Nigeria's Phosphate and Uranium Mineral Occurrences: Implication for Mineral Investment

S.O. Obaje[1*], A. Ojutalayo[2], O. Ogedengbe[3] and E.A. Okosun[4]
1.Nigerian Geological Survey Agency, Federal Secretariat, PMB 1423, Ilorin, Kwara State, Nigeria
2.Nigerian Geological Survey Agency, Federal Secretariat, Calabar, Cross River State, Nigeria
3.Consultant Economic Geologist, Ibadan, Oyo State, Nigeria
4.Department of Geology, Federal University of Technology, Minna, Niger State, Nigeria
* E-mail of the corresponding author: isolobaje2004@yahoo.com

Abstract
The main aim of this paper is to review the occurrences of phosphate and uranium in Nigeria 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. Available data indicated the viability of mineral investment in the Nigerian phosphate and uranium resources. With the current economic reforms and investment incentives in Nigeria, interested investors are highly welcome to take advantage of developing these mineral resources.
Keywords: phosphate, uranium, mineral resources, mineral investment, geochemical mapping

1. Introduction

The main aim of this paper is to review the occurrences of phosphate and uranium in Nigeria with a view to encourage local and international investors to develop and exploit these deposits. 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). Uranium occurrences have been reported in several Nigerian States in the pan-African Older Granites, Jurassic Younger Granites and sedimentary rocks. 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 practiced 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).

2. 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 Bornu 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.

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

3. Nigerian Phosphates

3.1 Phosphate Deposits in Sokoto and Ogun States

According to van Straaten (2002), the five major types of phosphate resources in the world are marine, igneous, metamorphic, biogenic phosphates, respectively, 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; Okosun, 1989). The overlying Paleocene Kalambaina and Gamba Formations are dominated by limestones and laminated ('paper') shales, respectively. The Gamba Formation also contains phosphatic nodules (Kogbe, 1976; Okosun, 1997). 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 neighboring 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 tons(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 tons, while McClellan and Notholt (1986) gave values of 1 million tons and the Ministry of Solid Minerals Development (2000) quoted 40 million tons 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).

3.2 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. The comparative geochemical analysis of trace elements of the Nigerian and Togo phosphates indicated uranium content of 65.0 ppm in Sokoto, 22.5 ppm in Ogun and 72.0 ppm in Togo phosphates, respectively (Table 2).

Table 1. Oxide Weight Percentages of Sokoto and Ogun Phosphate Rock Deposits (Source: [1]Akinrinde and Obigbesan, 2006; [2]NIPC, 2009)

	[1]SOKOTO	[2]SOKOTO	[1]OGUN (%)
P_2O_5	32.50	36.25	30.50
CaO	44.23	52.30	19.23
F	–	3.84	–
$CaCO_3$	79.0	–	34.30
MgO	0.95	–	1.35
Fe_2O_3	3.19	1.50	7.28
Al_2O_3	1.79	1.50	6.91
SiO_2	4.20	3.44	6.68
H_2O	–	0.75	–
Solubility in 2% citric acid	45.55	–	38.42
Cd (mg Kg^{-1})	0.63	–	9.70

Table 2. Trace Elements in PPM of Nigerian and Togo Phosphate Rock Deposits (Source: [1]Adesanwo *et al.*, 2010; [2]Ogunleye *et al.*, 2002)

ELEMENT	[2]SOKOTO (MEAN)	[1]OGUN (MEAN)	[2]TOGO (MEAN)
Cr	28.00	613.75	75.00
V	65.00	330.50	68.00
Ba	397.00	327.75	302.00
U	**65.00**	**22.50**	**72.00**
Th	3.20	9.25	17.40
Zn	59.00	126.00	143.00
Sc	11.80	12.00	11.60
Zr	810.00	89.75	765.00

4 Nigerian Uranium Occurrences

Uranium mineralization occurs in the Ririwai area of southern Kano State in the Jurassic anorogenic Younger Granite ring complex (Fig. 2). According to Ogedengbe (1984), uranium occurred in peraluminous and peralkaline granites and the content of uranium in peraluminous granite lies between 16 and 32 ppm (Table 3). In addition, Ixer *et al.* (1983) established uranothorite as the primary mineral source of uranium in these granitoids. Ogedengbe (1984) and other researchers

