ARTICULO

A RECONNAISSANCE OF THE GUAYANA SHIELD FROM GUASIPATI TO THE RIO ARO, VENEZUELA.[1]

By

K.C. Short[2] and W.F. Steenken[3]

ABSTRACT

The Guayana Shield between Guasipati and the Río Aro is formed by a series of low plateaux, interrupted in the northeast by the Serranía de Imataca. Five different erosion surfaces are identified of which only the lowest two can be dated.

A provisional stratigraphy is described consisting of pre-Imataca Basement rocks in the extreme south, thought to be overlain by the Imataca Group of biotite-microcline gneisses with ferruginous quartzites, the Guri Formation of epidote-mica-microcline gneisses, a series of amphibolites named the Yuruari Formation and a meta-volvanic series named the Guasipati Formation. A general increase in degree of metamorphism is described from possibly greenschist facies of the Guasipati Formation in the south to granulite facies in the north. The zonation of metamorphism is roughly paralleled by zones of increasing intensity of structural deformation. This resulted in a regional picture of a major fold belt trending WSW-ENE, cutting across the north-south trend of the pre-Imataca Basement. The overall structural picture is dominated by the Bolívar fault system, a series of three major left-lateral faults (Ciudad Piar fault, Guri fault and El Pao fault) crossing the fold belt from northeast to southwest. All these major structural features can be related to one single stress system.

A younger non-metamorphic quartz dolerite dyke swarm has been found which intruded along a series of NNW-SSE fractures. The composition of the dykes is similar to that of sills in the Roraima Formation to the south.

RESUMEN

El escudo de Guayana entre Guasipati y el río Aro está formado por una serie de mesetas bajas, interrumpidas en el noreste por la serranía de Imataca. De las cinco superficies que se observan solamente a las dos inferiores se les puede asignar una edad.

Una estratigrafía tentativa consiste en la descripción de las rocas del basamento pre-Imataca en el extremo sur, al cual se le supone suprayacente los gneisses biotítico-microclínicos con cuarzos ferruginosos del Grupo Imataca, los gneisses epidótico-micáceo-microclínicos de la Formación Guri, una serie de anfibolitas llamada Formacíon Yuruari y una serie meta-volcánica denominada Formación Guasipati. Un aumento general en cuanto

[1] Manuscript received 13 July 1962. Published with the permission of the Cía Shell de Venezuela.

[2] Geologist, Cía Shell de Venezuela.

[2] Geologist, Cía Shell de Venezuela.

al grado de metamorfismo existe entre la facies de esquistos glauconíticos de la Formación Guasipati en el sur y la facies granulítica en el norte. El cambio gradual de metamorfismo está accompañado por cambios paralelos en la intensidad de la deformación estructural; lo cual trajo como resultado una faja de plegamiento mayor con rumbo OSO-ENE que atraviesa el rumbo norte-sur del basamento pre-Imataca. El Sistema de Fallas Bolívar domina el cuadro estructural en su totalidad y consiste de una serie de fallas laterales-izquierdas (falla Ciudad Piar, falla Guri y falla El Pao) que atraviesan la zona de plegamiento en dirección NE - SO. Todas las características estructurales de mayor importancia se relacionan a un sólo sistema de esfuerzo.

Se ha encontrado un conjunto más reciente de díques de cuarzo dolerítico no metamórfico que se introdujo a lo largo de una serie de fracturas en dirección NNO - SSE. La composición de los díques es semejante a la de las capas intrusivas (sills) en la Formación Roraima al sur.

Table of Contents

Illustrations

Illustrations (continued)

INTRODUCTION

The region from the town of Guasipati to the Río Aro forms a low plateau broken by numerous knolls and ridges and more rarely by larger mountainous areas. East and northeast of Guasipati is the Sierra de Nuria. Further to the north is a more extensive range, the higher eastern end of which is named the Sierra Piacoa. These mountains continue westwards, north of Upata to the Río Caroní north of Guri. From here, a series of ridges continue further southwest to a group of mountains near Santa Barbara, ending in the westward pointing finger of the Cerro Bolívar. Taken altogether the mountains of this region are known as the Serranía de Imataca.

Most of the higher land, together with the swampy banks of the Río Orinoco, is forested. Over the plain from El Palmar-Miamo in the east to the Río Aro valley in the west, open savannahs dotted with chaparro and palm predominate. The forest margins are frequently lined with freshly cleared fields, the trees being cut and burned to allow cultivation of the good forest soil. Once deforested, the land quickly deteriorates under the tropical rainfall, leaving behind the thin sandy savannah soils. It seems probable that the present day savannahs of this region have been greatly enlarged in this manner by human agency.

Within the savannah area, numerous jeep trails allow easy access to most places during the dry season (November-April). Outcrops are numerous, away from alluvial filled valleys, and much geological information can be gained from the aerial photographs. By contrast the forest areas have few trails and are accessible only by using a great deal of time or expensive equipment. In addition, photogeological interpretation here is difficult and unrewarding.

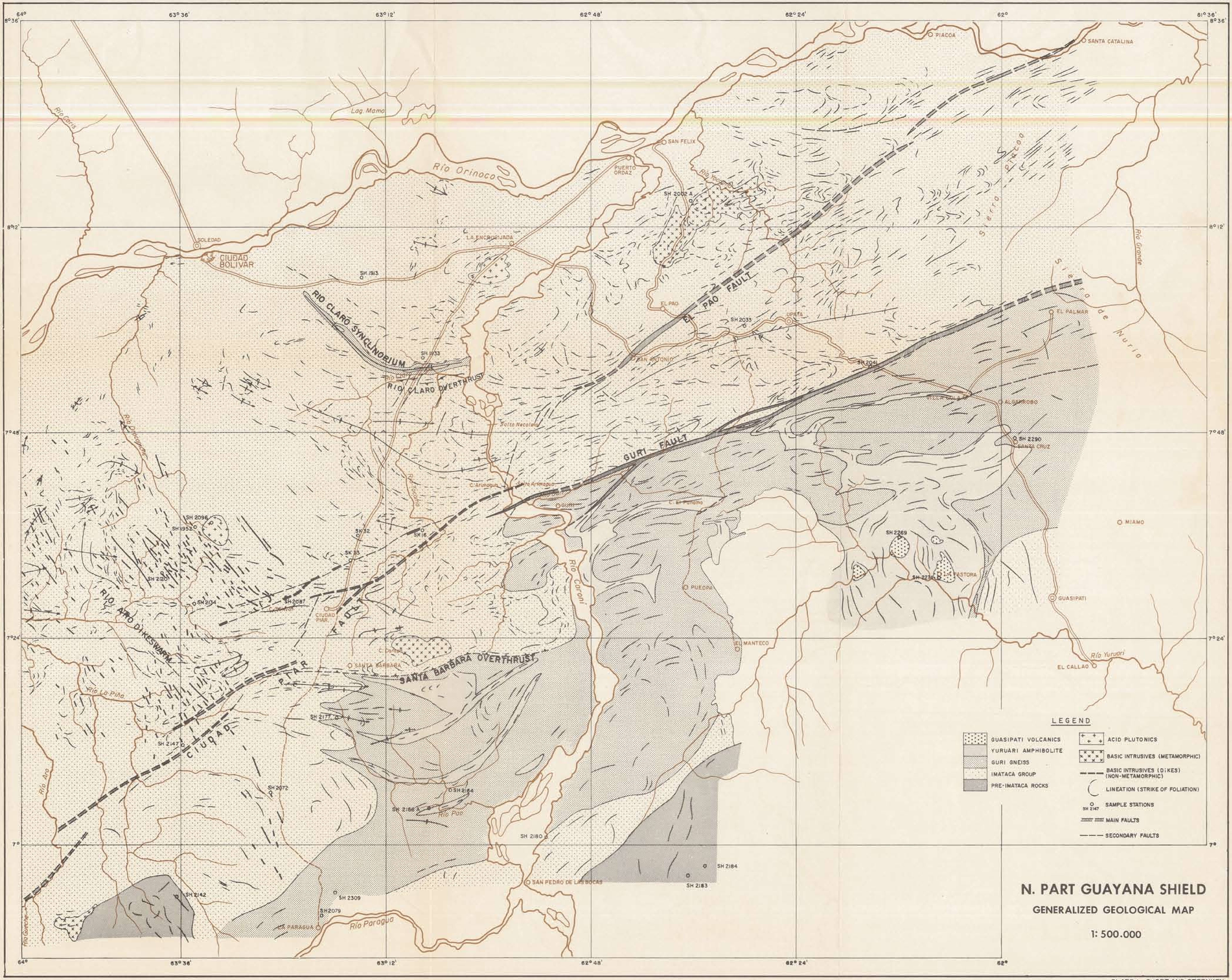
Work on this area was carried out during 1958 and 1959. Nine months were spent on photogeological interpretation by K.C. Short, followed by nine weeks by both authors in the field, during which more remote areas were checked using a helicopter. A further two and a half months were spent by W.F. Steenken on a petrological examination of thin sections from 450 field samples.

The authors are indebted to Compañía Shell de Venezuela for permission to publish this work and to geologists of Orinoco Mining Company and to R.B. McConnell of the British Guiana Geological Survey for much helpful discussion.

GEOMORPHOLOGY

The northern rim of the Guayana Shield is formed by a series of peneplanes. Five principal erosion surfaces were observed, each being separated from the next by a well marked escarpment. The location of these escarpments is independent of the underlying geology; their form varies from abrupt and precipitous, where they occur in sedimentary rocks, to a gradual climb through an extensive dissected area where they occur in the harder metamorphics.

Plate I Short and Steenken. Generalized Geological Map. Scale 1:500,000.


