Franco Urbani P.

Venezuela—The Guayana Highlands

Diamondiferous Alluvials of the State of Bolivar

By John C. Davey, A.C.S.M., M.Inst.M.M.

The fourth article of a series on Venezuela.

Introduction

The diamond deposits that have been worked in Venezuela up to the present time are all located in the State of Bolivar and are found in three distinct river basins—*viz.*: (i) Caroni—Paragua basin; (ii) Cuyuni River basin (Upper Cuyuni), and (iii) Mazaruni River basin (Upper Mazaruni, Kamarán River).

The first has proved to be by far the most important and work has been confined mainly to two areas in the Caroni-Paragua basin, locally distinguished by the names: (*a*) Lower Caroni area (Bajo Caroni) and (*b*) Gran Sabana area (Alto Caroni), to be described in that order in the following pages.

Although these diamond deposits are found over a large area and work on a small scale has been in progress for at least 30 years very little information has been published about them. This is due in part to the fact that probably not more than six mining engineers have any knowledge of these deposits and at least two of these were engaged by private interests to sample and make reports which precluded them from publishing any useful data. The production in the past seven or eight years is no criterion of the potential value of these diamondiferous alluvials which have been worked only by the primitive and wasteful methods that poor local miners are able to employ.

The impression of the few experienced engineers who have some knowledge of the extent and value of the diamondiferous alluvials in these areas is that some time in the future they will become a major source of diamonds and especially of gemstones. Their potential value to countries of the Western Hemisphere, and especially to the United States, should not be underestimated. In the past year two diamond-cutting companies were formed in Caracas and they are apparently developing a considerable business in gemstones, for a large proportion of the 1945 production of diamonds has remained in Venezuela.

Lower Caroni—Paragua Area

Location.—Diamondiferous alluvials have been found in the Lower Caroni River between the mouth of the Rio Carrao, on the south, to Guri on the north—a straight line distance of 105 miles. However, the greater part of all the work done in this region has been within a triangular area with the Caroni River from San Pedro de las Bocas to Guri, a distance of 60 miles, forming its vertical side and the Paragua River, from La Paragua to San Pedro, a distance of 30 miles, forming its base. A line drawn from La Paragua to Guri completes the triangle enclosing an area of about 900 square miles. (See Map No. 3.)[1]

Communications.—The small town of La Paragua lies about 144 miles south of Ciudad Bolivar, to which it is connected by an unimproved dirt road. About one mile from the town is a landing field, which can be used by local passenger planes, but is not at present on the itinerary of the three companies operating in Venezuela. Another cleared zone at San Pedro de las Bocas, 30 miles east of La Paragua, has also been used as a landing field on special occasions. Aeroplanes may be specially chartered for trips to these fields by arrangement with one of the domestic companies operating passenger and freight services from Maiquetia to all parts of the interior.

No reliable maps are available of this part of the country and distances where given are only approximate. The Caroni River may be ascended by launch from above the rapids at Uracapay and dug-out canoes with outboard motors can be used on the Caroni and Paragua Rivers, as well as on most of their tributaries. The gradient of these rivers is very small and there is a very big difference in the height of the river between the low level of the dry season (March) and the high level of the wet season (August).

History.—The first discovery of diamonds in the Lower Caroni River area has probably

[1] The Mining Magazine, Sept., 1945, p. 139.

never been recorded. Sir Walter Raleigh on his voyage up the Orinoco may have been shown diamonds by the Indians settled round the mouth of the Caroni, as he certainly reported the presence of iron ore and gold and was shown what were purported to be diamonds.

In 1887 two prospectors, probably Frenchmen (their names were respectively Bonet and Borderie) were granted permits by the Venezuelan Government to explore the left bank of the Caroni River from the mouth of the Rio Cebolla, a tributary, to the mouth of the Paragua and upstream to La Paragua village. They were searching for gold, but it would be most unlikely that they did not find some diamonds in the course of this work, as this same area has subsequently proved to be one of the most prolific sources of the gem.

Dr. Lucien Morisse, a French medico and botanist, who wrote a narrative of his travels in this region during 1902, records an encounter with a man who had acted as guide to two American prospectors working in the region of La Paragua. As a result of the conversation with this guide, and his report of their activities, Dr. Morisse was confident that they had discovered diamonds and were endeavouring to keep their discovery a secret. Since this secretive attitude would naturally be adopted by the few prospectors entering this region at that time it is more than likely that from 1887, or slightly earlier, a small number of men were employed in washing these alluvial deposits for both gold and diamonds. The total production must have been small and on account of the difficulties involved in working the richer alluvials, which were under water most of the year, these miners probably devoted their energies mainly to the recovery of gold and regarded the finding of occasional diamonds as only a "ñapa," a welcome extra, to their hard-earned income from the sale of gold dust, or in some cases may have saved their diamonds merely as curios. The first sale of diamonds, as far as is known locally, took place at Paviche in 1912, probably by miners who had come from El Manteco gold-mining area, which lies only a few miles east of the Caroni River (Map 4).[1] Every year when the river was unusually low following a drought the number of miners working on various sections of the Caroni increased and diamond recovery continued on a small, but steadily increasing, scale.

In the period from 1924 to 1927 there was an increase in the interest shown in diamonds and as 1926 was an unusually dry year the amount of diamonds recovered probably constituted a record up to that date. From time to time exceptionally rich concentrations of gold and diamonds were encountered, resulting in minor rushes to these particular places. Word of these rich finds gradually leaked out and in 1930 a French company with concessions on the Santa Barbara River, some 28 miles north of Las Nieves concession, reported the finding of diamonds in their ground. In 1933–34 some North American interests supplied standard rubber diving suits for their men working in the neighbourhood of Paviche and they were able to work in sections of the river that previously could not be sampled. The results of this work were said to have been exceptionally satisfactory. In more recent years other miners have rented diving suits and the diamonds recovered by them have been greater in size and value than those of miners working close to the river bank.

About 1935 the Rio Pao diamondiferous alluvials were discovered by a miner prospecting for gold, just as most of the other diamond deposits have been, and in 1939 the concessions that had been denounced in the meantime were transferred to a company which sent an experienced mining engineer to sample this property systematically.

The Venezuelan Government first reported the production of diamonds in 1937 and by the end of 1938 there were 11 mining concessions in production in addition to the areas of free avail. New finds were reported in other sections of the Rio Santa Barbara in the following year and more miners moved to this and the Rio Pao area, but owing to the high level of the rivers the annual production fell well below that of the two previous years and has continued to fall, until, in 1944, it was only 5,128 carats.

The largest diamond recovered from this field so far weighed 23 carats and on an average the stones are smaller than those recovered in the Gran Sabana area, but the concentration seems to be greater in the Caroni river bed.

Production.—The production of diamonds from the Lower Caroni field, as officially recorded from 1937 to 1944 inclusive, totals 67,264·10 carats. From 1912 to 1936 the estimated recovery is 73,000 carats, so that the total estimated production from the first recorded sale of diamonds up to the present is 140,264·10 carats.

[1] THE MINING MAGAZINE, Sept., 1945, p. 145.

Fig. 8. Diving for Diamonds, Rio Caroni.

Climate and Health.—The climate in the Lower Caroni region is healthy, as most of this diamond field is in open sabana country and the elevation above sea-level ranges from about 800 ft. to 1,320 ft. The wet season is the same as in other parts of the State of Bolivar, usually lasting from May to September. There is plenty of fish in the rivers and some small game may be obtained locally. Fruits and vegetables are not plentiful, but can be grown without much difficulty close to the rivers.

