

**X-RAY FLUORESCENCE (XRF) STUDIES OF THE IRON ORES OF
PANJAOPALLUMCHING - AN ANCIENT IRON SMELTING SITE IN MANIPUR,
INDIA**

Md. Rahejuddin Sheikh

Department of Physics, Dhanamanjuri University, Imphal, Manipur, India

Kh. Sapana

Department of Anthropology, Moreh College, Moreh, Manipur, India

O. Kumar Singh

Department of Anthropology, CMJ University, Jorabad, Meghalaya, India

Abstract

Two soil sample: one blackish venous soil and the other brownish red in colour were collected from two different places near the ancient iron smelting sites at PanjaoPallumching, Kakching Manipur, India. This paper reports the results of characterization of the two samples by X-Ray Fluorescence (XRF) Techniques. As per the results of the investigations, the brownish red sample is found to be more suitably used by the ancient smelters for extracting iron in traditional styles and techniques, the suitability of using the other being quite remote. Further, the XRF study reveals contents of minerals like iron, aluminium, carbon, silicon, calcium, potassium, magnesium and phosphorous in their oxide forms. The scientific analysis also shows that a huge energy and time were spent by the ancient iron smelters for extracting only a small lump of pure iron from a huge amount of ores with huge wastages as slag when smelting was practised in traditional styles and techniques. The study has possibly established an archaeometallurgical accounts which has been incorporated to the oral history and written records regarding iron smelting works in this part of the world. The scientific analysis of a piece of material evidence and the artefacts has contributed in great details to the studies of cultural heritage of a nation.

Keywords: X-Ray Fluorescence, Slag, Geo-tagged, Haematite

Introduction

The works of Iron production evolved with development of human society, the evidences of which came into existence since the inception of the oral historical accounting of mankind. The history of iron production in Africa extended over 2000 years back from now. The first systematic studies on Iron Age began in India by Banerjee with the excavating works at various sites pertaining to iron-using culture [1]. Chakrabarti successfully did his excavation works of few sites and extensively explored the eastern, western and northern India and published widely about Iron production and smelting processes [2]. However, no literature and detailed scientific studies in this field has been reported so far except few works by M R Sheikh, in his works on Physics for Cultural Heritage [3].

The evidence of iron smelting culture in the south eastern part of Manipur has been well documented [4]. The scientific analysis and dating of the iron slag found in the small hillock near Kakching area has also been reported [5]. The scientific studies such as characterization by Physical Techniques- XRD, XRF, EDX, SEM, FTIR etc. and determination of age by dating – TL and OSL other than Carbon dating techniques have also been well documented. This is therefore, treated as furtherance of the works in and around Kakching other than those which have already been documented in the earlier works.

Kakching is a district in the South Eastern part of Manipur mostly inhabited by the people belonging to the scheduled caste community who has a unique culture and tradition slightly different from those inhabiting in the other districts and capital city areas. In the ancient times, the people of Kakching are also called lois which means the outcasts in the local dialect. However, such terminology is no longer found in the present day society. The people of Kakching are hardworking and they always maintain unity and peaceful life. The way they speak resembles the way the Burmese speak in their accent and intonation. It is believed that people from Kabaw now called Myanmar often fought wars with the kings and chieftains of Manipur since the beginning of the early historical accounts. It is also evident from the works of Sheikh et al that the people from Tumu in Kabaw valley in Myanmar came in various stages in the history and developed traditional iron smelting works in the south eastern part of Kakching. The places of Keraching, PanjaoPallumching, YotshungPareng and TumuChing were mentioned in most of the works of the historians, archaeologists and researchers regarding the existence of

ancient iron smelters in this part of the world and evidences of the historical facts that traditional iron smelters flourished in this part of the World [3, 4].

According to the local informants, it has been known that PanjaoPallumching is one such place where the ancient people extracted iron in traditional styles and techniques. The place is not officially preserved or protected as archaeological site or historical places of public interest. The local elders pointed out the exact area of coverage under the iron smelting colony which is now demolished and used for agricultural purposes. The excavation has to be conducted based on the oral history by the local elders.

The people of Kakching worshipped Khamlangba as the God of Iron. It is believed that Khamlangba, a local chieftain who is later considered as one of the local deities, has founded an iron smelting colony in Kakching. When he came in search of iron deposits, he ultimately found the iron deposits at Kakching and settled there along with his followers who were all well trained in the smelting works. The iron smelting work, therefore, has a close relations with the settlement and development of the people at Kakching.

