

REPORT TO THE INDIAN NATIONAL ACADEMY OF ENGINEERING:

INAE DELEGATION TO BUMA-VI IN BEIJING, SEPTEMBER 15 TO 20, 2006

1 Dr K Kasturirangan , President, INAE graciously agreed to the request from Dr Baldev Raj, Foreign Secretary, INAE & Chairman , Study Group on Engineering Heritage (Metallurgy) to depute a delegation for participation in the International Conference on the Beginnings of the Use of Metals and alloys (BUMA-VI) with partial travel grant . It was intended to strengthen Indian contributions in this area by securing the hosting of BUMA-VII in India.

2 The delegation was led by Prof S Ranganathan, FNAE and included Dr Sharada Srinivasan (Member, International Advisory Committee, BUMA-VI), Prof Vibha Tripathi, Dr R N Singh, Dr P Upadhyaya, and Dr Anish Kumar. Full addresses are given in Annexure 1. Members presented 3 papers in oral sessions and 2 papers in poster session. The abstracts are given in Annexure 2.

3. The BUMA conference series was established in 1981 and held in Beijing by Prof R Maddin and Prof Tsun Ko with strong support from Prof Cyril Stanley Smith and Prof T Imai. These were followed by BUMA-IV in Shimane, Japan, 1998; BUMAV in Kyonju, Korea, 2002;BUMA-VI, Beijing 2006

4 BUMA-VI had ~125 participants from 14 nations. This included 58 (China), 13 (UK), 11(USA), 9 (Japan), 6 (India), 6 (Germany), 6 (Italy), 5 (France), 4 (Russia), Korea (3), 1 (Australia), 1 (Sweden), 1(Denmark) 1(Taiwan). 57 Papers were presented in 10 oral sessions and 10 in poster sessions.. There was a special An Yang Session when a visit to An Yang , the capital of the Shang Dynasty was arranged. The collection of bronze vessels was magnificent.

5 The proposal made earlier by Dr Sharada Srinivasan to the International Advisory Committee was discussed with Prof S Ranganathan as a Special Invitee. Even though Japan showed some interest in organizing BUMA-VII, the committee fully appreciated

the interest from India and especially the participation of a strong contingent of the INAE delegation and awarded BUMA-VII to be organized by the National Institute of Advanced Studies under the aegis of the Indian National Academy of Engineering in Bangalore in September 2009. Prof Ranganathan was also elected to the Standing Committee of BUMA.

6 The delegation expresses gratitude to Dr Kasturirangan, Dr Baldev Raj..It is also grateful to Prof Tsun Ko, Prof R Maddin nad Dr Jianjung Mei for the hospitality and the many courtesies extended by them

S Ranganathan

September 25, 2006

Annexure I

September 15, 2006

PARTICIPATION OF INDIAN DELEGATES IN BUMA-VI

INAE Delegation

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Annexure II

ABSTRACTS

Oral Presentations

1. Preliminary insights on megalithic iron technology with respect to the site of Kadabakele, southern India

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This paper touches on aspects of megalithic iron technology from parts of southern India. An overview is made of iron metallurgy from megalithic contexts in the modern day states of Karnataka, Andhra Pradesh and Tamil Nadu. One of the sites which will also be discussed more closely is Kadabakele, which is on the outskirts of the 14th-16th century world heritage site of Vijayanagara in Karnataka close to the village of Anegondi overlooking the Tungabhadra river. This site has been excavated by a collaborative team from the Karnataka Department of Archaeology, the University of Michigan, and the University of Chicago. The site was occupied from at least the early first millennium BC into the early centuries AD. Excavations revealed numerous iron artefacts. Carbon dates from the Iron Age or 'megalithic' period span from c. 800-400 BC. Preliminary investigations on some artefacts are explored.

