# GEOLOGICAL SURVEY
of
# BRITISH GUIANA

## REPORT ON THE GEOLOGICAL SURVEY DEPARTMENT FOR THE YEAR 1960

Geological Survey Department
P.O. Box 789
Georgetown, British Guiana
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# REPORT ON THE GEOLOGICAL SURVEY DEPARTMENT FOR THE YEAR 1960

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## I. INTRODUCTION

The Geological Survey of British Guiana is a Department responsible to the Minister of Trade and Industry. It is financed partly under free grants from the United Kingdom out of Colonial Development and Welfare Funds and partly out of local revenue. Colonial Development and Welfare Scheme D 2792 came to an end on 31 March 1960, and a new Scheme, D 4333 came into effect on 1 April 1960, and will run until 31 March 1961. Under the new Scheme (D 4333) 30% of the Recurrent Expenditure for 1960 was provided out of local revenue, 40% will be so provided in 1961, 50% in 1962, and 60% in 1963. The remainder, plus Capital Expenditure, will be provided from Colonial Development and Welfare Funds.

Expenditure for 1960 was as follows:

| | Local Funds | C.D. & W. | Total Expenditure |
|---|---|---|---|
| Scheme D 2792 | £ 6,981 | £34,575 | £41,556 |
| Scheme D 4333 | 21,904 | 52,325 | 74,229 |
| TOTALS | £28,885 | £86,900 | £115,785 |

Under the new scheme £309,048 has been provided of which £182,536 will come from C.D. & W. funds, and £126,512 will come from local funds. Under the old Scheme D 2792 a total of £436,930 was authorized. The total amount spent under this scheme was £310,988; £258,578 from C.D. & W. funds and £52,410 from local funds, leaving an unexpended balance of £125,942. The principal reason for the funds being underspent under the old scheme was the difficulty in recruiting both senior and junior staff to bring the Department up to the new establishment. The inevitable delay in filling these vacancies caused the authorized expenditure to be much less than had been planned.

With the new Scheme D 4333, however, the Department was able to start with a senior staff up to full strength, and, owing to the high pressure of field work, spent nearly up to the full allocation for 1960. A sum of £16,000 granted for necessary additional buildings, including a rock-store, minerals preparation laboratory, garage-workshop and vehicle park remained unspent, as the Public Works Department were unable to complete the building programme, but will be re-voted in 1961. The Estimates are thus shown to be well-balanced for the centralized Geological Survey Department now set up in British Guiana, and it is hoped that the Survey will continue at full establishment.

## ACKNOWLEDGEMENTS

The gratitude of the Geological Survey is once again expressed to mining companies and small miners for their co-operation during the year. The Demerara Bauxite Company Limited very generously provided funds to enable Mr D. Bleackley, Senior Geologist, to visit Leiden University while on leave in order to study methods of pollen analysis as applied to the dating and correlation of the coastal sediments of British Guiana in collaboration with Dr Th. van der Hammen. The Company have also been very generous with their hospitality at Mackenzie and kindly lent the Geological Survey an Empire drill for work on laterite deposits of Iron Mountain.

Thanks are also due to Reynolds Metals Company and the Northwest Guiana Mining Company Limited for their hospitality to members of the Geological Survey staff during the year.

During 1960 the Compania Shell de Venezuela very generously invited the Director to visit Venezuela as guest of the Company to study the geology of the Guayana Shield. The collaboration of the Director and staff of the Direccion de Geologia of Venezuela, and of Messrs. Martin, Sykes, and Associates in this visit is also gratefully recorded.

Mr D. Bleackley, Senior Geologist, was enabled to visit and study the bauxite deposits of Surinam owing to the kindness of the Surinam Aluminum Company and the Billiton Maatschappij who invited him as their guest.

The Commissioner of Lands and Mines and members of his staff kindly provided topographic maps, mining information and aerial photographs whenever possible. District Commissioners, particularly of Kamarang, Mazaruni-Potaro and the North West District provided a great deal of help to field geologists in making arrangements in connection with expeditions.

Thanks are also due to the Principal, Mineral Resources Division of the Overseas Geological Surveys, for carrying out chemical analyses of aluminous laterites from the Pakaraima Mountains and Iron Mountains and for a great deal of advice on methods of chemical analysis of such minerals.


## II REVIEW OF THE YEAR

The first shipment of manganese ore from the Matthews Ridge mine of the Northwest Guiana Mining Company Limited was made in August 1960. The start of these mining operations marked a most important milestone in the development of the mineral resources of British Guiana and brought much needed employment to the North West District. The company plans to continue exporting at the rate of about 180,000 tons per annum.

Prospecting of the ferruginous bauxites discovered in the Pakaraima Mountains in 1959 has shown that aluminous laterite extends over an area of some 1200 square miles. Much of this material is a low-grade ferruginous bauxite with fairly high silica. In the Kopinang basin, however, pitting over an area of some 250 square miles showed a large tonnage of promising ferruginous bauxites.

The geological mapping programme made great progress and a new record of 7785 square miles with 195 miles of river and railway traverses was achieved. From the results of the year's mapping it was concluded that the new stratigraphical table was sufficiently well established to be maintained in the future, and plans were made for the extensive publication of map sheets. A draft of the new geological map of British Guiana to be published in colour at 1:1,000,000 will be ready by the end of 1961, one year ahead of schedule.

After proving a considerable thickness of off-shore sediments by a marine seismic survey the California Oil Company (British Guiana) Limited abandoned their lease, but the area was again applied for by an American group.

A test borehole was completed in the Shelter Belt, Georgetown, by the Pure Water Supply under the supervision of the Geological Survey, to test an aquifer suspected from previous work. Below the "A" sands a new aquifer termed the Lower Sands was encountered from 1260-1360 feet with a hydrostatic head of 36 feet above ground level and a natural flow of 500 imperial gallons per minute of water of a high degree of purity.

This Shelter Belt test well was continued until basement rocks were met at 1951 feet and a complete section of samples was taken for pollen analysis. These have proved the existence of Palaeocene beds below the "A" Sands. Traces of oil were found in cracks in the basement rocks.

British Guiana was represented by the Director at the 21st International Geological Congress in Copenhagen and he exhibited a draft of the new geological map.

STAFF

The Senior Staff continued at full strength and consequently work proceeded at maximum pressure. One geologist left the Department on the completion of his contract and was replaced by a Guianese, thus bringing the number of qualified Guianese scientific officers up to six, which includes one Geophysicist-Hydrologist, two Geologists and three Assistant Geologists. There are still two Guianese Conditional Scholars in the U.K.

The Chemist-Petrologist, Dr J. Schilling, who left the Colony on 27 June 1960 on vacation leave has not renewed his contract.

Appointments and Promotions

Mr D. Bleackley, Senior Geologist was promoted to the new post of Deputy Director (Field) with effect from 1 April 1960. Mr Cannon was appointed to the vacant post of Senior Geologist with effect from this date.

Mr M.W. Carter, Assistant Geologist, was promoted Geologist with effect from 1 January 1960.

Mr M.A. Lee was appointed Assistant Geologist with effect from 26 November 1960.

Mr L.F. Choy, Examiner of Accounts, Grade I, Audit Department, was seconded to this Department with effect from 17 February 1960 to carry out the duties of Senior Accounting Officer pending approval for the substitution of such a post for the post of Class I Clerk. He was appointed to the new post with effect from 4 June 1960.

Subsequently Mr Choy was seconded to act as Accountant, Land Development Department from 25 August 1960 and his place was taken by Mr V.H. Campbell, Class I Clerk, Medical Department.

Mr R.V. Drakes Class I Clerk was transferred to the Medical Department with effect from 4 June 1960 after a period of secondment to the Audit Department from 17 February 1960.

Mr C.S. Massiah was appointed to the new post of Class II Clerk with effect from 22 February 1960.

Miss C. Young, Mr W. Davis, Mr L. La Rose, Mr S. Jagai and Miss J. Jardine were appointed Apprentice Draughtsmen with effect from 1 March 1960.

Miss Young and Mr Davis were subsequently promoted Assistant Draughtsmen Geological Survey and Drainage & Irrigation Departments respectively. Miss Young's appointment took effect from 1 March 1960 while Mr Davis' promotion was effective from 1 December 1960.

Miss J.A.B. Dennison was appointed temporary Clerical Assistant (typist Clerk) with effect from 1 December 1960 vice Miss Y.C. Mayers, Clerical Assistant on vacation leave.

Special Duties

Dr L.E. Ramsahoye, Geophysicist-Hydrologist was seconded to the Pure Water Supply Division, P.W.D. with effect from 8 November 1960 for special duties.

Leave and Acting Appointments

Dr R.B. McConnell, Director, left the Colony on 15 March 1960 on six months vacation leave to be spent in the United Kingdom and Europe, and resumed duty on 23 November after having spent a period on duty at the International Geological Congress in Scandinavia in addition to his leave. Mr C.G. Dixon acted as Director during this period.

Mr D. Bleackley, Deputy Director (Field) proceeded on 145 days vacation leave with effect from 17 October 1960, to be spent in the United Kingdom following the expiry of his contract. Dr E. Williams was appointed to act for him.

Dr J. Schilling, Chemist-Petrologist, departed on 120 days vacation leave on 27 June 1960 following the expiry of his contract. Mr D.D. Hawkes was appointed Acting Chemist-Petrologist from 12 December 1960.

Mr J.H. Bateson, Geologist, resumed duty on 3 May 1960 after vacation leave spent in the United Kingdom.

Mr M.G. Allderidge, Assistant Geologist, left the Colony on 20 December 1960 on six months vacation leave following the expiry of his contract.

Mr R.C. Sansom, Assistant Geologist, proceeded on vacation leave with effect from 1 July 1960 on the expiry of his contract.

Mr M.W. Carter, Assistant Geologist, resumed duty on 8 June 1960 after vacation leave spent in the United Kingdom.

Mr F. Johnson, Chief Clerk, resumed duty on 28 July 1960 after spending approximately seven months vacation leave in the United Kingdom. During his absence his duties were efficiently carried out by Mr C.E. Outridge, Senior Clerk, on secondment from the Post Office.

Mr K. Lall, Senior Assistant Draughtsman, went on 162 days vacation leave with effect from 16 May 1960. During his leave he undertook a three months course of study at Tolworth at the Directorate of Overseas Surveys. Mr Lall returned to the Colony and resumed duty on 7 December 1960.

Mr J.R. Briggs, Senior Field Assistant, resumed duty after six months vacation leave in the West Indies.

Mr D. Hope, Technical Assistant, was granted 111 days vacation leave with effect from 1 June 1960 to be spent in the West Indies and in the Colony. He resumed duty on 24 September 1960.

Miss Y. Mayers, Clerical Assistant, proceeded on six months vacation leave to be spent in the United States of America, on 1 September 1960.

<u>Higher Degrees</u>

During his present tour of service Mr D. Bleackley, Senior Geologist, and later Deputy Director (Field), made a special study of the bauxites and laterites of

British Guiana with special emphasis on their origin, geological setting and economic development. The results of his work were written up as a thesis lavishly illustrated with photographs, profiles and maps and presented at the University of Oxford for the degree of D.Phil.

This work has been made available in typescript and has been much praised by the geological staff of the bauxite mining companies in British Guiana. It will be published as a Bulletin of the Geological Survey as soon as possible.

Scholarships

Mr G.A. Sampson and Mr A.S. Persram, formerly Field Assistants, continued their courses of study at Edinburgh and Glasgow Universities respectively. Both had been awarded Conditional Scholarships to study for the degree of B.Sc. with honours in geology.

Training Courses

Advantage was taken of the number of experienced geologists on the staff during the wet season November-December to institute a series of lectures on geology and allied subjects for the benefit of the junior staff.

## CENTRALIZATION

The policy of the centralization of the Department in Georgetown and the provision of new buildings, which had been making steady progress, was unfortunately held up as it was found impossible to arrange for the construction of the new rock store, assay laboratory and workshop before the end of the year. Funds had been provided but the Public Works Department could not complete the plans and advertisement of the contract owing to shortage of staff. Parking facilities in the compound are also still lacking.

The new chemical laboratory was completed and occupied early in the year, and the old laboratory was demolished in readiness for the construction of a car park. On completion of the new rock store and assay laboratory the remaining old building will be demolished to make room for additional parking space.

Additional bedrooms and servants' quarters were added to two of the houses in the Geological Survey Compound. An entrance from Hadfield Street was completed and will come into use as soon as the parking spaces are laid down. This will ease the severe congestion at the other side of the main building.

## STAFF CONFERENCES

Two staff conferences of senior officers were held during the year, when administrative matters, especially accounting procedure, were discussed at length. In addition to these a number of conferences of junior staff were held and lectures were given by geologists as part of a programme of in-service training.

## VISITORS

On 11 January the Department was visited by His Excellency the Governor, Sir Ralph Grey, K.C.M.G., K.C.V.O., O.B.E. At that time all geologists were at headquarters and members of the staff had an opportunity of explaining the nature of their work, methods and results. All were greatly encouraged by the interest shown by His Excellency in their work and in the progress made by the Department.

Mr H.A. Stamers-Smith, C.B.E., Assistant Director of Overseas Surveys, visited the Department during his visit to the Colony in January when the Director of the Geological Survey Department had an opportunity of holding valuable discussions on the subject of mapping progress, aerial photography and other topics.

On 9 December the Department had a visit from the Hon. Dr C. Jagan, Minister of Trade and Industry. The Hon. Minister showed a keen interest in the results being obtained by the Department and particularly in the application of aerial photography to geological mapping. He expressed appreciation of the new developments in the Drawing Office and Darkroom which have greatly speeded up the production of maps.

Visits were also made by numerous other persons, among whom were: Dr Bassett Maguire of New York Botanical Gardens; Mr J.B. Snethlage and Mr S.J. Melihessik, specialist consultants from the United Nations Technical Organization; Mr S. Moment, Mining Consultant to the Government of British Guiana; Mr M.L. Dewan of the Food and Agriculture Organization in Rome, Mr J.G.H.R. Diephuis of the Hydrological Laboratory in Delft, Dr Watts of McGill University, Sr E.O. Miranda of the Geological Survey of Brazil, Mr R. Watson and other members of the Cambridge Expedition to British Guiana, and Dr Vine of the Imperial College of Tropical Agriculture.

Representatives of the following companies also visited the Department during the year:-

African Manganese (Mines Management) Ltd.
Colmar Surinam Oil Co.
Demerara Bauxite Company Ltd.
Fairey Air Surveys Inc.
Harvey Aluminium Inc.
Martin, Sykes and Associates, S.A.
Minerals Engineering
Offshore Exploration Inc.
Petromina (B.G.) Ltd.
Pickands, Mather and Co.
Reynolds Metals Co.
Revere Copper and Brass Inc.
Rover Company Ltd.
San Francis Metals Co. Ltd.
Sinclair and B.P. Explorations Inc.
Taylor Woodrow (Overseas) Ltd.
Union Carbide Ore Co.

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# MINERAL PRODUCTION

The following table gives a comparison of the mineral production of British Guiana in 1959 and 1960; the figures were supplied by the Commissioner of Lands and Mines:

| | 1959 Amount | 1959 Value $ W.I. | 1960 Amount | 1960 Value $ W.I. |
|---|---|---|---|---|
| Bauxite (Long dry tons) | 1,585,872 | - | 2,471,190 | - |
| Diamonds (metric cts) | 62,328 | 3,085,230 | 101,003 | 5,186,504 |
| Gold (oz. Troy) | 3,448 | 190,330 | 2,364 | 130,493 |
| Granite (long tons) | 67,287 | 672,870 | 85,539 | - |
| Manganese (long wet tons) | - | - | 122,726 | - |

N.B. Provisional valuation
$1 W.I. = $0.58 U.S.
= 4s. 2d. Sterling

The Comptroller of Customs and Excise kindly provided the following figures for the quantity and f.o.b. values of mineral exports for 1960:

| Minerals | Export | Value $ W.I. |
|---|---|---|
| Bauxite (long tons) | | |
| Metal and chemical grade | 1,780,297 | 15,942,508 |
| Calcined | 304,946 | 10,378,451 |
| Diamonds (metric carats) | | |
| Uncut diamonds | 92,224 | 4,733,762 |
| Cut and polished diamonds | 56 | 20,019 |
| Gold (oz. Troy) | - | - |
| Manganese (long wet tons) | 76,765 | 2,159,105 |
| | | 33,233,845 |

The value of minerals exported exceeds the figure for 1959 by $5,378,539. This is a very satisfactory result and is due both to the first shipments of manganese ore from the new Matthews Ridge Mine, and to the rising value of diamond exports. A further increase in the value of minerals exported can be expected in 1961 when the shipping of manganese ore gets well under way. No gold was exported during the year.

The improvement in world trade during 1960 is reflected in the increased production of bauxite. The great increase in diamonds is due to the development of the workings in the upper Kurupung River and to the discovery of a new diamond field in the upper Ekereku River. An important development is the export of manganese which started in August 1960. The continued inactivity of B.G. Consolidated Goldfields Ltd. and the emphasis on the diamond workings continued to have a very adverse effect on gold production, and the little that was produced all came from small workings and was sold locally for the production of jewellery.

## III GEOLOGICAL SURVEY

### SUMMARY OF FIELD WORK

Field mapping continued very actively as the Department was at full strength and additional air photographs became available. A further new record was established as a total area of 7,785 square miles was mapped at a scale of 1:125,000; some revision is included and 195 miles of river and railway traverses were also carried out. The mapping of certain critical areas has confirmed that the subdivisions adopted in the revised Stratigraphical Table are suitable and it will be possible to prepare a large number of maps for publication in 1961.

Geological mapping and prospecting of the aluminous laterites of the Pakaraima Mountains continued during the first field season under the direction of Mr D. Bleackley, Senior Geologist, with the help of Messrs J.H. Bateson, S. Singh, R.C. Sansom and J.W. Carter. An area of one square mile near the Kopinang River was drilled in detail, and reconnaissance surveys carried out over 2,500 square miles disclosed further sheets of gibbsitic laterite overlying dolerite sills at two different levels, corresponding to major planation levels already defined. Mr S. Singh continued the reconnaissance mapping during the second field season between Monkey Mountain and Kurungiku and Ebini Mountains, and studied the distribution of gabbros and aluminous laterites. Continuing the reconnaissance work Messrs J.H. Bateson and J.W. Carter prospected the aluminous laterites of the Kopinang and Kamarang-Kukui areas respectively.

Mr P.B.H. Bailey, Senior Geologist, mapped the country between the headwaters of the Wenamu and Ekereku Rivers where gold and diamonds are associated with conglomerates of the Roraima Formation.

A team consisting of Dr E. Williams and Messrs R.T. Cannon, K. Bramley and J.W. Lloyd, carried out further surveys in the upper Bartica and the Barama-Waini areas. The subject of study was the geological structure of the metasedimentary formations of the Barama Group, with special emphasis on the relations to the manganese deposits of the Matthews Ridge area.

Mr D.D. Hawkes carried out field surveys along the Puruni River on the south bank and also northwards from the Mazaruni River to the headwaters of the Puruni.

Extensive granites occur which have been subdivided and are associated with metasediments of the Mazaruni Group. Extensive sills and dykes of dolerite occur and some of these appear to be cone-sheets. Mr M.G. Allderidge mapped the country east of the lower Puruni River, including Peters Mine and Aremu Mine. By paying particular attention to structure he was able to add much to what was already known about this goldfield, which was once the most productive in the country but is now deserted. Dr E. Williams joined Messrs. Hawkes and Allderidge in the latter part of the first field season in order to map in detail the Puruni River from its mouth to Arabagai Falls.

Dr Williams in the second field season examined the rocks exposed along the Mazaruni River between Issano and Apaiqua, and in the Merume River. The Mazaruni Group of this region is divided by him into the Cuyuni Formation and the Haimaraka Formation, which has been considered to be a possible continuation of the Barama Group. However, evidence was found to show that the Haimaraka Formation conformably overlies the Cuyuni Formation and is, therefore, much younger than the manganiferous horizons of the Barama Group further north.