The iron smelting in Kakching area in Manipur dates back to 1600 ± 80 years during the reign of King KhuiyoiTompok and UraKonthouba [4]. It is reported that the King used to give presents in various forms of swords to other Chieftains like the king of Manipur at Kangla, the kings of Tripura or Takhel Kings and even to the king of Kabaw (Myanmar) [5,6].

The Excavation of the Iron Ore Samples

According to the local informants and oral history as mentioned above, two such samples that exhibit peculiar characteristics including unnatural physical outlook and morphological structures were identified by which one may think that it would have been used in the process of the ancient iron forging and smelting work in PanjaoPallumching in Kakching District, Manipur. The place which is now, found almost abandoned, has been utilized for agricultural purposes. The two samples as shown in the figures (a) and (b) were collected for scientific investigations. By conducting a proper survey of the possible sites of iron deposits near the smelting sites, the two samples of different physical and morphological structures were of great interest for the scientific investigations. The figure on the left hand side shows the geo-tagged photograph of one of the co-authors who is standing near the sampling site. The right hand side shows two

samples – (a) the brownish red soil and (b) the blackish soil. The lumpy heavy sample with brownish color in (a) was collected from the southern side of the identified smelting areas from a distance of about 500 meters south eastern wards. Another sample with blackish color in (b) was collected from the northern side of the smelting areas from a distance of about 700 meters north western wards. The samples are of special interest for the scientific investigations because the first one is a little heavier than the usual soil that were found in the areas around 500 meters in radius. The second one is unnaturally blackish in color with exceptionally brown veins found running in all the body parts. The vast land area of about 2 kilometres in radius extending down to the swampy low lying areas has such type of soil in abundance. Moreover, the brownish veins draw more attention of the scientific community specially the geologists and archaeologists exceptionally [6].

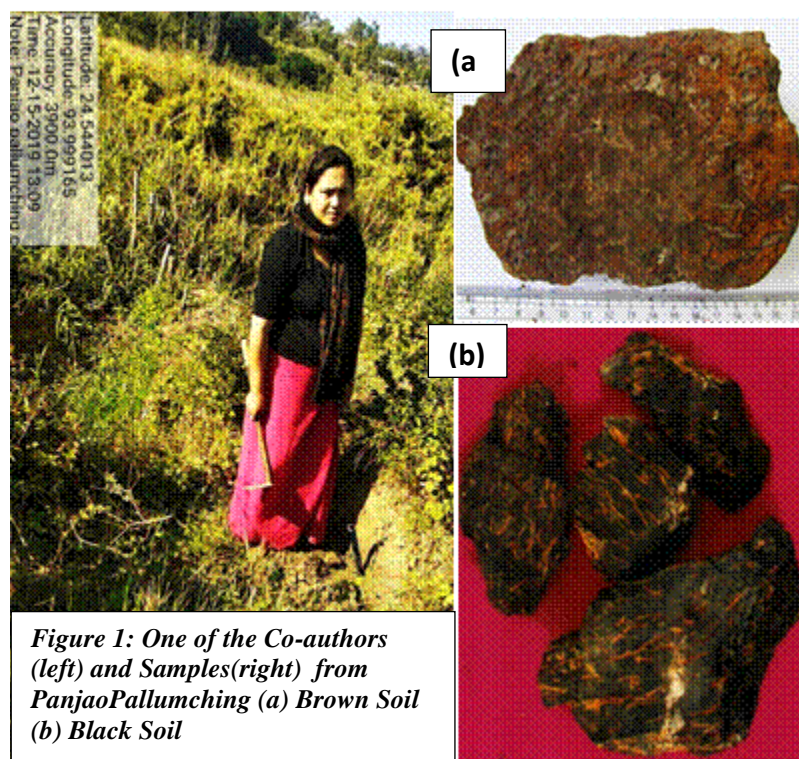


Figure 1: One of the Co-authors (left) and Samples(right) from PanjaoPallumching (a) Brown Soil (b) Black Soil

Experimental Results

The samples are dried to a very high temperature of about 1000°C and powdered into fine grains. The powdered samples are sieved through a mesh and taken to the XRF lab with IQ+ software for semi-quantitative determination. The corresponding XRF spectra of the two samples (a) the

brownish red soil and (b) the blackish soil are presented in table1;table 1(a) represents brownish red sample and table 1(b) represents the blackish soil sample.

