Quality of Iron ores in Kenya; TharakaNithi and Samia

Alvin Kiprono Bett, Joan A. Onyango, S. M. Maranga, B. K. Rop

Abstract~Iron ores have been identified in various parts of the country. These regions include Eastern region, Tharaka-Nithi County, and Western/Nyanza region,BusiaCounty. 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 XRFmachine. 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 Marimanteore was found to beilmenite.

Keywords ~ iron ore, grade, gangue,ilmenite

I. INTRODUCTION

Iron ores are minerals from which metallic iron can beeconomically 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 hematitehas 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 arein 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 steelaccounting 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 magnesiaas well as very small amount (usually under 1 %) of other compoundslike Zn, Cu, Ti, Cr, Mn, Ni, S, P [6].

Iron oresare normally classified as high grade (more than 64% Fe), medium grade (62 to 64% Fe) andlow grade (less than 62% Fe) [7].

A. *Iron Production*

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

a. iron ore e.g. hematite ore, or magnetite orethesource of iron
b. coke (carbon, C), used as fuel and reducing agent
c. hot air for the oxygen (O_2), in it to burn the coke
d. limestone (calcium carbonate, $CaCO_3$) used to remove impuritieslike silica inform of slag

For better productivityin the blast furnace, silica should be less than 2%, sulphur less than0.3% 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 orereduces the rate of fuel/coke consumption in the furnace [13].

B. *Mining in Kenya*

Mining in Kenya is primarily for production of non-metallic mineralsencompassing industrial minerals such as soda ash (trona), fluorspar,diatomite, natural CO_2, kaolin, gemstone and limestone [14].

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

II. METHODOLOGY

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

In Marimante area the ores were collected from residents carrying out small scale miningwith the aim of selling the iron ore to the cement industriesin 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 crashedto less than 30 mm. Crushed specimens were then pulverized to finepowder of mesh 16 for chemical analysis.

A. *Chemical Analysis*

The pulverized samples were subjected to chemical analysis in laboratoriesat Mines and Geology Department, Ministry of Mining, to determinethe iron oxide content and other

Alvin Kiprono Bett, Joan A. Onyango, B. K. Rop, Department of Mining Materials and Petroleum Engineering, JKUAT. *Corresponding Author; abett@jkuat.ac.ke*
S. M. Maranga, Department of Mechanical Engineering, JKUAT

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 Samiascanned using XRFMachine

S/No	Sample code	SiO_2	AL_2O_3	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	24.217	0.288	0	0	57.267
2.	M2	23.07	8.504	4.37	6.221	0.038	14.977	0.277	0.037	0	41.779
3.	M3	41.642	1.844	0.046	0	0.108	0.094	0.125	0.028	0.007	55.391
4.	$M_{average}$	24.005	6.485	1.494	2.073	0.0827	13.096	0.23	0.0217	0.002	51.479
5.	S1	80.266	0.69	0.031	0	0.072	0.026	0.105	0.128	0.099	18.457
6.	S2	70.977	4.125	0.045	0	0.126	0.046	0.111	0.05	0.095	24.264
7.	S3	69.009	4.637	0.1	0	0.559	0.083	0	0.159	0.068	25.009
8.	$S_{average}$	73.417	3.152	0.059	0	0.252	0.052	0.072	0.112	0.087	22.577

