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THE GEOLOGICAL SCIENCES IN THE SERVICE OF NIGERIA

by P. G. Cooray

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IN the year 1900, Charles Lapworth, the then President of the Geological Society of London, asked from the President's Chair: "What is this geology of which we are so proud and confident? What has it done for the mental or material benefit of the human race? And on what grounds does it justify its claims to respect and support as one of the facts in the advance of humanity?"

These questions appear to be as relevant today as they were at the beginning of the century, and my address this evening, as the title indicates, attempts to answer the first rather briefly, the second in some detail in so far as it applies specifically to the people of Nigeria, and the third not at all, as the answer lies with you—mine would be strongly prejudiced in geology's favour! The main body of my address falls naturally into three parts, namely, the manner in which the geological sciences have served Nigeria in the past, the ways in which they will continue to serve her in the future, and the contribution that the Department of Geology and Applied Geology at the University of Ife has made and will continue to make in the provision and growth of this service.

But first some definitions are necessary. The science of geology, which is more than 200 years old, springs from two main sources—the consideration of the origin of rocks, and the study of minerals and crystals from the old mining districts of Germany. This is neither the time nor the place to delve into the history of our science—suffice it to say that until relatively recently geology was largely an observational science with little or no relation to the other physical sciences. Today the picture is very different, and the barriers between geology and chemistry, geology and physics, and geology and mathematics are being broken down as fast as they are between physics and chemistry, and chemistry and biology. It is for this reason —dissatisfaction with the limitations of the term "geology"—that I have chosen the wider term "geological sciences" for the purpose of this talk. Geology is in essence earth history and it uses every available means to decipher this history. We can therefore say that the geological sciences are the various branches of geology and allied subjects that help to unravel earth history.

It is customary to regard such branches of geology as *palaeontology*, or the study of past life, *stratigraphy*, or the study of rock successions, *mineralogy*, or the study of minerals *petrology*, or the study of the origin of the rocks, *economic geology*, or the study of the occurrence and origin of minerals useful to man, and *structural geology*, or the study of the shapes and attitudes of rocks, all as branches of "pure" geology. *Hydrogeology*, or the study of underground water, *engineering geology*, or the application of geological principles to civil engineering problems, and *applied geophysics* and *applied geochemistry* or the application of the physics and chemistry of the earth to mineral

exploration are known as branches of "applied" geology. But the distinction, though useful for academic convenience, is often unrealistic. Ultimately, both work towards elucidating in detail the answers to problems concerning the history of the earth's crust that, in the final analysis, are beneficial to the physical, mental or spiritual well-being of the human race. As Professor V. C. Illing has said: "There is only one geology: its purity depends on its truth, not on its application".

Having said this by way of introduction, let me turn now to the specific ways in which the geological sciences have helped in the past development of that part of the earth's crust which we call "Nigeria" and how it may continue to do so in the future.

In any evaluation of the contribution that the geological sciences have made to the development of Nigeria in the past, primary place must be given to the Geological Survey of Nigeria. As in most colonial territories, the earliest investigations in Nigeria were chiefly for mineral deposits; these investigations were carried out by the so-called Mineral Surveys which were attached to the former Imperial Institute of London, and they lasted from 1903 to 1913. It is to them that we owe the knowledge that commercially exploitable deposits of tin, lead, zinc, gold, coal, and lignite occur in Nigeria.

The establishment of the Geological Survey of Nigeria in 1919, after World War I, saw the scope of the early Mineral Surveys greatly enlarged. In the succeeding years, those branches of activity for which geological surveys all over the world are renowned, namely, systematic geological mapping, investigation of mineral deposits, the search for groundwater, and the application of geological principles to problems of civil engineering were firmly established. The geological mapping programme, which was begun in 1920 and continued actively until the early sixties, has resulted in published geological maps on the scale of 1:250,000 of about forty percent of the country. Considering the nature of the terrain mapped and the quality of the maps produced, this is no mean achievement. Geological maps of many kinds are the basis of much development, so that the virtual decline of the mapping programme during the period 1960-1970, caused primarily by the retirement of expatriate geologists who formed the bulk of the Geological Survey, but also aggravated by three years of civil war, has had serious consequences for the country's economic and social progress. It is therefore a welcome sign that active steps are being taken to revive the geological mapping of the country.

