over with a dark-red paint (Mackay in Marshall 1931).

The majority of the toys were made of baked clay, a substance which can be easily modelled and baked even by the smallest child.*

Round terracotta rattles with small pellets of clay inside are well known at Mohenjo-daro. The one illustrated is among the best of those found. It is 2·55 inches in diameter and is of light-red ware decorated with parallel circles in red paint.

These rattles were probably made by wrapping the clay round a combustible core, in centre of which the roughly made baked clay pellets were placed to produce the sound. In every case they are hand-made, not moulded, and they are invariably well finished, but without a slip. They are found at all levels. In none of the rattles was there a vent-hole to allow the gases resulting from the combustion of the core to escape. Possibly the porous nature of the pottery would of itself permit a gas to pass through easily, and that may be the reason why these toys were not coated with a slip.

(b) WHEEL CONVEYANCE

A considerable number of terracotta wheels have been found in various

*MACKAY (in MARSHALL, 1931, I. p. 287) makes a similar statement about a few hand-made pots. However, it is doubtful if a child can bake pots and toys, even if we assume that a precocious child might make these.

parts of Mohenjo-daro and other Harappan sites. At first sight they might be mistaken for spindle-whorls, but that they are the wheels of carts and other toys is beyond a doubt.

Some terracotta chariot wheels found at Kish are very much like those found at Mohenjo-daro, the only difference being that the Sumerian wheels have a raised hub on both sides of the wheel instead of a hub on one side only, as was the rule in ancient Sind. It is reported that a spoked painted terracotta cart-wheel was found at Rupar. Another is illustrated from Prakash (Thapar 1967, pl. XXVIA, 1). We know for certain that the wheels of the Sumerian vehicles were built up from more than one piece of wood, and very much the same form of construction must be imagined for the wheels of the vehicles used by the Indus Valley Civilization, especially as the wheels of the modern Sindhi cart closely resemble those of Sumer, and like them were fixed to an axle that revolved with them.

C. Sculpture

All the statuettes from the Indus Civilization are made on stones—grey and yellow limestone, alabaster and in one case, steatite.

It is a moot point, at present, whether their faces were painted to make them look more life-like. On their smooth surfaces the colours, if they ever existed, may have disappeared long ago in the saline soil of the site. Traces of red paint, as a decoration, were found in the interiors of the trefoil ornaments of the shawl of the figure, but possibly only the dress was coloured. In this particular case a thick paste was used, and not merely a wash.

Other features indicate the very primitive nature of the statuary of Mohenjo-daro, but none the less, the art of sculpture had so far advanced as to separate some of the limbs from the body (Marshall 1931, C, 1-3).

A striking feature of these heads is the dissimilarity of the faces, which argues that they were intended for portraits. They are certainly not of a uniform type, as one would expect in statues of deities.

Apart from statues, the sculptors at Mohenjo-daro had little experience in the carving of stone. This and the lack of stone itself would be quite enough to account for their inability to express the human form in that material (Mackay in Marshall 1931, I, pp. 360-64).

(a) Sculpture in the round

The only other sculpture in the round from Mohenjo-daro that claims notice here is the bronze dancing-girl (Marshall, pl. XCIV, 6-8). This is a small figurine of rather rough workmanship with disproportionately long arms and legs. Almost, indeed, it is a caricature, but like a good caricature, it gives a vivid impression of the young aboriginal nautch girl, her hand on hip in half-impudent posture, and legs slightly forward, as she beats time to the music with her feet. Though this figurine is small, the modelling of the back, hips, and buttocks is quite effective and in spite of obvious defects shows sound observation on the part of the artist.

In the two statuettes, one of limestone (Fig. VIII) and the other

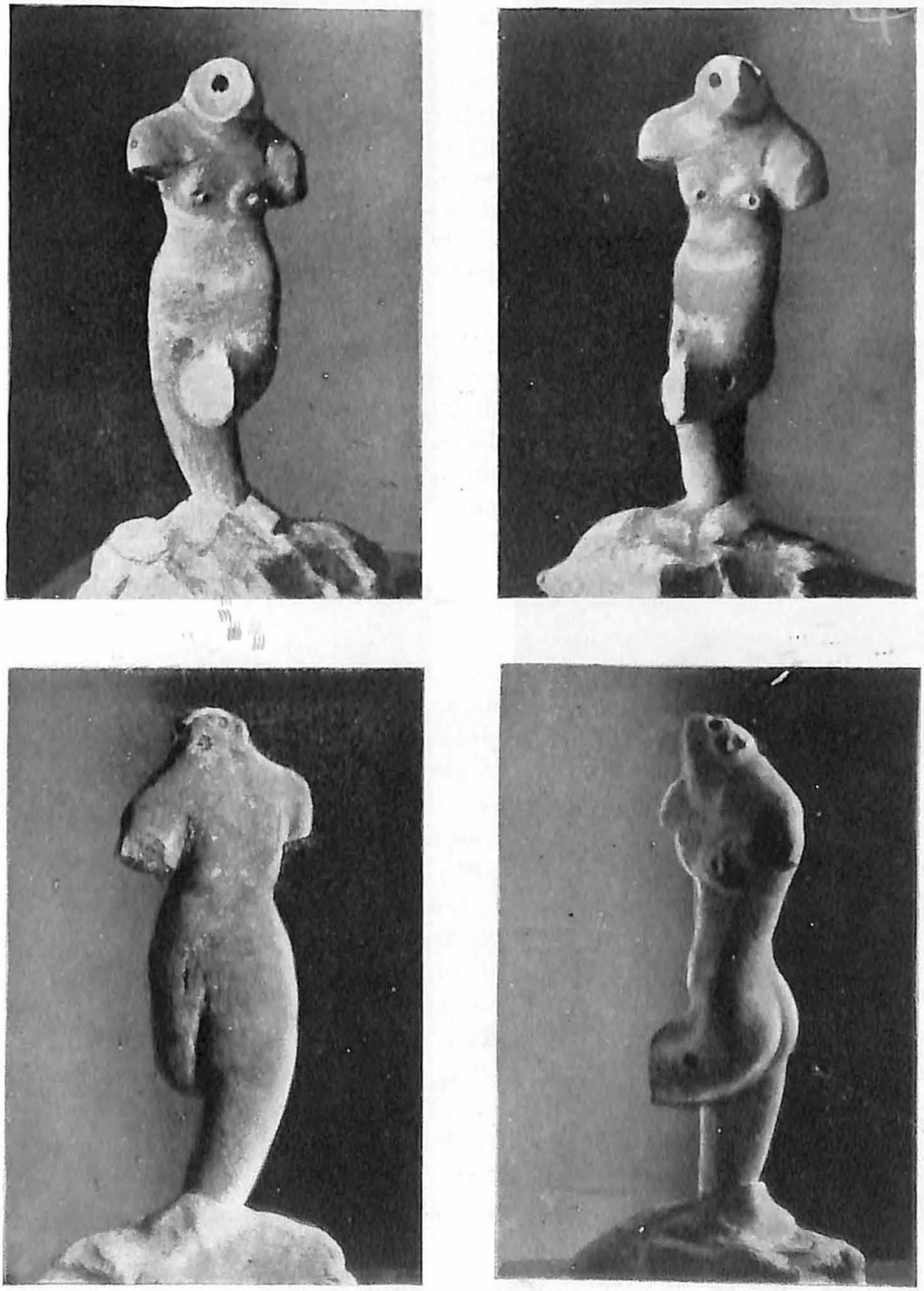

FIG. VIII. A female figure from Harappa illustrating the technique of making sculpture in the round.

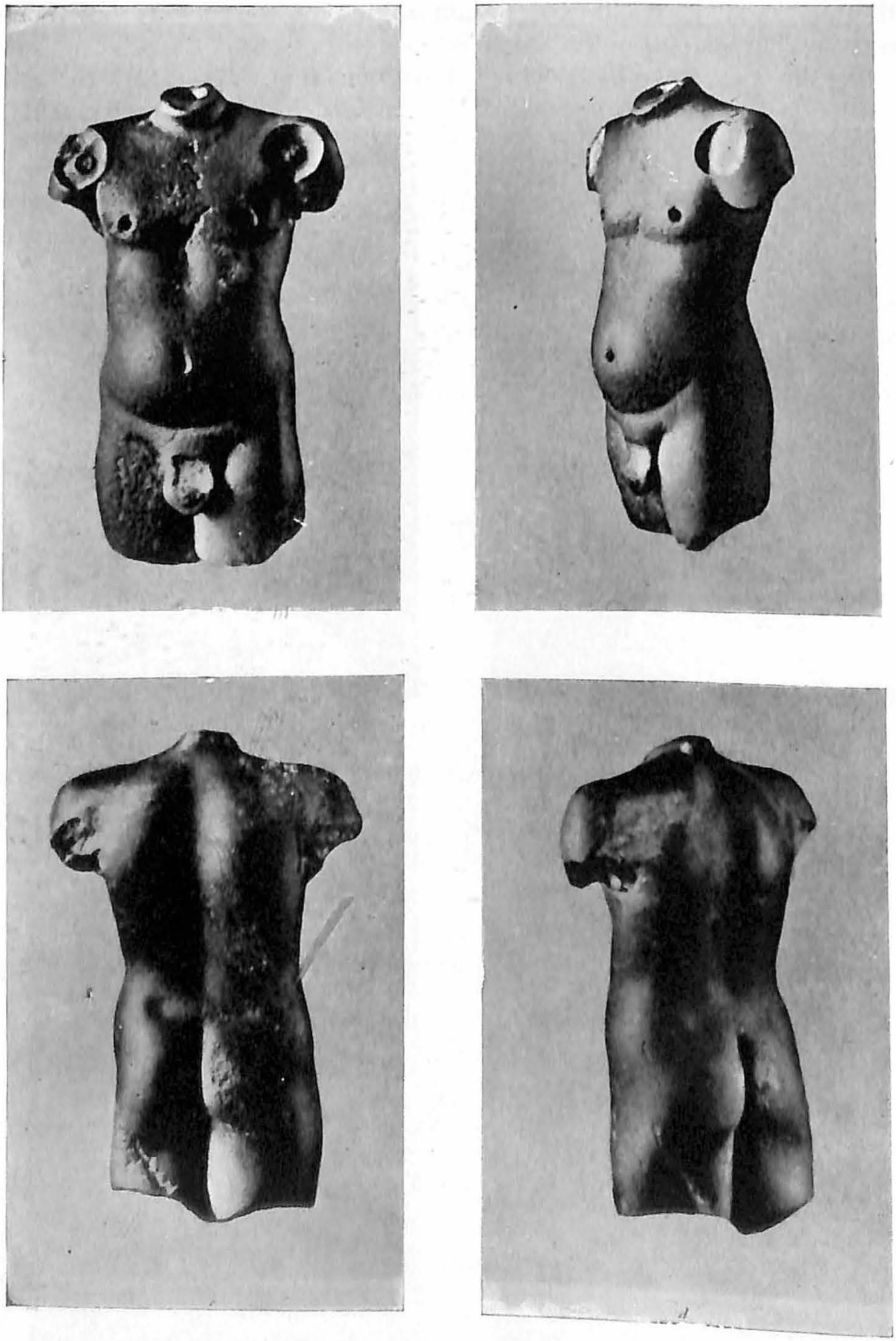

FIG. IX. Torso of a male figure from Harappa illustrating the technique of making sculpture in the round.

of sandstone. Fig. IX) there are socket-holes in the neck and shoulders for the attachment of the head and arms, which were made in separate pieces; and in both, moreover, the nipples of the breasts were made independently and fixed in with cement. This technique is believed to be without parallel among stone sculptors of the historic period, whether of the Indo-Hellenistic or any other school.