Labour.—It is not always easy to obtain labour in this area to work on days' pay basis, as in the dry season, when they are most needed, they prefer to work on the diamondiferous alluvials in the areas of free avail, where they often make enough in a few days to keep them in idleness for weeks or months. These men are all skilful manipulators of the batea and when available are generally very helpful and give little trouble.

Regional Geology.—This has already been described in the previous article on the gold mining region [1] and will not be repeated here since it has no connexion with the origin of the diamonds.

[1] The Mining Magazine, Nov., Dec., 1945.

Diamondiferous Alluvials of the Caroni-Paragua Basin

(a) Lower Caroni

In addition to the Caroni and Paragua rivers the following tributaries have been the principal sources of the diamonds recovered to date: The Pao (18 miles below San Pedro), the Santa Barbara, and La Cebolla. Places where specially rich concentrations have been found are San Pedro de las Bocas, Paviche, San Salvador, La Fortuna, Carrizal, Las Piedras, Costa Rica, Las Coitoras, and El Resguardo. Since the work on these alluvials has been mostly done by nomadic Venezuelan gold miners there is no record available of the diamond value per cubic yard of gravel treated. The writer knows of one case where a party of six Indians recovered more than 250 carats from about 20 cubic metres of gravel from the Caroni River, near San Pedro de las Bocas.

In 1943 Mr. R. W. Michael, of New York, gave the writer some reliable information regarding the values recovered earlier that year from the Caroni River and if those figures are at all representative then the bed of that river must constitute a veritable treasure house containing the highest con-

centration of diamonds known anywhere in the world.

The diamondiferous alluvials of the Lower Caroni may be divided into three main classes :—

(i) Old river terraces.

(ii) Diamondiferous gravels between the above level and the present low water level of the rivers (gravel slopes and flood plains).

(iii) Deposits in existing river beds.

The old terrace gravels are found up to a maximum of 80 ft. above the present river level and the thickness of the diamondiferous formation varies between 9 in. or 10 in. and 22 in. In many places there are only remnants of the old river terraces remaining, as some sections have been eroded away and re-deposited on the slopes, in the newer streams, or in the Caroni. These terrace deposits are usually thin and the overburden consists of a fine sand, an average section not being more than 5 ft. thick and the diamondiferous gravel about 20 in. The quartz pebbles rarely exceed 1 in. in diameter and about half the formation is composed of grains less than $\frac{1}{16}$ in. in diameter. The river bank gravels (of the slopes) have a heavier overburden, which varies considerably in thickness. However, an average section would be about 15 ft. of overburden and 12 in. of diamondiferous gravel.

Method of Working.—There are three different methods employed in recovering diamonds from the alluvials in this field—*viz.*, by

(i) pitting in old river terraces and in the banks of the rivers ;

(ii) men diving in the rivers without mechanical aid, and

(iii) men diving in the rivers in a rubber suit.

(i) These terrace gravels are not as rich as those located in the river bed and for that reason also are not of much interest to the local miner, who rarely works the old terrace gravels, but does try those of the river banks. After removing the overburden from a pit three or four feet square he carefully fills his batea with the diamondiferous gravel and proceeds to wash it. When all the lighter material has been discarded he places the heavy concentrate in a sieve and very carefully washes this, examining every particle closely and picking out by hand all the stones which may be diamonds.

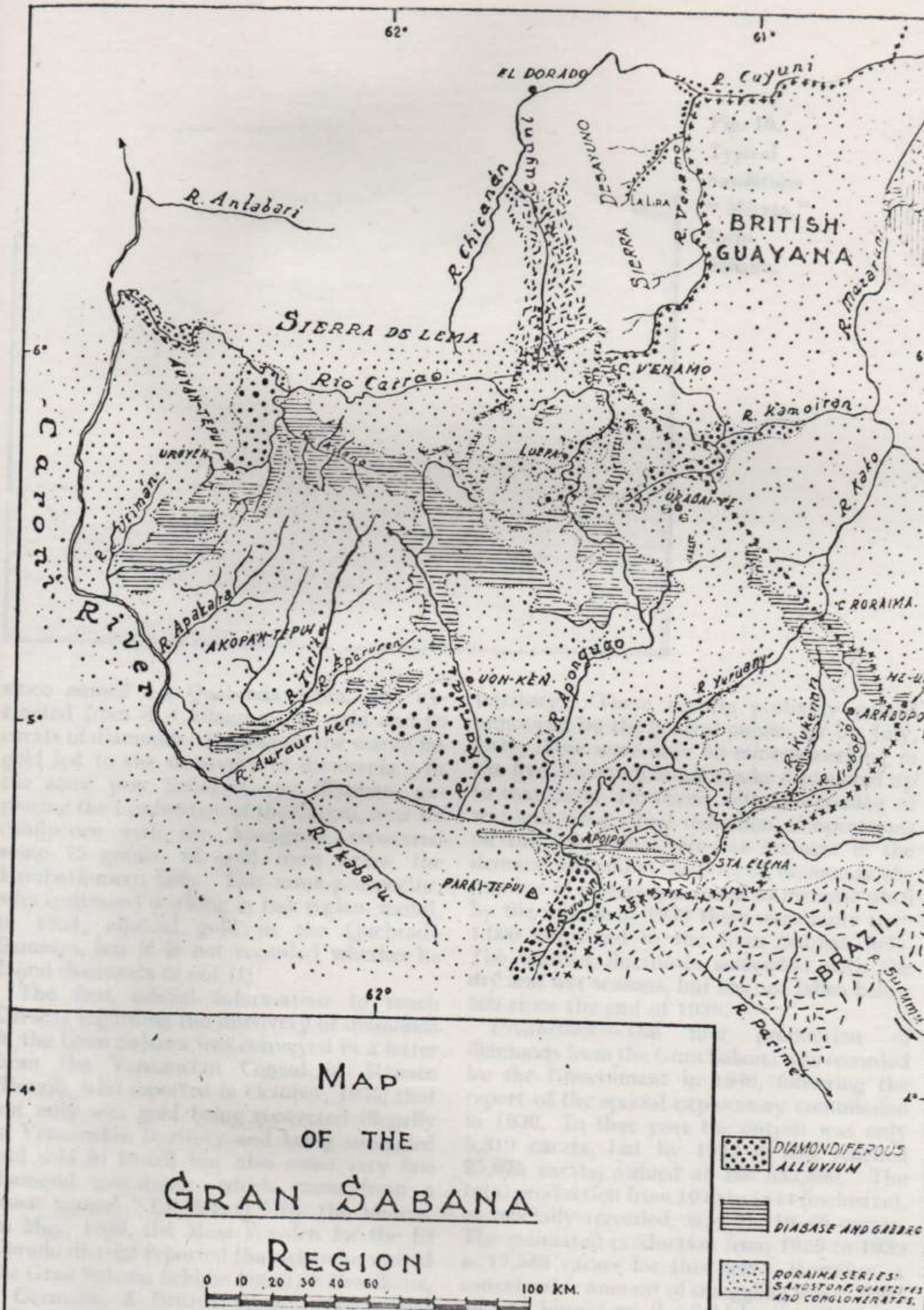
In the recurrent periods of drought, when the rivers are exceptionally low, some of the tributary streams become practically dried up and the miners are able to recover diamonds from the stream bed or from fairly shallow gravels in the banks of the river. Where the granite-gneiss of the Archæan complex forms the bed-rock the surface is often fractured, or small quartz veins protrude, forming natural riffles above which concentrations of diamonds are commonly found.

The " batea," or wooden bowl, that is used locally for washing the gravels is generally made of a local wood—named " morea." It is conical in shape, 24 in. in diameter, about 6 in. deep, and the rim is from $\frac{1}{2}$ in. to $\frac{5}{8}$ in. thick. This batea is usually somewhat deeper and more conical than the type used exclusively for gold washing.

