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NIGERIA'S POTENTIAL FOR THE PRODUCTION OF THE NEW METALS AND MINERALS

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NIGERIA'S POTENTIAL FOR THE PRODUCTION OF THE NEW METALS AND MINERALS*

PART I - Introduction

Nigeria has been a very important producer of columbite and has recorded small annual outputs of tantalite from certain of its mineral-bearing areas. We therefore welcome the opportunity of participating in this Seminar and of presenting in this Paper facts and data about both these minerals in particular, and about a number of others associated with them as accessory mineral constituents of the younger granites and pegmatites of our country.

The production and marketing of these minerals have provided us with experience of the behaviour of the world metal market. We have shared the good fortunes conferred by high prices and universal demand. We also know from experience what a blow it can be to our economy when these favourable conditions give way to a complete loss of market and precipitous fall in the price being offered for the small amounts that can be sold.

This paper is written from personal knowledge of the Nigerian mining industry; and in writing it, I have drawn considerably on the scientific work done by various officers of our Geological Survey Department whose publications I have acknowledged both in the body of this paper and in the Bibliography. It is hoped that we will profit immensely from learning about the experiences of other nations here represented, and that the Conference will not rise without discussing positive measures by which the resources of participating countries could be speedily brought into production to the advantage of all.

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PART II - Potential Sources

The most important mineral produced in Nigeria is tin. Tin does not fall within the same classification of minerals being discussed in this paper, but the mining of tin has resulted in the recovery of a variety of by-products among which are columbite, tantalite, monazite and zircon which are all relevant to this seminar. One of the most important potential sources of new metals and minerals in Nigeria is therefore the younger granite complexes of Nigeria from which Nigerian tin is produced. Primary mineralisation occurs in greisen veins which are most abundant near the margins of certain of the biotite-granite intrusions. Columbite occurs as an accessory mineral especially in some of the finer-grained albitic biotite-granites in which some zones show very high columbite values (sometimes as high as 2 lbs per ton). Several deposits of this type exist and where decomposed have been worked. In addition to columbite, other accessory minerals such as monazite, hafnium-rich zircon, xenotime and thorite have been extracted as by-products. Usually, only a small proportion of these minerals is coarser than 30 mesh IMM, the greater portion lying in the size range 60-200 mesh. The high proportion of the fine-grained fractions presents one of the major problems of recovery. A typical screen analysis of the columbite from one of the younger granite phases (the Rayfield - Gona phase) as given by Dr. W. N. MacLeod[1] is shown below:

TABLE I

Mesh IMM	% by weight
+ 30	1
- 30 + 60	12
- 60 + 100	24
- 100 + 200	32
- 200	32

In the Odegi area, where columbite was being produced at the rate of about 750 tons per annum, Mr. M. P. Jones[2] a Senior Geologist carried out tests on extraction of columbite from decomposed younger granite. He gave as the bulk composition of this ore the following figures:

TABLE 2

Mineral	% by weight
Quartz	45
Clay minerals (with minor amounts of felspar)	45
Mica	4
Zircon	1
Iron oxide and laterite nodules	0.5
Columbite	0.25
Cassiterite	0.08
Thorite	0.06

His analysis showed that the mica contained appreciable amounts of Lithium and that the zircon contains 5% hafnium. The above tests showed a definite relationship between the ore-reserve and the amounts of component minerals that may be found there.

Another important source of new metals and minerals are the pegmatites. These are widely distributed throughout the Pre-cambrian complex in Nigeria; and cassiterite and columbite-tantalite have been recovered from pegmatite dykes in the following Provinces: Plateau, Benue, Niger, Zaria, Kano, Kabba, Ilorin, Ondo, Oyo and Calabar. The most important known economic deposits are however confined to a broad belt of country extending from the Wamba-Jemaa region in Plateau Province to the Egbe area in Kabba Province. The above stated facts and greater details are contained in my country's Geological Survey Bulletin No.17[3]. The new metals and minerals

associated with the Nigerian pegmatites are Columbite, Tantalite, Zircon, Monazite, Beryl, Chrysoberyl and other varieties of Niobium and Tantalum minerals.