2 NONDESTRUCTIVE CHARACTERIZATION OF DELHI IRON PILLAR

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Ancient and medieval India made tremendous impact on the world scene through many spectacular achievements in iron and steel technology. An exemplary monument of the medieval India is the Delhi Iron Pillar (late fourth-early fifth century A.D.) standing on the outskirts of Delhi, the capital of India. It is a wrought iron product about 7.375 meter high, 41.6 cm in diameter at the bottom and 34 cm at the top. The top has an aesthetic ornamental structure. Estimated to weigh more than 6000 kg, it is believed to have been built by forge welding pieces of wrought iron. The Pillar bears testimony to the fact that iron workers were experts in cementing and forge welding small pieces or segments of

iron to shape such large objects a technique that was uncommon to the western world in that era.

The study presented in this paper is aimed at obtaining comprehensive and statistical information at a number of locations on the Iron Pillar through a variety of complementary NDE techniques. Such a study could enhance the understanding of the ancient metallurgy and fabrication technologies adopted for fabrication of the Iron Pillar. The NDE techniques chosen for the investigations included low frequency ultrasonics, impact echo technique, radiography, radiation gauging and in-situ metallography. The microstructural analysis of the pillar using in-situ metallography indicated the presence of cast and forged structure, which in turn indicates that two processes would have been used in the making of iron for the pillar namely i) direct reduction of iron from ore (sponge iron) followed by hot forging and ii) casting. This is the first time that use of casting process for making a portion of the pillar has been proposed. The radiation gauging, radiography, ultrasonics and impact echo testing indicated the presence of voids at different locations. The aspect ratio of the voids (larger dimensions in axial and circumferential directions as compared to the radial direction) indicates that the pillar could have been forged in the radial direction rather than in axial direction. This is the first experimental inference of the fabrication of Delhi Iron Pillar by forging in the radial direction.

3. Survival of Traditional Indian Iron Working

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India was well known for its high quality iron & steel production in the ancient world. There are both archaeological as well as documentary evidences to suggest that right upto the 18th-19th century there was a strong demand for Indian iron and steel in the world. Iron working was a flourishing industry with a sizeable population of full time iron workers involved in the field to meet the demand for it. Traders from the middle eastern countries flocked the south Indian ports for wootz steel ingots which they used to make swords known to the world as Damascus steel. Ship loads of iron was exported to many European countries. The French who reached Indian ports for trade were regular customers of Indian iron and steel. They later tried to establish their own manufactories in southern parts of the country. When the British came to India, they took a keen interest in the Indian iron and exported it to Britain using that iron in production of important steel structures like bridges. They invited experts from Britain who systematically studied the metallurgy to understand the intricacies of traditional Indian iron technology. However, gradually with the beginning of industrialization and import of pig iron from Britain, the traditional Indian iron industry that was not well organized could not withstand the competition. Iron production, thus almost came to an end in due course of time. This may be termed as end of an era in industrial production and skill which had produced master-pieces like the nearly 7 ton Delhi iron pillar, in 4th-5th century AD and the largest beams at Konark temple (9th-10th AD) that has ever been produced in the antiquity, and several other monumental structures of iron till pre-modern times. We are now faced with a big question like what happened to the traditional Indian iron

technology in the following years? Did it vanish altogether without leaving any legacy behind? The present paper seeks to answer these questions.

Recent investigations carried out by us have brought to light certain ethnic societies which were known for their association with iron production for generations. We could pick up the strands of a nearly lost technological skill, encourage them to recall and produce iron in their small furnaces, the type of which their ancestors had used for generations. We propose to discuss the process step by step here. This technique has surprisingly survived in the memory of the relatively senior members of the community. The demonstration of iron working by them has indeed provided an insight into the traditional Indian iron technology, that must have been in vogue in antiquity.

Poster Presentations

4 Beginning of Metallurgy in the Ganga Plain with special reference to Sarayupar Plain

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Although the vast Ganga plain has almost homogeneous geographical features everywhere, there are sharp differences in every area. Keeping these differences and several other factors in view, the Ganga plains have been divided into three sub-divisions: The Upper Ganga Plain, The Middle Ganga Plain and The Lower Ganga Plain. The region of Sarayupar or Trans-Ghaghara Plain of the Middle Ganga is a part of the Middle Ganga Plain comprising the present districts of Basti, Gorakhpur, Deoria and Gonda of eastern Uttar Pradesh and district Saran of north-eastern Bihar.

