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ANTIQUITY OF MINING AND METALLURGICAL ACTIVITIES AT AMBAJI, KUMBARIA AND DERI, GUJARAT AND RAJASTHAN

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Multidisciplinary approach to the problem of deciphering the antiquity and time spread of mining and metallurgical activities in Ambaji and Kumbaria areas of Gujarat and Deri area of Rajasthan by C^{14} method, ore-artifact correlation and early literary evidences, indicates that the mining and metallurgy of copper and possibly of lead, zinc, gold and silver, commenced in 2nd century B.C. (Maurya-Sunga time). Evidences for the continuity of the activities during Kshatrana period of 2nd to 4th century A.D. and again intermittently from early 11th century A.D., corresponding to Solanki period in the earliest part, are also present.

Scope for extending the beginning of mining activity to pre-second century B.C. and to narrow down the gaps in time spread, particularly by C^{14} and ore-artifact correlation methods, exists.

INTRODUCTION

The presence of a large number of ancient mining and smelting centres in the Aravalli region of Rajasthan and Gujarat on the one hand and the discovery of very widely distributed copper-using settlements of pre-Harappan, Harappan, Chalcolithic and historic periods on the other, in the northern, western and central parts of India, as well as in the Deccan Plateau, are already well known.

Archaeological studies have revealed extensive use of copper from the pre-Harappan period onwards in the Indian sub-continent. Recent excavations in the Mashiz valley of Iran and Timna valley of Israel have revealed extensive mining and continuous smelting of copper and a flourishing coppersmith's trade from 4000 B.C. In the light of this knowledge and in view of the fact that the Harappan settlements had trade links with early civilisations of West Asia, the copper artifacts of the pre- and Harappan settlements were presumed to have been imported from West Asia. However, the recent studies indicate that the Harappans had sufficient knowledge of copper mining, smelting and some advanced metallurgical techniques.

While considerable work has been carried out on the pre- and historic settlements by the archaeologists with regard to their antiquity, mode of life, environment etc., similar work in respect of ancient mining and smelting centres has not received due consideration. However, considerable information exists, scattered in a number of mineral exploration reports of the Geological Survey of India and some of State Directorates of Mines and Geology, wherein brief accounts of the nature of old workings are described. But, attempts to decipher the age of these mining and smelting centres is conspicuous by their absence or extreme rarity.

In the light of the above, an attempt is made here to describe the periods of mining and smelting activities in a group of mining and metallurgical centres in and around Ambaji.

Location

Extensive old workings for copper, lead and zinc ores, and for the by-product gold and silver, extend over an area of about two sq.km. to the north and north-west of Ambaji village (24°20'N : 72°51'E, Survey of India toposheet No. 45 D/15), in Danta Taluk of Banaskantha district, Gujarat. Another, smaller area of ancient workings for the same metals, occupying an area of 0.22 sq.km., is located at Deri (24°23'N : 72°50'E, Survey of India toposheet No. 45 D/15), in Abu Road Taluk of Sirohi district, Rajasthan situated about 4.5 km. north of Ambaji village.

Large dumps of ancient slag, enclosing various metallurgical tools, smelted metal, potteries etc. occur at Ambaji village itself and behind the group of Jain temples at Kumbaria (24°19'N : 72°51'E, Survey of India toposheet No. 45 D/15) which is located about 1.5 km. south-east of Ambaji village. Small dumps and scattered pieces of slag are also found near the ancient workings at Deri.

In addition to the above, ancient mine workings, in association with the slag dumps, are found at Watera, Pipala, Golia and Basanthgarh for copper (along with zinc at Basanthgarh) north of Ambaji, in Sirohi district of Rajasthan, between Abu Road and Sirohi.

Antiquity of Mining and Metallurgy in the Area

The antiquity of mining and metallurgy at Ambaji and Kumbaria has been worked out based on the following methods:

1. Radiocarbon dating of organic substances from mining and metallurgical centres;
2. Trace elements comparison amongst the ores, slag and smelted metal, and the artifacts obtained from ancient cultural sites; and
3. References from early literature.

Large amount of data on the description of the ancient mining and metallurgical activities in the region has already been collected based on which certain interpretations on the possible methods employed have been carried out. This will be presented in a separate article on the subject.

1. *Radiocarbon Dating*[1]

During the course of exploration of the Ambamata copper-lead-zinc deposit by the Geological Survey of India and the Mineral Exploration Corporation Limited during the period from 1965 and 1974, as well as in course of study of slag dumps by the author at Ambaji and Kumbaria, organic remains like wood and charcoal were obtained.

