THE DISTRIBUTION AND ECONOMIC POTENTIAL OF MANGANESE DEPOSITS IN NIGERIA

OJO ADEOYE AKINTOLA
Department of Geology, Faculty of Physical Sciences, Ahmadu Bello University, Zaria, Nigeria.
*Corresponding author. E-mail: adeoye.akintola@yahoo.com

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.

KEYWORD: Northern basement complex, schist belt, mineralizations, beneficiation, tectonic setting, concentrates.

INTRODUCTION

The surface area of Nigeria 923, 768sq.km is covered in nearly equal proportions by crystalline and sedimentary rocks (Rahaman, 1988). The Nigerian Basement Complex is characterized by different grades of metamorphism, orogenies and structural modifications (Odeyemi, 1977; Ajibade *et al.*, 1987; Caby, 1989) 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 (Woakes, *et al.,* 1987; Dada *et al.*, 1989; Oyinloye, 2006). Nigeria has over 5,000,000 metric tons (MT) of manganese deposit (Ministry of Solid Minerals and Development - MSMD, 1997; Raw Material Research and Development Councils -RMRDC, 2009).

PREVIOUS WORKS

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 (Truswell and Cope, 1963; Yaro, 1998).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 (Black, 1980). Figure 1).

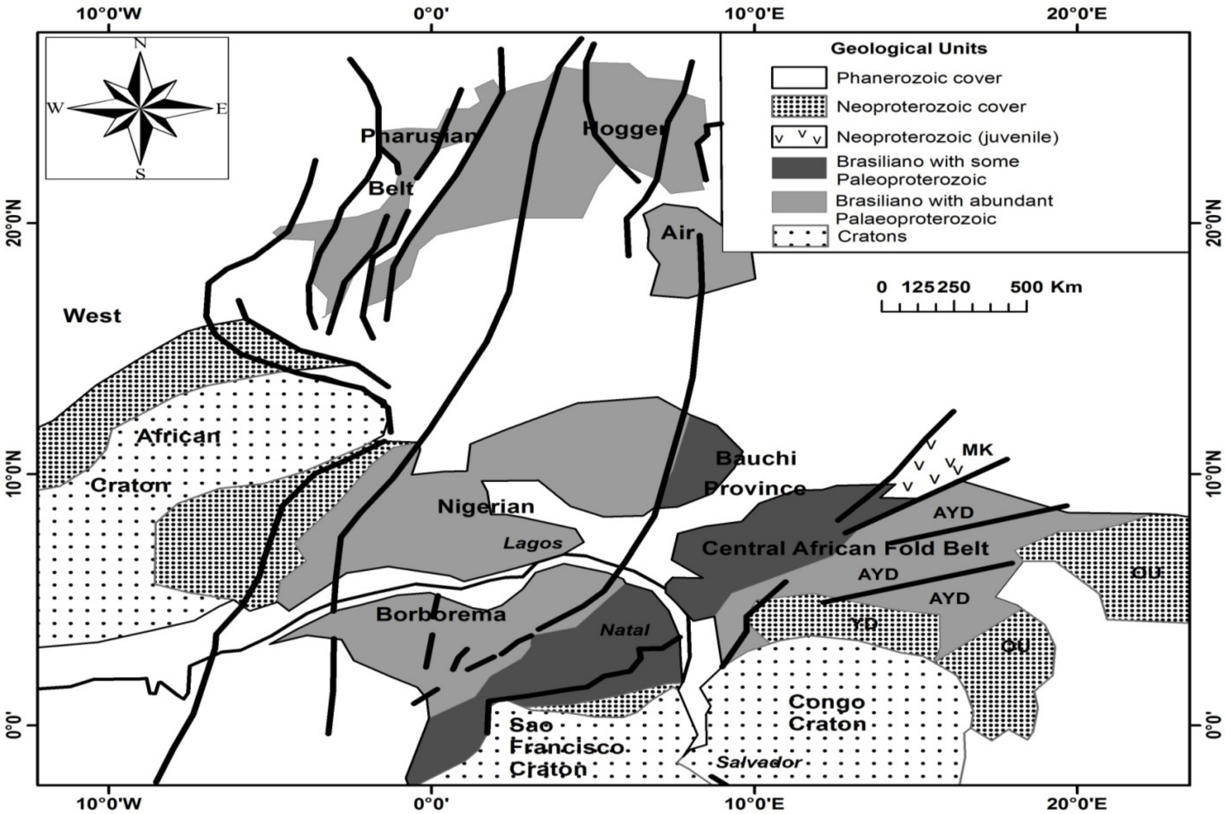

Figure (1): Pre- drift Proterozoic belts and their Phanerozoic cover rocks between the Cratons (Dada, 2008)

