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PROJECT REPORTS

An Ethno-Technological Study of Iron Working Around Sonbhadra Region*

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India was at the forefront of iron and steel production in the ancient world. Excellent quality steel was being produced and even exported to various parts of the ancient world right from 5th-4th century BC according to the Greek accounts. There were important iron production centres across the Indian subcontinent by the early centuries of the Common Era. The iron ore rich Vindhya-Kaimur belt, the area of the present study is a potential zone for evidence of ancient Indian iron technology. It is aimed to undertake a multidisciplinary study of iron technology in this part of India, especially around Sonbhadra region that is rich in archaeological, ethnological and metallurgical evidence. The traditional iron smelters of India such as the *Āgariās* and *Asurs* have produced iron and steel here in the age old manner till recent decades. Besides the ethno-archaeological study of iron technology, the project also aims to explore whether there is any possibility of cultural correlation between the production zone in the ore–rich hills and the growing urban centres in the nearby plains. It is also proposed to trace the metallurgical developments that took place at particular stages of Indian history and highlight India's heritage in the field of technology.

The study as conceived has been planned in the following seven chapters:

I. Introduction
II. The Region and its Geo-ecological Features
III. Iron Ore Deposits

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IV. The Archaeological Evidence of Iron Technology and Its Chronology
V. Ethnological Evidence and Living Tradition of Iron Metallurgy
VI. Investigations into Status of Metallurgy
VII. Conclusion: Reconstructing the Metallurgical Heritage of India.

The minerally affluent region of Sonbhadra appears to have caught attention of geologists right from the British period. The old records of GSI, gazetteers, correspondence and accounts of British officials etc. have provided valuable and up to date information on iron ore deposits, mining and metallurgical activities that were prevalent in the region. Taking clue from the information available from the literature survey and following topo-sheets of the region, we conducted extensive field investigation covering an area of approximately 4,000 sq. km. during the tenure of the present project. We could earmark 114 important localities having evidence of ore deposits, ancient mining pits and shafts and slag heaps, refractory material etc as remnants of old iron working (see table-1). We also noticed that several of these localities are inhabited by the ethnic communities who had been engaged

Table 1. Surveyed sites / villages of Sonbhadra region

No.	Name of the Village	Slag, Tuyeres etc.	Ore	Trace of Furnace	Known source of Iron
	Sonbhadra (U.P.)				
1	Tapu	√	√		Karia Pahar area
2	Gaura *	√			
3	Hardahwa *	√	√		
4	Gayghat *	√	√	√	
5	Ghatihata	√	√		Hills at Ghatihata
6	Agori	√	√		Hills at Agori
7	Kharahara *	√	√		
8	Devkhar	√	√		Hills near Devkhar
9	Khewndha *	√			
10	Mairadand *	√			
11	Parsoi	√	√		Madhukarwa Pahar
12	Kariya *	√			
13	Kanuhar	√			Patharsa Pahar
14	Pahar Daria	√	√		Patharsa Pahar
15	Pipara	√	√		Pipara
16	Jogail	√	√		Lohwadev Pahar
17	Panchperi	√			Panchperi