There is another point of technique that is also significant. In the red stone statuette (Marshall, pl. X) from Harappa there is a large circular depression in front of each shoulder, with a smaller circular protuberance broken off in the middle of it (Fig. IX). These depressions were made with a tubular drill, and that the tubular drill was habitually used by stoneworkers in the prehistoric, (though not yet found in any of the non-Harappan Chalcolithic culture), if ever, in the historic age. At Lothal has been found a twisted drill of copper/bronze (*See* Fig. X).

Thirdly, as to the style, the treatment of the red stone torso could hardly be simpler or more direct. The pose is a frontal one with shoulders well back and abdomen slightly prominent; but the beauty of this little statuette is in the refined and wonderfully truthful modelling of the fleshy parts. Observe, for example, in Fig. IX, *c* and *d*, the subtle flattening of the buttocks and the clever little dimples of the posterior superior spines of the ilium. Whatever it may have been, no parallel to this statuette is to be found among Indian sculptures of the historic period.

We know definitely that the Indus engraver could anticipate the Greek in the delineation of animal forms: and if we compare the statuette of Fig. IX with, for example, Seal 337, we must admit that there is a certain kinship between the two, both in the "monumental" treatment of the figures as a whole and in the perfection of their anatomical details. Experienced sculptors expressed the view that an artist who could engrave the seal in question would have had little difficulty in carving the statuette; archaeologists will probably take another view and prefer to wait for further discoveries before committing themselves.

A number of fine animal figurines have been found from Lothal and Kalibangan and Kot Diji in Sind, but at none of these Harappan sites a human figurine of the type found at Harappa and Mohenjo-daro has been so far reported. A recent author who claims to be an artist does not regard this red-stone figure in high esteem, though he would concede that it is an exercise in volume, and an exercise in the art of modelling (Guha 1967, p. 17).

Guha also does not much value the bronze dancer, particularly the flesh-less limbs, forgetting that a true dancer, a ballet one, has to be thin, careful enough not to allow much flesh and fat to accumulate on the bones. However, he has to grant "The mastery of the technical accomplishment, . . . in the vivid play of curve, counter-curve, angle and vertical"; but feels the absence of deeper feeling in the figure.

(b) Engraving

The art of engraving is best illustrated by the so-called seals of the Indus

Civilization, for, a majority are of steatite, a soft stone, though there are a few of copper also.

The steatite was carefully sawn, probably with a saw and then carved out with a burin or chisel-like tool. The seals were then coated with alkali, and baked in fire which gave a glaze-like coating, rendering them beautiful to look at, as well as more durable.

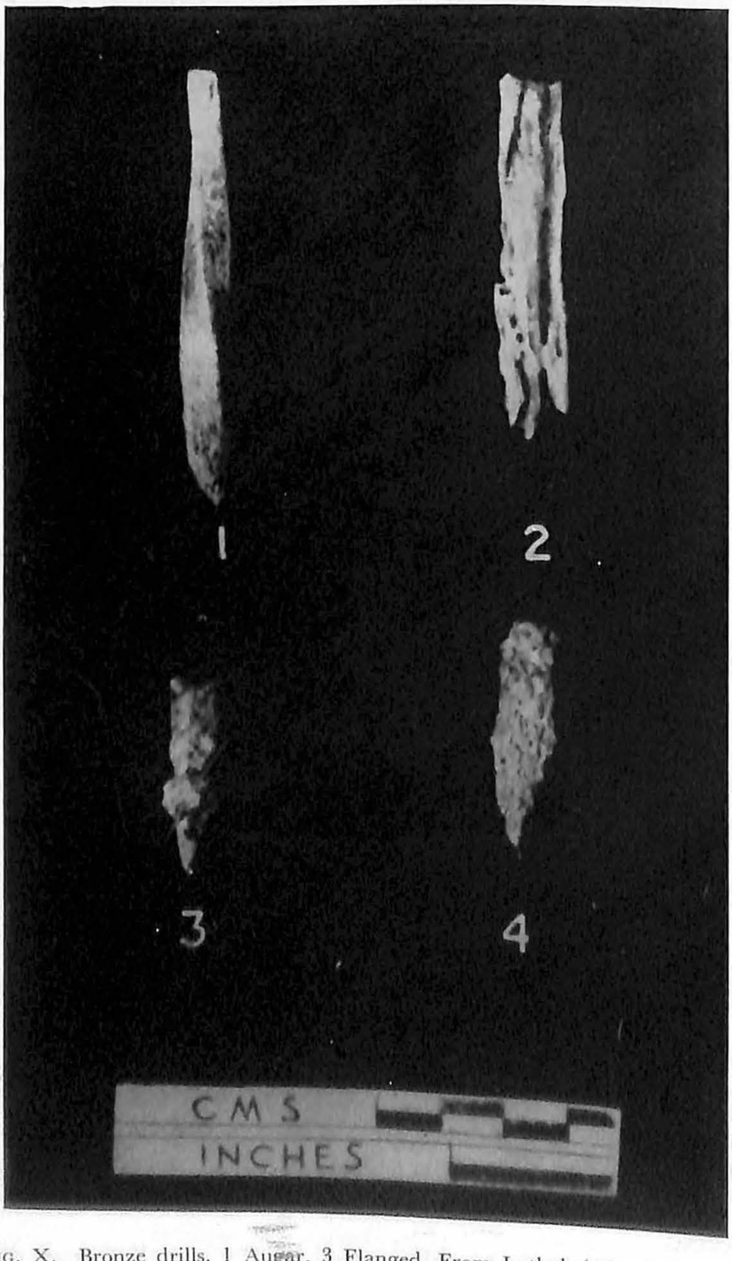

FIG. X. Bronze drills. 1 Augar, 3 Flanged. From Lothal. (After S. R. Rao.)

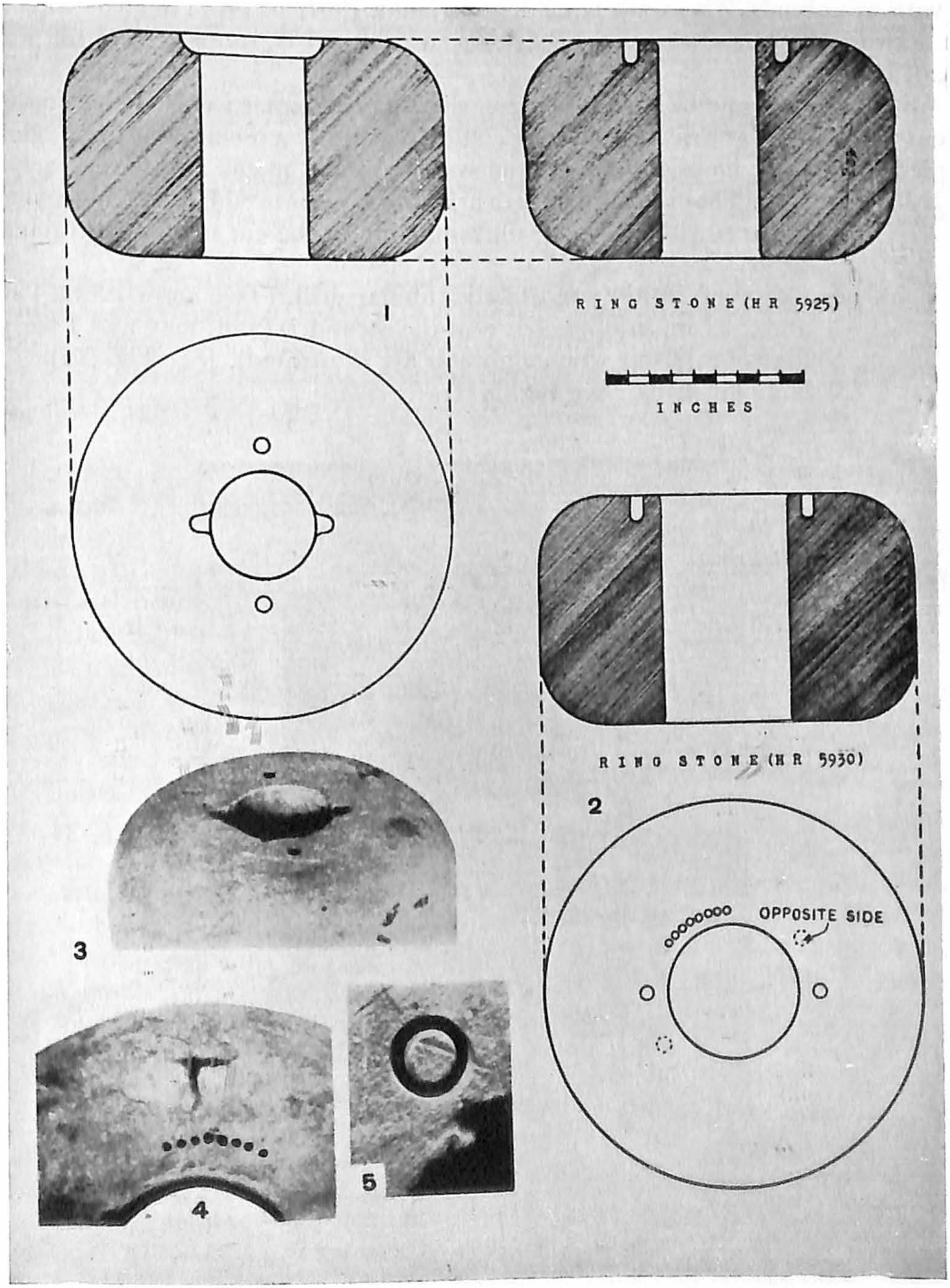

Fig. XI. Ring-stones showing the use of tubular drills from Mohenjodaro. Mackay, 1938, pl. CXLIV.

The engraving consists of pictographic script, as well as representation of various animals. These are not intaglio (Guha 1967, p. 24) in the true sense of the word, for the material in what these are carved is comparatively soft and not hard.

Small cups and toilet vessels of soft stone like alabaster were hewn or carved out with a tubular drill. These drills could be of either a metal tube, or a hollow piece of reed or bamboo and worked with fine sand as the abrasive (Mackay 1938, I, p. 323). That these inferences are justified is proved by the recovery of:

(1) Objects with the core still remaining in the cut made by a tubular drill.

(2) Cores left by the users of the tubular drill. (Two cores 1·3 in. long and 1·22 in. in diameter, and the second 1·75 in. long and 1·32 in. diameter of soft white alabaster are illustrated). (See Fig. XI)

(3) Tubular drills. (See Fig. XII)

FIG. XII. Tubular Bead-drills. Copper/bronze. Mackay, *Chanhudaro*, pl. XIII, 12-13.

Mackay makes a further interesting observation regarding the technique of making these stone and faience vessels. Some of these vessels were made in two or three pieces. These were later cemented together. A similar technique was prevalent in ancient Egypt. The reasons for such a practice was to have a cavity of considerable size inside the body but with a narrow mouth to prevent the drying of the contents of the jar (Mackay 1938).

D. Stone Vessels

Most of the tall jars were made on a lathe, as it appears from the remarkable regularity of their shape. The lathe was probably worked with a bow and a cord.

The interior of a dish was probably hollowed out by means of a specially shaped borer (Marshall 1931, pl. CXXX, 35*, and Mackay 1938, p. 317). The exterior was then roughly shaped afterwards and turned on a lathe, or the dish was laid upside down on a revolving horizontal wheel for the final trimming (Marshall 1931, CXLIII, 2).

