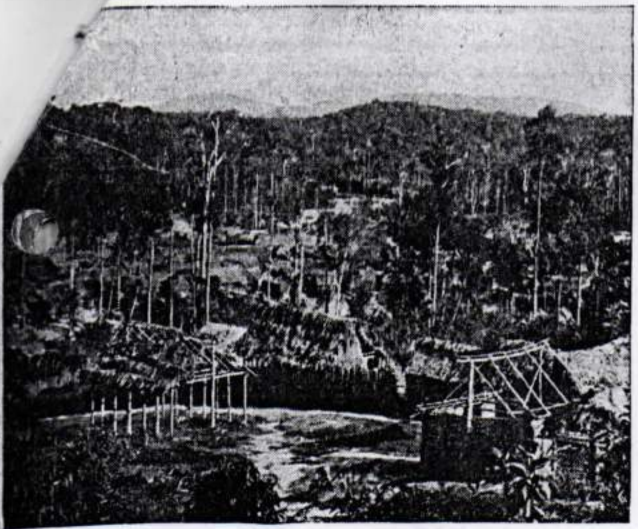

FIG. 1. DIAMOND DIGGINGS in alluvial deposits at La Faisca, Surukun Valley, Gran Sabana.

FIG. 2. WORKING DIAMONDIFEROUS GRAVEL at Quebrada El Polaco, Gran Sabana.

DAVEY, 1948

The Diamond Fields of Venezuela

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LITTLE INFORMATION has been published about the occurrence of diamonds in Venezuela although discoveries have been made over a w[illegible] area, especially during the past decade. Current production is small, but it is believed that present exploration and prospecting work will lead to a greater appreciation of the potential value of Venezuela as a source of gems of industrial stones.

Since 1946 considerable North American Capital has been employed in large-scale systematic examination of diamondiferous alluvials and if these pioneering companies are successful, much greater activity is expected to result in the region known locally as the "Venezuelan Guiana."

Location and History

The known diamond fields are all located within the State of Bolivar which has a total area of 91,-487 square miles and a population of 112,522 including some 18,000 Indians. Reports have also been received of diamondiferous alluvials in the Amazonas Territory which covers a total area of 67,558 square miles and has a population of 47,128, including about 43,400 Indians, but so far as is officially known, no mining has been done in this area.

[illegible] first sale of diamonds in Venezuela was recorded in 1912 at Paviche (lower Caroni River) but there is good reason to believe that diamonds were produced in this region, on a small scale, as early as 1887. From 1924 to 1927 it became more widely known that the lower reaches of the Rio Caroni were diamondiferous and numerous concessions were granted to Venezuelans and to foreigners. Many were obtained by promoters for purely speculative purposes. The owners in most cases hoped to sell their concessions to late-comers at a high price and leave the engineering problems and the expense of systematic sampling to others. However, the few concessionaires who worked their properties did well until technical difficulties arose which, with limited financial resources, they were unable to overcome. Consequently many local concessionaires, who were also small merchants, set up stores on their properties and threw their concessions open on condition that the gems recovered should be sold to them and all supplies and food should be purchased from their stores.

During 1925 the first white settler in the then completely unknown territory of the Gran Sabana discovered diamonds in the alluvial deposits of several tributaries of the Caroni River near its headwaters. These streams are close to the Brazilian border and the news of the discovery of diamonds first spread to Brazil and British Guiana because at that time there was no means of communication between this isolated part of Venezuela and the rest of the country. The first intimation of this discovery to be received by the Venezuelan Government in Caracas, the capital, was conveyed in a letter from the Venezuelan consul at Manaos, Brazil, who reported in October 1935 that gold and diamonds were being mined in Venezuelan territory and smuggled into Brazil. An investigation revealed that 68 miners, all foreigners, were at work some 15 miles inside the Venezuelan border. In 1939 there were only 50 miners at work in the Gran Sabana but by June 1943 the number was about 1,000. Since then the total has fluctuated considerably, depending largely on the length of the dry season and the amount of rainfall, but has not fallen below 300.