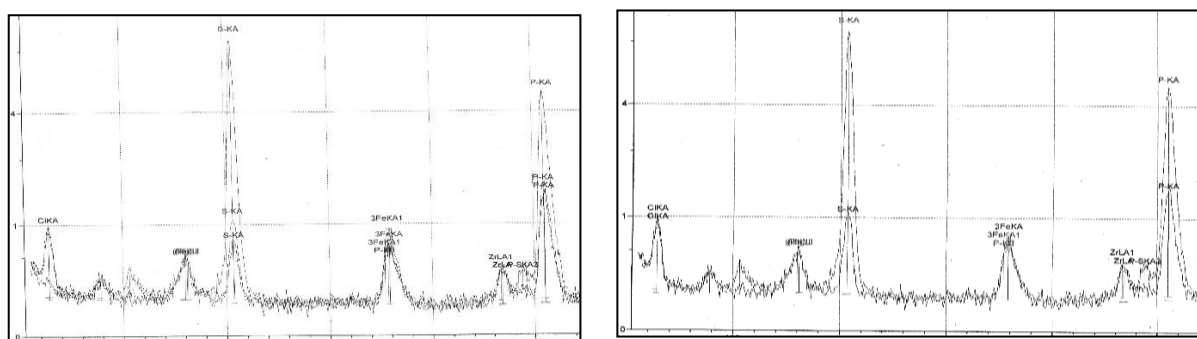


Figure 2: (a) XRF spectra of the Brownish red Sample (b) Blackish soil sample

The corresponding elemental compositional analysis after heating the samples to a temperature of 1000°C are presented in the following table. The comparative analysis reveals the clear picture of the percentage compositions of iron and its constituent elements in the sample in their compound forms.

Table 1: Comparative concentrations of the Brownish Red sample and Blackish Soil Sample

Sl.	Analyte	Compound	Concentration (%)	
			Brownish Red	Blackish Soil
1	Na	Na ₂ O	0.570	0.168
2	Mg	MgO	3.159	1.126
3	Al	Al ₂ O ₃	20.508	32.357
4	Si	SiO ₂	52.785	57.878
5	P	P ₂ O ₅	0.379	0.126
6	S	SO ₃	1.282	0.099
7	K	K ₂ O	2.131	2.105
8	Ca	CaO	3.050	0.795
9	Ti	TiO ₂	0.630	0.580
10	Fe	Fe ₂ O ₃	8.272	4.205

Observations

As per the results of the characterization by XRF, the two samples contain Calcium, Sodium, Iron, Magnesium, Potassium, Aluminium, Phosphorous and Sulphur in almost the similar percentages. However, the percentage of iron contents in the brownish red sample is 8.27 while it

is only 4.2 in the blackish soil sample. The percentage composition of silicates in brownish red sample is only 52.78 while it is 57.8 in the blackish sample [11-13]. The presence of silicates in both the samples clearly indicates that the iron ores were found in the form of soil which are naturally found in the crust along with other elemental constitutions in the usual soil. The blackish soil was collected from the low lying areas which were once a part of water bodies in the form of lakes. The areas where the blackish samples were found are also at the conjunctures of the two famous lakes in Manipur - the Loktak freshwater lake and the LousiLake which have historical and archaeological significances [12-15].

The brownish red sample was collected from the southern eastern side of the smelting place which has been lined up with the adjoining hills because of which it was also called the PanjaoPallumching which literally means ‘the big barrier making hills’ in the local dialect. The ancient iron smelters would therefore, have procured the necessary raw minerals for iron smelting from the adjoining hills or the nearby hills that extended in the southern eastern side of the site. In the southern villages of the smelting site, there is one worshiping place of Lord Khamlangba, a local deity worshiped by the people of Kakching as the god of iron. One colony of the locality of the village located on the same side i.e. on the southern part of the smelting site, which is named as the “YotshungPareng” which means a ‘family line of the iron smelters’ in the local dialect. All these evidences and historical accounts along with the results of the scientific investigations reveals that the place from where the samples were collected would be the archaeological sites famous for iron smelting works in the ancient past[6].

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