E. Beads

All protohistoric cultures, and occasionally the Late Stone Age cultures, yield beads, which formed one of the main decorations as necklaces, head-bands and pendants for the prehistoric man. These beads consist of:

(*a*) Bones, teeth and ivory.
(*b*) Shells.
(*c*) Stone beads (usually semi-precious such as agate, carnelian, steatite and faience)

(A) Bones, Teeth and Ivory

Teeth are the earliest material man used, as evidenced from the Upper Palaeolithic sites of Europe, and Palestine. Not much artifice was necessary in making use of bones and teeth, except boring a hole in cases where there was no natural cavity. So far no such specimens have been found in India. This hole could have been made with stone points made either on a nodule or on a flake.

A few beads of ivory are reported from Harappa (Vats 1940, I, p. 433) and recently from Inamgaon, a Chalcolithic site in Poona District.

(B) Shells

Among shells, probably the earliest beads are from the Mesolithic or Early Neolithic site of Langhnaj, North Gujarat, where man had cut or broken in suitable size dentalium shell, and made beads of various sizes, as at Mt. Carmel in Palestine, and Khirokitia in Cyprus. The Langhnaj specimens are datable by C-14 method and comparable cultures date it to C. 2000 B.C. (Sankalia 1965, and Agarwal *et al.* 1969, p. 188). Later such beads occur in the Harappan levels at Rangpur (Rao 1963, p. 147, pl. XXXVI, 35 who called

*This reference seems to be wrong. For the plate illustrates a large, ovalish object with (convex) edges on the shorter sides, and a notch each on the longer sides.

them ammonites). In these beads, except careful cutting, no further art or skill was necessary. And this the man must have made with microlithic blades.

When exactly the man learnt the art of manufacturing bangles from the large conch-shells, called chank *sankha* (*Turbinella pyrum* Linn.) is not known. The earliest specimens in India are from the Harappan culture.

At the present day, the shell used in the manufacture of bangles is the sacred Indian *sankha* or conch (*Turbinella pyrum* Linn.), most of which comes from the Gulf of Mannar between India and Ceylon. It is said that 4,000,000 to 5,000,000 of these shells are imported into Madras and Calcutta in a year.

Most of the shells that have been found at Mohenjo-daro, are, however, of another genus (*Fasciolaria trapezium* Linn.), though one specimen of *Turbinella pyrum* has been recorded by Colonel Sewell. A single specimen is also recorded of *Turbinella pyrum, var. fusus Sowerby*. It is probable, therefore, that the people of the Indus Valley civilization obtained their shells from a number of places along the coast of India and the Persian Gulf.

Technique

The method of preparing the conch shell in modern India is interesting. According to Hornell, the columella is extracted by sawing off a slice of the lip and then breaking down with a hammer the septa connecting it with the walls of the shell. The apex of the shell is then smashed and the columella freed. This leaves a hollow tubular piece of shell which can readily be sawn into bracelets.

The iron saw used in India at the present day is worked by hand and is of deep crescentic form with a horn at each end of the upper edge. The thickness of the blade is 2 mm, except for a distance of 2 cm from the cutting edge, where it is thinned down to a thickness of 0·6 mm. The teeth of the saw are extremely minute, and dentate in form instead of serrate. The upper edge of the saw is reinforced by a piece of iron piping, whose weight doubtless assists in the cutting. The saw requires frequent resharpening owing to the hardness of the shell, but this process does not take very long. Hornell remarks that shell-slicing calls for the possession of a highly trained eye, perfect steadiness of hand and arm, and an iron-like capacity to sit for long periods in a position of great discomfort. On an average it takes four minutes to saw once through a shell.

After a section has been sawn off the inwardly projecting break, which is the remnant of the septum between adjacent whorls left after removing the columella, has to be chipped off with the greatest care; this part of the ring is its weakest point. A sharp-edged hammer is used for the purpose.

The rubbing down of the inside of the segments is done with a wooden spindle coated with fine river sand embedded in lac, several segments being smoothed down at the same time by a to-and-fro movement. All that then remains to be done is to polish the outer surface and to engrave it, if required, the tools used for this purpose being drills, files and small saws.

The manufacture of shell articles was evidently carried on in certain parts of the L. Area at Mohenjo-daro. No less than thirty-five shells were found in

Chamber 44; eleven shells in Chamber 53; fifteen shells in Court 69; twenty-four shells in Space 70; and twenty-three shells in Chamber 27; as well as smaller numbers in other parts of the area. Most of these shells were whole, but from some the columella had been removed, and from the condition of the latter it is clear that the columella was detached from the walls of the shell by means of a hammer, just as is done at the present day.

At Mohenjo-daro practically the whole of the shell was utilized. The walls were used for bangles, both wide and narrow, and the columella for making beads. For the simpler forms, such as disc-shaped or cylindrical beads, the columella was simply sliced up with a saw (Mackay in Marshall 1931, II, p. 564 and Hornell 1918, pp. 433-48).

From the present and ancient distribution of the conch (*Sankha*) bangles and its intimate relation with the Dravidian peoples, Hornell further inferred that this wide-spread custom or fashion was possibly pre-Aryan.

Shell-Inlay

The shell-inlay illustrated (Hornell Pls. CLV and CLVI, No. 12), gives the reader a very good idea of the capabilities of the shell-cutter at Mohenjo-daro. Most of the circular designs must have been cut from the columella of the shell and were limited in size by its diameter. Others of the designs were cut from the wall of the shell, but these pieces, if large, suffer from the disadvantage, that is its natural curvature rendered them barely flat enough for inlay work. In the smaller pieces, where thinness does not matter, this difficulty could be over-come by rubbing down one or both surfaces; but in the larger pieces this process involved the risk of fracture.

It is not yet known how these pieces of inlay were fretted out, for no unfinished specimen is found. There are three possible ways: by means of a small chisel or burin, by means of a fine saw, or by means of a drill. The third method would certainly have been the simplest. Yet the edges of most of the pieces of inlay show marks that might have been made by either a file or a saw. Possibly, when the shape of the piece had been outlined with the drill, a fine saw was used to complete the cutting and then a file to smooth the edge.

In most of the simple designs the outer edges of the pieces of inlay, whether of faience or shell, were slightly bevelled for keying. In the more complicated pieces, this bevelling was unnecessary; there was enough surface without it to hold the inlay in place.

Owing to the fact that wood perishes in a salty or damp soil, no pieces of furniture have been found with the inlay still in position. The thickness of these pieces of inlay varies. They were probably embedded in plaster. The surface of the latter would probably have been coloured to make a contrast with the cream tint of the inlay itself (Mackay in Marshall 1931, p. 565-66).

It should be added that the art of shell working practically died with the Harappans, to be revived much later in historic times. For, besides bangles and beads the Harappans manufactured a number of other objects including cups and dishes.

(C) STONE BEADS

The various stone beads could not have been made unless and until the technique of pressure flaking had been achieved by man, and also he had made such pointed drills of a material harder than the material worked upon. First, whatever the type of stone, it had to be converted into a suitable block, roughly of the size required for the bead. The nodules and pebbles might have been treated in natural or artificial heat as is done even today in Cambay, Gujarat for getting the right colour in the case of agates (perhaps also for softening the stone ?). These were even artificially tinted as observed by Mackay at Mohenjo-daro or made artificially.

Technique

Then, as in blade cores, first by free flaking, then controlled flaking and lastly by pressure flaking, rectangular blocks were prepared. This is evident from the discovery of such blocks at Ujjain, Navdatoli, Chanhu-daro, Mohenjo-daro, Atranjikhera and Inamgaon. In stages three and four, the block was first ground and made smooth by rubbing it on a sandstone or such rough surfaced flattish stone with a little water and some abrasive.

Polishing was done last. That these were the most probable or even the exact stages can be inferred by two ways. First, from the actual discovery of unfinished and semi-finished beads from a few sites mentioned above and second, by observing the technique still followed at Cambay.

When everything was ready, came the most important stage, of boring a hole, usually along the longitudinal axes, in the case of long, cylindrical beads. This is now done at Cambay with a diamond-tipped drill, electrically worked. But only a few years ago, it was hand-worked.

How the various prehistoric centres worked, we can only guess. That the hole was attempted from both ends is undoubted, for we find occasionally rejects, where the hole has not gone through straight. Probably, this was a long, and tedious process, but that it was independently attempted at several sites all over India, is proved by the discovery of unfinished and unbored specimens.

The manufacture of these stone beads does not introduce us to some new techniques, for it merely employs the various methods of flaking, smoothening and polishing discovered during the earlier stone ages. What might be regarded as new is the careful art of drilling a hole.

Lothal provides evidence of one more stage, in fact, the first stage before the agate and carnelian nodules were taken up for bead-making.

Naturally red agates (that is carnelian) are not easily available. Agates of yellowish or whitish, greyish hue have to be heated over a slow fire of cowdung and then exposed to the sun for some time. This practice is still current at Cambay. It appears that this fact was realized by the Harappans. For at Lothal is found a specially built ovoid kiln to heat agates and produce carnelians of glowing red hue. Here were laid bare a large courtyard with working platforms in the centre and several living rooms for workers. Beads in various stages of manufacture and hundreds of carnelian beads, besides two types of bronze drills, one with a flange, and the other with twisted grooves, were found. (Fig. XIII)

At Chanhu-daro, Mackay discovered a workshop for making stone beads. This enables us to illustrate the various stages through which a stone bead passed and also show how holes were bored in these beads with the help of small drills. Briefly there are four stages:

(1) Cylindrical roughout was obtained by free, and probably careful pressure flaking as well.
(2) Removal of surface irregularities, called pecking.
(3) Grinding on hones of varying grades. (Fig. XIV)

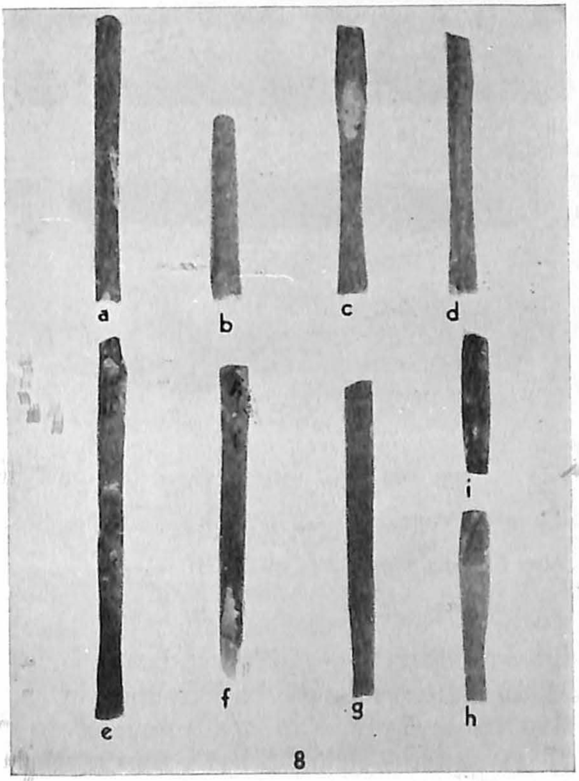

Fig. XIII. Bead drills. Copper/bronze. (Mackay, *Chanhudaro*, pl. LXXXVI b.)

(4) Boring a hole. This process was carried out at both ends by means of a stone drill. The working end of this drill was provided with a small depression to hold the fine abrasive and water that gave the drill the necessary bite. In the case of hard stones, the stone had to be roughened to prevent the drill from slipping (Mackay 1943, p. 211). (Figs. XIII and XIV)

Etched Beads

But something new, an advanced, skilful technique is witnessed in the preparation of etched carnelian beads. Very probably it was discovered in Sind, where it continues to be practised till today. Dikshit has reviewed, in detail, all the three techniques which for our purpose are summarized (Dikshit 1949).