No.	Name of the Village	Slag, Tuyeres etc.	Ore	Trace of Furnace	Known source of Iron
18	Harsadand *	√			
19	Bharhari (24°32': 82°45')	√	√		Bharhari
20	Kusahiya Tola (24°36':83°05'30")	√	√	√	iron ore was fetched from somewhere
21	Banpaisa *	√			
22	Bodarhwa *	√			
23	Bheriya *	√			
24	Makra	√	√		Chhuhiya Pahar
25	Agariadih *	√			
26	Benadah *	√			
27	Barohiya *	√			
28	Sidhahwa	√			Sidhahwa
29	Charkpathri	√	√		Charkpathri
30	Dhanbahwa *	√			
31	Karahiya	√	√		Datnipurwa Pahar
32	Sisahwa *	√			
33	Manarahwa *	√			
34	Mamuar	√			Mamuar
35	Dibulganj *	√			
36	Aunra Dand *	√			
37	Kuriya *	√			
38	Vichharitola *	√			
39	Kubri *	√			
40	Parrhawa				Iron ore
41	Amahwa *	√			
42	Siswa	√	√		Siswa
43	Injani *	√			Copper ore
44	Jarha *	√			
45	Sevkadand *	√	√		
46	Chanchallia				Iron ore
47	Bihwa *	√			
48	Kirwani	√	√	√	Dhou Pahari
49	Raspahari	√	√		Dhou Pahari
50	Kirwil *	√			
51	Gora	√			Chindol Pahar
52	Kharatia *	√			
53	Naodeha *	√			
54	Murta *	√			
55	Manbasa *	√			
56	Mahuaria *	√			
57	Matiyari Pahari (Jharo) *	√			

No.	Name of the Village	Slag, Tuyeres etc.	Ore	Trace of Furnace	Known source of Iron
58	Katauli *	√	√		
59	Majhauli *	√			
60	Sahgora (Charia) *	√			
61	Kudri (Agaria Tola) *	√			
62	Sardiha *	√			
63	Kachan *	√			
64	Darihera *	√			
65	Parni *	√			
66	Ajangira *	√			
67	Dhankhur *	√			
68	Baliari *	√			
69	Khursi Tola *	√			
70	Khairahi (Jogi pahar)	√			Dhou Pahari
71	Lohban * (Fagunmari Tola)	√			
72	Supachua *	√			
73	Sonwani *	√			
74	Amwar *	√			
75	Bagharu *	√			
76	Sundri *	√			
77	Manrutola *	√			
78	Dighul *	√			
79	Korchi (24°05':83°20')				Iron ore
80	Ningha (24°25': 83°01')	√			Iron ore
81	Devtara (near Tiwaritola)m	√			
82	Khokha Karhiya *	√			
83	Baurihwa *	√			
84	Hathwani *	√			
85	Hardi (24°27': 83°11')				Iron ore
86	Neruiyadamar *	√			
87	Harnakachar *	√			
88	Kewal *	√			
89	Kochnarwa *	√			
90	Naodiha (24°25': 83°16')				Iron ore
91	Khamuharia in GBP Sagar	√			
92	Gadaura	√			
93	Baragaon	√			
94	Judauli near Raipura	√			
95	Mahuwaria near Raipura	√			
96	Raipura Singarauli (M.P.)	√			
97	Domarchawa *	√			

No.	Name of the Village	Slag, Tuyeres etc.	Ore	Trace of Furnace	Known source of Iron
98	Bori	√			Bori
99	Jurwar *	√			
100	Garwani	√	√		Garwani
101	Gir *	√			
102	Gidher-Kanodah *	√			
103	Bodiya				Iron ore
104	Khadaura				Iron ore
105	Salhan				Iron ore
106	Pipara (24°11'33" : 82°15'23")	√	√	√	Pipara
107	Majhgawa (24°15'50" : 82°29'43")		√		Hematite and Limonite
108	Jadaura (24°16'40" : 82°24'28")		√		Iron ore
109	Amu (24°17'55" : 82°22')		√		Iron ore
110	Lilahara near Purva		√		Hematite
111	Hills along Gopad river (24°24'41" : 82°12'49")		√		Iron ore
112	Mudwani	√	√		Iron ore
113	Chamradol	√	√		Iron ore
114	Dhilari	√	√		Iron ore

* Ore is available in the vicinity.

in iron working for generations. We could successfully document the traditional iron working and collect archaeological material from these sites for analysis and in-depth study. We could also procure good number of ^{14}C dates that can provide a reliable chronology to Iron Age cultures of this region. An in-depth study of the material procured during the project has indeed helped us get real insight into the metallurgical heritage of India in general and in the study area in particular.

