Geology of AFRICA

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TRANSLATORS' PREFACE

The achievement of independence by many African countries in the last few years has necessitated bringing up to date the political geography of Professor Furon's book. In the case of the Malagasy Republic, however, the older and very familiar name of Madagascar is retained. The coming into existence of two new republics of the Congo is a potential source of confusion. In our translation the former French Congo is called the Congo Republic and the former Belgian Congo translated simply as the Congo.

The other main change concerns the references, present as footnotes in the original. These are now treated as in the standard English geological literature and placed at the ends of chapters. The index has not been expanded.

Stage terms have been left unchanged, even though there might be differences between French and English usage. Generally speaking, geographical names in French-speaking countries have been left untranslated. Similarly, such well-known stratigraphical terms as "Continental intercalaire" and "Continental terminal" have been retained as there is no satisfactory English equivalent.

We have found that a little confusion may arise with two frequently occurring words. *Schiste* can variously be rendered in Furon's book as schist, slate or shale. In deciding which, we have been obliged to consider the context and also, in a few cases, to check the relevant English literature. The term *série* has a more comprehensive use than the English "Series", which, as usually understood today, is merely the member of a whole hierarchy of specific stratigraphical terms. It is often best translated as "succession".

We should like to acknowledge our gratitude for the help received from Professor Furon in the translation of several difficult words and phrases.

One of us (L. A. S.) was responsible for the translation of the first nineteen chapters and the other (A. H.) for the remainder, but there has been a good deal of mutual consultation and discussion.

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FOREWORD

Although Africa is renowned for its richness in such minerals as petroleum, gold, diamonds, iron and manganese, its geology is still inadequately known. Except for a few favoured areas, Africa is poor in fossils. The geologist must therefore utilise all the resources at his disposal to establish sound stratigraphical successions and correlations. The first stage in the study of African geology has been the determination of local successions without consideration of age, and correlations between neighbouring areas have only been tentative. Geologists in Europe have tended to look down on this type of stratigraphy, worked out laboriously by a small number of geologists often working under exceptionally difficult conditions.

The four volumes of Krenkel's *Geologie Afrikas*, published between 1925 and 1938, summarise the knowledge acquired by the inter-war period. Slowly the blank areas on the maps have been filled by tenacious Belgian, British, French, Italian and Portuguese geologists. Progress has been so rapid that a committee of specialists has been able to agree on certain stratigraphical correlations and on the outlines of the *Carte géologique internationale de l'Afrique*, published by the Bureau d'Études géologiques et minières coloniales, Paris. This consists of nine 1:5,000,000 sheets, the last of which appeared in 1952. The first edition of this book (1950) summarises the state of work up to that time.

Much new work has been done in recent years. Application of new techniques in geochronology in the southern part of the continent and fossil discoveries in the northern part have thrown new light on matters which had hitherto been obscure.

In 1960 the geology of Africa required a new account, which is presented here. It is divided into two parts: (1) *General Geology*, which deals with the stratigraphical succession peculiar to Africa, and the broad outlines of the palaeogeography; (2) *Regional Geology*, divided into twenty-five chapters dealing with the present state of knowledge in each region. The Mediterranean domain of North Africa ("Outer Africa") is not considered. Other omissions will certainly be found.

Numerous references have been included to enable original texts to be consulted. Illustrations, reduced to a minimum, are

confined to sketch-maps and sections. Cartographic details will be found in the maps and works cited.

A beginning has been made in the understanding of the geological reasons for the long-recognised difference between the northern and southern parts of Africa, separated by the swell of crystalline rocks extending from Cameroun to East Africa.

The geology of Africa is the work of only two generations, of a small number of courageous men who have dedicated their lives to their passion, for which some have died, through assassination or by succumbing to the desert and tropical forest. The geology of the African continent has not yet fallen into the public domain. Each area evokes the name of a particular geologist. I have summarised the work of all of them, hoping to arouse fresh curiosity and stimulate new enthusiasm.

