INTERNATIONAL JOURNAL OF NATURAL AND APPLIED SCIENCES (IJNAS), VOL. 12, Special Edition (2019); P. 93– 98, 2 FIGS.

The metallic mineral deposits of Oban-Obudu Massif Southeastern Nigeria – a review

B. N. Ekwueme

ABSTRACT

Mineral deposits including metallic and non-metallic types occur in the Precambrian basement rocks of the Oban-Obudu area of southeastern Nigeria. This paper reviews the occurrence of metallic minerals in the area. These minerals include Iron and ferroalloy metals: manganese and ilmenite; non-ferrous and minor metals and related mineral deposits: tin, columbite and tantalite (Sn-Ta-Nb), monazite and precious metal: gold. These minerals are hosted in the metamorphosed basement rocks and intrusive pegmatites. The ages of these host rocks have been determined and correlated with the metallic mineral occurrences, hence defining the metallogeny of the Oban-Obudu area.

INTRODUCTION

A mineral is a naturally occurring inorganic crystalline solid material with its own characteristic, definite chemical composition and a set of distinguishable physical properties. Minerals can be classified as metallic and non-metallic. Metals are elements which can be ionized by electron loss whereas non-metals ionize by electron gain. Gribble (1988) listed the following as the common cations in minerals: Si^{4+} , Al^{3+}, Fe^{2+}, Fe^{3+}, Mg^{2+}, Ca^{2+}, K^{+}, and Na^{+}. O^{2-}, F^{-}, and Cl^{-} are common anions. The commonest minerals on earth are the rock-forming minerals. In these minerals, oxygen and silicon which are the most abundant elements in the earth's crust combine with metals to form silica tetrahedra hence silicates. These combinations are brought about by atomic bonding which are electrical forces which exist between the cations and anions. These are ionic and metallic bonding.

The process of metal-forming is known as metallogenetic which implies "mineralizing" especially ore deposits (Whitten and Brooks 1972). It is used in two phrases: metallogenetic epochs and metallogenic provinces.

Metallogenitic epochs are definite periods during which mineral deposits were formed. Metallogenic provinces are regions in which a series of mineral deposits possess common characteristics (Bateman 1950).

Attempts have been made to map metallogenic provinces in Nigeria (Orajaka, 1971, 1972, 1973, Woakes, et al., 1987). Basement metallogeny has been reported for Northwest Nigeria (Woakes, 1988).

For long it was thought that rocks in the southeastern part of Nigeria are barren of mineral deposits and that the lithologies and geologic conditions are not suitable for the formation of mineral deposits. In this contribution it is shown that economic mineral deposits occur in the Oban-Obudu region of southeastern Nigeria and the occurrence of these metallic mineral deposits have been correlated with geologic events, hence could be a metallogenic province.

GEOLOGICAL SETTING

Two basement spurs occur in southeastern Nigeria: the Oban Hills and the Obudu Plateau. These giant spurs form the western prolongation of the Cameroon Mountains into the Cross River Plains of southeastern Nigeria (Fig. 1). They are basement horsts which are separated like the Cameroon Mountain by sediment – filled graben or rift namely the Benue Through and the Cameroon volcanic Line (Fitton 1987, Ekwueme 2003). The Calabar Flank is a Cretaceous – Tertiary sedimentary terrain which overlies the Oban massif in the south. It is separated from the Ituk High by the Ikang Trough. To the north, the Oban massif is separated from the Obudu Plateau by the Mamfe Rift (Embayment). The Hawal massif is separated from the Obudu Plateau by the Yola Rift.

