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Archaeometallurgical Studies of the Ancient Iron Smelters in the South Eastern Part of Manipur, India

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Abstract:

During an investigation, a number of broken furnaces were found near the ancient iron smelting sites in and around *Kakching*, a village in the south eastern part of Manipur, inhabited mostly by the scheduled caste communities. On preliminary examinations, most of the rock samples collected from the sites were found to be debris of iron slag adhered to the big furnaces from which iron was extracted by the ancient smelters by traditional techniques [1]. However, one such lumpy rock which was found a bit heavier than other pieces of the same size was suspected to be iron ore. Apreliminary round of examination was done on the spot by using a simple magnet. The magnetic separation technique of the powdered sample reveals the presence of iron feelings. The X-ray Diffraction confirmed the iron contents to very small amounts. The possibility of using rocks from the adjoining areas as ores manifests the amounts of energy and time spent by the ethnic community in obtaining a small amount of iron for domestic tools.

Key Words: X-ray Diffraction, Slag, Magnetite, Haematite

1. Introduction:

The smelting of iron as a routine practice of the ethnic communities in*Kakching,* Manipur has been reported in the *Cheitharol Kumpaba*, the Royal Chronicles of Manipur [2]. The styles, techniques and rituals involved in the process of iron forging and smelting works in Manipur is well documented in the works of M. Gourachandra Singh of the People's Museum in *Kakching*. The story of founding of iron smelting colony at *Kakching* by *Khamlangba*, a chieftain of the village,was also written in most of the ancient *Puyas*, the historical accounts of the Manipuri people. *Khamlangba* is still worshiped by the people of Kakching as the local deity in the *Lai Haraoba* Festivals every year. *Khamlangba* is also considered as the founder of iron in Manipur [1,2].

Figure 1: Map of Manipur showing various districts and location of the smelting site at Kakching, Manipur

Generations of people in *Kakching*area in the south eastern part of Manipur, about 70 kilometres from the capital city of Manipur, have smelted iron and the skills have been taught from one generation to

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another. Iron working in *Kakching* has been the pre-eminent transformative process, a technology greedily sought and jealously guarded, for its control could promote a king's ambition and a soldier's fortune. In general, iron smelting technology has often been considered divine inspiration brought to humans by culture heroes. In other circumstances, the transformative powers of iron workers are deemed so great that smelters and blacksmiths are thought dangerous and avoided by ordinary people.

The widespread occurrence of the remains of the ancient iron smelting processes, small parts of technical ceramic including furnace shafts and tuyeres, traces of charcoal, as well as copious amounts of smelting slags- provide a rich materials base for reconstructing the technology used by the ancient smelters. Excavations at several locations in *Kakching* area have revealed evidence of Late Iron Age iron smelting in the south eastern part of Manipur. In many areas, layers of smelting debris, such as ash, charcoal, slag and pieces of possible tuyeres were found together with fragments of mud-brick walls associated with what may be the collapsed remains of furnaces [1,2].