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 (Truswell and Cope, 1963; RMRDC, 2009; Yaro, 1998; National Steel Raw Materials Exploration Agency - NSRMEA, 2010; Bamalli, *et al*., 2011; Muriana *et al.,* 2014).

DISTRIBUTION OF MANGANESE DEPOSITS IN NIGERIA

The manganese occurrences of north western Nigeria have been variously reported. Wright and McCurry, (1970) worked on the manganese deposits at Mallam Ayuba within the Maru schist belt. They observed that the manganese mineralization occurs in ridges for over 800m 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 110^0 (Bar and Mucke, 1982), having a conformable beds of quartzite that contains banded iron formation (BIF), gold and amphibolites (Moneme and Scott, 1983). 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 (Moneme *et al.*, 1982; Mucke and Okujeni, 1984).

Available studies show that small quantities of manganese deposits have been reported from basement rocks in South-eastern and South-western parts of Nigeria (Raeburn, 1927; Bafor and Mucke 1990). However, the mineralizations are mostly of poor grade, and thus require some processing to improve quality for industrial uses. Studies by (Yaro, 1998; Binta *et al.*, 2016) 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. Binta, (2013) 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 (Figure 2).

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	Muriana *et al.*, (2016).
		Alawa,	Low		Truswell and Cope, (1963)
2	Edo	Igarra	-	Nd	Bafor and Mucke, (1990)
3	Adamawa	Mubi	Low	Nd	Vandi, (2014)
4	Kebbi	Ka’oje.	Low	Nd	Muriana *et al.*, (2014)
		Wasagu/Danko	-	-	Binta, (2013), Binta *et al.*, (2016)
5	Borno	-	-	-	RMRDC,(1999)

7	Cross River	Duoala	Low	Nd	Raeburn, (1927)
8	Zamfara	Maikujeri, Darene	Low	-	NSRMEA, (2010),
9	Kaduna	Mallam Ayuba, Birnin Gwari	Low	Nd	Yaro,(1998) Bamalli, *et al.*, (2011) RMRDC. (1999) Moneme and Scott, (1983); Bar and Mucke,(1982);Wright and McCurry, (1970)
		Ugoge (S/W)	Low	-	Bartholomew, (1982).
		Ugoge (S/E)	Low	-	Widadason, (1982)