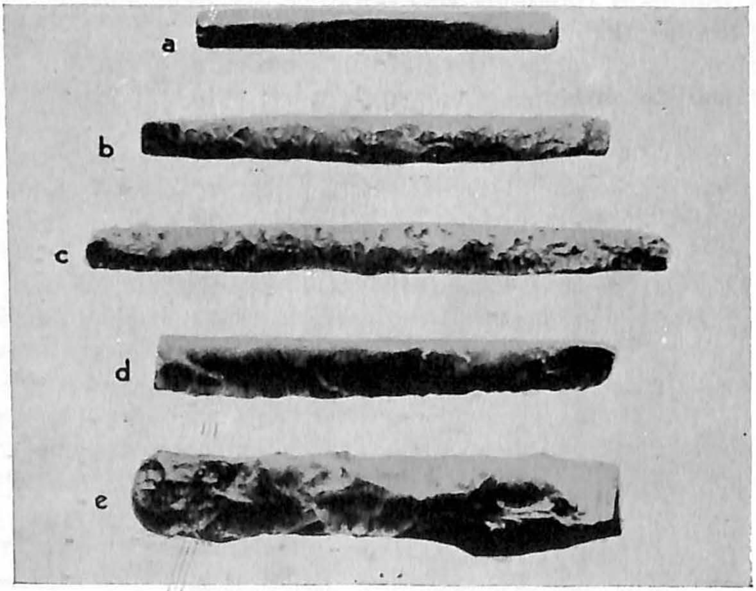

FIG. XIV. Agate beads in various stages of manufacture.
c = 1st stage
d, b = 2nd stage
a = 3rd stage.
(After Mackay, *Chanhu-daro*, pl. XCIII, 4.)

Technically, there are three types of etched beads.

Type I: White patterns on red background.
Type II: Black patterns on whitened surface of the stone.
Type III: Black patterns etched directly on the stone.

Beads of Type I are most common; of Type II rare, and that of Type III almost negligible, still all of them go back to the Indus or the Harappan Period, and thus the techniques should have been in existence by at least 2300 B.C.

Technique

1. The white patterns on the red surface were prepared by making a thick liquid of potash, white lead, and the juice of *Kiral* bush (*Copparis aphylla*). This was then applied directly with a pen on the carnelian. Heated on a charcoal fire the design became permanent.

Microscopic analysis of these beads showed that the etching produced a number of minute spots, under different coefficients of expansion. The white layers do not affect the extreme surface of the stone.

2. In Type II beads, the white surface is first prepared with alkali. On these are drawn lines in black, prepared from metals like copper and manganese. The effect is sometimes purplish.

3. In Type III, a pattern in black is etched directly on the original surface of the bead.

It is also further noted that the three techniques do not always appear exclusively. Combinations of Types I & II (Variety A) and of Types I & III (Variety B) are at times noticed.

Lapidary's art

Certain beads at Mohenjo-daro appear to have been cut from the same stone, their densities being nearly the same. The skill of the lapidary is well exhibited in the way in which these stones have been cut, so as to show white bands of quartz on the claret-brown background; also beads 2 and 28 show central mouse-grey bands with terminal cinnamon bands. The two agates 3 and 4 are probably made from the same stone (densities 2·616 and 2·608 respectively), and have been beautifully cut so that the white bands pass in a parallel manner across one side of each bead, the general colour of the stone being slightly darker than buckthorn brown; they are similar to the "Pagoda stones" or agates from Burma. On the reverse side of bead 5 there are visible a few bands which just come to the surface.

Another bead is also an agate which shows a series of white bands encircling a vandyke brown band. Bead 22 is a fine specimen of agate which has been cut so that the white bands which, in the natural stone, would be in the form of a spheroidal mass, now encircle the bead, being apart on one side and meeting on the reverse side. The stone had thus been cut across the base of the banded spheroid.

The moss-agates, have both been cut to show an oval aggregation of green (nearest colour: meadow green) enclosures in a white oval band on paler chalcedonic masses.

Another agate bead, which is of the riband-agate types, shows a fine "mitre" pattern on outer surface and the onyx bead, 11, shows concentric white bands on a black stone.

With reference to the riband-jaspers I and 27, the lapidary has so cut the beads that they exhibit two cross-bandings which form a cross-hatching, more consp'cuously displayed on the latter bead.

In addition to the stones specifically mentioned above, one could enthuse over most of the remainder; but enough has been written to indicate that the lapidary had brought his art to a high state of perfection in the days when the city of Mohenjo-daro was flourishing. All the beads possess a high polish and are in an excellent state of preservation (Mackay in Marshall 1931).

This careful selection of stones is seen at numerous sites. But it is best witnessed at Bagor, District Bhilwara, Rajasthan, where the banded beads are very tiny, hardly one mm. in diameter, and two mm. in length (Misra 1968).

Micro-Steatite Beads

The Harappan and other Chalcolithic sites yield small, tiny, disc steatite beads.

These occur at Chanhu-daro and recently at Kayatha (1968) literally thousands, originally strung, probably with cotton thread, are found, though the latter has not survived.

The technique by which these tiny beads were made was revealed at Chanhu-daro. Here in a room along with a number of beads of minute size were found six bead tools. From this context as well as an independent examination by W. J. Young, Mackay concluded that these were bead-making tools.

All the six tools are of copper or bronze tube with a point. They are about an inch in length. The one illustrated here is the best preserved. (Fig. XV). Its overall length is 0·93 inch, the tubular point measures 0·25 inch, having

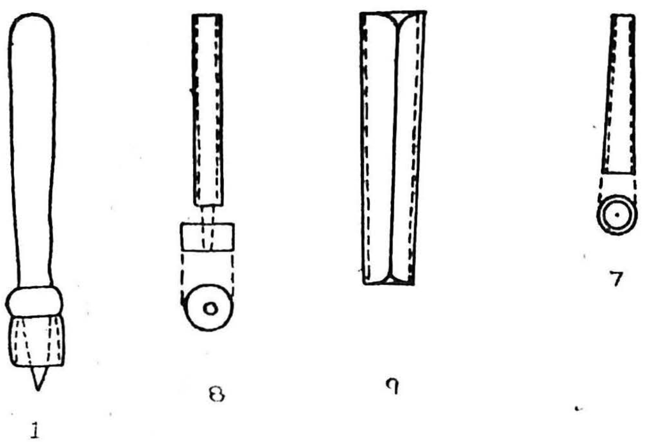

Fig. XV. Bead-drills. Copper/bronze. From Chanhudaro. (Mackay, 1943, pl. LXXX, 1,8,9, and pl. LXII, 7.)

a diameter of 0·8 inch. It is suggested that first a thick paste of powdered steatite was prepared. This paste was then forced through the tubular points of these tools, exactly as "confectioners today force frosting through tubes to ornament cakes." The necessary pressure could have been supplied by means of a metal or wooden rod sliding inside the upper tube of the tool which was carefully made with strictly parallel sides (Mackay 1943, p. 186).

(d) Faience

This is an artificial object resembling very much glazed or opaque glass ones. Principally beads, but also bangles, grooved bracelets, and other small objects occur for the first time in the Indus Civilization. Elsewhere only beads occur that too not in such a profusion as in this civilization.

Where earliest faience was manufactured is not yet known. Its manufacture and varieties are well described by Mackay (in Marshall 1931, I, and 1938, I, p. 583) and this description is here reproduced with a few omissions.

Faience, which was very popular with the Indus people, has a hard, fine granular body, covered with a glaze. The prevailing colours are bluish-green and greenish-blue although white, chocolate, and red specimens have also been found. The microscopic examination reveals a compact granular structure, composed of angular quartz grains bound together with a transparent cement. Its chemical analysis shows also that silica is the chief constituent, forming about 90 per cent of the total amount. From these facts it may be inferred that the original paste was composed of finely crushed quartz, or pure white sand, a glassy flux, and a colouring matter, if necessary. It is obvious that the moulded object had to be dried and fired to bring about the fusion of the flux; but the question how precisely the various ingredients of the paste were endowed with the necessary coherence and plasticity, is difficult to answer. The suggestions that clay or gum might have been employed for this purpose are untenable, as the material is free from clay; while gum, or any other organic matter, would be consumed in the course of firing long before the flux underwent fusion. Possibly, silicate of soda, which forms a highly viscous solution with water, was employed as a constituent of the paste and served to impart the desired property to the wet paste. It may be added here that the preparation of an alkaline silicate by the fusion of soda with sand, was well known to the ancient nations who practised the art of glazing.

Moulding on Sandy Core

The hollow objects were moulded on cores of sand, which was tied up in some fabric and raked out after firing. Impressions of the fabric, as well as remains of the sandy core, have been found in several specimens.

Colours in Faience

The white body is free from any metallic colouring matter and forms the basis for the coloured varieties. The blue and green shades were produced by the addition of copper oxide to the paste, probably in the form of a natural ore of this metal; and the chocolate colour is due to cuprous oxide, which was the result of reducing atmosphere in the kiln. The light red variety was prepared by the addition of red ochre to the raw paste.

To form some idea of the brilliant effect of these objects, due allowance should be made for the changes produced on them by the corrosive action of the alkaline soil in which they were so long buried. As a fact, the original glaze has survived on very few specimens, although the body material is generally well preserved. In some cases the decomposition has penetrated deeper, changing the blue or green colour into dull white or brown, which have resulted from the bleaching out of copper oxide and the precipitation of basic carbonates of iron, respectively.

Faience—glaze

Faience objects are covered with a distinct layer of glaze which must have been applied separately, as in the case of the steatite objects. It is highly probable that the glazing process was carried out in the second firing, as at present. The prevailing colours of the faience glaze are bluish-green or greenish-blue, although indigo blue, apple green, maroon, black, and colourless examples have also been found. The blue shades owe their colour to copper oxide, while the green contains iron oxide, in addition. The black or dark maroon blaze contains an excess of manganese oxide. It has been remarked already that the glaze has perished mostly through decomposition, and the material available is scanty for a complete chemical analysis. However, judging from its transparency, the nature of the colouring matter, and the iridescent films on these objects, one can safely conclude that it is of the nature of glass. Ancient specimens of glass consist of silicates of soda and lime and a metallic oxide for the colour, besides certain impurities derived from the raw materials. They were prepared by the fusion of an alkali, sand, saltpetre, and chalk, with a metallic oxide for the coloured varieties.

The question of faience beads which have a very wide—intercontinental—distribution, and which also turn up in small numbers in the Peninsular Chalcolithic Culture has received some critical approach outside India. The problem really is, as far as India is concerned, whether there is one source or many sources of manufacture. This can be settled when beads from different areas are spectrographically examined.

(e) STEATITE

Steatite is an impure massive variety of talc, containing 4-8 per cent of combined water. It is one of the softest minerals with a soapy feel; but at red heat it loses the water and is transformed into a very hard, white substance which can be polished.

The Indus Valley people were well acquainted with this property of steatite and made good use of it. The most likely source for the raw material was Rajasthan. The stone lent itself readily to carving with the aid of their bronze tools, and the finished product could be rendered hard and durable by careful ignition. The results of the chemical analyses leave no doubt that the material is steatite, which has been deprived of most of its combined water at a high temperature. Beads of various shapes were fashioned in large numbers out of steatite, the micro ones by an ingenious technique (see p. 42). But the largest piece of carved steatite is the statue. The most important objects in this class, however, are the numerous inscribed seals which are finished with an exquisite white enamel-like surface.