R. F.

Paris, 15*th December* 1959

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PART ONE

GENERAL STRATIGRAPHY

CHAPTER I

THE PRE-CAMBRIAN

The African basement of granites and associated metamorphic rocks is of Pre-Cambrian age. It outcrops mainly in Mauritania, the Hoggar, Sudan, West Africa (from Guinea to Cameroun), equatorial Africa (Gabon, Congo, Central African Republic), East Africa, Angola, South Africa and Madagascar.

Its geographical importance is equalled by its economic importance because the Pre-Cambrian contains rich beds of gold, copper, iron, uranium, tin, manganese, etc. Its beds record the evolution of Africa through several thousand million years.

Dating by radio-active minerals gives an age of more than 3,500 million years. The Earth's crust began to solidify at least 5,000 m.y. ago; and this represents a reasonable order of magnitude for the age of the Earth.

All the African Pre-Cambrian is intensely folded (as in other continents) with general fold directions of N.-S. or NE.-SW. Most of the rocks are of sedimentary origin but have been modified by folding, igneous intrusions and metasomatic phenomena. In the absence of fossils it is necessary to use other methods for determining the orogenic cycles. These include a study of unconformities, conglomerates, extrusive phases, mineralisation and finally the absolute age, calculated from radio-active minerals.

The 1 : 10,000,000 Structural Map of Africa, published late in 1958, was a difficult undertaking. It was produced after six years of discussion between specialists because the stratigraphical succession of the Pre-Cambrian, on which it is based, is still disputed.

Holmes and Cahen (1957) published a very important document on African chronology which gave 320 measurements of the relative age of 230 rock groups. By improved methods of analysis, the authors were able to show that the analyses published in the preceding year contained errors of about a thousand million years—lepidolite from Letaba: 2,815 m.y. instead of 3,850; galena from Stavoren: 2,010 m.y. instead of 880; lepidolite from Hombolo: 2,440 instead of 3,250; lepidolite from Southern Rhodesia: 2,810 instead of 3,740, etc. These dates are still liable to modification, but in view of the large number of analyses and the

improved knowledge of sources of error they may be regarded as reasonable.

Holmes and Cahen (1957) distinguished seven Pre-Cambrian orogenic cycles, mainly in Africa south of the equator.

In the oldest cycle, 3,200 to 3,400 m.y., the authors included the Western Nile System (Congo and Uganda), the Fig Tree and Onverwacht Series, the Swaziland and Eastern Transvaal System and doubtless the Sebakwian of Rhodesia. In West Africa the Dahomeyan should be included in this cycle. It is older than the Mount Sula Schists, which are 2,955 m.y. old.

2,800 to 3,100 m.y. The minerals of the Mt. Sula Schists in Sierra Leone (2,955 m.y.) define a cycle older than the Birrimian, but *perhaps* younger than the undated Dahomeyan. The Bulawayan of Southern Rhodesia and Nyasaland in East Africa may be part of this cycle, or younger (2,825 m.y.).

2,650 m.y. *Shamwaian Cycle.* A cycle only recognised in the two Rhodesias.

2,000 m.y. *Limpopo Cycle.* This cycle occurs in the south of Southern Rhodesia and in the north-east of South Africa.

A number of analyses give figures averaging 2,200 m.y. in West Africa; this may possibly indicate the occurrence of a Birrimian cycle.

1,040 m.y. *Karagwe-Ankolian Cycle.* This is an important cycle in central and equatorial Africa. It may link up with the Gordonia cycle in South Africa and the Witwatersrand formations dated between 1,100 and 2,000 m.y. The definition of this cycle is still uncertain.

875 to 900 m.y. A cycle uniquely defined by the age of monazite from a pegmatite at Goodhouse (South Africa).

620 m.y. *Katangan Cycle.* This is widespread in equatorial Africa—e.g. Katanga Group, Western Congo Group.