2. Sample Collection:

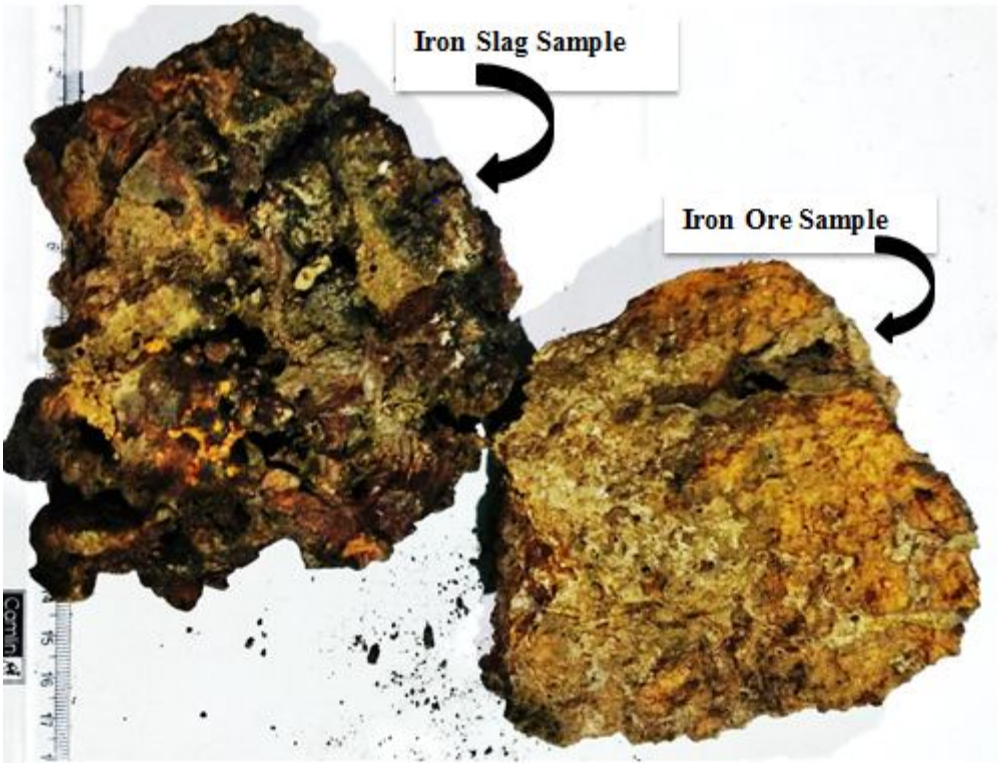

Figure 2: Difference between the physical appearances of Iron Slag and Ore samples

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figure 2 shows the two samples of almost the same sizes collected from the smelting site at *Kakching*. The sample on the left side has blackish surfaces with shiny glassy matrix which indicates the iron slag contents left over after the extraction of iron. The sample on the right side shows the brownish dull surface indicating iron contents in heavier rock.

As the ore sample was found near the smelting site, the ancient smelters would have collected the ore from the nearby areas. The shiny glassy matrix in the slag sample indicates that charcoal from burning wood would have been used in firing the furnace. The energy and time spent in obtaining a small amount of iron out of the lumpy ores have been evident from the glassy matrix which would be formed out of silicates.

3. Experimental Observations:

One of the easiest means for testing whether the samples are slag or ore is the magnetic separation. At the first instance, the author's Bluetooth headphone system is brought near the sample and found some impulsive force. Then, a small portion of the slag granules adhered to the sample has been collected and placed on a white paper (left side in figure 3). The magnetic poles of one of the earpiece Bluetooth headphone is placed just below the paper and moved sideways. Surprisingly, it is observed that the granules also move sideways along with the magnetic piece.

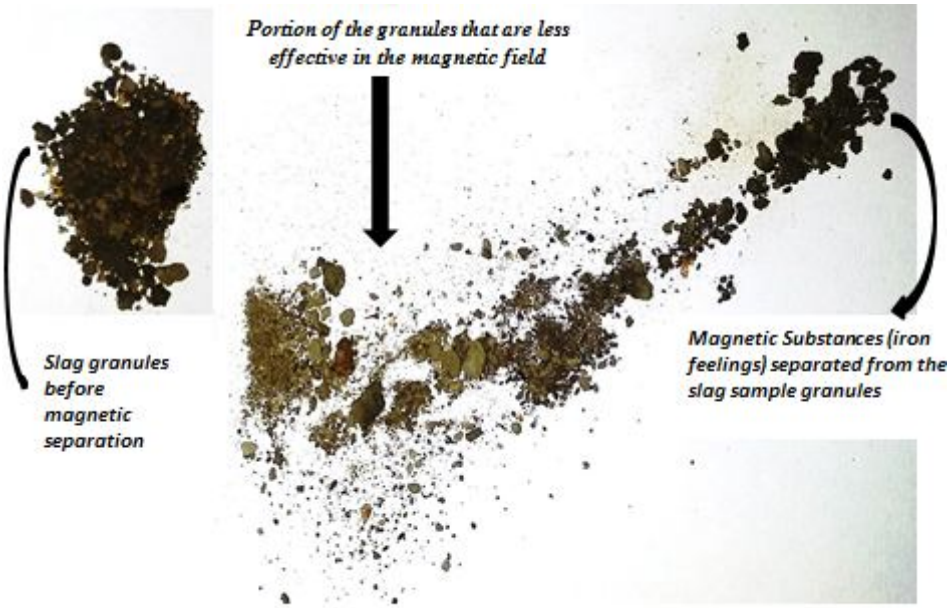

Figure3: Spot observation of the samples - some slag granules (left) and separated iron feelings under magnetic separation

The granules which are strongly effective to the magnetic field are drawn to the topmost right hand corner of the paper as shown in the figure. The portions of the granules which are less effective come at the midways and those which are not effective remain in the original positions. The magnetic separation shows large contents of iron feelings even in the slag sample. This shows that all the iron contents from the ore could not be extracted completely

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by using the traditional techniques. Most of the iron contents were left out which remained with the slag. This indicates that the techniques which were traditionally used by the ancient smelters with tuyeres and bellows were not so effective in the extraction of iron. Moreover, charcoal from burning wood used in firing the ore could not provide the required temperature at which iron was smelted effectively in the traditional style and technique.