Mr R.T. Cannon re-mapped the Kaburi area later in the year in continuation of his investigation of the rocks of the Bartica region. Amphibolites, biotite gneisses and hornblende-biotite gneisses are inter-banded on a large scale and are an extension of the Bartica Assemblage. Hornblende anorthosite occupies a large area in the Kaburi River basin. This rock consists of large crystals of labradorite/bytownite with interstitial hornblende.

During the second field season Mr J.W. Lloyd mapped the Waiamu area, Cuyuni River, where a series of bedded phyllites and quartzites, called the Waiamu Island Formation and believed to be of the Barama Group, is considered to be older than the adjacent sandstones and igneous rocks (Cuyuni Formation).

Mr M.G. Allderidge mapped an area east of the lower Puruni River south of the old Peters Mine road during the second season. This area is underlain entirely by gneisses and amphibolites of the Bartica Assemblage, with a few minor intrusives. The origin of these rocks is not known, but the frequency with which sillimanite occurs suggests that they may have a pelitic origin.

Mr C.N. Barron mapped in the earlier field season the Pott Falls and Omai areas, both of which have old deserted gold mines. The rocks are meta-sediments of the Muruwa Formation, with other volcanics and metasediments of the Mazaruni Group, associated with granites which underlie a large part of the area mapped. The gold mineralization occurs marginally to the granites. All have been sheared to a large extent and it is quite possible that the shearing, which is not uniform, may have some relation to the gold mineralization. During the second field season Mr Barron continued his mapping of similar rock-types to the south between the Demerara and Essequibo Rivers.

Mr L.L. Fernandes carried out reconnaissance surveys on the gabbro which intrude the Roraima Formation in the upper part of the Cuyuni River basin and samples of the bauxitic laterites and red earth were collected for chemical analysis. Reconnaissance prospecting for diamonds was also carried out during a tour of the Wenamu River diamond field.

Mr M.W. Carter mapped an area between the Ireng River and the Burro-burro River, and the southernmost part of the Pakaraima Mountains, between the Ireng River and the headwaters of the Siparuni River. The rocks mapped fall chiefly into two groups namely, acid and sub-acid porphyries, and rhyolites which may be extrusive. These are associated with granophyres which are believed to be genetically related to the volcanics because a notable feature is the number of transitional rock types which seem to link the two together.

In the area extending from the Mazaruni River above Apaiqua westwards towards the Ekereku River, Mr O. St. John, Field Observer, carried out field mapping and prospected the streams for gold and diamonds. The survey extended up on to the top of the Pakaraima escarpment. The oldest rocks are foliated volcanics and metasediments of the Mazaruni Group overlain by the Roraima Formation. The base of the Roraima is at a low elevation being about river level, and it is intruded

→ AGE OF SOUTH SAVANNA GRANITE

One of the great difficulties inherent in the study of the geology of the very old Precambrian rocks encountered in British Guiana is to establish the relative age of the various formations which we distinguish and mark on our geological maps. Various provisional stratigraphical tables, such as Appendix III in this volume, have been produced from time to time which aim at giving relative ages based on the observed geological and structural relationships of the rocks. The same difficulty is met in all countries composed of these ancient rocks, and in an attempt to find a solution methods have been developed in recent years for determinations of age based on the rate of decay of radioactive minerals. Such methods are still in an early stage of development and are expensive, hence they have not been applied hitherto in British Guiana.

Specimens of monazite, a radioactive mineral of thorium occurring in the South Savanna Granite, were however collected by members of the Atomic Energy Section, Geological Survey of Great Britain, and have been analysed. The results indicate the great age of 2,270 million years (plus or minus 185 million years). This age falls in the Lower Precambrian and thus confirms the place given to the South Savanna Granite in the stratigraphical table.

reconnaissance map in five years. As a preliminary it was found necessary to revise the definition of the geological formations of British Guiana and determine as far as possible their actual relationships, this involved drawing up a new Stratigraphical Table. The publication of maps was held up until it was felt that the newly defined rock formations were satisfactory and would, when mapped, give a picture of the geology and structure of British Guiana which would facilitate the interpretations necessary in modern prospecting. After the last field season of 1960 it was decided that this stage had been reached, and that the mapping cover would be sufficient by the end of 1961 to warrant the preparation of a draft geological map of the whole country for publication in colour at a scale of 1:1,000,000. This target should thus be reached one year ahead of schedule.

Arrangements are also being made for the publication during 1961 of a large number of map sheets at a scale of 1:200,000 (about 3 miles to 1 inch). These sheets are each one quarter of a degree square and will be published with geology and topography as line drawings in black and white, with about 1500 words of geological notes on the sheet itself. The maps are so drawn that the geological formations can be easily hand coloured by the recipient. This method is based on the practice of the Geological Survey of Canada, and means that the work of the geologist can be placed at the disposal of the public cheaply and very soon after receiving the final draft. Dr E. Williams and Mr R.T. Cannon have assumed responsibility for producing and editing these map sheets.

Owing to the reorganization of the Drawing Office under the present Chief Draughtsman, Mr T.M. Rahaman, the production of maps has been greatly speeded up. The new black and white 1:200,000 quarter degree sheets will be completely drawn at 1:125,000, photographed down and taken to the diapositive stage by the Drawing Office staff. The printing will be done by a local company in direct consultation with the Survey. It will thus be possible to produce the maps very rapidly and economically. If the Drawing Office staff can be maintained at its present level it is hoped to publish 25-30 sheets during 1961, and altogether some 50 sheets covering about 75% of British Guiana by the middle of 1962. The plan of publication of the sheets is shown on the map Figure.

PROSPECTING

The principal object of the survey carried out by Mr O. St. John in the Wakawakapu area was to prospect for gold and diamonds and, if possible, to open the area to prospectors and cut a trail to provide access to the recently discovered diamond fields at Ekereku River on the Pakaraima plateau to the west. Most of the streams prospected contained some gold, which was often fairly coarse and at times present in amounts that would probably repay small scale working. The gold is present both below the Pakaraima escarpment and above it, and normally accompanies diamonds in the Ekereku area. Before the expedition was concluded a number of local prospectors followed the lines cut by the Geological Survey and shortly afterwards it was reported that some had actually found diamonds in a small tributary of Wakawakapu Creek below the escarpment. After several attempts a route up to the top of the escarpment was eventually found but completion as far as Ekereku River will have to continue in 1961. The cutting of the trail has attracted the attention of local prospectors, and when completed, it will undoubtedly be much used and it will be a much shorter route to the upper Ekereku area than either by the Cuyuni River or by Kamarang.

Mr K. Bramley, during his survey of the upper Barima River area, found a specimen of hornblendic rock containing niccolite. Chemical analyses of this and of some soil samples he collected revealed the presence of traces of nickel, cobalt and molybdenum. During the second field season of 1960 Mr Bramley returned to the same area and extended his surveys, and collected more soil samples on a grid pattern. These were analysed and tested for lead, copper and zinc. When the results were available it was found that the highest proportions of the metals in the soils were associated with amphibolites and with a granite margin which had been mapped during the course of the survey. A further investigation is in progress.

## A I R   S U R V E Y S

A further contract for aerial photography was kindly arranged by the Directorate of Overseas Surveys and photographs were taken with a wide angle camera from an altitude of 15,000 feet giving an approximate scale of 1:51,000. Unfortunately cloud cover was even worse than normal and of only about 5,000 square miles were photographed. Although this was rather a disappointment, such photographs as were taken were in areas where they were badly needed and a large proportion of them have already been interpreted geologically. A large proportion of the Pakaraimas is now covered by aerial photographs and by interpreting these with the assistance of field surveys carried out during 1960 and also in earlier years it was possible to prepare a series of satisfactory geological maps which will be prepared for publication in black and white in the near future.

It has been emphasized many times that aerial photography is quite indispensable for the production of even reasonably accurate geological maps, especially in tropical countries where ground work is arduous and access difficult. The availability of aerial photographs contributed largely to the record square mileages mapped during 1959 and 1960. In the case of the Pakaraima Mountains as well as in other areas it was possible to make geological maps at headquarters with the minimum of previous field surveys, and in some cases field work can be cut to a minimum through using the compiler's knowledge of the terrain. Without continuing aerial photography over that part of the country that remains to be covered, progress in geological mapping must inevitably diminish very considerably in the future.

## AIRBORNE GEOPHYSICAL SURVEY

With a view to planning the campaigns of airborne geophysical surveying which will be required to locate any hitherto undiscovered mineral resources in the Interior of British Guiana, a test survey flight was arranged. This was flown on 31 January by a DC 3 aircraft of Aero Service Corporation equipped with magnetometer, scintillometer and Radan Doppler navigation. A traverse of 356 line miles was flown westward from Atkinson Airport to Saxacalli, thence southwest to the Merume chromium area where a box was flown, thence east-northeast to Itaki where another box was flown, thence directly to Atkinson.

A comparison between the geophysical records made and the existing geological maps enabled important comparisons to be made, and it was shown that the Radan Doppler navigation system would bridge gaps in the photographic cover. Interesting features were recorded over the chromium deposit which will guide more detailed work in the future.

## TOURS OF INSPECTION

During September the Deputy Director, Mr C.G. Dixon, spent a fortnight in the field with Mr O. St. John, Field Observer, in the Wakawakapu area, Mazaruni River, in order to study the geological formations and to study the possibilities for developing the gold and mining activities in the area.

From 13-15 October, through the courtesy of the Manager of Northwest Guiana Mining Company Limited, Mr Dixon accompanied the Commissioner of Lands and Mines on a visit to the manganese mines property as guests of the Company. They flew into the North West District, to the landing pool on the Kaituma River at the mouth of Sebai Creek, and then went by launch to Port Kaituma. A conducted tour was made of the bulk loading installation and railway terminus at Port Kaituma, after which the visitors went to the mine by railway. At Matthews Ridge a tour was made of the Mines and the operations were followed from the excavation at the working faces, through the assay laboratory and the washing plant to the railway terminus where the ore is loaded into the railway trucks for transport to Port Kaituma. The housing schemes and welfare facilities for staff and workers were inspected and the visitors were much impressed with the great developments that had been achieved in the few years that had elapsed since the company's operations had begun.

## IV MINERAL DEVELOPMENT

### GENERAL

A new phase in the mineral development of British Guiana opened in 1960 as Northwest Guiana Mining Company Limited begun exporting manganese ore from their Matthews Ridge mine in August.

In response to the growing world demand the production of bauxite was stepped up and reached a total of 2,471,190 long tons. There was considerable activity in bauxite prospecting by three major companies.

Diamond production, already greatly increased last year, reached a new record of 101,000 metric carats. This was due to the discovery of diamonds in the Ekereku River above Sakaika Falls which established yet another diamond field above the scarp of the Pakaraima Mountains. The entire production was from small workers.

The production of gold continued to decline as porknockers were drawn towards the new diamond finds.

Three areas were closed to prospecting or mining or the locating of claims, under Section 36(1) of the Mining Ordinance, in order to permit the Geological Survey to carry out further detailed investigations for bauxite in the Kopinang-Sukabi area, for chromite in the Merume area and for iron in the Iron and Wamara Hills area.

### BAUXITE

General

The production of bauxite was up by over 800,000 long tons on last year's figure, reflecting the improvement in world business.

Demerara Bauxite Company Limited

The mining of bauxite during 1960 was nearly up to capacity again and a total of 2,231,940 tons (dried basis) was produced, of which 397,180 tons came from the Ituni area. Market conditions improved in 1961 and a total of 1,921,468 tons of bauxite were sold, and carried in 415 vessels to 25 different countries. This compares with 1,332,307 tons sold in 1959. 180,000 tons were sold to the United States Government stockpile. The total was made up as follows:

| | |
|---|---|
| Metallurgical grade | 1,513,534 tons |
| Calcined grade | 317,542 " |
| Chemical grade | 90,392 " |
| | 1,921,468 " |

With the advance of the mine faces the depth of white sand overburden is increasing and a further heavy investment in excavating machinery became unnecessary. A new dragline with 235-ft. boom and 10-yd bucket came into service at a cost of W.I. 2 million dollars. A wheel excavator and allied equipment is also being purchased at a further cost of W.I. 3½ million dollars.

The new W.I. 65 million dollars alumina plant was nearing completion at the end of the year. The first unit of the new steam power plant came into operation and digesting operations began in January 1960. The first shipment of alumina is expected to take place in April 1961.

The gauging of rivers with a view to the development of hydro-electric power was continued and two new gauging stations were built for the Government at Hillfoot on the Mazaruni River and at Itabru on the Berbice River. Observations were made at four stations under licence, as well as at five Government stations including those newly constructed.

Exploration was stepped up during the year and directed towards E.P's 561 and 564 situated between the Demerara and Berbice Rivers and to the south of Ituni on the one hand, and E.P. 562 in the North West District which lies south of Mabaruma between the Venezuelan border and the Kaituma River.

South of Ituni the area investigated centred around the drainage systems of Kuruabaru and Ororokabra-Harakren Creeks, discharging into the Demerara River at 25 and 125 feet respectively above sea-level. In this area large portions of white sand depositional surface occur at a general elevation of 215-250 feet above sea-level, with several small steep-sided laterite-capped hills, having a core of dolerite or gabbro, rising about 200-300 feet above the surface, whereas in the creek valleys laterized outcrops of basement rocks are sometimes exposed. As very few outcrops of basement rock are exposed in the deep and widely spaced valleys it was decided to do some deep drilling to explore for concealed bauxite deposits and further detailed mapping was carried out, greatly facilitated by the use of precision altimeters. The southern portion of E.P. 564 is drained by tributaries of the Berbice and Demerara Rivers and terminated to the south by the scarp of the Makari Mountain outlier of the Roraima Formation. No laterite hills occur here and the white sand sediments appear to be underlain by granite, gabbro and volcanics.

Exploration in E.P.562 in the North West District showed that the hills rise sharply above the tidal sweep to heights of 200-300 feet and formations of hornblende schists and epidiorites were usually covered with a highly ferruginous laterite cap. South of the swampy area the land rises to an undulating surface at an average elevation of 100-150 feet. This surface, which is not laterized, is covered by light-coloured residual clayey sand derived from granitic rock which is often exposed in creeks. In the south this landscape is interrupted by a range of hills stretching from Yarikita Hill to Arukumai and Maridawa hills. The core of this range again consists of a hornblende schist which is at the surface covered by laterite which is best developed on Yarikita Hill at an altitude of 700 feet above sea-level.

Reynolds Metals Company Limited

About 200,000 long tons (dried basis) were shipped from Everton to the United States, about 50,000 went to the Chemical Industry and the balance to the Government stockpile.

Drilling was active throughout the year and was encouraging as four boreholes discovered new deposits in widely separated areas. Drilling has furnished conclusive evidence of sedimentary sands and clays below the bauxite horizons in the vicinity of Kurubuka. Lignite seams were encountered in a borehole beneath the bauxite horizon and samples submitted to the Geological Survey were shown to contain pollen grains which indicate a Palaeocene age for these sediments. Drilling was continued in the Corentyne area and proved more encouraging as lesser depths of overburden were encountered.

Harvey Aluminum of America

As noted last year Harvey Aluminum have revived their interest in British Guiana and during the past year two geologists were engaged in exploration chiefly in the area on the left bank of the Essequibo extending north to the Supenaam and Pomeroon Rivers. Some exploration was also done on the left bank of the lower Corentyne. A base camp was established in the Blue Mountains area and included a fully equipped field laboratory, the base camp was later moved to a point on the Supenaam River.

Petromina (B.G.) Limited

Exploration of the Southern Ebini and Itaki Hills was completed in 1959 and North Ebini was tackled during 1960. The laterite bench at the foot of the Ebini Hills lies between 350 and 450 feet above sea-level and mainly overlies a hornblende-biotite granite. However as the hills are approached outcrops of basic amphibolites and epidiorites occur. The white sands overlying the massive Ebini Creek laterites were found to be only 15-20 cms thick and it is evident that much of the laterite is detrital and sand beds occur within it in places.

Drilling was also carried out in the Itaki area but was suspended after affording poor results. Further work in the Omai area which is adjacent to the south of the Issano Road is planned for 1961.

During the year an additional E.P. covering 600,000 acres in the Konawaruk-Mowasi-Muruwa areas, south of the confluence of the Potaro and Essequibo, was granted to this company for bauxite exploration.

Geological Survey Department

A great effort was put into the exploration of the aluminous laterites discovered on the Pakaraima Mountains in the previous year and reconnaissance mapping was carried out over an area about 150 miles in length stretching east-southeast from the Kamarang River valley to the Kopinang Basin and beyond. Throughout this area aluminous laterites, locally enriched to ferruginous bauxites, were found at two main levels, 1200 and 1500 feet and 2200 to 2500 feet in elevation, corresponding to planation levels which have a wide extent in the Guiana Shield. The laterites have formed by weathering of dolerite wherever this has been exposed on the planation levels, and as these are probably greater than 25 million years in age, the weathering processes have been at work for long periods of time. The main deposits have formed over one of the thickest of the dolerite sills intruded into the Roraima Formation, known as the Lower Kopinang sill, which varies somewhat in altitude. Owing to the remote and rugged nature of the terrain and the thick bush cover, the exploration of the deposits is far from complete and further campaigns will be directed towards locating the areas of higher grade.

From the work already completed it is established that the Lower Kopinang dolerite sill has been weathered to laterite and lithomarge over the major portion of the 1000 square miles of its outcrop. The upper 10-15 feet of the "laterite" is enriched in alumina to form a ferruginous bauxite or aluminous laterite, the silica content is variable but increases sharply downwards at the base of the laterite to form a zone of "lithomarge".

Exploration has defined three areas of possible economic interest, in which the character of the laterites differs, as follows:

1. The Kopinang River Basin. In this area the upper 10 feet of the deposit, over some 300 square miles, is a ferruginous bauxite low in silica with an average analysis, based on the sampling of 35 pits, of 40.4% $Al_2O_3$, 6.1% $SiO_2$, 27.6% $Fe_2O_3$, 2.1% $TiO_2$ and L.O.I. 23.7%.

2. The Sukabi River Basin. Laterites cover some 250 square miles but only 3 pits have so far been sampled. These preliminary results indicate a higher content of silica, the average analysis for a depth of 16 feet shows 34.4% $Al_2O_3$, 16.5% $SiO_2$, 25.8% $Fe_2O_3$, 1.9% $TiO_2$ and 21.8% L.O.I.

3. The Kamarang-Kukui Area in the basin of the Upper Mazaruni River. 16 pits have been sampled over an area of some 400 square miles and the average analyses of the top 14 feet shows a considerable increase in silica ($SiO_2$ 20.3%) with a decrease in iron oxides ($Fe_2O_3$ 19.7%) and alumina ($Al_2O_3$ 33.3%).

The ferruginous bauxites of Kopinang appear to be of a slightly higher grade than those of Oregon and compare well with the "ferruginous bauxites" of Ghana and the "red ferruginous bauxites" of Antrim, N. Ireland. The material from the Kamarang-Kukui and Sukabi areas appears too high in silica for treatment by present day commercial processes.

Attempts to beneficiate the material by washing and screening, although not conclusive, seem to indicate that it would be possible to reduce the silica content, but the yield would be low and much alumina lost in the tails.

The grade of material from the Kopinang area, as estimated from only 55 pits (approximately 1 per 10 square miles) appears to be too low grade for treating by the normal Bayer process. The Pederson process utilizes lower grade ores recovering both alumina and iron, but requires low-cost electric power besides large quantities of lime and coal. There is a great undeveloped hydro-electric potential in the Pakaraima Mountains, but the lime and coal would have to be imported.

The future of these deposits appear to rest either (1) on the discovery of areas of higher grade bauxite, or (2) the development of a process for the economic extraction of both alumina and iron. Exploration continues, and possibilities of the second alternative are increased by the existence of additional vast deposits of low-silica aluminous laterites elsewhere in British Guiana, as well as by the great hydro-electric potential in the rivers descending from the Pakaraima Mountains.

