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MINISTRY OF COMMERCE AND INDUSTRY GEOLOGICAL SURVEY OF KENYA

GEOLOGY AND MINERAL RESOURCES OF THE SEYCHELLES ARCHIPELAGO

By
B. H. BAKER, B.Sc., F.G.S.
Geologist

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FOREWORD

Mr. Baker was seconded to the Government of the Seychelles Islands from mid-July, 1960, until 24th January, 1961, for the purpose of carrying out a comprehensive geological survey. The need for a geological survey had been realized by the late Sir John Thorpe soon after he became governor of the islands. He had previously been in Kenya, where he had lived in the goldfields in their more expansive days, and knew the economic and social advantages of even a small mineral industry. He quickly collected specimens of what he thought might be economically interesting rocks and sent them to the Geological Survey of Kenya for identification and evaluation. He maintained such an exchange with Kenya for some time, until it was possible for arrangements to be made for the geological survey.

The memoir produced as a result of the survey gives a most complete account of the geology of the hundred or more islands that constitute the Seychelles archipelago, as well as considerable information about the submarine surface around them. Detailed maps are provided of all the more important islands, and will undoubtedly be most useful for many purposes apart from the study of geology or mineral possibilities. The survey failed unfortunately to reveal possibilities of any notable mineral industry, though Mr. Baker points out that some smaller industries—such as tile manufacture and the extraction of salt from sea-water—could well be started, and that the production of constructional materials could probably be put on a more profitable basis.

The Seychelles Islands since 1895 have had, however, a typical oceanic island mineral industry in their production of guano and phosphate rock. Mr. Baker indicates that now in several islands the guano is exhausted or uneconomically small, but that on four islands sufficient reserves remain to enable the industry to continue for some years yet. It is stressed however that, compared with the major guano and phosphate producers in the world, the Seychelles Islands yield a minute proportion of the annual production, and that the success of exportation will depend on the material being sufficiently cheap to be able to compete with manufactured superphosphates.

WILLIAM PULFREY, Commissioner (Mines and Geology).

Nairobi, 19th May, 1962.

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ABSTRACT

The Seychelles archipelago consists of over one hundred islands concentrated mainly into four groups, and amounts to a land area of about 155 square miles. The principal group in the north-east, the Mahé-Praslin group, is of rugged topography and constructed mainly of granite, with minor porphyritic facies and zones containing intermediate and basic xenoliths. No occurrences of metasediments were observed during the survey. Metadolerite and olivine alkali-dolerite dykes cut the granites, and the islands of Silhouette and Ile du Nord at the western side of the group are composed of a younger olivine syenite and a microgranite stock. The granitic islands have marginal lime-sand formations and are partly surrounded by fringing coral reefs.

The remainder of the archipelago is of coral atolls with and without sand-cays, and of small sand-cays situated on patch reefs, all of comparatively recent formation. The Amirantes group of islands rises from a shallow bank situated to the west of the main Seychelles bank, but the other coral islands rise individually from the deep ocean. Among the latter are the raised reef-rock islands of the western part of the archipelago, which consist of partly recrystallized reefs now standing at heights of up to 20 feet above sea-level.

Numerous guano deposits are found on the islands and have been exploited with the production of some 700,000 tons of guano and phosphate rock for export. It is estimated that approximately 200,000 tons of guano of economic grade remain on the islands, 160,000 tons of which is on the reef-rock island of Assomption.

No valuable mineral deposits have been found on the archipelago apart from guano, but an account of small clay and sand deposits that may assist with local building is given.

I—INTRODUCTION

1. General

The geological survey of the Seychelles Islands was made between 24th June, 1960, and 20th January, 1961, when the writer was seconded from the Geological Survey of Kenya (Mines and Geological Department) at the request of the Seychelles Government. The survey was financed by an allocation from Colonial Welfare and Development funds.

As the Seychelles archipelago consists of well over one hundred islands scattered over some 400,000 square miles of the western Indian Ocean, a disproportionate amount of time was necessarily spent in sea travel. Nevertheless it proved possible in the seven months of field-work to visit all the major islands and most of the smaller ones. The need to adhere to a schedule of schooner sailings meant that the degree of coverage given to different islands varied considerably—for example it was possible to spend three days working on Farquhar atoll and only five hours on Providence Island.

The survey was carried out as part of the general development plan of the Seychelles Government, and had two main objectives: firstly, systematic exploration of the islands with a view to assessing mineral resources, and secondly the evaluation of the remaining guano deposits on some of the outer islands with a view to expanding the guano export trade.

The Seychelles archipelago is a British Crown Colony, and consists of well over 100 islands. Permanently settled islands number 46, 24 being of granitic structure, 17 sand-cays and 5 raised reef islands, but there are numerous small islands that are either uninhabited or visited only on occasion by fishermen.

The principal island of the archipelago is Mahé, which is approximately 55.5 square miles in area, and the capital town is Port Victoria, with about 10,000 inhabitants. The population is composed mostly of descendants of the original French settlers and their slaves, and in May, 1960, numbered 41,468. The most widely spoken language is a patois of French origin. English is now the medium of instruction in schools.

The islands have had a colourful history. They were originally uninhabited, but seem to have been visited by passing British merchant vessels of the East India Company in the last years of the 15th century. They appear on a Portuguese chart of 1501, and were visited by the Portuguese in 1505, but no important settlement was made till 1743, when Mahé de Labourdonnais, the French Governor of Mauritius at that time, sent an expedition to take possession for France. The main islands were colonized by the French, and the name of the group changed in 1756 to Seychelles after the French Minister Vicomte Moreau des Seychelles. The islands were captured by the British in 1810, and assigned to Britain by treaty in 1814. Seychelles was a dependency of Mauritius until 1903, when it was granted the status of a Crown Colony.

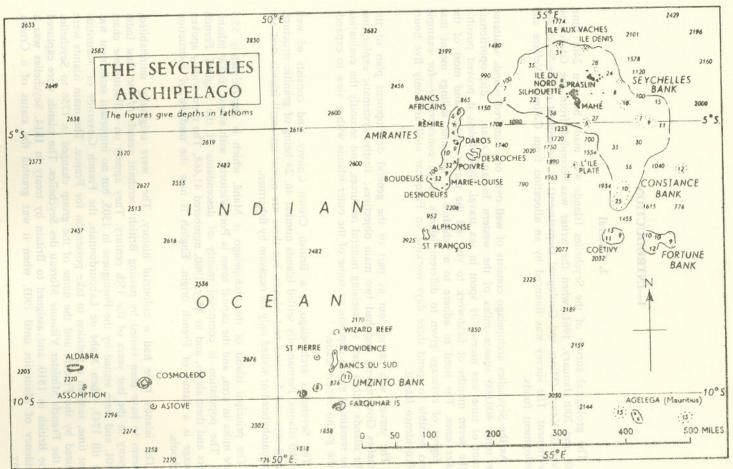


Fig. 1.—Map of the Seychelles archipelago

The wet season is between Moves equal .2 March, most rain falling in January. In general the mountainous upper parts of the highest islands receive the highest

The maps contained in this memoir were drawn by the writer from air photographs taken by Spartan Air Services Ltd., Ottawa, Canada, and supplied through the Directorate of Overseas Surveys, Tolworth, England. There are no previously published maps of any of the islands except Mahé save small-scale sketch-maps and Admiralty charts. The maps in the memoir were prepared by a simple method of radial line plotting, the scale and orientation being determined by the measurement of a base-line on the ground with a cloth tape and compass. In general the orientation should be accurate within $\frac{1}{2}$ per cent and the scale to within $1\pm$ per cent. The scales of the maps of Aldabra, Silhouette, Fregate, St. Joseph, St. François and Cosmoledo atoll were calculated by accepting the stated flying height of the air photography, owing to lack of time to measure base-lines, and the scales of these maps may have larger errors.

The place-names on the maps were obtained in all cases from local people, and checked so far as possible with literate Seychellois. The majority of the people speak the patois, and since this language has no literature, difficulties of spelling have arisen. Furthermore, Admiralty charts and the 1:50,000 maps of Mahé Island (General Staff No. 4712, published by the War Office, London) bear English names evidently added by the map-makers because of lack of local names, or in error. While some such names are in current use, the majority have been replaced on the maps by local names.

There is no lack of named coastal features, but considerable difficulty was encountered in obtaining names for inland features such as hills, mountains, rivers, streams and valleys. In many cases the writer was told that rivers and mountains have no names, or were named after the estate on which they occur or after the person owning the land. In some cases where the omission of such names would have left important features unnamed, estate and personal names are used for inland features.

No legend is included on the maps of the outer islands that appear as text-figures on subsequent pages, but a composite legend which refers to them all is given in Fig. 4 (p. 42).

3. Climate

The Seychelles archipelago lies between latitudes 4° and 11° south, and is in the tropical trade-wind belt. The seasonal weather is governed primarily by the two monsoons—the south-east monsoon which blows between May and November and at intervals during the remainder of the year, and the north-west monsoon which occurs between November and May. In general the period of the south-east monsoon is one of steady moderate wind, with moderate temperatures and little rainfall, while the north-west monsoon is a period of variable winds or calm periods, accompanied by squalls, high rainfall, and generally higher temperature and humidity. During the period November-May tropical cyclones are not uncommon in the southern Indian ocean, and some reach as far north and west as the southernmost islands of the Seychelles archipelago—Farquhar and Providence—both of which have experienced destructive cyclones within the last ten years.

Both temperature and humidity are uniform throughout the year, the temperature varying between 76° and 85° F. Humidity is normally moderate to high, the most humid and climatically enervating months being December and January.

The wet season is between November and March, most rain falling in January. In general the mountainous upper parts of the highest islands receive the highest rainfall, while the flat coral atolls particularly at the western end of the archipelago receive the least rain. The rainfall figures for 1959 are given below:—

Locality		Rainfall in 1959 (inches)	Average rainfall (inches)	Number of years recorded
agass. In general the orientation	no	r sloth tage and c	the ground with a	f a base-line on
Mahé: Port Victoria			90.89	59
		76.26	84.08	21
Port Glaud		80.51	86.67	22
Anse Royale		55.07	65.90	18
Anse Boileau		45.91	72.55	17
N.E. Point		63.13	68.59	31
Mont D'Or		115.44	108.94	13
Val Riche	8 1	106.37	107-92	10
Bel Ombre		94.82	96.75	9
Conan Point	iin	76.23	85.55	7
Union Vale		61.34	78.88	3
Praslin: Grand Anse		59.57	74.83	15
La Digue: La Passe		53.00	60.17	16
Silhouette: La Passe		63.34	71.23	4
Grand Parka		76.46	76.46	A STATE OF THE STA
Anna Mandan		75.05	89.46	e map to the
Dallais)	• •	53.90	56.30	2
				10
Alphonse		37.15	53.91	
Denis		64.17	60.16	8
Daros		63.40	54.35	8

4. Vegetation

The interesting flora of the Seychelles islands has been described by several writers, the best general accounts being the ecological works of Vesey-Fitzgerald (1942*) on the outer islands, and the Reports of the Percy Sladen Trust Expedition (Transactions of the Linnean Society, London, 1907-12). The following is a brief summary.

The granitic islands were originally covered by dense tropical rain-forest containing many endemic species. Human occupation has, however, drastically reduced the forest to a few patches on the upper slopes of Silhouette and Mahé islands. Now, on the principal granitic islands forest reserves have been established in several places, generally at more than 1,000 feet above sea-level. The belt between 500 and 1,000 to 1,500 feet is covered largely by cinnamon bushes and scrub, while the lowest slopes and the flat coastal plateaux are covered by coconut plantations, groves of *Casuarina*, vanilla plantations and vegetable gardens. The littoral plants characteristic of calcareous sand are present in all the sandy bays, and in saline swamps mangroves are found.

All the sand-cays among the outer islands with the exception of small inaccessible cays and Desnoeufs island, are given over to coconut plantations. On the raised reef islands, however, where plantation of any economic crop is virtually impossible except on the narrow coastal sand strips, the rough limestone surface supports only a scrub growth. Mangroves are important, however, on the lagoon shores of Aldabra and Cosmoledo.

5. Communications

Communications with the Seychelles islands are not good. Passenger vessels of the British India and Eastern Shipping Companies call at Mahé *en route* to and from Bombay and Mombasa about once or twice monthly. Occasional cargo vessels from Europe and the Far East call with stores, and small vessels from Mauritius and the East African coast call irregularly to deliver foodstuffs, cement, petrol and explosives. These are loaded and unloaded at Port Victoria by lighter.

There is no air service since there is no airfield, but tentative plans have been made for the construction of an air strip at Mahé.

Communications between the islands are carried on by four inter-island schooners of between 60 and 120 tons displacement, which are required by law to visit the islands at three-month intervals. There is a regular passenger vessel service operated by Government between Mahé, Praslin and La Digue islands of the main group. Cargo vessels occasionally call at St. Pierre and Astove islands to load guano.

Mahé is well served by motor-roads, many of which are tarred, and there is one earth motor-road round most of Praslin island and another on La Digue. Footpaths serve the remainder of the principal islands, but are difficult and widely spaced in the sparsely inhabited higher parts. On three of the outer islands—Coëtivy, Desroches and Farquhar—tractors and lorries are used on the coconut plantations, and on a few other islands hand-carts and donkey carts are used.

Flat-bottomed canoe-like boats called *pirogues*, propelled by between two and 14 oars, are used extensively for fishing, coastal transport of men and materials and the loading and unloading of schooners.

6. Economy

The Seychelles islands economy is almost entirely dependent on agriculture, copra comprising over 70 per cent of exports, minor exports being cinnamon oil and bark, vanilla beans, patchouli oil, guano, and dry salted fish. The Colony has to import all its rice, the staple foodstuff of most of the population, and sugar, wheat, flour, textiles and other manufactured produce. As a result of the rapidly growing population and a static level of agricultural production and resultant earnings the financial situation of the Colony would be precarious were it not for the fact that grants in aid have been provided by the United Kingdom Government. Recently, however, the Seychelles Government has prepared a development plan which is being implemented at the present time with the aid of Colonial Development and Welfare funds from the United Kingdom, the geological survey of the islands that has been carried out forming part of the development plan.

7. Acknowledgements

The writer wishes to acknowledge the help and encouragement of His Excellency the Governor, the late Sir John Thorp, and of the officers of his Government, and the hospitality and help given by the principal island owners and lessees, especially Mr. P. Moulinie, Mr. H. Savy and Mr. J. S. Oliaji.

Numerous chemical analyses of guano and phosphate rock, together with X-ray investigations, were carried out by the Mineral Resources Division of Overseas Geological Surveys, London, and by R. Kempton, Scott Agricultural Laboratories, Nairobi.

During most of the field work in the outer islands the writer was accompanied by Mr. C. J. Piggot, Agronomist to the Seychelles Government, whose advice and help is gratefully acknowledged.

