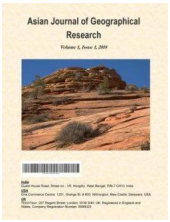

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Distribution and Economic Potential of Manganese Deposits in Nigeria: A Review

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

The Northern basement complex of Nigeria contains a large number of manganese deposits. So far, ten deposits of manganese have been reported by previous workers. These deposits occur within Precambrian metasediments (schist belt), mafic and ultramafic rocks which are Proterozoic in age and folded into synclinorial belts within the crystalline basement complex. Considering their widespread distribution in space, time and tectonic setting, some are considered to be of ensilalic mode of evolution while others are ensimatic. However, the mineralizations are mostly of poor grade, and thus require beneficiation processing. The local steel industries within the country have continued to depend on manganese ore. No satisfactory substitute for manganese in steel production has been identified as at present. The applications of manganese deposits by geologists, chemical and environmental engineers, ceramicists, soil scientists and microbiologists shows a bright future for manganese ore in Nigeria. The ever increasing demand for steel products has continued to put pressure on Federal Government of Nigeria to complete the construction work at the nation's steel producing plant which, will result in the need for a manganese concentrates for economic growth and development.

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Keywords: Northern basement complex; schist belt; mineralizations; beneficiation; tectonic setting; concentrates.

1. INTRODUCTION

The surface area of Nigeria 923, 768 km^2 is covered in nearly equal proportions by crystalline and sedimentary rocks [1]. The Nigerian Basement Complex is characterized by different grades of metamorphism, orogenies and structural modifications [2,3,4] and these have been reflected in its complex petrological, structural composition and mineralization potential. The younger metasediments in Nigeria are well known for their mineralization such as Gold, Banded Iron Formation (BIF), lead / zinc ores, tantalite manganese deposits and marble are associated with them [5,6,7]. Nigeria has over 5,000,000 metric tons (MT) of manganese deposit [8,9].

2. PREVIOUS WORKS

The geology of the Nigerian basement complex has received considerable attention from geologists in Nigeria and abroad, partly due to its economic significance and partly because of its unusual geological character. Prior to the minerals ordinances [10] a legal guidelines under which mining companies could operates in a particularly concession was passed in [11,12]. The mining companies had concessionary rights to commence their geological and geophysical investigations in the area allocated under the 1907 ordinance to explore parts of the Nigerian basement complex [12]. Since the pioneering work by several authors [13,14] that conducted the first geological description and introduced basement terrain in literature, several authors have contributed to the geology, structure, geochemistry and geochronology knowledge on granitic and volcanic rocks constituted of these lithology. Previous studies covered the schist belts includes the works of several authors [15-37] while the amongst the (earlier documentation on manganese mineralization appeared in the works of several authors [19,38-44]; [38] identified pelitic and semi pelitic rocks, banded iron rocks, amphibolites and other minor rocks, like magnesian rich (talcose rock) and schistose varieties in the basement complex.

Several studies have investigated the geochemistry of rocks identified by [38] in Kushaka belts includes [18,19,26,25,20], though the majority are concerned with the tectonic evolution of the area mainly on granites, amphibolites, gold and talcose rocks. [25,20] considered the Kushaka and Anka areas to be fault-controlled rift-like structures. [28] considered the Anka area to have formed in a separate basin.

Other works done on manganese mineralisations in Nigeria were related to beneficiation of manganese ores [43,44] The investigation carried out by [43] in Madaka focused on appraisal of manganese deposits in the study area with emphasis on its metallurgical features. They produced crystals of manganese II sulphate having 97% purity after purification process using dilute sulphuric acid as solvent. [44] affirmed the hydrometallurgical extraction of manganese metal by thermal decomposition of the purified manganous nitrate (MnN_2O_6) crystals to synthesized the chemical manganese dioxide (CMD) from Madaka area. Several authors [45,46] envisaged complex volcano sedimentary trough deposits, with the formation in the belt being lateral facies equivalents. In supporting this view, [47]; [1] proposed the formation of back-arc graben-like structures in Pan-African times to be responsible for the formation of the this belt. The study areas shown numerous features typical of an Archean basement, like grey gneisses and amphibolites displaying greenstone - belts affinities, Archean U-Pb zircon ages and numerous Nd models ages older than 2.7Ga [27,48,49]. Few studies focused on the Banded iron formations (BIFs) that are found alternating with manganese ores in the study area includes; [50,51,42,39,52]. A study by [42] revealed the association between BIFs and manganese in the Maru area. He recognized the presences of sedimentary cycles of BIFs and braunites, lutite in the area. He drew attention to the fact that the vast majority of manganese deposits are of sedimentary character and emphasized on the importance of additional processes like sea- floor volcanic activity, sea level fluctuations, climate changes, biological productivity) as critical in the development of large accumulation of maganiferrous sediments in depositional environment.