The number of cycles recognised since the beginning of the Cambrian (four or five during 500 million years) suggests that one might expect to find twenty or thirty during the entire Pre-Cambrian.

However, two facts are interesting: first, that experience in the preparation of the 1 : 10,000,000 Structural Map of Africa has shown that subdivision into seven cycles is not always possible for the whole continent, since some are only "known" at one place and by a single date; secondly, in the northern half of Africa, which has been studied more, and is better exposed, only two

large orogenic cycles are found: Dahomeyan-Suggarian and Pharusian-Birrimian, and two less important, comprising *a maximum of four cycles.*

Age determinations indicate intermediate ages for the phenomena of metamorphism and granite intrusions. I think, with M. Lelubre (personal communication), that one age determination of a granite does not signify an orogenic cycle, and that the succession can only be established by geological observations in the field; so that whilst absolute ages give the chronology of the events, this is not always the same thing.

It therefore seems to me that the subdivisions shown in the Structural Map of Africa, which divide this great extent of time (4,000 m.y.) into four cycles, should provisionally be adopted.

Lower Pre-Cambrian (Pr I) (3,000 m.y.+): this includes all the series actually dated and also the oldest undated series. Sahara: Suggarian and Amsaga; West Africa: Dahomeyan; equatorial Africa: Pre-Mayombe; Congo: Gangu (3,325 m.y.), Banzyville System; Congo and Uganda: Western Nile Formation; East Africa: Basement Complex, Dodoma Series (3,250 m.y.); Southern Rhodesia: Sebakwian (older than 2,980 m.y.); South Africa: Swaziland System (3,350 m.y.); Madagascar: Androyan.

All these series are essentially granito-gneissic, strongly folded and invaded subsequently by granitic batholiths.

In the earliest Pre-Cambrian the old eroded structures have locally variable fold directions but, taking Africa as a whole, they follow the meridians, with a few peculiar "noyaux" or nuclei (as in Sudan and Sierra Leone-Liberia). The Suggarian of the Hoggar is at least 20 km. thick.

These are the "dark ages" of African geology.

Middle Pre-Cambrian (Pr II) (2,000 to 3,000 m.y.): this includes folded and granitised series in many places but fewer metamorphic rocks. Morocco: Kerdous Series; Sahara: Lower Pharusian and Akjoujt (?); West Africa: Atacorian and Birrimian; equatorial Africa: Mayombe, Kibali, Ruzizi; East Africa: Toro System, Kavirondian and Nyanzan, Muva, Mozambiquian; Northern Rhodesia: Upper Basement; Southern Rhodesia: Bulawayan (2,850 m.y.), Shamvaian (2,650 m.y.); South Africa: Limpopo (to 2,000 m.y.); Madagascar: Graphite Series (2,420 m.y.).

The Pre-Cambrian II exhibits fine eroded groups: a large NE.-SW. range from the Hoggar to the Gulf of Guinea; the Kibali Range of the Congo which at first has a N.-S. virgation and then

bends SE. to continue into the Toro range. From there the Kavirondian-Nyanzian Range extends E.-W. to the south of Lake Victoria. In Madagascar the Graphite Range is at first N.-S. and then turns NW. towards Mozambique.

The main sediments of Pre-Cambrian II are schists, quartzites and marbles with the first authentic traces of life in stromatolite reefs.

Upper Pre-Cambrian (Pr III) (between 1,000 and 2,000 m.y.): Morocco: Zenaga Series (1,860 m.y.); West Africa: Tarkwaian (verified by a pegmatite of 1,850 m.y.?), Nigritian (?); Congo: Kibara and Urundi Groups (1,050 m.y.), Sansikwa and Upper Shiloango; Angola: Oendolengo (part); East Africa: Karagwe-Ankola (1,040 m.y.); Southern Rhodesia: Great Dyke (1,250 m.y.); South Africa: Ventersdorp, Witwatersrand.

