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# Characterization of iron ore Sample from the ancient iron smelting Site in Manipur by Energy Dispersive X-ray (EDX) Spectroscopy

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**Abstract:**

*Samples of iron ore collected from Lamdeng, Manipur has been characterized by using XRD, XRF, FTIR and EDX spectroscopy. The iron slag obtained from the ancient iron smelting site of Manipur has also been dated by TL techniques which reveal an age of about 1600±100 years. The characterization of the iron slag shows that iron of good quality was smelted in traditional styles and techniques by the ancient people of Manipur. The SEM and EDX analysis by Mineral Liberation Analyzer support the data obtained by XRD, XRF and FTIR.*

***Keywords: Scanning Electron Microscopy, Energy Dispersive X-ray, Haematite, Goethite***

## 1. Introduction:

The smelting of iron began in Manipur during the chieftainship of Khamlangba who ruled the area of Kakching, a village situated at the south eastern part of Manipur at a distance of 45 kilometres from the capital city of Imphal[1]. The art of smelting iron was a unique culture of the ancient people of Manipur [2].

The iron ore sample shown in the figure 1 has been collected from *Lamdeng* area which is situated at a distance of 10 kilometers from the ancient iron smelting site. The Scanning Electron Microscopic (SEM) investigations were carried out in a mineral liberation analyzer (MLA) of JK tech, Australia [3].


**Figure 1.** One scrapped portion of the lumpy iron ore

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## 2. Experimental:

The mineral liberation analyzer (MLA) is an automated mineral analysis system that can identify minerals in polished sections of drill core, particulate or lump materials, and quantify a wide range of mineral characteristics, such as mineral abundance, grain size and liberation. Mineral texture and liberation potential are fundamental properties of ore and drive its economic treatment; the data gathered by the MLA is therefore invaluable to geologists, mineralogists, and metallurgists for process optimization, mine feasibility studies and ore characterization. Commercially available since 2000, the MLA is being used by leading international resource companies to improve the processing efficiency of copper, nickel, lead, zinc, manganese, iron ore, mineral sands, and precious metals such as platinum, palladium, silver and gold. Its ore characterization capabilities are also used very effectively to evaluate exploration targets [4, 5].

## 3. Results and Discussion

The EDX spectra were taken at four points of the specimen photograph and the data have been shown in figures 2, 3, 4 and 5. The scanning electron microscopic photograph is shown in figure 6. It can be observed that Fe, Ca, Al, Si, Mg and O are the major constituents which, in their compound form, are present in the ore. Thus, the mineral phases identified by XRD are supported by both FTIR and EDX analysis [3].