Archaeological evidence of iron technology

In recent years Sonbhadra region has emerged as a key area of iron production having high antiquity as indicated by ^{14}C dates from excavations at sites like Raja Nal-Ka-Tila, district Sonbhadra (1300 BC), Malhar, district Chandauli (1700/1600 BC), Tokwa, district Mirzapur (having an uninterrupted cultural sequence from Neolithic period that dates back to 5000/4000 BC to

Iron Age). The site of Raipura, district Sonbhadra (1700/1600 BC) has been excavated by us in course of the present project has added valuable evidence in this regard. Raipura excavation not only re-enforces the earlier dates coming from this region, it has helped place the region of Sonbhadra on the map of India as the one of the early iron production centres. Before we recount other details of the project, a brief description of the evidence of iron working as revealed by Raipura excavation (2010-11) is being briefly narrated here:

The site of Raipura (Latitude 24°40′40″ N; longitude 82°58′20″E) is situated in the Valley of Belan River in Ghorawal block, 16 km. west of *tehsil* Robertsganj, district Sonbhadra, Uttar Pradesh, at a distance of 100 km from Varanasi. The excavation revealed a threefold cultural sequence that has been dated. Approximate date range along with cultural sequences is briefly indicated here:

Period I: RW and Black Slipped Ware deposit (without metal) (3200 - 2200 BC).

Period II: Pre-NBP – Black Slipped Ware (Early Iron Age) (1700/1600 - 800/700 BC).

Period III: NBPW Cultural Deposit (Mature Iron) (800/700 - 200 BC).

The site was first occupied by an early farming community. No metal has been recovered from period I. BSW and Red Ware of early variety were used. The ^{14}C dates of this period range between 3270±170 BC to 2410±140 BC. The chronology indicates a break in occupation between periods I and II.

It may be worthwhile talking in a little detail about the Pre-NBPW period during which iron was first introduced at Raipura. The small finds of this period comprised, number of iron objects, bone points and arrowheads, pottery discs, terracotta beads, semi-precious stone beads and an indeterminate copper object.

The most important discovery of period II (pre-NBPW period) is evidence of iron working with a smelting furnace (Fig.1). The size of the furnace was approximately 55 cm in diameter at base and its extant height was approximately 15 cm. At the base of the furnace a tuyere-hole for

Fig.1. Excavated Furnace at Raipura, Early Level of Period II

inserting tuyere was also noticed. The trench yielded number of iron objects along with iron slag pieces as well as fragments of burnt tuyeres. The ^{14}C dates of this period range between 1867 – 1848 cal.* BC (PRL-3317) and 1720±220 cal. BC (BS#3536) for its early level to 894 – 873 cal. BC (PRL-3319) for its upper levels, the latter coming from the transitional phase of Period I and III. It is during this period that iron was introduced at Raipura. We have also unearthed a smelting furnace from the earliest level of Period II datable to 1720±220 cal. BC.

Period III (NBPW Period) was marked by the occurrence of the NBPW with a maximum deposit of 65 cm in trench ZH-10, 60 cm in trench ZB-10, 60 cm in trench YI-11, 75 cm in trench YH-11. The evidence of two iron smelting/forging furnaces similar to previous one unearthed from period II is significant indeed. It gives us an idea about the furnace and forge used during this period. The ceramic assemblage of this period continues to be characterized by the Black Slipped Ware, Grey Ware and Red Ware along with NBPW, the deluxe pottery of this age. The shape of the smelting furnace mentioned above could be compared and reconstructed with the help of ethnographic evidence readily available in the neighbouring localities inhabited by the *Āgārias*.

For a real insight into ancient practices, ethnography is a great asset. Fortunately, we could successfully locate Pre-industrial iron working sites as well as Agarias. The *Āgāria* village at Pipara or Piparakhand (24°11’33":

*Calibrated

82°15’23") had still some idea about the traditional way of iron production of their ancestors. They could smelt iron successfully, even though not very efficiently. Briefly stated, it was observed that each operation needed 10 kg ore and 10 kg charcoal. It took about 3-4 hours to produce an ingot weighing approximately 1.2 kg.