<u>Pollen Analysis applied to Bauxite Prospecting</u>

Since the known high-grade deposits in the famous bauxite belt of British Guiana and Surinam disappear to the north below a cover of white sands, much attention has been given to the problem of discovering new deposits beneath the coastal sediments. The upper portion of these consists of a continental-deltaic deposit of alternating white sands and sandy clays in which it is impossible to establish recognizable lithological horizons owing to the lenticular nature of the beds. In an effort to find some criteria for recognizing the bauxite horizon in boreholes the Geological Survey decided to investigate the possibilities of the palynological methods developed nowadays to such perfection by the oil companies. Professor Th. van der Hammen, a pollen specialist, previously with the Geological Survey of the Republic of Colombia and now attached to the University of Leiden, agreed to act as our consultant and has already obtained very promising results. He states in a provisional report that it appears that the sediments beneath the bauxite are Palaeocene in age whereas those above are much younger. It appears thus very likely that the pollen analysis of borehole samples will indicate the position of the bauxite horizon. A number of mining companies have expressed their interest and have already contributed to the preliminary investigations.

660



On Prof. van der Hammen's advice the Geological Survey has proposed a scheme, to be financed by the principal bauxite mining companies in British Guiana and Surinam, to enable a graduate of the University of Leiden to develop a practical field method of recognizing the formations above and below the bauxite horizon by means of pollen grains. The first reaction of the mining companies has been favourable and it is hoped that the scheme will be implemented during 1961.

## CHROMIUM

During the test airborne geophysical survey referred to on page 14 a box was flown over the Merumé River area where the chromium mineral merumite occurs. A positive magnetic anomaly was detected whose upper surface was estimated to lie at a depth of some 1500 to 1800 feet. The fact that this anomaly lies in the area of greatest concentration of the detrital merumite indicates that it may be in some way connected with the deposit. The area is flat and bush-covered with scarce outcrops and the lines were flown NE-SW across the strike of the country. However the magnetic anomaly and general gradient proved to be aligned NE-SW and a further more detailed magnetic survey with NW-SE flight-lines is being planned.

## COLUMBITE

### Columbium Corporation

Mineral prospecting operations by this company were subordinated to site-work for a large-scale pulpwood operation to which the Corporation is committed.

## DIAMONDS

### General

Diamond mining on the plateau areas of the Pakaraima Mountains has increased in recent years, largely because of the lesser amounts of overburden to be removed before the diamondiferous gravels are reached. Some of the best concentrations have been found to occur in pockets of gravel in the stream beds. Boulders in swiftly flowing rivers have often to be cleared away in order to reach the gravel caught in pot holes or fissures. In deep water diving equipment has to be used, in shallow water the simple "water-dogging" method is employed. Some very good recoveries have been made in this way, and one miner is reported to have extracted some 2000 carats in the upper Ekereku after about three months work.

Another method of working is to climb down the large boulders on scree slopes, which sometimes requires the use of ropes to gather by lantern light the gravels caught beneath. Good recoveries are reported to have been made by this method also.

Ekereku River

Within the Pakaraima Mountains the Ekereku River became, in its course on the plateau above Sakaika Fall, the scene of increasing activity. Most of the diamonds were produced by diving methods and came from a section of the river not more than 12 miles long near Sakaika. Mr George Golas, an associate of Mr M.C. Correia, established several small airstrips and shops and using as many as three light aeroplanes maintained a shuttle service to Kamarang airstrip which is now capable of taking Dakota aircraft. Other interests also established the feasibility of a Grumman amphibian service from either Georgetown or Tumereng to a landing pool on the Ekereku, beside which a number of shops to supply miners were quickly built. It is doubtful whether this area would have developed without air transport, for the few arduous trails to the area are slow and expensive to use.

The Geological Survey opened up the Wakawakapu creek area below the Pakaraima escarpment east of the Ekereku River, where both gold and diamonds are now known to occur. Prospectors are now active in this new area, having followed the lines cut by the Geological Survey. A trail was cut westwards from the Mazaruni River up to the escarpment and this will be continued to the Ekereku early in 1961.

North West District

It was recently reported that diamonds are being worked in the North West District in the Mobaina Creek area, about 25 miles south-west of Mabaruma. The diamonds are small - about 1/8th or 1/16th carat in size.

Upper Kurupung - upper Eping

Diamond mining remained active in the upper Kurupung River and the increase in the overall production figures for 1960 is primarily due to operations in this area. The prospectors are spreading eastwards to the upper reaches of the Eping River where some are being supplied through Imbaimadai airstrip, although the Imbaimadai area itself has proved disappointing.

GOLD

The small miner has largely deserted the gold diggings for the newly discovered diamond fields. Considerable efforts to interest companies in large-scale dredging have so far met with little success. The chief producing area was the North West District.

Petromina (B.G.) Ltd.

A drilling campaign was carried out on holdings in the Puruni River below Peters Mine but the gold values proved uneconomic.

IRON

A representative of an important Canadian iron mining company visited the Geological Survey and expressed interest in the magnetite deposits in the South Savannas of the Rupununi District. At present these do not appear to justify exploitation in view of the great distance from tidewater, but further work is being carried out and the company will be kept informed.

MANGANESE

Northwest Guiana Mining Co. Ltd.

Mining operations commenced on 1 March 1960 and by the end of the year 122,726 tons of manganese ore averaging over 40% Mn had been produced. 119,279 tons were railed to Port Kaituma whence the ore is shipped to a stockpile at Chaguaramas, Trinidad. A tanker has been converted for this purpose and can negotiate the canal and deepened channel of the Kaituma River, and the bar at Waini Mouth, carrying a load of approximately 2500 tons. Shipping started on 5 August and at the end of the year 76,765 tons (wet) had been exported.

The exploration of EP 543, in the Kutuaú River area north of the Cuyuni River was completed. No promising deposits were found but laterites, which are not extensive, contain very small amounts of manganese. One block of good grade with lateritic structure was found, but a search in the area failed to discover any deposit. The conclusion of the Geological Survey that manganiferous phyllites form a belt in the Barama Group, immediately to the north of the Central Cuyuni Formation is confirmed. The eastern part of that belt has been systematically prospected for manganese ores and is known to extend also to the west of Kutuau River.

Exploration between Matthews Ridge and the Barima River disclosed deposits of bedded manganese ore in two hills. Pitting and trenching has established that the grade is too low for economic exploitation at present.

OIL

The California Oil Company (British Guiana) Ltd. (So Cal) decided to abandon their concession. The marine seismic survey carried out in 1958 indicated a promising thickness of sediments inside the 25 fathom bottom contour, but the conditions for the accumulation of workable reserves of oil were judged to be unpromising.

Since this work was carried out, however, the Geological Survey has shown that Eocene, Palaeocene and probably older strata are present in the coastal sediments, and additional indications of the presence of oil have been reported. A further application for exploration rights has been made by an American group.

## V CONFERENCES AND VISITS

From 19-27 January the Director paid a visit to Venezuela at the invitation of the Compania Shell de Venezuela. The major oil companies of the world now make a practice of studying the basement rocks underlying oil bearing formations, as much information is thus derived concerning the structure and distribution of oilfields. Correspondence with the Shell geologists in Venezuela who were mapping the Guayana Shield, which forms the basement of the oil fields, led to this generous invitation to visit the areas mapped by them. Six days were actually spent in the field on the Guayana Shield between the Orinoco River and the border of British Guiana, and the party was joined by geologists of the Direccion de Geologia, Ministerio de Minas e Hidrocarburos.

Outcrops of the Imataca Formation were studied in some detail in view of its economic importance as a bearer of iron ores, and visits were paid to the two great iron mines by courtesy of the companies concerned - (1) The Orinoco Mining Company, a subsidiary of the U.S. Steel Corporation, which mines the iron deposits of Cerro Bolivar and has done much valuable research on their geological history, and (2) The Iron Mines Company of Venezuela at El Pao, a subsidiary of the Bethlehem Steel Corporation. As a result of this visit it was decided that the Imataca Formation was not present in the North West District of British Guiana. The manganese deposit at Upata, also in the Imataca Formation, is of a type considerably different from the occurrences of manganese in British Guiana. A most interesting visit was also paid to the office of the Government Geologist stationed at Ciudad Bolivar.

Other geological formations which are probably represented in British Guiana were also examined, and problems of correlation discussed with the Government and company geologists. A good measure of agreement was reached. Very interesting information was also obtained regarding the altitude distribution of three planation or erosion levels which are now widely recognized in British Guiana. It is the tropical weathering on these nearly level plains or plateaux which has resulted in the enormous deposits of aluminous laterite now known to exist throughout British Guiana, and it was of very great interest to find that the same series of plateaux existed in Venezuela Guayana. It is now known that the high grade of the iron ores at Cerro Bolivar and El Pao is also due to the same weathering processes acting upon iron-rich formations exposed on a high, and consequently very old, erosion surface which can be correlated, following wide-spread evidence, with the Saliparu Surface (2250-2500 feet) in the Pakaraima Mountains which carries ferruginous bauxites[1].

the Director

While in Caracas / was invited to visit the well-equipped offices and laboratories of the Direccion de Geologia, and had the great pleasure of meeting the Director and his staff, some of whom had attended the Inter-Guiana Geological Conference in Georgetown in the previous year. I was also privileged to meet the Minister of Mines and Hydrocarbons and very pleased to accept an offer which he kindly made of close collaboration between the Geological Surveys of Venezuela and British Guiana; my acceptance was later confirmed by the Minister of Trade and Industry on my return to Georgetown. A move

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1. Geological Survey of British Guiana, Annual Report for 1959, p. 37.

to organize a joint expedition to settle questions of correlation and nomenclature on eitherside of the international border later in the year failed owing to previous commitments, but will probably take place in 1961.

The Director left for the United Kingdom on long leave on 15 March, passing through Port of Spain where three days were spent attending to business connected with his post as Geological Adviser to the Federation of the West Indies. A visit was also paid to the Consulting Geologist of Texaco Trinidad Incorporated to discuss recent developments in the exploration of the coastal sediments of British Guiana.

Four days were also spent in Jamaica visiting the Geological Survey offices, the bauxite mines and other points of geological interest, accompanied by the Director of the Geological Survey and others of his staff. Grateful acknowledgement is made for their kindness.

The Director subsequently attended the 21st International Geological Congress held in Scandinavia in August-September, as official delegate of the Government of British Guiana. A draft of the new Geological Map of British Guiana and a revised draft of the Mineral Map, both at a scale of 1:500,000 were exhibited and attracted comment. A paper entitled "A geological map of British Guiana" by R.B. McConnell and C.G. Dixon was read to the Congress. Comments on the new interpretation of the geology of British Guiana by Government and commercial geologists familiar with the Guianas were favourable, and publications of the new detailed map requested.

In addition to hearing many interesting scientific papers and subsequent discussions on subjects bearing on the type of geology, and the associated mineral deposits, which can be expected in British Guiana, the Director attended meetings of the International Commission for the Geological Map of the World and other Commissions. He was an ex officio member of the Council and Bureau and supported the choice of India as the host country for the next International Geological Congress to be held in 1964. Before and after the official sessions in Copenhagen, Field Trips were made to study structural and economic problems in Norway and Finland. Important discussions on the progress of the study of the fossil pollens contained in the coastal sediments were held with geologists representing British Guiana and Surinam bauxite mining companies and after the Congress a visit was paid to Prof. Th. van der Hammen at Leiden University, who is acting as Consultant to the Government. Details were discussed of a project to apply the methods of Pollen Analysis to the problems of prospecting for bauxite in the coastal sediments of British Guiana.

On the return journey to British Guiana consultations were again held with Federal Government officials in Trinidad, and a visit of inspection was paid to the stockpiling installation of Northwest Guiana Mining Co. Ltd. at Chaguaramas.

Mr D. Bleackley, Senior Geologist

From 29 February to 6 March Mr D. Bleackley visited Surinam as guest of the Surinam Aluminum Company and the Billiton Maatschappij. He was kindly shown many details of the bauxite occurrences in Surinam which were of value in interpreting the bauxite and laterite deposits of British Guiana, of which he is making a special study.

## VI WATER SUPPLY

The investigation of the water supply potential of the coastal artesian aquifers continued during the year and confirmed that the off-take could be greatly increased. Dr L.E. Ramsahoye, Geophysicist-Hydrologist was drawn more and more into the practical side of water supply work and was finally seconded to Pure Water Supply in November 1960. The most important achievement was the completion of the test borehole in the Shelter Belt, Georgetown, put down by the Pure Water Supply for the Geological Survey. The objectives of this borehole started in 1959 were twofold - (a) to collect samples of a complete cross-section of the coastal sediments to basement with a view to assessing their oil-bearing possibilities and establishing a type section to which further work can be referred, and (b) to test the potential of an aquifer which previous records indicated should lie at a depth of 1250-1350 feet and contain a good supply of water of high chemical purity. In spite of a great many difficulties these objectives were finally achieved under the supervision of Mr D. Bleackley, Senior Geologist, and Dr L.E. Ramsahoye.

The borehole proved a thickness of 1936 feet of sediments and was completed in solid basement amphibolite at 1951 feet; specimens of the core were collected every ten feet and are now stored at the Geological Survey. A complete set of samples of the core was sent to Professor Th. van der Hammen at Leiden University for pollen analysis and his report will be available shortly. The preliminary results of his study have been extremely interesting, and encouraging in the search for oil, and they are recorded in other pages of this report. The cracks in the basement rock were found to be lined with heavy oil which must have seeped in from off-shore beds.

The cost of the borehole was met from a C.D. & W. grant supplemented by a grant from the Georgetown Sewerage and Water Commissioners whom the well was handed over to on completion. Dr Ramsahoye reports on the satisfactory results of this test well as follows:

> "Field work in this sphere of hydrology has been confined to work on the deep well at Shelter Belt. This well which went right down to basement showed a total thickness of sediments of approximately 1950 feet. Three main sand horizons were encountered. The Upper Sands from 160-295 feet. The "A" Sand from 665-820 feet, and the Lower Sands from 1260-1360 feet.

"The opportunity was taken to check the characteristics of the Upper Sands. The hydrostatic head was 1 foot above land surface, and permeability 1,000 U.S. units, the Cl content was 1260 ppm and Fe content 60 ppm. From the chemical analysis it is obvious that this water is quite unsuitable for domestic use, and any possibility on the use of shallow wells in the Georgetown area is ruled out. The "A" Sands were not tested because enough information has already been acquired about this aquifer from two previous wells in the Shelter Belt which were completed in these sands.

"The Lower Sands comprising the lower aquifer are mixed grey coarse sand and gravel. The well was completed in these sands using 60 feet of the standard 8-inch everite and button screen. The hydrostatic head of this aquifer was 36 feet above ground level and the natural flow at ground level was 500 Imp. gallons per minute. On pumping, this well produced 1,000 gallons per minute with an additional draw-down of 24 feet. The chemical analysis showed a chloride content of 8 ppm and Fe content of less than 0.2 ppm. These results surpassed all expectations and confirmed the existence of a very productive aquifer with water of the highest degree of purity hitherto encountered in wells in this country.

"The results from this test well will undoubtedly have a marked effect on the future of artesian water in this country."

## VI HEADQUARTERS

### ADMINISTRATIVE OFFICE

In spite of much changing around in numerous key posts on the administrative staff the work continued most satisfactorily. A considerable amount of accounting was occasioned by the conclusion of Colonial Development and Welfare Scheme D 2792 on 31 March and the start of Scheme D 4333 on 1 April 1960, owing to the need for reconciling the accounts of the scheme which had just expired. This work was efficiently concluded by the Acting Senior Accounting Officer. Staff conferences of junior staff were held as part of a plan to conduct in-service training, and this was amplified by a course of lectures on geology, prospecting and allied topics, by senior officers of the Department.

### LABORATORY

The conditions under which laboratory work was carried out continued to be difficult until the new laboratory was occupied and work became fully organized. The most pressing work was the analysis of hundreds of samples of aluminous laterites collected during prospecting surveys for bauxite, and soil samples collected for geochemical prospecting. Priority was given to the laterite samples and by the end of the year a great deal had been done and progress was being made in catching up on arrears of work in this connection, so that it was possible to make a start on testing soil samples for geochemical prospecting. Work was also held up for a time owing to acid fumes having corroded the metal chimney leading from the fume cupboards, but this was temporarily remedied by the installation of a chimney made of more resistant material. Work was also interrupted since the Chemist-Petrologist decided not to take a new contract.

Nevertheless a good deal of work was done and the record for the year still compares favourably with earlier years. The new laboratory is very much better planned than the old one, and a continued effort is being made to bring the equipment up to date so that eventually the quality and quantity of results carried out will be brought up to the standard that is normally required of modern chemical laboratories.

The following work was carried out during the year:

| | |
|---|---|
| Analyses and identifications for the Dept.----- | 1209 |
| Sieve analyses & heavy mineral preparations---- | 52 |
| Thin sections prepared---------------------------- | 857 |
| Analyses, etc. for private firms or individuals | 20 |

The total of the above is 2,138; and the corresponding figure for 1959 is 2,166, but of these, during 1960, a total of 1,229 chemical analyses were carried out against 476 for 1959. Thus the new laboratory has already justified itself by nearly trebling the number of chemical analyses carried out.

## DRAWING OFFICE

The drawing office continued to develop rapidly and this was greatly assisted by the acquisition of a dark room and map printing machine. The full staff is now 11, including Apprentices, and during the wet seasons between expeditions an additional 15, including Field Observers and Field Assistants, work in the drawing office under the direction of the Chief Draughtsman.

The following work was carried out during the year:

| | |
|---|---|
| Prints of maps .. .. | 3379 |
| Photoscope stencils .. | 67 |
| Maps drawn or traced .. | 141 |

The quantity of work carried out in 1960 was much greater than in 1959. During 1959 the number of prints made, by ammonia-printing in frames, was 1710; the difference was due to the new dark room and printing machine. The photoscope, in addition to being used for making stencils of small maps for reproduction on a duplicating machine, is now being used for making ordinary photographic negatives of maps in readiness for publication. Several have already been made for the Controller of Printing and Stationery and were used for publication by a litho-offset process.

Using special materials, it is now possible to use the new Oce printing machine to make transparencies from old tracings or line drawings on opaque material. This is particularly useful for reproducing maps containing a great deal of very intricate detail, and saves time and effort that would otherwise be spent in tracing elaborate maps by hand. It is being used for making standard topographic quarter degree sheets, from which prints may be made for various purposes. These developments enabled a decision to be made to start the publication of a number of black and white geological maps.

In preparation for the 21st International Geological Congress, a new Provisional Geological Map and a revision of the Mineral Map of British Guiana were drawn on a scale of 1:500,000. Other maps prepared for special purposes were a geological map of the Colony on a scale of 1:2,000,000 for publication in black and white, and one on a scale of 1:1,000,000 hand coloured. A great deal of work was done in tracing all maps that accompanied papers read at the Fifth Inter-Guiana Geological Conference in 1959. Negatives of these were made in readiness for publication.

All maps are now arranged and indexed according to the number of the degree square to which they refer, and also according to authors. All astro-fixes are now written up in a ledger so that data can be found readily whenever required. The aerial photographs are arranged in folders in metal cabinets according to the quarter degree sheets they cover, and each folder is accompanied by a record card and index maps, photographs covering any area can thus be found in a few minutes.