A number of pegmatite dykes are mined for cassiterite with columbite and tantalite as by-products. Among these are those in the Wamba-Jemaa tinfields, Tarkwashara in Niger Province, and Egbe. Traces of cassiterite and columbite-tantalite are widely distributed in Ilorin Province. Workable pegmatite dykes for these minerals have been located in Ipoti, Ikoro and Ilesha in the Western State; and in the Oban hills of Calabar. Although beryl is one of the most common minor constituents of the pegmatites, no economic deposit of this mineral has been found. In the Egbe area a small deposit was found and an experimental shipment of 20 tons made. It is known that this deposit contains a lot of impurities and is therefore unsuitable for industrial application.

The next source of new metals and minerals is the vast pyrochlore deposit in the Kaffo valley, near Liruien-Kano. This potential source of low grade niobium and uranium minerals has an estimated 365,000 tons columbite content. The investigation of this deposit shows that the pyrochlore contains 3.3% uranium oxide, 3.3% thorium oxide and 41.1% niobium and tantalum oxides. Around 1960, plants were designed and put into commission in Brazil and Canada for the extraction of pyrochlore from granite. The dominant positions of both these countries as world suppliers of ferro-columbium provide eloquent testimony of the success of the process. This success represents a major break-through in extraction metallurgy since in pioneering the separation of pyrochlore from granite it has opened to Africa the possibility of future development of their vast pyrochlore resources. The significance of this is that research into new uses of wider applications of niobium in industry could now proceed without any reservations as to limitation in future supplies.

The last potential source of niobium and tantalum is the waste residue from the smelting of cassiterite known as slags. These slags contain appreciable amounts of combined pentoxide of niobium and tantalum and

when analysed under spectrograph gave an indication as to the presence of rare earths in the tinfields of Nigeria. An analysis of a slag smaple[4] carried out on my behalf in 1962 gave the following result:

TABLE 2(A)

	Per cent
TiO_2	6.3
Nb_2O_5	16.6
Ta_2O_5	11.1
MgO	0.76
CaO	20.15
$^+Fe_2O_3$	6.69
MnO	0.30
Al_2O_3	19.06
^+Sn	1.13
ThO_2 + Rare Earths .	1.85

$^+$Total iron as Fe_2O_3; total tin as Sn.

The tantalum oxide value was regarded as approximate only. These slags normally carry Niobium and Tantalum pentoxide values of between 18 and 22%. The most interesting aspect of the analysis was the reported presence in traces of Lanthanum (La), Ytterbium (Yb), Yttrium (Y), Lithium (Li) and Strontium (Sr). This was found when the sample was subjected to qualitative spectrographic analysis. Later, the thorium and rare earth fractions of the sample were examined under the spectrograph and the presence of all these metals was confirmed. In addition it was also found that the sample contained Gadolinium (Gd) and Europium (Eu).

PART III - Difficulties in Perspective

Having indicated broadly that the younger granite complexes have in store, particularly in primary mineralisation, an appreciable amount of columbite, monazite, hafnium-rich zircon and thorite; that the pegmatites

of Central Nigeria abound in columbite, tantalite and zircon; that the pyrochlores of the Kaffo valley are a potential source of niobium, tantalum, uranium and thorium; and that the tin slags are a further secondary source of these minerals, one would ask why Nigeria has failed to embark on large-scale production of these minerals. In order that the difficulties may be seen in proper perspective, I will attempt to present the position regarding Nigeria's production of each mineral and to identify the problem in each separate case.

Tantalite: During World War II, there was co-operation between Nigeria and the United States aimed at securing the production of this mineral. The pegmatites in the various areas already mentioned were prospected and simple devices for the gravity separation of the mineral were introduced and taught to local miners who were participating in the search, largely as their contribution to the war effort. Although tantalite was found and produced it was never in large quantities and few operators persisted in their search for this mineral after the war. Tables 3(a) and 3(b) give the figures of tantalite production for a total of twelve fiscal years beginning 1954/55.