White Coating on Steatite Seals

Generally, these seals bear evidence of strong ignition, containing only 1-3 percent of water; but some have the characteristic soapy feel of ordinary unburnt steatite, with over 4 per cent of water. This fact has an important bearing on the problem of the technique of the white coating, as it leads to the definite conclusion that a high temperature was not essential for this process. Therefore, it is not in the nature of a glaze or enamel formed by fusion above red heat. It is curious that its composition (Table I, p. 689) conforms also to that of steatite, which is clearly its principal constituent. From these facts it may be inferred that this coating is a slip which was prepared by levigating steatite in water, with a suitable medium to serve as a cement. Regarding the nature of this medium, it must be borne in mind that the coating or slip, on these seals, is generally very well preserved, which should preclude the possibility of a gum or any other perishable organic substance. Various experiments carried out in order to arrive at a solution of this interesting problem, have shown that durable coatings, similar to those on the seals, can be produced with a slip prepared by levigating ignited steatite in water with silicate of soda as the medium. After the application of the slip the object was dried in the oven at 100°C, and polished with agate. It is highly probable that a similar method was followed by the Indus people.

Steatite objects with well preserved glaze are rare but a careful search with the aid of a lens sometimes reveals traces of a green glaze. It is evident, therefore, that some of the objects (e.g. round and oblong beads) were originally glazed. The red paint on some of these objects consists of ferric oxide; for this yellow ochre appears to have been employed, which acquires a fine red colour after ignition at a moderate heat (Sana Ullah in Marshall 1931, II, p. 688).

(F) Copper-Bronze Technology

Until 1940, the chief data for having any knowledge of copper-bronze technology consisted of the objects found from the three sites of the Harappan civilization, viz. Mohenjo-daro, Harappa, and Chanhu-daro, and a few other sites in Baluchistan and the unstratified Copper Hoards.

(a) Chronological Review

During the last 30 years several Chalcolithic sites have been excavated in different parts of India, each yielding a few copper-bronze objects.

Mundigak in Afghanistan has produced evidence of great value, indicating a good sequence of metallurgical development. Further the earlier finds from Iran, particularly from Sialk, have been technologically examined. Most important, the site of Tal-i-Iblis, near the copper-rich Kerman range in Iran is at present regarded as the earliest known centre of metallurgy. From here the knowledge is believed to have spread to the east and the west by about 5000 B.C.

With regard to the eastern diffusion which concerns us vitally, and the development or retardation of copper-bronze technology within India, the sites can be arranged in the following groups and chronological order, though C^{14} dates are not available for all the sites within each group.

Iran

Tal-i-Iblis. Caldwell and Shahmirzadi 1966; Agrawal 1968, p. 134 c. 5000-3000 B.C.

Sialk

Period I-II: Tools made by cold hammering.
Period III, 4: Casting in open moulds.
Period III, 5: Casting in closed moulds.
Period IV: Smelting and casting by *cire perdue* method (Coghlan 1951, p. 156).

Afghanistan

Mundigak (*c.* 3300-3000 B.C.)

There are five periods (I-V), showing a development in tool typology, as well as the transition from copper to bronze, though no clear technological development is witnessed as at Sialk (Casal 1961).

Baluchistan

Several sites have been very partially excavated, but none stratigraphically, except the latest one, Anjira* (Beatrice de Cardi 1965, p. 100). So it is difficult to comment, for it is not proper to compare sparsely or badly excavated data with more fully excavated sites in Sind and the Panjab. The available evidence may be grouped as under.†

Kili-gul-Mohammed (K.G.M.), Anjira, Rana Ghundai, Damb Sadaat, Nal, Kulli-Mehi etc., and divisible roughly into:

Pre-Harappan (*c.* 3500-2300 B.C.).
Harappan and allied (*c.* 2300-1800 B.C.).

Sind and the Panjab

Pre-Harappan: Amri-I, Kot-Diji-I, Harappan-I etc. (*c.* 2600-2000 B.C.).
Harappan: Amri-II, Kot-Diji-II, Mohenjodaro, Chanhudaro, Harappa-II etc. (*c.* 2300-1800 B.C.).

N. Rajasthan

Pre-Harappan: (Kalibangan-I *c.* 2400-2000 B.C.).
Harappan: (Kalibangan-II *c.* 2200-1800 B.C.).

E. Rajasthan

Ahar-I: (*c.* 2000-1000 B.C.).
Bagor-II: (*c.* 2800 B.C.).

*No copper-bronze objects were found at any of the sites surveyed by De Cardi.

†These C^{14} dates have been adapted with some modification and re-arranged statewise from Agrawal 1968, pp. 115-27.

Gujarat

Harappan: (Lothal, Rangpur-II *c.* 2200-1700 B.C.).
Langhnaj-II: (*c.* 2000 B.C.).

Madhya Pradesh

Kayatha-I: (*c.* 2100-1900 B.C.).
Kayatha-II: (*c.* 1800-1700 B.C.).
Kayatha-III: Eran, Nagda, Navdatoli etc.: (*c.* 1700-700 B.C.).

Maharashtra

Chandoli, Jorwe, Nevasa, Sonegaon, Inamgaon: (*c.* 1400-1100 B.C.).

Andhra, Madras, Mysore

Kodekal, Utnur, Terdal, Tekkalkota, Sangankal, Hallur, Palavoy, Painampalli, T. Narsipur: (*c.* 2500-900 B.C.).

West Bengal

Pandu Rajar Dhibi: Mahishadal (*c.* 1000 B.C.).

Bihar

Chirand. (*c.* 1300-700 B.C.).[1]

Uttar Pradesh

Atranjikhera, Hastinapur: (*c.* 1100-500 or 800-400 B.C.).

Copper Hoards

None of the copper hoards or its site has been stratigraphically or otherwise dated.

(b) IMPORTANT DEFINITIONS AND TECHNIQUES

Before referring to the various copper-bronze techniques known during the pre-historic times in India it is necessary to define some of the fundamental conceptions.

Forging

This includes two processes:

1. Hammering of cold copper: This is regarded as a Stone Age technique, and thus the earliest technique employed in manufacturing copper objects.
2. Forging when the metal is heated.

Temperature of Recrystallization

When the work of bending or punching is carried out upon a metal below a particular temperature, it hardens. This temperature is termed as the temperature of recrystallization of the metal.

But this temperature is not fixed or definite, for, the purer the metal the lower the temperature. Thus pure copper recrystallizes at a low temperature of 280°C.

[1] Chirand-I has now one C^{14} date of *c.* 1600 B.C.

Cold Work and Work Hardening

Any work carried out on the metal below the temperature of recrystallization is known as "cold work", and the result as "work hardening".

The process of cold work leaves a distinct change in the internal microstructure of the metal. This can be ascertained by a metallographic examination of the sample.

Plastic Deformation

When a metal is beaten, its grains are deformed. These however regain their original position when the beating stops. However, if a very great force is applied, the grains lose their plasticity, until the metal is heated beyond the temperature of recrystallization. Such a deformation is called "plastic deformation". This deformation can be detected in a metallographic examination.

Annealing

Annealing is heating the metal above its recrystallization temperature and then allowing it to cool down slowly. This is done in copper above 500°C. The process of annealing relieves the strain within the metal; the atoms become mobile and return to the strainless, stable positions.

Grain Growth

If the metal is heated above the recrystallization temperature and is retained at that high temperature for some time, the new grains begin to grow rapidly. This effect is known as "grain growth", and it is a continuation of the process of recrystallization.

Twinning of the Grains

Twinning of grains is one of the consequences of work hardening and subsequent annealing. It is observed in the microstructure of the metal in the form of equiaxial polygonal grains and twinning of grains. Such a twinning of grains takes place in metal of face centred lattice structure, such as copper, silver, gold, aluminium, lead.

Casting

For producing good copper casts, it is necessary to heat it to a temperature that is above 1150°C, and also keep the molten metal completely covered under burning charcoal.

Pouring of the molten metal into the mould should be efficient and quick. The mould should be hot, while the metal is poured into it.

Crucible

These are small vessels of extremely well baked clay. So far only one crucible was found and that too at Mohenjo-daro. Crucibles should have been there at Ahar too. Recently one small cylindrical crucible was found at Inamgaon. From its small size and shape, it seems to have been used for smelting gold. However, small copper objects like a pin and fish hook could have been cast with this small crucible.

Mould

No moulds have been found in any of the Bronze or Chalcolithic sites except a stone mould at Chanhu-daro. Hegde therefore suggests that at this period they were probably shaped from a wooden pattern.

For casting copper implements the moulds were probably of sandy earth or clay. Particularly this is likely at Ahar and Chandoli because the axes from these sites have rough, uneven, corrugated surfaces.

Smelting of Copper

The original ore has less than 5% of copper. This is to be extracted from the other matter. The process of extraction is called 'smelting'.

Ore Dressing

To facilitate smelting the ore has to be dressed, that is, it is crushed, ground and then concentrated by flotation or gravity separation process. During the Chalcolithic Period, the crushed ore was probably concentrated by hand picking and winnowing as done by the *loharias* today.

Roasting

The selected or concentrated ore was then roughly roasted in the furnace at a high temperature over 500°C. This helped remove most of the sulphur and arsenic, which are detrimental to a good cast, making it brittle.

Matte and Slag

The roasted ore is then mixed with silica and heated in a furnace at a high temperature above 1200°C. This produces matte. This is further smelted after fluxing to extract the metal.

Poling

Copper artifacts of the Chalcolithic period include copper oxide. This is said to be due to the absence of the technique of poling. This is a simple process in which the percentage of copper oxide is reduced by inserting green hard wood into the molten metal. This at once catches fire and gives out carbon gases, and thus helps the reduction of copper oxide (Agrawal 1968, p. 169). This poling technique was probably not practised in India.

Pyrometallurgy

This entire metallurgical process is called pyrometallurgy. Hegde thinks that all these stages were gone through during the Chalcolithic Period.

We can readily accept this conclusion of Hegde, for, at Ahar, not only silica was found as a fluxing agent in the slag but a number of quartz nodules were found in the debris. These should have been crushed and ground and then roasted in the unusually large *Chulahs* which charactarize Ahar.

Only we do not know for certain how a temperature of over 1200° C. was obtained. The simplest is a crucible hearth blown by bellows, and used today by itinerant *loharias* as well as stationery ironsmiths.

Though it is possible that as in Egypt of the Old Kingdom, heat generated by mouth blow pipes was sufficient.

Spectrograph

Spectrographic studies of the ore, slag and the metal objects give only a probable clue to the source of the ore used, particularly if the impurity patterns of both the ore, the slag and the object closely correspond. Still there are a number of factors, and the impurities in the ore are found to vary from sample to sample from different depths in the same mine. Hence this study has a limited application.

Agrawal analysed a number of samples of copper/bronze objects by emission spectrography in the Bhabha Atomic Research Centre. This involves comparison of the wave lengths in the lines of the spectrum of the sample with the spectra of pure elements. To determine the concentration of each element in quantitative analyses, intensity of selected lines for each element has to be measured. Out of 37 elements, 20 elements including iron, silver, antimony, lead, tin, nickel, zinc, gold and others were chosen for study by Agrawal (pp. 159-60).

(c) Sources of Copper

The sources of copper have not yet been scientifically examined. Secondly, this is a complex process as work in other countries have shown. Not only the objects of copper/bronze from various sites in India are to be analysed and their constituent elements compared with similar analysis of ores from various likely areas, but samples of ores from the same place, the same quarry or mine have to be carefully collected and similarly analysed. Particularly useful in such a comparison is the impurity pattern in the ore and in the object compared, and not the presence of a few key elements, such as arsenic, lead and nickel.

Earlier, the sources of copper for the two main sites of the Harappan civilization, viz. Mohenjo-daro and Harappa, Rajasthan, Baluchistan and Afghanistan were suggested (Marshall 1931). Sana Ullah's study of impurity pattern (Vats 1940, I, p. 379) indicated that most probably Rajasthan ores were exploited by the Harappans. This is confirmed to some extent by Hegde's analysis of Khetri ore and its close affinity with the impurity elements in the copper objects from Ahar.

