GEOLOGICAL FIELD TRIP TO THE ISLAND OF LA ORCHILA [1]

by:

CARLOS SCHUBERT [2]

ITINERARY

July 12th, 1971

TIME

7:30 a.m.

Departure by airplane from Porlamar. Please have breakfast before leaving.

8:15 am.

Arrival at La Orchila. Reception by the military authorities of the Aero-Naval Base "Capitan de Navío Antonio Díaz".

9:00 a.m.

Station 1.—Cerro Walker. (20 min.).

Beach rock consisting of shell and coral fragments cemented by calcareous material. It forms a terrace of up to 1 m. elevation.

Station 2.Central Cerro Walker. (20 min.) .

Outcrops of schists and phyllites altered by the intrusion of granitic and granodioritic rocks (central part of Cerro Walker). Note the large feldspar crystals developed near the contact.

Station 3.—End of road to beacon. (40 min.).

From the end of the road to the beacon we shall walk on the metadiabase to the contact with the granitic rocks. The contact shows little alteration of the country rock (meta-diabase), but one can notice the fracturing and shearing due to the intrusion. Numerous dikes of aplite originate in the granitic rock and penetrate the metadiabase.

Station 4.—Eastern Cerro Walker. (20 min.). Meta-diabase (possibly various intrusions in dike form), itself intruded by dikes of meta-lavas.

12:00 m.

Lunch.

12:30 pm

Station 5.—Central and eastern hills. (20 min.).

Greatly weathered outcrops of serpentinites and peridotites. The relationship between these rocks and the others that crop out on the island are unknown, but it is suspected that they include the metamorphic rocks.

Station 6.—Eastern end of the Island. (10 min.).

Part of the metamorphic complex crops out here: garnetiferous quartz-epidote ortho-amphibolite, garnetiferous hornblende gneiss, and micaceous epidote gneiss and schists. They form a wide antiform with an east-west axis intruded by numerous pegmatite dikes.

Station 7.—Cerro del Medio. (45 min.).

From the road we shall walk south and partly up the flank of Cerro del Medio. There we shall see the contact (intrusive ?) between the metamorphic complex and a large mass of epidote gneiss which forms the central and highest part of the hill. Note the xenoliths near the contact.

Station 8. - (10 min.).

Schists and quartzites belonging to the metamorphic section crop out in this hill. These rocks are identical to those observed at Cerro Walker (Station 2), but less affected by contact metamorphism. Note the folds overturned to the south.

4:00 p.m.

Swimming at El Mangle.

5:00 p.m.

Departure for Maiquetia.

SUMMARY OF THE GEOLOGY OF LA ORCHILA AND GRAN ROQUE

by:

CARLOS SCHUBERT and PETER MOTISKA [3]

The islands of Gran Roque and La Orchila are part of a chain of islands which extends approximately in an east-west line, between Bonaire and Trinidad (Fig. 1). Their total area covers approximately 175 square km. and an igneous and metamorphic complex crops out on them. Of all the islands, La Orchila contains all the important rock types found scattered on the others. Gran Roque contains the best outcrops of the igneous complex.

Some important previous reports on these islands were published by SIEVRES (1898), RUTTEN (1931, 1940), AGURREVERE and LOPEZ (1938), ZULOAGA (1953) BOWEN (1964), and MALONEY (1971).

LA ORCHILA

The island of La Orchila is located approximately 50 km. east of the Los Roques archipelago and 160 km. northwest of Caracas (Fig. 1) . Its geographical coordinates are approximately: 11° 47' to 11° 55' North latitude, and 66° 05' to 66° 12' West longitude. It consists of a large island of triangular form, with a maximum diameter of approximately 9 km.; at its northeastern end there are a number of small islands of reef origin. Its surface is approximately 19.8 square kms. The largest island consists of three massifs near the northern edge (Fig. 2), surrounded by an extensive terrace of reef origin. The western massif is called Cerro Walker, at whose base the Apostadero Aero-Naval "Capitan de Navío Antonio Díaz" of the Venezuelan Navy is located. For convenience, the other two massifs are called central and eastern hills. The maximum elevation of approximately 135 m. is reached by Cerro Walker.