N. PART GUAYANA SHIELD
GENERALIZED GEOLOGICAL MAP
1: 500.000
LEGEND
GUASIPATI VOLCANICS
YURUARI AMPHIBOLITE
GURI GNEISS
IMATACA GROUP
PRE-IMATACA ROCKS
ACID PLUTONICS
BASIC INTRUSIVES (METAMORPHIC)
BASIC INTRUSIVES (DIKES) (NON-METAMORPHIC)
LINEATION (STRIKE OF FOLIATION)
SAMPLE STATIONS
MAIN FAULTS
SECONDARY FAULTS
EL PAO FAULT
GURI FAULT
RIO CLARO SYNCLINORIUM
RIO CLARO OVERTHRUST
SANTA BARBARA OVERTHRUST
RIO ARO DIKESWARM
CIUDAD PIAR FAULT
Río Orinoco
Río Caroni
Río Paragua
Río Yuruari
Río Grande
Río Caris
Río Aro
Río La Piña
Río Pao
Lag. Mamo
Sierra Piacoa
Sierra de Nuria
CIUDAD BOLIVAR
SOLEDAD
LA ENCRUCIJADA
SAN FELIX
PUERTO ORDAZ
PIACOA
SANTA CATALINA
EL PAO
UPATA
SAN ANTONIO
EL PALMAR
ALGARROBO
SANTA CRUZ
GURI
MIAMO
GUASIPATI
EL CALLAO
EL MANTECO
PUEDPA
SANTA BARBARA
CIUDAD PIAR
SAN PEDRO DE LAS BOCAS
LA PARAGUA
64°
63° 36'
63° 12'
62° 48'
62° 24'
62°
81° 36'
8° 36'
8° 12'
7° 48'
7° 24'
7°

The Río Orinoco floodplain, 0-50 m. Quaternary

The lowest of the five surfaces is formed by the Río Orinoco floodplain. This is a long strip of land rarely more than 20 km wide, usually more extensive along the north bank than along the south bank of the river. Near Barrancas it widens suddenly into the Delta Amacuro plain. Throughout its extent, this plain lies from 0-50 m above sea level.

In spite of its very slight gradient, the Río Orinoco lacks the characteristics of a mature river except for its extensive delta. Instead, within the present map area, it occupies a steep sided incised valley, now partially filled with alluvium to form the relatively narrow floodplain. This would suggest that the river has recently suffered a lowering of its base level followed by partial recovery. The Delta Amacuro plain extends into the coastal plain of British Guiana, which is covered by the Demerara clay of post glacial age. This depositional phase in British Guiana is attributed to depression and rise in sea level during and since the last glacial period (Bleakley 1959, p. 8). The evidence suggests that the Orinoco floodplain surface is also a recent phenomenon associated with the same Quaternary fluctuations of sea level.

The Llanos surface, 80-150 m. Pliocene-Pleistocene inter-glacial

The Llanos surface extends over the Río Aro basin below the confluence of the Río Gueche, over the Río Caroní basin below Guri, occurs as remnants around the north slopes of the Serranía de Imataca and also may include the Yuruari-Cuyuni basin below El Callao. It represents the continuation of the main Llanos surface north of the Orinoco. In areas close to the river this surface coincides with the top of the Mesa Formation, passing further south into the solid rock floor of the Shield. Although recognized over a wide area it is by no means as mature as its counterpart to the north of the Orinoco, owing to the greater erosion provided by the harder rocks of the Shield.

North of the Orinoco the Mesa Formation truncates the Oligo-Miocene Oficina and Freites Formations, and in the Unare area units as young as the Upper Miocene-Pliocene Sacacual Group (Hedberg 1950, p. 1213). This shows that the Llanos surface was formed at least as early as Pliocene time and possibly earlier, as some of the soft Neogene deposits could have been folded and peneplaned since the inception of this cycle of erosion.

The Middle Caroní surface, 200-350 m.

Within the area under discussion the Caroní surface extends over the Caroní basin above Guri and the Yuruari basin above El Callao. The boundary between this surface and the Llanos surface coincides with a scarp forming the watershed between the Río Aro and Río Caroní, and extending in an area from northwest of La Paragua past Cerro Bolívar to the Rúi Caroní at Guri (Plate I). From Guri it continues along the line of the Serranía de Imataca. The Río Caroní runs through a mature landscape on this higher level. Below Guri the river enters a narrow channel, dropping to the Llanos level in a series of falls and rapids of which the most prominent are the Saltos Arimagua and Neocaima. In general the Caroní surface has a more mature appearance and carries a thicker blanket of weathered debris than the Llanos surface.

In British Guiana two similar surfaces are known at altitudes of 250' and 350-450', respectively. The higher of these, known as the "North Savanna" surface, has been correlated with the Sur-Americana surface of Brazil (King 1956). However, the North Savanna surface lies at a much lower altitude, more comparable with the Llanos surface which is probably equivalent to King's Velhas surface. More information is required before the Llanos and Upper Caroní surfaces can be correctly correlated with British Guiana and Brazil.

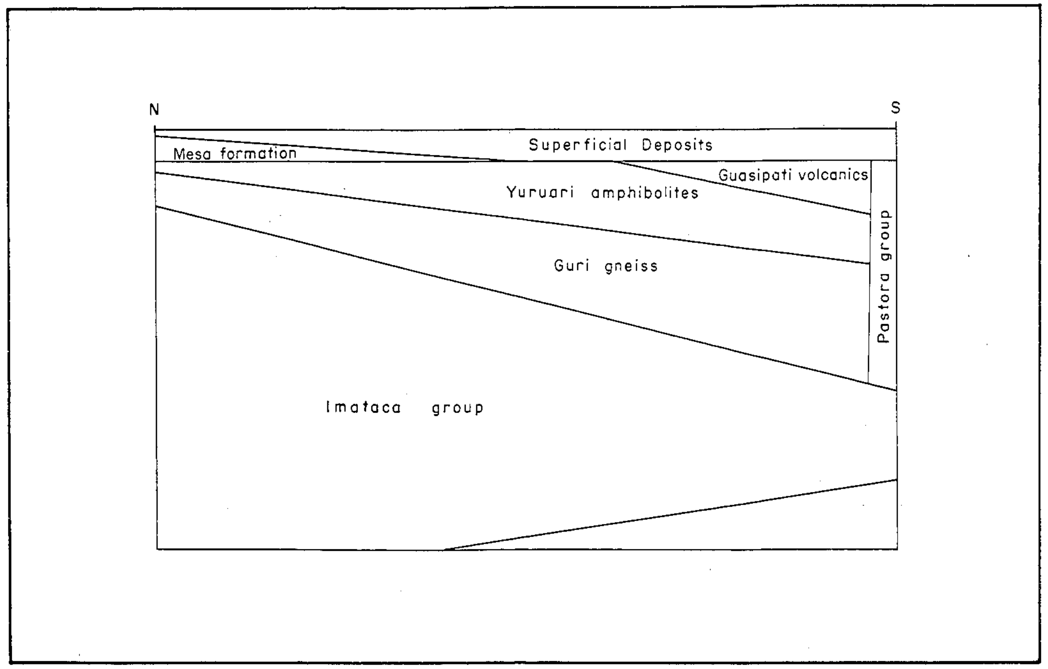


Fig. 1 Short and Steenken. Stratigraphic units and their relationship.

Fig. 2 Short and Steenken. Retrograde biotite-microcline gneiss of the basement. Triangular interstitial quartz filling (white) between subhedral plagioclase crystals (twinned and cleavage) and microcline (grid twinning). 7 x (crossed nicols), Sh 2183.

The 400-500 m. Intermediate level

Signs of an intermediate level, which may be equivalent to the extensive 400-500 m level of British Guiana, occur in the form of small, flat topped, canga capped hills between Ciudad Piar and La Paragua. This level may be more extensive to the south, as is suggested by the altitude of the surface used for the Canaima airstrip; 1,450' (480 m) above sea level.

The Nuria Plateau surface 600-700 m.

This surface is found in the present area only as isolated remnants. More evidence is available from British Guiana where the Pakaraima plateau is described in the Upper Mazaruni river valley as having an average height of 700 m. (Pollard 1956b, p. 11). Flat topped mountains rising to between 600 and 700 m occur at Cerro Carapo and adjacent hills southwest of Ciudad Piar, in the Sierra Piacoa, and the Sierra Nuria including the Nuria Plateau. On Cerro Carapo aerial photographs disclosed the abandoned valley of a mature meandering river on what today is an isolated flat-topped mountain. This surface is highly bauxitised in British Guiana and is said to carry some bauxite on the Nuria plateau and in the Sierra Piacoa. In the Cerro Bolívar area the rich extensive secondary iron ore deposits are associated with this erosion surface.

The ages of the erosion surfaces above the Llanos surface are unknown. Direct correlation with King's sequence in Africa and Brazil (King 1956a and 1956b) is not possible and the problem would be better left until more is known of the Guayana Shield sequence.

STRATIGRAPHY AND DESCRIPTION OF ROCK TYPES

Owing to the short time spent in this extensive and structurally complicated region, the stratigraphic units and their relationship as shown by Figure 1 can only be considered as provisional.

Pre-Imataca rocks

Two areas of rocks of possible pre-Imataca age were encountered. They were recognized first from aerial photographs due to their north-south lineation, the importance of which is discussed later. In hand specimen the rocks from these areas are coarser grained than adjoining formations to the north, which in themselves show a general decrease in grain size from north to south.

Southeast of a line between San Pedro de Las Bocas and El Manteco is a hilly area formed of coarse grained hypidiomorphic (epidote-) biotite-microcline gneiss of igneous aspect and granitic composition. This rock type is characterized by a quartz groundmass filling the openings between the feldspar crystals (Fig. 2). At least part of the microcline is of a secondary origin, replacing an acid plagioclase. A minor portion of both feldspars occurs in the form of perthitic intergrowths. Retrogressive metamorphism is conspicuous; the main part of the biotite is replaced by chlorite and the plagioclase is altered into fine grained epidote and sericite.

These rocks have recrystallized under the P-T conditions of the epidote-amphibolite metamorphic facies. The texture does not exclude an igneous origin and bears some resemblance to that of the meta-dacites of the Guasipati Formation described below.