Although diamonds have been produced in small quantities on the lower Caroni River for some 60 years, official records of the production from this area were not kept until 1937 and those for the Gran Sabana were begun in 1940. The estimated production from the latter region for the period 1925 to 1937 is based on various unofficial reports and information collected by the writer. The figures of the total annual output of diamonds from 1940 to 1946 have been supplied by the Department of Mines, Ministerio de Fomento, Caracas.

The Diamond Fields

The areas from which diamonds are produced at the present time are the following:

1. Lower Rio Caroni and some of its tributaries.

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Production of Diamonds in Venezuela

Year	Lower Caroni River & Other Areas	Gran Sabana Area	Total Output, Carats
Up to 1937	73,000 (x)	11,500 (x)	84,500 (x)
1937	13,242	1,500 (x)	14,742 (x)
1938	13,600	2,000 (x)	15,600 (x)
1939	7,969	2,580 (x)	10,569 (x)
1940	9,801	4,724	14,525
1941	5,549	23,868	29,417
1942	8,373	25,675	34,048
1943	3,385	19,461	22,846
1944	5,345	16,692	22,037
1945	2,541	10,228	12,769
1946	?	?	20,912

(x) Estimated.

Stratigraphic Column

Formation	Description	Age
Alluvium	Recent river deposits, flood plains and white sands. (The latter are not known south of 7°N Latitude).	Quaternary
Roraima series	Cross-bedded, ferruginous sandstones and conglomeratic-sandstones, shales, quartzites, jasper and a basal conglomerate all intruded by basic igneous dikes.	Trias (?)
Imataca series	Ferruginous-quartzites intruded by granite and basic igneous dikes, especially norites.	Early Paleozoic (?)
La Pastora series	Volcanic Tuffs, andesites, jaspers, calcareous-schist, hornblende schist and mica schists.	Pre-Cambrian
Archean complex	Granite gneisses and schists	Pre-Cambrian

2. Upper Rio Caroni and some of its tributaries.
3. Lower Rio Paragua and some of its tributaries.
4. Rio Cuyuni and some of its tributaries.
5. Rio Kamaran headwaters.

Lower Rio Caroni—This area includes the whole of the Caroni River between the falls near its mouth and the junction with the Rio Carrao, a right-bank tributary. The principal diamondiferous tributaries include: the Rios Pao, Santa Barbara and La Cebolla, all left-bank feeders of the Caroni River and covering an area of about 1,000 square miles.

The village of San Pedro de las Bocas is the center of all the diamond workings in this area. There is a big influx of miners here during the dry season (November to April) when the rivers are low.

Upper Rio Caroni—Near its headwaters the Rio Caroni splits into many tributary streams and loses its identity under this name. The large diamondiferous area, covering some 10,000 square miles and known as "La Gran Sabana," is bounded on the north by the Rio Carrao, on the south by the Sierra Pacaraima, on the west by the Rio Caroni and on the east by the mountainous chain forming the boundary between Venezuela and British Guiana. All the rivers in this area are tributaries of either the Rio Caroni or the Rio Carrao. The chief diamondiferous streams are the Rios Surukun, Kukenan, Ikabaru and Aponguao.

Most of the mining work at present is being done along the course of the first two streams mentioned and in their numerous small tributaries. The village of Santa Elena is the headquarters of these mining camps, or "diggings," and the favorite resort of local miners every week end. They come in to participate in various gambling games, for cockfights, or the purchase of hard liquor, none of which is permitted on the actual "diggings."

Lower Rio Paragua—The Rio Paragua for a distance of some 30 miles between the village of San Pedro de las Bocas and the small settlement of La Paragua on its south bank has long been known to be diamondiferous. The mining work done in this area has been limited owing to the considerable depth of water in some sections and because of rapids in others. La Paragua is the center of all diamond mining within a radius of 10 or 12 miles and supplies are brought in by truck over an unsurveyed dirt road from Ciudad Bolivar, the capital of the State of Bolivar, some 140 miles distant.

Rio Cuyuni—This river, which has its source in the north flank of the Sierra de Lema bordering the Gran Sabana, flows northwards to El Dorado where it turns at right angles and continues for some 35 miles to the east before crossing the international boundary into British Guiana, where it eventually joins the Mazaruni River. Diamonds have been found near its headwaters and on the south bank of this river opposite the village of El Dorado as well as to the east of it. The chief south bank tributary is the Rio Venamo which for several miles forms the boundary between Venezuelan and British Guianan territory. At El Dorado, which is the center of the present limited mining activity in this area, the main highway from Ciudad Bolivar into the interior terminates.