Studies by several authors [39,53] were aimed at upgrading of the manganese ore. These authors worked on decolourization of manganese ore from Maikujeri area using magnetic separation and acid bleaching as route for beneficiation. [52]

assessed the manganese deposits in the area with emphasis on its industrial application.

3. GEOLOGY OF NIGERIA

Nigeria is situated within the Pan–African mobile belt, which is a part of an Upper Proterozoic mobile belt, extending from Algeria across the Southern Sahara into Nigeria, Benin and Cameroon. The Pan- African belt continues into north-eastern Brazil, where manganese rocks are also known to occur [38]; [39]. It is situated between the Archean- Paleoproterozoic blocks of West African Craton in the west, the Congo Craton in the south east and the east Sahara block in the northeast [54] (Fig. 1). All models of evolution of the schist belts of Nigeria formulated over the years have been classified under ensialic and ensimatic processes of formation [55,23,56,22,57].

The Northern basement complex of Nigeria contains a large number of manganese deposits. So far, ten deposits of manganese ore have been reported in various parts of the Nigeria where they are associated with the mafic and ultramafic complexes and metasediments of the basement complex [38,9,39,41,59,60].

4. DISTRIBUTION OF MANGANESE DEPOSITS IN NIGERIA

The manganese occurrences of north western Nigeria have been variously reported. [61] worked on the manganese deposits at Mallam Ayuba within the Maru schist belt. They observed that the manganese mineralization occurs in ridges for over 800 m along a north- south strike and lying near Mallam Ayuba settlement. The ore bodies composed of massives brown- gray-black, jointed or fractured, fine-grained iron manganese mineralization dipping at 85^0 east with strike direction of 110° [62]; having a conformable beds of quartzite that contains banded iron formation (BIF), gold and amphibolites [63]. The Tudun Kudu manganiferous ore occur within Precambrian metasediments (Karaukarau schist belt) which are Proterozoic rocks, folded into synclinorial belts within the crystalline basement complex, and metamorphosed to phyllites, quartzites and psammitic schists of low to medium grade [64,65]. Available studies show that small quantities of manganese deposits have been reported from basement rocks in South-eastern and South-western parts of Nigeria [66,67] (Fig. 2).

