CHAPTER I
INTRODUCTION

Copper is the oldest metal known to man, who has been making use of its special properties since the early ninth millennium B.C (Muhly 1977). In the period upto 4000 B.C the copper used was probably exclusively native copper and copper metallurgy was of little importance and an insignificant trait in the cultural aspect of the period. As the advantages of this metal over stone and other materials became known to the people, the sources of copper began to deplete. This led to the exploitation of other sources of copper and thus, man entered the threshold of metal technology. Since then metallurgy has gone through various stages of development, most of the advances being a result of constant experiments by the craftsmen.

The most widely accepted theory for the origin of copper metallurgy is that the region of north eastern part of Persia was the homeland (Singer et al 1954). In the fourth millennium B.C, the Neolithic settlements of this part, first recognized the relationship between copper ore, heat and the metal. Even the complex process of casting and forging the metal to give it an enduring cutting edge was discovered by them.
It was these chain of events that laid the foundations of metal technology and heralded the Chalcolithic Cultures. In less than a thousand years, this newly found technology had spread to other parts of Asia, Africa, and Europe. The impact of copper metallurgy was felt in the Indian subcontinent, prior to the Indus valley civilization. The earliest evidence of metal working appears in the third millennium B.C in the post Harappan levels of Mundigak in Afganistan. A large number of copper artefacts like mirror, pins, knives, blades and flat axes were recovered from various pre-Harappan sites like Amri, Nal and Mehi. In the Harappan period, there is a sudden efflorescence of copper artefacts like tools, vessels and objects of art and ornamentation. Some of the artefacts recovered from the Indus valley sites like Harappa and Mohenjodaro, bring to light not only the early impact of metallurgy in the sub continent, but also the advanced craftsmanship of the smiths. Some of the objects recovered from Mohenjodaro have been analysed and their chemical composition has been determined. The Chalcolithic communities of western and central India and northern Deccan made use of copper to make tools and ornaments. With the decline of the Harappan Culture, began the emergence of these Chalcolithic settlements. The copper artefacts left behind by them are predominantly cutting and piercing implements such as axes, chisels, knives and spearheads as well as a few ornamental pieces like beads, bangles and rings. The Copper Hoards, concentrated mainly in the Indo Gangetic plains is also a part of the Chalcolithic cultures. Though the cultural assemblages associated with the Copper
Hoards is similar to the other Chalcolithic communities, the repertoire of copper artefacts consists of many new and unique types totally absent in even the Harappan assemblages. The main types are flat and shouldered celts, barcelts, double axes, antenna swords, harpoons, hooded swords and anthropomorphs. So far these have always been chance finds, with no definite cultural horizon except at Saipai, where a harpoon was found in association with the Ochre Coloured Pottery.

The techniques employed for the extraction of metal, combination of alloys and forging of metal may have been similar or different for each of these cultures. This depends upon various factors like sources of raw material, shapes of the objects fashioned and utility of the objects. The current work intends to compare and contrast the metal technology of the Harappan and Copper Hoard Culture by studying the surviving metal work and metal working debris left behind by them.

So far, the greatest amount of work on metallurgy has been carried out on the Harappan artefacts and to some extent on the Chalcolithic Cultures of western India. Contrary to this, information on the metal technology of the Copper Hoard Culture is rather scarce.

Most studies on copper artefacts especially those belonging to the Copper Hoards have been on typology. Lal (1951), was emphatic on the indigenous origin of the Copper Hoards and was supported by (Gupta 1963, 1965). Gupta (1963) further
distinguished two zones for the distribution area of the Hoards: The eastern zone with simpler types and the central Doab zone with the advanced types. He even tried to establish typological links of the Harappan and other Chalcolithic Cultures.

