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Comparative Geochemical Assessment of Nigerian Phosphates: An Abridged Review

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ABSTRACT: *The main aim of this paper is to review and compare the various geochemical assessments that have been carried out on the Nigerian phosphates with a view to encourage local and international investors to develop and exploit these deposits. Nigeria is located on latitude 10^0 North and longitude 8^0 East surrounded in the north by Niger and Chad and in the east by Cameroun and in the west by Benin Republic. The comparative geochemical assessments of the Nigerian phosphates show that they compare favourably with deposits from Togo, Morocco, Jordan, USA, Algeria, China, etc. With the current economic reforms and investment incentives in Nigeria, interested investors are highly welcome to take advantage of developing these deposits.*

KEYWORDS: *Nigerian phosphate rock, fertilizer, food security*

I. INTRODUCTION

The main aim of this paper is to review and compare the various geochemical assessments that have been carried out on the Nigerian phosphates with a view to encourage local and international investors to develop and exploit these deposits. Nigeria is located within the Equator and the Tropic of Cancer on latitude 10^0 North and longitude 8^0 East. Nigeria is surrounded in the north by Niger and Chad and in the east by Cameroun and in the west by Benin Republic (Fig. 1). It occupies an area of 923,768 m^2 made up of landmass of 910,768 m^2 and water area of 13,000 m^2. The Nigerian coastline is 853 km. The seat of government is Abuja. Nigerian has stable democratic system of government and the present President of the country is Dr. Goodluck Ebele Jonathan, GCFR. According to Wikipedia (2012), Nigeria's population is 170 million people with three major tribes, namely: Hausa/Fulani, Yoruba and Ibo. The official business language is English and the currency is Naira (₦) which has an exchange rate of ₦159.98 to US Dollar ($1) as at June 2nd, 2013. The major religions practised in Nigeria are Christianity and Islam, while there are minor adherents of indigenous religions, Hinduism, Buddhism, Baha'i and other faiths. Nigeria is a tourism and investment destination despite the recent security challenges. Nigeria has 4,660 km of standard/narrow gauges rail network across the entire country. Other modes of transportation are road network of 195,000 km, sea, inland water ways and air transportation. Nigeria has several international sea-ports (Lagos, Port Harcourt, Warri, Calabar, Onne and Sapele) and international air-ports (Abuja, Lagos, Kano, Port Harcourt, Enugu, Kaduna, Maiduguri, Yola, Calabar, Sokoto, Owerri, Jos, Ilorin) and local air-ports (Gombe, Minna, Yola, etc). The temperature ranges from 22 – 36^0c. There is rain forest in the South and savannah vegetation in the Northern part of the country (Wikipedia, 2012).

II. GEOLOGICAL SETTING OF NIGERIA

The geology of Nigeria is composed of 4 main groups, namely: the Basement Complex, Younger Granites, Sedimentary series and Tertiary-Recent Volcanic rocks. The Basement Complex is made up of the migmatite-gnesis complex, pegmatites, the schist belts composed of metasedimentary and metavolcanic rocks and the pan-African Granitoids comprising the Older Granites and the associated charnockitic rocks. The Younger Granites are of Jurassic age and they are found as ring-complex outcrops within the Basement Complex areas. The Younger Granites are rich in minerals such as columbite, cassiterite, etc. The sedimentary series are made up of seven basins, namely: Niger Delta, Dahomey, Anambra, Bida, Benue Trough related to the opening of the Gulf of the Guinea and the Sokoto (Illummeden) and Chad basins are parts of larger basins that extend beyond Nigeria. The Tertiary-Recent volcanic rocks are found in Biu and Longuda plateaux, Jos Plateau and the Benue Trough. Though phosphate occurrences in Nigeria have been reported in four States such as Sokoto, Ogun, Edo and Imo (Tian and Kolawole, 1999; Ojo, 2003), in this paper the focus will be placed only on the first two mentioned occurrences because only the phosphate occurrences in Sokoto and Ogun States are in commercial quantities (Akinrinde and Obigbesan, 2006; Okosun and Alkali, 2013)

Fig. 1. Location map of Nigeria (Source: Magellan, 1992)

III. PHOSPHATE DEPOSITS IN SOKOTO AND OGUN STATES

According to van Straaten (2002), the five major types of phosphate resources in the world are marine phosphates, igneous phosphates, metamorphic phosphates, biogenic and phosphates from weathering. Sedimentary, marine phosphate rock deposits provide 75% of the world's phosphate resources, while 15 – 20 % come from igneous and weathered deposits and only 1 – 2% from biogenic (mainly from bird and bat guano accumulations) resources (van Straaten, 2002). In Nigeria, the phosphate deposits are of the sedimentary, marine origin.