The ore sample was powdered in a mortar and taken toa *Brooker D8 Advance* X-ray Diffraction (XRD)Laboratory at the National Institute of Technology (NIT), Imphal. The XRD pattern of the ore sample is presented in the figure 4. The XRD pattern shows presence of Magnetite (Fe_2O_4), Quartz (SiO_2), Diopside [Ca (Mg,Al) $(Si,Al)_2O_6$], Hematite(Fe_2O_3)in large amounts along with some other minor constituents. The high content of quartz and magnetite indicates that the sample is an iron ore which was identified by the ancient smelters

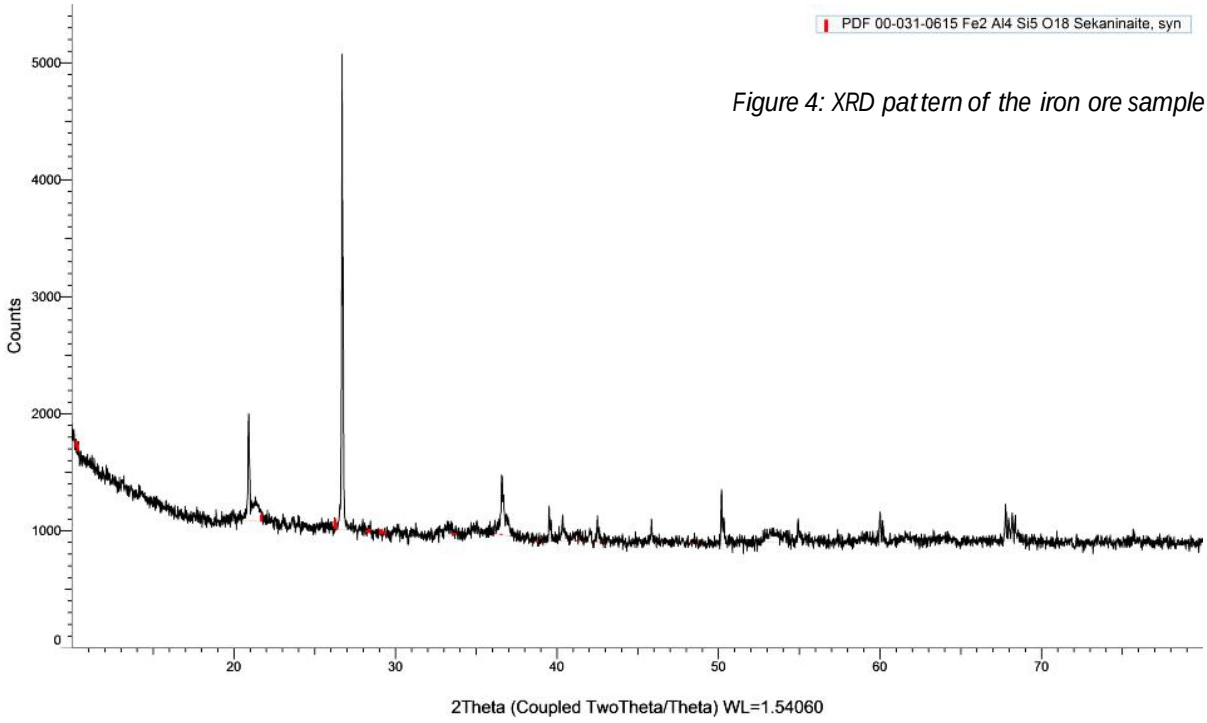

Figure 4: XRD pattern of the iron ore sample

by using primitive technology [4, 5]. The use of traditional techniques by the ancient smelters for identification of the ore deposits were well documented in many works [6, 7]. In the case of *Kakching* smelters, it is reported that the ancient smelters used bamboo sticks with magnetic pieces attached at one end [1]. However, the iron that was extracted in such a traditional process in the south eastern part of Manipur including some portions in Kabaw Valley now in Myanmar has been documented as of high quality [3]. Aluminium, Magnesium, Calcium, Phosphorous were also found to be present along with the iron contents in the form of oxides.