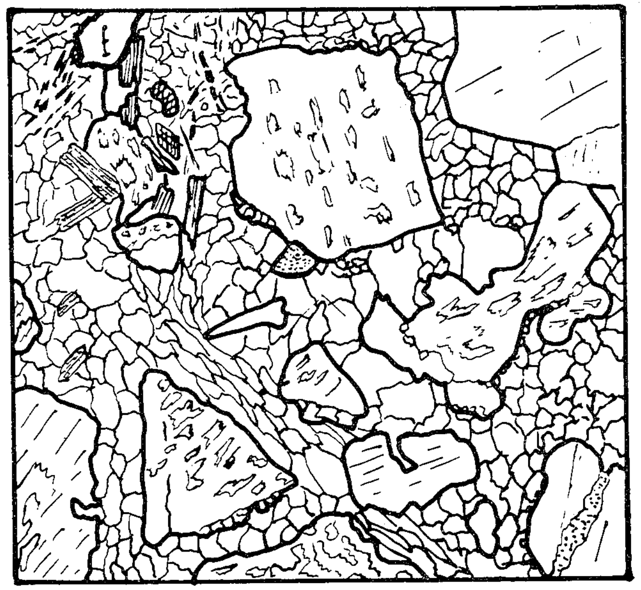


Fig. 3 Short and Steenken. Ferro-hastingsite-biotite-stilpnomelane-epidote-microcline gneiss. Perthitic aggregates (heavy outline) in a finer grained quartz groundmass. Upper left hand corner: thin needles of stilpnomelane, crystals of blue-green amphibole, flakes of biotite and some fluorite (f). A grain of titanite is seen in the center of the drawing (dotted). 10 x (ordinary light). Sh 2142.

Fig. 4 Short and Steenken. Biotite-microcline gneiss of the Imataca group with: quartz (white), oligoclase (albite twinning), microcline (grid twinning) and biotite (dotted). 27 x (crossed nicols), Sh 1933.

sample Sh 2184 collected east of San Pedro de Las Bocas was carried out by Shell Development Company, Houston. This determination gave an age of $2340 \pm 55 \times 10^6$ years.

West of La Paragua lies a second hilly area consisting of ferrohastingsite-biotite-stilpnomelane-epidote-microcline gneiss, a rock type unique to the region. These gneisses consist mainly of porphyroblastic feldspar crystals in a slightly sheared and generally fine grained quartz matrix (Fig. 3). The feldspar porphyroblasts are replacement perthites with varying oligoclase/microcline ratios. The relationship between the two feldspars is unclear; both idiomorphic potash feldspar crystals, slightly replaced by plagioclase, and aggregates of poikilitic oligoclase cores with irregular microcline rims are found.

The present mineral assemblage seems to have been formed under the P-T conditions of the epidote-amphibolite facies. The origin of the ferrohastingsite and the stilpnomelane is not clear; the occurrence of fluorite suggests metasomatic action.

Imataca Group

The name Imataca Series was first introduced by Newhouse and Zuloaga (1929, p. 798) and has been changed subsequently to Imataca Formation and Group by Zuloaga and Tello (1930, p. 412) and Morrison (1953, p. 50), respectively. The Imataca Group had been described by Bellizzia and Martin Bellizzia (Stratigraphic Lexicon of Venezuela, p. 255). It consists primarily of pink and grey biotite-microcline gneisses with numerous thin beds of ferruginous quartzite. The ferruginous quartzites form probably less than 1% of the succession but have attracted a lot of attention due to their economic importance and prominence as key beds.

Due to their extreme resistance to erosion these rocks form prominent topographical features along their outcrop, as shown on the geological map (Plate I). In the field these features are normally found to contain only a few thin bands of quartzite. The vertical distribution of ferruginous quartzites in the Imataca Group is not known. Laterally they appear to thicken towards a broad belt close to the Bolívar fault system. They are thinnest in the southernmost exposures near Guasipati and west of La Paragua.

The origin of the ferruginous quartiztes has been the subject of much discussion. Any theory must account for their unique composition, fine layering, great geographical extent, lateral variation in thickness, and their proportional rarity in the stratigraphic column. Accordingly, a primary origin has been suggested by Reynolds (1960).

Most previous authors have suggested an Algonkian age for the Imataca Group. A single absolute age determination according to the rubidium-strontium method has been made by Shell Development Company, Houston, on biotite from sample Sk 32, collected north of Ciudad Piar. This determination gave an age of $1540 \pm 60 \times 10^6$ years.

Petrological descriptions of typical rock types are given below:

Biotite-microcline gneisses

The typical Imataca gneiss is an allotriomorphic, usually medium-grained oligoclase-microcline gneiss (Fig. 4) with subordinate biotite and ironoxides as the only dark constituents. Biotite and rare muscovite flakes give the rocks a varying degree of foliation.

The three main constituents, quartz, potash and soda/lime feldspar usually occur in about equal proportions, though some samples contain a remarkably high

Fig. 5 Short and Steenken. Medium-grained charnockite. Quartz (white) enclosing hypersthene (dotted, showing cleavage). "Maschenstructure" with fine-grained biotite replacing hypersthene. Also amphibole (cleavage) and magnetite (black) are shown. 30 x (ordinary light), Sh 2002A.

Fig. 6 Short and Steenken. (Hornblende) Charnockite. On the figure are shown: perthite (irregular intergrowths), microcline (cross hatching), hypersthene (dotted), quartz (white), amphibole (60° cleavage) and plagioclase (albite twinning). 35 x (crossed nicols), Sh 1913.

content of quartz. In some thin sections this mineral tends to form big, relatively rounded crystals, whereas the feldspars occur as complicated intergrown finer grained aggregates. This texture is apparently lost during more advanced metamorphism, allowing a free arrangement of the constituents as seen in the charnockitic gneisses described below. A portion of both feldspars occurs in the form of an exsolution perthite. However, in the typical microcline gneisses of the Imataca Group this type of intergrowth never becomes a predominant element.

Occasionally rocks with little or no microcline occur, their texture is similar to that of the microcline-rich types, except for the relative abundance of biotite and/or hornblende.

In view of the absence of epidote and the stability of oligoclase, the rock types described above are placed in the amphibolite metamorphic facies.

Charnockites

Texturally these rocks strongly resemble the biotite-microcline gneisses of the Imataca Group, but the plagioclase is richer in calcium than that of the normal Imataca gneisses.

The charnockites usually contain strongly pleochroic hypersthene instead of biotite and sometimes monoclinic pyroxene occurs as lamellae in the rhombic pyroxene and as individual crystals. In many cases the hypersthene shows retrogressive alteration; partly to biotite with beautiful reticulate ("maschen") structure (Fig. 5), partly to fine-grained aggregates of serpentine and occasionally to calcite.

In some of the charnockites potash feldspar is rare or absent, while other samples contain more, mostly as a typical exsolution perthite (Fig. 6). Garnet occurs frequently but is not typical.

The charnockites and associated basic intrusions and quartzites appear to have recrystallized under the P-T conditions of the granulite metamorphic facies. Biotite-perthite gneisses are found, providing a transition between the biotite-microcline gneisses and the charnockites. These rocks contain biotite as the main dark constituent while hypersthene is absent. The potash feldspar occurs predominantly in the form of exsolution perthite. For mapping purposes the perthite gneisses are included in the granulite facies because of the predominance of perthite, a feature rather unusual for gneisses of the amphibolite facies (Fig. 14).

Ferruginous quartzites

This rock type is characterized by an extremely simple composition: the vast majority of the samples examined consists of quartz and of iron oxides and hydroxides. All gradations exist between almost pure quartzites and types containing more than 50% iron ore minerals. Haematite occurs most frequently, often closely related to and formed at the expense of magnetite. Smaller amounts of secondary limonite and possibly goethite occur. The iron minerals and quartz form bands in some specimens, whereas in others they form a more homogeneous texture.

One sample (SH 2033) contains hypersthene as a rock forming mineral. In the field this particular iron quartzite is closely related to the charnockites. In a few cases some small aggregates of amygdaloidal shape were found, made up of finely crystalline fibrous aggregates of distinctly positive relief, possibly prehnite.

Basic igneous rocks

Metamorphosed basic intrusives are found scattered throughout the area underlain by the Imataca Group, forming bodies ranging in size from a few to thousands of metres.

The smaller intrusions seem to form irregularly shaped masses within the Imataca gneisses. Of the larger intrusions the one overlying the El Pao ore body has been described as a laccolith.

Most of the amphibolites of the Imataca Group are of a massive type. The general absence of quartz and the occasional occurrence of pyroxene remnants indicate an igneous origin. Microcline is relatively rare. The plagioclase is mostly an andesine, although more basic varieties were observed ranging up to bytownite. The amphibole is normally a green hornblende, but brown hornblende was also observed.

A few schistose amphibolites occur as thin intercalations at certain stratigraphic levels in the group. They are considered to represent an effusive phase, possibly related to the basic intrusives. They grade on the one hand into massive types, on the other into rocks made up of alternating bands of amphibolitic and of clastic material. Except in the last case quartz is rare or absent. The absence of epidote and the chemical stability of the calcic plagioclase and hornblende suggest that these rocks belong to the amphibolite metamorphic facies.

In the area underlain by charnockitic rocks a special variety of basic intrusive is often found, of which the El Pao laccolith forms an example. Rocks of the El Pao type are considered by the present authors to be highly metamorphic derivations of gabbroic intrusions recrystallized under the physical conditions of the granulite metamorphic facies. The name Charnockitic gabbro seems most suitable, as it indicates the metamorphic past of these rocks.

The charnockitic gabbros are allotriomorphic, usually medium-grained rocks consisting mainly of pyroxene and calcic plagioclase (andesine to labradorite), with a varying amount of brownish green hornblende and occasionally some sparse grains of quartz and/or microcline. Magnetite occurs as a minor constituent.

Part of the pyroxene is a strongly pleochroic hypersthene very similar to that of the surrounding charnockites. Varying amounts of monoclinic pyroxene also occur. A purplish pleochroism in some of the pyroxenes and the small axial angle of some of the others point to the presence of members of both the augite-ferroaugite and the pidgeonite series.

The hornblende, which always is present and in some samples forms the main dark constituent, sometimes shows a distinct parallel orientation. Brownish varieties predominate in the charnockite gabbros in contrast to the common green hornblende in the basic metamorphics found elsewhere.

A few small outcrops of regional metamorphic ultrabasics were found in the Imataca Group. These peridotites are considered as the metamorphosed differentiation products of the basic igneous complex, with which they are closely related in the field. Orthorhombic pyroxenes occur only in those peridotite bodies embedded in charnockitic bedrock.