Cerro Walker and the eastern hills contain an association of metamorphosed basic intermediate. and acid rocks of igneous origin: ortho-amphibolites, meta-diabases, meta-lavas, orthogneisses, various kinds of schists, aplites and pegmatites. The central hills, in contrast, are entirely made up of ultrabasic plutonic rocks: serpentinized peridotites. This association of igneous and metamorphic rocks was called La Orchila Igneous-Metamorphic Complex. The presence of almandine amphibolite indicates that these rocks reached a somewhat higher metamorphic grade than that of the surrounding groups of islands (chlorite facies).

CHLORITIC PHYLLITES AND SCHISTS

These rocks crop out at the southern flank of the western end of Cerro Walker, in the form of southerly-dipping layers. They are on top of the granitic and granodioritic rocks described below, which are intrusive into these metamorphic rocks. The latter are finely foliated and deeply altered. The texture is equigranular, phyllitic to schistose, and very fine-grained. The micas are well oriented.

Mineralogy: they contain the following minerals: chlorite, sericite, feldspar, quartz, epidote, and opaques.

GARNETIFEROUS QUARTZ-EPIDOTE ORTHO-AMPHIBOLITE

The ortho-amphibolites crop out almost exclusively in the eastern hills, and are part of a metamorphic sequence which forms a wide antiform in the eastern part of the island. They may be aphanitic or phaneritic , fine to very coarse-grained. They all show schistose or gneissic foliation and their color is gray or dark green.

A complete report was deposited at the Direccion de Geologia, Ministerio de Minas e Hidrocarburos, Caracas (SCHUBERT and MOTICSKA, 1971).

Under the microscope, the texture is schistose or gneissic, equigranular, and very fine to coarse-grained. In some cases, mosaic structures among the plagioclase grains were observed.

Mineralogy: the following minerals are found: amphibole, 56% (40 - 70%); plagioclase, 23% (5—45%); quartz, 10% (2—20%); epidote, 6% (2 - 10%); chlorite (<1 - 15%); sphene, 1% (<1 - 2%); sericite (0 - 5%); garnet (0 - 5%); apatite (0 - <1%); opaques (0 - <1%).

GARNETIFEROUS HORNBLENDE GNEISS

These gneisses are lithologically similar to the amphibolites described above and are associated with them, but are much less abundant. They crop out as layers of variable

thickness within the metamorphic sequence of the eastern part of the island. Their texture is gneissic and equigranular, medium grained. Almandine is always present.

Mineralogy: These rocks contain the following minerals: plagioclase, 50% (30 - 65%); quartz, 30% (25 40%); hornblende, 11% (5—15%); epidote (<1 - 4%); garnet (<1 - 3%); colorless mica (0 - 5%); opaques (0 - 3%); biotite (0 - 1%); chlorite (0 - 1%); and occasionally sphene and apatite.

MICACEOUS EPIDOTE GNEISS AND SCHISTS

Very heterogeneous foliated rocks are grouped under this classification, as regards macroscopic aspect and mineral composition. They are part of the metamorphic sequence mentioned previously, and crop out as layers of variable thickness within it. They are phaneritic rocks, coarse-grained, with schistose to gneissic foliation, and light gray to dark gray in color. Under the microscope, the texture is equigranular of variable granularity, and schistose to gneissic. Mosaic, as well as poikilitic and porphyritic structures are rare.

Mineralogy: The following minerals are found: plagioclase, 46% (30 - 55%); quartz, 27% (10 - 40%); biotite (<1 - 2%); epidote (<1 20%); colorless mica (1 - 10%); sphene (<1 - 1%); apatite (<1 - 1%); chlorite (0 - 2%): opaques (0 - 1%).

META-DIABASE

The meta-diabasa crops out in the eastern part of Cerro Walker, as an irregular and relatively massive body, and also in the shape of tabular bodies interlayered with the metamorphic rocks of the eastern hills described above.

Under this classification are grouped rocks which show remnants of intersertal equigranular texture, sometimes slightly porphyritic. The general aspect is that of a hypabyssal rock. These rocks may be aphanitic or fine-grained phaneritic. Almost all show gneissic or schistose foliation, and their colors range from greenish gray to dark gray. Under the microscope, vestiges of equigranular intersertal texture are seen. In some cases it is slightly porphyritic. Grain size ranges from very fine to medium.

Mineralogy: These rocks contain the following minerals: plagioclase, 40% (25 - 70%); actinolite, 26% (2 - 50%); epidote, 16% (10 —20%); quartz (0 - 15%); chlorite (0 - 10%); sphene (0 - 3%); opaques (0 - 2%); calcite (0 - 1%) .