(ii) The local miner with only the most meagre equipment can rarely afford to rent diving equipment, nor can he afford the expense of pitting, unless the gravel is at a shallow depth and close to a river, so consequently he generally chooses the second method of working—*i.e.*, diving without mechanical aid. Most of the men who dive in these rivers to recover the diamondiferous conglomerate are negroes. They work without difficulty in 20 ft. of water, but rarely attempt to dive where the depth is more than 25 ft. and they can each recover from $\frac{1}{8}$ to $\frac{1}{4}$ of a cubic yard of gravel per diem. The method of working is to take two or more dug-out canoes into the stream where they intend to work and drive long wood poles into the stream bed. Then they dive overboard and remain on the river bed as long as possible, the average time being about one and a half minutes.

While under the water they remove as much of the diamondiferous formation as they can and this is brought up and dumped into the canoes. This is very strenuous work and occasionally causes serious injury to some of these men, but the possibility of recovering a large amount of stones in a short period is sufficient incentive for many of them to work in this manner every year during the time the rivers are low.

(iii) By diving in a rubber suit : A small number of diving equipments is available and with these the men work in depths up to 60 or 70 ft. It has been noted that generally the recoveries from the deeper parts of the Caroni River have been much greater per cubic yard than near the river banks.


62°
61°
EL DORADO
R. Cuyuni
R. Antabari
R. Chicanán
Cuyuni
DESAYUNO
LA LIRA
SIERRA
R. Venamo
BRITISH
GUAYANA
R. Mazaruni
SIERRA DE LEMA
Rio Carrao
C. VENAMO
R. Kamoiran
URUYEN
LURPA
URABAI-YE
R. Kako
Caroni
River
R. Apakara
AKOPAN-TEPUI
R. Tirika
R. Aparuren
UON-KEN
R. Aponguao
R. Yuruany
C. RORAIMA
NE-UE
ARABOPO
R. Aurauriken
R. Karuai
R. Kukenán
R. Arabopo
R. Ikabaru
APOIPO
STA. ELENA
PARAI-TEPUI
R. Surukun
BRAZIL
R. Parime
R. Surumu
6°
5°
4°
MAP
OF THE
GRAN SABANA
REGION
0 10 20 30 40 60 100 KM.
0 10 20 30 40 50 60 MILES
GEOLOGY BY: V. M. López et al.
TRACED BY: G. Gonzalez Bozo
DIAMONDIFEROUS ALLUVIUM
DIABASE AND GABBRO
RORAIMA SERIES: SANDSTONE, QUARTZITES AND CONGLOMERATES.
BASAL COMPLEX

MAP N°6.

(b) The Gran Sabana Field

The region known as the Gran Sabana covers an area of about 10,000 square miles and lies roughly within 4° 30′ N. and 6° N. Latitude and 60° 40′ W. and 62° 55′ W. Longitude. It is bounded on the west and south-west by the Caroni River and on the north by the Sierra de Lema, which traverses the parallel of 6° N. Latitude. The eastern limit is the boundary with British Guiana and to the south the boundary with Brazil.

Practically nothing was known of this region before 1939, when the Venezuelan Government sent a group of mining engineers and geologists to map and report on the important features encountered during five months' exploration (1).[1] Since that year considerable local interest has been taken in the diamondiferous alluvials, but foreign mining capitalists have apparently been quite unaware of the possibilities of this region.

Communications.—There are now three air-fields in the Gran Sabana area, situated at Kavanayen (near Luepa), Santa Elena, and Parai-tepui, but at present only the first two are being used. The Linea Aeropostal Venezolana operates a frequent and reliable service from Ciudad Bolivar and Tumeremo to these fields. The straight-line distance from Maiquetia (present airport for Caracas) to Ciudad Bolivar is 288 miles and from the latter city to Tumeremo is 155 miles, whilst the final stage to Santa Elena is 192 miles. The total flying time between these two extreme points is now about six hours, as on the flight to Ciudad Bolivar the planes call at Barcelona, Maturin, etc. Specially-chartered aeroplanes can fly direct to Santa Elena from Maiquetia and cover the distance in about 4 hours.

Santa Elena is the nearest village or settlement to the diamond diggings on the Surukun River and has a population of about 900 people. Until 1945 the only way to reach the diamond field from here was to travel on foot or mule, the former taking from one to two days and the latter two days. However, a new field has been completed at Parai-tepui, which is only 5 miles from the diggings in Quebrada La Patria and will materially help to reduce the time taken to reach the diggings from Santa Elena. A road is also projected to connect El Dorado to Santa Elena, *via* Luepa, and work has already been started. However, this will take a considerable time to complete and many natural obstacles have to be overcome before it will be ready for motor traffic. For those who care to venture on foot through this uninhabited region from El Dorado there is an old Indian trail, which can be followed over very difficult terrain, and it is not to be recommended, as one may take from 21 to over 30 days to complete the journey by this route. There is one means of access from Brazil and that is by river launches from Manaos, on the Amazon, to Boa Vista. Here goods and passengers are transferred to smaller launches which proceed to Visosa or Mocedad, from whence the journey may be made by truck in dry weather, or by mule in the wet season, to the Surumu river and across the international boundary to Santa Elena (Map No. 6).

History.—In 1125 the first white settler in the Gran Sabana area, Señor Lucas Fernandez Peña, discovered diamonds in a small creek,

[1] Figures in parenthesis refer to references given at the end of the article.

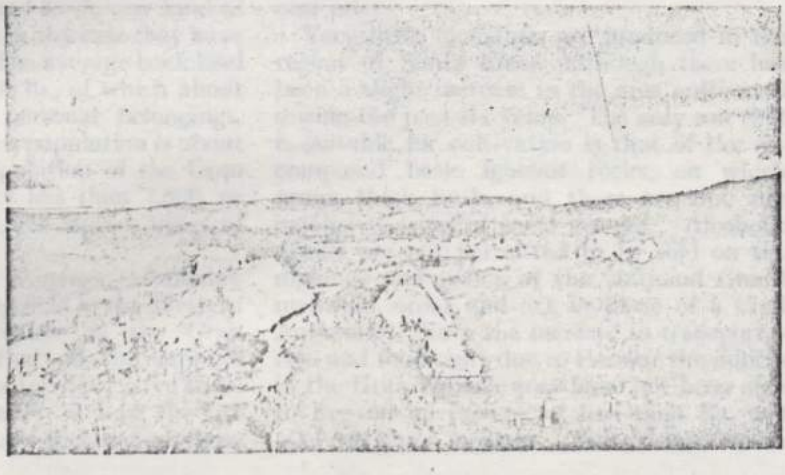


Fig. 9.—Santa Elena, Gran Sabana.

Fig. 10. Typical Sandstone "Meseta," Gran Sabana.

since named La Quebrada Peña, and extracted from it 4 kilograms. of gold and 60 carats of diamonds. Here again the search for gold led to the discovery of diamonds. In the same year Señor Xavier Guzman, exploring the headwaters of the Caroni, near its confluence with the Aponguao, recovered some 75 grams. of gold from below the Pambatá-meru falls. This same prospector, who continued working in this region, found, in 1934, alluvial gold in the Quebrada Samaiga, but it is not recorded whether he found diamonds or not (1).