Corresponding author**.** Email: **bachudo@yahoo.com**
Department of Geology, University of Calabar, Calabar, Nigeria

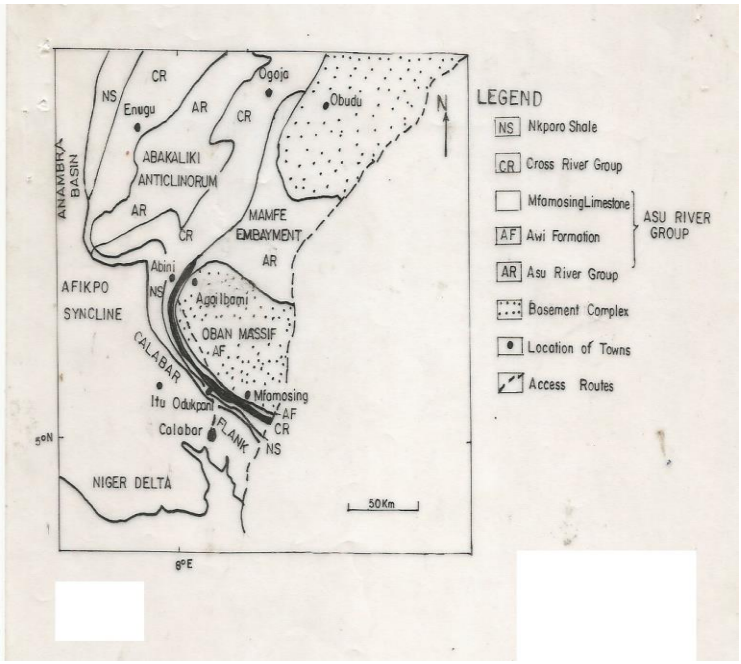

Fig. 1. Geological sketch map of Southeastern Nigeria showing the Oban-Obudu Massif and adjoining geological terrains.

The basement rocks of the Oban-Obudu massif have been described in detail in Ekwueme (2003). Ekwueme and Okoro (2019) have described in detail both the basement and sedimentary rocks in the Oban massif, Calabar Flank and Mamfe Embayment (see also Ekwueme, 2005)

The Precambrian basement rocks include the migmatite gneiss-complex, the schist belts and the older Granites. These rocks range in age from Archaean to Neoproterozoic. They are similar to those occurring in other parts of the Nigerian Basement complex and are comparable to the rocks of the Cameroon basement.

The sedimentary rocks include shales sandstones, limestones, mudstones, etc. ranging in age from Aptian-Albian (Cretaceous) to Tertiary sediments of the Benin-formation. All the lithologic types of the Nigerian sedimentary Basin occur in the sedimentary rocks overlying the Oban-Obudu Precambrian basement rocks. (Fig. 2 and 3).

OCCURRENCE OF METALLIC MINERAL DEPOSITS

Metallic mineral deposits in the Oban-Obudu area include:

(1) Iron and Ferroalloy Metals:

High-grade metamorphic rocks including schists, gneisses and amphibolites occur in the Oban-Obudu area (Figs. 2 and 3). These rocks contain ferroalloy metals such as manganese and ilmenite. Manganese ores occur in the banded gneisses in the Oban area. They are important raw material in Iron and steel metallurgy where it is used in form of ferro-manganese ore to improve strength, toughness, hardness and workability of steel and acts as deoxidizer and desulphorised. Abhulimen et al. (2006, 2007 and 2009) carried out a detailed mapping of areas of manganese occurrences in the Oban massif. They produced a geologic map of Oban massif showing the location of manganese ore (Ekwueme and Okoro 2019). Significant occurrences were reported in Oban town, Neghe, Okarara, Mankor, Ibe Quarters and Valentine Effiom farm. They occur in veins trending NE-SW which is also the trend of the host rock banded gneiss. The age of the host rock is 1932±2Ma which falls within the Eburnean orogeny of West Africa (Ekwueme and Kroner 1998).