In Sokoto State, phosphates of Paleocene sedimentary deposits occur in the Dange Formation. The Dange Formation also contains gypsiferous shales and phosphate nodules (Kogbe, 1972, 1976). The overlying Paleocene Kalambaina and Gamba Formations are dominated by limestones and laminated ('paper') shales. A horizon with phosphate pellets within the Gamba Formation (Kogbe, 1976, quoted by van Straaten, 2002) is probably equivalent to the phosphate-containing marine sequence in neighbouring Niger and Mali (Wright et al., 1985; Hanon, 1990). The exploration work by the Geological Survey of Nigeria (now called Nigerian Geological Survey Agency) also established the occurrence of phosphate nodules and pellets in Dange, Gidan Bauchi, Illela, Gada and Kalambaina (Ogunleye et al., 2002). The thickness of phosphate deposits ranges from 1 – 5 m in the Dukamaje Formation and the phosphatic nodules/pellets occur in sizes of 0.1 – 1 cm with varying concentration in different locations (Etu-Efeotor, 1998; Okosun, 1997; Ogunleye et al., 2002). The Sokoto phosphates have an estimated reserves of 5 – 10 million tonnes (Akinrinde and Obigbesan, 2006).

According to van Straaten (2002), Lower Eocene sedimentary phosphates have been known from south-western Nigeria since 1921 (Russ, 1924, quoted in McClellan and Notholt, 1986). Phosphate rocks are found in Oja-Odan and Ifo areas of Ogun State. Detailed work is needed to establish the actual reserves of the deposits. However, there are several conflicting reserve figures for the same deposits. Akinrinde and Obigbesan (2006) quoted 0.5 million tonnes, while McClellan and Notholt (1986) gave values of 1 million tonnes and the Ministry of Solid Minerals Development (2000) quoted 40 million tonnes as the reserves for the deposits. The phosphate rock deposits in Ogun State occur in nodules, granular and vesicular forms (Sobulo, 1994; Adediran and Sobulo, 1998; Adegoke et al., 1991; Akinrinde and Obigbesan, 2006).

IV. COMPARATIVE GEOCHEMISTRY OF NIGERIAN PHOSPHATES

According to Akinrinde and Obigbesan (2006), Sokoto phosphates have calculated average percentage of 30.5 – 36.6% P_2O_5, while the Ogun phosphates have 26.3 – 32.0% P_2O_5. The above average values for the Nigerian phosphates compare favourably with the Togo phosphate which have the values of 28.0 – 36.6% P_2O_5 (Akinrinde and Obigbesan, 2006) and imported to feed the superphosphate fertilizer plant in Kaduna, Nigeria (Ogunleye et al., 2002). Table 1 shows the oxide percentages of the Sokoto and Ogun phosphates in comparison to deposits from Jordan, Morocco, USA, Algeria, China and Syria. From the data in Table 1, Nigerian phosphates have values of P_2O_5 that range from 20.18% to 36.25%, while the Jordan, Morocco, USA, Algeria, China and Syria phosphates have the range of 30-35%.

The Nigerian phosphates have been proven to have very high reactivity, thus making it very suitable as fertilizer material even in direct application to soil to improve fertility and higher crop productivity (van Straaten, 2002; Akinrinde and Obigbesan, 2006; Okosun, 1997; Okosun and Alkali, 2013). However, in view of the high content of uranium especially in the Sokoto phosphates, the need to comprehensively extract out the uranium from the phosphates is necessary for environmental pollution control and health (Obaje, 2013). There are vast mining investment opportunities for interested investors in the Nigerian phosphate deposits to take advantage of because of the current economic reforms and investment incentives in Nigeria.