The first official information to reach Caracas regarding the discovery of diamonds in the Gran Sabana was conveyed in a letter from the Venezuelan Consul in Manaos (Brazil), who reported in October, 1935, that not only was gold being recovered illegally in Venezuelan territory and being smuggled and sold in Brazil but also some very fine diamond gemstones, which came from a place named "El Polaco" by the miners. In May, 1936, the Mine Warden for the El Dorado district reported that when he visited the Gran Sabana field he found 60 Brazilians, 4 Germans, 3 British West Indians, and 1 Roumanian working in a quebrada some 15 miles north of the border in Venezuelan territory. These reports probably passed unnoticed by the general public, for by July, 1939, there were only 50 miners working in the five diamondiferous creeks discovered up to that date. However, with the coming of war and the gradual reduction of operations on the gold mines, *plus* an increase in the demand for, and in the price of, diamonds, the number of miners continued to increase until by the middle of 1943 there were more than 1,000 employed in the Gran Sabana field. The number fluctuates somewhat with the dry and wet seasons, but has not fallen below 500 since the end of 1939.

Production.—The first production of diamonds from the Gran Sabana was recorded by the Government in 1940, following the report of the special exploratory commission in 1939. In that year the output was only 5,319 carats, but by 1942 it had reached 25,675 carats, valued at Bs. 633,800. The total production from 1940 to 1944 (inclusive), as officially recorded, was 91,419·69 carats. The estimated production from 1925 to 1939 is 17,580 carats for this field. However, a considerable amount of smuggling was carried on and buyers on the field have set this as high as 20% of the total production in some years, so that this would probably make the

Table 26

	Caracas Prices. Bs.	*Prices at Diggings.* Bs.	*Sterling Equivalent.* s. d.
Rice per kilogram. (2·20 lb.)	1·25	5·00	8 0
Black beans per kilogram.	1·00	5·00	8 0
Potatoes per kilogram.	1·00	6·00	9 8
Sugar per kilogram.	0·55	5·00	8 0
Cheese per kilogram.	1·75	11·00	17 8
Onions per kilogram.	0·60	10·00	16 0
Eggs/dozen	3·00	12·00	19 6
Coffee (ground)/kilogram.	2·00	10·00	16 0
Fowls each	4·00	20·00	32 0
Powdered milk/lb.	2·45	6·00	9 8

actual total production nearer 130,000 carats. By the end of the current year the production of the Gran Sabana field will have exceeded that of the Lower Caroni.

Climate and Health.—The climate on the open Sabana country is delightful, as the elevation ranges, from 4,600 ft. in the northern sector to about 3,000 ft. in the southern and it lies within a temperate zone. The annual mean temperature is 73·9° F. and the rainfall is light, ranging from 38 in. to 40 in. per annum, although spread over an average of 205 days per year. The rains are heavier in the southern part of the area than in the northern.

The health of the indigenous tribes is good and the few diseases amongst the population of the diamond diggings have been brought in from other areas.

Labour.—It is practically impossible to hire labour on the diggings, for every miner is busily engaged in looking for another Koh-i-noor, or even a second gemstone like "El Libertador," found in this field in 1942. The local Indians belong to two tribes—the Arekunas of the northern sector and the Taurepanes of the southern. They are willing to act as porters for a limited period, but generally are not prepared to do any kind of manual labour, of which in any case they have little or no experience. The average back load of an Indian porter is 60 lb., of which about 20 lb. will consist of personal belongings, food, etc. The indigenous population is about 1,100 and the total population of the Gran Sabana area is probably less than 3,000, or about one person for three square miles of territory.

Cost of Living at the Diggings.—Probably there has been no mining field in the Western Hemisphere so inaccessible as the Gran Sabana and the fact that all the supplies coming from Venezuelan territory have to be brought in by aeroplane, for at least the last stage of 192 miles, causes the cost of these goods at the mine to be extremely high. Road transport costs from Ciudad Bolivar to Tumeremo are also high and the storekeepers on the diggings feel they are entitled to somewhat more profit than the merchant, who enjoys all the comforts and luxury of city life.

Some idea of how the cost mounts up may be gauged from the following figures :—

Cost of freight from Ciudad Bolivar to Tumeremo by truck is about £28/ton.

Cost of transportation from Tumeremo to Santa Elena by aeroplane approximately £100/ton (Bs. 1·40/kg.).

From Santa Elena to the diggings—say, La Esperanza—by oxen or mules about £92/ton (Bs. 1·25/kg.).

Thus the minimum cost for transportation between Ciudad Bolivar and the diggings at the present time is equivalent to £220/ton.

As examples of food prices at the diggings in the Gran Sabana area the short list given in Table 26 may be of interest. As a result of these high costs the Government has made arrangements to start a co-operative scheme, which it is hoped will result in the miners obtaining essential foodstuffs at practically cost price.

Very little foodstuffs are produced in the region of Santa Elena, although there has been a slight increase in the area cultivated during the past six years. The only soil that is suitable for cultivation is that of the decomposed basic igneous rocks, on which grows thick bush, and there are not any extensive areas of level ground. Alcoholic drinks are not permitted to be sold on the diggings and police of the National Guard maintain order and act in place of a Civil Authority. Since the increase in transportation and food costs due to the war the miners in the Gran Sabana area have not been able to live on an income of less than Bs. 600 (£44 10s.) per mensem. This in itself is an

Fig. 11. La Faisca Camp, Surukun River.

indication of the richness of the diamondiferous alluvials of this area.

Topography and Drainage.—Nearly all the region west of the Karuai River is taken up by the indurated sandstone plateaux of Auyan-tepui, Chiman-tepui, and Akopan-tepui, which are flat topped, with their surfaces cut into blocks by fractures and joint systems. The plateau of Auyan-tepui covers a surface area of about 250 square miles and its average height above sea-level is 8,000 ft. The south face is a scarp with a height of about 2,000 ft. and this drop is broken by three separate benches, the lowest being connected to Akopan-tepui further south. This latter plateau is somewhat larger than Auyan-tepui and has a scarp about 3,300 ft. high.

The eastern part of the Gran Sabana is also flanked by high sandstone plateaux, extending south-east from Venamo to Roraima, with elevations varying from 5,000 ft. to 9,500 ft.

Between the western and eastern plateaux there are a number of smaller and lower mesetas, having a similar structure but not exceeding 4,000 ft. in height. The actual sabana area between these high plateaux consists of a gently-rolling open country at an elevation averaging about 3,000 ft. above sea-level.

The two main rivers—the Caroni and Carrao—flow roughly from east to west from their headwaters and with the high range of mountains extending from Roraima to Cerro Venamo encircle the Gran Sabana area. The other rivers have very irregular serpentinous courses, broken by numerous falls in the sandstone formation and all but the Kamarán are tributaries either of the Carrao or Caroni (Map No. 6).

Regional Geology.—Underlying the whole of the Gran Sabana are the rocks of the Archæan complex, which in this area consist of fine-grained red and grey porphyries. In the region of Santa Elena the former are visible, but near the border with Brazil the grey porphyries are more in evidence.

The sediments of the Roraima Series were deposited upon the peneplaned surface of the Archæan complex and the maximum thickness now exposed is about 8,000 ft. These sedimentary rocks consist of conglomerates, sandstones, and shales, with occasional thin beds of jasper, all of which have been intruded by gabbro and diabase. The oldest member of the series is a basal conglomerate, varying from grey to pink in colour and having a maximum thickness of about 33 ft. Above this lie the 8,000 ft. of interbedded sandstones, conglomerates, and shales.

Gabbros and diabases are intruded into the Roraima Series in the form of dykes, sills, and laccoliths, which often exhibit a chilled margin close to their contact with the sandstones. Later acid igneous dykes—such as, microgranites—are less common and these are found intruded into both the sediments and the basic igneous rocks.

The only other sedimentary deposits of the region are the thick deposits of sand and clay found in the present river courses and derived mainly from the Roraima formation. It is in these that the diamonds and a little gold are found.