II-PREVIOUS WORK

The first published work of note on the Seychelles islands was that of Charles Darwin in 1842 (see Darwin, 1889, pp. 235-237). Darwin was primarily interested in the coral reefs and mentioned the fringing reefs around the Mahé-Praslin group, and the coral atolls and islands of Plate, Alphonse, Coëtivy, Providence, St. Pierre, Astove, Assomption, Cosmoledo and Aldabra. He based his account on those of Capt. F. Moresby and Dr. Allan, for he did not visit the archipelago himself.

C. Velain (1879) published the first petrographic descriptions of igneous rocks of Mahé and adjacent islands. He described the hornblende granite in the neighbourhood of port Victoria, Mahé, and of the islands St. Anne and Ile aux Cerf. On Ile aux Cerf he observed two basalt dykes.

W. L. Abbott (1893) observed the natural history of Aldabra and Assomption, and described them as composed of coral-reef rock elevated above the sea.

The most detailed work to be carried out hitherto was by M. Bauer (1898) in describing the rocks collected by A. Brauer, who worked in the Seychelles islands collecting the fauna, but who also collected a suite of rocks and made notes on their occurrence (Brauer, 1896). Brauer's collection included the normal hornblende granite of Mahé from various localities and the hornblende syenite of Silhouette island. Veins and stockworks of granite porphyry were described and vogesite dykes from the Mamelles valley in Mahé and from Fregate were mentioned. A variety of diorites were described occurring as scattered xenoliths in the granites of the islands, and diabase (dolerite) dykes were mentioned. Of particular interest are two metamorphosed sedimentary rocks described by Brauer, an andalusite hornfels from Silhouette island, and a hornfels from Ile aux Cerf; the precise localities were not mentioned in either case. Brauer discussed the decomposition of the granites at length, concluding that the red soils are lateritic and that they resemble bauxite in composition.

P. R. Dupont (1907), when curator of the Botanical gardens at Port Victoria, in a report to Government described the guano deposits of St. Pierre when exploitation had only just begun, and estimated the reserves at 200,000 tons. For Astove he estimated the guano reserves to be 6,000 tons, and for Assomption 9,000 tons. He also commented on the presence of small guano deposits on Picard and behind Cinq Cases on Aldabra atoll. In addition to brief descriptions of the guano deposits he dealt fully with the agricultural possibilities and the natural history of these islands. A further report by Dupont (1916) dealt with Aldabra and its guano resources. In this report he concluded after seeing analyses of the Aldabra guano that it was not of sufficiently high grade for export owing to excessive leaching. He speculated on the origin of the iron and aluminium that occur in Aldabra phosphatic soils, mentioning the possibilities that these elements may have been concentrated out of reef rock by leaching, or have been introduced by floating pumice.

Dupont's most comprehensive report, in which he covered almost all the outer Seychelles islands, was written in 1929, when the outer islands were described as sand-cays or elevated reefs built on volcanic foundations. Each island was described, particularly from the agricultural point of view, and the formation of phosphatic sandstone beneath guano on the sand-cays was noted. Dupont reported that most of the high-grade guano of St. Pierre had already been exported, and that about 5,000 tons remained to be extracted. With reference to Assomption he mentioned the difficulty of estimating its guano reserves even after five visits, but concluded that the original total amount of guano before exploitation was 100,000 tons of pit guano (see pp. 124-126) and 70,000 tons of surface guano of lower grade. He stated that in 1929 some 70,000 tons of pit guano remained.

An undated unpublished report to the Seychelles Government on Aldabra, Astove, Assomption and Cosmoledo atolls was written by F. Durocher Yvon, when Acting Director of Agriculture. A general account of the structure and natural history was given and an estimate of the remaining guano at Assomption was put at 15,000 tons.

The most complete account of the raised reef islands Aldabra, Assomption, Astove and Cosmoledo is that by J. C. F. Fryer (1911), who went to the islands under the auspices of the Percy Slade Trust Expeditions organized by J. S. Gardiner in the years before 1914. Fryer gave a full description of the topography, structure, fauna and flora. He accounted for the raised reef islands by a general lowering of sea-level in the late Miocene times, and postulated that large amounts of guano were deposited on them as a result of the mass migration of sea birds to the equatorial regions during the Ice Age.

The Percy Sladen Expeditions to the Indian ocean in 1905 and 1908 under the direction of J. S. Gardiner yielded a great deal of information, mostly on marine biology, but also on the islands of the western Indian ocean and on physical oceanography and marine geology. Gardiner's (1906) views on the supposed land connexion between Africa and the Seychelles and the Chagos and Maldive archipelagoes via Madagascar are summarized as follows. The land connexion between Africa and India persisted throughout the Palaeozoic and most of Mesozoic times, but in the Cretaceous became narrower owing to subsidence until straits were formed across it in Eocene times. The subsequent enlargement of the straits to form the broad expanses of ocean was attributed to vigorous submarine erosion. Coral atolls then formed in late-Tertiary and Quaternary times on the submarine ridges and plateaux which were the remnants of the ancient isthmus connecting India and Africa, and on volcanoes built on this ridge. Gardiner showed that the banks extending northwards from Cargados Carajos were continuous below the 1,000 fathom line as a great crescent containing the Saya de Malha, Nazareth, Seychelles, Amirante and Alphonse Banks (c.f. Fig. 1, p. 2). During the 1905 expedition basaltic ash was dredged at a depth of 844 fathoms two miles from the south-western margin of Providence atoll, this being the only rock other than normal marine sediment and organic debris encountered during the dredging operations.

At intervals short notes on minerals and rocks from the Seychelles islands have been published in the Bulletin of the Imperial Institute (Anon., 1908, 1911, 1914-15), that of 1911 being a useful summary of the Assomption island guano deposit.

- W. A. K. Christie, of the Geological Survey of India, stayed in the Seychelles for a month in 1926 and carried out a rapid reconnaissance survey. It is uncertain whether Christie wrote a report on his survey, which was undertaken largely to establish whether the Mahé and Silhouette island residual soils were bauxitic.
- F. R. C. Reed (1949) summarized what was known of the geology of the Seychelles, basing his account on the work of Bauer.

Hutchinson (1950), in his work on vertebrate excretion provided a useful summary of knowledge of bird populations on the Seychelles islands, with brief descriptions of the islands and their guano deposits, including a few analyses.

A brief summary of the Seychelles guano deposits was given in a cyclostyled paper on the phosphate resources of the British Commonwealth issued by the British Commonwealth Geological Liaison Officer (1959).

A late Precambrian age was determined for the Mahé granite by Miller and Mudie (1961), who concluded that, though the Seychelles islands are generally oceanic in type, petrographically and on the age of the granite, they are allied to Africa (W.P.).

During late 1961 and early 1962 B. D. Loncarevic and D. H. Matthews (1962) carried out marine geophysical work in the Arabian Sea, during a reconnaissance for the International Indian Ocean Expedition. Magnetometer traverses over the central part of the Seychelles bank in the vicinity of the granite islands indicated large magnetic anomalies trending north-westwards parallel to the dolerite dykes on the islands, and possibly caused by extensions of the dykes. The northern marginal part of the bank proved devoid of magnetic anomalies, suggesting that granite or other relatively non-magnetic rocks extend to the edge of the bank. The authors indicate that seismic refraction experiments are planned to determine the structure of the Seychelles bank.

III—SUBMARINE TOPOGRAPHY AND GEOLOGY

Comparatively little is known of the submarine topography of the south-west Indian ocean, a situation that is likely to be much improved shortly by an international Indian Ocean Expedition, which proposes to carry out extensive oceanographical work during the period 1961-63, with the participation of 14 nations.

The principal features of the submarine topography are the Seychelles bank, and the Carlsberg and Murray ridges. The Seychelles bank extends from Cargados Carajos at the south end of the Nazareth bank through the Saya de Malha bank to the Mahé-Praslin bank, the gaps between the banks being up to 960 fathoms deep, while the banks themselves consist of shallows at 30 to 40 fathoms with a tendency to have higher rims on the eastern sides to within 10 to 20 fathoms of the surface. South of Mahé-Praslin bank are three outlying banks, the Constance, Coëtivy and Fortune banks separated by depths up to 1,400 fathoms. The Seychelles bank evidently continues as a crescent to link with the Amirantes bank and the Alphonse bank, between which there are depths of up to 950 fathoms. The banks are composed of corals and algae, the upper surfaces being level expanses of weed-covered sand. At the margins there is an abrupt descent composed of coral talus with little sediment, but the channels between the banks are gentle troughs.

North-east of the Seychelles bank the Carlsberg ridge rises over a mile from the deep ocean. It is evidently linked across a shallow depression to the Seychelles bank in the vicinity of longitude 65° E., latitude 15° S., from where it trends north and north-west to pass into the Gulf of Aden. A branch of the Carlsberg ridge, the Murray ridge, extends from a point 500 miles south-east of Socotra Island, north-eastwards across the Arabian Sea towards Karachi. The Murray ridge is reported to have a median depression, interpreted as a submarine rift valley (Wiseman and Sewell, 1937, pp. 225-227). Both the Murray and Carlsberg ridges are composed of basalt (op. cit. pp. 224-225) and volcanic islands occur also at the southern end of the Carlsberg ridge forming the islands of Roderigues, St. Paul, New Amsterdam and Heard.

At about latitude 20° S. the Carlsberg ridge appears to branch. One branch passes south-west to form the broad mid-Indian ocean ridge with the volcanic islands mentioned above, and the other trends south-west, to pass round the southern tip of Africa into the mid-Atlantic ridge.

These submarine ridges are clearly zones of instability, for there is a definite alignment of earthquake epicentres along them (Gutenberg and Richter, 1954, p. 74). It is notable also that both the Carlsberg and Murray ridges, and, indeed, the mid-Atlantic ridge with which they are connected, have been interpreted as rift structures, for they often have deep median depressions, gentle slopes on their flanks, and are formed largely of volcanic rocks.

Within the broad arc of the Carlsberg and associated ridges the Seychelles bank occurs as a smaller arc with numerous islands and banks of shallow water. The Mahé-Praslin bank with its granitic islands appears to be connected to the coralline

Amirante and Alphonse Banks by channels of relatively shallow water. The Farquhar-Providence group of islands, however, do not seem to occur on a well-defined bank, but are aligned on a slight ridge connected to northern Madagascar.

The atolls and islands of Cosmoledo, Assomption, Astove and Aldabra rise individually from great depths, and it is likely that they are built on volcanic foundations.

The occurrence in the Seychelles archipelago of a group of isolated Precambrian granite and Tertiary syenite islands in an oceanic environment has led to speculation as to their origin. Under the continental drift hypothesis they have been regarded as continental fragments left behind as a result of the disruption of Gondwanaland, and some consider them as the remains of a submerged continent, Lemuria, which in pre-Tertiary times formed a link between Africa, Madagascar and India (see also pp. 40-41).

IV—SUMMARY OF GEOLOGY AND GEOLOGICAL HISTORY

The oldest rocks in the Seychelles archipelago are the Precambrian granites that form the principal groups of islands—the Mahé and Praslin groups. Three main types of granite are distinguishable among these islands: the grey Mahé granite, the grey faintly gneissose granite of the Ile aux Cerf-St. Anne group near by, and the reddish Praslin-La Digue granite. All three granites are closely related in mineralogy, being composed of microperthite, quartz, oligoclase, minor amphibole and occasionally biotite. Zones of amphibolitic and dioritic xenoliths occur in the northern part of the Mahé granite, and tonalite, adamellite and granodiorite hybrid varieties of the granite are found in the xenolithic zones.

Porphyritic granite and granite porphyry are found as facies of the Mahé granite on the west coast of that island, and a porphyrytic facies of the Praslin-La Digue granite forms the island of Marianne at the eastern extremity of the group.

The island of Fregate is composed of aplitic rocks locally veined by granite, and the aplite grades into quartz porphyry. Sinuous vein-like bodies of aplite, aplogranite, and microgranite porphyry are common within the granitic areas.

A swarm of alkaline olivine dolerites and dolerites, now uralitized and saussuritized, was emplaced in the granites of all three types long after their consolidation. These dykes are found mainly in the principal tension joints of the granite bodies, and trend mostly to the north-west.

The Tertiary syenite and microgranite that form Ile du Nord and Silhouette contain no dolerite dykes, and are regarded as occupying the magma chambers of former volcanic piles that have now been eroded away.

The Mahé-Praslin submarine bank covers an area of approximately 16,000 square miles, within which the depth of water does not exceed 240 feet. This large area of bank is floored by coral sands and reefs and is presumed to represent a former land mass bevelled by wave action, and which has since subsided to permit coral growth on its upper surface. It is likely that the marginal parts of the Mahé and Praslin granites, and probably a variety of sedimentary rocks form the outer parts of the bank.

The remainder of the Seychelles archipelago—the numerous islands south and west of the Mahé-Praslin group—are composed entirely of coral rock or are calcareous sand-cays built on reefs. An older class of raised reef-rock islands and atolls can be distinguished in the south-west, for Aldabra, Astove and Cosmoledo atolls and Assomption and St. Pierre islands are composed of partly recrystallized reefs now elevated to heights of up to 20 feet above sea-level. Since a reduction

of sea-level of about 30 feet is recognizable in the granitic islands, it is suggested that the formation of the raised reef-rock islands dates from the time of this eustatic lowering of sea level.

The sand-cays are built on patch reefs and atolls, and clearly post-date the raised reef-rock islands. They vary widely in size, but display in their position on the reefs and in their structure the effects of the dominant south-easterly trade-winds, for the southern islands contrast with the northern ones in having marked storm-ridges and dunes on their coasts. Guano was formerly deposited extensively on the majority of the sand-cays and reef-rock islands, and leaching of the guano has brought about the conversion of the underlying sands to phosphatic sandstone on the cays, and the phosphatization of the lower layers of reef rock on the reef-rock islands. Much of the guano has been exported for use as fertilizer in the past 60 years, but some 240,000 tons of guano of exportable quality is believed to remain, principally on the islands of Assomption, St. Pierre, Desnoeufs and Astove.

Contemporaneously with the growth of the reefs and sand-cays of the outer islands fringing reefs were formed on parts of the coasts of the granitic islands. Behind these fringing reefs coastal sands derived from the erosion of the reefs accumulated to form coastal flats, locally called "plateaux", and on these most of the agriculture and settlement are situated.