TABLE 3(a) - TANTALITE
PRODUCTION IN LONG TONS

Provinces	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60
Benue	0.55	3.82	0.2	2.1	0.3	1.0
Kabba	0.84	9.50	2.7	4.0	4.8	2.2
Niger	1.54	2.16	1.9	3.3	3.7	1.7
Oyo	-	-	-	0.2	0.5	-
Plateau	6.00	5.53	5.7	5.2	6.7	2.6
Zaria	-	-	-	3.5	5.6	3.9
TOTALS	8.93	21.01	10.5	18.3	21.6	11.4

TABLE 3(b) - TANTALITE
PRODUCTION IN LONG TONS

Provinces	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66
Benue	2.5	5.2	4.4	5.1	3.0	3.4
Kabba	1.1	0.5	1.3	1.6	1.4	0.9
Niger	2.0	3.1	4.7	2.4	0.1	3.8
Oyo	2.0	-	-	-	-	0.5
Plateau	1.4	1.4	1.7	1.1	3.8	-
Zaria	3.1	1.4	5.2	5.6	2.9	5.0
TOTALS	12.1	11.6	17.3	15.8	11.2	13.6

Today's production of tantalite is mainly recovered as by-product in the dressing of cassiterite mined from pegmatitic sources. Since tin smelters were established in Nigeria, it has been found that tin slags could be sold for their columbite/tantalite content. There is no difficulty with the sale of tantalite and all Nigeria's production is disposed of.

Columbite: Nigeria is still an important producer of columbite and was for a long time the world's main supplier of this commodity. With the development of plants for the separation of pyrochlore from granite, Nigerian columbite ceased to be the only important source of niobium for the production of ferro-colubium. This development, I had personally hoped would establish ferro-columbium as an alloy with a future, and columbite as a commodity that would always find a market. After the completion of the United States strategic stockpile programme, in 1956 Nigeria lost her only customer and the future appeared bleak for columbite because many producers of steel and ferro-alloys did not see much sense in investing in expanding the use of a commodity the bulk of which came from one country only and in respect of which substantial reserves had not been proved. When the extraction problems associated with pyrochlore were overcome, the extensive reserves of Nb_2O_5 content of pyrochlores in Uganda, Tanzania, Kenya, Rhodesia and

Malawi (to name the African states first) and in Brazil and Canada, wiped out any remaining prejudice against expanding the application of this metal. Nigeria's production of columbite declined after 1956 and exports were even less than the indicated production since one or two of the more important producers stockpiled the columbite that they had produced but could not sell. Tables 4(a) and 4(b) below show Nigeria's columbite production for twelve years from 1954/55. It will be observed that with the slump in the columbite market resulting from the termination of the United States stockpile programme, Nigeria's columbite production for 1958/59 was only 846 tons. Following the production of niobium from Brazil and Canada the demand for Nigerian columbite built up gradually and the price improved. In 1965 the United States consumers of columbite demanded from their Government the release of columbite from stocks surplus to strategic requirements because supply from Nigeria was not adequate to their needs. Nigerian producers were subsequently urged to expand production. This high level of demand was unfortunately short-lived as 1967 witnessed the sudden disappearance of any demand of Nigerian columbite. It is known that world demand for ferro-columbium has risen and that the probable explanation of the present total loss of Nigeria's columbite market is the fact that in Brazil and in Canada the producers of niobium have now acquired converters and are marketing ferro-columbium themselves. There are indications too, that slags resulting from the smelting of tantalite and containing abundant niobium are now being made available at extremely favourable prices to American consumers of columbium.