Advice on water-supply, especially from underground sources, has always been an important function of the Geological Survey, as can be seen from the fact that nearly 2,000 wells were sunk by it between 1928 and 1947. When one realizes that human settlement in

large areas of Nigeria, especially in the North, is controlled almost solely by the availability of groundwater, and the fact that in recent years significant migrations of population have been taking place owing to the lack of water, the importance of the water-supply investigations of the Survey and its direct value to the public cannot be overestimated. It should also be remembered that it was in the search for water that applied geophysical methods were first used by the Geological Survey, as far back as 1932.

Finally, except in the case of oil, nearly all the known mineral deposits of Nigeria (both worked and unworked) have, at some time or other been mapped, drilled through, analysed or otherwise examined and reported upon by the Geological Survey. In fact, most of the credit for large-scale tin mining on the Jos Plateau and for the opening up of the coal mines at Enugu must be given to it. Add to this the amount of information that is known about deposits of limestone, clay, ironstone, lignite, and columbite, to mention only a few, and it can be seen how important have been the geological sciences, as practised by the Geological Survey of Nigeria, to the past development of the country in both economic and social terms.

But the Geological Survey has not been the only instrument through which the geological sciences have served Nigeria in the past. Private organisations and universities have also played their part—as it happens, an increasingly important part.

Of the private organisations, the oil companies have been contributing the major share to the recent economic development of the country. The search for oil, begun in 1937 by the Shell-BP Development Company of Nigeria, is essentially the search for certain rock types, successions of rock types, and rock structures at subsurface levels. The discovery of oil in the Niger delta and, in the last few years, in the offshore areas of the delta, must therefore be attributed primarily to the geological sciences, both pure and applied. It can be said without fear of contradiction that without the aid of the geological sciences oil would not have been discovered in Nigeria, and without the discovery of that oil, Nigeria would not now be enjoying its booming prosperity. Today, crude oil production in Nigeria is nearly 1.7 million barrels per day, which means that in terms of foreign exchange saved and earned and as a source of revenue, crude oil production is now one of the mainstays of Nigeria's economy.

How spectacular has been this development is vividly brought out by the fact that in March, 1970, crude oil production was under 1.0 million barrels per day, and that if the present rate of increase continues, production would have almost doubled by March this year—in the relatively short space of two years. Here I must digress to say that while therefore the statement, made by Reyment in 1964, that "no really large oil reservoirs have yet been discovered in

Nigeria" is basically true, it does not tell the whole story of oil in Nigeria. One assumes that Reyment was thinking in terms of the Mississipi delta with its very large reservoirs of oil, but we now know, largely through geophysical means and exploratory drilling, that there are a large number of small oil resevoirs in the Niger delta whose total reserves, nevertheless, far surpass those of the Mississipi.

Add to the monetary benefits of crude oil production the benefits derived from many forms of employment, urban development, the building of bridges, harbours, roads, railways, airfields and all other ramifications of the petroleum industry, and you will begin to realize the size of the contribution that the geological sciences have made, directly of indirectly, to the development of this country through the oil industry in particular, and through the mining industry in general.

A few figures may indicate to you the scale of this contribution to the economy of Nigeria. Crude oil production, for example, increased from twenty one million tons in 1965 to "ninety seven point three" million tons in 1970. Export figures show that whereas exports of crude oil and tin ore and metals formed thirty one percent by value of the total exports in 1965, by 1970 this figure had risen to sixty one percent.

Exports in Millions of N£

	1965		1970	
Crude oil	68.1		254.9	
Tin ore and metals	14.9		16.6	
Total for minerals		83.0		271.5
Cocoa	42.7		66.5	
Others	142.6		104.7	
Total for cocoa and others		185.3		171.2
Grand Total		268.3		442.7

Probably the best indication that the mining industry as a whole is playing an increasingly dominant role in Nigeria's economy is seen in its contribution to the Gross Domestic Product. The figures given indicate that mining shows the highest average growth rate of 9.6

percent in the growth of the Gross Domestic Product between 1966 and 1971, a figure that is more than double the average total growth rate of 4.1 percent over the same period.

While being impressed, however, by the contribution of the geological sciences that can, to some extent, be evaluated in terms of pounds, shillings and pence, we must on no account forget those that cannot be reckoned in terms of financial return. A considerable amount of research has been undertaken by individuals and teams in the universities, the Geological Survey, and in private organisations towards the unravelling of such problems as the palaeontology, stratigraphy, and groundwater potential of the sedimentary formations of Nigeria, the processes of mineralisation of the tin, lead, and zinc-bearing minerals, the geochemistry of the Younger Granites, the Pre-Cambrian basement geology of Nigeria in all its complexity, the goelogical history of Nigeria, and many others. Some of these problems may appear remote from practical application, but let me assure you that they are not—the history of the geological sciences abounds with examples of pure research which, in time, became of practical importance.