The geological history of the area is illustrated in the following table: -

	Coral Islands	Mahé-Praslin island group						
RECENT	Guano deposition Growth of cays Formation of atolls and patch reefs	Growth of coastal flats Formation of fringing reefs						
PLEISTOCENE	Eustatic fall of se	ea-level of 30 feet						
	Growth of Aldabra, Assomption, Astove, Cosmoledo and St. Pierre reefs	Coastal sediments at the 30-foot level						
PLIOCENE ?	Growth of reefs on the Amirantes, Mahé-Praslin, Constance and Fortune banks, accompanied by a rise of sea-level of about 300 feet, or 300 feet of subsidence. Cutting of a marine platform at —300 feet on the Mahé-Praslin bank, and perhaps on the other banks							
MIOCENE ?	(Hypothetical basalt vulcanicity to form the basis of the outer islands)	Erosion						
EARLY TERTIARY	Islanus)	Grand Barbe microgranite Silhouette and Ile du Nord syenites and microsyenites						
	——Uplift and	——Uplift and erosion——						
	(Hypothetical basaltic submarine vulcanicity)	Olivine alkali dolerites Metadolerites						
	——Uplift and	d erosion——						
LATE PRECAMBRIAN	refs. An older class of raised to beloosth-west gfor-inddeless, tAst Neigen islandel are-composed of a type see QQ feet about accelere	Quartz veins Aplites Emplacement of the Mahé and Praslin-La Digue granites						

V—DETAILS OF GEOLOGY AND PHYSIOGRAPHY

1. The Granitic Islands

The granitic islands of the Seychelles archipelago are the largest and most important group, and amount to about 90 square miles out of the total land area of the archipelago of about 156 square miles. It is on these islands that over 90 per cent of the population lives.

The granitic group occurs as scattered islands, islets and rocks in the north-centre of the Seychelles bank (Fig. 2), and occupies an area 40 miles by 50 miles in extent. Mahé is the largest island.

(1) MAHE

(a) PHYSIOGRAPHY

Mahé is 55.6 square miles in area and approximately 17 miles long by 7 miles in maximum width. The island is mountainous, with a central line of peaks reaching to altitudes just below 3,000 feet.

The island can be divided into three main physiographic regions—the central mountain range which extends in a south-east—north-west direction from Anse aux Pins to Bel Ombre and Baie Ternay; the northern part north of Port Victoria; and the southern area south of the Montagne Posée road.

The central mountain range rises steeply from the sea and from the localized coastal plateaux to summits generally between 1,500 and 3,000 feet in height. The axial summit ridge trends north-west-south-east from Mt. Noe through Morne Seychellois, the highest mountain, and past the La Misère col to the Planeau ridge south-west of Cascade. Lesser ridges of the same trend form the hills of Bayonne, Whernside, and Copolia on the north-east side, and Morne Blanc and Pot-a-Eau to the west. The shapes and orientations of the ridges are controlled to a large extent by a set of north-west-south-east and east-west major joints and dykes, and to a minor extent by north-east-south-west joints. The joints and dolerite dykes give rise to narrow deep valleys with V-profiles of which many excellent examples are visible on the air photographs.

Sub-horizontal sheet-jointing occurs conspicuously in the area between La Misère and Whernside. Here there are granite surfaces sloping at about 20 degrees to the north-west, cut by narrow gulleys eroded along joints. A similar surface is found immediately south of Morne Blanc. Bare rock surfaces due to complete removal of top-soil by land-slides and erosion are found at all levels in the mountains, and form nearly vertical cliffs, bare rounded hill sides and occasionally inselbergs such as the bare conical hill of Poulalier, west of Dan Ziles on the north-west coast. These rock faces are characteristically smooth and gently rounded, and are broken only by narrow gulleys eroded along vertical joints and by widely spaced sub-horizontal joints. Such cliffs are conspicuously developed on the north-east face of Trois Frères, the south face of Morne Blanc, and in the closely jointed area immediately south of La Misère.

Both the northern and southern parts of Mahé are less rugged than the central massif. The summits do not exceed 1,500 to 1,700 feet altitude, and in the area south of the Les Canelles road the topography is rounded, with broad, locally flat-floored valleys and moderate slopes that contrast with the form of the central massif.

Granite boulders varying from a few inches to 30 to 40 feet in diameter occur in variable concentrations at many places on the slopes of Mahé. These blocks are invariably well-rounded as a result of preferential weathering of corners and edges, and can be seen in various stages of development in the zone of weathering in

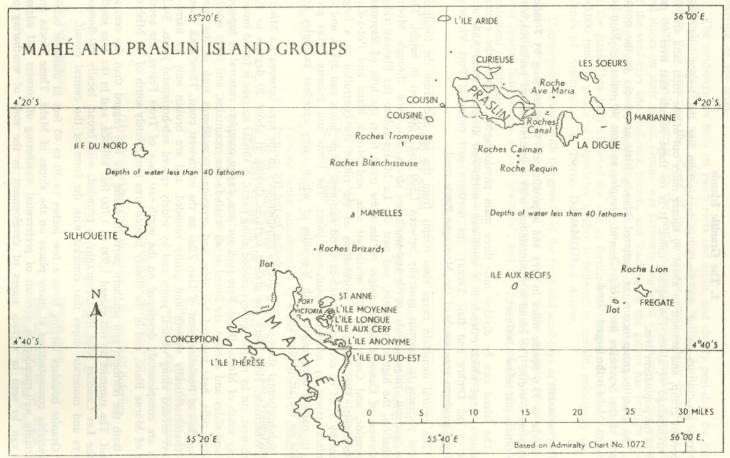


Fig. 2.—Map of the Mahé and Praslin Island groups

numerous road cuttings. As a general rule the steeper the slope the more numerous are the blocks, and in places the whole surface is littered with blocks resting on each other so as to form an almost impenetrable maze. In the higher levels of the rainforest steep slopes littered with such blocks are covered by ferns and mosses, bushes and trees, and being permanently wet are hazardous to the climber.

The flat low-lying coastal areas of calcareous sand and soil are built from the debris of the adjacent fringing reefs up to a level of 5 to 6 feet above mean sea-level. These areas are the most thickly inhabitated and intensely cultivated on the island. They are found at the head of nearly every bay around the coast, and vary from narrow sand strips to areas up to three-quarters of a mile wide. To the north-west of Port Glaud and Port Launay the "plateaux", as these areas are known locally, join outlying granite hills to the mainland, forming broad tombolos. The majority of the "plateaux" contain saline or fresh-water swamps connected to rivers and streams inland, and to tidal channels on the shore.

In two areas the form of the coastal zone differs from the normal, between Beauvallon and Dans Ziles in Baie Nord-Ouest and between Barbarons and Dondee hill on the west coast. In these areas the steep slopes descending from the hills flatten markedly at the 200-foot level, and descend gently from this level to the sea or to the coastal "plateaux". These gentle pediments form belts up to 600 yards wide, and are composed of small boulders, quartz sands and alluvium evidently deposited by streams descending from the hills behind. In these areas and in several other places broad gently rounded masses of boulders and soil are found on the floors of valleys immediately inland of the coast. In form these deposits resemble alluvial fans, but are convex in profile along both the long and the short directions, and are characterized by the presence in them of heaps of boulders of widely varying sizes. Some of these masses are clearly composed of landslide debris. Such masses occur at Bel Ombre, Beauvallon and Glacis on the north-west coast, and at Rochon, La Providence and Petit Paris on the north-east coast, and are often characterized by a shoreline littered with loose blocks of granite in great numbers. A further landslide area is occupied by the upper part of Port Victoria town, where a mass of slipped blocks and earth occurs on the northern side of the stream descending from St. Louis. This landslide occurred about the middle of the 19th century.

A well-preserved recent landslide is that on which the dairy at the Mission estate at Solitude, a quarter of a mile north-east of La Misère, is built. Here a landslide has occurred on a moderately steep slope of deep soil and weathered granite. The scar at the upper end of the slide is arcuate in plan and gives rise to a nearly vertical cliff 60 feet high. The main part of the slide took place on a fracture surface of almost perfect hemispherical shape, with rotation of the slipped mass and disintegration and down-sliding of its outer and lower parts. The heads of many of the small valleys in the area east of Solitude, on Rigi hill and on the south-east side of Whernside, show traces of old landslide scars.

Traces of small slides, of solifluction and of the movement of granite blocks are widespread, and the movements that lead to them occur mainly during the wet season. Periodically road cuttings collapse, and boulders slide down the steeper slopes. It would appear, however, that landslides are not a serious hazard under normal conditions. The large slides that have been noted above almost certainly were initiated by earth tremors.

Fringing coral-reefs are found off-shore along the greater part of the eastern coast. On the western side, however, they are narrow and confined to sheltered bays.

The continuous fringing reef in the Port Victoria area, between Ile Sud-Est and Anse Nord-Est, is characterized by its highly sinuous and steep outer margin, and by the occurrence of deep pools, narrow boat-channels penetrating almost to the

shore, and outlying patch reefs. In these features it differs from all other fringing reefs in the archipelago, which are characterized by a much more regular outline, such as is found along the eastern coast in the vicinity of Anse Aux Pins and Anse Royale. The differences in form are due in the main to the less exposed position of the sinuous reefs in the Port Victoria area, owing to the protection afforded by the group of off-shore islands and their fringing reefs. The steepness of the reef margins may be accounted for by the lack of detritus, and the sinuous nature of the margin is due to the lack of strong off-shore currents and the absence of the smoothing effect of heavy surf. In fact these reefs show many of the morphological features of lagoon reefs. The narrow boat-channels are in some cases connected to the mouths of rivers, as at Rochon, Mamelles and Cascade, and in these cases the channels are attributed to the inhibition of coral growth by muddy river-water.

When Mahé and its neighbouring islands are viewed from a mountain height or from a distance of 20 to 30 miles, they give a strong impression of being the tops of a partly submerged mountainous land. The step slopes that descend into the sea, the lack of grading of the river-profiles to sea-level, the absence of nearly all the features seen on mature and moderately stable coasts, all lead to the conclusion that the islands represent the remnants of a formerly greater land-mass which has become partly submerged in geologically recent times (see pp. 8-9).

In summary therefore, the land forms on Mahé typify the results of tropical weathering on massifs of homogeneous and resistant rock. The steep slopes are often of rounded bed-rock where soil wash or landslides have occurred. On more stable slopes quantities of boulders litter the surface as a result of removal of soil and the matrix of weathered rock. The land-forms are governed primarily by joints, fractures and dykes, giving the drainage a rectilinear pattern. The valleys are steep-sided and often choked by boulders too large for the rivers to transport. On the coast marine erosion has had little effect on the resistant rocks, but coastal plateaux of coral and algal sands have been built up behind the fringing reef, mainly on the exposed eastern coasts.

(b) GEOLOGY

Mahé is almost entirely formed of hornblende granite, with minor textural varieties such as granite porphyry. In localized zones on the coast xenolithic rafts and associated hybrid rocks of tonalitic, dioritic and gabbroic composition are found, and the whole mass is cut by aplitic dykes and veins. Dolerite and basalt dykes of a considerably younger age cut across the granitic massif (see geological map, at end).

Some mention of the variability of exposure on Mahé is necessary. Along the coast rock exposure is excellent in low cliffs and on wave-beaten rock surfaces, but there are breaks in the coast section where the calcareous sand coastal "plateaux" occur. Immediately behind the coastline, however, the slopes are of red-brown soils and quantities of granite boulders. These boulders are usually different from the types seen in places close by, showing that they are derived from the hinterland by landslips and solifluction, or simply by the progressive lowering of the surface by erosion, the blocks remaining at surface. In the hinterland exposure is variable, for there are cliffs and exfoliation pavements of bare rock interspersed with substantial areas containing only superficial blocks. The stream beds are generally choked with derived blocks, and bed-rock exposures in them are rare. It is, therefore, not easy to discover the structure of valleys, and although it can be inferred that most of them are cut along major joints, the occurrence of dolerite float in others suggests the presence of dykes. Areas of deeply weathered granite and superficial blocks conceal much of the solid geology. Nevertheless, the presence or absence of unusual rock types among the boulders, and variations in the nature of the soil give some hints on the nature of the underlying bed-rock.

(i) The Mahé Granite

The Mahé granite is the basis of the greater part of the island, and in the absence of varieties showing intrusive contacts is regarded as a single intrusive. The granite is of medium grain size with little variation, the grains averaging between 5 and 7 millimetres. When fresh it is pale grey, the felspars being white to cream with a tendency in some types to a pink tinge. The quartz grains are glassy and slightly smoky and frequently occur in aggregates. The ferromagnesian minerals are normally finely granular aggregates of fibrous hornblende occurring as small spots, but sometimes minute biotites can be made out. Hand-specimens vary in colour from the pale mottled grey of the fresh rock to the buff and pale grey-brown shades of the slightly weathered rock, when colour variations depend on the degree of sericitization of the alkali felspar. Weathered surfaces are buff-grey in colour grading to red-brown on boulders still in the soil, owing to the formation of limonite and goethite by the breakdown of the ferromagnesian minerals.

Locally the granite is full of basic xenoliths, which frequently exhibit flow alignment as in the quarry at North-East Point. Along the north-west coastal zone between Dans Ziles and North Point there are larger hybrid masses of dioritic and gabbroic rocks. Some of the more interesting of these xenolithic areas are described below.

In the road cutting three-quarters of a mile north of Glacis village the xenoliths are numerous and occur in a pale granite with larger than usual hornblende grains. At the shore opposite Ilot the granite is similar, with diorite and hornblende-biotite gneiss xenoliths, and having a faintly streaky appearance owing to variations in hornblende content. In the first bay south of the point opposite Ilot there are large exposures of hornblende diorite with patchy distribution of amphiboles and streaks of hornblende granite resulting from permeation by the surrounding granite. The dioritic hybrid rock is cut by pale brown aplite dykes which are locally full of angular diorite xenoliths, and this assemblage is traversed by porphyritic dolerite dykes. Similar dioritic masses showing gradational changes to hornblende granite are found on the coast a quarter of a mile south of Glacis village.

A further zone of intermediate and basic rafts and xenoliths occurs along a half-mile stretch of coast between Northolme Hotel and Sunset Café, from one and a quarter to one and three-quarters of a mile north of Beauvallon. The rocky point on which Sunset Café is situated is composed of rafts of hornblende diorite with relics of gabbro up to 50 feet long. These rocks are cut by north-east-trending narrow shear-zones in which there is mild granulation with the formation of much epidote. Immediately south of the point there are numerous narrow basalt dykes, which branch and are off-set along an east-west joint system. The basic rocks in the zone consist of large xenoliths of hornblende diorite with small amphibolite xenoliths, some of which show porphyroblastic felspars adjacent to granite contacts. The assemblage is penetrated by pale aplites and aplogranites in the form of non-planar dykes and veins. At the margins of the xenoliths there is a transition to hornblende granite through narrow zones of hornblende-rich appinitic hybrids in which the hornblende prisms are sub-parallel, giving the rock a foliated appearance.