However, this information will have a further implication that sites of these quarries or mines (?) going back to the Harappan times in Rajasthan have to be found.

Unless these are found, we might accept Agrawal's view that the various Harappan centres, such as Mohenjo-daro, Harappa and Rangpur relied upon the native copper and oxide minerals which generally occur on the surface. Copper technology, however, they knew from an early date (?), and could smelt sulphide ores (e.g. chalcopyrites).

Their successors and junior contemporaries in some cases, viz. the various Chalcolithic cultures seemed to have used native oxide ores only. The exception being Ahar, where there is evidence of smelting chalcopyrite.

(d) SOURCES OF TIN

The same is true of tin. Though it was held at one time that tin was imported from Khorasan and Karadagh districts in Northern Iran (Marshall, I, p. 483), the more likely sources are the alluvial deposits of cassiterite. These thin deposits might have been used up without leaving any evidence of the operations behind (Sana Ullah in Vats, I, p. 380).

Later iron was also worked in a similar way. In Kutch and elsewhere there is laterite or iron in the surface rocks. Itinerant smiths smelted it, and manufactured tools and weapons.

(e) ALLOYS

Fresh studies by Agrawal (1968, p. 176) indicate that the Harappans deliberately alloyed arsenic, lead and tin (though in many cases these might be due to the elements in the ore itself). The Aharians added lead only (because it was easily available); the Jorwe and Malwa people used lead and tin alloying, but the Copper Hoard people manufactured probably objects of pure copper only (though Smith's earlier analysis (1905) of four weapons showed a fairly good proportion of tin varying from 3·83% to 13·3%).

There is not only a great cultural hiatus between the Harappan and the post-Harappan cultures, but in technology the latter were very much backward.

Agrawal's studies (1968, p. 175) show that the Harappans deliberately alloyed tin and copper in order to strengthen it and arsenic as a deoxidiser for closed castings, whereas in the latter post-Harappan the alloying of tin is sporadic, and arsenic is generally absent, unless present in small (trace) quantities in the ore itself.

(f) TECHNIQUES OF CASTING

Three main methods of casting are:

(1) Open cast or mould
(2) Closed mould
(3) *Cire perdue* or lost wax process.

Open Casting

The most common and easy to operate are open casts. These consist of a depression made in the mould material—stone, refractory clay—to receive the molten metal.

All the flat axes of the Harappan and later Chalcolithic cultures were made in open moulds. These, in the former, were of stone, as evidenced from Chanhudaro (Mackay 1943).

Double Mould

No double moulds have been so far found, but the axes from Gungeria show ridges on the edges. Hence it is inferred by Agrawal (1968, p. 185) that these axes were made in a double mould. Similar ridges were noticed in the harpoons from Shahjahanpur and Shahabad. If these observations are confirmed, then we shall have to say that the technique of double mould casting was prevalent in Eastern Central India, during the period of the Copper Hoards (whatever it be).

Closed Casting

As opposed to this, closed casting is very difficult and needs for its successful working a good knowledge of copper-bronze technology. Closed moulds were made of two or more fitting pieces of stone.

Hollow Casting & Lost Wax Process (or Cire Perdue Technique)

These two techniques are in a way related; both are comparatively much more complex than the simple open and closed castings. First the Lost Wax Process. (Fig. XVI)

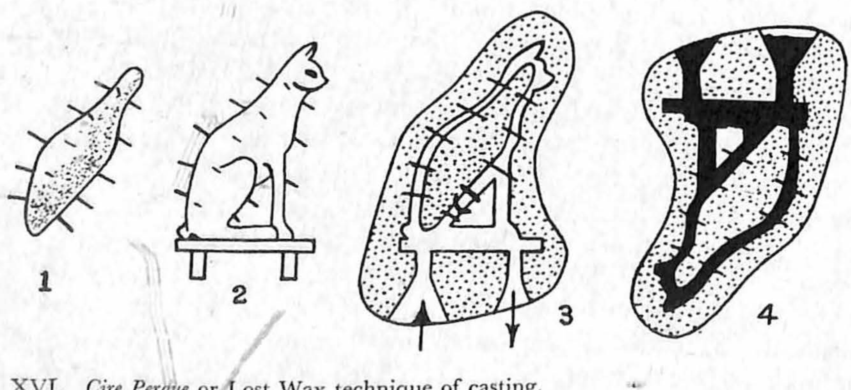

FIG. XVI. *Cire Perdue* or Lost Wax technique of casting.
1. The core with chaplets. 2. Wax model.
3. Wax drained out. 4. Filled with molted metal. (*After* Agrawal, 1968, Fig. 14.)

(*i*) In this the model to be made is first made on a clay core in wax. The thickness of the wax depends upon the thickness of the metal required.

(*ii*) Next to the wax model a single outer mould of clay was built up. This is provided with various devices to allow the wax to be drained out when melted, such as sprue-cup (the passage through which metal is poured into mould), runner (grooves), risers (arch or incline), and vents.

(*iii*) Then the entire thing is heated so that the wax melts and runs out. While this happens, the inner core of clay might shift. To prevent this happening chaplets (thin rods) were inserted which held the core to the outer mould; these later became part of the final cast object.

(*iv*) The molten metal is then poured into the cavity thus prepared.

(*v*) The outer clay mould was broken. The inner core sometimes remained; sometimes it was broken into pieces.

(*vi*) When the mould is broken, the object cast comes out, but this has a rough surface. This is later made smooth by polishing.

The only known example of the *cire perdue* process is the figure of dancing girl from Mohenjo-daro, though Sana Ullah said (without giving any reasons) that the process was probably unknown (Vats I, p. 381). Since then, another copper-bronze figure was found at Mohenjo-daro and some fine toy animals and birds have been found at Lothal which might have been made by this technique (Rao 1962, Figs. 31-34).

Spinning and Turning

In these methods as the names connote, copper and bronze objects were made on the lathe. So far no positive proof of the existence of this method in the Indus (Harappan), let alone the later retrograde Chalcolithic cultures has been met with. However, it was suggested by Mackay that dishes and covers (Marshall, pl. CXL, 4, 5) cannot be turned on the lathe. No lathe marks exist to decide this issue (Agrawal, p. 182).

Method or Technique of Joining Metals

At present besides welding, two other methods are employed, viz. soldering and 'running on' or 'casting on' or 'burning on'. Both these are very old methods and can be traced back to the Indus Civilization, though their use during the subsequent period is not yet attested.

'Running on'

In this method the essential thing was that the parts to be joined should be quite clean. Molten bronze when poured over them would fuse with them. This method was often employed for joining a tanged sword and its hilt. It is said that several vessels from Mohenjo-daro exhibit this technique (Marshall 1931; Agrawal, p. 184).

Soldering

In this two pieces of metal are joined by a different alloy, which has a lower melting point.

No instance of copper soldering has yet come to light from the Indus or later Chalcolithic sites. But we have instances of gold and silver soldering according to Sana Ullah (Vats, I, p. 381).

Rivetting

Rivetting is joining metallic or non-metallic objects by short rods hammered down at both ends. In true rivets these rods have domed or conical-shaped heads like nail-heads.

The earliest instances of metal rivetting are found at Mohenjo-daro (Marshall 1931, p. 369, Agrawal 1968, p. 184); and rivet holes have been noticed in bracelets, knives and lances of metal.

Welding

This method of joining of which we hear so much in our times is indeed comparatively a recent technique. It can be done in three ways:

(1) Pressure welding, cold or hot, without fusion (as in shoe-soles).

(2) Sweating or surface welding without pressure; the areas to be joined were clamped together with the solder in between and heated.

(3) Fusion welding which involves heating the metal approximately to its melting point and then hammering thereby causing them to fuse.

Though the Harappans knew the alloying of tin with copper, still objects such as flat axes, chisels, saws, knives, arrow- and spear-heads, razors, fishhooks, and handled mirror are said to be made of (pure) copper, though the statement needs to be qualified, for, all such objects have not been scientifically examined. From the examination of a larger sample, Agrawal says that the use of bronze was more frequent in the upper layers than in the lower layers, the percentages being 23 and 6, respectively.

The copper used in the various objects is of three kinds:

(1) Pure copper, with a few other trace elements.

(2) Copper with a good percentage of arsenic. The latter was used as dioxidizer for closed casting.

(3) Copper with tin deliberately added in order to strengthen it.

The Harappans were also well aware that the best bronze from the point of strength, elasticity and toughness and ability to withstand the shock should contain 8 to 11 percent of tin. For the celts and chisels from Harappa, as found later by Sana Ullah, do not contain more than 11 percent of tin (Vats, I, p. 380).

(g) TECHNIQUES IN THE HARAPPAN CIVILIZATION

A careful study has revealed the employment of following methods or techniques of copper-bronze working in the Harappan Civilization.

(1) *Hammering or forging and annealing.*

(2) *Open mould and annealing.*

(*i*) Chisels were hammered out from round or square sectioned rods.

(*ii*) Knives, arrowheads, spearheads and razors were chiselled out from sheet metal.

Tubular drills which have a tapering end and made of thin sheets are so carefully made and perfectly rounded without the edges overlapping in any way that the use of mandrel for hammering a jointless cast ring is clearly indicated (Mackay 1943, p. 186; Agrawal 1968, p. 182).

(3) *Raising*

In this, deep pots and pans are raised from a flat disk of copper or bronze by repeated hammering on the outside, the inner side being slowly revolved against the surface of the metal worker's stake. By constant hammering and turning, the metal is raised up through a series of concentric rings.

(4) *Hollowing or Sinking*

Shallow pans and bowls showing hammer marks on the inside were made by this method. In such cases the metal is placed above a cup-shaped depression hollowed from a block of wood and is hammered and turned until sunk to the depth and shape (Coghlan 1951, pp. 88-91).

(5) *Cire perdue or Lost Wax Method*

In addition to the four simple methods, this highly advanced and complicated method was also employed for making objects in the round, such as the woman dancer, and figures of animals. A female dancing figure and figures of swan and a dog, all in the round, have been found at Lothal, but it is not yet known how these were made (*IAR.*, 1956-57, p. 16.; 1957-58, p. 13) and Rao (1962, p. 23).

(6) *Lapping*

This is also an advanced method in which two parts of a vessel—carinated bowl—are placed over one another and joined. These two methods are said to have been in use in Periods II and IV of Mohenjo-daro, according to Gordon (1958, p. 66).

(7) *Wire-Drawing*

This technique in which rods are passed through a plate with progressively smaller holes and a draw plate used which repeatedly lengthened the rod and reduced the diameter is so far not evident.

(h) TECHNIQUES IN OTHER CHALCOLITHIC CULTURES

Outside the domain of the Indus or Harappan civilization, the principal stratified sites are:

(1) Jorwe, Nevasa, Chandoli, Songaon and Inamgaon in Western Maharashtra.
(2) Eran, Kayatha and Navdatoli in Madhya Pradesh.
(3) Brahmagiri, Tekkalkota and Hallur in Mysore.
(4) Ahar and Bagor in S. E. Rajasthan.
(5) Hastinapur and Atranjikhera in Uttar Pradesh.
(6) Sonepur and Chirand in Bihar.
(7) Pandu Rajar Dhibi and Mahishadal in West Bengal.

At all these sites, the most recurring object is a flat copper axe, less frequently a bangle, and occasionally a spear-head as at Chandoli and Navdatoli;

and Rajar Dhibi; beads (Nevasa and Chandoli); fishhook, tongs and a pin (Inamgaon); and small double-axe-like objects at Hallur.