The following are the known diamondiferous rivers in the Gran Sabana area (Map No. 6):

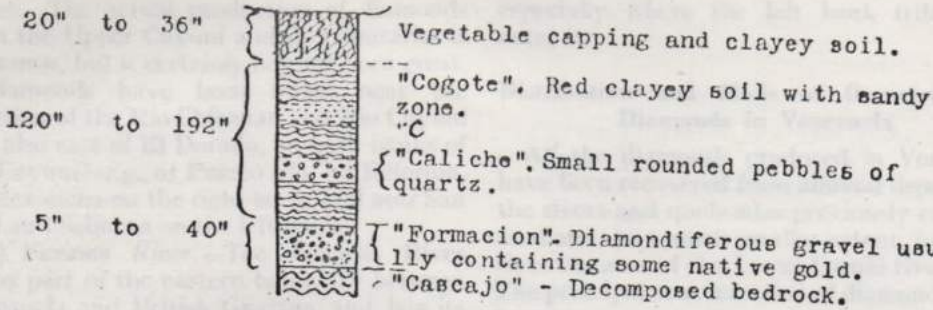


Fig. 12.

(i) Surukun and its tributaries—*viz*: The Quebradas El Polaco, La Esperanza, Galito, Santa Teresa, La Patria, Peña, Samaisó, La Faisca, San Mino, Maturin, and El Valle.

(ii) Rio Icabarú and its tributaries (Ikabarú).

(iii) Headwaters of the Rio Cata (Rio Kukenan), near Santa Ana, close to the boundary with Brazil.

(iv) Rio Aponguao.

(v) Rio Kukenan (Cuquenan).

Most of the work to date has been confined to the Surukun River basin and probably 95% of the total declared production has been derived from this river and its tributaries.

The alluvials near the headwaters of the Surukun River are shallow and for that reason the local miners have been able to work them by primitive means. If the overburden exceeds 20 ft. they rarely attempt to do any pitting. A typical section through the alluvial deposit is given in Fig. 12. The diamondiferous gravel, which contains a small amount of gold also, is locally called *la formación* and varies from 5 in. or 6 in. to as much as 40 in. thick, but the average is probably less than 24 in.

Characteristics of the Diamondiferous Alluvials

In the Gran Sabana field the miners have noticed that the thicker the *formación* the lower the values or concentration of diamonds and the thinner the *formación* the higher the concentration. It is also noteworthy that when the percentage of large stones or pebbles in the *formación* is abnormally high usually the value of diamonds recovered per cubic yard is correspondingly greater and the stones are above average in size.

The diamondiferous gravels consist from 75% to 80% of rounded quartz pebbles, ranging in size from 4 in. to $\frac{1}{4}$ in. diameter. The remainder of the *formación* consists of clayey material, ranging from 8% to 14%, and small amounts of fine sand.

The miners rarely work the old terraces because of the distance from the streams and the lower concentration of diamonds in these deposits. They use rather coarse-meshed

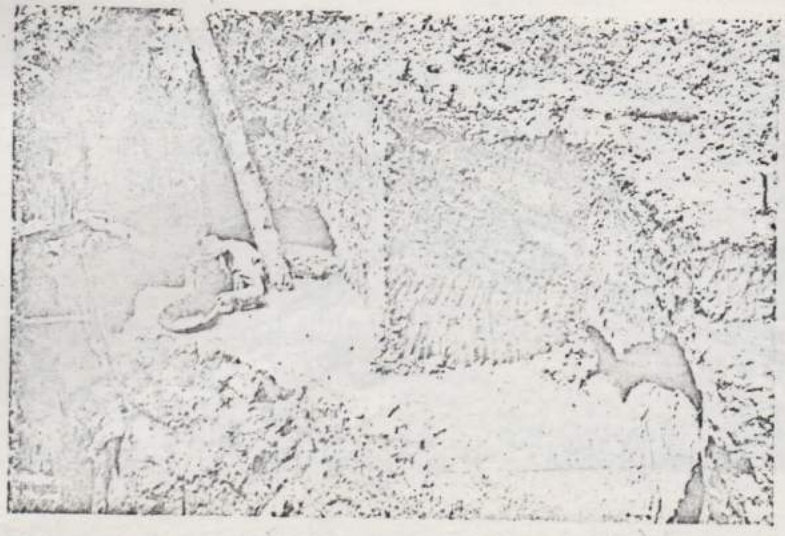


Fig. 13.—Diamond Washing in a "Barranco," Gran Sabana.

Fig. 14.—"Barranco," Gran Sabana—Surukun Field.

sieves and probably a high percentage of small stones—say, below 5 points or $\frac{1}{20}$ carat—are lost.

The Lower Caroni alluvial sands are generally much finer than those of the Gran Sabana deposits as might be expected.

Method of Working.—Since the mining regulations applied to these deposits are those pertaining to areas of free avail no miner, or group of miners, may work at any time an excavation greater than 10 metres square. The worker is also limited by law to the use of sluices, bateas, sieves, picks, bars, and shovels, as no power-driven machinery is permitted. Usually after selection of a site the group of miners begin operations by sinking a prospecting pit about 3 ft. in diameter to bed-rock, as seen in Fig. 13. They test the gravel cut in sinking and if the section exposed in the pit is of little value they then make four exploratory drifts—north, south, east, and west—and extend them as far as they can penetrate with safety. The material obtained from these drives is also treated and if the results from these are also unsatisfactory then this site is abandoned and another selected. However, should the preliminary work expose a payable concentration of diamonds then the miners proceed to enlarge the excavation to the maximum size permitted. The overburden may be deposted close to the excavation if the ground is "free"—that is, unclaimed—and in that event the area covered by this overburden may be mined by whoever is the first to tunnel under it from adjoining pits—called locally "*barrancos*" (Fig. 14). This, however, is not legal and oftentimes leads to serious disputes amongst adjacent groups of miners. Sometimes the ground is wet and loose and requires support. The miners cut round poles from the surrounding bush and hold the ground as shown in Fig. 15.

When the *formación* has been exposed it is removed in gasoline tins or sacks and, if the nearest stream is not more than 250 to 300 ft. away, it is washed there. If the distance is greater than this then the gravel is washed in the excavation (Fig. 13).

When the gravel is taken to the stream in sacks or tins, containing 75 lb. to 80 lb., it is dumped beside a long-tom made on the spot. Material less than $\frac{1}{2}$-in. diameter passes through the coarse screen made out of mild-steel plate and flows down the lower half of the tom which contains a number of riffles. These usually have mercury on the upper side to catch the gold that may be associated with the diamonds. The heavier fine material and the mineral concentrates are transferred to a brass-wire sieve, about 24 in. in diameter, and again washed in the stream until finally only the diamonds and associated heavy minerals are left in the centre. This residue is then carefully scanned and any diamonds that may be there are picked out by hand.

The Cuyuni Basin

This river basin has already been described in the article on the gold mining regions of the State of Bolivar.[1] Diamonds have been found in or near the following rivers and streams in this area: (*a*) Upper Cuyuni and (*b*) Venamo River and its tributaries.

(*a*) *Cuyuni River.*—This river has its source in the Sierra de Lema, which is capped by conglomerates and sandstones of the Roraima

[1] The Mining Magazine, Nov., Dec., 1945.

Series. The actual production of diamonds from the Upper Cuyuni and its tributaries is unknown, but it certainly has not been great.

Diamonds have been found near the junction of the Rio Chicanan and Rio Cuyuni and also east of El Dorado, on both banks of the Cuyuni—*e.g.*, at Puerto Pio, La Reforma, La Revancha on the right bank, and near San José and Sebucan on the left bank.

(*b*) *Venamo River.*—The Venamo River forms part of the eastern boundary between Venezuela and British Guaiana and has its headwaters in the Cerro Venamo. The upper part of this river, above the Kura falls and all the country east of it, consists of sandstones of the Roraima Series with numerous intrusions of diabase in the form of sills and dykes. Most of the diamonds in this area—called locally Araguay—have come from the left bank of the Venamo, near La Lira, El Tesoro, etc.