## LIBRARY

The indexing of books, magazine articles and reports in departmental files has been completed. The following was the position at the end of the year:

| | |
|---|---|
| Publications catalogued during the year | 972 |
| Total catalogued to date | 7,433 |
| Number of loans made | 750 |
| New publications received | 690 |

The Department distributed its publications to 180 universities, colleges, libraries, [illegible]ogical surveys and other bodies in 47 countries, and the publications of these are received in exchange. The number of publications sold or distributed free during 1960 are as follows:

| | |
|---|---|
| Bulletins | 350 |
| Annual Reports | 303 |
| Mineral Resources Pamphlets | 150 |
| Maps | 110 |
| Miscellaneous Pamphlets etc. | 665 |
| | 1,578 |

The Department also produced cyclostyled copies of publications that have gone out of print, in addition to other miscellaneous reports that are required especially for distribution as follows:

| | |
|---|---|
| Bulletin No. 3 | 94 |
| Bulletin No. 10 | 195 |
| Annual Report for 1949 | 248 |
| Mineral Resources Pamphlets | 583 |
| Miscellaneous | 800 |

A bibliography of geological and mining literature relating to British Guiana was compiled and has a total of 350 published references. It is hoped that it may be possible to issue this in published form during 1961. A bibliography of 217 unpublished reports was compiled and also a separate bibliography for some 150 references on bauxite. The compilation of an index to mineral localities in British Guiana that have been mentioned in reports and publications was started and when this is complete it will be possible to look up quickly all references to a particular economic mineral.

## VII <u>PUBLICATIONS & REPORTS</u>

The following were published during 1960:

Annual Report for 1959.

Addresses to the Opening Session: Fifth Inter-Guiana Geological Conference, Georgetown.

The Takutu Formation in British Guiana and the probable age of the Roraima Formation by R.B. McConnell. Trans. 2nd Caribbean Geol. Conf., p.163-170; Puerto Rico.

A Geological Map of British Guiana by R.B. McConnell and C.G. Dixon, Rep. 21st Int. Geol. Congress, Copenhagen 1960, p. 39-50.

Intro-Stratal Flow and convolute Folding; by E. Williams. Geol. Mag., v. 97, no. 3, p.208-214.

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Contributions to "Lexique Stratigraphique International" v.5, fas. 2a Amerique Centrale, p.18-37 (British Honduras section), by C.G. Dixon, (Principal author R. Hofstetter); Paris.

The following unpublished maps and reports were prepared:

R.B. McConnell, Director

Report on a visit to Venezuela from 19-27 January, 1960; RBM 1/60.

Report on the half-year July-December 1959; RBM 2/60.

C.G. Dixon, Deputy Director

Report on the half-year January-June 1960. CGD 1/60.

Report to the Advisory Committee on Overseas Geology, and Mineral Resources on the year to August 1959.

Report on a visit to the Wakawakapu area, Mazaruni River, CGD 3/60.

Provisional base map from Aerial Photographs of the Wenamu-Ekereku-Mazaruni-Kamarang area; scale 1:125,000 (geological); P3/F3.36.

D. Bleackley, Deputy Director

Occurrences of Bauxite in the Pakaraima Mountains. DB . 1/60.

Report on a short visit to Surinam. D.B. 2/60.
Thesis presented for The Bauxites and Laterites of British Guiana, degree of D. Phil., Oxon.

D. Bleackley, Deputy Director and M.W. Carter, Geologist.

Report on (i) Muruwa-Siparuni; and (ii) Muruwa-Konawaruk Expeditions. DB 3/60.

P.B.H. Bailey, Senior Geologist

The Kako-Mazaruni area. PBHB 1/60.

P.B.H. Bailey, Senior Geologist, and J.H. Bateson, Geologist.

Report on a shale locality, Karau-uda-tipu, Kako River. PBHB 2/60.

Map showing the Geology of the lower Kako River; 1:250,000; P5/F1/10.

# PUBLICATIONS AND REPORTS

## P.B.H. Bailey, Senior Geologist

The Kako-Mazaruni area. PBHB 1/60.

Map showing the Geology of the lower Kako River; 1:250,000: P5/F1/10.

Geological map of the Paruima-Wenamu-Ekereku area; 1:125,000, (with six figures and sections); P5/F1/17.

## P.B.H.Bailey, Senior Geologist & J.H.Bateson, Geologist

Report on a shale locality, Karau-uda-tipu, Kako River. PBHB 2/60.

Geological map of northern flank of Karau-uda-tipu, Kako River; 1:20,000; P5/F1/11.

Section along a portion of the Uda Creek and tributaries; 1:3,000. P5/F1/12.

## E. Williams, Senior Geologist

Geological map of Matthews Ridge-Kaituma Railway; 1:125,000. P1/F3/13.

Geological map of part of the Barama River; 1:125,000. P2/F1/15.

Geological map of part of the Barima River; 1:125,000. P2/F1/16.

Geological map of Peaima Falls-Merume River area; Mazaruni, 1:125,000. P3/F1/19.

## E. Williams, Senior Geologist, R.T. Cannon & K.Bramley, Geologists

Kaituma-Matthews Ridge railway traverse. EW 3/60.

Barima River traverse (Eclipse Falls to Koriabo). EW 4/60.

## E.Williams, Senior Geologist, J.W.Lloyd & D.D.Hawkes, Geologists

Report on the Cuyuni traverses between Makapa Hills and Amamuri Rapids. EW 1/60.

## C.N. Barron, Geologist

Report on the upper Berbice-Corentyne Expedition. CNB 3,4/60.

Report on the Canister-Corentyne Expedition. CNB 5,6/60.

Map of Kamwatta headwaters; 1:30,000. P7/F3/13.

Geological map of Macari Mountain; 1:100,000. P7/F3/12.

Geological map showing the Muruwa Formation east of the Berbice Rivers; 1:100,000. P7/F3/19.

Geological map showing the Muruwa Formation west of the Berbice River; 1:100,000. P7/F3/20.

R.T.Cannon, Geologist

Geological map of an area south-east of Arakaka; 1:50,000. P1/F3/11.

Geological map of Bartica area: 1:100,000. P4/P1/24.

Geological map of Kaburi-Rockstone area: 1:125,000. P6/F1/26.

R.T. Cannon and K. Bramley, Geologists

Report on the Geology of the area south-east of Arakaka. RTC 2/60.

R.T.Cannon, Geologist, & J.W. Carter, Assistant Geologist

Preliminary report on the Geology of the Waini (SW) quarter degree sheet. RTC 1/60.

J.H. Bateson, Geologist

Use of differential thermal apparatus in the preliminary investigation of aluminous laterites in the Pakaraima Mountains.

J.W. Lloyd, Geologist

Report on the Geology of the lower Barama and Waini Rivers. JWL 1/60.

Report on the Geology of the Waiamu and Mopay Rivers, Cuyuni River. JWL 2/60.

Geological map of lower Barama River and Waini River; 1:125,000. P2/F/17.

Geological map of Waiamu and Mopay Rivers (Cuyuni River); 1:125,000. P3/F3/26.

J.W.Lloyd, Geologist & E. Williams, Senior Geologist

Traverse of part of the Barama River. EW 2/60.

K. Bramley, Geologist

Rewa-Makarapan Expedition report. KB 1/60.

Kaituma-Barima Expedition report. KB 2/60.

Upper Barima Expedition, 1959. KB 1/60

Note on the occurrence of Nickel in the Five Stars area, North West District. KB 4/60.

D.D. Hawkes, Geologist

Provisional report on the Geology of an area south of the Puruni River. DDH 1/60.

A note on the Petrography of the Kopinang sill. DDH 2/60.

A note on the Contact Metamorphism of shales of the Roraima Formation above the Kopinang sill. DDH 3/60.

Field report on the Geology of an area between the Mazaruni and Puruni Rivers. DDH 4/60.

Geological map of an area south of the Puruni River; 1:125,000. P3/F3/17.

S. Singh, Geologist

Report on the upper Mazaruni-Ekereku-Kamarang survey. SS 1/60.

Geological map of Kamarang valley, and Mazaruni River from Imbaimadai to Kuwaima; 1:125,000. P5/F1/9.

Geological map of the area from Monkey Mountain to Kurungiku and Ebini Mountains; 1:125,000. P7/F1/17.

M. W. Carter, Geologist

Preliminary report, Siparuni-Burro-burro Watershed. MWC. 1/60.

Final Expedition report, Siparuni-Burro-burro watershed. MWC 2/60.

Geological map of Karasabai-Annai area; 1:100,000. P7/F1/19.

M.G. Allderidge, Assistant Geologist

The Potaro (NW) square and adjacent areas. MGA 1/60.

The northern portion of the Puruni (SE) square. MGA 2/60.

Traverses of the Puruni and Kartuni Rivers. MGA 3/60.

Map showing geological traverses on the Puriari and Mazaruni Rivers. P5/F3/32.

L.L. Fernandes, Assistant Geologist

Report on a tour of the Goldfields, North West District. LLF 1/60.

Report on the upper Cuyuni Expedition. LLF 2/60.

Diagram showing localities of soil samples taken around a galena and sphalerite occurrence, Wenamu River. P3/F1/10a.

R.C. Sansom, Assistant Geologist

Report on the Kopinang valley and the adjacent area to the north as far as Ayanganna Mountain. RCS 1/60.

Map of a portion of central Kopinang valley showing Kopinang drilling programme; 1:6,000. P7/F1/3.

J.W. Carter, Assistant Geologist

Preliminary report on the Kukui valley-Chinowient-Ayanganna Expedition. JWC 1/60.

Map of Bauxite reconnaissance survey; Kukui valley-Ayanganna-Semang; 1:125,100. P5/F1/14.

Map of part of Kamarang Hill showing detailed pitting of aluminous laterite deposit; 1":500'. P5/F1/15.

O. St. John, Field Observer

An inventory of the Shell Deposits on the North-West Coast of British Guiana. OStJ 1/60.

Report on the geological reconnaissance of the trails radiating from Paramakatoi, Pakaraima Mountains. OStJ 2/60.

Geological map of trails radiating from Paramakatoi; 1:100,000. P7/F1/12.

A.O. Edwards, Field Observer

Report on drilling Expedition, Iron Mountain. AOE 1/60.

Map of Iron Mountain showing drill holes; 1"=1200'. P6/F1/10.

## APPENDIX I

## PRELIMINARY GEOLOGICAL REPORTS

### C O N T E N T S

PAGE

## A. PARUIMA-WENAMU-EKEREKU AREA

By P.B.H. Bailey, Senior Geologist

This report deals with an area of 500 square miles in the Pakaraima Mountains of western British Guiana which was surveyed on a reconnaissance basis during three months in the latter part of 1960. This region lies between the Kamarang River in the south and the Wenamu River in the Northwest, and includes a portion of the Ekereku River and its tributaries in the east.

The level of the Kamarang at Paruima is about 1600 feet above sea level whereas the Wenamu in the neighbourhood of the Tshuau and Korabu mouths is about 750 feet above sea level. The Ekereku, over much of the portion surveyed, flows at levels between 2600 and 2100 feet above sea level, in a north-easterly direction. The highest point in the surveyed area is the mountain of Uwaritipu at about 4300 feet above sea level.

4. Younger Basic Intrusives

3. Roraima Formation

2. Younger Granite

1. Mazaruni Group.

Rocks classified within the Mazaruni Group occur in the northwest in the floor and sides of the Wenamu valley. In the valley floor there are few exposures due to deep weathering and these were generally amphibolites, sometimes schistose. Two localities in the lower Tshuau had schistose amphibolite in place with foliation directions 010° and 025° with near vertical dips. At another locality, where the Tshuau drops over the lowest sandstone scarp, feldspathic porphyries and hornfelses were observed as well as amphibolites; foliation directions of 160° and 170°, steeply dipping to the west, were noted.

Biotite granites occur in the lower Tshuau and these are assumed to be part of a Younger Granite body intruding the Mazaruni Group rocks and pre-dating the deposition of the Roraima Formation.

The contact between the Mazaruni Group and the overlying Roraima Formation lies at about 1980 feet above sea level at the Tshuau fall and this is consistent with observations made at the two places where trails cross the lowest escarpment.

The Roraima Formation consists of fine- to coarse-grained sandstones, pebbly sandstones, conglomerates, shales and quartzites found in horizontal or near horizontal attitudes. In the area surveyed the total thickness must be in excess of 1500 feet. The conglomerates are the most resistant and are responsible for the scarp features to the north of the Kamarang valley and lining the savanna of Aymatoi, and also the lowest Wenamu scarps to the west of the Korabu savannas. Conglomerate pebbles are generally well-rounded and are predominantly of quartz, although sandstone, quartzite and acid volcanic pebbles may occur. The rounded pebbles seen scattered in some sandstones are similar. The sandstones are dominantly quartzose and in this area feldspathic varieties are rare.

Some thin beds of horizontal grey and purple shales may be seen below the lowest Wenamu scarp at an elevation of 2300 feet on the trail west of Tshuau. The underlying rocks were obscured by talus but the shales appear conformable with the conglomerate above and are classified as Roraima. Hornfelses, shales, metamorphosed by the underlying gabbro sill, occur at 4200 feet on Uwaritipu.

Observations of **forest bedding** in Roraima sandstones indicate depositional current directions to the west and southwest, which conforms with observations over a wide area including the Kako, Partang and Haieka rivers[1].

Younger Basic Intrusives occur in the form of two dolerite sills. The lower, or Kamarang, sill is present in the south and appears to be about 850 feet thick in the Uluk creek although it may vary elsewhere. Specimens include augite dolerite and biotite-pyroxene dolerite (with both clino- and ortho-pyroxene). The upper sill occurs on Dwaritipu and to the west and northwest of that mountain. On Uwaritipu the sill appears to be 500 feet thick. Specimens collected include augite dolerite, biotite-pyroxene dolerite, noritic dolerite and hornblende dolerite.

Prospecting of creek alluvials shows that both GOLD and DIAMONDS are associated with the conglomerates and that gold may be a fairly reliable 'indicator' mineral for diamonds in alluvial gravel. Two small diamonds were recovered from a right bank tributary of the Ekereku.

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1. BAILEY, P.B.H., 1959. A reconnaissance survey of the Haieka, Kako and Kukui river areas of the upper Mazaruni river. Ann. Rep. for 1958. Geol. Surv. B.G., p.32.

# B. TRAVERSES OF THE NORTH-WEST AND MAZARUNI-POTARO DISTRICTS

by

E. Williams, Senior Geologist

During February-April, 1960, a number of river traverses and a railway traverse were made by the writer with colleagues.

## Kaituma-Matthews' Ridge Railway

Between the 15th and 29th February outcrops occurring along thirty miles of this railway were examined by K. Bramley, R.T. Cannon and the writer[1]. The work was carried out under the writer's supervision.

Interbedded quartzites, manganiferous quartzites, and mudstones occur best exposed near Matthews' Ridge between the railway mileposts 26 and 30. The mudstones are normally represented by clays colour-banded parallel to original bedding. The quartzites are up to two feet thick. This sequence is folded in a convolute manner, for the folds die out to a smooth base and top. The general strike of these rocks is 070-250°, which is also the strike of the axes of convolutions, and they dip 30° to 70° to the northwest. These rocks are much intruded by feldspar porphyry and the contacts are sharp and variously disposed.

Phyllites and slates, probably derived from mudstones, are best exposed between mileposts $17\frac{3}{4}$ and $19\frac{1}{4}$, and $25\frac{1}{2}$ and 26 respectively. They are usually weathered to colour-banded clays. Their age relationship with the quartzites and mudstones was not determined.

Amongst the phyllites and slates are tabular bodies probably of igneous origin of amphibole schists, recognized by Bramley as such on thin section examination, and greenschists.

Quartz-feldspar porphyry, which intrudes phyllites (milepost $17\frac{3}{4}$), is often deeply weathered to banded clays with an extensive surface residue of idiomorphic quartz grains up to 4 mm. in size.

Planar masses of brownish clays behave transgressively towards the phyllites and quartz-feldspar porphyries in which they occur. The original rock type is unknown but appears to have been of igneous origin.

A regional foliation, associated with a low greenschist facies grade of metamorphism, sweeps through all the abovementioned rock types with a general ENE-WSW strike. Between mileposts $5\frac{1}{4}$ and $5\frac{1}{2}$ a boundary between phyllite and fine-grained amphibole schists may be observed, and it is evident that the regional foliation crosses the boundary regardless of rock type, although elsewhere it generally appears to be sub-parallel to the rock distribution trend. The foliation is so well

1. Bramley, K., Cannon, R.T., and Williams, E. Report No. EW 3/60, Geol. Surv. B.G., Unpublished.

developed that much of the original textures and structures of the rocks, which may have aided in determining relative ages, are obliterated.

At milepost 2 is a quarry in biotite-aegirine granite[2] in which minerals have been aligned, probably by flow. Simple pegmatites, containing small amounts of fluorite, are associated with the granite.

Medium-grained dolerite sheets of varying thicknesses intrude all the rock types encountered in the traverse. Dislodged blocks of the marginal country rock occur within the dolerite dykes near milepost 30. The dolerites and the biotite-aegirine granite are of later age than the regional foliation affecting the other rock types.

Barima River

From 1st to 6th March, K. Bramley, R.T. Cannon and the writer checked previous work and mapped the rock exposures in the Barima River between Eclipse Falls and Koriabo [3]. The results of the Kaituma-Matthews' Ridge Railway traverse and this traverse was subsequently successfully made use of by Cannon and Bramley in the regional mapping of the area to the south-east of Arakaka[4].

Red, buff, and black-banded white quartzites are encountered some three miles downstream from Arakaka. Generally, the quartzites are fine- to coarse-grained and compact. However, horizons of flaggy sericite-quartzites occur. These rocks are considered to be an extension of the quartzites and mudstones of Matthews' Ridge.

Phyllites with occasional greenschist horizons outcrop to the north, both upstream and downstream, of the quartzites. Examination by Cannon of a thin section of a rock near Arakaka indicates that amphibolites, euhedral and cross-cutting the foliation, are developed in a quartz-chlorite schist.

A regional foliation sweeps through these rock types with a general E-W trend near Arakaka and NE-SW trend below the Monkey Falls granite. The foliation is associated with a greenschist facies of metamorphic grade. Quartz boudins, related in origin to minor folding of the foliation, occur in a sericite rich horizon two miles upstream from the railway bridge. Lineations of the crests and troughs of contorted quartz veins were recorded.

Biotite granite, with feldspar phenocrysts and probably flow foliation occur at Eclipse Falls[5] and Monkey Falls[2]. Simple pegmatites are rare. No

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2. Bramley, K. 1960. Kaituma-Barima Expedition. Ann. Rep. for 1959. Geol. Surv. B.G., pp. 50-52.

3. Bramley, K., Cannon, R.T., & Williams, E. Report No. EW 4/60. Geol. Surv. B.G. Unpublished.

4. Cannon, R. T., and Bramley, K. This publication p.44-45

5. Bramley, K. 1960. Upper Barima Expedition. Ann. Rep. for 1959. Geol. Surv. B.G. pp. 52-54.

observed disturbance of the regional foliation described above is associated with the emplacement of either granites.

To the west of Monkey Falls granite, andalusites are developed along the foliation planes of the phyllites. In general, their size increases to the granite boundary. In one locality large (up to 2.5 cms.) andalusites occur in a psammitic horizon. To the east of the granite small (?)garnets appear in the phyllites.

Of interest is the occurrence of a belt of schistose granite, some seven miles downstream from Monkey Falls. This shear belt, trending ENE-WSW, is some three-quarters of a mile in width, and although there is no notable dislocation along it in the river section there may be large displacements elsewhere along its length.

The boundary of the Eclipse Falls granite exposed in the river is marked by schistose rocks, which appeared in thin section to Cannon to be of apparently mechanically sorted layers of quartz, feldspars, epidote and chlorite-biotite. This shear belt is of a similar direction to that described immediately above.

Medium-grained dolerite dykes of NE-SW trend cut all the rock types listed above.

Lower Barama River

The writer visited J.W. Lloyd from the 9th to 18th March, and they mapped the rocks exposed in the Barama River between Kokerit Mission and St. Bedes' Mission[6].

Cannon and Carter[7] defined the Kokerit Formation as consisting "mainly of schists.....derived from psammitic sediments with a well-defined conglomerate band and occasional pebbly horizons. Subordinate pelitic rocks occur and altered lavas (formerly augite andesites) are intercalated within the schists" (p.45). It was considered possible that the formation resembled the Western and Central Cuyuni Formations[8]. In general, these descriptions and conclusions were confirmed during **this expedition**.

All the rocks are foliated and a cataclastic texture is dominant. Calcite and siderite rhombs, which weather to large limonitic patches, occur in a number of horizons.