Of the six Jorwe axes, the one examined is of low grade bronze (Sankalia 1955, p. 1) having 1·78 percent tin and was made probably in an open mould by casting (Medhekar and Pathak in Sankalia and Deo 1955, pp. 159-60). The scientists however felt that the addition of tin might not be deliberate. The axe is thick in the middle and tapers slightly towards the butt as well as the edge. This must have been done by hammering and helped to strengthen the edge as inferred by Mackay in the case of Mohenjo-daro axes.

The Jorwe bangle is of pure copper and made from a cast rod, which was cut later to necessary size (length and diameter). Though annealing has taken place, it could not be determined whether it was intentional or otherwise.

The same indiscriminate use of copper and low grade bronze is witnessed at a nearby site, viz. Nevasa. Three specimens—a chisel, a bangle, and a bead—were examined at Trombay. The chisel contained 2·72 percent tin, whereas the bangle and bead were almost cent percent copper. The first two were cast, and the hollow bead was produced by hot hammering (Sankalia *et al.* 1960, pp. 523-24).

However, at Chandoli on the Ghod river, an axe and spear-head from an identical cultural horizon were found to contain no traces of tin. The axe was made, it is inferred, by unsound casting technique. The mould was not provided with proper ventilation for the escape of evolved gases, with the result that these got trapped and made the metal porous. However, after casting it was subjected to hot work, and was allowed to cool slowly, under a cover of hot ash. It was not subjected to work hardening. From this it is concluded by Hegde that while the cutting edge was shaped by hammering of the hot metal, the body of the axe was not subjected to forging. Along the edge, the body of the axe was subjected to heat (Hegde, p. 155).

Further south, at Tekkalkota the axe was found to be of copper with trace elements, but no tin (Hegde in Nagaraja Rao and Malhotra 1965, p. 163).

As opposed to this, one of the five axes from Navdatoli was found to be of pure copper, but a rod contained nearly 12 percent tin (Atomic Energy Establishment's brief report in Sankalia, *et al.* 1958, p. xii). However, a fuller examination by Hegde revealed that the axe contained 3·1% tin. Thus it too is of bronze. This axe was first cast, then subjected to hot and cold work and intermittent annealing to impart to its present shape and the smoothness of the surface finish (Hegde, p. 149).

The chisel from the same site was cold worked and then recrystallized. After it was finally heated, it was not allowed to cool slowly, nor covered under hot ash while cooling. Instead it was exposed to the atmosphere. This resulted in quicker cooling and consequent fine grained structure (Hegde, p. 151).

Probably as a survival of the Harappan influence, the axe from Somnath turned out to be of bronze. Its splayed edge was shaped by repeated cold work with intermittent annealing. That is, the blade end of the axe was shaped by forging but not the rest of the body (Hegde, p. 159).

At Langhnaj, so far only a single copper object (knife) has been found. It was found to be of pure copper and forged into its present shape by the application of hot and cold work. This shows advanced technique (Hegde, p. 163).

Samples of Ahar material—an axe, copper sheet, slag—as well as a sample of ore from Khetri were studied by Hegde spectroscopically and by metallographic examination. These studies reveal that:

(1) The copper was probably from the Aravallis, near Jaipur.
(2) The copper was smelted at Ahar.
(3) The smelting was done by fluxing the axe with silica (probably ground locally by crushing quartz nodules).
(4) The metal of the axe is highly impure containing 6·48 percent of iron.
(5) The axe was cast in a crude sand or earthy mould and was left in the cast condition. It was not subjected to work hardening. Slow cooling was probably brought about by covering the mould under hot ash. In such a slow cooling conditions, the impurities get around the cellular boundaries (Hegde in Sankalia *et al.* 1969, p. 228).

Further the mould was probably crude and not supplied with vent holes. Hence the internal surface of the metal showed dendritic segregation, porosity due to the gas holes, cracks, and globular gray inclusions. The casting at Ahar, it is inferred, was not advanced.

Quantitative chemical analysis of the slag samples showed that the process practised during the period was quite advanced. The ore was thoroughly roasted to eradicate the volatile elements like sulphur and arsenic. Further the ore was fluxed with silica so as to bring down the temperature of the fusion of the ore and also to facilitate the separation of the extracted metal from the impurities in the ore.

G. Other Metals

(a) Lollingite

Löllingite or leucopyrite and cerussite (a natural carbonate of lead) and cinnabar (sulphide of mercury) seemed to have been utilized for medicinal purposes by the Harappans: the first and the third for the extraction of arsenic and mercury respectively, and cerussite for cosmetics (Sana Ullah in Marshall 1931, I. p. 690-91).

(b) Gold, Silver and Electrum

These two precious metals were known and their use fairly common, that of silver probably more. However, the sources from which the metals were obtained and what ores were used is not yet ascertained. Gold coils have been found at Daimabad (*IAR*, 1958-59 p. 18). Gold is said to have been mined or quarried in South India in Neolithic Times (Allchin 1962). For this inference there is no indubitable evidence. Most probably gold was collected from river sands, and then smelted. Whatever be the truth, gold was known and ornaments were made by at least 2,000 B.C. in the Deccan (Nagaraja Rao and Malhotra 1965, p. 74), and slightly earlier is the Harappan evidence. In the latter, not only do we have bangles which have retained their lustre and finish for more than 4,000 years, but the goldsmith had acquired the art of making tiny beads. Literally thousands of these strung in a necklace, have been found at Lothal and Rojadi (*IAR*, 56-57, p. 16, pl. XV, C). Probably these minute beads were made exactly as the steatite beads (see p. 42).

There is some evidence of the use of electrum. Whether this was extracted from ore or made by adding other metals is not yet determined. One sample analysed by Dr. Hamid suggests that the silver was extracted from argentiferous galena (Marshall 1931, p. 524).

On the whole it is evident that the people of the Harappa Civilization had a considerable knowledge of metallurgy. The manufacture of gold and silver objects reveals the knowledge of casting as well as filing. Soldering was done so skilfully that joints are not visible. The same might be said of the southern Neolithic, if the two solid gold ornaments from Tekkalkota are not made by casting.

H. Bone and Ivory Tools

Occasionally a few tools or implements like points, awls, and rarely knives and fish-hooks, are found in Neolithic and Chalcolithic settlements of the Deccan. Finer objects have been found in the Neolithic habitation at Burzahom in Kashmir. (*IAR*, 1961-62, p. 19 and pl. XXXVII, B). In the Harappan, so far, very few implements have been noticed (Mackay 1938, p. 431, pl. cv. 55).

A bone normally breaks into splinters longitudinally. But such a broken piece cannot be used (for long). It was soon found out by man that such broken or usually thin, long limb or end bones could be used. These have to be made pointed and then ground. This strengthens or toughens the object.

So far no ivory tools or objects have been found from the Stone Age deposits. But these, as in Western and Eastern Europe, are found to be carefully sawed with a stone saw and later worked with a graver (burin).

At Mohenjo-daro and Chanhu-daro these were few, but at Harappa, a slightly larger number was found (Vats, I, p. 459). One object, a shaft with a flat base was made on a lathe. As at Mohenjo-daro where in the later excavations (Mackay 1938, p. 579) a number of elephant tusks were found; so also at Chanhu-daro and Lothal an elephant tusk was found indicating a local industry. However, Mackay draws our attention to the difficulty experienced by the craftsman in sawing this material, In an unfinished ivory plaque saw marks are found to run in every direction (Mackay 1938, p. 579, pl. CV, 57).

I. Building Techniques

As in pottery, the earliest traces of houses are found in Baluchistan in the Kili Ghul Mohammad and other cultures (mainly from Damb Sadaat or Site Q. 24), roughly datable to the beginning of the fourth millennium B.C., leaving out the earliest. These houses have mud walls, sometimes on a single course of boulders, with the crevices filled in by smaller stones; or as in Group II, flat roughly rectangular slabs of stone laid lengthwise. There is some evidence of the preparation of a floor with broken brick, hard clay, charcoal, sherds or gravel, a method which was continued upto very recent times and known as *koba*. The walls were supported by wooden posts. Occasionally walls were set on a thin gravel foundation or on the older brick-walls. The roofs were invariably thatched.

Except planning or laying out a fairly regular rectangular room not much engineering skill is involved. The use of boulders or pebbles is but natural and a matter of common sense.

Such wattle and daub constructions continued to be made throughout the Chalcolithic Period in Peninsular India and the Gangetic Valley, with a few regional variations as at Navdatoli, where wooden posts were closely set and then covered with a screen made of half-split bamboo which was plastered from both sides with clay and white-washed; or as at Ahar where a good stone plinth was made because schist blocks were easily available (Sankalia *et al.* 1969, Fig. G).

In the south or the Peninsular India proper, advantage was taken of the flat-topped granite surfaces, enclosed by huge boulders on the castellated hills. Here too, wherever necessary, a plain, even surface was made by levelling the hollows with flat slabs of stone, so that water might not collect. On this was spread clay etc. and the living floor prepared. Where, however, there was plain murrum surface, holes were dug into it and wooden posts inserted. Thus a round wattle and daub hut, probably with conical roof was constructed (Ansari and Nagarajarao 1964-65).

It is indeed strange, nay a mystery, that such primitive methods should have continued when the whole of Western and Northwestern India, including parts of Western U.P., had witnessed highly advanced methods of town-planning and building techniques. In fact, what one beholds in any excavated town of the Harappan or Indus Civilization could still serve as a lesson to a civil engineer and an architect of today.

An Indus or Harappan town was laid out in a chessboard pattern, the main roads running almost north-south, and east-west, taking advantage of the prevailing north-south winds as at Mohenjo-daro. Such a careful layout must have been preceded by a contour survey o' the land, and accurate instruments—such as compass, and a footrule. Both Mohenjo-daro and Lothal have yielded length-measuring instrument of shell (very ingeniously thought of, because this material does not warp in any condition) and a bronze rod (Vats, I, p. 365, Wheeler 1953, p. 62). These measuring rods follow two systems, "foot" and "cubit" because the former (shell) follows a "foot" of 13·2 in; the latter a cubit measurement of about 20·7 in.

For accurate, vertical alignment of walls, plumbbobs were used. Further, battered outer walls a'so have been well aligned by setting each course a little back and also by using spec'ally moulded bricks (Marshall, pl. LXXII, c).

Since the houses and other buildings were mainly rectangular, no more complex techniques of architecture were probably required. No true-voussoir-arch was known, though this should not have been difficult, for such curved surfaces were spanned by wedge-shaped bricks. For the trebeate construction, a corbelled arch—for instance, the construction of a high-roofed drain—was preferred.

No round column has so far been found, probably because these were not necessary, (though Marshall speaks of a columnar hall at Mohenjo-daro. But this is not illustrated in drawing, and it is difficult to say, whether the columns are round or square) when naturally round pillars could be had in the form of tree trunks. On these probably stood the limestone capitals.

Foundations of houses were carefully made, sometimes using a filling between two such brick foundations. Further artificial platforms were also preferred for houses and to protect them from flooding. Those at Kalibangan might have had some religious significance (Lal and Thapar, 1967, p. 82).

These platforms as well as other important walls had a batter, which has also been traced in the pre-Harappan walls at Kalibangan.

The bricks are exceptionally well made, without any binding material, such as straw. These were made in open mould and struck along the top with a piece of wood, whereas their bases are invariably rough, indicating that they were made and dried on dusty ground. No bricks have been found to be made on matting (though large storage jars from Nevasa and Tekkalkota as well as Burzahom do bear such matting marks). For making bricks alluvial soil free from salt was used. They were well baked but not graded by their colour. Nor do they have grooves or impressions for grogging purposes, except in two examples. However, the bricks do bear footprints of cattle, crows, dogs, and a cat-like animal, all suggesting that the brick-yard was laid out in the open.Evidence of such an open brickyard was found at Devnimori is Gujarat, (Mehta and Chaudhuri 1966) and continues till today.