The earliest evidence of the use of metals in the Sarayupar Plain is in the form of a small copper arrowhead reported from Lahuradeva (datable to about 2700 BC) in Sant Kabir Nagar -Basti district, a recently excavated site in Uttar Pradesh (personal information by Dr. Rakesh Tewari, Director, U. P. State Archaeology Department). The arrowhead was made by copper sheet and is similar to the Harppans. Almost identical arrowhead was also reported from Imlidih (Gorakhpur district).

Similarly, recent archaeological discoveries attribute the first emergence of iron to the copper using societies in different parts of the subcontinent in protohistoric period. The date and origin of the beginning of iron working into India has remained a much debated research problem. The earlier contention of diffusion of iron has been questioned in light of new discoveries. Earlier most of the scholars associated it with the Aryan homeland and the Hittites monopoly of iron smelting.

Now it's certain that the India was a separate and possibly independent centre of manufacture of early iron. Shaffer in 1984, on the basis of the context, early dates and

different functional nature of iron artefacts in the subcontinent, suggested that iron technology was an indigenous development and not diffused from western sources. Recently, on the basis of new C¹⁴ dates, Tewari (2003) has tried to establish that the India was an independent centre for the development of the working of iron since c.1800 BC and its origin can be taken back up to 2000 BC, if not earlier. Hence, India did not receive the technical know-how of iron smelting and smithery from outside sources (Singh, 2005).

In present communication, an attempt has been made to discuss the beginning and use of copper and iron object from the Ganga plain along with their technological background with special reference to the Sarayupar Plain. On the basis of our analyses and the data available from the other sites, two fold developmental stages can be ascertained. The Chalcolithic people made the initial development of iron technology. But due to inability of successful reduction, much of the iron was lost in slag during this stage. But soon after, the technology was modified and perfected during the second stage and as such the iron implements of this stage was completely free from slag particles due to successful reduction under sufficiently high temperature. The second stage also witnessed the introduction of mild and case steel as evidenced from the presence of carbon contents (at Hatigra-0.35%, Mahurjhari and Tekkalghat-Khapa-0.9% and even higher at Rajghat-1.2%). The deliberate addition of iron is definitely a step forward in iron technology. This highly technical knowledge was definitely acquired by the blacksmiths of Ganga valley and Central India by about 7th-6th century BC.

References:

- Singh, Ravindra N., 2005, Iron in the Ganga Valley: An Archaeo-technical Assessment, *Indo-Koko Kenkyu-Indian Archaeological Studies*, 26; 17-32, Tokyo.
- Tewari, Rakesh, 2003, The Origins of Iron Working in India: New Evidence from the Central Ganga Plain and the Eastern Vindhyas, *Antiquity*, LXXVII-297;536-545, Cambridge.

5 Living Tradition of Iron Smelting in India

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History of iron metallurgy in India goes back to first half of the 2nd millennium BC. It assumed great importance towards the middle of the 1st millennium BC. Indian iron and steel finds frequent references in the Greek and Persian documents of this age. The most famous ones are the iron swords presented to the Greek ambassador Ktesias in the Persian court dating back to 5th century BC. Curtius refers to the iron tipped arrowheads used by the Indian army fighting against Alexander who was gifted with 30 lbs. of Indian steel ingot by the Indians. In the subsequent century, Indian iron and steel was being exported to different part of the old world as a much-valued commodity. The

tradition continued till pre-modern times till the advent of modern blast furnaces. What happens to the centres of iron production is a question that is still being discussed.

After the decline and disintegration of indigenous iron industry its traces could hardly be found by the historians of iron metallurgy. However, recent interest in the history of iron metallurgy has brought to light a few pre-industrial societies, which were engaged in iron production since time immemorial. Our recent investigations in the bordering area of Sonbhadra-Sidhi region of the provinces of Uttar Pradesh and Madhya Pradesh have brought to light such ethnic groups who still had a faint memory of their ancestral skill.

The present paper proposes to throw light on the techniques of iron smelting as practiced by the Agaria tribe residing in the forested area of this region. They successfully demonstrated the metallurgical skills possessed by them. We proposed to discuss it at length here.