Granitic rocks of possible igneous origin

In two areas granitic rocks of igneous aspect and possibly igneous origin were found. The most easily accessible locality is along the Puerto Ordaz-Ciudad Piar road just south of the intersection with the Ciudad Bolívar-Upata road. The composition of these granites is very similar to the normal Imataca biotite-microcline gneisses. They are, however, coarser grained, no direction is present and as a whole they are very homogeneous. The transition into the surrounding Imataca gneisses appears to take place over a few hundred metres. An age determination based on Sr-Rb from biotite from a sample of this granite gave a figure of $2000 \pm 45 \times 10^6$ years.

An outcrop of rocks very similar to those described above was found about 30 km northwest of Ciudad Piar.

These directionless granitic complexes are possibly rejuvenated mobilized parts of the Imataca Group and of still older rocks. The above absolute age determination might indicate the presence of relics of minerals formed before the last phase of transformation of the Imataca gneisses.

Guri gneiss Formation

Extensive areas in the southeastern half of the region are underlain by white gneisses without ferruginous quartzite bands, provisionally grouped together under the name Guri gneiss Formation. Type locality is designated at a quebrada near Santa Cruz on the main road from Upata to Guasipati. Here the rock is a white Epidote-mica-microcline gneiss. Throughout the area the Guri gneisses are characterized by the abundance of both micas and of epidote. The composition seems to be fairly uniform but differences in texture occur. The most common gneiss type, as found at the type locality, is made up of big crystals of a porphyroblastic aspect of both feldspars (mainly plagioclase) in a finer grained, predominantly quartz groundmass (Fig. 7).

The composition of the plagioclase ranges from albite-oligoclase to oligoclase. A distinctive feature of this mineral is the abundance of sometimes well directed inclusions of sericite, epidote and some calcite. The proportion of microcline present in these rocks varies widely; types devoid of potash feldspar and varieties containing microcline as a main constituent occur.

These porphyroblastic gneisses grade into allotriomorphic gneisses of a rather constant grain size, resembling the microcline gneisses of the Imataca Group. The epidote-mica-microcline gneisses of the Guri gneiss Formation are recrystallized under the P - T conditions of the epidote-amphibolite facies.

Sharp contacts between the Guri and the Imataca gneisses were observed at two places. South of Santa Barbara at Sh 2177 (Plate I) white hornblende microcline gneisses overlie fine-grained grey and pink biotite-microcline gneisses of the Imataca Group. The attitudes of the two formations are identical and no basal conglomerate was seen. In the Río Claro syncline southeast of Ciudad Bolívar there is an inlier of Guri gneiss. Approaching the Río Claro from Puerto Ordaz along the highway to Ciudad Piar, typical pink and grey medium-grained Imataca gneiss can be seen overlain by fine-grained, grey Guri gneisses. These are succeeded in turn by massive amphibolites comparable to the Yuruari amphibolites described below. If these provisional formations are valid, then the Guri Formation must be very much thinner in the Río Aro syncline than in the main outcrops to the south. In view of this and of the fact that the amphibolite/epidote-amphibolite metamorphic facies boundary roughly coincides with the Imataca-Guri boundary, the relationships of the two formations are not yet clear.

Fig. 7 Short and Steenken. Epidote-mica-microcline gneiss. Plagioclase, with inclusions of sericite and epidote, partly untwinned potash feldspar (k) of porphyroblastic aspect with respect to quartz. Biotite (b) and muscovite (m) as well as epidote (t) are present. 35 x (crossed nicols), Sh 2164.

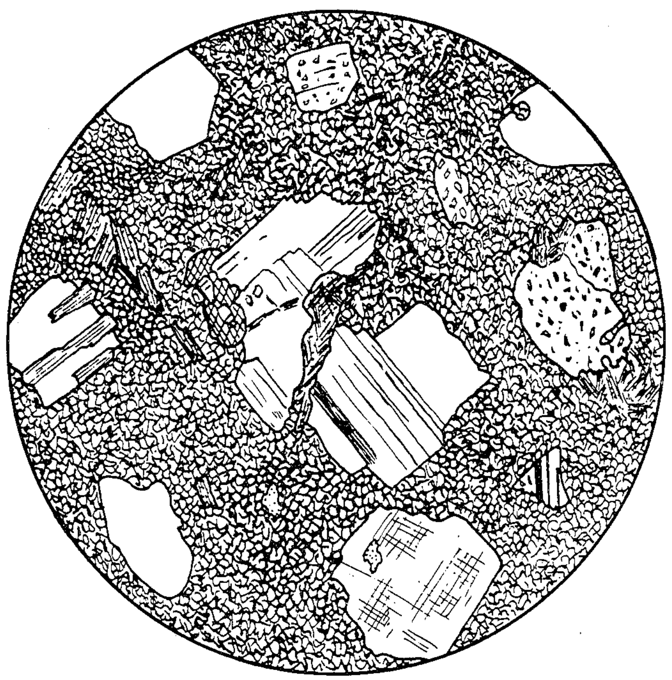


Fig. 8 Short and Steenken. Dacite. Phenocrysts of quartz (white) plagioclase (albite twinning) and microcline (grid twinning) in a fine-grained groundmass (quartz-feldspar). Some of the plagioclase phenocrysts show inclusions of sericite. In the groundmass some flakes of muscovite (dotted and dashed) and of calcite (cross-hatched). 10 x (crossed nicols), Sh 2269.

Yuruari amphibolite Formation

Thick sequences of dark green and greenish grey amphibolites and amphibolitic schists were observed overlying Guri gneiss in the Río Claro, at a point 14 km southeast of Santa Barbara and at several localities on the road from Upata to Guasipati. These sequences are provisionally grouped together as the Yuruari amphibolite Formation. The top of the formation is not known.

The amphibolites of the Yuruari Formation are distinguished from those of the Imataca Group by the abundance of epidote. The composition of the plagioclase ranges from andesine to bytownite. Besides common green hornblende, actinolitic varieties were also found. In a few specimens a colorless pyroxene occurs. Quartz is present only in a few cases in accessory quantities. Massive amphibolite types are more frequent than schistose ones. In one thin section (Sh 2168A) big zoned plagioclase crystals of porphyric aspect were observed under the microscope, possibly forming remnants of the pre-metamorphic texture of the rock.

Metamorphic ultrabasics were found only in one region, 20 - 25 km southeast of Ciudad Piar. The samples collected were all tremolite schists with varying amounts of talc and chlorite. Schistose and massive textures were both observed.

The Yuruari amphibolites and related ultrabasics bear evidence of being recrystallized in the epidote-amphibolite facies.

Guasipati Formation

In the area west and south of Guasipati, extensive areas of meta-dacites and associated meta-sediments were observed. Contacts with the nearby Yuruari amphibolites and Guri gneiss were not seen. Although these rocks were grouped separately in the field, petrological examination of samples revealed the possibility of a progressive transformation from the typical Guasipati meta-dacites into typical white Guri gneiss.

The lowest metamorphic acidic volcanics were encountered a few kilometers northwest of La Pastora. In the field they are recognizable as porphyritic rocks, consisting of dark grey phenocrysts (up to 0.5 cm in size) embedded in a light grey to white fine-grained groundmass.

Under the microscope they are porphyritic holocrystalline volcanic rocks (Fig. 8) consisting of phenocrysts of an acidic plagioclase (albite to albite-oligoclase), quartz and some microcline in a groundmass of roughly the same composition although possibly somewhat poorer in plagioclase. The quartz phenocrysts have undergone slight resorption. The potash feldspar has the optical properties of microcline, but often shows the characteristic crystal shapes of sanidine. Apart from dacitic lavas, effusive equivalents were also encountered containing broken fragments of quartz and feldspar crystals and grains made up of groundmass (Fig. 9).

Whether plutonic members of this acidic magmatic series exist in the area is not certain; it is conceivable that some of the Guri gneisses may be considered as such.

In the available samples, which were taken at locations widely scattered over a large area (Fig. 15), progressive metamorphism appears to exist, although these changes could not be proven in a continuous sequence. The changes observed, however, are too consistent and follow too regular a pattern to be ignored.

The first change in the slightly metamorphic dacites is the formation of tiny and

Fig. 9 Short and Steenken. Dacitic tuff consisting of (generally sharp edged) fragments of: quartz (white) plagioclase (albite twinning cleavage and enclosures of muscovite) as well as grains of groundmass in a very fine-grained matrix, partly made up of quartz and feldspar, partly of sericite (dashed), calcite (cross-hatched) and ore minerals (black). 35 x (crossed nicols). Sh 2274.

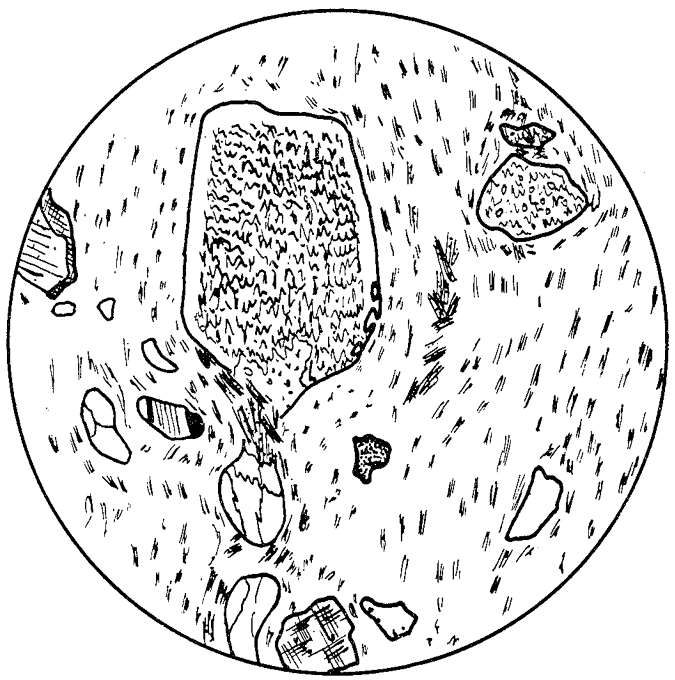


Fig. 10 Short and Steenken. Meta-dacite. Phenocrysts (partly drawn out) of quartz, sericitized plagioclase and microcline in a fine-grained quartz-feldspar groundmass. Of the latter only the (secondary) biotite is indicated. 10 x (crossed nicols), Sh 2309.

well directed biotite flakes, a sericitization of the plagioclase and occasionally a stretching and rolling out of the phenocrysts (Figs. 10 and 11). These changes were probably post-magmatic. In the stage of transformation represented by Figures 10 and 11 the groundmass still remains finely crystalline.