In the Ambamata deposit, pieces of wood forming part of the timber used as roof support in the ancient mines, were obtained from five locations. Four of these were obtained from exploratory boreholes while the fifth one was from an underground mine opening. The details of the location of the same are as follows:

Borehole No./ mine location	*Name of mineralised zone*	*Vertical depth from surface*	*R.L. of intersection*
A-100	North-western	82 m.	395 m.
A-114	Central	39 m.	477 m.
A-34	North	48 m.	470 m.
UB-4	North	73 m.	442 m.
No. 3 west drive	North	65 m.	450 m.

In addition, pieces of charcoal embedded in the slag in the dumps located behind the Jain temples at Kumbaria were scooped out and two such samples were collected.

Two samples of timber from borehole Nos. A-100 and A-34 and one from the No. 3 west drive of exploratory mine at 450 metres R.L., as well as the two samples of charcoal collected from the slag dumps at Kumbaria were sent to the Radiocarbon Laboratory at Tata Institute of Fundamental Research, Bombay and Physical Research Laboratory, Ahmedabad. Results of four of these samples have been received from the Laboratory. The same is reproduced below:

Sample location	*Half life of 5568 years*	*Half life of 5730 years*
1. Wood sample from No. 3 west drive	—	2110±200
2. Wood sample from A-100	825±100	850±100
3. Charcoal from Kumbaria (AC-4)	880± 85	905± 85
4. Charcoal from Kumbaria (AC-3)	515± 90	535± 90

Considering the dates in B.P. $\frac{1}{2}$ life =5730 years, the earliest mining activity falls in 2nd century B.C. The other dates are in the 11th, 12th and 15th centuries A.D.

The antiquity indicated by sample No. 1 above is the earliest date recorded and corresponds to the Maurya-Sunga times. The other dates indicated by C^{14} dating correspond to the dates mentioned in the early literature, which will be discussed in another part of this article.

2. *Ore-Artifact Correlation*

Comparison of the trace element contents in the ore from Ambamata deposit was made with the impurity pattern obtained in some of the artifacts from cultural sites located in northern Gujarat and the surrounding region.

Such a correlation is normally difficult and in many cases is of doubtful authenticity. However, one such comparison comes closest to the acceptable standards. This is described below.

The trace elements content in the Ambamata deposit varies considerably depending upon the major metal combinations and the associated host rocks. About 2800 ore samples, collected systematically from various parts of the deposit have been analysed for Cu, Pb and Zn and another 800 ore samples for a number of trace elements. In addition, over 60 samples of slag and 6 samples of metal and matte have also been analysed.

Based on the analysis of the ore samples, it is seen that the trace elements pattern obtained in the northern and north-western zones of mineralisation in the Ambamata deposit compares well with the pattern noticed in the silver coins obtained from excavations at the Buddhist site at Devnimori (23°41'N: 73°26'E).[2]

Trace elements contents of Ambamata ores are compared below with that of two of the silver coins from Devnimori, whose analysis was carried out by Hegde (1967).[3]

Out of the 23 elements which have been indicated in the coins, it has been possible to compare only 18 of ore as 5 other elements were not determined in the ore sample. Of these, 17 compare well with the elements contained in the coins. Only in case of Sn, a very small amount of 5 ppm has been found in the ore which has not been detected in the coins. This may be due to the fact that Sn is a highly volatile constituent which may have escaped/passed on into the slag during smelting or may have been greatly reduced in quantity, thereby falling below the detection limit of the spectroscope.

Right from the early times, about 8 to 12 % Cu was being mixed with silver coins to impart the required strength and hardness. However, the silver coins from Devnimori, as per Hegde, contain much higher amounts of copper, of about 18 %. This appears

Samples	Ag	Au	Pb	Zn	Cu	Al	Mn	Cr	Co	Ni	Hg	Bi	Cd	As	Sb	Sn	Be	V	Ru	Pt	Mo	Ir	U
Coin I	+	−	+	+	+	+	+	+	+	+	−	+	+	+	+	−	−	+	−	−	+	+	+
Coin II	+	−	+	+	+	+	+	+	+	+	−	+	+	+	+	−	−	+	−	−	+	+	+
Ambaji ore (copper-rich)	20	NF	H	H	H	H	600	2	15	15	NF	5	400	+	20	5	ND	10	ND	ND	5	ND	ND

+ Present
− Absent

H —High (over 1000 ppm)
ND —Not determined

NF —Not found or below detection limit

20—in ppm (semi-quantitative spectroscopic analysis)

to be much beyond the necessary limits for coinage purposes. As such, it was presumed that the debasing of the noble metal to this extent may have been adopted to overcome the shortage of silver in the Kshatrapa treasury.