/the The sediments of/Kokerit Formation are turbidites **usually** of fine-grained siliceous siltstones, sandstones, pebbly sandstones and conglomerates. The pebble distribution indicates poor sorting and gradation within

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6. Lloyd, J.W., & Williams, E. Report No. EW 2/60, Geol. Surv. B.G., Unpublished.
7. Cannon, R.T. & Carter, J.W. 1960. A preliminary Report on the Geology of the Waini (SW) Quarter Degree Square. Ann. Rep. for 1959. Geol. Surv. B.G. pp.44-45.
8. Williams, E., Lloyd, J.W. & Hawkes, D.D. 1960. Cuyuni River traverse. Ann. Rep. for 1959, Geol.Surv.B.G.pp.39-41.

depositional units of normally a foot or so in thickness. At Maikuru Rock the conglomerates are coarse with pebbles up to two feet long, and an analysis of the grains larger than 4 mm in one horizon shows that some 93% were derived from quartzitic rock types, and 7% from phyllitic. Mudstones considered to be "normal" deposits, and their metamorphic derivitives are uncommon in the sequence.

Fine-grained igneous rocks occur about a mile upstream from Kokerit Mission, and also about four miles upstream from Maikuru Rock. They are often grey or greyish-green in colour with saussuritized plagioclase (probably albite), ragged amphiboles and bundles of chlorite set in a quartzo-feldspathic groundmass.

Immediately to the north of the Kokerit Formation exposures, quartzites, normally cream coloured, extend from some two miles upstream from Tasawinni to a granitic occurrencefive miles downstream. The quartzites are usually medium-grained, sugary textured, and contain sub-rounded zircons of sedimentary origin; some layers are rich in manganese oxides. Flaggy sericite-rich horizons occur, which when deeply weathered resemble weathered phyllites.

Quartzites, normally interbedded with phyllites, associated with occurrences of manganese oxides are typical of the Barama Group. It appears likely, therefore, that the rocks at Tasawinni belong to this group.

The mineralogy, textures and structures of the rocks of the Kokerit Formation match exactly those of the Western and Central Cuyuni Formations[8]. By comparison, the Tasawinni quartzites are of a similar stratigraphical position to the quartzites in the Kutuau River mouth area in the Cuyuni River, and underlie conformably the Kokerit Formation.

A regional foliation, of a general WSW-ENE trend associated with cataclastic textures and the development of sericite,chlorite, biotite and actinolite-tremolite, occurs throughout all the rock types. Pebbles of pebbly sandstones and conglomerates have been rotated into the foliation planes.

Many bedding plane readings were obtained within the Kokerit Formation, although a fold pattern could not be determined.

<u>Puruni River</u>

The writer worked in the Mazaruni-Potaro District from 26th March to 29th April. Much of the time was spent with M.G. Allderidge mapping the rocks exposed in the Puruni River between its mouth and Paiyuka Falls.

Gneisses and amphibolites of the Bartica Assemblage, foliated in a general N-S direction, are encountered between the Puruni River mouth to near Peter's Mine.

Younger Granites are represented by a biotite granite with quartz phenocrysts, which extends from the northern boundary of the Bartica Assemblage to near the Mara-Mara River mouth.

A pre-Younger Granite sequence of sediments and fine-grained igneous rocks occurs between the northern boundary of the biotite granite and a thick dolerite inclined sheet forming Paiyuka Falls. This sequence, for purposes of field mapping, has been termed the Puruni Formation[9].

The Puruni Formation consists of siliceous turbidites - poorly sorted but graded conglomerates, pebbly sandstones and sandstones - interbedded with mudstones, which are believed to be the 'normal' deposits of the area. Included within this formation are fine-grained irngous rocks consisting of feldspar porphyries and rare rhyolites. The Puruni Formation matches in mineralogy, textures and structures the rocks of the Central and Western Cuyuni Formation[8], and the Kokerit Formation described above. Regional mapping has shown that the Puruni and Cuyuni Formations are in continuity.

A regional foliation is developed throughout the Puruni Formation and trends approximately WNW-ESE. The rock constituents have been rotated and entrained in the foliation planes, the development of which is associated with a greenschist facies grade of metamorphism.

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9. Allderidge, M.G. Report No. MGA. 2/60, Geol. Surv.B.G. Unpublished.

## C. NOTES ON THE PEAIMA FALLS-MERUME RIVER AREA

by E. Williams, Senior Geologist

River sections in this area were mapped between 24th September and 5th November, 1960. Mr J.W. Lloyd accompanied the writer for the last three weeks of the expedition.

These notes supplement Bulletin No. 29[1] and repetition of information given in the publication has been avoided as far as possible.

The oldest examined rocks of the area belong to to the Mazaruni Group[2] which has been defined as corresponding exactly to the Volcanic Series[3], which was first mapped in the Mazaruni and Puruni diamond areas. Provisionally the group is subdivided into (1) the Cuyuni Formation which is defined as consisting of those rocks which have been correlated by regional mapping and lithology with the Central Cuyuni Formation[4], the Western Cuyuni Formation[5], the Kokerit Formation[6], and the Puruni Formation[7], and (2) the Haimaraka Formation;, formerly known as the Haimaraka Shales. Regional mapping has shown that the Central Cuyuni Formation is continuous with the Puruni Formation[8], and the Western Cuyuni Formation has been traced to the vicinity of Fleming's Island in the area under consideration.

The type area of the Cuyuni Formation is that of the Central Cuyuni Formation[4], which is a mappable unit extending from the Quartzstone granite to the gneisses and granites of the Devil's Hole Range in the Cuyuni River. The best section of the formation is exposed in the Cuyuni between Quartzstone granite and Pigeon Island. Williams[4] has described the sequence as "consisting of laterally impersistent tongues of predominantly (1) conglomerates, pebbly sandstones and sandstones, and (2) porphyritic fine-grained igneous rocks".

/in The Cuyuni Formation/the Peaima Falls-Merume River area is represented by poorly sorted conglomerates and sandstones, with the coarser fragments, up to 6 inches in length, usually of quartzite and phyllite. The finer material of the sediments is quartzo-feldspathic. Between Anabarong River mouth to near Illiwa Island conglomerates contain well-rounded fragments, up to 18 inches in length, of feldspar porphyries in a quartzo-feldspathic matrix. These sediments of the Cuyuni Formation are believed to be turbidites.

Associated with the older sediments are fine-grained igneous rocks, which are generally porphyritic and usually of intermediate composition[10]. Meta-dolerites with hornblende schist developed at the margin in some localities[11], appear to be confined in the main to areas of the Cuyuni Formation.

The Haimaraka Formation, formerly known as the Haimaraka Shales[1], is best exposed in the Mazaruni River between Issineru River mouth and Illoma Island, and in the Issineru and Haimaraka Rivers. This is the type-area of the Formation. The term 'shales' has been discarded for no true shale has been found within the sequence.

The Haimaraka Formation in its type area is a monotonous sequence of banded grey mudstones interbedded with greywacke sandstones, considered to be turbidites. The sandstones are poorly sorted and graded with variously shaped fragments of quartz, feldspar and mudstone set in a mudstone matrix of quartz, feldspar, sericite and chlorite. Occasional intercalations of conglomerate with mudstone pebbles have been noted. To the east of the area in the Merume River, this formation is represented by a predominantly deep red coloured mudstone sequence with rare sandstone horizons.

The Haimaraka Formation is folded about a synclinal axis steeply plunging to the south-east in the Issineru River-Illoma Island area. Available evidence indicates a conformable relationship between the Cuyuni Formation and the overlying Haimaraka Formation of the Mazaruni Group. In the Merume River area cross-folding occurs within the Haimaraka Formation resulting in a basin and dome structure.

A secondary regional foliation, in general striking NW-SE affects the rocks of the Mazaruni Group. The foliation is more noticeable within the Cuyuni Formation, and quartz, feldspar, sericite, chlorite and biotite have been noted developed within the foliation planes. In the Kurupung River mouth area original features have been obliterated and chlorite-(?)-albite, and quartz-(?)-albite-sericite schists occur[1].

The Younger Granites are represented by biotite-granite gneiss, hornblende-granite, quartz-diorite, granodiorite and syenites. Granite country rock contacts have been observed at Enachu, Iliwa Island, the northern granite boundary in the Eping River and in the Kurupung River where a boundary granitization phenomenon has been observed (McConnell, verbal communication).

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## D. A PRELIMINARY REPORT ON THE GEOLOGY OF THE OMAI (NW) QUARTER DEGREE SQUARE

by R.T. Cannon, Geologist

A reconnaissance map on the scale 1:125,000 of the Omai (NW) quarter degree square was made during the second field season of 1960. This square is located between the parallels of latitude 5°30'N and 6°N and meridians of longitude 58°30'W. and 59°W. The following geological units were mapped:

| | |
|---|---|
| Superficial Deposits: | Alluvium and laterite |
| White Sand Formation: | White and brown sands |
| Younger Basic Intrusives: | Gabbro and dolerite |
| Younger Granites (?): | Biotite granite and biotite microgranite |
| Uncorrelated: | Hornblende anorthosite |
| Bartica Assemblage: | Porphyroblastic gneisses, biotite gneisses and granites, hornblende-biotite gneisses and amphibolites. |

Amphibolites, biotite gneisses and hornblende-biotite gneisses are interbanded on a large scale and are an extension of the Bartica Assemblage in the Bartica quarter degree square immediately to the north[1]. Occasional irregular areas of biotite granite occur associated with the biotite gneisses and are part of the same cycle. A large area of porphyroblastic gneisses on the Essequibo River forms a unique, mappable unit. Abundant, large (up to three inches), perfectly euhedral, zoned crystals of perthite weather out to form protuberances on the rock surfaces. The crystals are clearly porphyroblastic enclosing hornblende, quartz and plagioclase of the matrix. The alignment of the K-feldspars is discordant to the foliation of the surrounding gneisses (as defined by the mafic minerals) and it is suggested that this localization of K-feldspar was formed late in the metamorphic-metasomatic cycle.

Hornblende anorthosite occupies a large area in the Kaburi River. The rock is of striking aspect consisting essentially of large plagioclases with interstitial black amphibole. The anorthosite is of variable grain size; the plagioclase occurs as euhedral crystals from a half inch to four or five inches long and the amphibole varies from small interstitial areas to large crystals, also enclosing the plagioclase, the largest noted being twelve inches long. Preliminary measurements on the plagioclases indicate a composition on the labradorite-bytownite border. The anorthosite has an irregular, finer-grained facies near the margin with the Bartica Assemblage which, together with the

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granulated nature of the fabric, suggest that the anorthosite was probably intruded into the gneisses of the Bartica Assemblage.

Areas of biotite microgranite around the mouth of the Kaburi River and biotite granite on the Essequibo River intrude the Bartica Assemblage and have tentatively been assigned to the Younger Granites. Dolerite dykes intrude all the above rock types, and the Younger Basic Intrusives are also represented by Arisaru Mountain, a large, laterite-capped gabbro intrusive approximately circular in outline.

White and brown sands of the White Sand Formation occupy a considerable area of the present quarter degree square. The large alluvial flats were mapped from air photographs in addition to the laterite caps occurring on the amphibolites of Ebini Hills and the gabbro of Arisaru Mountain.

The hornblende anorthosite in the Kaburi River valley could be a source of the mineral **FELDSPAR.**

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## E. REPORT ON THE GEOLOGY OF THE AREA SOUTH EAST OF ARAKAKA

by R.T. Cannon & K. Bramley, Geologists

The following formations have been designated and mapped in this area:

Superficial Deposits
Younger Basic Intrusives
Younger Granites
Porphyry Intrusions
Tenapu Formation
Matthews' Ridge Formation
Arakaka Formation

All the above rock types, except the Tenapu Formation, were characterized by mapping the Kaituma-Matthews' Ridge railway and the Barima River (see page 34 above). The information so obtained was successfully made use of in the mapping of the present area. The Arakaka and Matthews' Ridge Formation should be considered as an integral unit with no stratigraphic significance attached to the above order.

The Arakaka Formation is dominantly pelitic consisting of phyllites and mudstones with subordinate chlorite schists occasionally amphibolitic and representing original basic intrusives) and quartzites. The Matthews' Ridge Formation consists of interbedded phyllites and quartzites (approximately four thousand feet thick) forming a well-defined ridge. The various rock types at Matthews' Ridge exhibit a distinctive form of convolute folding and are locally manganiferous. The Tenapu Formation is considered a large, locally defined area of metamorphosed basic intrusives with subordinate psammitic horizons and rare phyllites. The basic rocks (now chlorite schists and amphibolites) which also invaded the Arakaka and Matthews' Ridge Formations later than the development of convolute/which ante-dates all other phenomena. Porphyry Intrusions, quartz-feldspar porphyries and feldspar porphyries, occur within the above mentioned formations.

/folding

All the previous rock types were subject to a low-grade metamorphism converting mudstones to phyllites and basic intrusions to chlorite schists, etc. The metamorphism was within the lower Greenschist Facies and the railway traverse demonstrated that the impressed foliation is independent of rock type distribution.

The railway traverse also demonstrated that the above foliation was subsequently corrugated. The air photographs examined in the present area show abundant evidence of folding which proved difficult to establish on the ground and also difficult to relate to foliation. Faulting accompanied this period of folding.

The Younger Granites are represented by the Monkey Falls granite (probably syntectonic) which was emplaced with concomitant contact metamorphism. The spotting of the phyllites with the occasional development of andalusite demonstrated on the Barima River traverse proved a widespread phenomena around the granite.

Psammitic horizons within the Arakaka Formation contain garnet, staurolite and kyanite. The latter schists are intimately associated with amphibolites which were presumably also formed by the thermal effects of the granite. Rocks of the aureole adjacent to the granite are within the upper Amphibolite Facies in contrast to the bulk of the rocks in the present area which are within the lower Greenschist Facies.

Retrogressive metamorphism is shown by some amphibolites within the Tenapu Formation. The Barima River traverse showed that faulting and shearing occurred after granite emplacement and a well defined shear zone was mapped within the granite on this traverse.

The intrusion of the Younger Basic Intrusives was the last major geological event in this area.

The Superficial Deposits consist of the alluvial flats of the rivers and irregular, laterite caps on the amphibolite hills.

## F. REPORT ON THE AREA BETWEEN THE CORENTYNE AND DEMERARA RIVERS NORTH OF CANNISTER FALLS

by C. N. Barron

The following formations were mapped:

White Sand Formation
Laterite

Younger Basic Intrusives

Roraima Formation

Younger Granites

Iwokrama Formation

Muruwa Formation

Sedimentary and volcanic rocks of the Muruwa and Iwokrama Formations dip generally southwards under most of the area, and are cut by several small granite intrusions. Resting on the Iwokrama Formation is a considerable outlier of the practically flat-lying Roraima Formation. All these rocks are intruded by dolerite sills and dikes which are correlated with the Younger Basic Intrusives. The Roraima Formation outlier forms a series of high, concentric mesas, whose base is largely concealed by extensive White Sand Formation which also covers most of the low lying country around the outlier. Several of the larger dolerite intrusions are now covered by vesicular laterite.

The Muruwa Formation consists in this area of some 4000 feet of clean quartz sandstone, with occasional red or black cherty grains. Pebble beds occur locally, and both the pebbles and sand grains are rounded to sub-rounded. The rock is not well graded, and graded bedding is rarely seen, but current bedding with foresets from 6-18 inches deep and facing roughly westwards is quite common. The matrix is largely recrystallized and the larger grains may show cataclastic effects. Pale brown biotite has developed in the vicinity of rare thin stringers of iron oxide granules. The Muruwa Formation has now been followed from Warakabra falls on the Corentyne, to a point some miles west of the Berbice river.

Forming a conformable transition with the overlying volcanics of the Iwokrama Formation are a few hundred feet of sandstones and red siltstones interbedded with small flows of intermediate composition. These sediments, while including quartzitic types similar to those already described are more often largely composed of sub-rounded cherty grains.

The Iwokrama Formation was examined in the areas immediately to the north of the Roraima outlier. Here it consists almost entirely of acid flows with variable amounts of quartz and feldspar crystals in a strongly flow-banded aphanitic matrix.

The Younger Granites are represented by the Marlissa Granite, a small intrusion on the Berbice River, which has caused some recrystallization of the adjacent Iwokrama volcanics. It is a medium-grained, unfoliated rock, with prominent red-brown microperthite, sericitized oligoclase, chloritized brown biotite and iron oxide. It carries no xenoliths.

The Roraima Formation lies unconformably on volcanics of the Iwokrama Formation. Its base is covered by the White Sand Formation in the Demerara basin, but is well exposed in the headwaters of the Kamwatta and Marlissa Rivers, which drain into the Berbice. Its base here is about 200 feet M.S.L., and the outermost scarp, which was examined in 6 places, rises to about 600 feet. The formation consists of coarse, current-bedded sandstones and pebble conglomerates (increasing upwards) with some 20 feet of red, flaggy, ripple-marked mudstones around 350 feet M.S.L. The grains and pebbles are of rounded quartz and very minor fine-grained sandstone and chert. A few thin beds carry unsorted angular fragments resembling the underlying Iwokrama volcanics, and these occur both near the base and associated with the red sandstones. Secondary silicification is prominent in fresh sandstone, and authigenic muscovite occurs near the base.

The Younger Basic Intrusives are represented a few small intrusions up and down the Roraima scarp and by a large intrusion forming a ridge behind Doringbang landing, on the Berbice River. The latter is a medium-grained dolerite for the most part, but a striking variety, with large feldspar phenocrysts is locally faulted against it. A flow-banded basalt in the Berbice River below Kuia lake may be a marginal facies of the same intrusion.

Laterite covers the Doringbang dolerite ridge, and also occurs below the sand in many places on the Muruwa sandstone ridge, at about 275 feet M.S.L. It forms a sheet on Christie hill where it rises to 576 feet M.S.L. in the south. Dolerite is exposed around the hill foot.

The White Sand Formation is represented in the west by an extensive sand plateau lying between 200 and 150 feet M.S.L which has nowhere been penetrated by the Demerara River or its tributaries below Canister Falls. It also hides the base of the Roraima Formation in this area. Its base is about 150-200 feet along the eastern edge of the plateau. Further east, brown and white sands attributed to the formation stretch between the Berbice and Corentyne Rivers, but although it is much more dissected here, even the ridge formed by the harder rocks of the Muruwa Formation, is only exposed in the bottoms of steep gullies in the sand.

Alluvial DIAMONDS have been worked in the Kamatta head, where the White Sand Formation has been stripped from the base of the Roraima outlier. KAOLIN occurs below the white and brown sands in many places. There is some alluvial GOLD in the Doringbang area, but the Muruwa and Iwokrama Formations show no other evidence of mineralization.

## G. GEOLOGY OF THE TAKWARI MOUNTAIN-OMAI AREA, RIGHT BANK ESSEQUIBO RIVER

by C. N. Barron

The survey carried out during the second field season of 1960 covers the Essequibo River fromTakwari Mountain northwards to a few miles below Omai Landing where it was linked with a current survey by R. T. Cannon of the area to the north. The Potaro and Konawaruk Rivers were also surveyed up to their lowest falls, and the Yucuriba Itabu was traversed in preference to the Itanime route, previously surveyed by M.W. Carter in 1958. In addition, lines were cut inland from the east bank of the Essequibo, and two of these were extended as far as the Demerara River.

The rock formations examined may conveniently be arranged in the following tentative stratigraphical succession.

Superficial deposits: River alluvium
White Sand Formation
Laterite (350 feet and 750-1000 feet levels)

Younger Basic Intrusives
Younger Granites
Muruwa Formation: Sandstones and jaspers
Allegro Island Formation: Biotite, hornblende-, and quartzitic schists
Acid and intermediate fine-grained igneous rocks (Potaro Mouth area)
Amphibolites (Omai area).

The above formations are not necessarily in stratigraphic order as their mutual relations are not understood in every case. The Muruwa and Allegro Island formations occur to the south of the main granite mass, and the amphibolites and fine-grained acid and intermediate igneous rocks lie to the north. The granite dominates the centre of the area.