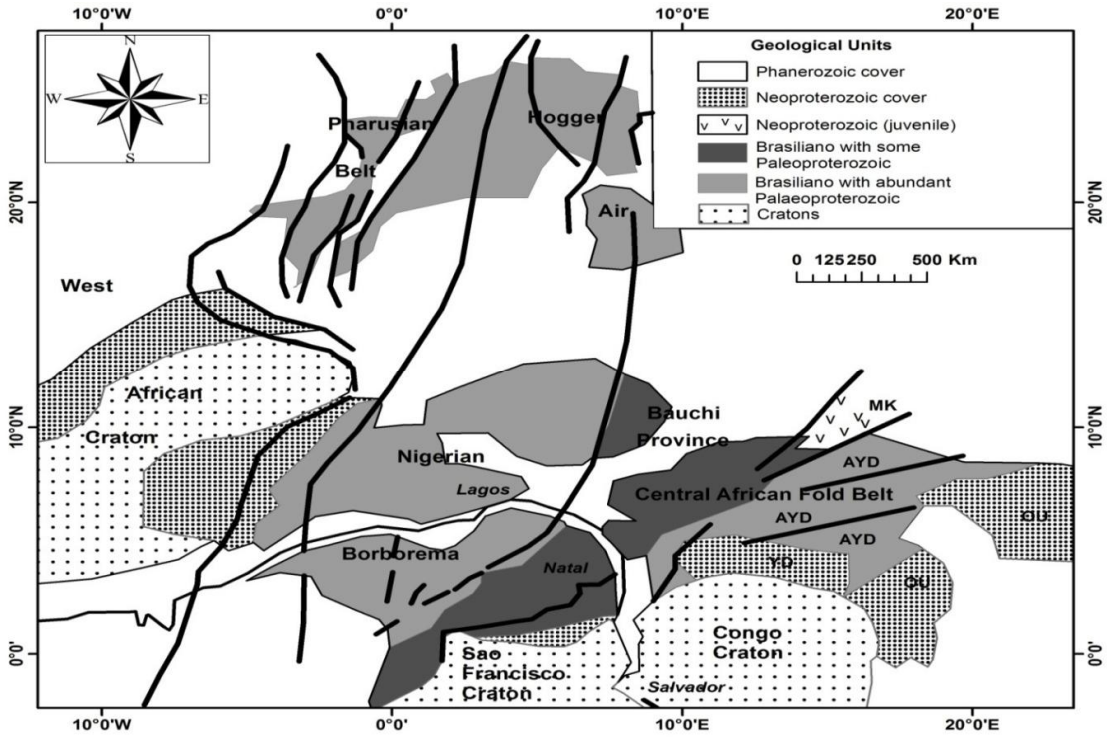

Fig. 1. Pre- drift Proterozoic belts and their Phanerozoic cover rocks between the Cratons [58]

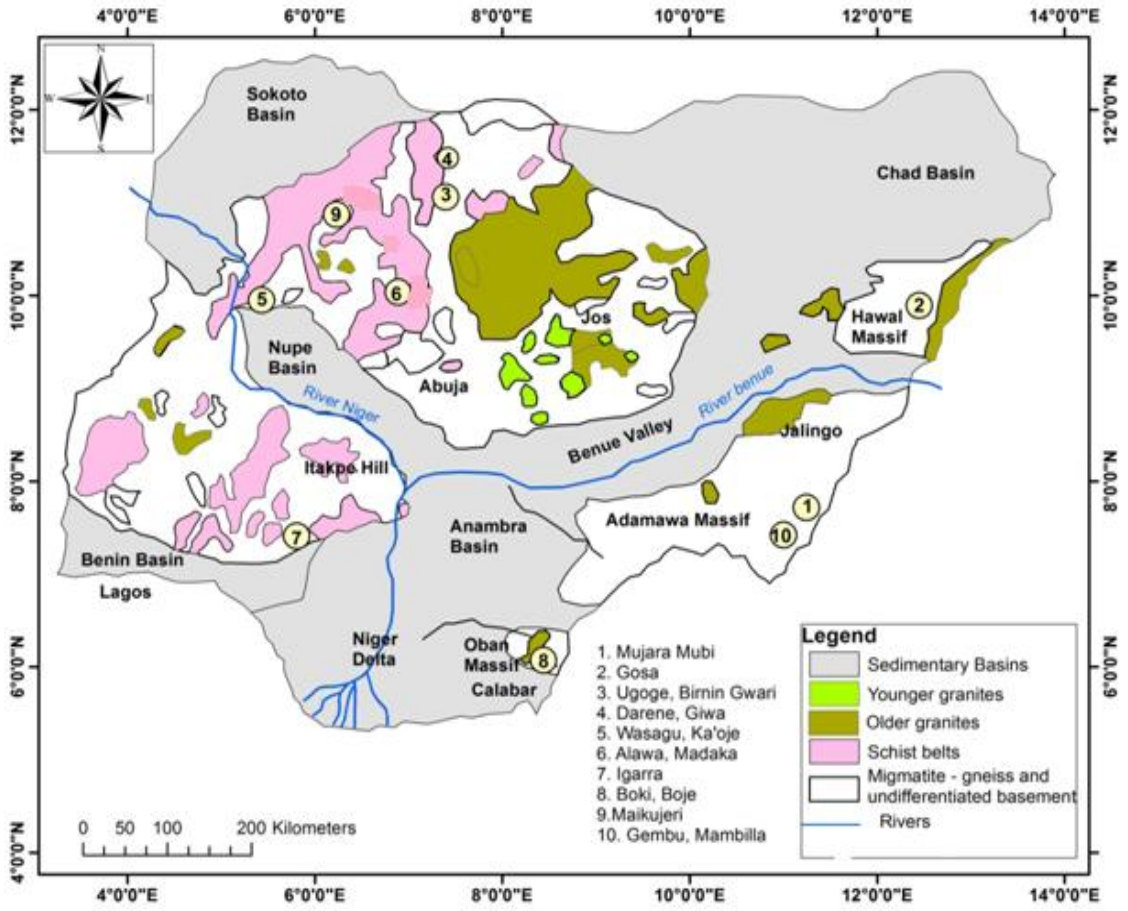

Fig. 2. Simplified geological map of Nigeria Basement Complex showing the occurrence of manganese deposits (Modified after [5,57])