The quantitative chemical analysis of the silver coins from this area also indicates 0.86 to 1.21 % Pb and 0.17 to 0.21 % Zn. Similarly, a smelted copper metal piece from Ambaji and Kumbaria has shown high amounts of about 11 % Pb and 0.85 % Zn. This appears to be mainly due to limitations in the extractive metallurgical techniques employed. Another smelted metal sample shows 47.72 % Cu, 45.97 % Pb and 0.15 % Zn. Since silver normally occurs intimately associated with lead and in the earlier metallurgical practices adopted it was not possible to obtain pure fractions of individual metals from a multimetal ore as of Ambameta, it is likely that the high percentage of Cu and appreciable quantities of Pb and Zn in the silver coins of Devnimori could also be due to deficiencies in extractive metallurgy than due to any deliberate attempt at debasing. Further, the similarity of impurity pattern in both the coins from Devnimori and the ore samples from Ambamata suggests that the source of metals for these coins could be Ambamata itself.

The silver coins from Devnimori have been ascribed to the Kshatrapa dynasty which ruled over parts of western and central India from the beginning of 2nd century to the end of 4th century A.D. As such, the mining and smelting activity at Ambamata could also be in existence during this period.

3. *Literary Evidences*

Evidences of foreign travellers who visited the country between *circa* 200 B.C. and 150 A.D. attest to the abundance of copper in India and their export to the West Asian countries through the Port of Barygaza (present day Broach in South Gujarat). The metal is believed to have been extracted from the deposits in the Aravalli region. Ambamata being the nearest of these to Barygaza, the likelihood of the metal from Ambamata being exported through Barygaza exists.

Literary evidences of mining of the metals at Ambamata and probably at Deri, and the smelting of the same at Ambaji and Kumbaria come from the Jain literature of 11th century and onwards. The period commencing from about the early part of 11th century and extending upto the early part of 17th century witnessed a tremendous growth of Jainism in Western India of which the Jain temples at Delwara (Mount Abu), Kumbaria, Ranakpur and a few other places, are classic examples. Several religious texts written by Jain saints who visited Delwara and Kumbaria temples, make passing reference to the mining and smelting activities at Ambaji and Arasan (present day Kumbaria) and the use of wealth thus obtained in the construction of the temples at Kumbaria and Delwara.

Many such interesting references are compiled in *Sri Arasan Tirth* (1961)

by Muni Vishal Vijayji[4]. The following description is taken from this reference and is also based on the dates inscribed in the Kumbaria temples.

The book *Puratan Prabandh Sangrah* describes that Vimal Shah, minister to King Bhimadeva-I of Solanki dynasty, built the first of the five temples at Kumbaria in 1030 A.D. from the wealth won by mining the metals (ore) occurring in the vicinity.

Vimal Shah also built 'Vimal Vishahi' a temple of great artistic eloquence at Delwara (Mt. Abu) at a huge cost of eighteen crore rupees. It is likely that this construction was also financed from the wealth obtained from Ambamata-Deri deposits.

A similar story in '*Vichar Shreni*' is that of Pasil Shreshti, a businessman and son of Gogha Mantri, who "by the grace of Ambaji found a treasure of metals near Arasan from which he realised abundant wealth and used the same for construction a temple there". This temple of Neminath at Kumbaria was built in 1138 A.D.

Poet Meh, while describing his visit to various pilgrim centrees in his book *Thirthmala* (1447 A.D.), has this to say about Arasan —"the land of marble and gold with treasure of seven metals ....." Old workings for marble occur in large number in the nearby Koteswar, Jarivav and other areas, the marble from which was used for construction at Kumbaria, Delwara and many other places in Gujarat and Rajasthan.

Incidentally, the present village of Kumbaria was known by the name of 'Arasan' until about the 17th century. This name was probably derived from '*Ar*' meaning metal, which is found in the vicinity.

The inscriptions in the various parts of the five temples at Kumbaria contain dates from 1087 *Samvat* (1038 A.D.) at the earliest to 1675 *Samvat* (1619 A.D.) at the latest. This indicates that a town flourished between early 11th and early 17th century, although with intermittent periods of inactivity or destruction, particulraly around the end of 13th and beginning of 14th centuries.

Conclusions

1. Efforts are made to determine antiquity of mining and smelting activities of Ambamata, Deri and Ambaji by C^{14} method, ore-artifact correlation and early literary evidences.

2. The earliest mining activity in the area has been traced back to 2nd century B.C., corresponding to Maurya-Sunga times.

3. Subsequent activities have been noticed around 2nd-4th centuries A.D. and early 11th to early 17th centuries A.D.

4. The antiquity of the mining indicated here does not purport to be the earliest date of mining. Nor is the time spread deciphered considered exhaustive. As a matter of fact, there is need for carrying out this work further, particularly by C^{14} method and ore-artifact correlation for the purpose of extending the antiquity backwards and to abridge the existing gaps in chronology.

The present C^{14} dates are based on only four samples of timber and charcoal. With the opening of the Ambamata deposit, which is now in progress, likelihood of obtaining more samples of timber and other organic materials from the old mines exists. Similarly, if the slag dumps lying in private properties at Kumbaria are excavated, it may be possible to obtain more samples of charcoal from lower and earlier levels.

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