Rio Kamaran—This is the most inaccessible and least known of the diamond fields and the river Kamaran, which rises in the eastern flank of the Gran Sabana plateau, flows eastwards into British Guiana and joins the Mazaruni River. A number of small tributary streams near its headwaters have been proven to be diamondiferous.

Other Potential Areas

The areas already listed are those in which diamondiferous alluvials are being worked, but there are several other places where diamonds have been found, including

1. Upper Rio Paragua and some of its tributaries.
2. Upper Rio Ventuari, a tributary of the upper Rio Orinoco.
3. Upper Rio Orinoco above its junction with the Casiquiare.

The first lies within the State of Bolivar but the other two are in the little-known Amazonas Territory.

It is evident that diamonds occur over a very extensive area in Venezuelan Guiana, and future prospecting may well prove it to be much larger than is now generally believed.

Geology

Practically all Venezuelan territory south of the Rio Orinoco forms part of the Guiana shield which extends into Brazil and British Guiana. In the State of Bolivar and in the Amazonas Territory the oldest rocks are granite gneiss, hornblende gneiss and schists of Archean age. This basement complex has a fairly level, peneplaned surface on which lie extensive remnants of thick sedimentary deposits of much younger age. (See stratigraphic column on page 76.)

In the greater part of the Guayana shield the metamorphic rocks of Archean age have been intruded by granites, pegmatites, aplites, gabbros, diabases, porphyries and aplites but in the southeast sector, in which lies the Gran Sabana, the basement rocks are mainly red and grey porphyries, and all the basic igneous intrusives are younger than the sediments of the Roraima formation. No fossils have yet been found anywhere in Venezuelan territory south of the Rio Orinoco and the ages of the sedimentary and intrusive rocks cannot be determined, except relatively.

In the diamondiferous areas of the Gran Sabana only the sediments of the Roraima series are found above the Archean complex and they attain a maximum thickness of about 8,000 ft. This formation is the same as that named the Kaieteur series in the diamondiferous region of British Guiana.

Lying directly upon the peneplaned surface of the porphyries the Roraima series of sediments consists of a basal conglomerate, some 30 ft. thick, ferruginous sandstones, coarse conglomerates, shales and thin beds of green and red jasper, all of which have been intruded by dikes or sills of gabbro and diabase. Acid dikes are much less common and consist principally of micro-granites and quartz diorites. These are the youngest intrusives.

The diamond deposits are mainly found in the sands and gravels of the numerous streams and rivers having their headwaters in the Roraima formation. So far no diamonds have been found "in situ" in any igneous rock in Venezuelan Guiana.

It is believed that the diamonds found in the geologically recent alluvial deposits of existing rivers have been derived from the conglomerates of the Roraima formation. Early geological reports suggested that only the basal conglomerate was diamondiferous, but more recent work over a larger area has shown that other conglomerates at higher levels in the Roraima series are also diamondiferous. This is an important factor in any consideration of the potential value of this region as a future diamond producer on a big scale. Another even more important factor is, in the writer's opinion, the extent of the original area covered by the diamondiferous conglomerates of the Roraima series. Remnants of these sediments are found over the whole of Venezuelan Guiana south of 6° N latitude, a region which although it has been penetrated, has not yet been surveyed. The geology of only a very small part of this vast area has been studied. It is of considerable economic interest that the former geographical limits of the basal conglomerate should be determined as far as possible.

There is reason to believe that wherever rivers and streams have cut through these conglomerates, diamondiferous alluvials may be found somewhere along their course. These deposits may not be located in the present bed of the river throughout its course but may exist in old alluvial terraces within the area drained by it. The importance of these two features has not yet been recognized by mining engineers in their appraisal of the future of Venezuelan Guiana as a diamond producer. In view of the very extensive area in which geological conditions favor the occurrence of diamondiferous alluvials in the State of Bolivar and in the Amazonas Territory, these areas merit further investigation.