ND= Not Determined, - Unknown

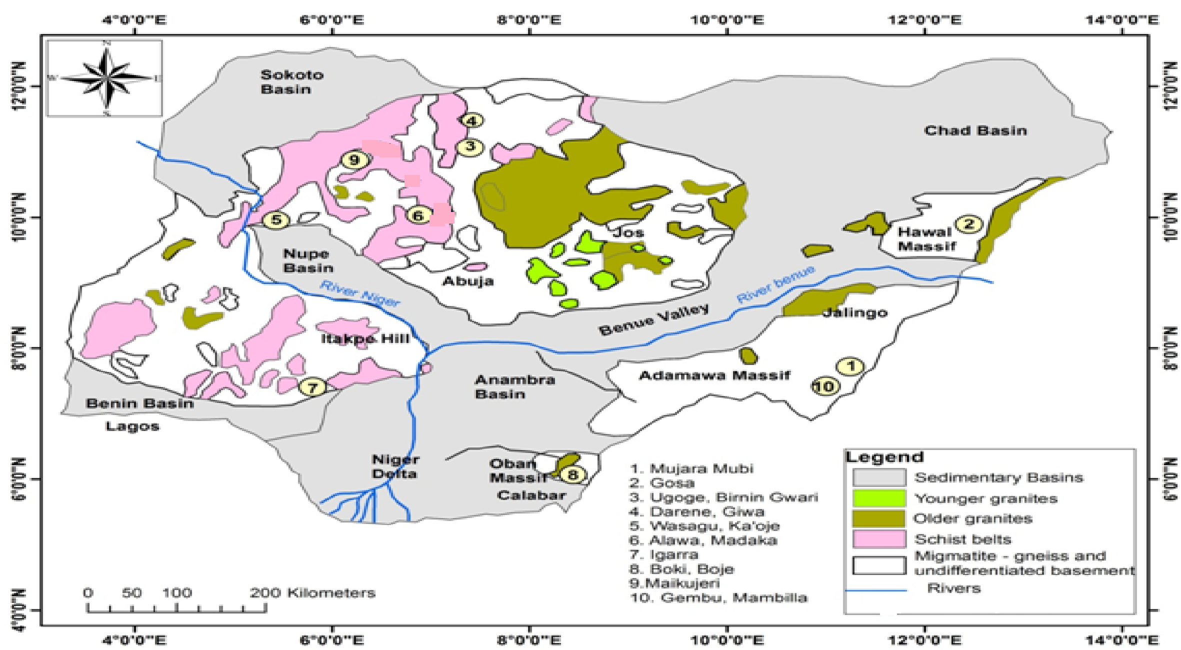

Figure 2. Simplified geological map of Nigeria Basement Complex showing the schist belts where manganese occurs (Modified after Woake *et al.*, 1987 and Danbatta, 2008).

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 (Bamalli et al., 2011).

(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 (Yaro, 1998; Muriana *et al.*, 2014) Manganese has two important properties in steelmaking: its ability to combine with sulphur to form alabandite (MnS) and its deoxidation capacity (Imer, 1997).

(2) As alloy: Binta, (2013) 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 (Mucke 2005).

(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.

CONCLUSION

Previous workers like (Truswell and Cope, 1963; Mucke and Bafor, 1990; RMRDC, 2009; Yaro, 1998; Bamalli *et al*., 2011; Muriana *et al.,* 2014, and Muriana *et al.,* 2016) 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.

REFERENCE

Ajibade, A.C., Woakes, M., and Rahaman, M.A., (1987). Proterozoic crustal development in the Pan-African regime of Nigeria. In: A. Krooner (Editor), Proterozoic crustal evolution *Geodynamic Services American Geophysics union* 17, pp. 259 - 271.

Bamalli, U. S, Ali, M., and Mohammed, S.C., (2011). A review of Nigerian metallic minerals for technological development, *Natural Resources* 2, pp. 87 – 91.

Bar, P. and Mucke, A. (1982). Mineralisation and genesis einiger Nigerian ischer manganv rkornrncn (Tudun Kudu Hill,Ungwan Malam Ayuba, bei Gangara, Ruwan Doruwa and Maraba Hill). *Fortschr* 1, pp. 148 - 149.

Bafor, B. E and Mucke, A., (1990). The genesis of manganese concretions in the Igarra area, Southwestern Nigeria. *Journal of African Earth Sciences* **10**, pp. 595 - 601 ·

Bartholomew, A., (1982). The geology and geochemical secondary dispersion pattern of manganese occurrence in Ugoge via Giwa, Kaduna State, Nigeria. Unpublished B.Sc Thesis, Ahmadu Bello University, Zaria, Nigeria. 61pp.

Binta, H., (2013). Upgrading of Wasagu manganese ore to metallurgical grade concentrate, Unpublished M.Sc Thesis, Ahmadu Bello University, Zaria, 66pp.

Binta, H., Yaro, S.A., Thomas, D.G., and Dodo., M.R., (2016). Beneficiation of low grade mangansese ore from Wasagu, *Journal of Raw Materials and Development* 10 (2). pp. 45-51

Black, R., (1980). Precambrian of West Africa, *Episodes* 4: pp. 3–8.

Caby, R., (1989). Precambrian terranes of Benin-Nigeria and Northeast Brazil and the Late proterozoic South Atlantic fit, *American Spectrum Paper* 230**,** pp. 145 – 158.

Dada, S. S., (2008).Crust-forming ages and Proterozoic crustal-evolution in Nigeria. *Geoscience Letters* 2. pp. 5-11

Dada, S. S., Birck, J. L. and Rahaman, M. A., (1989). Archean Migmatite – Gneiss Complex of North-central Nigeria: Its geochemistry and evolution. *International colloquium on African Geology*, Mbabane Swaziland 1, pp. 97-102.