GRANITIC AND GRANODIORITIC ROCKS

This type of rock crops out in the western part of Cerro Walker, and is clearly intrusive in the meta-diabase. The evidences of intrusion are: granitic dikes which originate in the granitic and granodioritic rock and penetrate the metadiabase; the contact between the two types of rocks crops out in the northern flank of Cerro Walker and shows a very altered meta-diabase, and in some parts, granitic apophyses penetrate the meta-diabase. In the extreme western end of Cerro Walker, xenoliths of altered diabase were found within the granitic rocks.

These rocks are characterized by their conspicuous deformation and cataclastic texture. They are very acid and alkaline. Originally. they were granites and granodiorites, as shown by samples of less deformed rocks. The less sheared rocks are phaneritic, coarse to very coarse-grained, and porphyritic in many cases. They always present a slightly gneissic texture. As the deformation intensity increased, the rock acquired a schistose-laminated look. The colors are gray and light brown. Under the microscope, the texture varies in the way described before. In the less deformed rocks there appear quartz veinlets with mortar structure. In highly sheared samples a mineral differentiation into laminae can be observed. Bands of quartz with mortar structure alternate with mica-rich bands.

Mineralogy: The following minerals were found: plagioclase, quartz, potash feldspar, colorless mica, epidote, biotite, actinolite, sphene and opaques.

EPIDOTE GNEISSES AND SCHISTS

These rocks crop out in the southernmost of the eastern hills (Cerro del Medio in Fig. 2), forming a broad band which cuts the hill in an east-west direction. They are intrusive into the metamorphic sequence exposed in the eastern hills, and consist of micaceous epidote gneisses and schists, and ortho-amphibolites (described previously) . Evidence for the intrusive character can be found in the large amount of xenoliths of country-rock which occur near the contacts.

These are epidote-rich foliated rocks, which are associated with cataclastic zones. They are phaneritic, fine to medium-grained, foliated and sheared. Their color is dark green, green and brown-speckled white, and generally they are weathered. Under the microscope, the texture is medium-grained equigranular, schistose to gneissic. The minerals were oriented mechanically by shearing.

Mineralogy: The following minerals are found: quartz, 40% (30 - 45%); plagioclase, 36% (30 - 40%); epidote, 17% (12-25%); chlorite (0 - 15%); hornblende (0 - 5%); opaques (0 - 3%); biotite (0 - 1%); colorless mica (0 - 1%) ; and occasionally sphene and apatite.

PORPHYRITIC ORTHOGNEISS (META-LAVAS)

In the eastern part of Cerro Walker, intruding the meta-diabase, there are numerous dikes of meta-lavas, of various thicknesses (0.5 m. to several meters). At the eastern end of the mountain there are excellent examples of these dikes. These are foliated porphyritic acid rocks, which show vestiges of lava texture.

They may be considered as metamorphosed originally volcanic or hypabyssal acid rocks. In some cases it was observed that they are associated with the granitic and granodioritic rocks, since some dikes may be traced to the contact between the meta-diabase and the granitic rocks.

The rocks are phaneritic with variable grain size, rarely porphyritic, but always gneissic. Their color is generally light gray, but there are green to dark green varieties. Under the microscope their texture is porphyroidal and gneissic, with a microgranular matrix, fine- to very fine-grained. The phenocrysts and micas are oriented.

Mineralogy: the following minerals were found: quartz and plagioclase in variable amounts; colorless mica 10% (5 - 15%); epidote, 5% (1 - 10%); chlorite (<1 - 5%); sphene (<1 - 28%); apatite (1 - 1%); opaques (0 - 1%), and occasional secondary carbonates.

GRANODIORITIC APLITES

In the eastern hills, intruding the metamorphic sequence, there are numerous dikes and veins of aplite of various thicknesses, but generally not more than 10 cm. These are massive, medium-grained, phaneritic rocks, whose color is white, light brown or light gray. They are somewhat weathered. Their texture is equigranular aplitic, medium-grained, and allotriomorphic. In some cases the micas are oriented.

Mineralogy: the following minerals were found: plagioclase, 54% (45 - 60%); quartz, 26% (20 - 30%); microcline, 12% (7 - 20%); colorless mica, 4% (<1 - 10%); epidote, (<1 - 5%); biotite (0 - 5%); chlorite (0 - 1%); apatite (0 - <1%); sphene (0 - <1%).