Diamondiferous Alluvials

There are three distinct types of diamondiferous alluvial deposits present in Venezuelan Guiana:

(a) Old river terraces.

(b) Flood plains and slope gravels.

(c) Alluvials of present river beds.

Deposits of the old-terrace type are more easily recognized on the Lower Rio Caroni than in the Gran Sabana area, although they occur in both. They have been noted as much as 80 ft. above the present river level, although often only remnants of a once more extensive deposit now remain. In some cases it is possible to trace the redeposition of these older diamondiferous alluvials between their present limits and the existing river.

The amount of overburden varies, but in this type of alluvial deposit it rarely exceeds five feet, and the diamondiferous gravel ranges from 9 in. to about 22 in. thick. The gravel, or "formacion," consists of milky white quartz pebbles rarely more than one inch in diameter and about half consists of a siliceous sand with grains less than 1/10 in. diameter.

Flood plain and slope deposits, which are located between the old terrace gravels and the present streams, may consist of alluvial flats, which are often under water in the wet season (the rivers may rise as much as 50 ft. in some places), or they may be shallow deposits on sloping ground between the present river and the old terraces. Such alluvials vary considerably in depth, and in the flood plains the overburden is often 4 to 6 ft. thick, but may be as much as 20 ft.

The thickness of the diamondiferous gravel also varies widely and extremes of 6 ft. and 40 ft. have been noted. The bedrock in the lower Caroni area is either granite, granite-gneiss or a decomposed, basic igneous intrusive whereas in the Gran Sabana it is generally a sandstone or sandstone-conglomerate, a decomposed diabase ("cascajo") or a porphyry.

The diamondiferous alluvials of the present perennial streams vary considerably in character. On the lower Rio Caroni the diamonds may be found in a hard conglomerate of quartz, jasper and rounded fragments of igneous rocks cemented by iron oxide, or as hyper-concentrations in loose gravel behind natural riffles formed by intrusives and quartz veins that cross the river beds.

Prospecting

Prospecting for diamonds in Venezuela has shown that commercially valuable deposits are frequently found:

(a) near the headwaters of streams whose source is close to the scarps of the Roraima formation,

(b) in old river terrace gravels,

(c) near the junctions of streams,

(d) above the natural riffles formed by dikes and quartz veins traversing the river beds, and

(e) at the foot of falls.

Some streams in the Gran Sabana area disappear underground through fissures in the sandstone and conglomerates leaving a dry bed exposed which is highly dissected by fissures and potholes for distances up to 3/4 mile. These sections usually contain a hyper-concentration of gemstones. The local miners have observed that the greater the thickness of "formacion" or diamondiferous gravel, the lower is the value of the ground and vice-versa. Another feature is that where the "formacion" contains a big proportion of boulders or large pebbles it usually has a higher than average concentration of diamonds per cubic yard and the stones are above the average in caratage. These deposits are usually found close to the bases of scarps at an elevation of about 3,000 ft.

Methods of Working

The method generally employed in working these diamond deposits is pitting and washing the gravel extracted in sluices and "bateas." On the lower Caroni River in the dry season (November-April) a small percentage of the diamond output is obtained by divers.

On the Gran Sabana there are concession areas held by local and foreign companies but none is yet past the testing stage. The largest producers are the local miners who work in areas of free avail granted to them by the Government. Each miner, or group of miners, is permitted to work an area of ten meters square to bedrock. They are not permitted to use power machinery and are restricted to picks, shovels, bars, hoes, "bateas," sieves and similar primitive tools.

A group of five or six men, sharing equally in expenses and profits, begin operations by sinking a trial pit, about three feet in diameter, to bedrock. The "formacion," or wash, is tested to see if it is diamondiferous and if so the excavation is gradually enlarged to the maximum size allowed by the mining law. These pits and excavations are termed "barrancos" and if situated far from a stream the gravel is often washed in them, but if a supply of water is less than 300ft. away it is transported in four-gallon kerosene tins to the sluices. A small amount of gold is usually present in these alluvials and this is caught by mercury traps or riffles in the upper section of the sluice. The sluice beds are periodically cleaned up and the heavy concentrates recovered are washed on sieves. The diamonds are picked out from among the small residue of diamond "satellites." These consist of rutile, "carbonados," red and green jasper, and zircon.