TABLE 4(a) - COLUMBITE PRODUCTION - LONG TONS

Provinces	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60
Bauchi	548	464	314	214	48	95
Benue	393	215	347	272	67	337
Kabba	9	19	3	-	1	-
Kano	240	237	210	171	48	118
Plateau	1,930	1,723	1,507	1,041	668	1,140
Zaria	29	24	13	10	14	11
Others	3	7	3	1	-	-
TOTALS	3,152	2,689	2,397	1,709	846	1,701

TABLE 4(b) - COLUMBITE
PRODUCTION - LONG TONS

Province	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66
Bauchi	148	91	101	80	100	131.9
Benue	380	303	385	380	596	599.8
Kabba	-	-	-	-	-	-
Kano	105	92	98	95	87	100.9
Plateau	1,554	1,916	1,590	1,372	1,654	1,731.9
Zaria	12	12	11	13	10	13.9
Others	2	2	-	1	1	1.2
TOTALS	2,201	2,416	2,185	1,941	2,448	2,579.6

In 1958, the Nigerian Government conceived the idea of forming an International Research and Development Institute for the purpose of stimulating the demand for columbite. Although certain alloy manufacturers had done considerable work on alloys with columbium, such work was usually kept a trade secret and there had always been a fear in the minds of alloy makers that expensive research may be wasted since supply of columbium appeared to be limited. Therefore the Government proposed that a Research and Development Institute would be required to publicise the vast reserves of columbite in Nigeria and in other countries which may be associated with her in establishing the Institute. The idea of the Nigerian Government was that the Institute should operate much along the same lines as the International Tin Research Council and be empowered to carry out original research as well as collating and disseminating the research work of others. The Government expressed willingness to support the Institute to the tune of £50,000 spread over a period of five years if other columbite producing countries agreed to subscribe not less than £15,000 in the same period. In addition to Government's contribution of £50,000 the columbite producers of Nigeria were prevailed upon to accept a production cess of £1 per ton on columbite exported, in order to provide additional support for the Institute. In

London an interim Columbium Development Council was set up under the sponsorship of Nigeria, and interested parties were invited to take part in it. Those invited included companies such as Union Carbide Development Company, A/S Norak Bergverk, the Uganda Development Corporation, Geomines and the Billiton Company together with representatives of the Colonial Development Corporation and the Department of Scientific and Industrial Research of Great Britain. Largely through the failure of firms and other countries to commit themselves to regular financial contributions to the Institute, the proposal was finally abandoned in 1962.

It is needless to say that the type of situation with which the Nigerian columbite industry is faced is not conducive to its growth. No industry exposed to the vicissitude of violent change of this nature can thrive. It may very well be that the industry has not moved with advancing technology and that the product which we have always offered and still offer is not in the form in which our customers can most profitably utilise it.

Zircon: In Odegi, it has been indicated that for every ton of columbite extracted from ore, four tons of zircon are rejected with the tailings. This zircon is known to be rich in hafnium. Mr. M. P. Jones[2] stated that the hafnium content is 5%. This Nigerian zircon is recognised particularly in America where it commands premium price. The demand was however sporadic varying widely from year to year as can be seen from table 5 below:

TABLE 5 - ZIROCN EXPORTS - LONG TONS

Provinces	1958/59	1959/60	1960/61	19[illegible]/62	1962/63	1963/64	1964/65	1965/66
Benue	45	1,575	1,681	415	-	795	66	400
Plateau	-	-	-	-	-	109	-	-
TOTALS	45	1,575	1,681	415	-	904	66	400

The main exporter of zircon sands from Nigeria is Tin and Associated Minerals and the product is marketed through their associated company - Kennecott Sales Corporation of New York. Typical analysis for this mineral as supplied by the Company is given in Table 6 below:

TABLE 6

NIGERIAN ZIRCON SANDS: TYPICAL ANALYSIS

	%
ZrO_2	53.70
HfO_2	3.20
Cb_2O_5	1.17
Ta_2O_5	0.34
SnO_2	0.57
ThO_2	3.10
TiO_2	0.26
U_3O_8	0.26
SiO_2	28.80
Rare Earth Oxides	1.26
FeO	4.77
Al_2O_3	1.40

It is confirmed that the rare earth oxides associated with this zircon include yttrium about 50%, and europium - less than 2%. Recently the sole exporting comapny had indicated that a plan was in the offing to produce from their vast stockpile of zircon a new product which they propose to export as enriched xenotime. This product was expected to be directed towards supplying some users of yttrium in the United States. This plan has been abandoned owing to the sudden curtailment of operations by the company which resulted from the present lack of a market for columbite.