I would like to end this section by giving you a very striking example of the application of geological science to engineering in the recent past. At the time of its construction, Kainji Dam was the largest engineering project being constructed in Africa south of the Sahara, and preliminary estimates indicated that ten million cubic yards of constructional material (including rock, gravel, sand, and earth) would be needed for the dam and its associated works. After the preliminary selection of the site, involving intensive exploration by geological mapping, trial borings, and geophysical methods, the comprehensive investigation and assessment of the local materials for building the dam and associated works had to be carried out. This itself involved comprehensive tests on the physical characteristics of the material, selection of the best quarry sites, and investigation of the soils of the area by means of thirty three boreholes, seventy four trial pits, and a large number of mechanical analyses and physical tests. What is more important, the design of Kainji Dam was, in fact, evolved while the material investigations were going on. The final design was largely governed not by theoretical considerations but by the situation, qualities, and properties of local constructional materials and the necessity to make the most economic use of them.

Let me turn now to the future, to see how the geological sciences can and will contribute to the development of Nigeria in the coming decades.

Nigeria is now in the early stages of a Four-year Plan which, in turn, will be succeeded by other plans, all aimed towards the fuller development of the country's resources. However, the success of any

planned development depends largely on proper evaluation of the country's resources—both natural and human—and it is in this area, and more specifically in evaluating the mineral resources of the country, that the geological sciences will make their greatest and most significant contribution.

One of the first needs will be the surface geological mapping of the remaining sixty percent of the country that is as yet unmapped, for the reason that geological maps form the essential basis of mineral and groundwater exploration, engineering geology, and soil studies. Furthermore, there can never be an end to geological mapping because the present series of maps must be followed by more detailed maps of selected areas and for specific purposes on larger and larger scales. Geological mapping is a continuing process with, if I may take Hutton's dictum out of its context, "no prospect of an end".

Concurrently with geological mapping will be the follow-up investigations of the country's known but hitherto undeveloped mineral resources, of which there are many, as can be seen from the following table.

MINERAL DEPOSITS OF NIGERIA

Mineral Fuels	*Coal, Lignite, Oil, Natural Gas, Uranium, Thorium.*
Iron and Ferro-alloy Metals	*Iron, Niobium, Titanium,* Tungsten
Non-ferrous Metals	*Lead, Zinc, Tin.*
Minor metals and non-merals	*Zirconium,* Beryllium, Tantalum
Precious metals	*Gold, Silver.*
Industrial Rocks and Minerals	*Limestone, Marble, Sand, Gravel, Building and Ornamental Stone, Quartz, Feldspar, Brick-and-Tile Clays, Silica Sand, Bituminous Sands, Barytes, Gypsum, Diatomite, Phosphates, Kaolin,* Marcasite, Fluorspar, Cryolite, Graphite, Sillimanite, Mica, Talc, Monazite, Garnet, Brine, Sodium carbonate, Sodium sulphate, Sulphur.

(Minerals in *italics* are those being mined or are capable of being mined. Others are known to occur but reserves are insufficient or unproved).

To take but one example of a hitherto undeveloped deposit. Lignite (or brown coal), first discovered in 1908, is now known to be very extensive in the south-eastern part of Nigeria, but its utilisation has been side-tracked and overshadowed by the extraction of coal at Enugu. Its exploitation can only be accomplished by detailed geological surveying and drilling, coupled with technological studies so that the deposit can be developed according to a plan in which all aspects of utilisation are integrated. Such an integrated plan has, for example, been used with great success in exploiting the lignite deposit of Neyveli in South India.

Similarly, the industrial minerals and rocks like sands, gravels, clays, limestones, building stones, phosphates, brine, bituminous sands, and a host of other constructional and chemical raw materials, of which Nigeria has large reserves, are very inadequately utilised today. Unfortunately, the glamour of oil and its revenue-earning capacity has been allowed to swamp, almost completely, the development of these industrial minerals and rocks, with the one exception of limestone for cement manufacture. It is now generally recognized that the increased production and use of industrial minerals within any region reflects better than almost any of the metals do, the standard of living of that region as shown in improvements in transport and communications, housing, and the size of the consumer market.