Mazaruni River Basin

Kamarán River.—This river, a tributary of the Mazaruni, in British Guiana, rises in the Gran Sabana, at the foot of a range of hills separating the basin of the Aponguao from that of the Kamarán. The latter has many tributaries near its headwaters, mostly coursing south-east from their source in the Lomas Uaicabopai. A few years ago a number of concessions was taken out on these rivers, but there is no record that any systematic work was done on them. The same applies to the Upper Cuyuni and Upper Venamo rivers.

The river Kamarán, although the most inaccessible of the three (Cuyuni, Venamo, and Kamarán), appears to offer the best prospects, especially where the left bank tributaries enter it.

Distribution and Mode of Occurrence of Diamonds in Venezuela

All the diamonds produced in Venezuela have been recovered from alluvial deposits in the rivers and quebradas previously enumerated and, to a much smaller extent, from old river terraces of the Lower Caroni river area. The principal concentration of diamonds seem to occur :—

(i) Near the headwaters of streams whose source is close to the scarps of the Roraima formation ;

(ii) near the junction of streams ;

(iii) behind natural riffles in the stream beds due to the intrusions of dykes, quartz veins, depressions, or faults ;

(iv) in old river terraces, or,

(v) at, or near, the foot of falls.

Practically all the diamondiferous rivers have an extremely small gradient and this is especially true in the case of the Paragua, Pao, Aponguao, and Kukenán rivers.

Minerals Accompanying the Diamonds.—The mineral satellites of the diamond in the Lower Caroni are relatively few and include limonite concretions, rutile, and what looks like small carbonados—called by the miners "carbon" ; magnetite and hæmatite are also fairly common. In the Gran Sabana area, in addition to gold, the heavy minerals found in the diamondiferous alluvials include carbonados (?), called by the Surukun miners "punta de lapiz," and rutile. Rounded pebbles of red jasper and fragments of quartz crystals are common, whilst small crystals

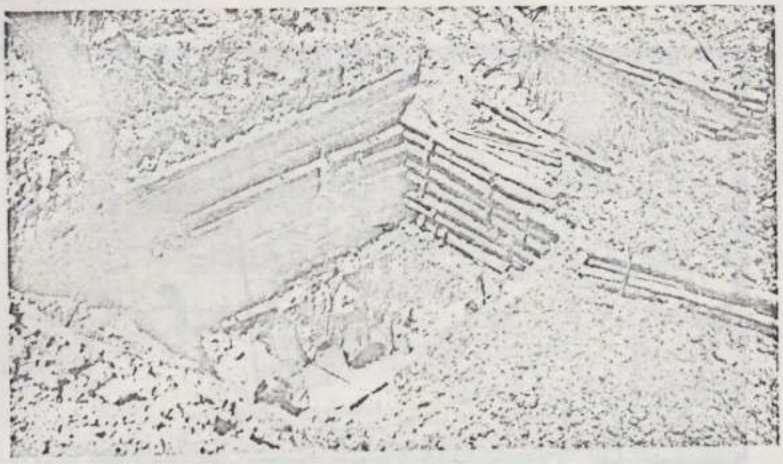


Fig. 15.—Timbered Excavation, La Faisca.

Table 27

Year.	1st District, Carats.	2nd District, Carats.	3rd District, Carats.	Totals. Carats.	Value Bs.	Average Value. Bs./Carat.
1940 . .	9,205·47	—	5,319·63	14,525·10	512,741	35·36
1941 . .	6,467·46	—	22,949·46	29,416·92	1,491,875	50·71
1942 . .	8,372·58	—	25,675·37	34,047·95	1,905,543	55·97
1943 . .	3,385·06	—	19,460·70	22,845·76	1,395,156	61·06
1944 . .	5,128·15	217·30	16,691·62	22,037·07	1,357,372	61·59

1st Mining District includes the Districts of Cedeño, Heres, Piar, and Sucre in the State of Bolivar, the Federal Territory of Amazonas, and the Federal Territory of Delta Amacuro.

2nd Mining District. The District of Roscio, State of Bolivar.

3rd Mining District. The Gran Sabana area, in the State of Bolivar.

of zircon and ilmenite occur in much smaller quantities.

Characteristics of Diamonds.—Most of the diamonds found are octahedrons, but dodecahedrons probably range from 12% to 15%. The Gran Sabana stones are on the average of better quality and larger than those recovered from the terraces of the Lower Caroni. One lot of 8,396 carats purchased contained 6,159 carats of gemstones and 2,237 carats of industrials. This shows about 73% of the total to be gemstones and corresponds to the average as reported by some of the buyers in the field. In one lot of 17,921 gemstones 9·92% were from 1 to 3 carats and the smalls totalled 39·98%. Stones of 3 to 6 carats are not uncommon and those between $\frac{1}{4}$ and $\frac{1}{2}$ carat account for 40% to 50% of the total production.

About 25% of the Surukun gems have some defect and the average of all the stones purchased run about 4 to the carat. However, it remains to be proved that the stones in the present bed of the Caroni River—that is, the deep alluvials—are smaller than those of the Surukun field.

The diamonds have very few macles, but a greater proportion of the Lower Caroni stones have broken edges than those of the Gran Sabana field. The gemstones are of good quality, although some have a ferruginous coating which can easily be removed by washing in an acid solution. About one-half of the gemstones recovered are completely translucent and have no inclusions, whilst some 25% to 30% have a ferruginous or greenish coating. The remainder have a milky white film or have yellow to brown shades of colour.

The largest stone yet purchased from the Gran Sabana field is " El Libertador " of 155 carats and was found by three miners who started to rework an abandoned " barranco " and encountered this stone within six inches of the face of a pillar left by the former workers !

Diamond Prices and Values.—The Foreign Economic Administration of the United States Government had a diamond buyer in Caracas until January 31, 1945, and all Venezuelan production was supposed to be sold to this agency. In the field were a number of registered diamond buyers who usually paid prices from 10% to 20% below those of the Government agency. At the end of 1944 the maximum prices paid by the F.E.A. buyer were as follows :—

3·0 carats, $85 U.S.	0·75 carat, $40 U.S.
2·5 carats, $75 U.S.	0·50 carat, $34 U.S.
2·0 carats, $65 U.S.	0·25 carat, $18 U.S.
1·5 carats, $60 U.S.	Smalls, $18 U.S.
1·0 carats, $54 U.S.	

Table 27 shows the registered production of diamonds from the three mining districts and their estimated value for taxation.

Diamond Content of Gravels.—No reliable figure of the value of any diamondiferous alluvial in Venezuela has yet been published and in fact only two relatively small areas of terrace gravels in the Lower Caroni area have been systematically sampled by competent engineers employed by concession owners. However, it is known that in each of these cases the average values were considered very satisfactory and it was recommended that these deposits should be worked as soon as the specially designed plant for treating these gravels could be obtained.

Diamond Production in the Western Hemisphere

At the present time only three countries are producing diamonds in the Western Hemisphere—*viz.*, Brazil, British Guiana, and Venezuela. Table 28 shows the declared diamond production for each of these countries since 1937, in carats. The production of diamonds in the Western Hemisphere during the period 1941–1943 (inclusive) has averaged only slightly more than 4% of the total world output, as shown in Table 29.

Table 28

Year.	Brazil.	British Guiana.	Venezuela.
1937	?	35,039	13,242
1938	350,000*	31,691	13,600
1939	350,000*	32,491	7,969
1940	325,000	26,764*	14,525
1941	325,000	27,000*	29,417
1942	300,000	27,000*	34,048
1943	275,000*	27,000*	22,846**

* Estimated. ** Low output due to floods.