The foliation of the fine-grained igneous rocks near Potaro mouth and of the rocks near Omai dip steeply to the SSW and the banding and foliation of the Allegro Island Formation is also near vertical but strikes NNE. In the south, the bedding of the Muruwa Formation dips moderately to the SSW and is not foliated. It is possible that shearing observed mainly among the fine-grained igneous rocks may have some control over the occurrence of **GOLD**.

The amphibolites of the Omai area consist of a variable assemblage of dark, fine-grained rocks which sometimes show poorly developed ribbing on eroded surfaces. Thin sections show them to be plagioclase amphibolites for the most part, with abundant epidote and chlorite. A black manganese mineral occurs in sheared quartzitic rocks of this formation near the large dyke west of Omai. In addition there are some subvertical quartzites and amphibolites on the Demerara River, east-south-east of Waraputa Falls; their strike and lithology suggest correlation with the amphibolites of the Omai area.

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Around Tigri Falls the amphibolites are intruded by acid and intermediate fine-grained igneous rocks with quartz and oligoclase phenocrysts, which extend up to Waraputa Falls. The fine-grained groundmass is usually somewhat metamorphosed, with the development of chlorite, sericite and occasional biotite; phenocrysts of dark minerals, pseudomorphosed in chlorite and epidote also occur. Around Potaro mouth itself, these rocks are intensely cleaved in E-W and SE-NW directions, and carry abundant chloritoid. Both these and the amphibolites are locally cut by quartz veins and tension cracks.

The Kumaka Granite and similar granite bodies south of the river, carry quartz and microcline, sometimes enclosing euhedral zoned plagioclase crystals, together with biotite, hornblende, sphene and opaque minerals, and is locally foliated. The Temple Bar Granite is of granoblastic texture, and includes a few xenoliths. Mineralogically it is characterized by quartz-oligoclase microperthite, and hornblende altering to chlorite. Sphene is a common accessory. The Waraputa Granite is similar, but carries biotite as the principal dark mineral, together with quartz, microperthite, albite/oligoclase, secondary chlorite and sphene. In addition to a local mineralogical foliation, it is sometimes sheared, and even mylonitized, along an E-W or NW-SE direction. The Waraputa Granite is intruded by the mineralogically similar but finer grained Yucuriba Granite in the south. The latter is rarely foliated of sheared, and locally carries phenocrysts of potash feldspar and oligoclase.

To the south, the Yucuriba Granite gives place to schists of the Allegro Island Formation which are locally intruded by a similar granite. These schists include interbanded biotitic, hornblendic and quartzitic types, and usually carry more or less epidote and chlorite. Near Takwari Mountain they are in ill-defined contact with apparently much less steeply dipping quartz sandstones of the Muruwa Formation, which also includes jasperized banded greywackes showing small scale cross-bedding and convolute folding. Small ring-shaped bodies less than a quarter of a millimetre in size have been seen in several thin sections of the Omai and Muruwa sediments. They are always well-defined and appear isotropic between crossed nicols.

## H. THE GEOLOGY OF AN AREA BETWEEN THE MAZARUNI AND UPPER PURUNI RIVERS

by Donald D. Hawkes, Geologist

During both the field seasons of 1960 reconnaissance mapping was carried out in the south-western portion of the Puruni degree square. Much of the topography is between 300-400 feet in altitude but thick intrusions of dolerite form steep and rugged hills attaining a maximum height of 1900 feet on Sororieng Peak. The stratigraphical succession which has been established in this area and its tentative correlation with the succession suggested for British Guiana (McConnell and Dixon, 1960[1]) is shown below:

| Upper Puruni | Regional Succession |
|---|---|
| Superficial Deposits | Superficial Deposits |
| White Sand | Corentyne Series |
| Basic Intrusions | Younger Basic Intrusives |
| Granitic Rocks | Younger Granites |
| Metasedimentary Group | Mazaruni Group |
| Granite-gneiss Complex | ? |

The Granite-gneiss Complex is a well defined unit in the Upper Puruni River where it consists of biotite gneisses and hornblende-biotite-gneisses with a pronounced (NW-SE) mineralogical foliation. In this area the relationship of the gneisses to the Mazaruni Group is uncertain.

When traced toward the southwest the unit looses to a large extent its identity, and is extensively invaded by granodiorites. Locally, well-foliated gneisses apparently grade into non-foliated granitic rocks.

The Metasedimentary Group consists of metamorphosed argillaceous and fine-grained arenaceous sediments mainly within the greenschist facies, locally attaining the albite-epidote-amphibolite sub-facies. Over the greater part of the area the metasediments have an EW foliation.

Much work both in the field and laboratory remains to be done on the Granitic Rocks of this area. At present two subdivisions have been recognized: (i) granodiorites and (ii) the leucocratic microcline-granite. The granodiorites occur in the west and are characterized by an abundance of epidote and sphene. Some granodiorites merge imperceptibly into the gneisses of the Granite-gneiss Complex. The leucocratic microcline-granite appears identical in composition and texture to the Kartabu granite[2] of the Bartica area.

The Basic Intrusions occur as dykes (trending NE-SW) and thick inclined sheets. These dolerites are tholeiitic in character and consist essentially of labradorite, clinopyroxenes and iron ores. Olivine is rare but may occur in small amounts in some marginal facies. Two distinctive features are the presence of pigeonite (or hypersthene which has inverted from pigeonite) and acid interstitial areas of quartz and micropegmatite. Late stage granophyric veins cut the dolerite intrusions.

It is probable that the topography of the area is formed by a 350-foot planation surface. The residual hills of this surface are capped with deposits of White Sands. Superficial Deposits include river terraces and alluvium.

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# I. GEOLOGY OF THE KOPINANG VALLEY

by J.H. Bateson, Geologist

The Kopinang River empties into the Potaro River at approximately 5°N, 59°35' W. Its valley is surrounded on the north, west and southwest by an arc of mountains with the southern boundary marked by a 200-foot escarpment overlooking the Chenapau River.

The geological succession of the valley is outlined below:

Laterites and gravels

Upper Kopinang Sill

Kopinang Sandstones

Kopinang Hornfels

Lower Kopinang Sill

Chenapau Sandstones

The sandstones and hornfels are the local representatives of the Roraima Formation - here represented up to 3000 feet of sediments, whilst the two sills, a combined thickness of at least 2000 feet, belong to the Younger Basic Intrusives and are of a later date than the Roraima Formation.

Approximately 500 feet of homogeneous fine-grained pink, fawn and white sandstones compose the Chenapau Sandstones together with a thin band, about 20 feet thick, of interbedded shales. Thin regular bedding is characteristic of the sandstones except for the top of the succession where contact with the overlying sill has converted them into metaquartzites. The regional dip is shallow, 3-5°, to the southwest with festoon current bedding the dominant sedimentary feature.

The overlying dolerite, the Lower Kopinang Sill, forms the floor of the Kopinang valley, and itself appears to be conformable with the sediments into which it has become intruded. On the basis of preliminary work Sansom (1960)[1] subdivided the sill into three zones, a lower noritic dolerite, a normal dolerite and an upper hornblende variety. Subsequently this sub-division has been amplified by Hawkes (Appendix I).

The top of the sill occurs over a wide area at approximately 2100 feet above M.S.L. with the base at 1770 feet. On Kowa the top rises to a maximum of 2900 feet.

Overlying this sill there is a considerable thickness, 250 to 750 feet, of fine-grained, well laminated, dark-coloured metamorphosed sediments, the Kopinang Hornfels. These rocks near to the contact have been completely recrystallized with the development of sillimanite, cordierite and andalusite embedded in a hornfelsic groundmass of quartz and alkali feldspar. Further away from the dolerite they still have a typical hornfelsic texture but with only the development of andalusite and cordierite. These rocks have an average dip of $2^o$-$4^o$ to the southwest.

Resting upon these metasediments are up to 1800 feet of variously coloured and textured quartzose sandstones and interbedded jaspers of the Kopinang Sandstones. The sequence begins with a basal conglomerate and pebbly sandstone facies which passes upwards into finer-grained pebble-free, dominantly pink, white and fawn sandstones with bands of jasper and jasperized sandstone. The unit from conglomerate to jasper is approximately 600 feet thick and is repeated two or three times in the 1800 feet exposed.

Bedding dips are shallow, $2$-$5^o$, with the regional dip to the southwest. Graded bedding occurs on all scales accompanied by scouring and festoon bedding.

Restricted to the top of Kowa and the higher parts of the Kopinang-Wokomung mass are exposures in the Upper Kopinang Sill, its thickness being in excess of 800 feet in both these areas. Generally it is of coarse grain with large pyroxene crystals particularly in the upper layers. Sansom[1] suggests that it is of a more basic composition, and therefore earlier than the lower sill.

Of the superficial deposits the gravels are the most important from an economic viewpoint since they are DIAMOND bearing. Although production has decreased considerably over the past few years the stones obtained are of good gem quality. Extensive laterites are developed on the outcrop of the Lower Kopinang Sill usually forming hard surface layers up to 8 feet in thickness. The laterites have been examined over the past two years as a potential source of BAUXITE.

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## J. THE WAIAMU AND MOPAY AREA, CUYUNI RIVER

by J.W. Lloyd, Geologist

During September an area of approximately 250 square miles was mapped between the Waikuri River and the Quartzstone granite.

The river flats are restricted in the area by terraces though extensions occur along the consequent creeks. The lowest terrace at 195 feet above M.S.L. is extensively developed in the area between Mopay Creek and the Quartzstone granite. A higher level occurs at 350 feet M.S.L. Areas underlain by the Central Cuyuni Formation are extremely dissected and rise to 750 feet along the Waiamu-Kopashi (Puruni) watershed. In the east the Quartzstone granite forms undulating, sandy clay hills rising to 200 feet and separated by intervening swamps or sandy valleys.

The rocks of the area are provisionally grouped in order of age as follows:

Younger Basic Intrusives

Younger Granites

Central Cuyuni Formation

Waiamu Island Formation

The Waiamu Island Formation outcrops over a lenticular area of approximately 20 square miles striking southwestwards from Waiamu Creek mouth to about 2 miles inside Waikuri River. It is composed of a succession of interbedded phyllites and quartzites, the latter varying in width from 6 inches to a quarter mile. The thinner bedded members occur along the northern boundary outcropping extensively at Waiamu Island. Bedding strike directions are variable for they are undulating in the Waikuri-St. John's Creek area and become tightly folded with vertical axes in Waiamu Island. The tectonic style of these rocks is dissimilar to that of the neighbouring sandstones and igneous rocks and so is considered to be an infaulted older formation. It should be noted that the lithology is similar to the Barama Group.

The Central Cuyuni Formation underlies the central and southern portions of the area. It is composed of sandstones, conglomerates, quartzites and fine-grained igneous rocks. The sediments are of the greywacke suite and show grading and scour structures. The fine-grained igneous rocks interdigitate with the sediments in the Waiamu-Mopay area. They are occasionally porphyritic with chloritized hornblende and feldspar phenocrysts, though they are usually evenly fine-grained and probably karatophyric in composition. Vesicular varieties occur but it is not known whether they are extrusive or not.

The Younger Granites are represented by the Quartzstone granite which forms the geological feature limiting the area to the east. It is a medium-grained hornblende granite well exposed in the Quartzstone Islands of the Cuyuni River. The margin has been extensively foliated by the same strain which has effected the neighbouring greywacke series; the resulting texture is gneissose. The strain effects diminish inwards from the margin until only well-spaced joints parallel to the regional foliation are visible in the field. The foliation has resulted in the chloritization of the original hornblende and biotite.

The dolerite dykes of the Younger Basic Intrusives has been intruded into the greywackes off Kutuau Creek Mouth.

Details of structure are observed inland due to the lack of outcrop. Metamorphic effects are seen in the presence of cataclasites, schists and gneisses, all of the Lower Greenschist Facies grade, which occur in all rocks older than the Younger Basic Intrusives. The foliation directions resulting from this metamorphism runs northeast to southwest across the area.

An extensive "Banka" drilling programme carried by Cannon has shown the area to be uneconomic for any large scale GOLD working. In 1954 African Manganese surveyed the area but record no manganiferous horizons. No other minerals of economic value are recorded in the area.

## K. THE LOWER BARAMA AND WAINI RIVERS

by J.W. Lloyd, Geologist

During the first field season of February to May an area of approximately 800 square miles was mapped between the lower Barama, Imotai and Waini Rivers.

The topography is rather diverse owing to the complexity of the geology. The highest areas are in the west where Pakiria Hill reaches 1300 feet M.S.L. To the east the country is dissected but only below the 400-foot contour. Plateau areas of white sand decrease in height from 500 feet to 300 feet M.S.L. in a northerly direction.

The rocks of the area are provisionally grouped in order of age as follows:

White Sand Formation

Younger Basic Intrusives

Muscovite Granites and metasomatism

Undifferentiated Amphibolites and Diorites

Minabaru-Haiari Igneous Complex

Wanaparu Granite

Warapoko-Baramanni Granite

Maka Granite and Gneiss

Kokerit Formation

Barama Group

The Barama Group extends from the upper Waini to the lower Barama and westwards to form the Barama-Barima watershed, northeast of Tasawinni. Mudstones and phyllites are common and quartzites are exposed at Tasawinni. In the vicinity of Maka Falls, the lower Imotai River and upper Waini schists occur which are derived from the Barama Group sandstones. Biotite-garnet-staurolite schists are common together with kyanite and sillimanite. Original bedding planes are found in the lower Imotai. The schists are with similar rocks described from Pomeroon and Supenaam.

The Kokerit Formation (Cuyuni Formation) is exposed extensively in the lower Barama and consists of fine- to medium-grained sandstones, pebbly sandstones, conglomerates, mudstones, siltstones, quartzites, and fine-grained igneous rocks. Poor sorting and graded bedding features peculiar to a greywacke suite are common but structures such as current bedding and scour marks are rare. The conformable distribution of the fine-grained igneous rocks with respect to the sediments and the alignment of partially mineralized vesicles suggest a possible extrusive origin.

<u>The Maka Granite Gneiss</u> consists of medium-grained granites and gneisses which occur at Maka falls interdigitating with folded Barama schists at the contact. The fact that the granite cuts across metamorphic grades shows it to be younger.

<u>The Warapoko-Baramanni Granite</u> occurs as isolated areas of biotite granite in the Warapoko Creek and in the vicinity of Baramanni. Examples of both flow and cataclastic foliation are present.

<u>The Wanaparu Granite</u> found in the Wanaparu Creek is a medium-grained biotite granite which has a fine-grained, quartzitic rock along its southern margin in which hornblende porphyroblasts are developed.

The Minabaru-Haiari Igneous Complex occupies the area between the upper Imotai Creek and Waini River and contains all gradations from hornblende diorite to biotite granite. From central areas occupied by biotite granite a continual gradation can be followed through biotite granodiorite, biotite hornblende granodiorite to hornblende diorite which generally forms the margin. The intermediate members incorporate xenolithic material predominantly of biotite composition which are distinct and elongated in the foliation close to the diorite border but become diffuse with increasing acidity. From field and microscopic evidence it would appear that the intermediate rock types are hybrids, rather than differentiates, formed from the intermixing of a biotite granite magma intruded into a hornblende diorite.

<u>Undifferentiated Amphibolites and Diorites</u> occur in the aureole to the Aranka-Wenamu batholith in the upper Imotai. The rocks are of fine-grained amphibolites, hornblende schists and medium- to coarse-grained diorites.

<u>Muscovite Granites</u> which are coarse- to fine-grained, and simple pegmatites are interspersed in phyllite areas between the lower Barama and Waini Rivers where the presence of muscovite becomes increasingly important eastwards. The muscovite granites and pegmatites are also extensively developed at Maka Falls.

<u>The Younger Basic Intrusives</u> are chiefly represented by a dolerite sheet intrusion of some 18 miles in length which strikes along the eastern side of the Waini River from Maka Falls southwards. Gabbro developments are common and residual granophyric veining occurs at Cannister Falls.

<u>The White Sand Formation</u> occurs on isolated flat-topped plateaux between the lower Barama and Waini, the lower Imotai and Waini and along the Waini-Kutuau watershed.

Cursory examination of the rocks of the Kokerit Formation exposed in the Lower Barama River indicated folding. Regional mapping suggests the existence of a westerly plunging syncline at Kokerit and a westerly plunging anticline near Warakshuru Creek.

The Kokerit and Barama rocks have been affected by a late subvertical cataclastic foliation. The Barama schists show signs of more than one metamorphism by the presence of two lineations, corrugations, and sets of boudin and the development of retrogressive chlorite.

Extensive alluvial gold was worked up until 1938 in the Good Hope Creek area, but although a few traces can still be found throughout creeks flowing off the Aranka-Wenamu batholith aureole and Minabaru-Haiari Igneous Complex no deposits of any consequence appear to exist. COLUMBITE has been recorded in the Waini and MICA claims have been taken out in the vicinity of Maka Falls, but neither of these minerals appear to occur in economic quantities.

In the Tasawinni quartzites and occasionally in the phyllites bordering the Barama River, MANGANESE staining and veining becomes significant. Analysis however shows the content not to rise above 11.30% and mapping indicates that the areas are of limited extent.

## L. THE BARIMA-BARAMA WATERSHED

by K. Bramley, Geologist

A reconnaissance map (1:125,000) was produced of part of the middle Barima-Barama watershed, covering an area of some 250 square miles.

The rocks examined in this area have been provisionally grouped in order of age as follows:

Superficial

Younger Basic Intrusives

Younger Granites - Teki Granite

Kokerit Formation - Mazaruni Group

Tenapu Formation )
Pipiani Formation) - Barama Group

The Pipiani Formation forms the Chi Chi Hills in the southeast of the area, and is composed there, of phyllites, quartzites and sericite schists. Manganiferous deposits are found locally. The formation is strongly foliated in a NNW-SSE direction, i.e. parallel to the boundary of the Teki Granite but contrasting with the ESE-WNW structural trend of the adjoining Kokerit Formation. Webber[1] describes this formation in detail and his name is retained, but its use limited to the rocks of the type locality.

The Tenapu Formation[2] is here made up of chlorite, talc, and sericite schists with subordinate quartzite lenses. Phyllites were mapped in only one locality. The foliation directions of this formation are conformable with those of the neighbouring Kokerit Formation. The psammitic schists and amphibolites of the Tenapu Formation in the adjoining area[2]* were not seen in this area, though a prominent laterite-covered ridge forming a part of the southern boundary to the formation may be underlain by amphibolite.

The Kokerit Formation[3] is comparable to the Cuyuni Formation of Williams[4], and consists of chlorite and sericite schists, quartzites, psammitic schists and intermediate volcanics; it is poorly exposed throughout the central and southern part of the area. The schists, particularly the psammitic varieties, are largely of sedimentary origin. Volcanics are of minor importance and consist of fine-grained porphyritic (augite phenocrysts) igneous rocks; no pyroclastics were observed. The boundary between the Tenapu Formation and the Kokerit Formation is marked by a zone of undifferentiated schistose rocks some of which may be derived from metamorphosed basic intrusives, similar to those of the Tenapu Formation but which have been intruded into the margins of the Kokerit Formation. The formation has an east-west structural trend which changes in the eastern area to swing northeastwards and southeastwards around the Teki granites.

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* See also p. 47.

The nature of the contacts between the Kokerit Formation, Teki Granite and Pipiani Formation is not known in this area though it is suggested that the Kokerit Formation unconformably overlies the Pipiani Formation. In the adjoining southeastern area the Kokerit Formation is hornfelsed by the Teki Granite[3].

The Teki Granite occurs in the eastern part of the area and is believed to extend northeastwards to Koriabo, and southwards a little beyond the Barama River. It is a coarse-grained biotite or hornblende-biotite granite, apparently unfoliated. Hornblende-biotite granite gneisses were observed on the northern boundary of the granite. The foliation directions of the Kokerit Formation swing around the granite while those of the Pipiani Formation are parallel to the granite boundary. Beyond the limit of the field survey in the northeast, aerial photography shows changes in relief (and jointing patterns) which may indicate changes in facies of the granite.