The average recovery on the Gran Sabana field runs four stones to the carat and those ranging from ¼ to ½ carat represent some 50% of the total. The largest diamond yet reported, "El Libertador," weighed 155 carats and stones up to 16 carats are not rare. About 73% of all diamonds recovered are gems. The majority of these are free of flaws and translucent, but some 30% are colored or have broken edges.

In conclusion it may be said that of the three diamond producing countries of the Western Hemisphere the Republic of Venezuela today offers the largest potential area for exploration and development. Although it may never offer serious competition to the African fields, it does possess sufficient potential value to merit the attention of independent mining interests.

Titanium Takes on New Importance

Demand for Titanium pigments is growing so rapidly that large chemical companies are unable to build plants fast enough to supply them according to Otto Herres, vice president, Combined Metals Reduction Co.*

Titanium dioxide, most opaque and whitest of all good pigments, is gradually replacing white lead, lithopone and other white pigments in better quality paints. All high-grade white house paints today contain some titanium dioxide to improve the hiding power of the white lead. In finishes for refrigerators, washing machines and porcelain enamels, titanium dioxide predominates. Large quantities are also used in paper, plastics and rubber, whitening toilet soaps, face powder and textiles.

Rayon manufacturers use titanium dioxide as a delusterizing agent. Use would probably double if adequate quantities could be obtained. A new 7-million-dollar plastic plant erected by one of the large rubber companies is reported to be virtually idle today for lack of titanium dioxide.

Use of titanium pigments by the paper industry has increased tremendously during a few years to more than 30,000 tons annually. High strength is imparted to lightweight thin papers to supplant heavier stocks. Thin paper becomes unusually opaque. Magazines will be published on thinner stock with large savings in handling costs when titanium dioxide is available in sufficient quantities to paper manufacturers.

The two commercial titanium ores are ilmenite and rutile. Ilmenite is cheaper and more plentiful and finds its greatest use for the manufacture of pigments. Relatively small amounts go into the production of ferro-alloys, cemented carbides, and titanium tetrachloride used in sky writing and as a wartime ingredient for smoke screens. Rutile is used principally for welding rod coatings, but finds use also for alloys.

Titanium, as a deoxidizer and denitronizer, is one of the best purifying agents for the production of steel and cast iron because of its strong affinity for oxygen and nitrogen. It has become almost indispensable for welding rods, tending to improve steadiness of the electric arc, and prevent embrittlement of the weld. The output of rutile-coated rods has more than trebled in recent years.

Between 1937 and 1947 plant capacity of the U. S. producers of titanium pigments was expanded three and one-half times despite construction difficulties. During 1947, the industry output was increased approximately 22% to an all-time high. In 1948 expansion to somewhat similar extent is expected. And yet of chemicals in short supply, titanium dioxide is one of the scarcest today, and no early end of the shortage is foreseen.

There are four U. S. producers of titanium: DuPont; National Lead Co.; Calco Chemical Division of American Cyanimid Co.; and Chemical & Pigment Co., a division of Glidden Co.

The MacIntyre operation of the National Lead Co. is presumably the largest producer in the world today. Production is approximately 750 tons of ilmenite daily, or 200,000 to 250,000 ton annually.

In December, 1947, DuPont signed a long-term lease for state-owned ilmenite bearing lands in north central Florida, believed to be sufficient to end reliance on foreign supplies, it is reported, when large-scale mining operations get under way.

Glidden Company's ilmenite mines are in North Carolina. The recent company report states ore reserves are in excess of requirements for production of titanium pigments over the next ten years.

American Cyanimid mine operations are in Virginia. New Plant facilities went into operation at Gloucester City, N. J., last year.

Large tonnages of ilmenite are mined in open cut operations with power shovels and concentrated from beach sands in Florida and India at relatively low costs. Production of titanium dioxide is a different matter, however, and requires heavy capital outlay for processing facilities. A moderate sized titanium dioxide plant at today's prices is estimated to require a capital expenditure in the magnitude of about $20,000,000. There is no shortage of principal raw materials for pigment production. These are ilmenite ore and sulphuric acid.

*Abstracted from address delivered before the Colorado Mining Association, February 1948.