Table 1. Summary of occurrences and distribution of manganese deposits in various locations in Nigeria

S	State	Location	Grade	Estimated Reserve (Ton)	References
1	Niger	Madaka	-	Nd	[60]
		Alawa,	Low		[63]
2	Edo	Igarra	-	Nd	[67]
3	Adamawa	Mubi	Low	Nd	[68]
4	Kebbi	Ka'oje.	Low	Nd	[43]
		Wasagu/Danko	-	-	[52]; [53]
5	Borno	-	-	-	[40]
7	Cross River	Duoala	Low	Nd	[66]
8	Zamfara	Maikujeri, Darene	Low	-	[41]
9	Kaduna	Mallam Ayuba,	Low	Nd	[39]
		Birnin Gwari			[59]
					[40]
					[63]; [62]; [56]
		Ugoge (S/W)	Low	-	[69]
		Ugoge (S/E)	Low	-	[70]

ND= Not Determined, - Unknown

However, the mineralizations are mostly of poor grade, and thus require some processing to improve quality for industrial uses. Studies by several authors [39,53] were aimed at upgrading of the manganese ore. These authors worked on decolourization of manganese ore from Maikujeri and Kaoje area using magnetic separation and acid bleaching as route for beneficiation. [52] assessed the manganese concentrates in the area with emphasis on its industrial application. Table 1 gives the summary of the major manganese deposits occurrence in Nigeria.

5. ECONOMIC POTENTIAL OF MANGANESE IN NIGERIA

The use of manganese in steel production is a double-edged sword, as the metals fortune is intimately tied to the steel industry. Hence, the need to develop a simple and practicable route for the processing and extraction of manganese from its ores is necessary. The use of Manganese in dyes, paints, battery cells, glass and textiles industries is also of great importance.

In Nigeria, for instance, the per capital consumption of steel is very low. About 10 kg or less is the index used to determine the level of industrialization of a country. Statistics showed that Nigeria is lagging behind; and other countries with lesser endowments like Zimbabwe (25 kg), Egypt (42 kg), Algeria (38 kg) and South Africa (112 kg), are ahead of Nigeria in terms of steel production and consumption [59].

(1) Steel processing: The various end-uses of manganese have different ore requirements giving rise to the classification of manganese ore into metallurgical, chemical and non-metallurgical grades. The biggest use of manganese is for the production of steel and cast iron [39,43,60]. Manganese has two important properties in steelmaking: its ability to combine with sulphur to form Alabandite (MnS) and its deoxidation capacity [42].

(2) As alloy: [52] reported that about 94% of the manganese ore is converted into manganese alloy, These are used in production of stainless steel, heat resistant steel and electric welding electrodes, and as an alloying element in steel where it improves the strength, toughness, hardenability, workability, abrasion resistance of steel and electrical conductors.

(3) Environmental uses: Mn oxides have been used for many different applications in water and waste water treatment as deoxidizer; soil and sediment remediation (of metals and organics); For example, a widely used filtration medium for drinking water is manganese greensand (glauconite with Mn oxides of various Mn valence states), designed specifically to remove Mn(II), Fe(II), hydrogen sulfide, and arsenic [51].

(4) It serves as catalysts and adsorbents in the laboratory: The oxidation of Mn^{2+} to Mn^{3+} and Mn^{4+} is largely catalyzed by micro organisms and greatly accelerates the rate of oxidation in many environments. Owing to the high activation energy, the oxidations of Mn^{2+} act as adsorbents in the laboratory.

6. CONCLUSION

Previous workers like [38,67,9,39,59,43,60] revealed that manganese deposit reserves exist in Nigeria, which have potentials as raw materials for industrial applications such as batteries, steel and electrical appliances. The present level of exploitation is, however, very low and in most cases, appropriate processing would be necessary to attain desirable qualities.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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