Younger Basic Intrusives are represented by dolerite dykes striking NE-SW throughout the area. An important dolerite body (about 1 mile in width) occurs in the northwest cutting across the Kokerit and Tenapu Formations; it may be a composite dyke as fine-grained material (typical of a marginal facies) is found within the normal medium-grained variety. A small body of altered gabbro was encountered close to this dolerite suggesting two ages of basic intrusives.

Gold has been obtained from the alluvial flats bordering the Barama River on its main tributaries in this area (e.g. the Munosse River). Gold has also been worked from the country north of the Chi Chi Hills on the borders of the Teki Granite.

The economic possibilities of the manganese, in the Pipiani Formation, have been considered at length by Webber 1952[1].

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[1]Webber, B.J. 1952. Manganese Deposits in the North West District, British Guiana, Geol. Surv. B.G. Bulletin 23.

[2]Cannon, R.T. and Bramley, K. 1960. Report No. RTC 2/60. Geol. Surv. B.G. Unpublished.

[3]Cannon, R.T. and Carter, J.W. 1960. A preliminary report on the geology of the Waini (SW) quarter degree square. Ann. Rep. 1959. Geol. Surv. B.G.

[4]Williams, E. 1961. Notes on the Peaima Falls-Merume River area. Ann. Rep. 1960. Geol. Surv. B.G.

## M. GEOLOGY OF THE UPPER BARIMA AND AMAKURA RIVERS

by K. Bramley, Geologist*

A reconnaissance expedition during the second field season, 1960, produced a geological map (1:125,000) covering an area of some 950 square miles lying between the upper Barima River and the Amakura River.

The rocks of the area were provisionally grouped as follows:

Superficial deposits

Younger Basic Intrusives

Younger Granites: Amakura-Barima Granites

Barima-Whanamaparu Gneisses

Amphibole schists and amphibolites

Undifferentiated amphiboles and fine-grained igneous rocks

Quartz and quartz-feldspar porphyries

Barama Group

The geology of the area is dominated by the Amakura-Barima Granites and the Barima-Whanamaparu Gneisses, which are bordered to the south by rocks of the Barama Group.

The Barima-Whanamaparu Gneisses are made up of medium-grained foliated granite, granite gneisses and banded gneisses associated with amphibolite and amphibole schists often occurring as narrow bands parallel to the ENE-WSW structural trend of the gneisses. The gneisses form the southern margin of the complex in contact with rocks of the Barama Group, the latter often appearing as enclaves within the marginal gneisses. The gneisses vary in composition from granitic to dioritic types, the latter being found on the southwestern margin of the complex. Biotite, pyroxene or hornblende may be present as the dominant ferromagnesian minerals. Close to the amphibolites and amphibole schists hornblende becomes the dominant ferromagnesian mineral within the gneiss. The gneisses represent the early phase in the formation of the complex; the later facies, represented by the coarse-grained foliated granite and the porphyritic biotite granite, followed after an unknown interval. The Barima-Whanamaparu gneisses are penetrated by pegmatites, quartz-feldspar and quartz veins.

The Amakura-Barima Granites include microgranite, pegmatite, aplite and quartz veins; porphyritic foliated biotite granite; and coarse-grained biotite granite. The porphyritic foliated granite is characterized by coarse grain size, foliation (aligned biotite) and potash feldspar phenocrysts ($\frac{3}{4}$-4 ins. diameter). These phenocrysts are irregular in occurrence, locally giving the rock a pegmatitic appearance. The phenocrysts

*Revised by E. Williams.

are often aligned parallel to the foliation. Biotite is the dominant ferromagnesian mineral of the facies; occasional small lenses or schlieren of finer-grained biotite rich material are seen within the porphyritic facies. Foliation directions of 140° were observed in the western area; eastwards these swing through a NE-SW direction back to the SE-NW direction on the Amakura River in the northeast. Pegmatites (quartz, feldspars, biotite and/or a light mica) and quartz veins were common; dykes of finer-grained biotite granite were noted.

The coarse-grained biotite granite facies is closely related to the porphyritic facies and can be regarded as a subfacies of the latter. The foliation directions measured in each facies are conformable with each other. Foliation is mineralogical rather than cataclastic.

The Barama Group rocks in the southeast are described in another report[1].

Quartz and Quartz-Feldspar Porphyries were observed in a Barama River traverse in the southwest of the area, to be in contact with, and penetrated by the Amakura-Barima Granites. The porphyries have a foliation similar to that of the adjoining granitic rocks. The extent of these porphyries is not known. Quartz-rich chlorite-sericite schists, possibly derived from the porphyries were found within the granitic rocks of the same area.

Undifferentiated amphibolites and fine-grained igneous rocks of basaltic texture, are closely associated in the southwest of the area with the fine-grained igneous rocks of basaltic texture; insufficient field information was obtained to map these two rock types as individual facies. Nowhere has it been possible to decide whether the igneous rocks are extrusive or intrusive, but the similarity between these igneous rocks and a basaltic dyke (Younger Basic Intrusive) in the granitic rocks of the Amakura River was noted.

The amphibolites and amphibole schists are of unknown origin although, previously, similar rocks of neighbouring areas have been referred to as arising from clay sediments, volcanics or basic intrusives. These rocks occur as bands, parallel to the foliation within the granitic rocks, particularly in the Barima-Whanamaparu Gneisses. Larger irregular bodies of amphibolites occur on the margins of the gneisses. The amphibole schists appear as medium- to fine-grained rocks, medium grey in colour, with the schistosity imparted by aligned amphibole crystals. The amphibolites are variable in grain size (largest crystals $\frac{3}{4}$ inch in length). The amphibole schists may pass locally into amphibolites. Both amphibolites and amphibole schists are penetrated by quartz veins and pegmatites.

Younger Basic Intrusives representing the latest igneous activity in the area are not common. One continuous dolerite dyke (25 miles in length) penetrates the Barima-Whanamaparu gneisses and has a strike roughly parallel to the structural trend of the country rocks.

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1. Bramley, K. 1959. Upper Barima River Expedition. Geol. Surv. B.G. Unpublished report.

A small dyke of basaltic texture was noted within the granite of the Amakura River; rocks of similar appearance were seen in the southwest of the area (see above) closely associated with amphibolites.

Regular soil sampling was carried out following the discovery of the nickel mineral niccolite in the Five Stars area (Branley 1959). Analyses of soil samples collected are now being carried out.

Diamonds have been reported from the headwaters of the Mobaina Creek in the northeast of the area. It is possible that they are derived from White Sand which may have occurred in the area (e.g. a similar source to diamonds recovered in the Waini River headwaters.)

# N. THE UPPER MAZARUNI-EKEREKU-KAMARANG SURVEY, 1960

by S. Singh, Geologist

During the first field season a reconnaissance survey was made of part of the Northern Pakaraima Mountains included in the Kamarang Valley and part of the Upper Mazaruni valley, with the object of investigating the nature and extent of the lateritization of the gabbro sills in the area.

The entire area is underlain by the sedimentary sequence of the Roraima Formation and its intercalated sills. The following is a composite section of the rock series in the area:

| | | Thickness |
|---|---|---|
| The Upper Sill | - | 300-320 feet |
| The Middle conglomerates and sandstones | - | 1800-2200 feet |
| The Middle Sill | - | 80-100 feet |
| The Lower Sill | - | 200-250 feet |
| The lower conglomerates | | ? |

The Lower Conglomerates, exposed along the upper Mazaruni River from about Meseta rapids eastwards towards Imbaimadai, are the oldest beds seen in the area. They are essentially arkosic quartz conglomerates, showing strong current bedding and frequently weathering to a surface of loose white sands.

Rocks forming the Middle Conglomerate and Sandstones are responsible for the escarpments and table mountains to the north and south of the Kamarang valley including Puluwatipu, Pwipwitipu and Kariengtipu. It would appear that the lower part of this series is predominantly coarse conglomerates with lenses of sandstones which give way upwards to pebbly sandstones containing lenses of conglomerates. Two shale horizons can be identified in this middle arenaceous series of the Roraima Formation, but their actual extent and thickness were not measurable. The lower shale horizon was touched at the foot of Eboropu mountain, between the lower dolerite sill and the overlying arenaceous Roraima rocks at a height of about 1900 feet. It is for the most part hornfelsed and a search for fossils was made without success. The second shale horizon was approximate to that occupied by the middle sill to the north of the Kamarang valley. On the south side of the valley at a similar height (2800-2900 feet) a light brown soft and friable shale is seen along a line from Akapai to the top of the Kariengtipu escarpment.

The dolerite sills are the representatives of the Younger Basic Intrusives in these parts. The Lower Sill is about 300 feet thick, though localized thickening up to 400 feet seems to have occurred. The Middle Sill at its thickest point is probably not more than 100 feet and is exposed along a line up Puluwatipu and Kayape. The Upper Sill is exposed on Eboropu and is about

910



250-300 feet thick. Thin sections fail to show any signs of gravity stratification within these sills. Petrologically they seem to be noritic in parts, though quartz dolerites are more common.

Because of observed inclinations of strata on both sides of the Kamarang Valley, it is felt that an anticlinal flexure is displayed and that the Kamarang River has gouged its valley approximately parallel to the axis of this anticline.

Laterites commonly occur overlying dolerites and in the country covered, three such sills were identified. Their levels of occurrence are on an average 1500-2000 feet for the lower sill: 2500-2700 feet for the middle sill; and 3700-4200 feet forthe upper sill. The lower sill almost entirely floors the valley of the Kamarang River and the section of the Upper Mazaruni River examined. It is deeply lateritized over most of the area. Pits were sunk at regular intervals over the lateritized areas and samples taken at 2 feet intervals in depth. The results of chemical analyses of these samples are still pending. The middle dolerite sill is thin and impersistent and not important for laterite. The upper sill is exposed on Eboropu and is of fresh rock without laterite.

There have been good strikes of DIAMONDS in this area during the first part of the year. Many creeks in the Imbaimadai area are still giving good yields. The writer saw diving operations at Kuwaima falls below Kamarang Mouth, where it is reported that working is very profitable in the dry season. The most recent strikes are, however, in the Ekereku River and its tributary creeks, and the Imbaimadai area was deserted as the deposits proved to be very limited.

## O. A TRAVERSE FROM MONKEY MOUNTAIN, ACROSS THE ENWARAK, AKOROBI AND KURUNGIKU MOUNTAINS TO EBINI MT.

by S. Singh, Geologist

This area forms part of the southern Pakaraima Mountains of British Guiana and was explored during the second field season, with the object of investigating possible occurrences of bauxite.

Mountains cover most of the area and the terrain is very rugged. The subdued undulating savanna landscape extends northeastwards from Monkey Mountain to the Echilebar River at an altitude of 1750 to 2200 feet. The highest mountains are generally formed of dolerites and the following heights were measured: Enwarak Mountain is 3200 feet; Akorobi Mountain 3000 feet; the Kurungiku Mountains up to 3200 feet; Matopi Mountain 2800 feet.

The rock succession is as follows:

Younger Basic Intrusives: Gabbro sills and dolerite dykes

Roraima Formation: Conglomerates and sandstones

Mazaruni Group: Acid hypabyssals and pyroclastics

The volcanic rocks of the Mazaruni Group are the oldest rocks of the area and their upper surface was touched at different levels. At one point the Roraima sandstones rest on them at 1750 feet and at another at 2000 feet. They are predominantly acid volcanics and include hypabyssal acid rhyolites, quartz porphyries, quartz-feldspar-porphyries and pryoclastic agglomerates and tuffs. One specimen seems to be spilitic in mineralogy.

The Roraima Formation consists mainly of quartz conglomerates and pink to red sandstones. The conglomerates contain many accessory rock fragments including quartz-porphyry, chert, sandstone and conglomerate. In the Echilebar savanna there is an unusual concentration of pebbles and large fragments of quartz porphyry. The sandstones are the dominant member of the Roraima Formation in the area. They are pink and red sandstones which are frequently argillaceous and weather to thin pebbly lateritic surfaces. The exact relationship between the sandstones and the conglomerates is uncertain. In the Monkey Mountain area the sandstones appear to overlie the conglomerate. Elsewhere it seems that one might be the lateral equivalent of the other.

The Younger Basic Intrusives are quartz dolerite sills and dykes intruded in the Roraima Formation. At least two sills can be identified, an upper sill at heights of between 2400 feet and 3200 feet, and a lower sill occupying heights of between 1800 and 2600 feet. Mineralogically these rocks appear to be consanguineous.

Details of the structural relationship is not forthcoming. Rocks of the Roraima Formation show an overall horizontal attitude though minor flexures and low angle dips exist. Faulting has occurred but no considerable displacements seem to have taken place.

From evidence in this area and elsewhere in the country, it seems that the Roraima sandstones unconformably overlie the volcanic rocks of the Mazaruni Group.

The development of laterite over the dolerite sills is only localized, thin and superficial. A fair quantity of massive lateritic ironstone occurs around Wamarak Mountain but no promising areas of aluminous laterite were found. Bands of specular haematite occur interbedded with the Roraima sandstones and a specimen subjected to laboratory analysis yielded 70% $Fe_2O_3$. The thickest band observed was about 9 inches.

Diamonds are still worked in the area. There are two main concentrations of porknockers, one around the Monkey Mountain area and the other in the Upper Echerak creek. In both these localities a significant amount of stones are extracted annually. The Roraima Mining Company is laying down equipment for large scale diamond operation on a concession located in the lower Echilebar River. It is significant that in all the areas, diamond workings are selectively located in the conglomerates or in gravels derived from the conglomerates.

Gold is mined as a supplement to diamond workings. It is generally extracted from alluvial sands which form the upper layers of pits sunk for diamonds in the Echerak area. The writer thinks that despite the fact that mining for diamonds and gold in this area has been going on since the beginning of the century, future prospects are still good.

## P. THE KARASABAI-ANNAI AREA

by M. W. Carter, Geologist

The country mapped lies in the northern savannas of the Rupununi District between Karasabai and Annai villages, and mapping was carried out between September and December 1960. The formations encountered in the area traversed may be grouped as follows:

Younger Basic Intrusives and granite porphyry dykes

Graphic granite and granophyres

Good Hope-Annai Volcanic Formation

The acid volcanics and granophyres give rise to steep narrow ridges which have an east-west trend reflecting the geological structure of the region as a whole. The dominant structural feature is, in fact, E-W to WNW-ESE foliation and jointing which affects the volcanics only; the granite suite being massive. The foliation and jointing dip steeply either to the north or to the south. Flow banding, when not complex, strikes generally east-west, parallel to the foliation, and dips of 45° were recorded. The same dip and strike were also seen in the sediments.

The rocks of the Good Hope-Annai Volcanic Formation are assigned to the Mazaruni Group. They are dominantly igneous with minor pyroclasts and sediments. The igneous rocks are mainly feldspar porphyries, and grade into rhyodacite and dacite, and a minor amount of altered andesite also occurs. The volcanics have in places been thermally metamorphosed or sheared to produce hornfelses or schists. One of the meta-volcanics is foliated riebeckite rhyolite and is of interest in view of the occurrence of riebeckite granite at Makarapan Mountain, farther east than the area mapped.

The tuffs are sheared crystal tuffs. Sediments also are subordinate, may be argillaceous, arenaceous or siliceous, and show current bedding and graded bedding. Some are tuffaceous sediments and match those of the upper Siparuni area almost exactly. Hornfelses occur at granite contacts.

Graphic granite and granophyres underlie a large part of the area mapped. The dominant rocks are pink granophyres, with minor graphic granite, and one very small outcrop of biotite granite. The Good Hope-Annai Volcanics are intruded by the granite-granophyre suite and there are clear signs of contact alteration of the sediments by the granophyres, while the arenaceous sediments are converted to hornfelses. Where gabbroic rocks are adjacent to granophyre alteration of the gabbro suggests that the emplacement of these preceded the granophyre; if these gabbros are to be grouped with the Younger Basic Intrusives, as appears likely from their petrology and structural relations, then the granophyres would be younger than the Roraima Formation.

At one locality, moreover, a dolerite dyke is cut by a small dyke of feldspar porphyry.

Younger Basic Intrusives and granite porphyry dykes. Numerous dolerite dykes cut both the volcanics and granophyres and have the NE-SW trend which is characteristic of the dykes of the Younger Basic Intrusives in neighbouring areas as well as in other parts of the Colony. A few small dykes of granite porphyry cut the volcanics and are believed to be genetically related to the granites. Their age relations to the basic intrusives was not ascertained.

Two gabbro plutons occur, and one of these is clearly intrusive into the volcanics. The other has volcanics on one side of it and granophyre on the other. Where it is adjacent to the granophyre the gabbro appears to be progressively more altered as the granophyre is approached, which suggests that some of the gabbros may be earlier than the granophyres.

## 2. THE PURIARI RIVER

by M.G. Allderidge, Assistant Geologist

The triangle of country between the Puriari River, the Mazaruni River and the eastern boundary of the Puriari SE Square was surveyed.

The area is entirely underlain by gneisses and amphibolites of the Bartica Assemblage, with a few minor intrusives. The field work was mainly confined to traverses of the Puriari and Mazaruni Rivers where the rocks were best exposed. Mr C.G. Dixon very kindly carried out microscopic examination of the thin sections and particular attention was paid to the basic bodies present in the gneisses.

The northern part of the area and the upper part of the Puriari River are occupied by high, deeply dissected hills of quartz-feldspar amphibolites, and quartz-feldspar-amphibole schists. Exposures are poor and the relationship of these rocks to the gneisses has not been demonstrated, although it is thought that they may be similar to other basic bodies in the gneiss complex.

The rocks at the east of the Mazaruni traverse are medium- to coarse-grained hornblende-biotite gneisses with porphyroblastic feldspars. The foliation is marked by the orientation of the ferromaagnesian minerals. Further west the gneisses, although similar in composition, take on a banded structure, the bands being in the form of elongated lenticles, often involved in ptygmatic folding.

Throughout the gneisses are numerous basic inclusions of hornblende schist, hornblende-biotite schist, biotite schist and biotite-chlorite schist, which are generally in the form of boudins and lenses parallel with the foliation of the gneisses. When the gneisses are ptygmatically folded the basic lenses are also involved in the folding. Other basic bodies are more massive but are interdigitated with the gneisses at the contacts, parallel with the foliation. A further type occurs where a basic body partially cross-cuts the foliation of the gneisses and is partially boudined parallel with the foliation.

It is considered that all the structures seen in the gneiss complex could have been derived by mechanical deformation of rocks which were previously separate masses of leucocratic and basic rock, by a process of flow and differential movement along foliation planes. As well as the larger basic bodies, the lenticular structure of the banded gneisses can also be accounted for by the same mechanism.

The origin of the rocks which were affected by this deformation is not known. Sillimanite is present in many specimens which may indicate a pelitic origin. Porphyroblastic feldspars are common but may be the result of chemical mobility during or or after the foliation.

A number of fine-grained granitic veins cut the gneisses, being particularly prominent at Itaki falls. They have been demonstrated to be intimately connected with the joint system of the gneisses and appear to be intrusive in origin.

Dolerite dykes cut the gneisses in the Mazaruni, generally along joint planes. Some larger cykes occur to the north of the river and are also present in the area of amphibolites.

Alluvial gold has been worked in this region but very little work now goes on as most prospectors have moved up river in search of diamonds. In the area to the north the gold in the Peter's and Aremu Mine area is thought to be associated with intrusive granites at the contact of the gneisses and metasediments. This situation is not repeated here; but granites intrude the gneiss complex and are very similar to other granites to the north and west associated with alluvial gold.

## R. THE PURUNI S.E. SQUARE NORTH OF THE PETER'S MINE ROAD

by M.G. Allderidge Asst. Geologist

The rock types occurring in the area are in order of age as follows:

White Sands

Basic Intrusives

Granites

Puruni Formation: Metasediments

Gneisses and Amphibolites

White Sands consisting of pure quartz sands, showing evidence of water transport, cover a ridge north of Peter's Mine-Koriabo road and also smaller areas on the road itself. Small outlines of these flat surfaced sands occur to the north-west of this area. It is estimated that the sands are not less than 70 feet thick and are at an elevation of approximately 400 feet above sea level.