A more advanced stage of transformation is characterized by the growth of bigger flakes of biotite and of muscovite in the groundmass and a strong alteration of the plagioclase phenocrysts into sericite, epidote and calcite. The latter change is found to take place in rock types with a coarser-grained groundmass, so recrystallization of the groundmass may take place at the same time (Fig. 12).

Figure 13 represents a further step towards the transformation of the original dacite into a poikilitic white gneiss of the Guri type (Fig. 7). An increase of the proportion of microcline and a slight shift of the anorthite content of the plagioclase towards oligoclase seem to take place in the direction of higher transformation.

The degree of metamorphism within the meta-dacites ranges from greenschist facies to epidote-amphibolite facies. Chlorite is absent throughout this range; biotite seems to be among the earliest metamorphic minerals to be formed.

The relationship of the Guri, Yuruari and Guasipati Formations to the Pastora Group as defined by Duparc (1922, p. 52) and Newhouse and Zuloaga (1929, p. 780) is uncertain. The Yuruari amphibolites were traced into the Pastora type section near the village of Pastora but the original description includes several other rock types.

Non-metamorphic basic igneous rocks

A dense swarm of quartz dolerite dykes filling a NNW-SSE trending fracture system crosses the western half of the region. These completely unmetamorphosed, medium-grained ophitic rocks show clouded feldspar laths (±40% An), commonly enclosed by an augitic pyroxene. Members of the pidgeonite series might also be present in view of occasional observations of small axial angles. Minor amounts of brown/green hornblende, mainly as rims around the pyroxene, and of biotite occur. Interstitial fillings with quartz and feldspar, most as granophyric intergrowths, are common.

In addition, a large basalt dyke is emplaced in a WSW-ENE trending series of fractures extending from west of Cerro Bolívar to near Upata. Samples of this type are invariably fine-grained and unmetamorphosed. Granophyric quartz-feldspar aggregates were not observed, green hornblende and dust inclusions in the plagioclase, which has an An-content of 55%, are absent. Two out of four basalt samples contain strongly corroded phenocrysts of orthorhombic pyroxene, partly altered into serpentine.

The main characteristics of the two types of igneous basic rock are given below:

		Grain size	An % plag. (HT)	Clouded plag.	Granophyre	Orthorh. pyrox.	Hb. rims around pyr.
Quartz dolerites	Sh 1952	med.	40	x	x	-	x
	Sh 2096	med.	40	x	x	-	x
	Sh 2072	med.	40	x	qz+ k-fld	-	x
	Sh 2120	med.	35	x	x	-	x

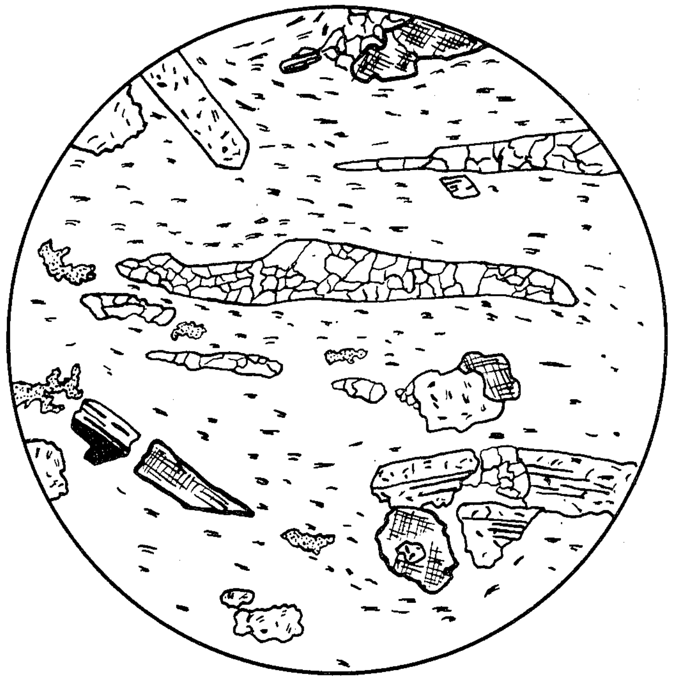


Fig. 11 Short and Steenken. Meta-dacite, in a more advanced state of foliation than the one shown in Fig. 10. Some flakes of muscovite (dotted). 10 x (crossed nicols), Sh 2290.

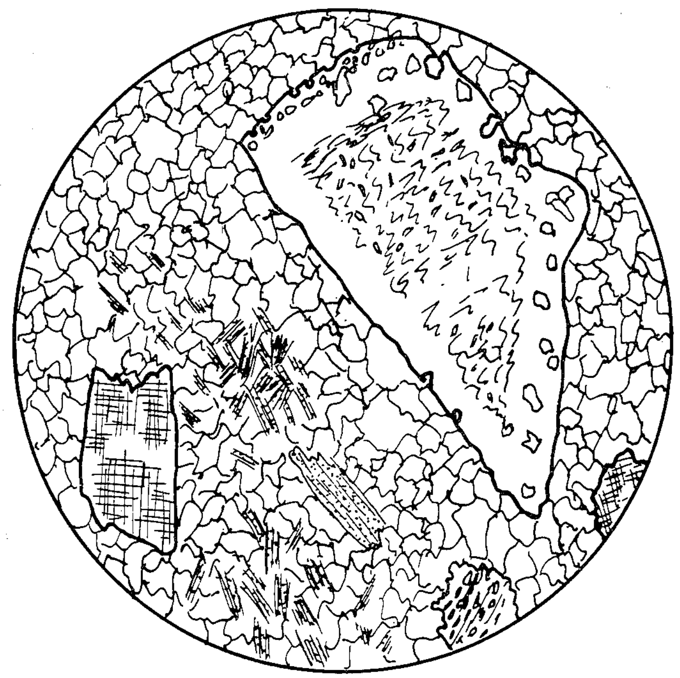


Fig. 12 Short and Steenken. Meta-dacite in a further stage of re-crystallization than shown in Figs. 10 and 11. Phenocrysts of microcline and plagioclase. The latter showing a perthitic core and evidence of younger growth; inclusions in the rim of quartz of the same size as the grains of the matrix (av. grain size 0.7 mm) growth of biotite. 10 x (crossed nicols), Sh 2079.

10

Fig. 12

Fig. 13 Short and Steenken. Epidote-mica-microcline gneiss. Phenocrysts or porphyroblasts of poikilitic plagioclase and microcline in an uneven grained matrix of mainly quartz. Further shown are flakes of biotite and grains of epidote (dark outline, dotted). 10 x (crossed nicols), Sh 2180.

		Grain size	An % plag.(HT)	Clouded plag.	Grano-phyre	Orthorh. pyrox.	Hb. rims around pyr.
Basalts	Sh 2087	fine	55	-	-	x	x
	Sk 16	fine	55	-	-	x	x
	Sk 35	fine	60	-	-	-	-
	Sh 2041	fine	55	-	-	-	-

Despite the differences between the two types, there seems to be consanguinity. The rapid cooling of the basalts apparently froze the resorption of the rhombic pyroxene and the conversion of the plagioclase into less calcic members. It also prevented the formation of amphibole rims around the pyroxene and the eutectic crystallization of granophyre.

The contact rocks of the basaltic dykes are poorly exposed. One sample (Sh 2134) of Imataca gneiss from the vicinity of a dolerite dyke containing abundant diopsidic pyroxene and dust inclusions in its plagioclase, possibly represents a thermal contact.

The phase of injection of basaltic magma appears to be related to the Bolívar fault system. The WSW-ENE trend of the basalt dyke discussed above coincides with one of the main fault directions, and the density of the quartz dolerite dyke swarm markedly changes across the faults in the region of Ciudad Piar. The basalts and dolerites, however, show no cataclastic effects, which proves that they are younger than the movements along the faults. This youngest magmatic phase produced rocks of a tholeiitic type, which in other parts of the world generally occurs as continental flood basalts (Turner and Verhoogen, 1951). The region of the quartz dolerite dyke swarm in the present area might be considered as a deeply denuded prevolcanic basement, showing numerous fissures, which were once connected with volcanics now completely removed by erosion. The basalts and dolerites are markedly similar in composition to the gabbroic intrusions in the Roraima Formation to the south. Most likely they belong to the same magmatic phase and possibly they can be correlated with intrusives and volcanics of tholeiitic type, widely distributed still further south, in Brasil.

REGIONAL METAMORPHISM AND GRANITIZATION

The majority of rocks in the area have been subjected to at least two important petrogenetic processes:

First, a phase of regional metamorphism as expressed by the present mineral associations. There is no evidence for earlier phases, although a poly-metamorphic history cannot be excluded.

Second, some of the formations (e.g. the Imataca and the Guri gneisses) have undergone a process of granitization. These two phenomena may have occurred at about the same time but they are not closely related in space. The area of highest metamorphism seems to be located east of the Río Caroní (Fig. 14), but granitization does not appreciably increase towards this region.