Thorite and Monazite: Nigeria's production of thorite and monazite is not much. Between 1955 and 1958, Nigeria exported 1,923.5 tons of thorite and nothing more since then. From 1960 to date, we have been exporting monazite at the average rate of 9 tons per annum. In the five years immediately preceding this period, a production of 239 tons of this material was recorded.

Quite recently a certain Professor H. I. Sharma, Professor of Zoology, University of Nigeria, Nsukka, called attention to the presence of high level gamma radio-activity in the area of Nsukka. Later his counterpart of the Physics Department of the same University, a Professor A. V. Brancker, prepared a report in which he stated that in the course of research on the physics of powders he detected the presence of rare earths in pulverised rocks of local origin. He claimed that upon further investigation he confirmed that certain types of local sands were comparable in all chemical/physical respects to the monazite sands obtained from Northern Nigeria. He claimed that these sands were wide-spread in the region of Nsukka and that he had found them in local quarries, in the beds of rivers deep in the bush, and even in villages where they were being used as building material. These reports have still to be confirmed by the Geological Survey of Nigeria when further work on the area is undertaken.

Seen in perspective, the problems of developing our resources of new metals and minerals, arise out of the following considerations:

(i) lack of domestic capital to undertake development of these resources;

(ii) established foreign mining interests in Nigeria having tended to continue to serve a vastly changing world market with their products marketed in the traditional way;

(iii) international mining finance having shown little interest in Nigeria.

In common with other developing countries, Nigeria has really not got down to considering the proper role of the metals industry in the growth and development of a nation and the urgent need to set up the necessary Governmental machinery for promoting it.

PART IV - Towards Understanding and Co-operation

It is widely known and accepted that the emergent nations of Africa have potential resources of mineral wealth which should be developed to meet the world's increasing requirement of metals and minerals. It is also appreciated that the development of these resources can be most effectively and efficiently prosecuted if the vast financial resources and skills of the advanced countries can be deployed in these new nations. What stands in the way of this is the mutual fear and distrust with which overseas financial interests on the one hand and governments of the new nations on the other, regard each other. The overseas financiers fear risking capital in ventures which may subsequently be appropriated without payment of adequate compensation whereas in the new countries there is often a deep suspicion of foreign capital as possible agency for economic exploitation. The differences of viewes between the two could and should be reconciled in the mutual interest of both, and for the overall benefit of the world. Many countries now appreciate the role of free enterprise in the generation of wealth and the sharing of prosperity and have sufficient experience of measures by which checks and balances could be applied which would ensure sufficient profits for enterprise and at the same time safeguard workers from exploitation. The 1963 United Nations Conference on the Application of Science and Technology for the benefit of less developed areas made a number of recommendations touching upon this subject. The report listed four requirements of a developing country desiring to attract overseas mining investment. The first is the creation of a national mining service - a centralised establishment for the storage and processing of mining and geological information which would provide the framework of knowledge upon which investment decision may be based. The second is a well equipped, well staffed geological survey which would produce base maps of the more promising mineral areas and proceed with the development of field geology using the most recent specialised techniques. The third is that the Government should decide whether the mineral resources shall be developed by private enterprise or by the state. The fourth is that mining legislation should be sound, ensuring the employment, training,

safety and welfare of local employees and at the same time providing incentive subsidies, reliefs and protection. These ideal requirements will take some countries longer than others to meet. In Nigeria, we had anticipated that given another ten years under conditions of relative political stability we will have established a mining service worthy of the name in every respect, and would have brought our mining law in line with those of Canada and Ireland. The present crisis in Nigeria will have to be resolved before another time estimate can be made for the attainment of these objectives. It is my view that we need not however wait another twenty or more years to begin to think of developing these minerals resources. Like other developing countries we are anxious to reach understanding with capital exporting governments on a number of arrangements by which the safety of mining investment would be guaranteed. The Nigerian Government has stated on several occasions in Parliament and in the public utterances of the responsible Minister that the country was committed to a free enterprise economy and that the Government would not nationalise the mining industry. Our mining law is flexible and thus enables us to negotiate favourable terms according to the merit of investment proposal. We also enjoy a high reputation for abiding by contracts entered into by ourselves and for honouring those entered into on our behalf.