All the diamonds recorded as produced in Venezuela have either been sold to North American firms or have been retained in Venezuela by local buyers and diamond cutters.

Table 29

Year.	World Output.	Western Hemisphere Output.	Western Hemisphere as % of World Output.
	Carats.	Carats.	
1941	9,127,694	381,417	4·18
1942	9,272,356	361,048	3·89
1943	8,140,200	324,846	3·99

Since many of the buyers in Venezuela are Europeans some of the post-war production may find its way to the Low Countries cutting industry as the gemstones are of high quality and can compete with the African product.

Gold in the Diamondiferous Alluvials

The amount of gold in the diamondiferous gravels of the Surukun field varies considerably, but there is no reliable figure available of the average value recovered per cubic yard of alluvials treated. The gold output reported to the Government from this field in 1940 and 1944 was 28,006 grams. and 2,554 grams. respectively. An appreciable amount was probably disposed of to merchants and others trading with Brazil and was not recorded.

Future Development of the Diamond Deposits

Contrary to general belief the Government of Venezuela does not prohibit, or seek to prevent, the working of diamond deposits. This impression may have been created to some extent by the fact that since 1936 the chief diamondiferous areas have been made Reserved Zones (Zonas Reservadas) (Map No. 3).[1] This was done to protect national interests, to provide for closer control, and to prevent speculation. It means that these diamondiferous areas may not be denounced like most other mineral deposits but are subject to exploration and exploitation by special contracts and to the regulations provided for in Book 3 of the Law of Mines.

Early this year (1945) the Government granted the first exclusive exploration permit in the Gran Sabana (Surukun) area to the Compañia Anonima Minera y Comercio (C.A.M.Y.C.) giving them the sole right to explore and sample an area of 40,000 hectares. At the end of the contract period the company is bound to decide what areas it will select for exploitation, if any, and the total must not exceed 50% of the 40,000 hectares granted for exploration. The contract conditions are not onerous; the area granted is large and is situated close to the present diggings on the Surukun river. The diamonds recovered in sampling should pay for a considerable part of the cost of exploration.

These diamondiferous alluvials are found over a large area and those being worked now are undoubtedly rich, but unfortunately the present methods of exploitation are hap-

[1] *loc. cit.*

Fig. 16.—Washing Gravel in Long Toms, Surukun Field.

hazard and wasteful. To develop and exploit them systematically will require larger capital resources than local interests can supply and good technical direction by mining men experienced in the working of diamondiferous alluvials.

Exploitation of the deposits of the Lower Caroni River bed requires special study as an engineering problem but it is not insurmountable and here again aerial photographs should be a great aid to the field engineer. The river bed has a hyper concentration of diamonds, but the terraces and flood plains too have valuable deposits and these require more careful sampling, as the values per cubic yard are very much lower and the gravels under a heavy overburden make prospection expensive. What the Upper Paragua River, and others, that have their source in the basal conglomerate of the Roraima Series, may contain remains to be proved. If the diamonds come from the basal conglomerate of this formation, as there is good reason to believe, then Venezuela one day may well become much more widely known as a diamond producer.

Undeveloped Areas of the Venezuelan Guayana

Included under this heading are :—

(i) The Caura-Cuchivero Region (State of Bolivar).

(ii) The Upper Orinoco Basin (Amazonas Territory).

These are in the western portion of the Venezuelan Guayana shield between 64° W. Long. and 68° W. Long. and bounded on the north by the Orinoco river and on the south by the Pacaraima mountains on the frontier with Brazil. Gold has been found in the area between the Caura and Cuchivero rivers in the State of Bolivar and also near Cerro Yapacana in the Federal Territory of Amazonas.

Diamonds have been reportedly found by local Indians close to Esmeralda, on the Orinoco river, south of Cerro Duida. Hitherto these areas have been considered too remote and too sparsely populated to warrant consideration as possible new mining fields. However, the time is fast coming when these areas will be just as accessible as the established mining camps and a favourable change in the price of gold, or some improvement in the Venezuelan exchange situation, may well result in more attention being directed to this little known part of the Guayana Shield.

Introduction.—The Caura and Cuchivero river basins were referred to in the first article of this series. The former occupies part of the District of Sucre and the latter lies within the District of Cedeño, both in the State of Bolivar.

The region reported to contain auriferous deposits lies between these two rivers and covers an area of 6,500 square miles, bounded on the north by the Orinoco and on the south by the 6° 30′ parallel of N. Latitude.

Communications.—The only means of entering this region is by motor launch, river steamer, and dug-out canoe. The usual point of departure is Ciudad Bolivar, where an expedition can be equipped and a boat hired with a pilot to go as far up the Caura River as La Mura rapids, which may be considered the southern limit of the Lower Caura.

Climate and Health.—The climate and weather of the Lower and Upper Caura areas are quite different. In the former area there is a distinct dry season lasting from early November to the end of April. The driest months are January, February, and March and the wettest are July and August.

In the Upper Caura there is a season of heavy rains lasting from April to September, followed by a period of light rains from October to March. This area is one of heavy rain forest and high humidity and there are no habited places, other than the temporary camps of small local Indian tribes—such as, those of the Macuses, Guahibos, and Maquiritaris.

A cool breeze prevails during the dry season except during the middle of the day from about 10 a.m. to 3 p.m. In the Lower and Middle Caura there are very few mosquitoes or bugs during the dry season, but in the wet season a mosquito net is required. The inhabitants of the few small settlements close to the river in the Lower Caura suffer from malaria fever, but to the west, in the hilly country between the Caura and the Cuchivero, the region seems to be much more healthy. Apart from malaria the local people suffer from ankylostomiasis and anæmia, but foreign engineers and prospectors with reasonable care should enjoy good health.

Labour.—The Caura basin (District of Sucre) has only 3,471 inhabitants in 34,745 square kilometres of territory and these are mostly found in the villages and settlements of the Lower Caura. The region between the Lower Cuchivero and the Lower Caura is more populated and the whole of the Cedeño District has a population of 7,949. These people are only seasonally employed and

usually it is not difficult to obtain casual labour.

The Caura Basin

Geological Notes.—No geological work has yet been done in this area, but samples have been brought to Caracas of the granite and granite-gneiss which are the oldest rocks here as in other parts of the State of Bolivar. Quartz veins are fairly common in the granites and these may be the source of the gold reported to have been found in the alluvials. However, it is probable that on the hills—such as, the Cerro Matos, Surapure, Monte Oscuro, etc.—between the Caura and the Cuchivero rivers there are remnants of the Roraima formation, in which case the basal conglomerates will no doubt have yielded a certain amount of fine gold. Samples of basic igneous rocks have been brought to Caracas from the Upper Caura, but whether they are from dykes or a greenstone complex like that of the Callao area is not yet known.

The Lower Caura Area

The mouth of the Caura River varies from 320 yd. to a quarter of a mile wide, depending on the time of the year, for there is a maximum rise in the river level of about 50 ft. Usually the river is at its lowest level in March and at its highest in August. From its mouth up to Las Culatas the river is bordered by high banks covered with "salado" and "Yagrumo" trees, which form a narrow belt hiding the sabana country beyond and where clearings have been made in the wooded belt the cucurito palm is commonly seen.

To the West of Las Culatas beyond the tree belt the sabana is characterized by a low undulating surface broken by flat outcrops of peneplaned granite-gneiss and granite. Further up the Caura, less than one mile from its right bank, is Maripa—the capital of Sucre District, in the State of Bolivar. Here is flat, open, sabana country quite different to that between the mouth of the Sipao River and the entrance to the Caura. The inhabitants are mostly negroes, said to be descendants of slave labour imported in early Colonial times.