Scientific studies on the Copper Hoard objects have been very few. Smith (1905) has reported analysis of four objects with tin content varying from 6% to 13%, but this has been refuted by Agrawal (1969) as not being completely reliable since most of the objects belonged to the British Museum and their find spot was not known exactly. Lal (1951) analysed the anthropomorph from Bisauli and found it to be pure copper. Agrawal (1969, 1971), has tried to examine the problem of the Copper Hoards from a technological angle. He suggested that the alloying technique of this Culture was different from the other Chalcolithic Cultures. Regarding the metal forging techniques, he said that the authors of the Copper Hoard Culture neither annealed nor cold worked their wares. A good number of studies have been conducted on the Harappan and post Harappan metal artefacts by Lamberg-Karlovsky (1967), Agrawal (1971), Hegde (1972) and Bharadwaj (1965-66).

These investigations have centered on the origin and development of copper-bronze metallurgy in the Indian subcontinent. Analytical studies to determine the chemical composition have been carried out by Sanaullah Khan (1931, 1940), Agrawal (1971), Hegde (1965) Rao (1979) and Bhowmick (1981). Provenance determinations have been tried by a few analysts. Hegde (1969) gave due consid-
eration to lead, cobalt, gold, silver, tin, nickel and bismuth which pass on to the extracted metal without much loss in quantity from the ore; while others are transmitted only in traces. By comparing the impurity pattern based on spectroscopic analyses, he indicated a correlation between Ahar copper artefacts and the Khetri ores. Agrawal (1976) used Friedman"s method to determine the types of copper ore and found that the Khetri ores and the Mohenjodaro artifacts showed closer resemblance than any other Indian ores.

These studies mainly used wet chemical analysis or spectroscopy for the elemental analysis.

With the increasing number of metal objects from archaeological excavations and modern analytical tools available for studying the material, the urge to gain more and more information about the metal technology of the ancient smiths has become irresistible. This thesis is an attempt to use the modern non destructive analytical techniques to determine the chemical composition and technique of manufacture of a few representative samples from the Harappan and Copper Hoard Culture sites. The aim of this study is to reinvestigate the metal technology of these cultures to draw significant information about the alloy pattern, metallurgical processes and smithery techniques. Using this information a comparative study on the metal technology of the Harappan and Copper Hoard Culture has been carried out.
The major objectives of the study are:

1. To analyse the representative samples of both the Cultures using modern analytical techniques, in order to understand the purity of the metal, alloy patterns and smelting technology.

2. To carry out metallographic studies of the samples to reveal the microstructure for understanding the smithery techniques.

3. To determine the trace element pattern of the samples to make an attempt to trace the sources of raw material for the manufacture of artefacts.

4. To compare the knowledge of metal technology of the two Cultures.

The metal samples of Harappan affiliation utilized in this study are from the excavated sites of Nagwada, Kuntasi, Pithad and Somnath in Gujarat. The Copper Hoard samples are unstratified chance finds from district Mayurbhanj in Orissa, Ranchi and Palamau districts of Bihar, Hardoi and Bijnaur districts in Uttar Pradesh.
The details of the samples is given in table No I.

The Energy Dispersive X-ray Fluorescence proved to be the most effective tool for the chemical analysis. The results of this analysis helped to understand the alloy patterns, purity of metal, smelting technology and trace element pattern. The metallurgical microscope was employed to study the microstructure of the samples in order to reconstruct the smithery techniques.

The study has added useful information to our existing knowledge of the metal technology of the two cultures. It has given sufficient data for the comparison of the metallurgical traditions.

The quantitative chemical analysis has revealed that the Copper Hoard smiths used only pure copper, while the Harappans even alloyed copper with tin and arsenic. Of these tin bronzes were intentional while arsenical bronzes were accidental. The composition of the alloys varied according to the utility of the artefacts.

The study has indicated that the smelting technology of the Harappans was much advanced than the Copper Hoards. The ore was roasted thoroughly in the furnace at a high temperature along with the flux. This way, they were able to eliminate iron from the molten metal.
The metallographic examination of the representative samples has helped in understanding the smithery techniques employed by the two cultures. Artefacts of both Cultures have shown instances of hot work and annealing; while evidence of cold work is seen only in some Harappan samples.

The introductory chapter, is followed by a detailed discussion on the archaeological background of the Harappan and Copper Hoard Culture.