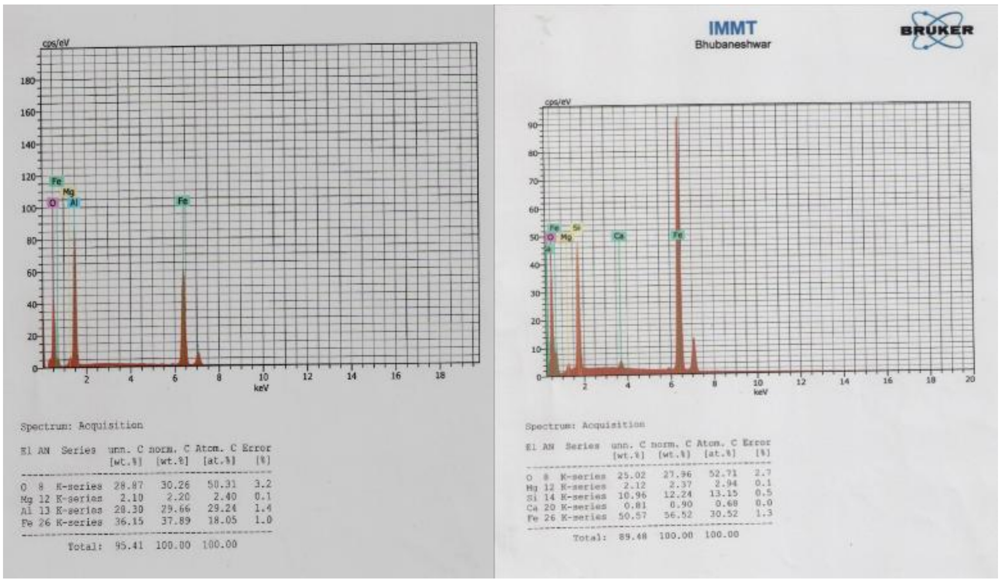


**Fig.2.** EDX taken at the first point (left) and the second point (right)

Table 1. Acquisition at the first point

| Element | Atomic Number | Series | Unn.C [wt.%] | Norm.C [wt.%] | Atom. C [at.%] | Error [%] |
|---|---|---|---|---|---|---|
| O | 8 | K | 28.87 | 30.26 | 50.31 | 3.2 |
| Mg | 12 | K | 2.10 | 2.20 | 2.40 | 0.1 |
| Al | 13 | K | 28.30 | 29.66 | 29.24 | 1.4 |
| Fe | 26 | K | 36.15 | 37.89 | 18.05 | 1.0 |

Table 2. Acquisition at the second point

| Element | Atomic Number | Series | Unn. C [wt.%] | Norm. C [wt.%] | Atom. C [at.%] | Error [%] |
|---|---|---|---|---|---|---|
| O | 8 | K | 25.02 | 27.96 | 52.71 | 2.7 |
| Mg | 12 | K | 2.12 | 2.37 | 2.94 | 0.1 |
| Si | 14 | | 10.96 | 12.24 | 13.15 | 0.5 |
| Ca | 20 | K | 0.81 | 0.90 | 0.68 | 0.0 |
| Fe | 26 | K | 50.57 | 56.52 | 30.52 | 1.3 |