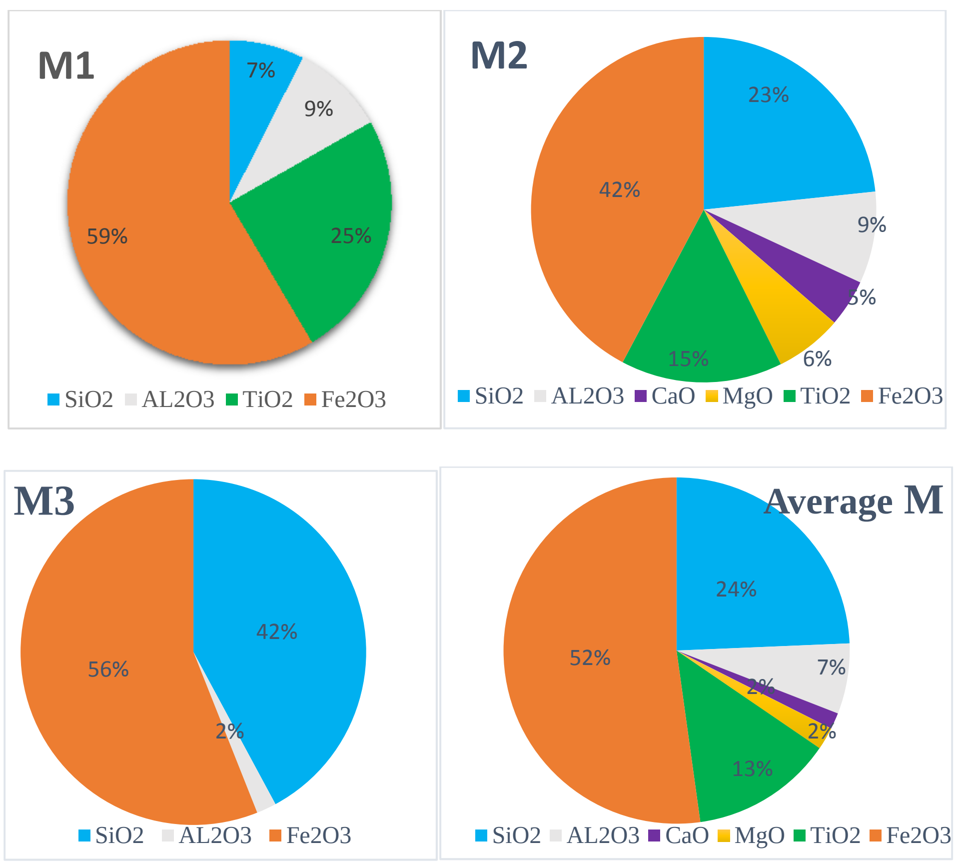

Figure 1: Pie Charts showing the composition of Marimante Iron Ores

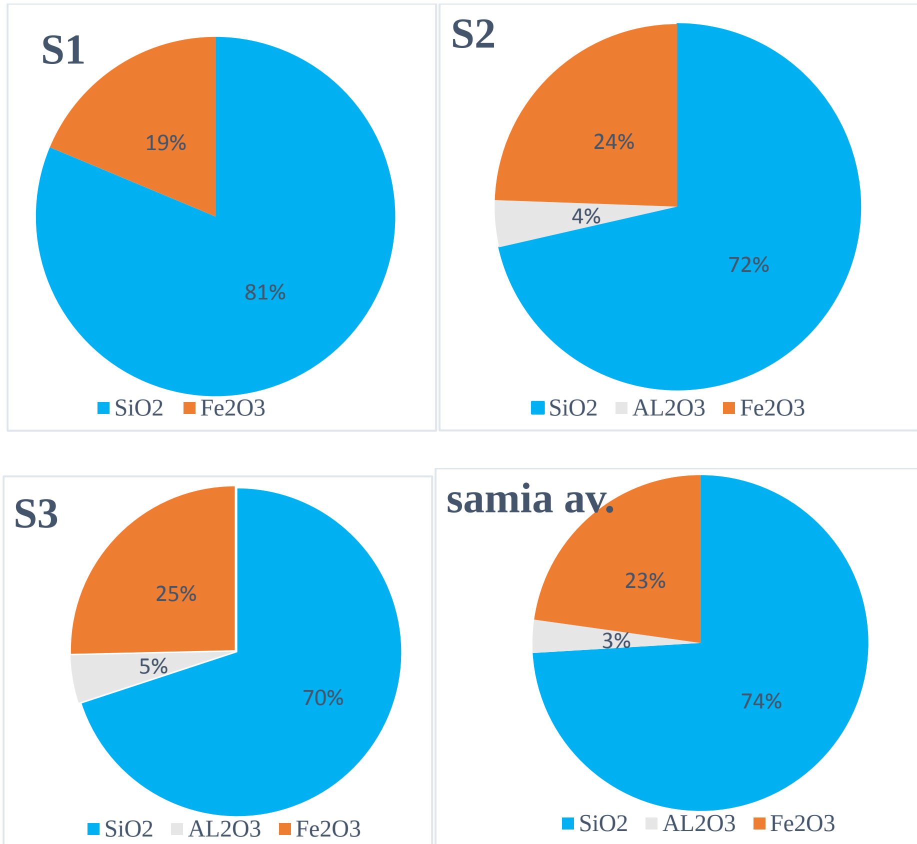

Figure 2: Pie charts showing the composition of Samia Iron ore

Table 2: Ratio of Silica to Alumina in the samples

S/No	Sample code	SiO_2	AL_2O_3	Ratio(SiO_2: AL_2O_3)	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