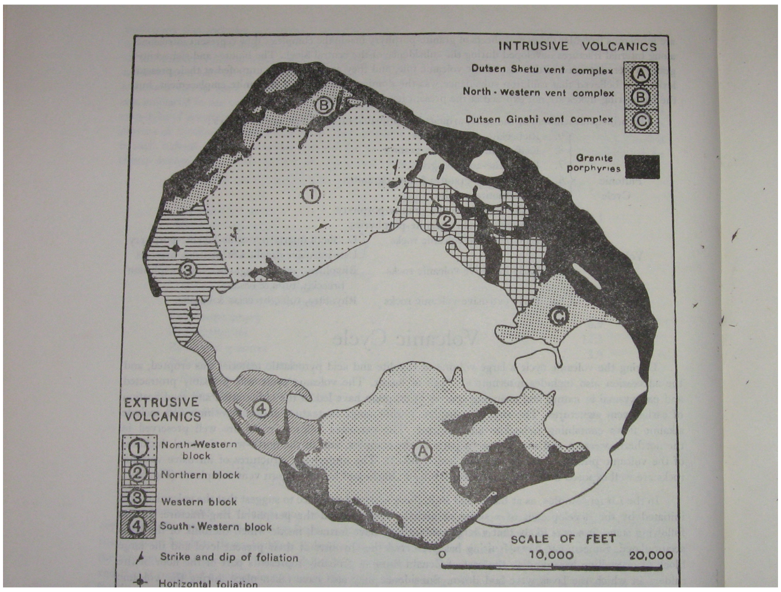

Fig. 2. Map of the Ririwai Ring Complex (Source: Jacobson and Macleod,1977)

stated that the uranium bearing mineral in the peralkaline albite arfedsonite granite is pyrochlore, which is an ore of niobium in association with cerium, tantalum and uranium.

Adekanmi *et al.* (2007) using a 16-channel gamma ray spectrometer found uranium in some residual soils in parts of Kaduna, Katsina, Niger and Zamfara States (Fig. 3). It was established that uranium in the areas has background values between 1 – 12 ppm (Table 3), which is much greater than the published crustal value of 2.8 ppm (Romberger, 2007).
Uranium also occurs in Mika, Gumchi, Zona and Mayo Lope areas of Adamawa State in Northeastern Nigeria. In Mika area, uranium mineralization occurs in the pan-African granite and the Jurassic rhyolite dykes that cross cut the Older Granite suites. While uranium occurs in meta-autunite and apatite form in the rhyolite in about 114 ppm, on the other hand, it is found in meta-autunite, coffinite and pitchblende form in the granite in about 10 ppm concentration (Funtua and Okujeni, 1996). Gumchi area has good uranium exploration prospect localized in the mylonitized, sheared and brecciated fine-grained to porphyritic granites. Analysis of cores from 40 drilled holes gave values of 2,000 ppm uranium content (NUMCO, 1983).