There is, in fact, a direct relationship between industrial mineral production and utilisation and the internal economic growth of a region, and the present under-utilisation or non-utilisation of Nigeria's resources of, for example, silica sands and vein quartz for glass industries, kaolin and feldspar for ceramics, phosphates for fertilisers, and clays for bricks and tiles is to be greatly deplored.

The third need will be for the extended search for new mineral occurrences using more sophisticated techniques such as geophysical and geochemical methods, specially adapted to local conditions. The problems involved in looking for new deposits of oil, iron, tin, lead, zinc, and gold are so complex that they must of necessity be based on co-operative efforts in which stratigraphy, structures, and processes are studied. All these will require both practical work and research of the highest calibre.

A fourth need—and one that is of vital importance to this country—will be the intensive search for sources of groundwater for human and industrial consumption. Here again sophisticated techniques like geophysical prospecting and basic research into the behaviour of groundwater in different rock formations is a fundamental necessity for the future.

A fifth need—and one to which very little attention has been paid in the past—must be the application of geological principles in civil engineering works. One need only mention the future development

of roads, highways, dams, bridges, harbours, airports, and buildings in Nigeria in the next few years to realize the potentially large amount of advice that should be sought concerning foundation conditions and constructional materials. Such advice would be given if the value of engineering geology were really appreciated in this country. Unfortunately this is not so, unlike in the developed countries where it is now fully recognized that specialist advice not only avoids disasters (like the collapse of dams and buildings due to inadequate foundations), but significantly reduces cost, and is therefore economic in the long run.

To sum up (in social terms), one looks forward to the day when the crumbling mud walls of village houses will be replaced by kiln-baked or even sun-baked bricks, and clay tiles will replace what must be one of the most drab roofing materials ever devised by man, the corrugated iron sheet; when modern macadamized roads with sound foundations will replace the thin layers of tar mixed with sand laid on laterite which now pass for major roads: and when there will be at least conveniently-situated central wells in centres of population, or better still, proper piped water supplies in every town and village.

I have tried to review the five or six priority areas where the geological sciences will play a decisive part in the future development of this country. For this contribution to be effective however—and in fact if the geological sciences are to contribute anything at all—the manpower must be provided, and it is here that the role of the universities and technical institutes is critical. Some attempts have been made to estimate the future manpower needs of this country in the geological sciences. I will not add to these attempts for the reason that the bases of projections are really unknown, but will only say that a considerable number especially of field geologists, geophysicists, and hydrogeologists, but also of geochemists, mineralogists, petrologists, palaeontologists, and engineering geologists will be needed for the public as well as the private sector and in the universities in the coming years. To these must be added the technical staff at junior and intermediate grades to assist in the field and to man the specialised laboratories that need to be set up in support of these services. It will therefore be the task of the universities to provide this manpower, and further, to engage in those areas of research that will have application (either directly or indirectly) to the problems facing the development of the mineral resources of Nigeria.

So we come to the part that the Department of Geology and Applied Geology at the University of Ife has played and hopes to play in the service of this country. The Department, which is one but the youngest of the four fully fledged geology depatments in Nigeria, is now in its seventh year of existence. Its first students

graduated in 1968 and we have now produced a total of twenty graduates, including the only first class honours graduate in geology from any Nigerian university. Of these twenty, fourteen are now working with the Geological Survey of Nigeria, one with the National Iron and Steel Corporation, and five with oil companies or their associated organisations. In other words, the placement of our graduates as professional working geologists is one hundred percent—a record that we are proud of indeed!

What this means in practice is that in many of the spheres of activity in which the geological sciences are serving Nigeria, our Department is providing persons with the necessary basic knowledge and training to provide those services—and this, moreover, is where the future emphasis will lie. Our contribution will continue to be two-fold, namely, the provision of geologists with a good all-round training in the geological sciences, and fundamental research in several aspects of the geology of Nigeria.

The first will be achieved by a constantly evolving programme of teaching, the philosophy behind which can be said to be based on two concepts, well illustrated by the following quotations. The first is from the exhilarating sayings of one of the giants of modern geology and my own teacher, the late H. H. Read: "the best geologist is, other things being equal, he who has seen the most rocks"; and the second is an anonymous one: "all exploration from pick and shovel to country-wide aerial surveying is based on someone's geological concept". Consequently, future emphasis will be not only on giving the student a sound foundation in the basic concepts of so-called 'pure' geology but also on introducing him to the principles of applied geology through such subjects as applied geophysics, applied geochemistry, hydrogeology and engineering geology. All these, I am glad to say, are now a regular part of our three-year programme for the honours degee in geology. I should like to add that we are now the only Geology Department in Nigeria teaching applied geophysics, the techniques of which are of utmost importance and use in large-scale surveying and reconnaissance exploration. Such techniques are even more important in a tropical country like Nigeria where accessibility is poor and the weathered overburden very thick. Increasing emphasis is also being placed on field work, particularly on geological mapping, so much so that this year, for the first time, first-year geology students will undergo a course of field mapping in sedimentary rocks in Eastern Nigeria, and the second-year students will undergo a similar course of mapping in the Younger Granite region of the Jos Plateau, in addition to the already established four- to six-week independent mapping exercise in the crystalline basement in the area around Ife. Thus we hope that our graduates in geology will constitute good material for any of the more specialised