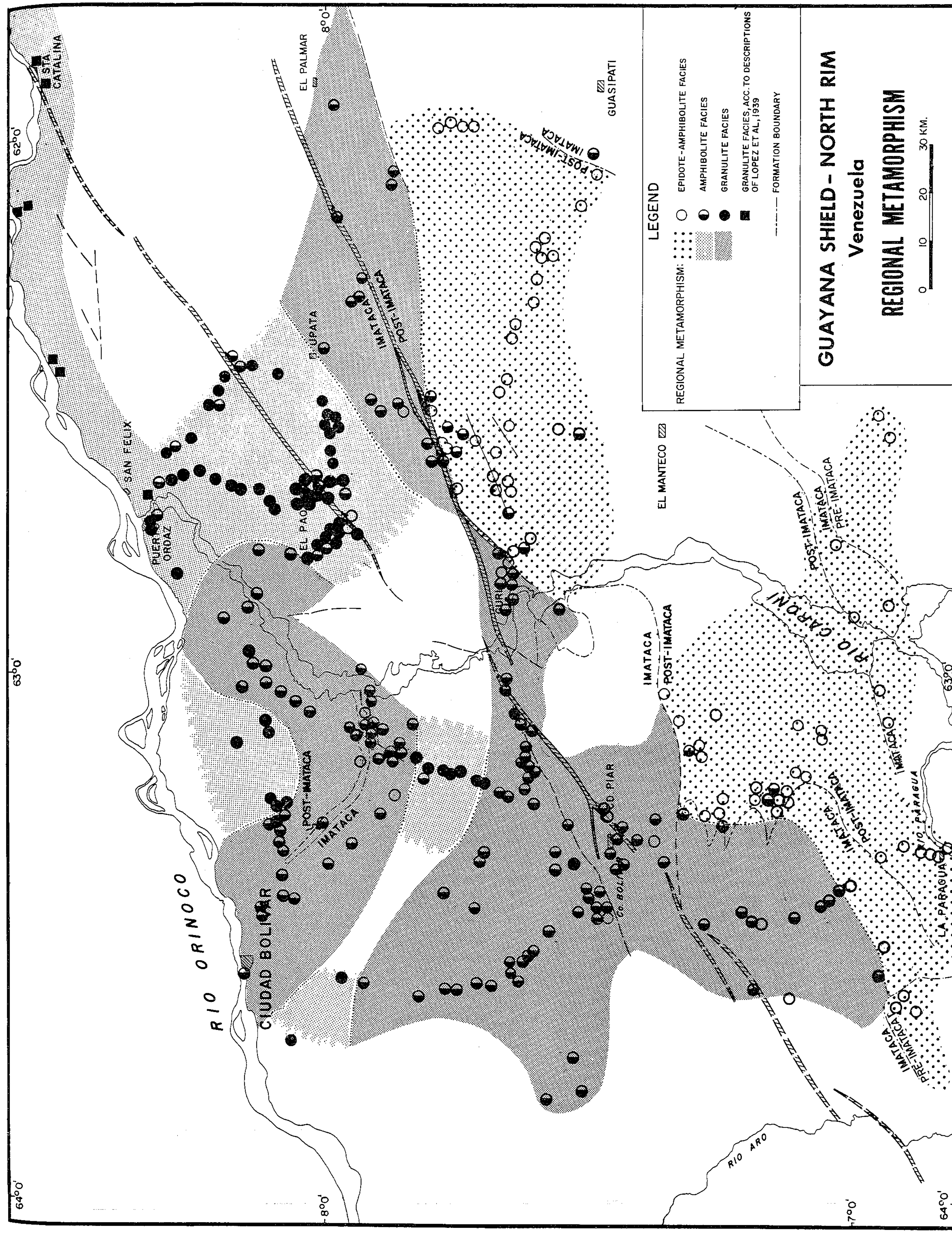


Fig. 14 SHORT AND STEENKEN

Regional metamorphism (Fig. 14)

The degree of metamorphism generally increases from south (epidote-amphibolite facies and possibly greenschist facies) to north (granulite facies). In the acid rocks the epidote-amphibolite facies is characterized by the chemical stability of minerals of the epidote-zoisite series together with a relatively acidic plagioclase[1] (albite or albite-oligoclase). The frequent abundance of newly formed sericite and epidote inclusions in the plagioclase crystals, may be caused by the adjustment of more calcic plagioclase to the acidic equilibrium composition of the epidote-amphibolite facies.

The advance of metamorphism towards the amphibolite facies is marked by the disappearance of epidote and of the poikilitic aspect of the plagioclase. The composition of the plagioclase shows a slight shift towards the calcic end of the series; oligoclase is common.

The gneisses of the granulite facies are characterized by the instability of biotite and of homogeneous microcline. The biotite is replaced by hypersthene (and sometimes garnet) while the potash feldspar is taken up in an exsolution perthite. The optical properties suggest a higher anorthite content for the plagioclase, percentages around 30% were frequently measured. Macroscopically the charnockitic gneisses have a rather dark greenish grey appearance, apparently due to absorption of Fe in the Na-Ca feldspar lattice (Turner and Verhoogen, 1951).

The advance of metamorphism in the derivatives of basic igneous rocks is roughly parallel to that described for the gneisses. In the lowest grades found in the area, epidote is slightly less common in the amphibolites than in the gneisses and an increase in anorthite content in the plagioclase is not conspicuous.

The mineral assemblage of the charnockitic rocks of the area seems mainly a result of extreme temperature and pressure conditions and not of a specific chemical composition. Chemical analyses of the Imataca gneiss and its charnockitic equivalent are not available so that this point cannot be settled for the acidic members of the suite. The composition of the El Pao charnockitic gabbro, however, is similar to that of an average gabbro as is seen in the table below:

	(1) %	(2) %
SiO_2	48.2	48.5
Al_2O_3	17.9	16.5
$FeO + Fe_2O_3$	9.2	9 4
MgO	7.5	5.8
CaO	11.0	13.1
Na_2O	2.5	2.2
K_2O	0.9	0.01
Total	97.2	95.5

(1) Gabbro (incl. olivine gabbro), mean of 41 analyses, refl Daly, 1914.

(2) El Pao charnockitic gabbro. (Analysis kindly provided by the Iron Mines Company of Venezuela.)

[1] c.f. Rosenqvist (1952)

The only notable difference is the low potash content of the El Pao sample. This remains unexplained but seems insufficient to account on its own for the mineral assemblage of the charnockitic gabbros.

The coincidence in the field of the area of charnockitic rocks and that of abundant metamorphic basic intrusions is striking. Along the Ciudad Bolívar-Upata road, west of the Río Caroní, where intrusive bodies are only small, the charnockitic gneisses even appear to form local aureoles around the amphibolitic masses. In these cases it seems that the emplacement of gabbros in an amphibolite facies environment resulted in an increase of temperature (and possibly of pressure) sufficient to create locally, the conditions typical for the granulite facies. If this is true, the phase of basic intrusion is necessarily syn-metamorphic and the "charnockite" facies should be considered as thermal metamorphism on a regional scale.

Figure 14 shows the distribution of the metamorphic facies in the area. The boundary between the amphibolite and the granulite facies lies entirely within the Imataca Group. West of the Río Caroní a narrow belt of charnockitic rocks is suggested by the available data; the trend of this belt parallels that of the narrow inlier of Guri gneisses and Yuruari amphibolites further north in the Río Claro area.

The amphibolite/Epidote-amphibolite facies boundary appears to coincide roughly with the Imataca-Guri contact. The significance of this is not clear and needs further investigation.

Granitization

The sedimentary origin of the Imataca Group is proved by the presence of the banded ferruginous quartzites and schistose amphibolites of tuffaceous aspect. It is highly improbable that the monotonous lithology of the present Imataca Formation represents the original sedimentary sequence and it must be assumed that general and widespread changes of the original sediments have taken place. The ferruginous quartzites and amphibolites then become relics with greater resistance against granitization.

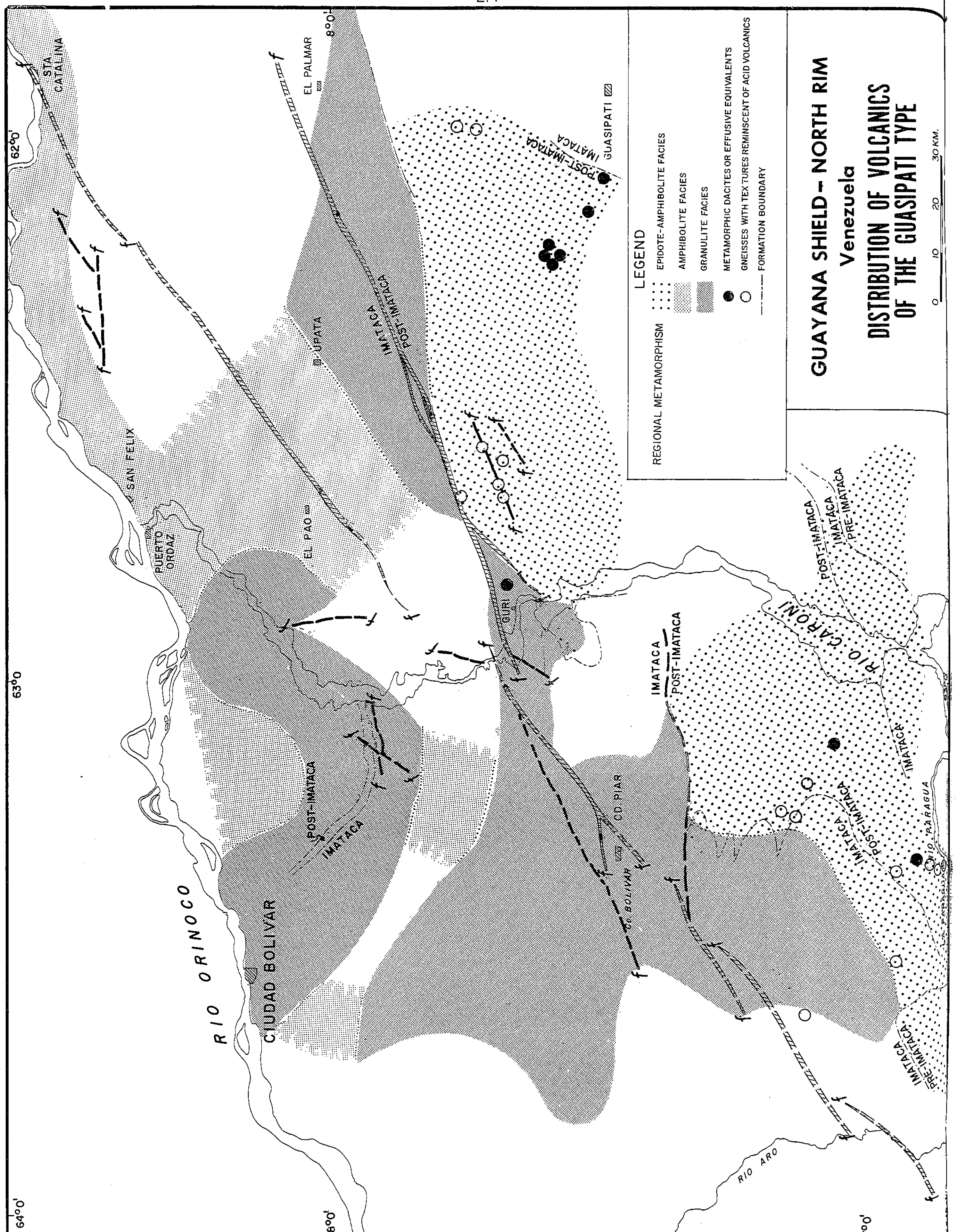
As can be observed everywhere in the field, pink material rich in microcline invades the greyish Imataca gneisses. In thin sections frequent evidence is found for replacement of plagioclase by microcline. In general the apparently deepest stratigraphic units, i.e. the Imataca and pre-Imataca rocks contain the largest proportion of potash feldspar.