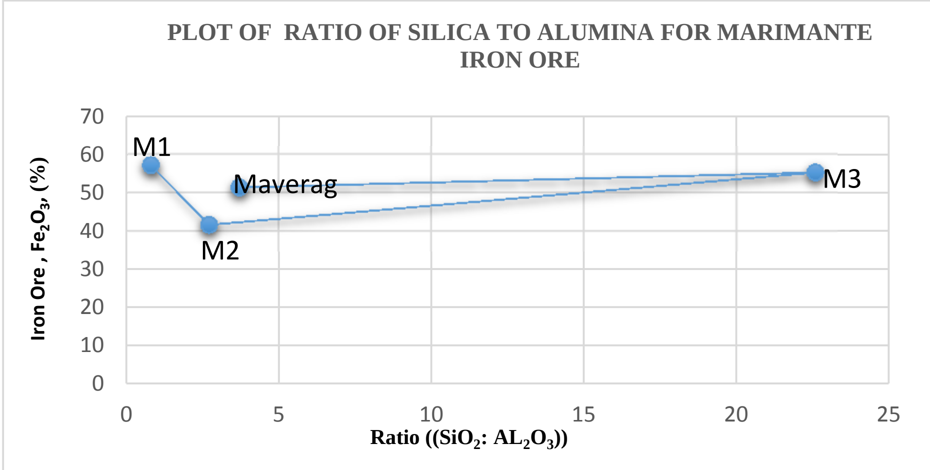

Figure 3: A graph of Silica:Alumina for Marimante Ores

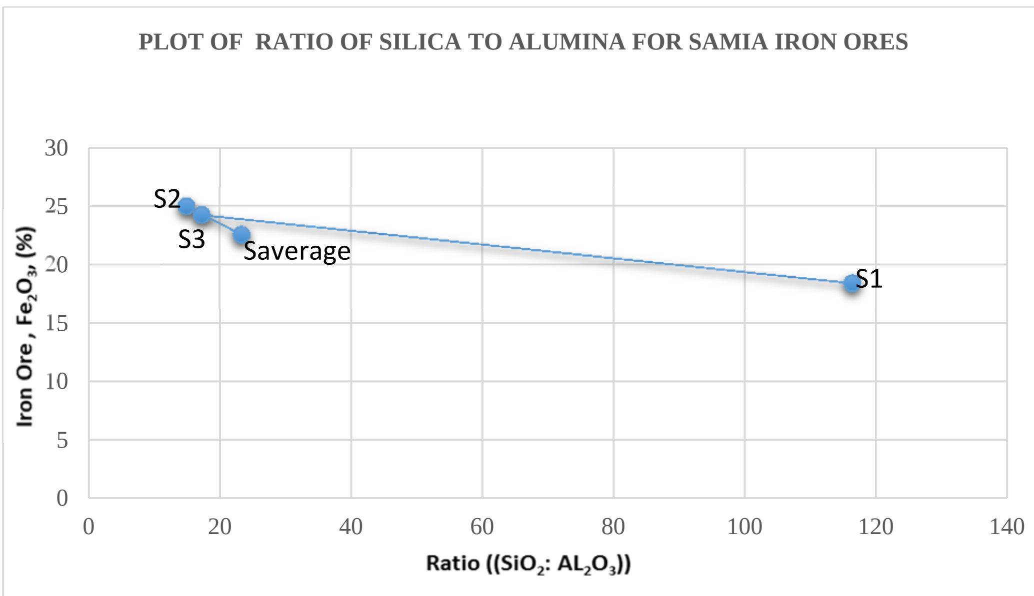

Figure 4: A graph of Silica:Alumina for Samia ores

III. DISCUSSION

A. 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 Marimanteiron 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.

B. 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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