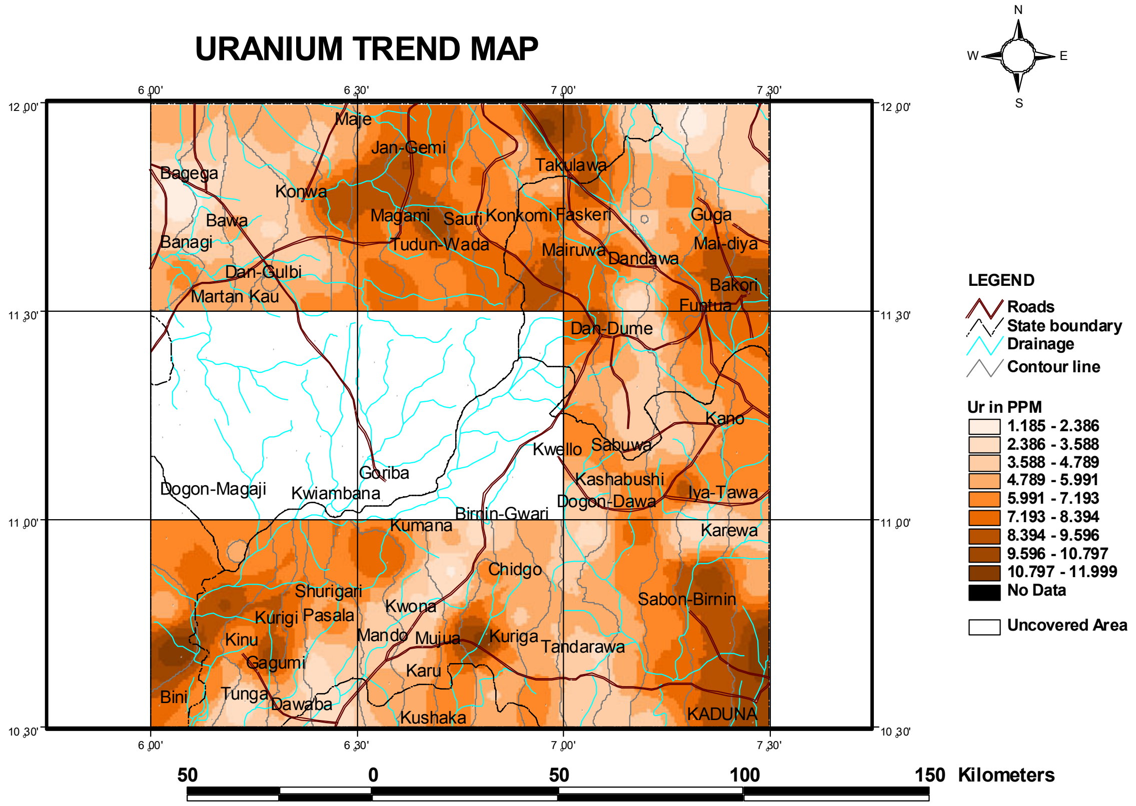

Fig. 3. Geochemical Map showing the distribution of Uranium in the Residual Soils of parts of Kaduna, Katsina, Niger and Zamfara States (Source: Adekanmi *et al.*, 2007)
In Mayo Lope syncline, uranium has anomalous concentration in the range of 1,826 – 2,375 ppm (Table 3) in the sediments of Bima Sandstone in Bille and Passam Hills, respectively (NUMCO, 1983). On the other hand, in Zona area of Adamawa State, uranium occurs in fine-grained arkosic sandstone with values in range of 0.01 and 128 ppm (Ogunleye and Okujeni 1993).
According to Arisekola *et al.* (2007), using a hand-borne Gamma-ray Spectrometer for geochemical mapping of Global Reference Network cell number N06E04 that covered parts of Osun, Kwara, Kogi and Ekiti States, indicated high uranium concentration above 500 ppm in some areas, especially within the pegmatite rocks in Osun State.

Table 3. Comparative Uranium Content in Nigerian Rocks (Source: [1]Ogedengbe, 1984; [2]Adekanmi *et al.*, 2007; [3]Funtua and Okunjeni, 1996; [4]NUMCO, 1983; [5]Ogunleye and Okujeni 1993; [6]Arisekola *et al.*, 2007)

LOCATION		ROCK TYPE	URANIUM CONTENT
Ririwai, Kano State		Peraluminuous granite	16 – 32 ppm[1]
Kaduna, Katsina, Niger and Zamfara States		Residual soils	1 – 12 ppm[2]
Adamawa State	Mika	Pan-African granites	10 ppm[3]
		Jurassic rhyolite dykes	114 ppm[3]
	Gumchi	mylonitized, sheared and brecciated fine to porphyritic granites	2,000 ppm[4]
	Mayo Lope	Bima Sandstone	1,826 – 2,375 ppm[4]
	Zona	Bima Sandstone	0.01 – 128 ppm[5]
Osun, Kwara, Kogi and Ekiti States		Residual soils	> 500 ppm[6]

5. Discussion

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. Furthermore, 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).

Uranium occurrence has been reported in Ririwai area of Kano State in peralkaline and peraluminious granites with uranium content of 16-32 ppm (Ogedengbe, 1984). Uranium concentration of 1 – 12 ppm has also been discovered in residual soils in Kaduna, Katsina, Niger and Zamfara States (Adekanmi *et al.*, 2007). The amount is well above the published crustal value of 2.8 ppm uranium (Romberger, 2007).

Also, uranium occurs in four localities in Adamawa States, namely: Mika, Gumchi, Mayo Lope and Zona areas. In Mika area, uranium occurs in the pan-African granites with 10.0 ppm uranium, while in Gumchi area, the assessed uranium content is 114 ppm in Jurassic rhyolite dykes (Funtua and Okujeni, 1996). In Mayo Lope and Zona areas, uranium occurs in sedimentary rocks of the Bima Sandstone. Uranium concentration of 1,826 – 2,375 ppm was assessed for Mayo Lope area, while in Zona area, the uranium concentration is 0.01 – 128 ppm (NUMCO, 1983; Ogunleye and Okujeni, 1993). Lastly, uranium concentration of greater than 500 ppm has been reported in the residual soils in Osun, Kwara, Kogi and Ekiti States (Arisekola *et al.*, 2007). One of the primary mineral sources of uranium in granitoids is uranothorite (Ixer *et al.*, 1983). In addition, pyrochlore, an ore of niobium in association with cerium, tantalum and uranium, is a major source of uranium in the peralkaline albite arfedsonite granites (Ogedengbe, 1984). Moreover, uranium has been confirmed to occur in meta-autunite, apatite, coffinite and pitchblende minerals in the Nigerian granites (Funtua and Okujeni, 1996; Ogedengbe, 1984). The mineral investment implication of these findings is that the present status of uranium mineralization occurrences is grossly under-reported.