Continuing up the Caura from Maripa the village of Suapure is reached in about two hours and here the river widens and turns sharply to the east and there is a marked change in the topography and vegetation. The sabana type of country gives way to densely-wooded hills and, to the west, mountain ranges rising to over 3,000 ft. in height. The tops of these hills are flat and appear from a distance to be capped with sandstone or some other sedimentary formation.

It is possible to proceed up the Caura as far as the Salto de Para, which consists of a succession of five falls making it impassable. However, any exploratory work in the near future would probably be confined to the hilly and well-watered country between the Caura and Cuchivero rivers, as the east and west limits, and between the Orinoco River and Rio Nichare as the northern and southern limits respectively. These limits enclose an area of some 4,000 square miles in which gold has been found, but no detailed information is available as to the nature and extent of these auriferous deposits. At the present time several hundreds of people are seasonally employed collecting tonka beans and it would not be difficult to work in this area.

No reports are available of any prospecting work done in the Caura basin, although some is believed to have been done within the past ten years by local people. This area has the advantage of accessibility and sufficient labour but definite information of gold deposits is lacking.

The Upper Orinoco Basin (Amazonas Territory)

Upper Orinoco Region

This region lies within the Territory of Amazonas and is the least known of the Venezuelan Guayana shield area and will probably be the last to be developed because of its remoteness and lack of population. However, alluvial gold definitely has been found in several places and it is also reported that diamonds have been discovered near the headwaters of some of the rivers by local Indians.

Communications.—The area may be entered either by river-boat or by aeroplane. There is a regular plane service from Caracas to Puerto Ayacucho, but preparations for any extended field work in this area would have to be made in Ciudad Bolivar. From Puerto Ayacucho, capital of the Amazonas Territory, all supplies would have to be transported by the portage road past the Atures and Maipures Rapids to Sanariapo. Here passengers and supplies would re-embark and continue upstream to San Fernando de Atabapo, which is the trading centre for the

Fig. 17.—Indians on the Upper Orinoco.

Upper Orinoco region. Above this town there are only a small number of scattered settlements where very few, if any, supplies are obtainable (Map No. 3). San Fernando de Atabapo is situated at the junction of three rivers—*viz.*, the Orinoco, Atabapo, and Guaviare—and is built on a granite outcrop some 370 ft. above sea-level. The Rio Atabapo, a so-called " black " river, has red-coloured water in which there are few fish or crocodiles and mosquitoes and sandflies are not common near it, but proceeding up the Orinoco to its junction with the Ventuari river the water is clear and the ferocious caribe and other fish are plentiful. At this junction are the rapids of Santa Barbara and it is necessary to have a good pilot for work in this area. The journey from San Fernando de Atabapo to Cerro Yapacana, which is in the best known auriferous area, requires about two days in a small launch. The Cerro Yapacana is a very prominent landmark and can be seen long before it is reached.

Climate and Health.—The rainfall in this area is somewhat heavier than in the eastern part of the Venezuelan Guayana shield and ranges from 70 in. to 90 in. per annum. South of San Fernando and Yapacana the heavy rain forest begins. The " dry " season is short and extends from December to March when the rainfall is usually less than 5 in. per mensem. Humidity is high and averages about 86° whilst the mean monthly temperature ranges from 70° to 88° F. The climate is not unpleasant because the nights are cool and there are many cloudy days which help to alleviate the intensity of the sun's rays.

The population in this area does not exceed 3,800 and about 70% of this total is located in the few towns and settlements close to the principal rivers. The native Indian tribes are spread along the numerous rivers in small settlements and include Maquiritares, Banibas, and Guahibos. (See Fig. 17.) The health of the permanent dwellers in this area is generally poor, mainly on account of their disregard for even elementary sanitary rules, but the general conditions of the area are not unfavourable to a healthy existence. Malaria is endemic but this is largely due to the lack of anti-malarial measures and medicines. Ankylostomiasis, beri-beri, pellagra, and dysentery are common amongst the natives but other diseases—such as, yellow fever and typhoid—are not known in this region. One pest, which is more annoying than harmful, is the " jejen " or black fly that is active during all the hours of daylight. This insect is less prevalent in the dry season and is not so active when a strong breeze is blowing on the " black " water rivers.

Gold Deposits.—In 1936 the first authentic report of gold in the Federal Territory of Amazonas was made public and the Government made provision for the registration of denouncements etc. in that area. Subsequently some prospecting and sampling was done in the region of Cerro Yapacana which lies within the Upper Orinoco basin at 3° 30′ N. Lat. and 66° 55′ W. Long.

Geology.—The principal rock outcropping in this region is granite, which is intruded by numerous dykes of younger granite and basic igneous rocks. These granite intrusions are often several kilometres wide as in the Ventuari delta. The granites range from muscovite granite, with much coarse felspar, to hornblende granite. There are many pegmatite dykes and small quartz veins are common in the granite. Resting unconformably on the older granites and granite-gneiss are high sandstone plateaux such as the Cerros Yapacana and Duida. The latter is 8,100 ft. high and the former slightly over 4,000 ft. above sea-level. The base of the sedimentary series is a conglomerate and above this a coarse sandstone, which grades into a finer sandstone towards the summit of the plateau.

Gold has been found in alluvial deposits in all the streams of the Yapacana area, but only the headwaters have been systematically sampled. The average value of these shallow alluvials is not high enough to repay working by primitive means and the yardage is too small for mechanical equipment to be used. These alluvials consist of a coarse sand and gravel containing a considerable number of boulders and the auriferous zone is not more than 33 in. thick in the area sampled. The overburden is light, rarely more than 40 in. thick, and consists of a sandy clay. However, the sampling of the deeper alluvials further downstream may well disclose much bigger areas of alluvial sands which might be of commercial importance even if the values were somewhat lower than those obtained near the headwaters.

The gold apparently originates from the sandstones and conglomerates of the Roraima Series, as well as from the numerous small quartz veins in the granite-gneiss. Generally these quartz veins contain gold values averaging less than 2 dwt./ton, although much higher values have been reported from other places in this Territory, but no qualified engineer has yet examined these occurrences.

Gold and diamonds are also reported to have been found by local Indians in the streams near Esmeralda, at the foot of Cerro Duida, but these reports have not been verified.

To sum up it can be said that in the future the Amazonas Territory may prove to have valuable deposits of gold and diamonds, but its inaccessibility and lack of populated areas will probably retard exploration and rapid development. The Roraima Series of sediments cover a considerable part of the area and wherever the basal conglomerate is present there is the possibility of finding commercial deposits of gold and diamonds in the river beds similar to those of the Gran Sabana area. The author has to thank his friends Victor Lopez and Carlos Freeman for some of the photos used to illustrate this article.

This article concludes the series on the Venezuelan Guayana, which covers an area more than three times as large as England. The mineral resources are great and in the future some of these will be developed. How soon this will be depends on several factors already mentioned, but none of these is sufficient to prevent exploration and exploitation at the present time of a few of the most favourably situated deposits.

The potential investor can count on the assistance of the Government and especially of the officials of the Ministry of National Development (Ministerio de Fomento) in all matters relating to the development of the mining industry.

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Mathematics for Industry

During the War mathematics have become increasingly harnessed to the needs of industry and research. To assist industry and Ministries the Department of Scientific and Industrial Research has set up a Mathematics Division in the National Physical Laboratory.

Of recent years there has been considerable development in mechanical computing and it is to undertake this work for industrial concerns as well as Government Departments that the Mathematics Division has been set up. The Division is at present organized in three sections, dealing respectively with computing, statistics, and the development of calculating machines. The staff of the Division will also be available for consultation in the field of applied mathematics, particularly on those aspects allied to industrial research.