QUALITY OF IRON ORES IN KENYA; THARAKA NITHI AND SAMIA.

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ABSTRACT

Iron ores have been identified in various parts of the country. These regions include Eastern region, Tharaka-Nithi County, and Western/Nyanza region, Busia County. Kenya has had various challenges in the iron and steel sectors which include unavailability of data on iron ore. This paper focuses on chemical analysis of iron (Fe) ores. Chemical analysis was carried out at the Ministry of Mining at Mines and Geology Department Laboratories using XRF machine. The iron ore sampled had Fe_2O_3 composition ranging from 41-57% for the ores from Marimante and 18-25% for Samia samples. It was found that the common gangue in the ores from both sites were silica and alumina with traces of other elements. The Marimante ore was found to be ilmenite.

Keywords: iron ore, grade, gangue, ilmenite

I. INTRODUCTION

Iron ores are minerals from which metallic iron can be economically extracted [1, 2]

The main iron ores are magnetite (Fe_3O_4) and hematite (Fe_2O_3). Magnetite contains 72.4% Fe and usually black while hematite has 70% Fe and red in colour. Other ore include limonite (2 Fe_2O_3 _$3H_2O$) containing 59.9% Fe and brownish; and the carbonate siderite, $FeCO_3$, containing 48.3% Fe, brown [3]. The composition are in pure state but in the case of ores they are at lower levels [4].

Iron ores are majorly used for the production of iron and steel accounting for 98% of the ore mined globally [5].

Iron ores have different metal (iron) composition ranging between 48-72%, the remainder being impurities. Impurities/gangue mostly contain silica, alumina, lime and magnesia as well as very small amount (usually under 1 %) of other compounds like Zn, Cu, Ti, Cr, Mn, Ni, S, P [6].

Iron ores are normally classified as high grade (more than 64% Fe), medium grade (62 to 64% Fe) and low grade (less than 62% Fe) [7].

i. Iron Production

The following raw materials are used in production of molten/pig iron in the blast furnace [8]:

1. iron ore e.g. hematite ore, or magnetite ore the source of iron

2. coke (carbon, C), used as fuel and reducing agent

3. hot air for the oxygen (O2), in it to burn the coke

4. limestone (calcium carbonate, $CaCO_3$) used to remove impurities like silica inform of slag

For better productivity in the blast furnace, silica should be less than 2%, sulphur less than 0.3% and alumina less than 2% [9-10]. The alumina and silica ratio should be 1:1 [11]. High alumina content increases slag volumes and thus coke consumption [12]. Low gangue in iron ore reduces the rate of fuel/coke consumption in the furnace [13].

ii. Mining in Kenya

Mining in Kenya is primarily for production of non-metallic minerals encompassing industrial minerals such as soda ash (trona), fluorspar, diatomite, natural CO2, kaolin, gemstone and limestone [14].

Iron ores are mined from small localized deposits that have not been fully developed/explored and are largely sold to cement industries where they are used as additives in the manufacture of cement [15].

II. METHODOLOGY

The samples were sampled from two regions in Kenya, Tharaka-Nithi County and Bungoma County. Random method of sample collection was applied in both cases.

The samples were obtained from the residents in Marimante carrying out small scale mining on the sites with the aim of selling the iron ore to the cement industries in Kenya. Sampling was done on the surface. Some of the ores collected were from a mine of approximately 6 m deep.

In Samia iron ores samples were collected from a mine of approximately 0.5 m deep and from the surface. Residents assisted to identify old mines in the area.

The samples were then labeled as, M1, M2 and M3 (Marimante) and S1, S2 and S3 (Samia). The first experimental work was grinding of the samples using laboratory jaw crusher. All the

samples were crashed to less than 30 mm. Crushed specimens were then pulverized to fine powder of mesh 16 for chemical analysis.

i. Chemical Analysis

The pulverized samples were subjected to chemical analysis in laboratories at Mines and Geology Department, Ministry of Mining, to determine the iron oxide content and other compounds. X-ray fluorescence (XRF) machine, *Bruker model* was used to scan the specimens. The results of the analysis were as tabulated below for the two sites under the study.