Up till the end of 1965, in spite of the impressive record of stability that we had and the moderation and sound judgement shown by the Nigerian Government in national and international matters, there was no firm commitment on the part of international mining interests to invest in the development of mineral resources in Nigeria. This may have been due to certain economic and political considerations which had no bearing on the stability of our government or the fears of unfair appropriation of assets. The first is that a number of overseas mining interests regard Nigeria as falling within that group of African States in which only British capital would be welcome. Some even fear that if they ventured to establish, they would eventually be pushed out by British influence. Another is that some mining companies operating in Nigeria have in recent years set up holding companies in London to finance other enterprises in Europe and in other countries.

This has not created a favourable impression for mining investment in Nigeria. Another of these considerations is the absence of adequate facilities for assaying and testing of samples. This means that companies exploring for minerals in Nigeria have to depend on laboratories in Europe or America with consequent additional cost and loss of time. This factor has discouraged a number of enquirers. The last consideration is the scarcity of trained mining engineers and geologists both for employment by Government and for service as independent consultants promoting the national interest through offering to carry out investigations on behalf of would-be investors. Such investigations would facilitate the decision whether or not to proceed further, and thus assist in cutting initial costs. Industry can import all the skills necessary for it to prosecute a profitable business, but Government cannot always import all the skills that are necessary for the efficient execution of policy. What seems most improtant is that Government should promote the spirit of co-operation between industry and itself in securing the development of mineral resources. This is the thinking in the Ministry of Mines and Power and has underlined our contacts and approaches to international mining interests.

I have discussed largely the co-operation between private companies from capital-exporting countries on the one hand and the Governments of developing countries on the other. It is important here to note that a number of Governments pursue a policy of domestic self-sufficiency which in various ways could militate against the interest of the newly emergent developing states. In the first place it could mean that metals and minerals from developing countries would be discriminated against in favour, not only of minerals produced within the borders of a country but by the means of its "domestic capital". In the second place it could lead to the expenditure of vast sums of money in research directed at displacing the products of these newly emergent nations. It does appear therefore that understanding and co-operation between Governments is also desirable. The advance of science and technology demands the production of metals and minerals in increasing amounts and variety and for the service of manking. Through understanding and co-operation, we can bring about the development of known resources and the discovery of new ones.

PART V - Suggestions and Recommendations

Since it appears that some of the difficulties experienced by Nigeria are due to marketing certain products in a form which it is either inconvenient or unprofitable to use them, my first suggestion relates in the case of columbite to the production of partially separated metals rather than minerals, so that niobium and tantalum could be marketed separately in a semi-fabricated form. I would even go further to suggest that a study should be undertaken of the feasibility of producing ferro-columbium locally. A decision favouring this trend would have far-reaching consequences and immediately bring into full production all the main sources of the new metals and minerals and our products would compete on a footing of equality with similar materials from other countries.

The greatest of all our problems is the training of personnel. Governments must have their own nationals trained in mining and related disciplines so that they can help with the taking of policy decisions which in the long run will promote the understanding and co-operation discussed in the last part of this paper. Not only are trained people required to help Governments to reach the correct decisions on policy, they are also required to execute these decisions and to serve as watch-dogs of the interests of their nations. Training is therefore an important aspect in which the emergent nations can be assisted.

Another point which was brought up in the earlier portions of this paper is the lack of adequate facility for scientific research and services. This impinges on the last problem - training, since such facilities must be manned by competent people. The urgent need is for the establishment on regional basis of facilities for assay services and research. The emergent countries would be unable to pay for, or staff this sort of facility and their establishment must be considered only on the basis of technical assistance.

Finally, our hosts the Economic Commission for Africa can usefully establish a division devoted to market study in respect of metals and minerals and publish from time to time information and data which might

help the various countries to understand market trends and therefore to guide them. Most African countries would greatly value such a service whilst they are still unable to establish their own.

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