The plagioclase occurring in minor quantities as myrmekitic intergrowths formed at the expense of the potash feldspar is certainly of secondary origin, and is probably the result of addition of material.

The original composition of the present granitic gneisses is unknown; quartzites, arkosic quartzites or acidic volcanics and their effusive equivalents may have prevailed in the original sedimentary column.

STRUCTURE

On the aerial photographs trends of the regional lineation are clearly visible in all areas not covered by forest. Within the outcrops of the Imataca Group the quartzite features parallel this lineation and these together outline the major structures of the region.



The foliation measured in the field is invariably parallel to the lineation recorded from the photographs. Moreover, the dip of the quartzite bands is similar to that of the foliation in the adjoining gneisses. From this evidence it is presumed that the foliation is parallel to the original bedding.

Therefore, it is clear that the lineations and dips observed on the photographs can be accepted as genuine structural observations.

Structural trends and folding

Apart from the Río Aro dike swarm the structural feature which catches the eye most is the bend in the general strike occurring roughly along the meridian of 63° 12'. West of this meridian the structural trends are not very constant. The predominant strike varies from NW-SE in the north to E-W more to the south, but in the vicinity of the Bolívar fault system the strike turns to SW-NE, to parallel these faults (e.g. S.W. of Ciudad Piar). In this area a series of steep-flanked elongated domes and basins occurs, the longer axis of which trends NW-SE to E-W, i.e. parallel to the most frequent regional strike direction.

It is to be noted that the strike of the Río Aro dike swarm, which is undoubtedly superimposed on the strike predominant in the southern part, is more or less parallel to the general strike of the area near Ciudad Bolívar.

East of the 63° 12' meridian the regional strike bends towards a WSW-ENE direction more or less parallel to the strike of the Bolívar fault system.

The structures in the area east of the 63° 12' meridian consist mainly of large, open, complex folds, frequently anticlinoria and synclinoria. Owing to the prevalent steep dip and to the lack of detailed stratigraphic knowledge, comparatively few of the folds observed on the photographs could be definitely determined as anticlinal or synclinal. No predominant direction of overturning was observed in this region except for the Río Claro synclinorium which is overthrust from the south and the Santa Bárbara fault which is an overthrust from the north.

A third structural zone occurs south of a line running approximately from La Paragua through San Pedro de las Bocas, Puedpa and south of Algarrobo towards the Sierra de Nuria along the southern margin of the map area. This zone is typified by a major change of strike from E-W to N-S. The strike direction is derived from the older pre-Imataca rocks and is thought to have been adopted by the adjacent younger rocks during the later orogenesis.

The Bolívar Fault System

A dominant structural feature observed in the region is the Bolívar fault system. It consists of three different elements (Plate I): the Ciudad Piar fault extending from

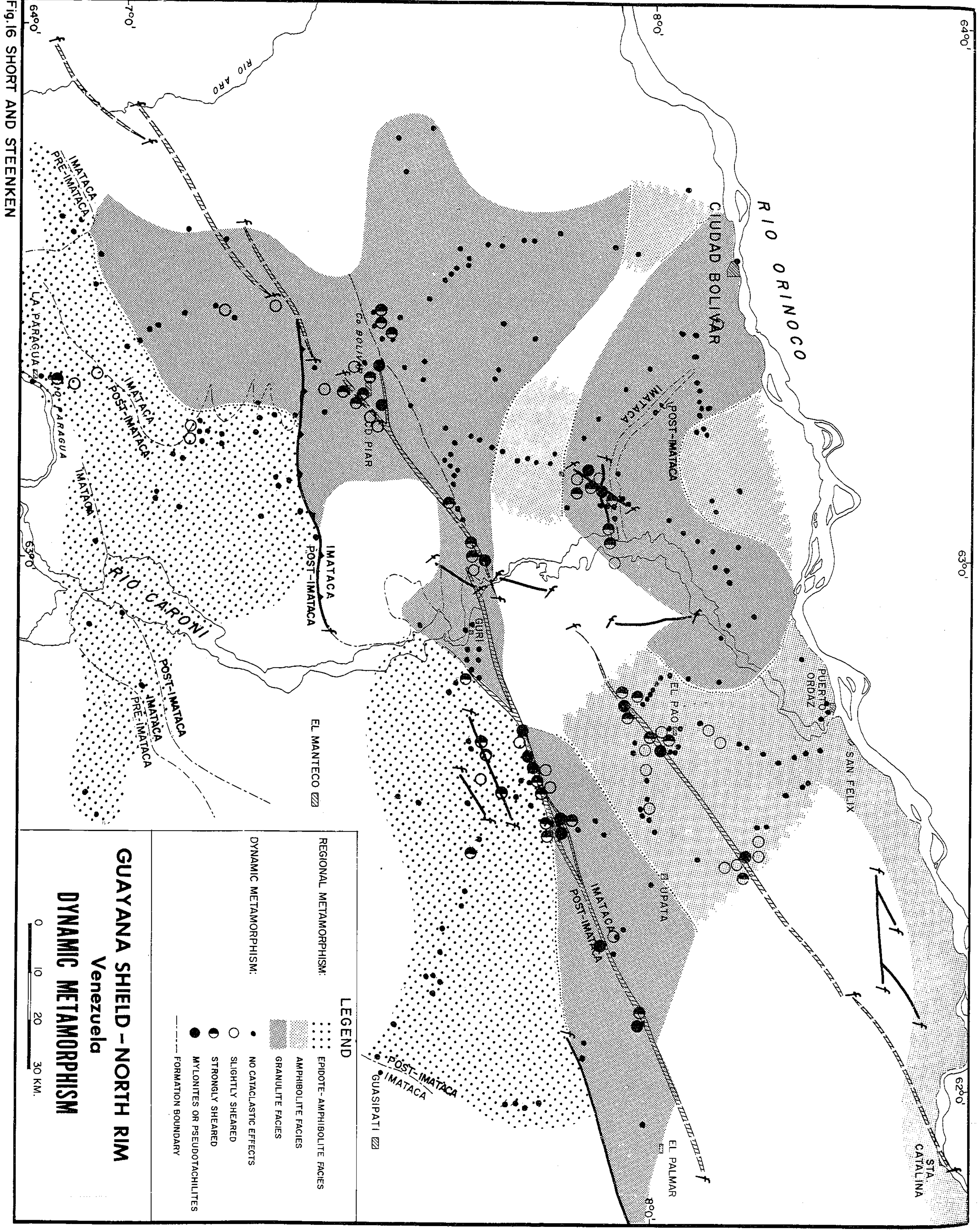


Fig.16 SHORT AND STEENKEN

the Río Gueche-Río Aro junction to the north slopes of Cerro Arimagua near Guri; the El Pao fault extending from southwest of San Antonio to Santa Catalina, and the Guri fault running from the south slopes of Cerro Arimagua and passing north of El Palmar. These faults were recognized first on the aerial photographs and have been checked in the field at many points. Where visited in the field they appear as alternating bands of mylonite, pseudotachylite, and strongly sheared gneisses and amphibolites, usually 1 km or more wide. Crushing can be detected in thin sections for a further 2 km or more on either side of this zone. Over extensive areas the original foliation of the rocks is wiped out and replaced by a lineation parallel to the direction of movement. Gradual transitions were observed from pseudotachylites via mylonites into sheared gneisses (Fig. 16). The strongly mylonitic zones often reach a thickness of tens of meters, an indication of the large movements which have occurred along these faults. The main mylonite zone often forms notable topographic features as seen east-northeast of Guri, and on the old Spanish trail from San Felix to Upata. In thin sections the irregular behavior of the metamorphic index minerals is striking; hypersthene and biotite often remained stable, even under conditions of extreme shear. Locally diaphtoresis occurs, lowering the degree of metamorphism (Fig. 14). In general no recrystallization has taken place in the sheared rocks. At least the last movements along the Bolívar fault zone must postdate the regional metamorphism.

A left lateral movement along the Bolívar fault system is demonstrated by horizontal slickensides in the mylonite zones and by adjacent drag folding observed near El Pao, near San Antonio, on the Upata-El Manteco road, and at Sh 2147 southwest of Ciudad Piar. Further evidence for the same movement is provided by the change in strike of features which approach the faults at an oblique angle. This is particularly well demonstrated west of Santa Barbara and northwest of Cerro Arimagua. Other evidence for the transcurrent character of the faults includes their long straight courses, the variable but normally steep to vertical dip of the fault planes, and by the orientation of adjacent fold axes, thrust faults and secondary faults.

The total displacement along the Bolívar fault system is not known although the size and extent of the faults suggest very large movements. Although the main displacement was lateral, some vertical movement has also occurred. For most of its length, the Guri fault marks the boundary between rocks of the Imataca Group and the Guri gneiss. The presence of possibly younger rocks south of the fault suggests a downthrow on this side. In addition, the fresh nature of scarps along the El Pao fault near El Pao and near Piacoa, suggests that young vertical movements have reactivated the old lines of faulting.