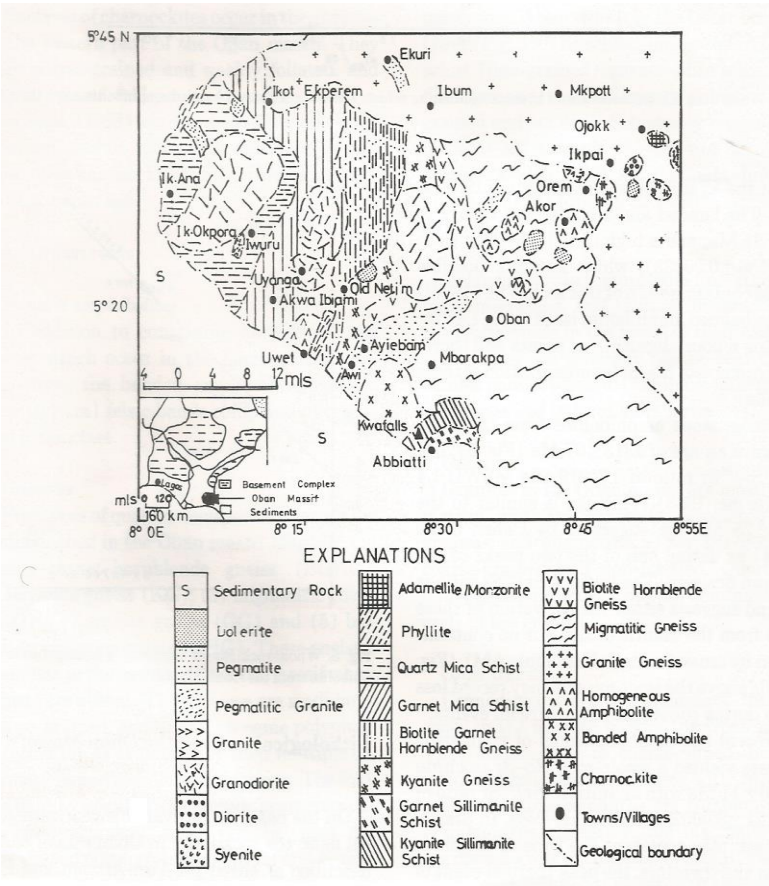

Fig. 2. Generalized geological map of Oban Massif, southeastern Nigeria.

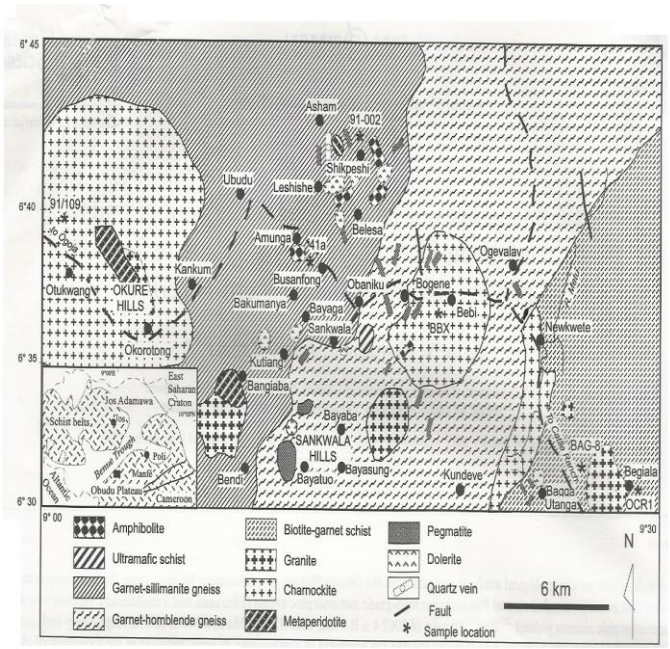

Fig. 3. Simplified geological map of the Obudu area, southeastern Nigeria,

Amphibolites are interlayered with the banded gneisses in the eastern Oban massif. They are homogeneous amphibolites which occur as scattered rounded massive outcrops enclosed within the migmatitic gneisses near Akor and New Ndebiji. Ekwueme (1995) analyzed these amphibolites and found they are enriched in TiO_2 upto 4.33%.

The Obudu Plateau is a high-grade metamorphic terrain. High grade gneisses, amphibolites and granulites occur in the area (Ekwueme 2003). Pegmatites are associated in some places with these rocks. In the Bayasung-Bayatuo area of Obudu Plateau there are large exposures of altered pegmatites and these rocks contain layers and slags of an iron mineral which upon analysis was found to be pure ilmenite.