GRANODIORITIC PEGMATITES

In addition to the aplite dikes, pegmatite dikes (of similar thickness) crop out in the eastern hills, which are intrusive into the metamorphic sequence. These are coarse~to very coarse-grained phaneritic rocks, almost white in color. They are somewhat weathered and their aspect is pegmatitic. Under the microscope, the texture is heterogranular pegmatitic, coarse-grained, without preferential orientation. The grains are allotriomorphic.

Mineralogy: the following minerals were found: plagioclase, 55%; quartz, 25%; microcline, 13%; sericite, 50%; opaques, <1%, and epidote, <1%.

EPIDOSITES

Epidosites are frequently found at the contacts between the metadiabases and the granitic rocks or granitic dikes. The original texture and mineralogy of these rocks were destroyed by the high grade of epidotization. Their high quartz content is remarkable. These rocks are aphanitic dense or fine-grained phaneritic, massive to slightly schistose, and their color is intermediate green. Under the microscope, the texture is equigranular, fine-grained, allotriomorphic, massive to schistose. The samples with a high content of calcite show a mosaic structure.

Mineralogy: these rocks consist of the following minerals: epidote (40 - 60%); quartz (15 - 50%); actinolite (5 - 15%); chlorite (2 - 15%); plagioclase (variable amounts); sphene (<1 - 5%), and occasional biotite, opaques, apatite and carbonates.

QUARTZ VEINS

Quartz veins are found in Cerro Walker and, in less quantity, in the eastern hills. These rocks contain more than 99% quartz, and their texture varies from one sample to another: equigranular fine-grained and well oriented, hetero-granular with mortar around the larger grains, or simply very fractured and with wavy extinction. The grain size varies between 0.1 and 10 mm. One sample contained muscovite, chlorite and opaques in amounts less than 1%.

SERPENTINITES AND PERIDOTITES

The central hills consist exclusively of serpentinites and peridotites. The original rock was a peridotite (lherzolite) of which a few remnants remain. Most of the rock is almost totally serpentinized.

As the samples are representative of all phases of serpentinization, their grain size varies from phaneritic coarse-grained, through partially phaneritic with a porphyroid appearance to dense, and aphanitie. The color varies from brown to dark gray or brown. These colors are not typical of the rock and are caused by the abundance of metallic oxides. Under the microscope, the texture is one of alteration; it shows mafic mineral grains, rounded or fragmented by serpentinization, in a matrix of antigorite with a felty structure, which sometimes appears like a mosaic.

Mineralogy: the following minerals were found: serpentinites, orthopyroxene, clinopyroxene, olivine, spinel, and opaques.

QUATERNARY DEPOSITS

Along the southern coast of the island, a beach rock crops out at sea level, which consists of coral and shell fragments of all sizes. Also along the southern coast and in some localities of the northern coast, for example at El Mangle (Fig. 2), there is a terrace at 1.5 to 2 m. elevation above sea level. It consists of a beach rock and reef rocks composed mainly of coral fragments. This terrace crops out at some localities in the central part of the island; along the southern coast and in the northern part of the island it is covered by coral debris which may represent a storm terrace.

STRUCTURES

The metamorphic sequence of the eastern hills was folded into a wide antiform, the axis of which strikes east-west (Fig. 2). The foliation of the metamorphic rocks was folded into numerous mesoscopie folds. The antiform is slightly overturned to the south, as indicated by the higher dip of the southern flank. The tabular body of epidote gneiss and schist, intrusive into the eastern hill (Fig. 2), probably is conformable and dips in the same direction as the country rock (to the south).

The foliation of the chlorite schists and phyllites exposed in the small hill of Angola (Fig. 2) is intensely folded. All these folds are overturned to the south. A small northwest-trending high angle fault cuts the hill. Thrusting to the southwest is the probable movement along the fault, as indicated by the drag of the foliation.

At Cerro Walker, the metamorphic rocks which crop out in the southern flank of the western end have a southern dip (Fig. 2). The contact with the granitic and granodioritic rocks is transitional, from altered schists and phyllites, through contact metamorphic facies characterized by the formation of large feldspar crystals (up to a few centimeters in length), to the phaneritie, porphyritie, slightly gneissic rock which represents the granite-granodiorite intrusion.

The contact between the granitic and granodioritic rocks and the meta-diabase crops out on the northern flank of Cerro Walker. It is characterized by a zone of intense alteration and cataclastic deformation. At the western end of the island the granitic rocks contain irregular xenoliths of country rock, probably altered chlorite schists and phyllites, and meta-diabase. The foliation of the granitic and granodioritic rocks strikes generally to the northwest.