Three types of smaller faults were observed in the region. Faults running parallel or sub-parallel to the Bolívar fault system occur near Villa Lola, north and south of the Cerro El Panamo east of Guri, southwest of Piacoa, and on the northwest flank of Cerro Bolívar. The last of these faults has been intruded by a nonmetamorphic basalt dyke, samples from which show no sign of crushing. This intrusion must post-date the last major movement of the fault.

Faults oblique to the Bolívar fault system were observed in the Guri area and along the road to Ciudad Piar where it crosses the Río Claro synclinorium. The relationship of this group of faults to the Bolívar fault system suggests that they are secondary to the larger faults, mostly fitting the left lateral category.

The third group of faults are overthrusts which generally parallel the regional strike. The largest is the Santa Barbara overthrust, which along much of its length brings rocks of the Imataca Group in contact with rocks of the Guri Formation. Hot springs and some unusual mineralization along this fault suggest some recent reactivation.

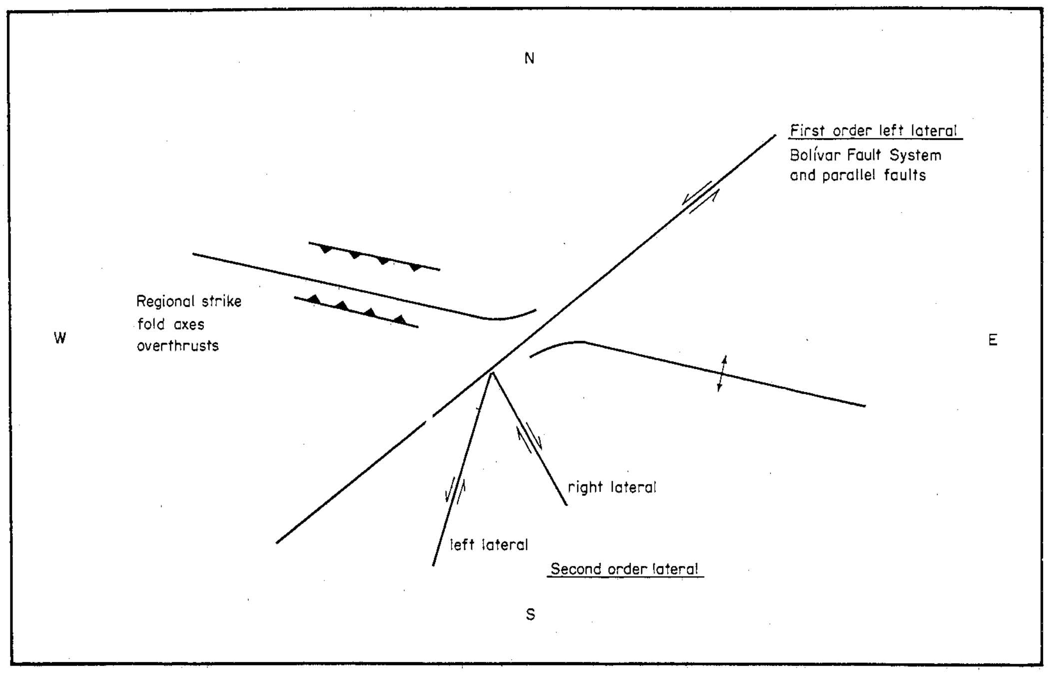


Fig. 17 Short and Steenken. Main structural elements associated with the Bolívar fault system.

TABLE I

VENEZUELA	MAIN TECTONIC EPISODES	BRITISH GUIANA
Quaternary Alluvium Mesa Formation	Time of periodic uplift	Demerara Formation, Coropina Formation, Berbice Formation } Corentyne Group
post-Roraima basic intrusives	Period of folding	Younger basic intrusives
	Uplift and erosion	Takatu Formation
Roraima Formation		Roraima Formation
Granites	Major orogeny	Younger granites
Guasipati Formation, Yuruari amphibolite, Guri gneiss }		} Barama-Mazaruni Assemblage
Imataca Group		No equivalent
pre-Imataca rocks	Major orogeny	Marudi Group
		South Savanna-Kanuku Assemblage

Table I Short and Steenken. Comparison of geological events in British Guiana and Venezuela.

The Río Claro overthrust shows displacement opposite to that of the Santa Barbara overthrust. The plane of this thrust was observed dipping 70° to the south in a railway cutting of the Puerto Ordaz-Ciudad Piar railway. A further east-west fault is throught to occur southwest of Piacoa. It is backed by a fresh looking escarpment suggesting recent normal faulting.

All of these faults together with the regional strike pattern can be brought into a single mechanical system following the principles demonstrated by Anderson (1942) and enlarged by Moody and Hill (1956). The elements concerned are shown on Figure 17.

Major tectonic units

The large northern tectonic zone characterized by complex open folds and thrusting to both north and south is considered to represent part of the central zone of the Imataca fold belt. This zone also includes the center of the Imataca Group depositional basin, the possibly syntectonic granites of La Encrucijada de Puerto Ordaz and northwest of Cerro Bolívar, the highly granitized zone without quartzite features, the belt of major gabbroic intrusions of El Pao and the zones of highest metamorphism.

The second tectonic zone with its more consistent trends presumably forms the southern flank of the Imataca fold belt.

The third and southern tectonic zone is thought to form part of the southern foreland of the fold belt. This is the only region not dominated by the Bolívar fault system, being characterized by a north-south strike. The manner in which this north-south trend is truncated by the ESE-WNW trend to the north suggests the former to be the older trend. This is supported by suggestions that the north-south trend originated in the pre-Imataca basement. Similar trends are reported to extend far to the southeast in British Guiana in areas of ancient basement rocks. Their extent immediately south of the present region is not known.

The northern flank of the Imataca fold belt presumably extends under the Llanos, north of the Orinoco.

CORRELATION WITH BRITISH GUIANA

The only known succession which is comparable to the present region is that of British Guiana. However, the continuation of the structural elements of British Guiana has to be sought to the south of the area of present investigation and, in addition, a large gap without photographic coverage exists between the eastern boundary of the present area and British Guiana.

The succession in British Guiana is shown on the provisional stratigraphic table given by McConnell (1958, p. 37). In this table McConnell correlates the Barama Group in part with the Imataca Series and the Mazaruni Group in part with the Pastora Series. The Imataca Group as described in this paper, typified by microcline gneisses and ferruginous quartzites, apparently does not occur in British Guiana (Stockley 1955, p. 59). From descriptions, however, it appears that parts of McConnell's Barama Group do bear affinity to the Guri and Yuruari Formations described above. For example, in the extreme north of British Guiana in the Amakaru-Aruka area Pollard (1956a, p. 40) describes rocks very similar to those of the Guri and Yuruari Formations. Pollard included the granite gneisses of the area in the "Basement Series" of British Guiana, but McConnell (1958, Fig. 3) prefers to place most of the outcropping rocks of northwestern British Guiana provisionally in the Barama Group.

With this evidence in mind, a comparison of geological events is given on Table I.

REFERENCES

ANDERSON, E.M. (1942): The dynamics of faulting and dyke formation with applications to Britain; Edinburgh.

BLEAKLEY, D. (1959): Status of investigations into the bauxite deposits of British Guiana; paper presented before the V Inter-Guiana Geological Conference, October 1959.

DALY, R.A. (1914): Igneous rocks and their origin; London & New York.

DUPARC, L. (1922): Las rocas verdes y los filones de cuarzos auríferos de El Callao, Venezuela; informes geológicos y mineros de las minas de oro de El Callao, Estado Bolívar. Ministerio de Minas e Hidrocarburos, p. 51.

HEDBERG, H.D. (1950): Geology of the Eastern Venezuelan basin; Bull. Geol. Soc. Am., Vol. 61, No. 11, p. 1173.

KING, L.C. (1956a): A geomorphological comparison between Eastern Brazil and Africa Central and Southern; Quart. Jour. Geol. Soc., London, Vol. 112, Part 4, p. 445.

———— (1956b): A Geomorfología de Brazil Oriental; Revista Brasileira de Geografía, No. 2, Año XVIII, April-June, p. 1.

LOPEZ, V.M., DAVEY, J.C., and RUBIO, E. (1939): Informe preliminar de la región sur del Departamento Antonio Díaz, Territorio Federal Delta Amacuro, Venezuela; Revista de Fomento, No. 19. (Reprinted in 1948 by Ministerio de Fomento, Servicio de Publicaciones).

McCONNELL, R.B. (1958): Provisional stratigraphic table for British Guiana; Geol. Survey of British Guiana, Annual Report for 1957; Georgetown.

MINISTERIO DE MINAS E HIDROCARBUROS (1956): Stratigraphical lexicon of Venezuela; Boletín de Geología, Special Publication No. 1.

MOODY, J.D. and HILL, M.J. (1956): Wrench fault tectonics; Bull. Geol. Soc. Am., Vol. 67, No. 9, p. 1207.

MORRISON, R.P. (1953): Informe geológico de la zona manganesífera del Cerro Guacuripia; Rev. de Hidrocarburos y Minas, Tomo 4, No. 13, p. 43.

NEWHOUSE, W.H. and ZULOAGA, G. (1929): Gold deposits of the Guayana Highlands, Venezuela; Econ. Geol., Tomo 24, No. 8, p. 797.

POLLARD, E.R. (1956a): Report on the Amakuru-Aruka area, Northwestern District; Geol. Survey of British Guiana, Annual Report for 1954; Georgetown.

———— (1956b): The geology of the Issineru-Enachu district, Mazaruni River; British Guiana Geol. Survey Bull. No. 29.

REYNOLDS, C.D. (1960): Sugerencia relativa a la sedimentación de cuarcitas ferruginosas; Memora, Tercer Congreso Geológico Venezolano, Tomo III, p. 963.

ROSENQVIST, I. (1952): The metamorphic facies and the feldspar minerals; Univ. Bergen Årbok 1951, Nat. Vid. R. 4.

STOCKLEY, G.M. (1955): The geology of British Guiana and the Development of its mineral resources; British Guiana Geol. Survey Bull. No. 25.

TURNER, F.J. and VERHOOGEN, J. (1951): Igneous and metamorphic petrology. London & New York.

ZULOAGA, G. and TELLO, M. (1939): Exploración preliminar de la Sierra de Imataca; Rev. de Fomento, Tomo 3, No. 19, p. 397.