Table 1: Chemical Composition of Iron ores from Marimante and Samia scaned using XRF Machine

| S/N	Sample	SiO_2	AL_2	CaO	MgO	K_2O	TiO_2	MnO	P_2O_5	S	Fe_2O_3
1	M1	7.302	9.108	0.067	0	0.102	24.21	0.288	0	0	57.26
2	M2	23.07	8.504	4.37	6.221	0.038	14.97	0.277	0.037	0	41.77
3	M3	41.64	1.844	0.046	0	0.108	0.094	0.125	0.028	0.007	55.39
4	M average	24.00	6.485	1.494	2.073	0.082	13.09	0.23	0.021	0.002	51.47
5	S1	80.26	0.69	0.031	0	0.072	0.026	0.105	0.128	0.099	18.45
6	S2	70.97	4.125	0.045	0	0.126	0.046	0.111	0.05	0.095	24.26
7	S3	69.00	4.637	0.1	0	0.559	0.083	0	0.159	0.068	25.00
8	S average	73.41	3.152	0.059	0	0.252	0.052	0.072	0.112	0.087	22.57
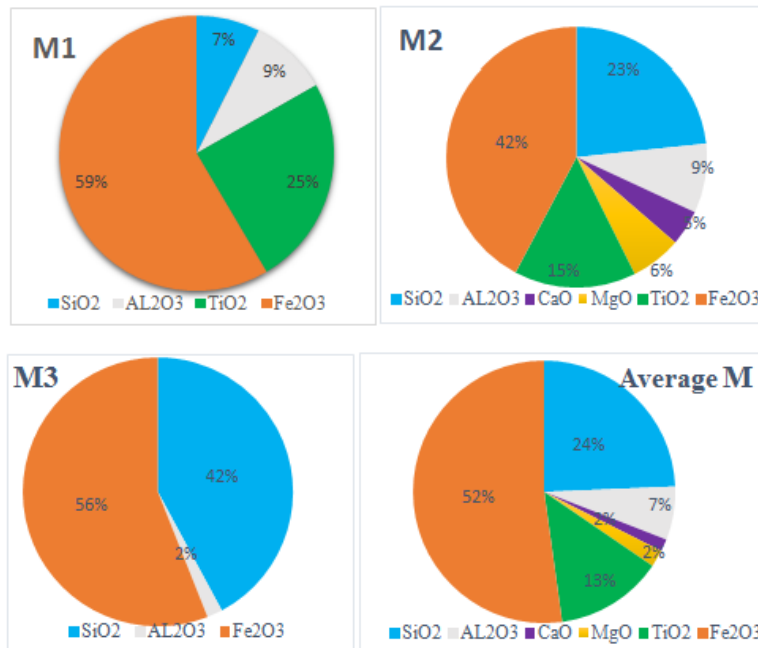
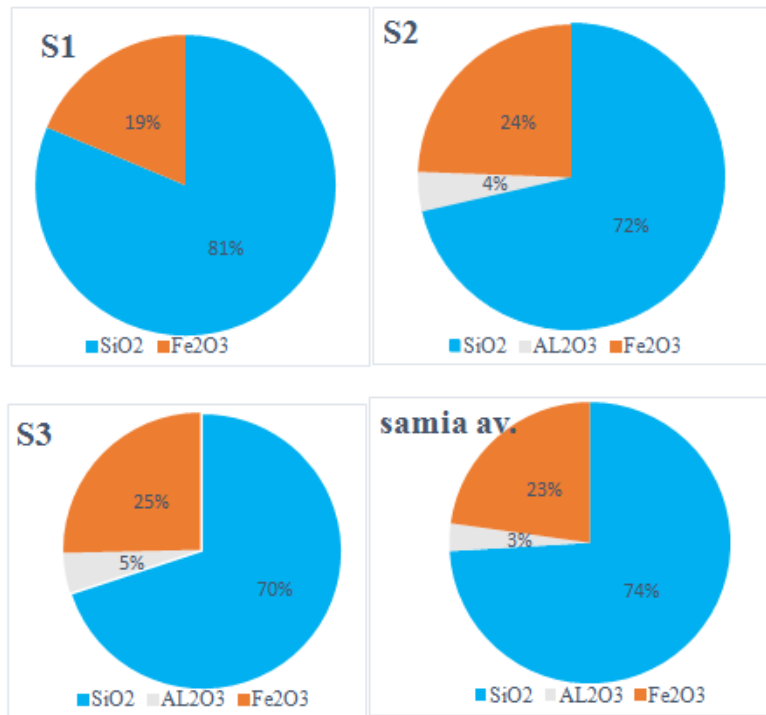**Figure 1: Pie Charts showing the composition of Marimante Iron Ores**