Danbatta, U. A., (2008). A review of the evolution and tectonic setting framework of the schist belts, Northwestern, Nigeria. *Journal of science*, pp. 24-35

McCurry, P., (1970). The geology of Sheet 21, Zaria Unpublished M.Sc thesis, Ahmadu Bello University, Zaria

Moneme, P. C., and Scott, P. W., (1983). The mineralogy of Malam Ayuba manganese mineralization in Maska, Sheet (101). *Nigerian Mining Geosciences Society 19th Annual Conference*, Warri. pp. 23 -24.

Moneme, P. C; Scott, P. W; and Dunham, A. C., (1982). Occurrence of manganese ores in Zaria Area, Kaduna State. *Nigerian Mining Geosciences Society Abstracts*, 18th Annual Conference, Kaduna. pp. 17-18.

MSMD, (1997). Ministry of Solid Minerals and Development: An Inventory of solid minerals in Nigeria. *Geological Survey of Nigeria* Press. 59pp.

Mucke, A, (2005). The Nigerian manganese –rich iron formation and their host rocks- from sedimentation to metamorphism, *Journal of Africa Earth Science*s 41**,** pp.407 – 436.

Mucke, A. and Okujeni, C., (1984). Geological and ore microscopic evidence on the epigenetic origin of the manganese occurrences in Northern Nigeria. *Journal of Africa Earth Science*s 3**,** pp. 209 – 225.

Muriana, R. A,. (2016). Discharge evaluation of battery-active chemical manganese dioxide produced from Madaka (Nigeria) manganese ore. *Journal of Engineering Research* 20**,** pp. 67-78.

Muriana, R. A., Muzenda. E. and Abubakre, O. K., (2014). Extraction and production kinetics of industrial – grade manganese sulphate crystal from manganese. *Journal of Engineering Research* 19, pp.78 – 90.

NSRMEA, (2010). National Steel Raw Materials Exploration Agency, geological report on manganese deposit in Kaoje Bungudu, *Issue* 3, pp. 45 -58.

Odeyemi, I. B., (1977): Late -Proterozonic metconglomerates in the Schist Belt of Nigeria: origin and tectonostratigraphic significance revisited. *Journal of technoscience* 3 pp. 48-55.

Oyinloye, A.O., (2006). Geology and geochemistry of some crystalline basement rocks in Ilesha area Southwestern Nigeria: Implications on provenance and evolution. *Journal of Science India Research,* 50, pp. 223-231.

Rahaman, M. A., (1988). Recent advances in the study of the basement complex of Nigeria. In: Precambrian Geology of Nigeria. *Geological Survey of Nigeria*. pp. 11-14

Raeburn, C., (1927). Tinstone in Calabar. *Bulletin of Geological Survey of Nigeria* 11, pp. 72-88.

RMRDC, (2009). Non Metallic in Nigeria: *Raw Material Research and Development Councils, Abuja*, 13p.

Truswell, J. F., and Cope, R.N., (1963). The geology of parts of Niger and Zaria provinces, northern Nigeria. *Bulletin of Geological Survey Nigeria* 29**,** pp. 34 – 48.

Vandi, D. K., (2014). Geology and geochemistry of manganese ores in Mujara, Mubi South, Northeast Nigeria, B.Sc Thesis Modibbo Adamawa University of Technology, Yola. 32pp.

Widadason, G. A., (1982). The geology and geochemical secondary dispersion pattern of the manganese occurrence at Ugoge (Tudun Kudu) Southeastern sector, Department of Geology, Ahmadu Bello University, Zaria, Nigeria (unpublished). 67pp.

Woakes, M., Ajibade C.A., and Rahaman, M.A., (1987). Some metallogenic features of the Nigerian Basement Complex, *Journal of Africa Science* **5**. Pp. 655-666.

Wright, J. B., and McCurry, P., (1977). First occurrence of manganese ores in northern Nigeria. *Economic Geology* 65, pp. 103 - 106.

Yaro, S. A., (1998). Development of a process route for the beneficiation of Mallam Ayuba manganese deposit to ferromanganese feed grade. Unpublished Ph.D. Thesis, Ahmadu Bello University, Zaria, 79pp.