Geologically this site is situated in Raniganj formation. Depending on the type of iron required to be produced, both high grade hematite as well as low grade ore was smelted by the traditional workers of this region. The iron ore available there ranged between low grade one (20%) to high quality one having up to 65% metallic content. Nodules of ore are easily available on the surface. However, small mining pits measuring up to 10-15 ft. depth or shafts can occasionally be traced in this belt. Wood charcoal generating temperature up to 1200°C was used for energy in simple clay furnaces. An iron ingot procured as a result of demonstration of smelting by the *Agarian* of Pipra village in Singrauli district was analysed with Image Analyzer. It shows a ferrite network on colonies containing prearlite. Resolved pearlite is also seen in the microstructure.

In course of field investigation, we have recovered a 60-70 year old iron pick axe from an *Āgāria* family of Katauli village, district Sonbhadra. The iron is slightly reddish in colour. That pick axe manufactured by traditional method was analyzed, courtesy Department of Metallurgical Engineering, IIT, BHU. It had a Vicker’s hardness - 125 and Rockwell hardness - 106. The EDAX analysis showed iron content of 99.48%, silicon 0.52% and carbon 0.2%. Further analysis of iron objects from Raipura is under way. However, one thing may be stated that samples indicate knowledge of carburization in samples belonging to early level of Period III that is assignable to 800/700 BC.

By 7th-6th century the Vindhya-Ganga region was producing high quality iron as indicated by analysis of samples from sites in the plains. Our SEM and EDAX analysis of iron sample of a sickle and chisel from the site of Anai excavated by us indicates knowledge of carburization, quenching, and tempering with evidence of lamination in the sickle datable to 900 BC. High carbon (4.19 %) has been noted in certain parts of this sample.

Concluding Remarks

In course of our study we have conducted field work in an area of 4000 sq. km. bringing to light a large number of sites of ancient and traditional iron working (see list).The area is very rich in iron ore along with other minerals. Many of the areas having high iron content of about 65%, we feel can be economically viable for small scale production of iron. The possibility may be explored.

The region of Sonbhadra is rich both in archaeological as well as ethnological evidence of iron therefore ideal for such a study**.** Our sustained work brought to light ancient iron production centres like Raipura. The excavation yielded furnaces, forges along with finished iron objects from an early context. The ^{14}C dates show that iron started at the site in the Pre-NBPW period around 17/1600 BC if not earlier. It suggests an independent beginning of iron metallurgy in this land-locked area. The region seems to be a production centre supplying iron to the nearby sites in the plains for several centuries as indicated by its presence right up to the strata datable from BC 17/1600 to 200.

Our study has thrown light on furnace design, complete with tuyeres and stone slabs used for pressing down bellows. Equally significant is the fact that similar furnaces have been in use by the ethnic iron workers till recently (Fig.2). Thus our investigations prove it to be an ideal place having ethno-archaeological evidence on iron technology.

The analytical examination of the material recovered from excavations suggests that there was an evolution in metallurgy from wrought iron to high

Fig. 2. Iron Smelting in Modern Agaria Furnace, Singarauli, Madhya Pradesh

quality steel iron. The tradition has survived with the ethnic society of the *Āgārias* and the *Asurs*. There appears to be a mechanism of iron production in the ore-rich hills and its distribution in the nearby areas in the alluvial plains which emerged as urban centre over the centuries. The Sonbhadra region thus has a unique history of iron technology lasting for approximately 3000 years. In a nut shell, we may conclude that close investigation in selected areas like the present one may throw a much needed light on the ancient Indian iron metallurgy for which India was famous in the ancient world. With inputs from the modern metallurgists and inter-disciplinary researches, it may even be possible to reproduce high purity corrosion resistant phosphoric iron like the Delhi iron pillar.

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