6. Conclusion and Recommendations

According to Obaje (2013a), many countries such as USA, Canada, Belgium, Syria, Israel, Taiwan, Egypt, Morocco, etc., have active process plants for the extraction of uranium from phosphates. Comparative geochemical analysis of trace elements of the Nigerian and Togo phosphates indicated that the Nigerian phosphates meet the minimum international benchmark for uranium extraction from phosphates and phosphogypsum (Obaje, 2013a). The Nigerian phosphate has been proven to have very high reactivity, thus making it very suitable as fertilizer material even for direct application to soils to improve soil fertility and higher crop productivity (van Straaten, 2002; Akinrinde and Obigbesan, 2006; Okosun, 1997). Mineral investment in the Nigerian phosphate and uranium deposits is very viable. Besides, there are enormous mining investment opportunities for interested investors in the Nigerian phosphate and uranium deposits to take advantage of because of the current economic reforms and investment incentives in Nigeria (Obaje, 2013b).

The following recommendations are given:

- Capacity building for local personnel to improve competence and for sustainable development of the resources.
- Detailed exploration should be carried out in target areas.
- Collation and centralization of database on the scattered data on phosphate and uranium occurrences in Nigeria.
- Develop new exploration strategies to cover new frontier areas.
- International and regional cooperation and partnership in development of the resources.

Acknowledgment

Prof. Siyan Malomo, FNMGS, former Director-General of the Nigerian Geological Survey Agency, is gratefully acknowledged for sending the first two authors to the IAEA/NMA training workshop in Cairo, Egypt in 2012.

References

Adediran, J. A. and Sobulo, R.A. (1998). Agronomic evaluation of phosphate fertilizers developed from Sokoto rock phosphate in Nigeria. *Communication in Soil Science and Plant Analysis* **29**, 2415-2428.

Adegoke, S.O., Ajayi, J.A., Rahman, M.A. and Nehikhare, J.I. (1991). Fertilizer raw material situation in Nigeria. *In*: Anonymous (ed.), Proceedings of the National Organic Fertilizers Seminar held at Kaduna, March 26-27, Federal Ministry of Agriculture, 51– 66.

Adekanmi. A. A, Ogunleye. P.O, Damagum, A.H. and Olaseheinde, O. (2007). Geochemical map of uranium distribution in the residual soil of GRN cell number N08 E05. Unpublished Report Nigerian Geological Survey Agency.

Adesanwo, O.O., Dunlevey, J.N., Adetunji, M.T., Adesanwo, J.K., Diattas, and Osiname, O.A. (2010). Geochemistry and mineralogy of Ogun phosphate rock. *African J. Environ. Sci. Techn.* ***4***(10), 698 – 708. Available at http//:www.academic journals.org/AJEST

Akinrinde, E.A. and Obigbesan, G.O. (2006). Benefits of phosphate rocks in crop production: Experience in benchmark tropical soil areas in Nigeria. *J. Biol. Sci.* **6**(6), 999 – 1004.

Arisekola. T. M, Yakubu, S., Nichodemus, A.U. (2007). Geochemical map of uranium distribution in residual soil and stream sediments of GRN cell number N06E04. Unpublished Report Nigerian Geological Survey Agency.

Etu-Efeotor, J.O. (1998). A review of the mineral resources of Sokoto basin, northwest Nigeria. *Journal of Mining and Geology,* **38**(2), 171 – 180.

Funtua, I.I. and Okujeni, C.D. (1996). Element distribution patterns in the uranium occurrence at Mika, Northeastern Nigeria. Chemie der Erde, Gustav Fischer Verlag Jena, 245 – 260.

Hanon, M. (1990). Notice explicative sur la carte geologique de L'Ader Doutchi. Ministere des Mines et de Recherches Geologique et Minieres, Niamey, Niger, 1 – 36.

Ixer. R.A, Bowden, P. and Kinnaird, J.A. (1983). Mineral studies of tin-zinc mineralization. Mineral Deposits Study Group University of Manchester, United Kingdom.

Jacobson. R.R.E. and Macleod, W.N. (1977). Geology of Liruei, Banke and adjacent Younger Granite Ring-Complexes. Geological Survey of Nigeria Bulletin **33**.