Dioritic and granodioritic xenolithic granites form the rocky point immediately north and north-west of Bel Ombre Church. The main rock type is hornblende-biotite granodiorite, a medium-grey rock with subhedral plagioclase insets in a fine ferromagnesian matrix. The granodiorite contains angular blocks of sheared schistose metadolerite, and at the eastern end of the exposure the granodiorite passes by a narrow transition zone to normal Mahé granite. The granodiorite with metadolerite xenoliths is cut by a plane granite aplite vein, and this complex is cut in turn by plane unaltered dolerite dykes. Further west in the same exposure the granodiorite becomes more basic with hornblende diorite and amphibolitic patches with felspar insets, which are

evidently partly recrystallized and felspathized basic igneous rocks. The assemblage is again cut by dolerite dykes. The sequence of events that can be deduced from these exposures is:—

- Granite intrusion (Mahé granite)—recrystallization and felspathization of doleritic and amphibolitic xenoliths and rafts.
- 2. Shearing along north-east-south-west lines.
- 3. Aplite vein injection.
- 4. Intrusion of dolerite dykes.
- 5. Slight shearing along dolerite dykes with formation of epidote.

The account above covers the main outcrops of xenolithic granite, which all occur on the north-west coast. There are, however, other small outcrops of similar rocks elsewhere, or of loose blocks presumably derived from xenoliths within the granite. One such occurrence is at the western end of Anse Poules Bleu, south-west Mahé, where there is a zone 50 yards wide in granite of coarse vogesite, a green-grey rock studded with euhedral hornblende phenocrysts. The occurrence nearby of loose blocks of a monzonitic rock with epidote and saussurite suggests that the vogesite is a xenolith incorporated in the granite. Similar monzonitic and hornblende diorite blocks with pyrite were seen at the junction of the motor-tracks north-east of Petit Anse, and a quarter of a mile west of Baie Lazare Church, in the same area.

An exposure 40 feet long at the roadside at the 300-foot level on the western side of the Montagne Posee pass consists of almost unaltered gabbro. Its relationship to the enclosing granite is not exposed.

Loose granite blocks and scattered poor exposures in the area of La Misère reveal the presence of intermediate hornblende xenoliths. On the northern side of the col by the roadside at Pont Sec and at the top of the col hornblende monzonite, granodiorite and metadolerite xenoliths, often with disseminated pyrite, occur in the granite, and similar rocks with a variable hornblende content are found loose in the bed of the Mamelles river, which drains this area.

Under the microscope the Mahé granite is seen to be remarkably homogeneous. Its principal character is the ubiquitous presence of microperthitic felspar, which often tends to form insets slightly larger than the quartz, and much larger than the ground-mass of plagioclase, perthite and ferromagnesian minerals. The perthites are frequently Carlsbad twinned and display a tendency to stout tabular habit, but are generally subhedral, with sutured margins and small areas of albite. Often the margins are sieved with globular quartz, and more rarely mortar structure at inter-granular boundaries occurs when the granites are slightly sheared. In composition the perthites are of turbid orthoclase with clear spindle-shaped lamellae of albite, and in a number of sections patch-perthite is developed also, and in these rocks the place of perthite is locally taken by microcline.

Quartz occurs characteristically as aggregates of rounded corroded grains up to 6 millimetres in diameter showing slight optical strain. There is, however, a considerable variation in quartz content in these rocks, and in the quartz-poor varieties it occurs as intergranular crystals, often in myrmekitic intergrowth with oligoclase, or as vermicular grains in perthite.

Plagioclase occurs mainly in the patch-perthite and sometimes is not present as discrete crystals. In the majority of specimens, however, oligoclase forms small stout subhedral prisms between the larger grains. In a few cases, usually found in areas of resorbed basic xenoliths, the plagioclase content equals that of perthite and the rocks become adamellites. Two examples of these are specimen S/479*, from the western

^{*} Specimen numbers refer to specimens in the regional rock collection of the Mines and Geological Department, Nairobi.

end of Anse Poules Bleu, and specimen S/28, from the top of Signal Hill, north of Port Victoria. In the xenolithic areas hornblende granodiorites and tonalites are found and these are closely associated with appinites and diorites.

The amphibole of the granite is brown or green, strongly pleochroic, with small extinction and optic axial angle, and is a variety of hastingsite. It is commonly associated with small brown biotite flakes, and can be seen to be partly replaced by that mineral. In rocks in which slight shearing has taken place chloritization of the amphibole is evident, and in these cases epidote occurs also. Among the accessory minerals apatite and sphene are the commonest; zircon is also present and small grains of ilmenite commonly occur within or adjacent to the ferromagnesian aggregates. Epidote occurs rarely as small grains included in felspar, when it has the appearance of a primary mineral. Quantities of epidote and zoisite occur sieving the granites in the immediate vicinity of sheared dolerite dykes.

(ii) Porphyritic Granites and Granite Porphyries

In western Mahé a substantial area between Port Glaud, Port Launay and Mare Cochons, and including the islands of Thérèse and Conception, is composed of porphyritic granodiorite and microgranite. These rocks are very similar to the Mahé granite in general appearance and mineralogy and grade into granite imperceptibly by increase in the size of the groundmass minerals. The porphyritic granite is therefore regarded as a facies of the Mahé granite rather than a separate intrusive.

The porphyritic granites have porcellanous cloudy perthite phenocrysts of subhedral form reaching up to 10 millimetres in size set in a matrix of small anhedral perthites, prismatic oligoclase, fibrous green hornblende and occasionally biotite also. Granite porphyries of similar composition, but in which anhedral corroded quartz phenocrysts occur together with alkali felspar were seen at the south-eastern end of the outcrop three-quarters of a mile south-east of Port Glaud Church (specimen S/21), where the porphyry contains xenoliths of cognate porphyritic microgranite. A specimen (S/106) of porphyritic granite collected from one mile north-north-west of Port Glaud Church has albite phenocrysts in place of the usual perthite.

Two specimens (S/401 and S/402) collected from Thérèse Island differ somewhat from the usual rock of the mainland in having a low quartz content, and the perthite phenocrysts are sieved with flecks of green hornblende and iron ore.

A further area of granite porphyry was found on the west coast of Anse Louis. The rocks here are composed of subhedral quartz and perthite phenocrysts in a granular matrix of sodic plagioclase, quartz and aggregates of hornblende. Slight chloritization of hornblende is visible in one thin section. Cubes of pyrite up to one centimetre in size were seen in these rocks four hundred yards south of Anse Boileau Church.

(iii) Granite of St. Anne-Ile aux Cerf Island Group

The granites of the five islands east of Port Victoria differ slightly from the Mahé granite, and form a separate category. They are distinguishable by their hypiodiomorphic inequigranular texture and the extreme scarcity of plagioclase. The felspar is almost entirely perthite as ragged grains with sutured margins and microline-perthite is not uncommon. The quartz grains are rounded, often vermicular and extensively corroded. Ferromagnesian minerals are confined to sparse intergranular aggregates of deep greenish brown hornblende granules, associated with iron ore and frequently altered to deep brown ferriferous biotite. Mortar structure is common on

grain boundaries, and most of these rocks have suffered some granulation and recrystallization. Faint gneissosity is visible in a few specimens. The Ile aux Cerf and St. Anne granites are therefore slightly deformed alkali-granites, which may represent a marginal facies of the Mahé granite.

(iv) Chemical Composition of the Granites and Allied Rocks

Three analyses of Mahé granite, one of granite aplite and one of quartz diorite are given below:—

					per cent	per cent	per cent	per cent	5 per cent
					o amsion r	de alubiga	B) somme	and Aristi	ed African
SiO ₂	II O		1		72.83	74.12	71.17	71.78	52.60
A12O3					13.20	12.78	13.34	14.63	17.12
Fe ₂ O ₃					1.09	1.40	2.03	0.91	4.19
FeO					1.50	1.28	2.20	1.32	5.52
MgO	ns. cen	10.1	oa.b		0.05	0.08	0.28	0.09	4.30
CaO		DOM:	CHILLIAN CO.		0.95	0.51	0.92	0.97	6.99
Na ₂ O				T Ale	4.34	4.08	4.48	4.55	3.76
K ₂ Ō				1 45	4.85	5.05	4.30	3.42	1.90
H2O -	110°C.	milani	adimi a	musig	0.09	0.10	0.20	0.12	0.10
Loss on	ignition	abov	e 110°0	Z	0.46	0.60	0.58	0.99	0.72
TiO ₂		100	DVARATI	HUMA	0.38	0.25	0.64	0.52	1.48
P2O5	EIK DE	0X 30	Inte I	net	0.04	0.04	0.09	0.05	0.68
MnÖ	Elage	phode	chipte	g.vi	0.12	0.08	0.15	0.10	0.23
	T	otal	EDGO A	18.30	99-90	100.37	100.38	99.45	99.59

Anal.: G. Luena, Geological Survey of Tanganyika.

				No	RMS			
Ouartz	om k	iscla sii	ghtly	27.00	29.58	25.86	29.82	3.24
Corundum	D-DOE	INT ORS	2017	HOTE BAIDS	IDS TOPPE	Din Tur is	1.53	SOMI
Orthoclase	as Da	HOS E	TERR	28.91	30.02	25.58	20.02	11.12
Albite		o non-	bns 9	36.68	34.58	38.25	38.77	31.96
Anorthite				1.95	1.39	3.06	4.17	24.19
Diopside	7 7.60		40. A	1.70	0.96	0.46	her well	4.70
Hypersthene		Art. of		0.53	0.50	2.05	1.12	13.03
Magnetite				1.62	2.09	3.02	1.39	6.03
Ilmenite	HIOL	10		0.76	0.61	1.22	0.91	2.89
Apatite	to da	escale o		0.33	o he stell	0.34	0.30	1.68

(calculated: W.P.)

- 1. Granite, north-west end of Grand'Anse, Mahé.
- 2. Granite, near the trigonometrical beacon, Ile aux Cerf.
- 3. Granite, north end of Anse aux Pins, Mahé.
- 4. Aplite, Anse Etoile, Mahé.
- 5. Quartz diorite, Baie Nord Ouest, on the coast north-east of Bel Ombre, Mahé.

The chemical compositions of the granite and the granite aplite fall well within the granite field, but with a tendency to slightly low contents of silica and alkalies so that they appear to incline towards granodiorites. This is brought out by the norms, in which normative plagicalse is in excess of normative orthoclase.

The analyses of the granites are similar to those of many of the larger granite masses of other parts of the world.

These conclusions are confirmed by the partial analyses of further samples of the Mahé granite given below:—

			per cent	per cent	per cent	4 per cent
MgO	- SVISI	uni.	0.26	0.09	0.12	0.22
CaO	10. bi	15 .JT	0.68	0.31	0.97	0.68
Na ₂ O			3.96	4.45	4.05	4.46
K ₂ O	to sis	SOSTA	5.06	4.70	4.59	4.49
mah la	emi e	Assis.	5	6	7	8
			per cent	per cent	per cent	per cent
MgO	Posee	ingne relatio	0·51	0·12	per cent	figurilo s
MgO	Posee onship os sut	elagne relatio	enital sett na	<u>forum) 280</u> Floring G	energy le	0.58 1.02
MgO CaO Na ₂ O	Posce onship os sut	cingno relatio contac in a	0.51	0.12	0.39	0.58

Anal.: A. P. Muley, Geological Survey of Tanganyika.

- 1. Granite, west end of Ile Moyenne.
 - 2. Aplite, north end of Anse Nord-Est, NE. Mahé.
 - 3. Granite porphyry, Cascade river, Mahé.
 - 4. Granite, Montagne Posee road, Mahé.
 - 5. Granite, Mare aux Cochons, Mahé.
 - 6. Granite, on coast south of Anse Etoile, Mahé.
 - 7. Granite, Glacis, NW. Mahé.
 - 8. Granite, north end of Anse Nord-Est, NE. Mahé.

(v) Dolerite Dykes

Dolerite dykes occur plentifully in the Mahé granite, and wherever they are seen they cut the granite and its included xenoliths and veins, and are the youngest intrusives. The main occurrences of dykes are on the north-west coast at Bel Ombre, and between Anse Boileau and Anse Polite. A number of dykes were seen also in the La Misère area.

The dykes are generally between a few inches and thirty feet wide, and are vertical in attitude. Frequently the narrow dykes are basaltic in grain size, and are offset along tapering joints in the granite. Shearing is seen along the length of some of the dolerites resulting in the formation of hornblende schists, epidote-rich lenticles and prehnite veins, but such shearing is limited to zones an inch or two wide and of little lateral extent.

Seven of the dolerites collected are pyroxene dolerites, of which four have plagioclase phenocrysts. In the hand-specimen they are compact dark grey rocks of variable grain size and phenocryst content. The majority are substantially altered to uralitic metadolerites. They then often retain ophitic texture, but the plagioclase

prisms are variably turbid or occasionally saussuritized, the pyroxene is converted to a felted mass of uralite with a dusting of magnetite, and small pools of chlorite are associated with the uralite. An exceptionally coarsely porphyritic dyke (specimen S/125) was found as loose blocks at the western end of L'Ile Longue. This rock contains white closely-spaced tabular plagioclase phenocrysts up to three inches in size, some containing brown glassy patches. The matrix consists of variably saussuritized plagioclase, prominent magnetite grains and uralite, with relics of pigeonite. Chlorite and epidote occur as alteration products. The southernmost of the two dykes at the north-west of Mahé (specimen S/24a) is similar though more fine-grained and all the pyroxene has been converted to uralite. A notably porphyritic dolerite with tabular plagioclases up to one and a half inches in size was found at the north-west coast of Ile aux Cerf (specimen S/117).

Four completely unaltered olivine dolerites without plagioclase phenocrysts were found, however, and probably belong to a separate intrusive episode. These rocks are represented by specimens S/100 from the western end of Trois Frères; S/155 from Père Mort, south-east of La Misère; S/395 from Liberia, south-west of Mt. Whernside; and S/505 from Ile Sud-Est. In three of these rocks, specimens S/155, S/395 and S/505, analcite was recognized as a mesostasis or as minute veins in plagioclase. The analcite must be primary for there is no trace of deuteric alteration, and the rocks are alkali dolerites.

A coarse olivine "gabbro" was found on the Montagne Posee road, three-quarters of a mile north-east of Anse Boileau Church. Its relationship to the surrounding granite is not exposed. This rock (specimen S/430) contains subhedral zoned labradorite phenocrysts and occasional augite phenocrysts in a groundmass of plagioclase, augite, olivine and iron ore. The groundmass augites are sometimes ophitic. This gabbroid rock may be related to the olivine dolerites.

The plagioclase of the few dolerites that have been sheared has become granulated and sodic, and in these rocks rare quartz grains can usually be found. An extreme example of shearing was noted in a dolerite, which is cut by an unaltered dolerite, outcropping on the shore north of Bel Ombre Church (specimen S/92). The sheared rock is a hornblende schist, with actinolite, actinolite-chlorite and actinolite-chlorite-epidote lenses in a matrix of actinolite and oligoclase grains.