Basic Intrusives in the form of dolerite dykes cut all the rock types except the white sands. In the north-west of the area they have a marked trend a little north of east. They also cut the amphibolites in the south and east of the area but no definite trend was noted.

Granites: Three areas of granites are present in this region. (a) In the north a hornblende-biotite granite - the southern extension of the Aremu-Quartzstone granite bears intrusive relationships to the metasediments and to the gneisses and amphibolites. It is slightly foliated close to the margin, parallel with its contact. It is on the southern margin of this granite that the Aremu Mine was situated.

(b) A porphyritic biotite granite outcrops in the Puruni River between Peter's Mine landing and Mara Mara creek mouth. Towards the northern margin where Peter's Mine was situated is a mineralized shear zone. The main mass of the granite is unfoliated but small areas of cataclastic foliation were seen. Its contact with other rock types is not exposed.

(c) In the region of the Puriari River head there is a foliated biotite granite, named the Puriari granite by Bishopp. It may be a southern extension of the Aremu-Quartzstone granite linked to the latter below the surface, and thus it probably intrudes the amphibolites and the metasediments. However it is also possible that it is more intimately connected with the gneiss and amphibolite complex.

<u>Metasediments</u> of the Puruni Formation (Cuyuni Formation*) and subordinate lavas which are continuous with those in the Puruni River underlie the central and northwestern part of the region. The formation is represented by foliated conglomerates, pebbly sandstones, sandstones of varied grades, silts and quartzites. Fine-grained igneous rocks are present as a subordinate type. These rocks are cataclastically foliated in a fairly constant direction between $280^\circ$ and $300^\circ$. Metamorphism of the sericite-chlorite grade has taken place.

<u>Amphibolites and Gneisses</u> in the south and east are large hills underlain by amphibolites, amphibolite schist and mineralogically foliated gneisses. These are continuous with the gneisses and amphibolites in the lower Puruni which can be traced into the Mazaruni gneiss complex. The mineralogical foliation is generally in a northerly or northeasterly direction. It is thought that the gneissose southeast portion of the Aremu-Quartzstone granite belongs to this complex, into which the granite has been intruded.

Owing to the difference in metamorphic grade and type and direction of foliation demonstrated in a detailed traverse of the Puruni River made by E. Williams, it is considered that there is a hiatus between the gneiss amphibolite complex and the metasediments.

Aremu and Peter's Mines are two areas from which large quantities of gold were extracted in the past. More recently only a very few prospectors have worked in the area owing to difficulty of transport.

Both mines were situated on the margins of granites, thought to be associated with the contact of the metasediments and gneisses, and a mineralized shear zone is present in the Peter's Mine area. Much vein quartz is present along the line between the two mines and it seems that the <u>gold</u> is associated with a zone of weakness picked out by the granites.

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* This publication p. 43

## S. EXPLORATION OF ALUMINOUS LATERITES IN THE KUKUI AND KAMARANG RIVER VALLEYS

by J.W. Carter, Assistant Geologist

In 1959 areas of aluminous laterite were discovered in the Kopinang Valley associated with dolerite sills. Dolerite was already seen in the Kukui Valley and further to the east but the extent of lateritization or bauxitization was not known. A rapid reconnaissance survey was carried out during the first field season 1960 in order to delimit the area of lateritization and to test its depth. A preliminary map was prepared on the scale of 1:125,000 with attention being paid mainly to dolerite areas. The general succession at Ayanganna is as follows:

| | |
|---|---|
| Roraima Formation | Sandstone |
| | Gabbro |
| | Sandstone |
| | Conglomerate |
| | Shale |
| | Gabbro |
| | Sandstone or Pebbly Sandstone |
| | Conglomerate |

In the Upper Mazaruni Region, the Roraima Formation is well exposed on the plateaux and mesas collectively known as the Pakaraima Mountains. The sandstones, conglomerates, shales, quartzites and dolerites are predominantly flat-lying giving rise to table lands, plateaux and mesas.

Lateritization and bauxitization has developed on flat planation surfaces which have remained undisturbed for very long periods. Several flat surfaces have been noted in the region, the most important of which are (a) the Kamarang-Kukui Valley Surface; (b) the Pungaik-Kanow Surface and (c) the Kraimarutipu Surface.

The Kamarang-Kukui Surface is an extensive surface, underlain chiefly by dolerite, in the Kamarang Valley, up the Mazaruni to the Kukui and then further south. The general level of the sill is between 1550 and 1800 feet M.S.L. and is underlain by sandstone and pebbly sandstone. The surface is lateritized throughout, and in a few places pockets of good bauxite were noted.

The Pungaik-Kanow Surface dolerite occupies the high ground between Phillipai and Chinowieng, at an average elevation of about 2550 feet M.S.L. Most of the features displayed here are rather similar to those of the Kamarang-Kukui surface.

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On the Kraimarutipu Surface at an elevation of approximately 3500 feet dolerite is also exposed and is lateritized and bauxitized. However, creeks have cut steeper and deeper valleys so that the topography is more rugged. Lateritization is not as complete as on the other surfaces and large masses of fresh dolerite are seen. Lateritic deposits of the kind found in the Pakaraimas are in common occurrence throughout the tropical world and have been formed as special weathering products of basic rocks. However, the deposit is rich in iron and only moderately rich in alumina content so that any portions workable as bauxite would be restricted, and would have formed due to certain peculiarities in the deposit.

## T. REPORT ON THE UPPER CUYUNI RIVER EXPEDITION, 1960

by L.L. Fernandes, Assistant Geologist

The expedition was carried out in the first field season of 1960 with the object of:

(i) Determining the nature of the lateritic cover over doleritic rocks in the Pakaraima Mountains of the area with a view to the possible occurrence of bauxite.

(ii) Summing up the diamond and gold mining potentialities of the area, and

(iii) Revising the geological map of the area with the aid of aerial photographs.

The main physical features of the area are the high plateau of the Pakaraima Mountains and the lowland area bordering the Cuyuni and Wenamu Rivers. The mountainous region comprises an extensive plateau of about 2000-2200 feet high which is dotted with a few outliers that reach up to 2500 feet and surrounded by lower erosion surfaces at about 1500-1700 feet and 700-800 feet. The plateaux have been deeply incised by the rivers with the formation of steep escarpments and several waterfalls.

A stretch of relatively low land under 500 feet high extends on the right bank of the Cuyuni River between Wenamu and Ekereku Rivers.

The succession represented in the area is as follows:

5. The Younger Basic Intrusives

4. The Roraima Formation

3. The Younger Granites

2. The Older Basic Intrusives

1. The Mazaruni Group

The majority of the rocks of the Mazaruni Group are fine-grained igneous rocks of intermediate (trachytic) composition. The rocks are slightly foliated and usually very altered containing chiefly plagioclase $An_{15-25}$, orthoclase, secondary chlorite, epidote and calcite with some occasional quartz. Feldspar porphyries with phenocrysts of oligoclase and orthoclase are widespread, while ther are scattered occurrences of sediments. (See page above).

The Haimaraka Formation is included in this group. It consists of shales which are usually purple in colour but may be darker coloured near intrusives. They are intensely folded and may be interbedded with the fine-grained igneous rocks.and sediments noted above.

The rocks of the Mazaruni Group are intruded by <u>Older Basic Intrusives</u> as dykes and sills which are now much altered by metamorphism. Feldspars are often saussuritized and the pyroxenes altered to chlorite.

The Younger Granites are represented by three small outcrops of intrusive granites found in the Wenamu River area. Some specimens display large pink orthoclase and plagioclase $An_{10}$ crystals, and slight foliation.

The Roraima Formation in this area comprises about 2500 feet of sandstones, quartzites, grits, conglomerates and shales. Conglomerates occur near the base of the formation while white and cream coloured sandstone predominates in the upper part. The beds are mainly flat-lying.

The Roraima Formation and the older beds are intruded by a number of Younger Basic Intrusives as sills and dykes. Thick gabbro sills occurring within the Roraima Formation often cause contact metamorphism of the intruded sediments.

In the investigation for bauxite three pits were put down in the weathered mantle over gabbroic rocks. Positive identification of bauxite has been possible in one pit; the results of analyses are awaited.

The lower Ekereku River yielded very poor results in the prospection for diamonds. Good diamond indications and gold colours were seen in the right bank tributaries of the Wenamu River.

APPENDIX II

GEOLOGICAL SURVEY OF BRITISH GUIANA
SENIOR STAFF AT 31.12.60

| ESTABLISHMENT | NAME |
|---|---|
| Director ... ... ... | R.B. McConnell, C.B.E., M.A., D.es Sc. (Lausanne) D. Phil., M.I.M.M., F.G.S., F.R.G.S. |
| 2 Deputy Directors ... | C.G. Dixon, B.Sc., F.G.S. |
| | D. Bleackley, M.A., D. Phil., A.M.I.M.M., F.G.S. |
| 3 Senior Geologists ... | P.H.A. Martin-Kaye, B.Sc., Ph.D., A.R.C.S., F.G.S.* |
| | P.B.H. Bailey, M.A., F.G.S. |
| | R.T. Cannon, B.Sc., M.I.M.M., F.G.S. |
| | E. Williams, B.Sc., Ph.D., F.G.S. |
| 9 Geologists ... ... | C.N. Barron, B.A., F.G.S. |
| | D.D. Hawkes, M.Sc., F.G.S. |
| | J.H. Bateson, B.Sc., F.G.S. |
| | J.W. Lloyd, B.Sc., F.G.S. |
| | K. Bramley, B.Sc., F.G.S. |
| | S. Singh, B.Sc. |
| | M.W. Carter, B.Sc. |
| | Vacant |
| | Vacant |
| 3 Assistant Geologists ... | L.L. Fernandes, B.Sc., A.R.S.M. |
| | M.G. Allderidge, M.A. |
| | J.W. Carter, B.Sc., A.R.S.M. |
| Chemist-Petrologist ... | Vacant |
| Geophysicist-Hydrologist ... | L.E. Ramsahoye, B.Sc., D.I.C., Ph.D. |
| 2 Scientific Assistants ... | D.O. Pollard |
| | Vacant |
| Chief Draughtsman ... | T.M. Rahaman, Graduate of Technical Institute, Trinidad. |
| Chief Clerk ... ... | F. Johnson |
| Supervisor of Library and Records ... | H.K. George |
| Senior Accounting Officer.. | L.F. Choy |

*Seconded to Windward Islands

## GEOLOGICAL SURVEY OF BRITISH GUIANA

### APPENDIX III

### REVISED STRATIGRAPHICAL TABLE OF THE GEOLOGICAL UNITS IN BRITISH GUIANA

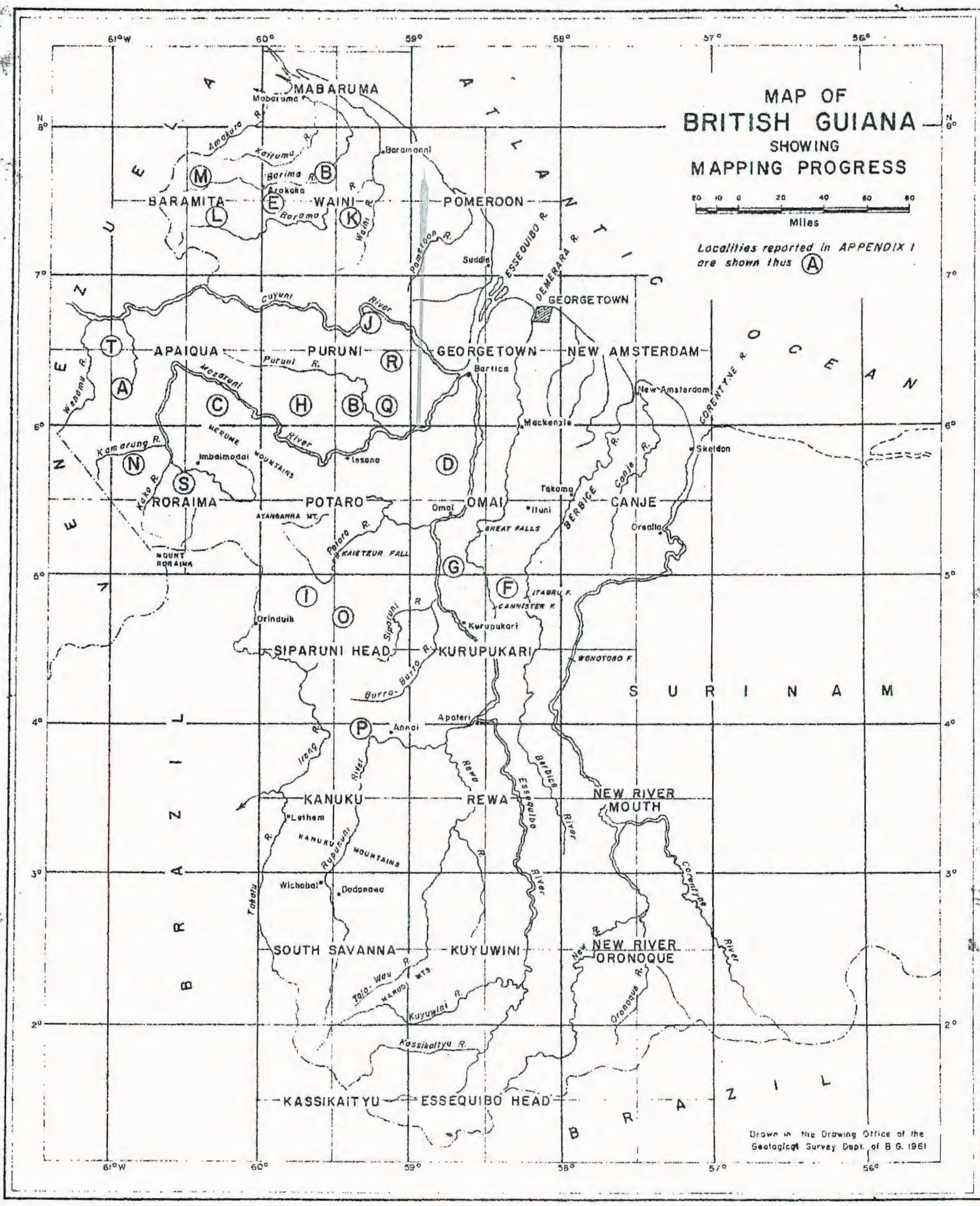
| AGE | STRATIGRAPHICAL UNIT | | ROCK COMPONENTS AND MINERAL DEPOSITS |
|---|---|---|---|
| Recent | | Demerara Formation | Marine clays with rare lignites and sands containing shells. Includes recent alluvial deposits. Clays for bricks and pottery, shell deposits (lime). |
| | Corentyne Group | Coropina Formation | Marine and brackish clays with some lignites and sands. Marine terrace level. |
| Upper Tertiary to Pleistocene | | Berbice (or White Sand) Formation | Sands, sandy clays, lignites, and localized basal conglomerates. Continental-deltaic and littoral-deltaic. Gold, diamonds, glass sands, ? oil (off-shore only). |
| | Unconformity with localized bauxite deposits | | |
| Lower Tertiary and (?) Cretaceous | Rose Hall Group (coastal area) | | Sands, sandy clays and clays, with some lignites towards the top. Some Eocene and Palaeocene microfossils and pollen grains now under study. Group established from borehole cores. ? Oil (off-shore only). |
| Tertiary or Cretaceous | | Takutu Formation (Rupununi District only) | Red and grey shales and sandstones with plant remains, ostracods. |
| ? Mesozoic | Younger Basic Intrusives | | Dolerites and quartz dolerites. Quarry stone |
| ? Palaeozoic | | Roraima Formation | Current-bedded quartzitic sandstones and quartzites with conglomerates and some shales and jasper. Colour dominantly pink, light grey and red. Diamonds, gold, stone. |

725B

Great Unconformity

| | | | | |
|---|---|---|---|---|
| PRECAMBRIAN | Middle to Upper | | Younger Granites | Biotite and hornblende granites, including foliated and gneissic facies. Gold, columbite, ? base metals, beryl, etc. |
| | | | Amphibolites | Amphibolites, hornblende schists and granulites - may belong either to Younger Granites, Bartica Assemblage or intrusives of various ages. |
| | | Bartica Assemblage | Kartabu granite | Muscovite granite passing to muscovite-biotite gneiss. |
| | | | Essequibo Gneiss Group | Banded biotite or hornblende-biotite gneiss, hornblende-schist, amphibolite. Mica, feldspar, quarry stone. |
| | Middle ? | Barama-Mazaruni-Assemblage | Mazaruni Group | Greywacke-sandstones, pebbly sandstones and conglomerates; lavas, pyroclastics and quartzites with intercalated mudstones; basic intrusive rocks, hornblende schist and amphibolite. Gold, base metals (? chromium). |
| | | | Barama Group | Mudstones, quartzites, argillites; lavas and tuffs; manganiferous schists and gondites; phyllites, sericite and sericite-chlorite schists, including metasediments, metavolcanics and basic intrusives; biotite and biotite-hornblende gneiss; hornblende schist and plagioclase-amphibolite. Manganese, gold. |
| | ? Unconformity ? | | | |
| | Lower | Rupununi Assemblage | South Savannas Group | South Savannas biotite granite, biotite gneiss; enclaves of banded biotite and basic gneisses. Monazite, magnetite, mica. |
| | | | Marudi Group | Metaquartzites, psammitic metasediments, biotite schist and banded biotite gneiss. Stratigraphical position uncertain. Gold, iron. |
| | | | Kanuku Group | Hypersthene and biotite-garnet granulites, charnockitic gneiss and hypersthene granites. Iron. |
| | Uncorrelated | | Kuyuwini Group | Rhyolites, andesites and corresponding tuffs. (Possibly of Middle Precambrian age). |
| | | | Gneisses and granites | Biotite and hornblende gneiss, granite - in partially unexplored portions of Southern British Guiana. Mica, etc. |

NB. Bauxite and lateritic iron ores are associated with lateritic deposits of different ages.


MAP OF
BRITISH GUIANA
SHOWING
MAPPING PROGRESS
Miles
Localities reported in APPENDIX I are shown thus (A)
MABARUMA
BARAMITA
WAINI
POMEROON
APAIQUA
PURUNI
GEORGETOWN
NEW AMSTERDAM
RORAIMA
POTARO
OMAI
CANJE
SIPARUNI HEAD
KURUPUKARI
KANUKU
REWA
NEW RIVER MOUTH
SOUTH SAVANNA
KUYUWINI
NEW RIVER ORONOQUE
KASSIKAITYU
ESSEQUIBO HEAD
ATLANTIC OCEAN
VENEZUELA
BRAZIL
SURINAM
Mabaruma
Baramanni
Arakaka
Suddie
Bartica
Mackenzie
New Amsterdam
Skeldon
Imbaimadai
Issano
Takama
Ituni
Omai
Orealla
MOUNT RORAIMA
KAIETEUR FALL
GREAT FALLS
Orinduik
Kurupukari
Apoteri
Annai
Lethem
Wichabai
Dadanawa
KANUKU MOUNTAINS
MERUME MOUNTAINS
Cuyuni River
Mazaruni River
Puruni R.
Potaro R.
Essequibo River
Demerara R.
Berbice River
Corentyne River
Canje R.
Rupununi River
Takutu R.
Ireng R.
Siparuni R.
Burro-Burro R.
Rewa R.
Kuyuwini R.
Kassikaityu R.
Oronoque R.
Waini R.
Barima R.
Barama R.
Kaituma R.
Amakura R.
Pomeroon R.
Wenamu R.
Kamarang R.
Kako R.
ITABRU F.
CANNISTER F.
WONOTOBO F.
61°W
60°
59°
58°
57°
56°
8°
7°
6°
5°
4°
3°
2°
Drawn in the Drawing Office of the Geological Survey Dept. of B.G. 1961