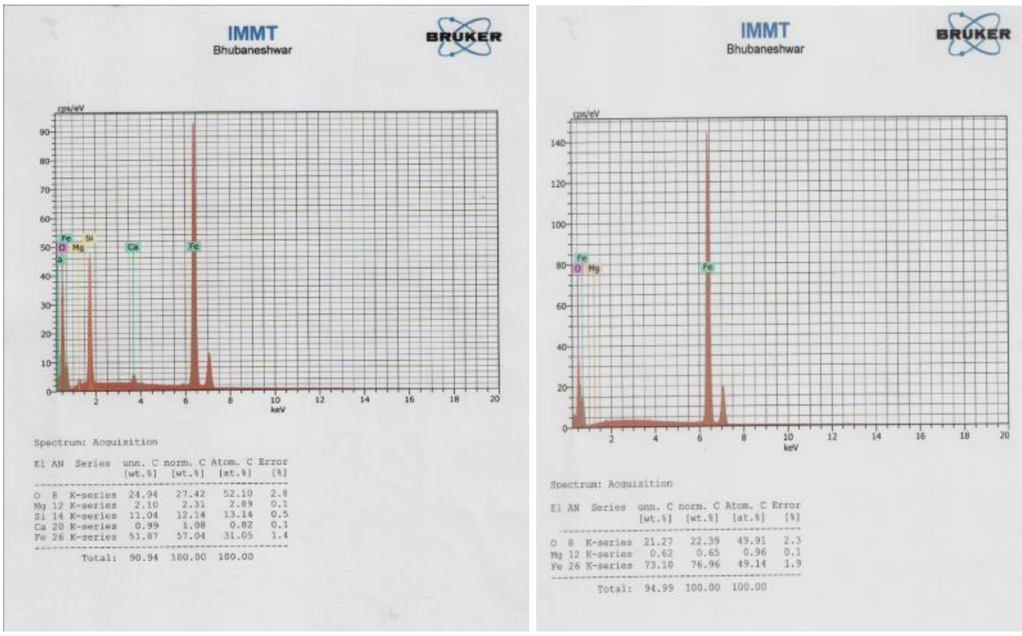


**Fig. 3**. EDX taken at third point (left) and fourth point (right)

**Table 3.** Acquisition at the third point

| Element | Atomic Number | Series | Unn.C [wt.%] | Norm.C [wt.%] | Atom. C [at.%] | Error [%] |
|---|---|---|---|---|---|---|
| O | 8 | K | 28.87 | 30.26 | 50.31 | 3.2 |
| Mg | 12 | K | 2.10 | 2.20 | 2.40 | 0.1 |
| Al | 13 | K | 28.30 | 29.66 | 29.24 | 1.4 |
| Fe | 26 | K | 36.15 | 37.89 | 18.05 | 1.0 |

**Table 4.** Spectrum acquisition at the fourth point

| Element | Atomic Number | Series | Unn.C [wt.%] | Norm.C [wt.%] | Atom. C [at.%] | Error [%] |
|---|---|---|---|---|---|---|
| O | 8 | K | 28.87 | 30.26 | 50.31 | 3.2 |
| Mg | 12 | K | 2.10 | 2.20 | 2.40 | 0.1 |
| Al | 13 | K | 28.30 | 29.66 | 29.24 | 1.4 |
| Fe | 26 | K | 36.15 | 37.89 | 18.05 | 1.0 |

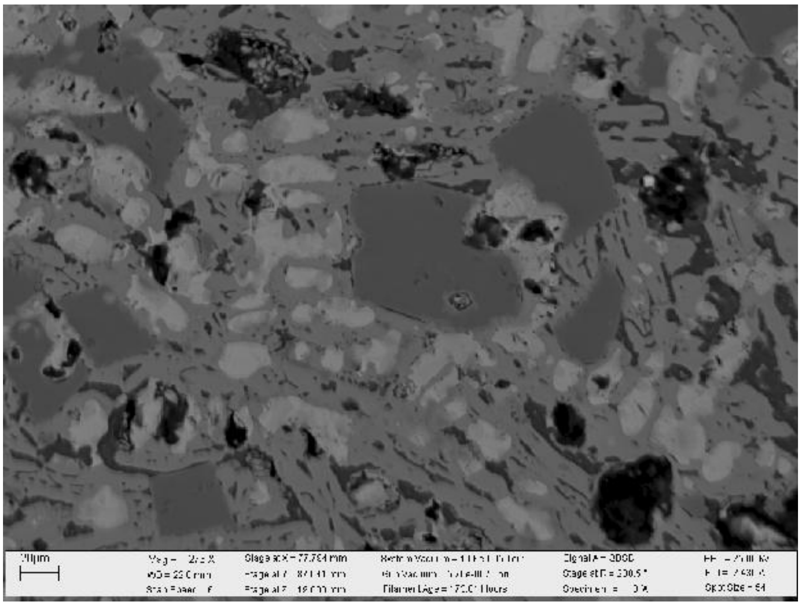

**Fig. 4.** Scanning Electron Microscopy (SEM) photograph of the ore

## 4. Conclusion:

The first systematic studies on Iron Age began in India by Banerjee by excavating various sites pertaining to iron-using culture [6]. Chakrabarti excavated few sites in India and extensively explored eastern, western and northern India and published widely about Iron [7].

The EDX analysis at four different points of the sample reveals the presence of iron. The presence of Goethite in the slag sample from *Tumu* hills has been documented [8, 9]. This confirms that the smelters at *Tumu* hills used the ores from this area. The type of ore was mainly Goethite which is also supported by most of the Geology works [10].

It is clear that the ancient iron smelters of Manipur procured raw ore minerals from the adjoining areas. Physics has contributed to the study of Indian cultural heritage materials [11-14]. This becomes the first of its kind in the study of ancient iron smelting work in the north eastern part of the country [10].

## 5. Acknowledgement:

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