Three chemical analyses of the dolerites are given below:-

					per cent	2 per cent	per cent
SiO ₂			1.9		45.74	47.61	47.68
A1 ₂ O ₃	nd win	n' oli	TENN M	BIN	17.22	18.58	17.19
	otis br	ins. an	and ve	ell li	6.28	3.36	3.13
Fe ₂ O ₃	teeoo	123W-1	nome	di ne	7.84	6.90	7.95
FeO			Today.		5.13	4.28	7.52
MgO					7.67	10.23	11.21
CaO					3.33	3.80	2.61
Na ₂ O		1:00	asidon	ive	0.60	0.60	0.21
K ₂ O	1000		200 20	dvh	0.10	0.11	0.08
$H_2O - 1$	10°C.				2.39	2.23	1.19
Loss abo	ve 110	C. on	ignitio	n	2.53	1.48	1.25
TiO ₂	usts. c	197.90			0.73	0.72	0.02
P ₂ O ₅	tori p					0.16	0.19
MnO					0.22	0.10	0 17
	Total	1600	F BHBX	GIV.	99.78	100.06	100.23

Anal.: G. Luena, Geological Survey of Tanganyika.

a control and had	sagao	Links (Non	MS	undaya-ati	nach Adagh	
Quartz	stlolise	phast 1	Gldaid	0.42	destree great	obtintion and	
Orthoclase	ROUBBE	IO HOL	1501834	3.34	3.34	1.11	
Albite	and si	JI JEG	gests t	27.77	31.96	22.01	
Anorthite	all stee	19 10 3	C-Stage	30.86	31.97	34.75	
Diopside	To Date	midd i	abreid k	2.48	11.60	16.90	
Hypersthene	30000	id sitt	Opd Do	17.15	0.48	7.67	
Olivine	dele la	10.1	bdillans	lan Alab ab	8.74	9.69	
Magnetite		et of s	Te 9	9.05	4.87	4.41	

Apatite 1.68 1.68 1.11

Ilmenite 4·71 2·89 2·28

(calculated: W.P.)

- 1. Basalt dyke, coast south of Glacis, Mahé.
- 2. Porphyritic dolerite dyke, west end of L'Ile Longue.
 - 3. Dolerite dyke, north end of Anse Nord-Est, Mahé.

Two other dolerites and a dark-coloured dyke were analysed for alkalies, calcium and magnesium only:—

				4 per cent	5 per cent	6 per cent
MgO	 ox to be	studi	ed in	7.39	7.92	1.19
CaO	exemply.	- 174		9.82	6.98	1.25
Na ₂ O	 Z III.	HOLLS		2.76	3.24	5.91
K ₂ O	THE HOLD	displa	Suring Strice	0.98	0.70	3.74

Anal.: A. P. Muley, Geological Survey of Tanganyika.

- 4. Dolerite xenolith in granite, Glacis, Mahé.
- 5. Dolerite Dyke, Glacis, Mahé.
- 6. Dyke, Anse Etoile, Mahé.

It is clear that though basaltic in appearance, the dyke-rock at Anse Etoile is much more felspathic and potassic than basalts and must be a silica-rich rock.

The analytical results show that the dolerites approximate to the composition of oceanic basalts, as represented for example by the average basalt of St. Helena (Turner and Verhoogen, 1960, p. 188), and this is confirmed by the occurrence of notably olivine-rich dolerites which have been mentioned above. The Seychelles dolerites are distinguished from the tholeiite-quartz diabase flood-basalts, which might have been expected to occur in a "continental" environment associated with granite, by their low silica and potash percentages. In the three full analyses given above the alumina is considerably higher than in most basalts, and is explained by the high felspar content of the dolerites. In the L'Ile Longue dolerite there are many large plagioclase phenocrysts, making up approximately 40 per cent of the total rock volume.

(vi) Structures in the Granitic Rocks

The Mahé granite has flow foliation in only a few places in the vicinity of xenoliths, and in these cases the foliation is sub-parallel to the xenolith margins.

Among the granite exposures on Ile aux Cerf, Longue and St. Anne, however, there are faintly gneissose granites in which a crude foliation is imparted by ill-defined lighter and darker streaks with varying ferromagnesian mineral content. The nature of this slight gneissose structure suggests that it is due to primary flow-banding, possibly emphasized by movement at a late stage of crystallization, for mortar texture and granulation of grain margins are notable in thin sections of these granites. The suggestion that there was flow is supported by the presence on the north-west coast of St. Anne, at the western end of Anse Cabot, of slightly sheared flow-orientated xenoliths trending north-east-south-west.

Structures originating from deformation of the Mahé granite after consolidation are limited to narrow shear-zones normally less than one inch in width, in which the granite is converted to a dark fine-grained crush-rock with porphyroclastic texture. Of the 12 cases of shearing noted two were at the margins of dolerite dykes, with accompanying saussuritization of the dolerite and the formation of prehnite veins. One of these was observed at the rocky point north-east of Bel Ombre, and the other in the valley a quarter of a mile north-east of Port Glaud. Several cases of narrow shears in granite containing quartz veins were observed, for instance in the valley above Anse Major on the west coast, at the south end of Anse Forbans on the south-east coast, and on Ile aux Vaches. In one exposure, however, at a point on the coast north-west of Dondée, north-easterly-trending shears displace north-westerly-trending quartz veins. Many instances were observed of slight movement on north-westerly-trending joints; such movement is invariably slight and gives rise to granulation of the granite fabric along planes usually one to two millimetres wide. Iron-staining on such fractures is commonplace.

Jointing is well-developed in the Mahé granite, and plays a leading part in determining the direction of valleys and gulleys. The dominant system is of large north-westerly-trending joints, which are prominently displayed on air photographs of the central massif. Minor joints form a symmetrical system about these major joints and trend west-north-west and north-north-west. They are best developed between Mt. Whernside and Morne Seychellois. A very widely spaced set of joints trending east-north-east also occurs, approximately bisecting the obtuse angle between the minor joints, but locally they have a more northerly trend.

The dolerite dykes often occupy the major and minor joints trending into the north-western quadrant. Only two dykes trending north-east were observed. The quartz veins similarly trend north-west except for two examples. Most of the shears trend north-east, however, and in nearly all cases indicate a displacement of the western side to the south-west. These shears are the latest structures recognizable in Mahé, for they displace granite, quartz veins and dolerites alike.

The orientation of the quartz veins and major joints suggests that after the solidification of the granite and its veins, stresses developed involving north-east-south-west compression followed by tension, at some later stage dolerite dykes being injected into the joint system. Slight shearing then occurred on north-easterly directed lines, the sense of the movement being a south-westerly displacement on the western side of the shears.

(vii) Coastal Sediments

Coastal "plateaux" consisting mainly of calcareous beach sands occur at numerous localities on Mahé and the adjacent islands, and are the sites of most of the intensive agriculture and are also the most densely populated areas. The plateaux consist of level expanses of sand fringing the granite massif, reaching a height of about 6 feet above mean sea-level, and are best developed in broad bays with fringing reefs on the more exposed coasts. Thus, the largest plateaux are on the east coast, at Anse aux

Pins and Anse Royale, but others are found on the west coasts of Anse à La Mouche, Anse Boileau, Grand 'Anse, Port Glaud, Port Launay and at Beauvallon. Many other smaller "plateaux" occur, and grade down into small bay-head beaches.

The sand of which these plateaux are built is derived almost entirely from the erosion of the fringing reefs, and consists of broken up coral rock, molluscs and algae, and in this respect the composition and structure of the plateaux differs little from that of the sand-cays of the coral islands. The structure of the plateaux is, however, locally modified by the effect of streams descending from the mountainous hinterland, which have deposited spreads of quartz sand near their mouths, and which form swamps and tidal channels where clays are frequently deposited. Furthermore, there are no pronounced storm-ridges, gravelly deposits or dunes such as characterize the sand-cays of more southern latitudes, because of the absence of severe storms.

In general, the seaward and major parts of the plateaux are composed of calcareous sands covered by a variable soil rarely more than 12 inches thick. In the interior parts of the plateaux, however, soils washed from the slopes behind and lenses of quartz sand form an increasing proportion of the plateaux until a narrow fresh-water swamp, which frequently occurs at the inland margin, is reached. In the swamps, which vary from narrow fresh-water channels to broad areas of marshy ground, the soils are dark-coloured glutinous clays. Notable expanses of quartz sand forming shallow alluvial fans occur only where large streams emerge on to the coastal plateau, at Grand Anse, Bel Ombre, Rochons, Mamelles, Petit Paris and Cascade. In the last three areas the quartz sands occur also as deltas on the inshore part of the reef platform (see pp. 130-131).

The only plateaux to be studied in any detail by pitting was that at Grand Anse, where a line of pits extending from close to the mouth of the tidal swamp to near the end of the La Misère road was measured. The sections found are given below in order progressing inland from the sea, and are at about 75-yard intervals:—

(1) Section in pit on sand-spit between the tidal channel and the shore, 10 yards from the sea:—

	Inches
Pale brown sand, slight humus staining	17
Fine sand, narrow layers of shell fragments and quartz	
grains	25
Well-laminated quartz sands with mollusc fragments	
and fine gravel	8
Sand with 2-inch layer of quartz	3
Faintly laminated sand with mollusc fragments	19
Water-level 73 inches below top of section.	

(2) Section in pit on edge of tidal channel 80 yards from the shore:—

						Inches
Grey loamy sandy soil	TEUP	cent	199.0	sand,	Pale	9
Grey-brown sand	neup	deficed	-III. di	sand. w	Pele	6
Cream sand	ead ,	dstone	ous san	calcarec	Pale	19
Pale grey-cream sandy clay	with	roots				3
Pale sand, slightly coherent		orad sa	incine	r-level 5	DIBAA	19
						8
Pale sand, loose	ins n	quarr eases in	it iner	od that	HOUSE BE	12

Water-level 76 inches below top of section.

(3) Section in pit on plateau 150 yards from the shore: - Section in pit on plateau 150 yards from the shore:	
Inches	
Grey slightly loamy disturbed sand 9	
Pale brown sand	
Pale sand	
Cream sand with nodular cementation	
Water-level 81 inches below top of section.	
(4) Section on plateau 225 yards from the shore:—	
Inches	
Grey-brown loamy sandy soil 18	
Laminated pale sand with quartz-rich layers 26	
Quartz sand, slightly cemented 1	
Quartz-rich pale sand 8	
Quartz-rich sand 5	
Water-level 57 inches from top of section.	
(5) Section on plateau 300 yards from the shore and 15 yards from margin of marshy area:—	
Inches	
Grey clay with much quartz 9	
Grey-brown clayey sand with clay nodules 9	
Water-level 18 inches below top of section.	
(6) Section on plateau 40 yards south-west of end of La Misère road 400 yards from the shore and at edge of marsh:—	,
Inches Constant	
Grey-brown quartz sand with clay matrix	
Water-level 31 inches below top of section.	
(7) A further section was measured in a pit by the road-side 600 yards west north-west of the end of the La Misère road:—	
Inches	
Grey loamy sand 12	
Pale sand, 50 per cent quartz 12	
Pale sand with ill-defined quartz-rich layers 70	
Pale calcareous sandstone, base not seen 5	
Water-level 99 inches below top of section.	

The sections illustrate that quartz is an important constituent of the plateau at Grand Anse, and that it increases in amount away from the sea, and forms much of the visible part of the swamp deposits.

Screen analysis was carried out on samples taken at various depths below surface from the sections quoted above:—

Screen	mesh (B.S.)	rabais e. din	per cent	per cent	per cent
Retained on 8	office de	psowi	ed Ma	0.4	0.9	0.2
- 8+ 16				3.5	3.4	2.4
-16+30	HALL BE			26.4	14.8	14.3
-30+60	1000	a cumin	tear pa	53.0	47.1	42.5
-60+100	200 0	as als	m spu	15.4	31.9	36.3
-100	my n	OUTTO	228 9	1.3	1.9	4.3

- 1. Pit 1, 18 to 24 inches
- 2. Pit 1, 48 to 54 inches
- 3. Pit 1, 64 to 70 inches

Screen mesh (B.S.)		B.S.)	dahé.	4 per cent	5 per cent	6 per cent	7 per cent	8 per cent	
Retained on 8	12988	HW 616	dish	nil	nil	0.9	0.3	2.5	
-8+16	TUE I	ani ra	RETT	4.1	5.9	18.1	6.6	36.9	
-16+30		1.5	B 278	16.4	19.5	21.4	45.4	38.2	
-30+60	Do. I			61.1	56.1	25.1	37.4	16.8	
-60+100				16.7	16.6	27.3	9.1	4.0	
-100				1.7	0.9	7.2	1.2	1.6	

- 4. Pit 2, 18 to 24 inches
- 5. Pit 2, 48 to 54 inches
- 6. Pit 2, 72 to 78 inches
- 7. Pit 3, 24 to 30 inches
- 8. Pit 3, 42 to 48 inches

				12				
Screen mesh (B.S.)	per cent							

rains, and are accumulations of eluviated top-soil in p

Retained on	8	0.1	7.6	0.3	12.4	0.3	1.0	1.0	1.2
-8 + 16		1.2	44.5	1.3	46.8	21.4	15.4	28.9	37.8
-16+30		4.9	26.9	16.4	29.9	45.2	60.3	57.7	51.9
-30+60	II DUI	18.4	9.2	32.7	7.6	29.3	21.4	11.2	7.4
-60+100	Jales:	55.8	8.5	37.8	1.8	2.0	1.3	1.0	1.0
-100	TLAKE	19.6	3.3	11.5	1.5	1.8	0.6	0.2	0.7

- 9. Pit 4, 24 to 30 inches
- 10. Pit 4, 42 to 48 inches
- 11. Pit 4, 60 to 66 inches
- 12. Pit 5, 6 to 12 inches
- 13. Pit 6, 24 to 26 inches
- 14. Pit 7, 42 to 48 inches
- 15. Pit 7, 66 to 72 inches
- 16. Pit 7, 90 to 93 inches

Examination of the size fractions shows that in all cases the plus 16 mesh material is composed largely of quartz grains, often in aggregates. Rounded mollusc shell fragments are also common. In samples 12 and 13, taken from the pits near the swamp the minus 16 mesh material is nearly pure quartz, with an increasing proportion of brown clay in the fines. Among the remainder of the samples the minus 16 mesh fractions are mostly of calcareous sand, with only a little quartz.

In pits 2, 3, 4 and 7 the sands at levels between 5 and 20 inches above water-level display evidence of calcareous cementation varying from a slight tendency to form friable sandstone to the formation of hard calcareous sandstone nodules. The cementing material in each case is fine-grained calcium carbonate. This type of cementation near the water-level in calcareous sands was also observed many times in the sand-cays of the outer islands, where the association with water-level was noted repeatedly. The cementation is due to the breakdown of calcium bicarbonate in descending meteoric water on contact with slightly saline ground-water, and is comparable in nature if not in degree to the formation of beach sandstone on beaches. The subsurface sandstone layer at Grand Anse and on the sand-cays is, however, gradational and not nearly so hard and well-developed as beach sandstone. Where the layer exists, however, it is of some agricultural importance, for it may form a bed sufficiently hard to prevent the penetration of coconut-palm roots to water-level, with detrimental effect on the palms.