Terminal Pre-Cambrian (Pr IV) (from 600 to 1,000 m.y.): the Terminal Pre-Cambrian includes the rocks between the intensely folded Pre-Cambrian and the fossiliferous Cambrian. It includes: Morocco: Ouarzazate Series; West Africa: "Falemian", Rokell Series and Buem (?); equatorial Africa: Western Congo System; Congo: Katanga Group (Roan, Mwashya, Great Conglomerate and Kundelungu) (620 m.y.), Bushimaie, Lindi, Western Congo Group; Angola: Bembé System; East Africa: Bukoban and Bunyoro; South Africa: Waterberg, Matsap, Transvaal, Otavi and Damara.

Isotopic analyses of galena from Kipushi (Katanga) and Hapilo give the age of this succession (Kundelungu and Western Congo) as about 620 m.y. This interpretation is disputed and M. Robert, in particular, thinks that the uranium and copper mineralisation of the Roan Series took place well before the Cambrian, but that the veins cutting the Kundelungu are younger, probably Palaeozoic, and consist of reworked lead. Such a phenomenon is known for uraninite in the Witwatersrand; and in Morocco, where galenas found in the Mesozoic have all given Palaeozoic ages. The international congresses have, however, accepted the age of 620 m.y. for the veins cutting the Kundelungu and the Western Congo.

The Falemian and the Rokell Series are still so poorly defined that it is possible that a part of this Late Pre-Cambrian should be included in the Lower Palaeozoic. The majority of field geologists hold this opinion, and I only mention these two series as I personally consider them to be Infra-Cambrian.

I have mentioned the existence of "young granites" and "old granites", such as the "Younger Granites" of Nigeria, which are widespread, and are studied for their tin mineralisation. They often occur as ring complexes, and have intruded the Pre-Cambrian II. Their relationship with Pre-Cambrian III-IV is unknown, but Holmes and Cahen (1957) have given an age of 435 to 485 m.y. for a monazite from a "Younger Granite" of Nigeria.

REFERENCE

HOLMES, A. and L. CAHEN, 1957. Géochronologie africaine 1956. Résultats acquis au 1er juillet 1956. *Mém. Ac. R. Sc. Col.*, Brussels 1957 (n.s.), **5**, 1, 169 pp.

CHAPTER II

THE LOWER PALAEOZOIC (?): THE INFRA-CAMBRIAN

It is generally understood that the Cambrian began about 520 m.y. ago and that the first fossiliferous zone contains olenellids. However, in many parts of the world there is a more or less concordant sedimentary series, unfossiliferous or without determinable fossils, below the fossiliferous Cambrian. These are considered either as the base of the Palaeozoic or as the top of the Pre-Cambrian. Menchikoff (1949) and Pruvost (1951) have named these intermediate rocks the Infra-Cambrian.

The Infra-Cambrian is particularly important in Africa because a major unconformity occurs above the Pre-Cambrian. Thus it may be described either as Terminal Pre-Cambrian (Pr IV), early Palaeozoic or true Cambrian. I consider it as Lower Palaeozoic because of the structure: a major unconformity above the folded basement. It was marked by volcanic activity, glaciers and the transgression of an extensive but shallow sea containing stromatolites.

At the western end of the Moroccan Anti-Atlas mountains, near Ifni, Bourcart (1936) has recorded a series of rhyolites covering the folded and eroded Pre-Cambrian, then an alternation of volcanic tuffs and dolomites and finally a last extrusion of rhyolite before the basal Georgian conglomerate. The same series has been seen in other parts of Morocco by Choubert and Nelter and by Menchikoff in the Ougarta Ranges as far away as Guinea. Thus in a large part of north-western Africa the final Pre-Cambrian movements were accompanied by volcanic activity producing outpourings of rhyolite.

The Stromatolite Sea

The Infra-Cambrian of north-west Africa was marked by the broad extension of a stromatolite sea. The sediments are shales, mudstones, phtanites and dolomitic limestones with stromatolites.

These stromatolites are not determinable fossils to which generic or specific names can be given; they are reefs formed by