fields of professional employment. Furthermore, we are trying to teach our students the art of writing good geological reports and to this end have produced a manual, *Geological Mapping and the Writing of Reports*, for their guidance. It is gratifying to know that this manual has found wider acceptance and is now used by all field officers in the Geological Survey of Nigeria.

I mentioned earlier our two-fold contribution, the second being staff and post-graduate research, and I think it would be appropriate here to record the more important research projects that are being currently undertaken within the Department, These are: the stratigraphic palaeontology of the Lower Tertiary formations of Nigeria; the ecology and distribution of living foraminifera in the Gulf of Guinea; the feldspars of the Older Granites of western Nigeria; contact metamorphism in the Ubo Marble; the groundwater resources of south-western Nigeria; the chemical composition, sediment content, and radioactive properties of river waters; the geology of the Iullemmeden Basin in the Sokoto region; river processes and modern deposition on both large and small scales; and the charnockites of western Nigeria and their bearing on the origin and nomenclature of charnockites in general. In addition, we have now embarked on a project that will meet a long felt need in Nigeria, namely, the preparation of a bibliography of the geology of Nigeria both alphabetical and annotated; and the Department is actively involved in the preparation of tectonic and metamorphic facies maps of Nigeria under the aegis of the Nigerian National Committee of the International Union of Geological Sciences (I.U.G.S.).

Owing to the present demand for geologists, it appears that post-graduate students are in short supply. Such a situation is likely to continue until a saturation point is reached, or until employers alter their policies and begin to require some post-graduate training in their future employees. We look forward to such a time and have accordingly geared our post-graduate programmes towards specialisation in applied geology fields. There is, however, some hope that we may have a post-graduate school at Ife before long, if plans for collaboration with the Geological Survey of Nigeria materialize.

In many parts of the world, and especially in France, Canada, and the Scandinavian countries, active collaboration goes on between university geology departments and the geological surveys, in which the former carry out geological mapping for the survey, using facilities provided by it, but use the data so collected for their own research. Such collaboration and co-operation is naturally of great mutual advantage to both parties. Though not in quite the same way, we hope to establish close contact with the Geological Survey of Nigeria so that their officers can obtain more specialized training in a field such as palaeontology where we have the neccessary expertise, and

our experience in geological mapping can be placed at the service of young relatively inexperienced Survey officers mapping in this part of the country. We hope, too, to assist actively in the programme of the E.C.A. Training Centre for Photogrammetry, Photointerpretation and Aero-Geophysics that is shortly to be opened on this campus—another area of co-operation that we hope will be of mutual benefit.

Finally, I must crave your indulgence for a few minutes more to ride what has become my favourite hobby-horse. It is a commonplace fact that man lives *on* the earth and *by* the earth, and the very existence of man, whether in the most primitive communities or in the most highly industrialised societies, depends ultimately on the earth's crust. Yet how little mankind in general knows *about* the earth. Fortunately, in the more developed countries, earth science is being recognized more and more as a fundamental aspect of basic education, the aim of which is to produced well-informed citizens. This is not so in the developing countries where so much emphasis is placed on what Read has called "the unholy trinity"—mathematics, physics, chemistry, but so little attention given to man's own natural environment—the atmosphere, the oceans, and the continents.

I would therefore like to end this Inaugural Address with the plea that instead of geology being a highly specialized subject taught to a very small minority at university level, earth science should not only form an essential part of basic studies in the university, but it should also permeate more and more into education at secondary school level. It is here that an integrated earth science course, oriented towards the local environment, should form an essential part of the child's curriculum of learning. The earth is the background to so much human activity—agriculture, settlement, industrialisation, movements of population, engineering, administration, economics, planning—that a proper understanding of the environment must ultimately lead to richer and fuller living. Is not this, after all, what mankind is striving to attain?

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