(viii) Superficial Deposits-Soils, Laterites and Clays

The granite of Mahé weathers deeply to a reddish brown lateritic soil, which can be seen in road cuttings to extend locally to depths greater than 30 feet. Commonly the texture of the subsoil shows that the granitic felspars and ferromagnesian minerals have weathered to kaolinitic red-brown iron-stained clay in which quartz grains are set in their original positions. The granites have therefore weathered deeply in situ, as is amply confirmed by the observation of partly weathered granite boulders at various levels in sections. A true soil layer is generally thin or absent, being rarely more than 18 inches thick, and is usually grey-brown in colour and often contains charcoal fragments derived from burnt vegetation. The grey-brown soils with roots occur mainly on well-drained slopes, but brown sticky clays with few quartz grains are also occasionally found in hollows and flat-floored valleys high in the mountains, and are accumulations of eluviated top-soil in poorly drained areas. Over large areas on the steeper slopes, however, top-soil is virtually absent, having been eroded away and having had no chance to re-form.

The innumerable granite blocks and boulders that litter the surface of Mahé, even on the steepest slopes, are derived from the partly weathered granite from which the weathered matrix has been washed away, leaving the blocks on the surface. Erosion has proceeded to such a degree that on some quite gentle slopes large expanses of bare rock are exposed, with an occasional granite boulder perched on them. In Mahé therefore, and in most of the granitic islands, erosion has outstripped the processes of weathering and soil formation owing to the high relief and high rainfall, and to a certain extent to the recent destruction of much of the vegetation by man. Extreme examples of soil erosion, where sheet erosion has been overtaken by gulley-formation, are to be seen on the bare ridge-tops of the northern slopes of Aux Mornes. Here expanses of bare sub-soil are littered with granite gravel, harder lumps of lateritic soil and quartz fragments, forming a gravel cover resulting from eluviation of the finer fractions of the sub-soil. Gulleys are already established on the sides of these ridges, and erosion can probably be measured in several inches per annum.

On the upper slopes, however, in areas in which reafforestation has been instituted by the Government, a thin layer of soil is re-forming. In the rain-forest belt above 2,000 feet the rocks and soil are frequently deeply covered by ferns, mosses and other forest-floor plants, and the soil is a wet clay, occasionally leached of iron oxides to form pockets of pale brown and yellow bauxitic clays.

The soils on the porphyritic granite outcrop in western Mahé do not differ markedly from the remainder. The bed-rock in this area, however, seems to be more quickly weathered than the Mahé granite, for there is a smaller concentration of blocks on the surface, and the soil is darker, deeper and more quartz-rich.

Pale-coloured, occasionally white, kaolinitic clays were found in several localities. Good white clay was found as pockets up to two feet in size low down in the road cutting 200 yards west of the top of La Misère col, and a part of the flat-floored valley at Mare Cochons was found to have impure pale grey clay in its floor. No doubt there are other small occurrences of clay in valleys of poor drainage, but it is not anticipated that they will be of notable size.

The soils of the coastal plateaux are basically mixtures of granular calcium carbonate and humus, and the layer with humus that is penetrated by the roots of vegetation is rarely more than 18 inches. In the swampy areas, however, clay soils that accumulated under anaerobic conditions are common, and in the saline tidal swamps calcareous muds, frequently populated by mangroves, are found. As far as most economic crops are concerned the alkaline calcareous plateau soils are more fertile than the granite soils of the uplands.

Bauer (1898) investigated the microscopic and chemical character of several samples of granite sub-soil from Mahé, and showed that the original texture of the granite could be recognized in them. The transformation observed by Bauer was the conversion of felspar to aggregates of very fine pale-coloured micaceous minerals of high birefringence stained by iron hydroxide obtained from the decomposition of the ferromagnesian minerals. Bauer separated the clay fraction from the quartz and oxidized ferromagnesian minerals and analysed it, with the following result:—

		ranas re as	1 per cent	per cent
A1 ₂ O ₃ Fe ₂ O ₃ H ₂ O	100/70 30 · 93.0go 86.03co	10 12 0.38 0.38	60·68 9·56 29·76	67·09 — 32·91
	there bare en	Over Ok ar	100-00	100.00

- 1. Clay as analyzed.
- 2. Analysis 1 calculated to eliminate Fe₂O₃.

Bauer showed that the iron content was due to staining and not an essential component of the clay, which was composed essentially of aluminium hydroxide, probably gibbsite (A1₂O₃.3H₂O) with some diaspore (A1₂O₃.H₂O), a conclusion confirmed by X-ray analysis of some of the writer's samples (the proportion of diaspore is about 10 per cent in the sample analysed judging from analysis 2 above). The common reddish brown granite sub-soil is composed of unaltered quartz, gibbsite, diaspore and in all probability a mixture of goethite and limonite, with some unaltered ilmenite.

X-ray analysis of some of the pale-coloured clays has been carried out by the Materials Branch of the Ministry of Works, Kenya, on samples supplied by the writer. Two samples of white clay from small pockets in the road cutting of La Misère, two hundred yards on the southern side of the col, proved to be mainly of kaolinite with minor gibbsite. A pale yellowish brown clay from the 2,000-foot level on the eastern slope of Morne Seychellois, and similar yellow and pale grey clays from the floor of the valley of Mare Cochons, western Mahé, proved to be of kaolinoid type, with minor gibbsite, goethite and quartz.

The transformations leading to soil formation from granite thus involve the leaching of alkalies and the release of iron. In extreme cases of leaching all iron may be removed, leaving aluminium hydroxide clays of the gibbsite-diaspore type or the aluminium may remain in combination with silica as in kaolinoid clays. It is implicit in Bauer's discussion of the clay fraction that he regarded any silica in his analysis as resulting from free quartz. The identification of kaolinite as the major constituent in four clay samples from Mahé suggests that some of the silica occurs in this mineral, and that the clays are kaolinitic rather than bauxitic, or are mixtures of the two types.

Four analyses of "laterite" from Mon Plaisir, south Mahé, are given below (cf. Anon, 1908, p. 125):—

			per cent	per cent	per cent	per cent
SiO ₂	mol s	102	17.58	16.35	19.41	35.55
A12O3	Silve i		37.12	27.20	40.80	32.42
Fe ₂ O ₃			19.94	28.99	12.70	12.60
Loss on ig			23.00	22.01	24.03	17.03
TiO ₂		eirio	2.23	4.20	2.55	2.45
			99.87	98.75	99.49	100.05

Three further sub-soil analyses were carried out by the Imperial Institute in 1921 (unpublished):—

			vation	per cent	per cent	per cent
SiO ₂				17.07	22.14	36.92
SiO ₂ (combined)	10	. 88	00. 1	2.30	4.14	0.31
A12O3			000	38.13	32.43	31.45
Fe ₂ O ₃	St. 1	1 1100	66. 8	17.86	17.80	14.28
FeO				0.57	0.35	n.d.
MgO	OOL	. 00	Other	0.09	0.17	n.d.
CaO				nil	nil	n.d.
Loss on ignition				21.84	19.51	15.10
TiO ₂				1.62	2.40	2.00
MnÕ	A. 50	se.mil	Q. 5	trace	0.33	n.d.
			of sul	99.48	99.27	100.06

n.d.=not determined.

The low content of combined silica in the analyses is notable, and suggests that the clay fraction is mostly of the gibbsite-diaspore type.

(2) SILHOUETTE AND ILE DU NORD

(a) PHYSIOGRAPHY

Silhouette and Ile du Nord are situated at the western edge of the Mahé-Praslin group of islands, and differ from the remainder of the group in being composed mainly of syenite (see geological map, at end).

Silhouette is a precipitous island rising to a height of over 2,200 feet. It is formed of a semi-circular ridge open to the south-west on which are the peaks of Cor Gatte, Gratte Fesse, and Mt. Daubin with, on a subsidiary spur, Pot-a-Eau and

Grand Congoment. The upper part of the interior face of the main ridge is formed of cliffs up to 500 feet high to the east of the summit, and steep smooth rock-faces are found on the east side of Pot-a-Eau, to the west of Mare Cochons, and on the south coast between Glacis Platte and Pte. Grande Barbe. The hinterland of Grande Barbe is a broad amphitheatre with comparatively gentle fern-covered slopes, owing to the outcropping of a stock-like body of easily eroded microgranite. The island as a whole has the appearance of a ring complex.

The imposing bare rock slopes at Casse Tonnerre and above Pte. Civine are furrowed by eroded joints trending to the north-west, and joints of the same trend are responsible for the direction of all the major valleys except those on the microgranite outcrop.

Coastal "plateaux" of calcareous sand are not well developed on Silhouette, and occur only at La Passe and Grande Barbe, with minor occurrences at Anse Lascars, Anse Patates, Pte. Etienne and Anse Mondon. The remainder of the coast-line consists of steep rock slopes descending unbroken to the sea, with patches of vegetation whereever some soil remains,

Below the 750-foot contour the less rocky parts of the island are planted with coconut-palms except in the Grande Barbe hinterland, where the soil is poor, and in the area enclosed by a line drawn through Roche Marceline, Mare Cochons, Mt. Daubin, Pot-a-Eau and Anse Mondon, where the ground is either rocky or too inaccessible. Above the coconut-palm belt the island is clothed with forest, mostly secondary growth after the destruction of most of the indigenous forest.

At Mare Cochons, or Scott Vale as it is sometimes called, there is an oval swampy area in a hollow on the ridge top at a level of 1,100 feet. This has been cleared and partly drained and planted with bananas, coffee and citrus trees.

The settlements on the island are as follows, in order of importance: La Passe, Grande Barbe, Anse Mondon, Pte. Etienne, Anse Lascars and Belle Vue. Communications between these are by footpath or boat.

Ile du Nord rises to a height of 650 feet at Mt. des Cèdres, and consists of rocky steep slopes except on the western and eastern sides, where there are calcareous sand "plateaux". The plateaux and the lower slopes are planted with coconut-palms, while the upper slopes are mostly bare rock or are partly covered by scrub.

(b) GEOLOGY

The basis of both Silhouette and Ile du Nord is a buff to grey syenite with subhedral felspars up to 10 millimetres in size and with intergranular clots of ferromagnesian minerals. There is considerable variation in grain size, and the syenites are cut by dark-coloured dykes and veins of porphyritic microsyenite on Mt. des Cèdres on Ile du Nord and at Anse Mondon on Silhouette. These veins have a north-westerly trend. On the Ile du Nord the only unusual rock is an olivine-bearing biotite diorite which forms the Congoment promontory. This rock (specimen S/454) is medium-grained and grey in colour, and consists of a plexus of zoned andesine grains between An₄₃ and An₅₀ in composition, with numerous pale green augite crystals scattered throughout it and a few irregular olivine crystals. Large deep brown skeletal biotites are common and there is a speckling of iron ore grains. Apatite is a prominent accessory mineral. This rock is cut by a network of anastomosing syenite-aplite veins trending north-north-west.

The Silhouette syenite is somewhat variable. The commonest type is a dark grey rock, the dark colour being the result of the sieving of the felspars by numerous small ferromagnesian and iron ore grains. The rocks consist of interlocking microperthite with scattered small pigeonitic pyroxenes, which are sometimes associated with and

partly replaced by a deep brown biotite. In two specimens, numbers S/460A from Pte. Etienne, and S/472 from Pte. Grand Macabé, olivine was identified in aggregates with pale green pigeonite, iron ore and associated biotite, or with brown hornblende and apatite. A coarse pale syenite facies was noted locally, in which the perthitic felspar tends to form tabular insets, with prismatic subhedral pigeonitic augite as the dominant ferromagnesian mineral. On the shore at Petite Passe, Grande Barbe, there are patches of coarse syenite in which the tabular felspars reach one inch in size and in which fibrous amphiboles and milky quartz grains occupy the interspaces.

Under the microscope the syenites are seen to be composed of turbid microperthite grains, rarely showing patch-perthite. Pigeonitic pyroxene occurs in all the rocks, often as small rounded grains sieving felspar, or as ragged plates with partial or complete coronas of brown pleochroic alkali-hornblende. Green hornblende is also prominent in some specimens. Deep brown biotite is usually present and has often partly replaced the pyroxene and amphibole. The ferromagnesian minerals occasionally occur as aggregates showing the replacement sequence pyroxene-hornblende-biotite. Apatite is present as an accessory mineral and ilmenite, cubic pyrite grains and rare epidote granules were observed.

One quartz syenite was collected—specimen S/456 from the Rende d'Avance path just east of the microgranite contact. This rock is similar to the usual syenite, but contains about 10 per cent of quartz as interstitial granules. Small amounts of quartz were noted in others of the syenites, for example in the Grande Barbe rock mentioned above and in some others of the porphyritic syenites.

The microgranite that forms the Grand Barbe amphitheatre is poorly exposed, and its margin was mapped by the occurrence of quartz in the soil. The rock is brown to buff and finely speckled, with a fine saccharoidal texture. It is represented by specimen S/470 from the Jardin Marrons-Grande Barbe path at the 750-foot contour. The felspar is microperthite and tends to have tabular habit; it is interspersed with quartz grains and a little deep blue-green hornblende. The circular outcrop of the microgranite suggests that it is a stock-like body.

Along the east coast of Silhouette between Pte. Vareur and Pte. Zeng Zeng there is a zone of mixed rocks of considerable complexity. At Pte. Vareur the principal rock-type is a pale porphyritic microsyenite with 5 millimetre-long felspar crystals in a pale fine-grained felspathic base. Locally included in this rock are angular xenoliths up to two inches in size of dark green-gray fine-grained microsyenite. This latter rock type occurs in large masses at Pte. Ramasse Tout, where the pale microsyenite occurs only as thin veins. The dark microsyenite is itself xenolithic and contains diffuse patches of dark grey fine-grained finely porphyritic microsyenite. The whole complex is cut by thin microgranite veins. In spite of the dark colour of most of the rocks in this area they are found under the microscope to be microsyenites with corroded and sometimes sub-rounded orthoclase microphenocrysts up to about 3.5 mm. across in a fine felspathic matrix crowded with minute grains of pyroxene and iron ore and containing rare euhedral augite microphenocrysts and occasional small pools of quartz (specimen S/468, from Pte. Ramasse Tout).

At the south end of Anse Lascars grey coarse syenite of the normal type encloses rounded xenoliths of medium- to fine-grained quartz syenite and porphyritic microsyenite. A further exposure on the coast 75 yards to the south is entirely of fine-grained buff microsyenite containing thin diffuse ramifying veins of dark microsyenite, the whole being cut by thin veins of microgranite. These relationships are seen again at an exposure half-way between Anse Lascars and Anse Patates, where the dark microsyenite occurs, but here it is penetrated by dyke-like bodies of explosion breccia consisting of rounded pale microgranite fragments in a microgranite basis rich in opaque iron ore. These rocks are cut again by thin ramifying microgranite and granite veins.