The elemental compositional analysis of the sample was carried out by using X-ray fluorescence (XRF) techniques. The XRF analysis was performed with IQ+ software for semi-quantitative determination of elemental composition which is presented in table 1.

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Table 1: Elemental Composition of the Ore Sample

Sl. No.	Compound	Composition (%)
1	CO_2	**6.05**
2	Na_2O	**1.05**
3	MgO	**0.54**
4	Al_2O_3	**4.98**
5	SiO_2	**52.02**
6	P_2O_5	**1.07**
7	SO_3	**0.09**
8	Cl	**0.54**
9	K_2O	**2.07**
10	CaO	**4.02**
11	TiO_2	**0.18**
12	Cr_2O_3	**0.02**
13	MnO	**0.12**
14	Fe_2O_3	**26.8**
15	SrO	**0.06**
16	ZrO_2	**0.04**
17	BaO	**0.12**

XRF analysis reveals that the sample has a very high content of silica (SiO_2) and moderately high contents of iron oxide (Fe_2O_3)along with Aluminium Oxides (Al_2O_3), Carbon dioxide (CO_2), Calcium Oxides (CaO) and Potassium Oxides (K_2O). The phosphorous content has been found to be more compared to the conventional iron produced in any other parts of India [7, 8]. The presence of both Fe_2O_3 and also Fe_3O_4 were also recorded. In ancient times, traditional smelters sometimes used a high amount of P (0.05 to 0.5 wt. %) which were found in many of the iron implements [8, 9]. This has been attributed to iron production using Indian bloomer furnaces where limestone was not used [9, 10].

4. Conclusions:

Material evidences of civilization are considered to be an important asset for ethnographic and anthropological documentation of a nation. Archaeology is taken together with Physical Sciences and Engineering for better documentation of cultural heritage of a nation which is sometimes referred to a new field of study called Archaeometry. Cultural heritage on the other hand has also been defined as the material evidence of civilization [11]. Thearchaeological masterpieces, iron implements& tools, war weapons, iron slag, iron ore and any piece of art and artefacts may be treated as a basis of

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establishment of cultural heritage of a nation. The material evidences which are found in and around the ancient iron smelting sites in this part of the world reveals that iron was extracted in large scales by the people in the ancient times. Apart from oral evidence, scattered excavations and ethnographic data, not much has been known previously about the technological process of iron smelting in Manipur. The analytical study of the sample depicts the high level of skill possessed by the ancient smelters, in that they spent energy and time so that even a few part of the iron oxide were left in the smelting processes.

5. Acknowledgement:

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References:

1. M. Gourachandra, *Traditional Iron smelting and forging in Manipur, Peoples Museum Publications, Kakching, Manipur* (1997) 37
2. S. Bormani, *Meitei Ningthourol*, 3 (2005)
3. R. Sheikh, S.Nabadwip Singh, S. Basanta Singh, R.K. Gartia, *Proceedings of National Conference on Luminescence and Applications (NCLA) - Kolkatta* (2009)
4. R. Sheikh, B.S. Acharya, *Indian Journal of Pure and Applied Physics,* 48(9) (2010) 632
5. R. Sheikh, S. Nabadwip Singh, S. Basanta Singh, R.K. Gartia, *Sanatan,* 19(3) (2009) 3
6. P. Piccardo, M.G. Ienco, R. Balasubramaniam, P. Dillman, *Current Science*, 87(5) (2004) 650
7. P. Dillman, R. Balasubramaniam, *Bulletin of Materials Science*, 24(2001) 317
8. R. Balasubramaniam, *Ind J Hist Sci*, 26 (1991) 4
9. D.V. Rao, B. Sasisekaran, T. Satyamurti, R.K. Gartia, S. Badrinarayanan, S. Sundararajan, G.S. Rao, P.C. Rao, *Sangam: Numismatics and Cultural History , New Era publications* (2006) 146
10. F.A. Miller, C.H. Wilkins, *Analyst. Chem.*, 24 (1952) 1253
11. R. Sheikh, Physics for Cultural Heritage, Ruby Press & Co., New Delhi, 2013

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