Table 1. Oxide Weight Percentages of Sokoto and Ogun Phosphate Rock Deposits (Source: [1]Akinrinde and Obigbesan, 2006; [2]Ghoridashrath, 2002; [3]NIPC, 2009; [4]Okosun, 1997; [5]van Kauwenberg, 1985 quoted in Okosun, 2013)

	[1]SOKOTO	[3]SOKOTO	[4]SOKOTO	[5]SOKOTO	[1]OGUN	[2]PS
P_2O_5	32.50	36.25	20.18-34.7	34.2	30.50	30-35
CaO	44.23	52.30	35.96-56.60	47.9	19.23	45-52
F	-	3.84	2.26-3.03	3.40	-	4
Cl	-	-	-	0.01	-	0.04-0.2
$CaCO_3$	79.0	-	-	-	34.30	-
MgO	0.95	-	0.10-0.99	0.10	1.35	0.5
Na_2O	-	-	0.15-0.95	0.24	-	0.2-0.8
K_2O	-	-	0.03-0.05	0.08	-	0.1-0.3
Fe_2O_3	3.19	1.50	0.22-3.57	3.00	7.28	1
Al_2O_3	1.79	1.50	0.43-6.24	1.70	6.91	2
SiO_2	4.20	3.44	2.7-9.71	4.2	6.68	5-8
H_2O	-	0.75	1.17-2.81	0.77	-	2.4
Solubility in 2% citric acid	45.55	-	-	35	38.42	-
Moisture %	-	-	-	-	-	1.5-2.5
Cd (mg Kg^{-1})	0.63	-	-	-	9.70	-

PS:- Jordan, Morocco, USA, Algeria, China and Syria

V. DISCUSSION

The above average values for the Nigerian phosphates compare favourably with the Togo phosphate which have the values of 28.0 – 36.6% P_2O_5 (Akinrinde and Obigbesan, 2006) and imported to feed the superphosphate fertilizer plant in Kaduna, Nigeria (Ogunleye et al., 2002). Nigerian phosphates have values of P_2O_5 that range from 20.18% to 36.25%, while the Jordan, Morocco, USA, Algeria, China and Syria phosphates have the range of 30-35%. Furthermore, the percentage weight values of CaO, MgO, Na_2O, etc. in Nigerian phosphates are higher than those of the phosphates from Jordan, Morocco, USA, Algeria, China and Syria. Nigerian phosphates have been established to have very high reactivity, thus making them very suitable as fertilizer raw materials even in their direct application to soils to improve fertility and higher crop productivity (van Straaten, 2002; Akinrinde and Obigbesan, 2006; Okosun, 1997; Okosun and Alkali, 2013). Nevertheless, in view of the high content of uranium especially in the Sokoto phosphates, there is need to comprehensively extract out the uranium from the phosphates to protect the environment and health (Obaje, 2013). There are enormous mining investment opportunities for interested investors in these deposits to take advantage of in view of the current economic reforms and investment incentives in Nigeria.

VI. CONCLUSION

In Nigeria, the phosphate deposits are of the sedimentary, marine origin. In Sokoto State, phosphates of Paleocene sedimentary deposits occur in Dange, Gidan Bauchi, Illela, Gada and Kalambaina (Ogunleye et al., 2002). In Ogun State, phosphates deposits are located in Oja-Odan and Ifo. According to Akinrinde and Obigbesan (2006), Sokoto phosphates have calculated average percentage of 30.5 – 36.6% P_2O_5, while the Ogun phosphates have 26.3 – 32.0% P_2O_5. The above average values for the Nigerian phosphates compare favourably with the Togo phosphate which have the values of 28.0 – 36.6% P_2O_5 (Akinrinde and Obigbesan, 2006) and imported to feed the Superphosphate fertilizer plant in Kaduna, Nigeria (Ogunleye et al., 2002). The Nigerian phosphates occur in nodules, pellets, granular and vesicular forms (Sobulo, 1994; Adediran and Sobulo, 1998; Adegoke et al., 1991; Akinrinde and Obigbesan, 2006; Etu-Efeotor, 1998; Okosun, 1997; Ogunleye et al., 2002). The comparative geochemical assessment of the Nigerian phosphates indicated that they contain very high P_2O_5, CaO, MgO, Na_2O, etc. values in comparison to the phosphates from Jordan, Morocco, USA, Algeria, China and Syria.

Finally, because of the very high reactivity of the Nigerian phosphates, they are very suitable fertilizer raw materials even in direct application to soil to improve soil fertility and higher crop productivity (van Straaten, 2002; Akinrinde and Obigbesan, 2006; Okosun, 1997; Okosun and Alkali, 2013). There are enormous mining investment opportunities for interested investors in the Nigerian phosphate deposits to take advantage of because of the current economic reforms and investment incentives in Nigeria.

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