Kogbe, C.A. (1972). Geology of the Upper Cretaceous and Lower Tertiary sediments of the Nigerian sector of the Illummeden Basin (West Africa), *Geol. Rdsch.* **62**, 197 – 211.

Kogbe, C.A. (1976). Outline of the geology of the Illummeden Basin in North-Western Nigeria. *In*: Kogbe, C.A. (ed.), Geology of Nigeria. Elizabethan Publ. Co., Surulere (Lagos), Nigeria, 331– 343.

Magellan (1992). Nigeria Atlas: Maps and Online Resources. Available at www.infoplease.com/atlas/country/nigeria.html.

McClellan, G.H. and Notholt, A.J.G.. (1986). Phosphate deposits of sub-Sahara Africa. *In*: Mokwunye, A.U. and Vlek, P.L.G. (eds.), Management of nitrogen and phosphorus fertilizers in sub-Sahara Africa. Martinus Nijhoff, Dordretch, Netherland, 173 – 224.

Ministry of Solid minerals Development (2000). An inventory of solid minerals potentials of Nigeria. Prospectus for Investors, 1 – 15.

NIPC (2009). Rich deposits of phosphate rock found in Northern Nigeria. Nigerian Investment Promotion Council (NIPC) web publ., April 22, 2009. Available in www.tradeinvestnigeria.com/investment_opportunities/183759.htm

NUMCO (1983). The Nigerian Uranium Mining Company Annual Report.

Obaje, S.O. (2013a). Towards a win-win scenario in national energy and food security: The role of the

comprehensive extraction of uranium from phosphates. *Intl. J. Sci. & Engineering Inv.* **2**(7), 25 – 30.
Obaje, S.O. (2013b). Comparative geochemical Nigerian phosphates: An abridged Review. *Intl. J. Sci. & Engineering Inv.* **2**(8), 6 – 9.
Ogedengbe. O. (1984). A study of the geochemistry, mineralogy and ore genesis in the mineralized plutonic rocks of the Ririwai comlplex, Kano State, Nigeria. Unpublished M.Sc. Thesis, Univ. of Manchester, United Kingdom.
Ogunleye. P.O. and Okujeni C.D. (1993). The geology and geochemistry of Zona uranium occurrence, Upper Benue Trough, N.E. Nigeria. *Journal of Mining and Geology* **29**(2), 175–182.
Ogunleye, P.O., Mayaki, M.C. and Amapu, I.Y. (2002). Radioactivity and heavy metal composition of Nigerian phosphate rocks: possible environment implications. *J. Environ. Radioactivity* **62**, 39 – 48.
Ojo, O.D. (2003). Growth, development and yield of amaranth (*Amaranthus cruentus* L.) varieties in response to different sources of phosphorus. Unpublished Ph.D. Dissertation, University of Ibadan, Nigeria, 1 – 300.
Okosun, E.A. (1989). A review of stratigraphy of Dange Formation (Paleocene) Northwestern Nigeria, Nigeria. *Newsletter on Stratigraphy* **21**(1), 39 – 47.
Okosun, E.A. (1997). The potential application of Sokoto phosphate for the manufacture of fertilizer. *Journal of Agricultural Technology* **5**(2), 59 – 64.
Okosun, E.A. and Alkali, Y.B. (2013). The geochemistry, origin and reserve evaluation of Sokoto phosphate deposit, North-western Nigeria. *Earth Science Research* **2**(2), 111 – 121.
Romberger. S. B. (2007). Geochemical factors important in developing genetic models for hydrothermal uranium deposits. *In*: Andrew, C.J. (ed.), Proceedings of the ninths biennial SGA Meeting, Dublin, **2**, 1104 – 1110.
Russ, W. (1924). The phosphate deposits of Abeokuta Province. *Geol. Surv. Nigeria, Bull.* **7**, 1 – 43.
Sobulo, R.A. (1994). Final report on agro-mineral project. Raw Materials Research and Development Council and National Fertilizer Company of Nigeria, Port Harcourt, Nigeria.
Tian, G. and Kolawole, G.O. (1999). Comparison of various plant residues as phosphate rock amendment on Savannah soils of West Africa, **27**, 571 – 583.
van Straaten, P. (2002). Rocks for crops: Agro-minerals of sub-Saharan Africa. ICRAF, Nairobi, Kenya, 19, 238 – 240.
Wikipedia (2012). Nigeria. Available at https://en.wikipedia.org/wiki/Nigeria.
Wright, J.B., Hastings, D.A., Jones, W.B. and Williams, H.R. (1985). Geology and mineral resources of West Africa. Allen and Unwin, London, UK, 1 – 187.