Figure 2: Pie charts showing the composition of Samia Iron ore

Table 2: Ratio of Silica to Alumina in the samples

S/No	Sample	SiO_2	AL_2O_3	Ratio(SiO_2:	Fe_2O_3
1.	M1	7.302	9.108	0.80171278	57.267
2.	M2	23.07	8.504	2.712841016	41.779
3.	M3	41.642	1.844	22.5824295	55.391
4.	M average	24.005	6.485	3.701619121	51.479
5.	S1	80.266	0.69	116.3275362	18.457
6.	S2	70.977	4.125	17.20654545	24.264
7.	S3	69.009	4.637	14.88225146	25.009
8.	S average	73.417	3.152	23.29219543	22.577

PLOT OF RATIO OF SILICA TO ALUMINA FOR MARIMANTE IRON ORE

(graph: Iron Ore, Fe_2O_3, (%) vs Ratio (SiO_2: AL_2O_3), points labelled M1, M2, M3, Maverag)
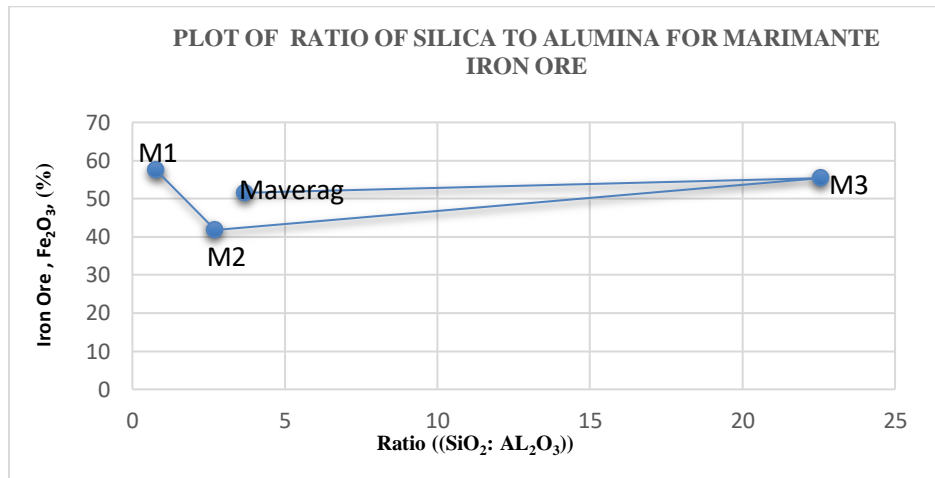
Figure 3: A graph of Silica:Alumina for Marimante Ores