The complex of rocks between Pte. Vareur and Pte. Zeng Zeng is a narrow belt, for massive syenite occurs a short distance from the shore. The generalized injection sequence that which can be deduced from the exposures is as follows:—

- 1. Dark-coloured porphyritic microsyenite with diffuse xenoliths of similar rock.
- 2. Explosion breccia of cognate microgranite fragments.
 - 3. Local thin dark granular microsyenite veins.
 - 4. Porphyritic microsvenite veins.
 - 5. Thin microgranite veins.

Although it cannot be proved on the evidence available, it is likely that the main Silhouette syenite consolidated after stage 4 of the sequence above, and that the microgranite veins represent the period of injection of the Grande Barbe microgranite. The veins in the injection complex are characteristically curving and variable in width, forming anastomosing networks of a general north-easterly trend. These rocks are in all probability the marginal types of the Silhouette ring complex, representing the chilled facies of several separate intrusive episodes. The explosion breccia is of a type common in the margins of alkaline intrusives.

Bauer (1898, p. 19) described a specimen of andalusite hornfels which had been collected from the area of Pte. Ramasse Tout. This rock was described as consisting of fine-grained quartz and magnetite grains with andalusite prisms. In spite of a careful search of the area no sedimentary rocks were seen by the writer, but it is possible that the rock Bauer described was collected from one of the xenolithic microsyenites of the area, in which sedimentary xenoliths may be expected to occur.

Coastal "pleateaux" of calcareous sands occur on both Ile du Nord and Silhouette, and are of the same general structure and composition as those described from Mahé. On Ile du Nord, however, the inland portion of the main plateau is covered by 9 to 12 inches of dark brown soil washed from the adjacent slopes. On the seaward side of the plateau, however, brown phosphatic sandstone outcrops over most of the area, and indicates that the soil is a mixture of guano and soil from the syenite slopes. Guano was exported in the early years of the Seychelles guano trade, but was reported to contain 2 to 3 per cent of iron oxide, no doubt through contamination by syenitic soil.

On Silhouette island the coastal plateaux are small, being confined to narrow strips at La Passe and Grande Barbe, with minor occurrences at Anse Patates, Anse Lascars, Pte. Etienne and Anse Mondon. In all these cases the interiors of the plateaux are covered by rich brown soil. Owing to the heavy rainfall and great run-off on Silhouette island substantial rivers descend onto the main plateaux at Grande Barbe and La Passe, forming swamps with tidal channels.

(c) JOINTS

The principal joint-system on Silhouette and Ile du Nord trends north-west, the joints being widely spaced. A subsidiary set of joints of minor effect trend north-south.

(d) SUPERFICIAL DEPOSITS

The syenite of Silhouette and Ile du Nord gives rise to a rich brown loamy soil, which passes into a pale brown or buff leached bauxitic soil in swampy areas such as Mare Cochons. Much of this soil occurs on the inner parts of the coastal plateaux, where it forms the basis for intensive vegetable cultivation. In the Grande Barbe amphitheatre, however, the microgranite gives rise to a poor red-brown lateritic soil with a small quartz content, and this soil has been found to be very infertile, and is now overgrown with ferns and Latanier palms.

At Mare Cochons the swamp occupies an area of approximately six acres, much of which has been drained and planted with bananas and coffee. The floor of the swamp is formed of brownish grey clay, which grades at 6 to 9 inches depth to a pale buff kaolinitic clay.

Signs of soil erosion are numerous on both islands, but the most denuded island is undoubtedly Ile du Nord, where the indigenous tree cover has been entirely removed for the planting of coconuts, and where there are extensive bare rock areas that are enlarging rapidly on all but slight slopes. On Silhouette island there is a marked decrease in the amount of bare rock exposed as one climbs from the cultivated belt below 750 feet into the forest above. As is the case in the whole of the Mahé-Praslin group of islands the destruction of the original forest cover and its secondary growth, and the planting of coconut palms on steep slopes has resulted in the suppression of shrubby growth and in a great acceleration of soil erosion.

(3) THE PRASLIN-LA DIGUE GROUP OF ISLANDS

The Praslin-La Digue island group lies north-east of Mahé, and comprises the second-largest island of the archipelago, Praslin, and its satellite islands (see geological map, at end). Like Mahé the group is composed of granitic rocks. Praslin and La Digue are administered by local District Boards, with headquarters at Grand Anse and La Passe respectively, for these islands are divided into a number of estates and plots, unlike Félicité, Les Soeurs, Marianne, Aride, Cousin and Cousine, which are single properties. Curieuse is Crown Land, and there are Crown Lands at Amitié, Midland and Anse Marie-Louise on Praslin Island.

The Praslin and La Digue group is connected to Mahé by a twice-weekly passenger vessel which calls at Grand Anse and Baie St. Anne, Praslin and La Passe, La Digue. Communication with the other islands is by privately owned schooners.

Economically the islands are primarily dependent on coconut cultivation, but vanilla is also grown extensively on Praslin and La Digue. Communications on Praslin consist of an earth motor-track which passes from Anse Kerlan along the western coast to Grand Anse, across the island to Baie St. Anne, and from there up the east coast as far as Anse Boudin. There are motor-tracks on La Digue, but there were no motor vehicles at the time of the survey.

Physiographically the islands are hilly and steep-sided ranges rising directly from the sea except where coastal plateaux intervene. The central hills of Praslin and La Digue rise to heights between 1,000 and 1,250 feet, but the smaller islands are lower. In form the islands are controlled by the major north-westerly joints which traverse the granitic rocks, and all the major valleys trend along these joints, and along dolerite dykes trending north-west or west.

The coastal plateaux of Praslin and La Digue are the most extensive among the granitic islands, and in the case of Praslin support almost all the agriculture and population on that island.

With the general exception of the Crown Land at Anse Marie-Louise and of the Midland valley, including the famous Vallee de Mai, where the Coco-de-Mer palm is preserved, the indigenous forest which was mostly of palms has been destroyed, and the present vegetation consists of scattered trees of Adenanthera, Albizzia and others, with clumps of Casuarina, and some Eucalyptus at the south-east end of Grand Anse. The general cover on the hills is a thin highly inflammable scrub of Pandanus, Latanier palms, etc., with a curious widely spaced clump-grass, Cyperus. In general there is little utilization of the upper slopes, which are periodically ravaged by fire, and which show the effects of advanced soil erosion over large areas.

La Digue, unlike Praslin, is planted with coconuts up to its summit, and presents a much better aspect. There is much patchy cultivation of cassava, bananas and tobacco among the coconut palms, but there is little evidence of soil erosion.

On the smaller islands Félicité, Marianne and Les Soeurs coconuts are the main crop, but on parts of Félicité and Les Soeurs there are large expanses of bare rock. On these islands small reefs occur only on the western sides, and are backed by small coastal plateaux on which the settlements are situated.

Curieuse is Crown Land, and until recently was the site of a leper settlement. Physiographically it is similar to the other islands, but from the vegetational aspect it is perhaps the most barren and eroded island in the Seychelles archipelago. Most of the upper parts of the western ridges are bare sub-soil covered by patches of quartz gravel, and with boulders on soil pedestals. In the south-eastern part, on the reef platform, a free-stone wall has been built to form a large turtle-pond, but owing to the rarity of turtles in the vicinity is not used for this purpose. Inland of the turtle-pond is a saline swamp with patchy mangroves.

L'Ile Aride is a precipitous small island, with extensive rock exposures on its hillsides, with a small coastal plateau on the south side. Sea-birds breed on the island seasonally, and are no doubt partly responsible for the suppression of the natural vegetation, and the consequent vigorous erosion.

Cousin and Cousine, the two small islands west of Praslin, are small granite knolls with reef-sand plateaux on their north-eastern sides.

(a) GEOLOGY

Granite forms the basis of all the islands of the Mahé-La Digue group with the exception of Marianne, which consists mainly of granite porphyry and is described separately. The granite is homogeneous, showing only slight local variations in texture and composition. No orientation of minerals owing to flow or any banding can be made out in it, such variations as exist resulting from textural change or to later dykelike injections.

The Praslin granite, as it will be called for convenience, is typically pale reddish grey in colour owing to the fleshy colour of its alkali felspars. It is of moderate to coarse grain size, the commonest varieties containing felspars of subhedral form up to 10 millimetres in size, but a few porphyritic varieties have tabular felspar phenocrysts reaching a size of 15 millimetres. The quartz grains are clear and glassy, and occur as rounded individuals or aggregates. The ferromagnesian minerals form fine-grained granular aggregates, or rarely are identifiable as prismatic hornblende reaching 10 millimetres in length. In texture, grain size and mineralogy therefore the Praslin granite closely resembles the Mahé granite, and differs only in its constant reddish colour.

Under the microscope the granite is seen to consist of orthoclase microperthite, which occurs as ragged subhedral to anhedral grains with sutured margins, occasionally has developments of patch perthite and is frequently sieved with quartz globules at grain margins. Discrete grains of albite-oligoclase appear in the groundmass in minor amounts in some specimens, but plagioclase is absent from most. Quartz forms aggregates and small grains set in felspar and is sometimes micrographically intergrown with the felspar. The ferromagnesian minerals are usually green or brown biotite in aggregates of flakes, and often show the development of chlorite. In a few rocks minor green hornblende remains, but is seen to be partly converted to biotite.

Aplites are plentiful as irregular non-planar veins rarely more than one foot wide. They are finely granular pale reddish buff in colour. A notable occurrence of aplite forms the whole of Point Ma Flore, at the eastern end of La Digue, and aplite dykes

trending north-north-east are common on the large granite pavement a quarter of a mile north of La Passe, also on La Digue. Irregular aplite veins trending north-east were also seen at Camp Fregate on Grande Soeur, where they are traversed by narrow shears with quartz, trending north-west.

Aplites varying to aplogranite with lenticular quartz veins were seen on north Praslin island on the ridge-top due east of Anse Lazio, and at the coast at Roche Caret, at the southern end of Grand Anse. Reddish aplites with diffuse patches of granite porphyry were observed at the southern end of Anse la Blague, where a 15-foot shear-zone penetrates these rocks, and a zone of aplite with granite porphyry patches occurs in a shallow valley 150 yards inland of Roche Ira, at the north-eastern end of Félicité.

Granite porphyry with oval phenocrysts of felspar and round phenocrysts of quartz in a reddish aplitic matrix were found in several areas on the islands as dyke-like bodies. Cap M'sieu Emile at the northern end of Anse Kerlan, north-west Praslin, is formed of such rocks, and a small body of porphyry at the south end of Anse Citron was observed to grade into granite without sharp contacts.

A large dyke-like body of granite porphyry was traced across the island of Félicité from the settlement to Baie Chauve-Souris. West of Baie Chauve-Souris and east of Grand Anse this body was seen to be separated from the adjacent granite by a greenish grey metadolerite dyke. The granite porphyry has sharp plane contacts against the granite and varies greatly in width. It is displaced by a small fault trending east-west.

Aplogranites of rather fine grain and unusually deep red colour were found as tabular dyke-like bodies on the side of the trans-island road 600 yards west of Baie St. Anne, Praslin, and forming a broad dyke traversing the eastern end of Curieuse island.

In the hand-specimens and thin sections the aplites, aplogranites and granite porphyries display their obvious close relationship with the Praslin granite. In the porphyries the felspar is microperthite, but in the fine-grained rocks the perthitic structure cannot be made out, and myrmekitic intergrowths are common. In one aplite from the ridge east of Anse Lazio clusters of epidote granules were observed in quartz, and there are patches of fibrous chlorite. Some of the quartz grains in this rock are euhedral or subhedral with rounded edges.

Quartz veins are not uncommon on Praslin island, and are usually found as narrow medium-grained pure quartz veinlets occupying narrow north-east-trending shear fractures, or north-west-trending off-set tension gashes. Examples of these were found in the head of a small valley 500 yards south-west of Grand Fond beacon, where there is a stockwork of narrow veins of quartzitic texture. Plane quartz veins with coarser texture and a tendency to have vugs with well-terminated crystals were found on the ridge 600 yards south-west of Anse Possession, on the ridge east of Anse Lazio, and in the vicinity of the beacon on the hill top west of Pt. Josephine. Quartz veins of a similar nature and a north-westerly or west-north-westerly trend were also seen on the top of the ridge due south of Curieuse beacon, near the summit of Cousine, and at Camp Fregate on Grande Soeur. Quartz veins are numerous on the summit ridge of Aride, particularly at the western end, but trend east-west in this locality.

(b) MARIANNE GRANITE PORPHYRY

Marianne differs slightly from the remainder of the Praslin-La Digue group in structure. The island is a mile and a quarter in length and rises to a conical peak at a height of 420 feet near its northern extremity. Traversing the island from the small settlement at Anse La Daube to Fond Zile is a low broad col. A fringing reef

with a narrow and difficult boat-passage occurs on the west, and is backed on the coast by a small sandy coastal "plateau" about 50 yards wide. The inhabitants total 25 persons, engaged in coconut and vanilla cultivation.

The basis of the island is a granite porphyry of unusual appearance. The rock has pale pinkish buff tabular felspar phenocrysts up to 15 millimetres in size, and rounded quartz phenocrysts up to 4 millimetres in size in a fine-grained pale reddish grey aplitic base with clusters of ferromagnesian minerals. This porphyry is remarkably uniform over the island, and weathers characteristically in small blocks, which occur in enormous numbers on the steeper slopes. At Roche L'Escalier and Pte. Ozon the porphyry is sheared along planes trending east-north-east, and the rock has been extensively epidotized along zones up to two inches wide. At the southern end, at Pte. Grand Glacis, in a large rock pavement there are groups of beautifully fluted pillars of rock developed by weathering.

Under the microscope the porphyry is seen to contain subhedral to euhedral phenocrysts of microperthite and tabular oligoclase in almost equal proportions. Some of the phenocrysts are broken and incomplete, others have been corroded and even eviscerated, the interior being later filled by coarsely crystallized plagioclase-quartz intergrowths. In specimen S/52 quartz phenocrysts are developed also, and the matrix is of granular aplitic quartz and felspar with crystals, aggregates and small specks of green hornblende, small crystals of biotite and occasional chlorite aggregates. In specimen S/49 from Roche Girondel, however, the quartz occurs as angular and irregular interstitial crystals among the small tabular perthites and plagioclase of the groundmass or adjacent to the phenocrysts. There is slight saussuritization of plagioclase. The ferromagnesian minerals are aggregates of deep green hornblende sometimes intergrown with biotite, and are associated with opaque iron ore, apatite prisms and rare zircons. The two specimens described can be classified as porphyritic adamellite and quartz monzonite respectively.