(2) Non-Ferrous and Minor Metals and related Minerals

Pegmatites are abundant in the Precambrian basement of Oban-Obudu area. Jacobson and Webb(1946) recognized two tin fields in Nigeria namely the older tin field pegmatites of Pan African age (750-450Ma old) the younger tin fields associated with the younger Granites of Jurassic age (176Ma old).Sn-Ta-Nb productive p=egmatites in Nigeria were believed to be confined to a distinct belt which extends in a NE-SW direction for about 400km and finally passes into the more productive Jos tin fields associated with the younger Granites (Matheis, 1987). The age of these pegmatites in SW Nigeria is 530-580Ma (Matheis and Caen-Vachette 1983).

Raeburn (1927) did not find the pegmatites of southeast Nigeria as productive as those of southwest and northcentral Nigeria and considered the pegmatites of no economic value. Ekwueme and Schlag (1989), Ekwueme and Matheis (1995), Ekwueme (2003) and Ero and Ekwueme (2009), mapped more pegmatites in southeast Nigeria basement and found that they have similar petrographic and geochemical features as those of southwest and northcentral Nigeria. They are predominantly of the muscovite-tourmaline bearing type. Few samples of Obudu pegmatites and most samples of Oban pegmatites analyzed have Na/K ratios greater than one, pointing to a high degree of albitization of these pegmatites. Jacobson and Webb (1946) emphasized the association of tin mineralization with intense albitization in the older tin fields of Nigeria, which is consistent with the occurrences of cassiterite and columbite in the highly albitized pegmatites of Oban massif (Raeburn 1927, Ekwueme and Schlag 1989, Ero and Ekwueme 2009). Ero and Ekwueme (2009) found that pegmatites in Iwuru 1 and Iwuru 2 have high albitization indices of 2.45 and 1.33 respectively and hence have high concentration of tin. These pegmatites belong to Li-Be type which is characterized by elements such as Li, Rb, Cs, Be and Sn (Cerny 1989). The pagmatites of Akwa Ibiami and Igbofia belong to tin-bearing pegmatites. Iwuru 2 has the highest Nb/Ta ratio (4.9) and is the least fractionated. it is rich in columbite-tantalite minerals. The pegmatites in Obudu area are not enriched in rare-metal mineralization as those in Western Oban massif (Edem et al. 2015).

The rocks cut by the pegmatites in Oban massif have been dated radiometrically. Ekwueme and Kroner (1995) obtained a Pb/Pb zircon evaporation age of 616.9±1.0Ma from the Igbofia granodiorite which encloses muscovite-tourmaline bearing rare-metal pegmatites of Akwa Ibiami in western Oban massif. Hence the pegmatites were emplaced during the Pan African orogeny.

(3) Monazite

This rare-earth bearing phosphate possesses a radioactivity that can be used for locating and sampling of accumulated minerals. The composition of monazite also sheds some light on the genesis of source rock hence, it can be used to detect the source rock and estimate the ore-bearing potential of the source area. Raeburn

(1927) analyzed a single monazite from the Netim-Ibum triangle and from the result concluded that the host rock pegmatites contain tin, columbite etc. Ekwueme and Schlag (1989) analyzed many more monazites from granites , pegmatites and stream sediments in the Oban-Obudu area. They recognized two major groups of monazites: pure pegmatitic monazite and pegmatites with monazites showing high pneumatolytic affinity. Monazites showing pneumatolytic affinity which were found in abandoned tin mines in Akwa Ibiami and in pegmatites in Iwuru have the highest potential to accumulate light and easily mobilizable elements such as Li, Sn, Nb, Ta, Cs and associated minerals as tourmaline, topaz rare-earth bearing minerals. This was confirmed by Ero and Ekwueme (2009).