The surface of the bathrooms was invariably well-made and to ensure close fits and extreme smoothness and evenness the bricks were often sawed. Further they were plastered with gypsum to make them leakproof. In a very few cases, bitumen was used for a similar purpose. This is because, the former is easily available, while the latter had to be imported. This was however exceptional. Normally mud was used as mortar, and at times lime, which was burnt and used as cement for fine brickwork (Mackay 1938, p. 598).

In most of the walls the bricks were laid in alternate fashion, headers and strechers, care being taken to break the joints, as in English bond.

Moreover, in bathroom again the bricks were cut to size, particularly for accurately paving the sides or corners. In some bathrooms again the foundations were from four to five courses thick, to avoid subsidence, perhaps. Further, care was always taken to slope the bath surface towards one corner, where a drain carried off the water; again, when the bath occupied the whole room, the bases of the walls were protected by a wainscot of bricks placed on edge, and projecting 2 or 3 inches above the floor of the bath.

Floors of the room were paved either by baked bricks, sun-dried bricks or made by beaten earth. Though the streets and lanes were lined with closed baked brick drains, they were not paved at Mohenjo-daro or at Harappa. However, in a recent excavation at Kalibangan, one street of a late-Harappan phase is found paved with burnt clay nodules and broken terracotta cakes (Lal and Thapar 1967, p. 84). Such well-made houses had the plainest doorways. They were seldom rebated. It is inferred that wooden doors must have simply closed against the jambs. Nor can we understand how they were locked, as only one or two jambs have a hole to accommodate a bolt. But from this we might infer that there was a single door and not a pair.* Door sockets also were very uncommon.

Curious as this deficiency is, remarkable is the entire drainage system. It can rival the one today in many towns. Not only these were closed, made of baked brick and water-proof, well-aligned and sloped towards the road and street drains, but there were baked earthen pipes with faucet and joints to carry away the water from the upper floor. Such an advance technique is witnessed only in the Minoan palaces at Knossas, in Crete.

One might also mention the knowledge of making wells and docks which require further insight into hydraulics. Navigation was of course known and also the technique of making boats or ships with a sail. Models of those found at Lothal (Rao 1962, p. 20, pl. VI, fig. 13) confirm the previous view based on an engraving of a seal from Mohenjo-daro (Mackay 1938, I. p. 340, pl. LXIX, 4).

The basin of the dock at Lothal measures 219 metres north-south and 37 metres east-west. It is enclosed on all sides by walls of kiln-fired bricks, the maximum extent height being 4·5 metres. Ships entering the Gulf of Cambay were sluiced into the basin at high tide through a channel which is 7 metres wide and 2·5 kilometers long. It joins the eastern embankment at the inlet gap. The scouring effect of the tidal water was stopped by building two brick-walls, one on either side of the inlet gap. Ships had to enter and leave the basin at high tide when the water leval was maintained sufficiently high above the inlet sill.

"From all these it is inferred that the Lothal Harappans possessed a sound knowledge of hydrography and maritime engineering" (Rao 1962, p. 17).

Although not falling under this head in the strict sense, mention may, however, be made of the building of megalithic monuments such as dolmens and cists. The regular use of boulders and slabs of huge dimensions in their construction certainly speaks for the technical skill of the people. The presence of these monuments usually at or close to hills suggests that the stone blocks were simply rolled down from the hills. But it is also likely that in certain cases the blocks were quarried or obtained by fire-setting from the hills with some metal tools and then transported over considerable distances either manually or by carting.

*Strangely the inference is supported by the evidence from Kalibangan. Here in 1967 was found "a single socket on the sill of the entrance to a room" from which it is thought "that probably single-leaf doors were used" *(IAR).*, 1967-68, p. 44).

J. Weights

The great majority of the weights are cubical and made of chert. These are on the whole more accurate than those of other shapes and materials. Normally, they are made with considerable accuracy, much more so than in other countries at that period. The unit remained unchanged during the whole period of the occupation of the site. Not only Hemmy repeatedly notes the great accuracy of the Indus weights, but adds "In India we have the advantage that we can study an ancient system of weights without the complication due to conflicting systems being coexistent". And after a careful examination of the Egyptian and the Babylonian systems he came to the conclusion that the Indus system was quite independent of both. The weights found at Mohenjo-daro form a series in the following ratios:—1, 2, 8/3, 4, 8, 16, 32, 64, 160, 200, 320, 640, 1600, 3200, 6400, 8000, 128000. The unit weight has the calculated value of 0·8570 gms., the largest weight 10970 gms. (Hemmy in Mackay 1938, I, pp. 601-606 and p. 672).

In the working of flint, agate, and other hard siliceous stones the people of Mohenjo-daro were extremely proficient, as is proved by the chert weights (discussed above), the burnishers, and some of the harder stone beads. These materials were not, however, used for tools and weapons, copper and bronze being used exclusively; and it is evident that these latter metals were both plentiful and cheap. Flint was, however, employed for ordinary domestic purposes. A large number of flakes were found in nearly every house, together with the cores from which they were struck. From the occurrence of the crested ridge flakes, it is evident that this technique was followed (Sankalia 1964).

In the late Chalcolithic cultures, intentionally prepared solid stone balls were used as weights (Banerjee in Sankalia *et al.* 1958, p. 240).

K. Textiles

(a) Cotton

Until 1960, the only evidence of the use of cotton was given by Mohenjo-daro. This knowledge was increased by the discovery of the impression of cotton fibre on pottery from Rupar. Now Nevasa has given additional evidence.

At Mohenjo-daro the cotton fibre was exceedingly tender and broke under small stresses. However, some preparations were obtained revealing the convoluted structure characteristic of cotton. All the fibres examined were completely penetrated by fungal hyphae.

1. Fibre: cotton
2. Weight of fabric: 2 oz. per square yard
3. Counts of warp: 34's
   Counts of weft: 34's
4. Ends (warp threads): 20 per inch
   Pock (weft threads): 60 per inch

From this it is inferred that the cotton resembled the coarser varieties of present-day Indian cotton, and was produced from a plant related to *Gossypium arboreum* (Marshall, I. p. 33).

Examination of specimens found in subsequent excavations has also indicated the existence of cotton as well as the use of some bast fibres (Mackay 1938, I pp. 592-94).

(b) SILK AND FLAX

Cotton and silk, possibly wild from trees, have both been attested to from the Chalcolithic levels at Nevasa, and flax from Chandoli, datable respectively to 1200-1300 B.C. (Gulati in Clutton-Brock *et al.* 1961, pp. 55-58) and (Gulati in Deo and Ansari 1965, pp. 195-201).

(c) SPINNING AND WEAVING

The threads of cotton and flax were spun with the help of spindle-whorls, numerous specimens of which—either simple, flat, holed discs or large, oval or roundish areca nut-like pieces, both of terracotta—are found in all the excavations. The knowledge of stitching is attested to by the discovery of bone needles at Burzahom and copper-bronze needles at Mohenjo-daro and Lothal.

L. AGRICULTURE

How agriculture was carried on is not yet well known. A small terracotta object found at Mohenjo-daro is believed to be a plough.

Fortunately, 1968-69 excavation at Kalibangan brought to light an extensive patch of furrow-marks belonging to the pre-Harappan period in the open ground between Mounds I-II. These have also been seen by the writer with the courtesy of Shri B. K. Thapar. The existence of the furrows implies that there must have been a plough. Very probably it might have been of wood.

The grinding of grain was done on boat-shaped stone-querns and possibly in large deep wooden hourglass like contrivances with long wooden pounders as still done today. A grinding floor was found at Harappa (Wheeler 1968). Naturally when grain was grown extensively and probably collected by the State, huge granaries with vent-holes were required. The earliest so far found are at Harappa, Mohenjo-daro and Lothal.

M. MEDICINE AND SURGERY

The occurrence of *śilājit* (Śilājatu) as well as arsenic, coral and stag and rhinoceros horn at Mohenjo-daro has led to the belief that these objects which have acquired such a reputation as powerful drugs in early historical periods were probably known for their efficacy from a prehistoric period.

Surgery was certainly known. Now, besides the carved knives from Mohenjo-daro, have been found trephined human skulls, one each from Burzahom and Kalibangan. These holes in the head could have been, and were probably, made with a stone blade, as was still the practice in Peru and Mexico.

It is also presumed that the Early Man and his successors had some (empirical) knowledge of gynaecology.

III CONCLUSIONS

This survey of whatever little we know about the prehistoric technology in India will show that in every respect there was a sudden spurt in technological development under the Harappan or Indus Civilization from the previous stage. Though this civilization had an enormous extent, some 84,000 sq. miles, and fairly long duration, at least 500 years, if not 1,000 as previously held, still this civilization had left little impact on the rest of India in almost every branch of technology that is here reviewed, except the mass production of stone blades, and the allied industry in agate and other beads.

Secondly, this civilization itself, though otherwise so highly advanced, did not borrow the advanced metal technology and tool forms, such as socketed axes[1] and swords with midribs from the West—Sumer, which were in existence there much earlier[2].

Thirdly, not a word has been said about iron and iron technology. This is because, except for some lumps of iron from Phase II of Hastinapur (Lal 1954) we have no clear stratigraphical evidence. Its occurrence at Atranjikhera is very important. For here occur not only a large number of tools and weapons, but perhaps furnaces, as the evidence is interpreted by the excavator. If all this can be stratigraphically proved to go to Period I or II, and also dated to 1,000 B.C., iron will have to be included in a survey of prehistoric technology.

However, this is not enough. Whether iron finds this "honoured" place or not, is immaterial. What is more important is to study the technology of iron tools and weapons regionwise and relate them to the likely sources in the respective regions and these are many. This alone will give a true knowledge of iron technology. The first step is to identify the shapes by x-ray radiography. This is a non-destructive method, which can give some meaning to these otherwise deformed masses of iron. Then could follow by competent scholars spectroscopic, chemical and metallographic analyses of the selected objects and ores from various regions. Unfortunately both the Museum Curators/Directors and many excavators are obsessed by the collector's point of view so that hitherto no iron object was allowed to be examined. Now with co-operation of the

[1] Excepting the two solitary examples, one of an axe-adze from Mohenjo-daro, and the other from Chanhu-daro are, in our present knowledge, not products of the Harappan civilization. Though as Mackay has pointed out, the Harappans were acquainted with this advanced tool, as two pottery models from very early levels show (Mackay 1938, I, p. 458, and 1943, p. 188.)

[2] Rao (1962, p. 24) while trying to question this statement, in fact supported it. The various types of drills do suggest advance technology but not in metal casting.

National Laboratories and the Indian National Science Academy, formerly National Institute of Sciences, this should not be difficult. When sufficient number of iron objects from c. 1000—400 B.C. are examined, we shall know how the iron/steel swords made by Indians had been admired by the earliest Greek writers on Indian history. Was the inspiration Iranian as supposed by Wheeler, or a gradual indigenous development ?

Petrological examination of the Neolithic ground or polished stone axes from different parts of India, will show whether the raw material was local everywhere, or very often imported, from regions where it was abundant and easily available.

Steatite and faience beads can be similarly studied, whereas a more extensive study is needed of copper and bronze objects than attempted so far by Agrawal and Hegde for the protohistoric and Bhaumik (1968) for the historic material.

I hope this review will encourage us to do the right thing at the right time. Then only a much better account of Prehistoric Technology in India will be written.

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