PLOT OF RATIO OF SILICA TO ALUMINA FOR SAMIA IRON ORES

(graph: Iron Ore, Fe_2O_3, (%) vs Ratio (SiO_2: AL_2O_3), points labelled S2, S3, Saverage, S1)
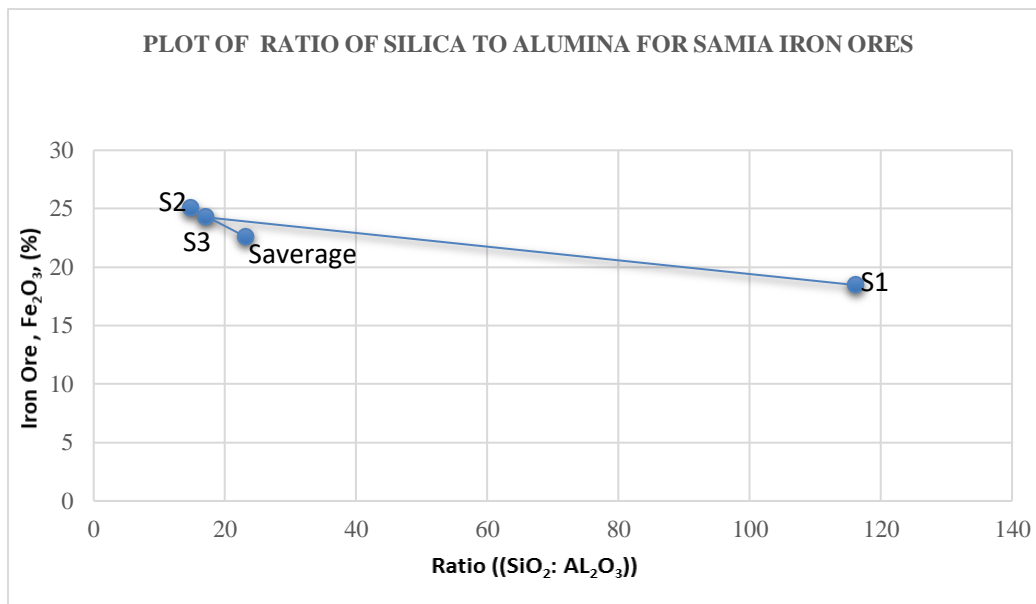
Figure 4: A graph of Silica:Alumina for Samia ores

III. DISCUSSION

i. Chemical Analysis

From Table 1 above the compounds contain in the ores were noted. From the Marimante area the iron ore composition ranges from 41 – 57 %. For M1 and M2 samples the unique gangue compound was titanium oxide. Titanium has a higher melting point of about 1800^0 C as compared to iron thus the iron ore of about 1590^0C. Blast furnace route will not be applicable for the Marimante ores. Other gangue in the Marimante iron ores are alumina, silica, magnesia

and calcium oxide. The sample M2 also has various compounds; this includes calcium oxide (CaO) and magnesium oxide. M3 samples has only three major compounds of iron ore, alumina and silica. From Figure 1 above the average percentage of iron ore is 52% of Fe_2O_3.

The Samia iron ore have the least iron ore of between 18-25% with an average of 23% for the three samples studied. S samples mainly consists of three compounds; silica, alumina and Fe_2O_3 with silica having an average of 74% SiO_2, AL_2O_3 at 3%.

In both cases as the silica content increases the iron value decreases.

ii. Silica: Alumina Ratio

The ratio of silica to alumina for M1 is approximately 1:1 but for other Marimante samples its 2.7 and 22.5 for M2 and M3 respectively. For Samia site this ratio varies from 14-116. S1 has the highest ratio of 116 and it has 80% silica and 0.69% alumina with the least iron ore content of 18% Fe_2O_3.

IV. CONCLUSION

Iron ores in Kenya are of lower grade and the have to be upgraded for them to be suitable for blast furnace. Marimante iron ore is of ilmenite type because of the titanium oxide. The Samia iron ore have the lowest grade and for it to be economical in iron processing it shall require intensive startup capital only on condition that the quantity of deposit is large enough.

Further research work should be done on the beneficiation methods of the ores. Exploration work has to be carried out on the areas identified to be having iron ore deposits to ascertain the quantity of the deposits.

Silica:alumna ratios clearly indicates that the Kenyan iron ores have high content of silica gangue.

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