The precious metals

Gold is among the metallic minerals which early explorers of the geology of the Oban massif reported its occurrence in the area (Raeburn, 1927). However, there has not been a detailed exploration of gold in the Oban-Obudu massif compared to detailed exploration of gold in southwest and northwest Nigeria (Woakes et al., 1987, 1988). Gold has been explored for in detail and mined in the schist belts of southwest and northwest Nigeria. The schist belts also described as metavolcanosedimentary series are low-grade metamorphosed rocks which constitute the supracrustal cover on the migmatite gneiss quartzite complex of the Nigerian Basement Complex (Rahaman, 1976). These schist belts which are comparable to the greenstone belts (Kleman et al. 1988; Attoh and Ekwueme 1997) were thought to be non-existent in the eastern part of Nigeria (Oyawoye 1972). Greenstone belts are the principal host rocks for gold mineralization all over the world (De wit and Ashworth 1997). They are dominantly Archaean in age.

Ekwueme (1985, 2003) reported extensive occurrences of low-grade schists in Oban-Obudu massif and these rocks are extension of the Poli schists of Cameroon (Toteu et al., 1986). The Obudu schists have been dated and they yield Pb/Pb evaporation ages of 1788.8±2.1Ma and 2504.5±0.5Ma which fall into Eburnean and Liberian orogeny (Archaean) (Ekwueme and Kroner 1997; Ekwueme, 2003). The schists in Oban massif yield Rb-Sr and K-Ar ages of 527±16Ma and 519±10Ma respectively (Ekwueme, 2003) and are Pan-African in age. This shows that just as in southwest (e.g. Ilesha schist belt) and in the northwest Nigeria (e.g. Anka schist, Zamfara) are suitable host rocks for gold those schists in Oban-Obudu area are also suitable host for gold and call for exploration and exploitation. Garba (2000) pointed out that early Birrimian rocks (ca. 2000Ma) in West Africa and Archaean greenstone belts (2500Ma) in East and Southern Africa, Australia and Canada have very high potentials for discovery of large gold deposits. Garba (1992) observed that gold mineralization has no preferential host rock but is rather more due to favourable, physical, chemical and rheological properties of the rocks situated along gold mineralizing fluid pathways. In another paper, Garba (2001) suggested that it is likely that areas which have rare-metal bearing pegmatites may also contain gold deposits. He noted that the Sn-Ta-Nb mineralization in the Pan-African terrain of Nigeria is late-tectonic (Ca. 500Ma) like gold mineralization (550±100Ma) in the supracrustal schist belts of western half of Nigeria. This has been corroborated by Dada, et al. (2001) in Isanlu-Egbe area of SW Nigeria where gold, tantalite and associated minerals occur. This is also the situation in the Oban massif where gold is associated with Sn-Ta-Nb mineralization and there is evidence of gold deposit in the homogeneous amphibolites interlayed with banded gneisses in Akor and New Ndebiji areas of eastern Oban massif.

DISCUSSION

The search for mineral deposits in the Oban-Obudu area started in the early 19th century. Messrs Parkinson and Huddart of Mineral survey of Nigeria in 1904 and 1905 after exploration traverse of the Oban district reported the occurrence of gold, tin, and monazite. Raeburn (1927) reported that tinstones, gemstones and gold showed commercial prospects in Akwa Ibiami in the Calabar district. He also reported the occurrence of limestone deposits of Calabar and Ogoja provinces. Akwa Ibiami was famous as a colonial mining camp due to the mining activities by the then Nigeria Proprietory company limited of Great Britain though production ceased during the second world war. Even though further studies in the 1900's and 2000's unraveled the geology of the Oban Obudu area (Ekwueme 2003 and references therein) the metallogeny of the area remained in doubt. It was believed for instance that there were no schists in this area and that the schist belts of Nigeria containing gold deposits were localized in the southwest and northwest part of the country and did not extend beyond longitude 8^{O}00'E. Workers in the Oban-Obudu area e.g. Orajaka (1972, 1973) had lamented the absence of mineral deposits found in a similar terrain in

Canada. Some attributed the non-occurrence to the high-grade metamorphism which could have expelled
ore-forming fluids thereby rendering the area barren of economic mineral deposits.

Recent researches have however shown that gold, manganese, ilmenite, tin, tantalite and columbite occur in the Oban-Obudu area. The host rocks have been dated radiometically and the mineral deposition is linked to the Liberian, Eburnean and Pan-African events that affected the Oban-Obudu area.

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