Traversing the island in a north-westerly direction and forming the low col is a tabular deeply weathered and closely jointed metadolerite. This rock is a speckled green and brown rock with grains of about one millimetre in size. Under the microscope (specimen S/46) it is seen to be composed of subhedral hornblende grains with associated fibrous uralite. The hornblendes are commonly partly replaced by patches of chlorite, which also forms pools in the matrix of pale brown clouded sodic plagio-clase prisms. Epidote occurs plentifully as grains and aggregates. There are scattered interstitial quartz grains and small iron ore grains.

(c) DOLERITE DYKES

Dolerites occur on most of the islands of the Praslin-La Digue group but are particularly numerous on Félicité. They are only slightly altered, and are of medium to fine grain, and clearly post-date the granitic rocks in which they occur. The dykes are generally of north-westerly trend and are frequently found in valleys and gulleys produced by differential erosion of the dykes and the joints in which they were emplaced.

The majority of the dolerites are grey or slightly greenish grey non-porphyritic rocks with average grain size of half a millimetre. Under the microscope they are seen to be mostly pyroxene dolerites with ophitic texture and prismatic plagioclase, though one olivine dolerite (specimen S/77) was collected from Anse Bois Rose on the south coast of Praslin. In nearly all the thin sections examined some alteration is evidenced by the presence of pools of chlorite. One unusual dolerite from Roche Criminel at the north end of Grande Soeur (specimen S/54) contains numerous pyrite metacrysts, and felspar phenocrysts were observed in one of the dolerites at Roche Navire at the south end of Félicité.

Metadolerites in which substantial alteration has taken place, and in which the grain size is greater than in the unaltered dolerites, were found on Marianne Island (specimen S/46, described above), on Félicité at the western margin of the granite porphyry body east of Grand Anse, where the rock is a uralite-chlorite-epidote metadolerite (specimen S/58b), and as a sill-like body closely resembling the Marianne metadolerite on the western side of Grande Soeur.

An unusual dyke of microsyenitic composition was found on the slope above Anse Papaie at the eastern end of Curieuse Island. This rock is composed of felted subhedral orthoclase prisms, with a few slightly saussuritized plagioclases, much chlorite and some iron ore. In the hand-specimen (S/84) it is of doleritic appearance.

(d) COASTAL DEPOSITS

At a number of places on the coasts of the Praslin-La Digue group of islands conquinoid limestones and calcareous conglomerates and sands containing coral and algal pebbles were observed as masses adhering to granite blocks at altitudes between sea-level and 30 feet above sea-level. Such occurrences are particularly numerous on the south-west coast of La Digue, between Pte. Source d'Argent and Anse aux Cèdres, and between Roche Caret and Anse Bateau on the south-west coast of Praslin. These deposits are the remains of littoral calcareous sediments laid down during a period when sea-level stood up to 30 feet higher than at the present day. That this higher level of the sea was short-lived is suggested by the small and scattered nature of the deposits, by the absence of any coastal features such as a wave-cut benches and by the absence of reef-rock islands off-shore that might date from such a period.

The coastal "plateaux" of the Praslin-La Digue group are closely comparable in appearance, age and structure to those of Mahé. The extensive plateaux on the western side of Praslin, and at Côte d'Or on the north-east, are composed of calcareous beach sands, and are furrowed by swamps and tidal inlets. Such plateaux occur on all the islands, but vary greatly in size, their extent being related to the width and exposure of the adjoining fringing reefs.

Guano deposition on the coastal plateaux has taken place at Cousine, Cousin and Aride, and phosphate rocks resulting from the deposition of guano on granite soil were observed on Marianne and Grande Soeur.

The plateau on the north-east side of Cousine shows the development of two low storm-ridges parallel to the shore, one on the coast and the other 30 yards inland. Behind the seaward storm-ridge the plateau surface is of impure sandy guano, and on the northern half of the plateau there are small guano pockets resting on a phosphatic sandstone layer up to one foot thick. On Cousin the phosphatic sandstone is thicker and occurs as a surface layer over most of the northern half of the island. Little guano occurs on it, and it is suspected that the guano has been largely removed.

The narrow plateau on the south side of Aride is composed of phosphatic sandstone behind the low coastal storm-ridge. Towards the inner margin of the plateau, however, the surface is a rich brown loamy soil washed from the hillside behind. Some guano was formerly exported from Aride, but was reported to be high in iron oxides owing to contamination with soil

Brown earthy rocks with cavernous and pitted weathering occur on the northern slopes of Marianne, among the porphyry boulders and filling crevices in them. These rocks contain small quartz grains and closely resemble the phosphatized granite of Ilot, near Fregate Island, and are the result of guano deposition on granite soils with the conversion of the clay minerals to aluminium phosphate.

(e) SUPERFICIAL DEPOSITS

The coastal plateaux are overlain by alkaline soils, which are basically mixtures of calcium carbonate and humus,

On the Praslin uplands soils are rarely seen except in small sheltered patches in valley bottoms. Over large areas the top-soil is missing owing to soil erosion, the exposed surface is gravelly sub-soil or bare rock. Notable exceptions to this occur in the Midlands area, on the northern slopes of Fond Boffay, and in the larger well-wooded valleys in the mountains.

The most serious soil erosion has undoubtedly taken place on Curieuse Island, where the whole western ridge is bare sub-soil with a gravelly accumulation on the surface and much gulleying of the soil. The islands of La Digue, Marianne and Les Soeurs on the other hand have suffered much less soil erosion, La Digue being by far the least affected. The reason for this is not apparent to the writer. Possibly the denudation during the rush to cut cinnamon which took place in the islands in the early years of the present century did not affect La Digue. Certainly there is not the evidence of recurring fires on La Digue that is seen on Praslin. The La Digue granite soils are red-brown and yellow-brown loams in which eluviation of the fine fractions with the production of quartz-rich residues is rarely seen.

(4) FREGATE

Fregate is situated to the south of La Digue and is nearly a mile and a quarter by one mile in size (see Figs. 2 and 3). It is a low rocky island reaching to a height of 380 feet, with a sizeable coastal plateau on the north-east side where the settlement is situated, and a smaller one on the south-west side. The greater part of the island is planted with coconut palms, and there are vanilla plantations on the inland side of the main plateau and in the valley of the Bambou river. The plateau behind the settlement is covered by a rich brown soil on which vegetables are grown.

Fregate differs markedly from the remainder of the granitic islands in being composed largely of aplite and quartz porphyry, with only minor patches and veins of granite. The aplite that forms the greater part of the island is a buff fine-grained rock with saccharoidal texture. It locally varies by gradation to a microgranite by increase in grain size, and also develops a porphyritic facies having small subhedral felspars up to four millimetres in size set in an aplitic base. The two main porphyry areas are on the bare rock surfaces immediately south of Anse Maquereaux, and a quarter of a mile north-west of Anse Parc. In this last area the porphyry is locally dark grey in colour and with flinty fracture. Under the microscope this rock (specimen S/447) is seen to consist of perthite, sodic plagioclase, quartz and green hornblende grains, which are often markedly sieved and occasionally intergrown with biotite.

Porphyritic granites with tabular perthite insets occur as diffuse patches and veins in the aplite-porphyry area, and are well exposed on the rock pavement traversed by dolerite dykes south of Anse Maquereaux, where the porphyritic granite occurs as anastomosing veins up to five feet in width trending north-south. Patches of similar granite occur on the coast at the south end of Grand Anse, immediately north of Anse Parc, scattered about on the bare rocky slopes above Anse Victoria, and in the lower part of the Bambou valley.

Pale brown quartz porphyry, with small rounded quartz grains in a pale felsitic matrix outcrops in the Bambou valley and in the valley linking Grand Anse to the settlement. The quartz porphyry weathers into pitted and fretted small blocks, which litter its outcrop in large numbers. Between these blocks is a brownish grey quartz-rich top-soil low in fertility and subject to rapid erosion. The contacts of the quartz porphyry with the surrounding aplite are gradational, the aplite forming the higher ground and outcropping as large bare rock pavements.

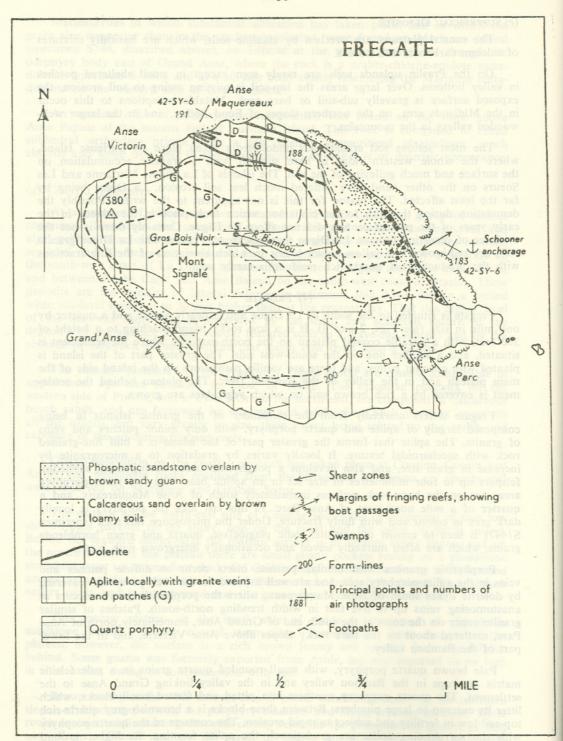


Fig. 3.—Geological Map of Fregate

A porphyritic dolerite dyke trending slightly north of west traverses the rock pavement south of Anse Maquereaux, and four other narrow dykes outcrop near this dyke on the coast. The narrow dykes are basaltic, lensing and characterized by offshoots into cracks in the aplite. Dolerite float was seen at Gros Bois Noir and immediately west of the summit, and may represent a dyke trending along the Bambou valley.

The two coastal plateaux of Fregate are composed of calcareous sand, and have narrow belts of phospatic sandstone near the shore. Some sandy guano was seen on the phosphatic sandstone in the area near the settlement and in a narrow belt along the coast at Grand Anse. The interior parts of both plateaux are covered by thicknesses of up to 5 feet of deep brown loamy soil derived by alluviation from the slopes of the interior. Quartz was not observed in these soils, which are very fertile, and seems to have remained behind to form the quartzose soils of the low-lying ground on the quartz porphyry outcrop.

Ilot, to the south-west of Fregate, is an uninhabited rocky islet about 200 yards in length consisting of rugged cliffs and large round blocks lying loose on the bare rock surfaces. The granite is slightly reddish in colour, and is traversed by numerous sub-horizontal aplite veins one to two inches thick. The granite, which is almost completely bare rock, shows interesting weathering features. On the island's main ridge large rounded unweathered granite blocks up to 30 feet in diameter are surrounded by concentric shells of weathered rock. The innermost shells within one to two feet of unaltered rock, are soft and slightly iron-stained, while the outer shells are rather harder, and have porcellanous "felspars" resulting from conversion to variscite (aluminium phosphate AlPO₄.2H₂O). The upper surface of the granite over a wide area and the outer shells of the weathered blocks are affected by phosphoric acid, for the islet is a breeding place of sooty terns and the felspars have been altered to variscite to a depth of up to 2 feet. An analysis of a phosphatized granite (specimen S/444) is given below (analysis 1).

	1 per cent	per cent
Total P ₂ O ₅	 24.8	14.2
P2O5 c.a.s.*	 0.3	2.0
Total N	 nil	0.7
Organic matter	 1.1	11.1
Acid insoluble	 42.3	54.8
H_2O at $100^{\circ}C$.	 12.6	6.0

Anal.: R. Kempton, Scott Agricultural Laboratories, Nairobi.

- 1. Phosphatized granite, Fregate.
- 2. Guano, Fregate.

Fresh guano mixed with decayed grass and quartz derived from the breakdown of the granite occurs in pockets on the less steep parts of the island to a depth of one foot. An analysis of this guano is given above (analysis 2). In both analyses the high figure for the acid insoluble residue is due to quartz.

^{*}c.a.s. = citric acid soluble, the acid used being a 2 per cent solution. This abbreviation will be used in subsequent analyses. The solubility in 2 per cent citric acid is an empirical method of determining the availability of the phosphate to plants in the case of relatively insoluble phosphatic materials such as rock phosphates and guano. In North America the practice is to determine the solubility in neutral ammonium citrate (Waggaman 1952, pp. 610-611); the solubility in neutral ammonium citrate is normally less than in 2 per cent citric acid.

(5) MAMELLES

Mamelles is a small island situated between Mahé and Praslin (see Fig. 2). It is uninhabited but has a small lighthouse. The island is composed of coarse reddish granite exposed in cliffs and bare rock surfaces, but in the low col that divides the island a stockwork of quartzitic veins up to two feet wide and with north-south trend traverses the granite. On the southern coast, near a derelict hut, two aplite dykes are exposed and vary from 1 to 7 feet in width. The granite of the hill on which the lighthouse is built is phosphatized and transformed to a brown amorphous rock with unaltered quartz grains on the upper surfaces and along joints. In some of the joints thin veins of opaline silica occur.

In the low divide on the island, there are coarse granite gravels and boulders piled up on the southern side by wave-action. In the centre of the divide, at a height of about 8 feet above sea-level, there are a few poor exposures of a pale brown quartz grit with a pale brown cement which probably consists largely of the aluminium phosphate, variscite.

The Mamelles granite is indistinguishable from Praslin red granite in hand-specimen and thin section.

(6) ILE AUX RECIFS

The writer did not visit Ile aux Recifs (see Fig. 2) because of lack of time, but passed close by on one occasion. The island is approximately a quarter of a mile long and about 200 feet high, with a smooth rounded outline. Cliffs of granite are visible at the eastern sides, but on the west there is a coastal plateau composed largely of gravel, with a central swamp. From the appearance of the rock it is judged that the island is formed entirely of Praslin red granite.

(7) GEOCHRONOLOGY OF THE INTRUSIVE ROCKS AND GENERAL CONCLUSIONS AS TO THEIR ORIGIN

A number of age determinations by the potassium-argon method have been carried out by Miller and Mudie (1961) on whole rock samples from Mahé, and further determinations on hornblende concentrates supplied by the writer have become available recently (Miller, personal communication). The results are summarized in the following table:—

Material analysed	Locality	Method	Age and estimated experimental error (millions of years)
Grey granite	Quarry behind hospital, Pt. Victoria, Mahé.	Total volume	536 ± 23 534 ± 23 495 ± 22 501 ± 22 531 ± 23
Pink granite	box de trans	,,	$\begin{array}{c} 497 \pm 22 \\ 507 \pm 22 \\ 530 \pm 23 \end{array}$
Biotite from pink granite	s give abo et analy, is 2). I	Isotope dilution	654 ± 17
Hornblende from granite	Aux Mornes, N. Mahé	,,	509 ± 45
Hornblende from granite	Trois Frères, central Mahé	,,	549 ± 48
Hornblende from granite	Petite Police, S. Mahé	,,	580 ± 50
Hornblende from red granite.	Nouvelle Découverte trig. beacon, Praslin.	,,	647 ± 55