The ultrabasic rocks (peridotites and serpentinites) exposed in the central hills show numerous joints and fractures, both vertical and horizontal, as well as along curved planes, which gives the outcrops a pillow appearance.

The relationship between the ultrabasic and all the other rocks which crop out on the island is not known with certainty, because there are no contacts between these rocks. Taking into account the stratigraphic and structural relationships of the ultrabasic rocks in the Caribbean Mountains (the closest to those described here), it is possible that they represent bodies intruding the metamorphic rocks.

GRAN ROQUE

The island of Gran Roque is located at the northeast end of the Los Roques archipielago (Fig.1), which lies approximately 150 kms. northeast of the mainland coasts. Its geographical coordinates are approximately 11° 57' North latitude, and 66° 40' West longitude.

It measures 3 km. in length and its maximum width is 1 km. Its surface is approximately 1.7 square km. Most of the northern shore of the island consists of cliffs, to the south and east there are lagoons salt flats, and mangrove swamps. The village of Gran Roque is located in the southeast end. The most prominent topographic features are three small hills reaching heights of 110-120 m. (Fig. 3); for convenience, these have been named eastern, central and western. They are separated by two small inlets of the sea.

Fig. 3 represents a geologic map of Gran Roque. Basically, it consists of a meta-diabase massif (central and eastern hills) and a meta-lamprophyre, spessartite massif. Both massifs are intruded by small quartz-diorite bodies, dikes and veins of granitie and alkaline aplites, graphic pegmatites and meta-lavas. This group of rocks has been named the Gran Roque Igneous Complex. Mineral evidences indicate that the oldest rocks (meta-diabase and metaspessartite) were regionally metamorphosed to the chlorite facies.

META-DIABASE.

The meta-diabases form the central and eastern hills, which reach elevations of 60-70 m. The rock is phaneritic, fine-grained, equigranular, massive, and dense. The color varies from dark gray to black; the weathered rock shows lighter colors. In outcrop the rock shows abundant fractures, many of which are filled with light brown material, probably phosphatized. In some cases there exists an incipient foliation, although this may be a jointing effect. Under the microscope, the texture is equigranular and typically intersertal. Occasionally slight orientation of the grains can be seen; the grains are xenomorphic and rarely hypidiomorphic. The quantity of mafic mineral always exceeds that of leucocratic minerals. A faint cataclastic texture is also evident.

Mineralogy: the principal minerals are: actinolitic hornblende, 51% (40-70%); plagioclase, 45% (40-50%); clinopyroxene (0-1O %); hematite and magnetite (2%), and accessory sphene. Occasional epidote is found.

META-LAMPROPHYRE (SPESSARTITE)

The western hill consists of a meta-spessartite massif. This rock is phaneritic, equigranular, coarse-grained, massive, and dark gray in color. Under the microscope the texture is ophitic, equigranular and coarse-grained. No preferential orientation of the grains is evident. The mafic minerals represent more than 50% of the rock.

Mineralogy: the rock is made up of the following minerals: actinolite, 39% (30 - 65%); clinopyroxene, 25% (14 - 30%); plagioclase, 35% (20 - 40%), and sphene and opaques as accessories.

QUARTZ-DIORITE (TONALITIC)

Quartz-diorite occurs as small bodies intrusive into the metadiabase and meta-spessartite. It crops out at the eastern end of the eastern sides of the small inlets, and at the western end of the island. At these localities it occurs as irregular bodies or wide dikes, with clear intrusive relationships with the country rock. Among these one finds apophyses penetrating the country rock (meta-diabase or meta-spessartite) and xenoliths of the latter within the diorite.

The rock is phaneritic, coarse-grained, equigranular, and massive. Its color varies according to the mafic mineral content, from almost white to dark gray. Under the microscope the texture is equigranular, coarse-grained, and with no preferential orientation. The proportion of mafic minerals varies widely, but does not exceed 30% of the rock.

Mineralogy: the main minerals are: plagioclase, 44% (35—60%); quartz, 36% (15 - 60%); hornblende, 10% (0 - 20%); biotite, 6% (1— 15%); the primary accessories are: apatite, orthoclase, zircon, and rutile; secondary accessories are epidote, chlorite, sphene, sericite, and carbonate.

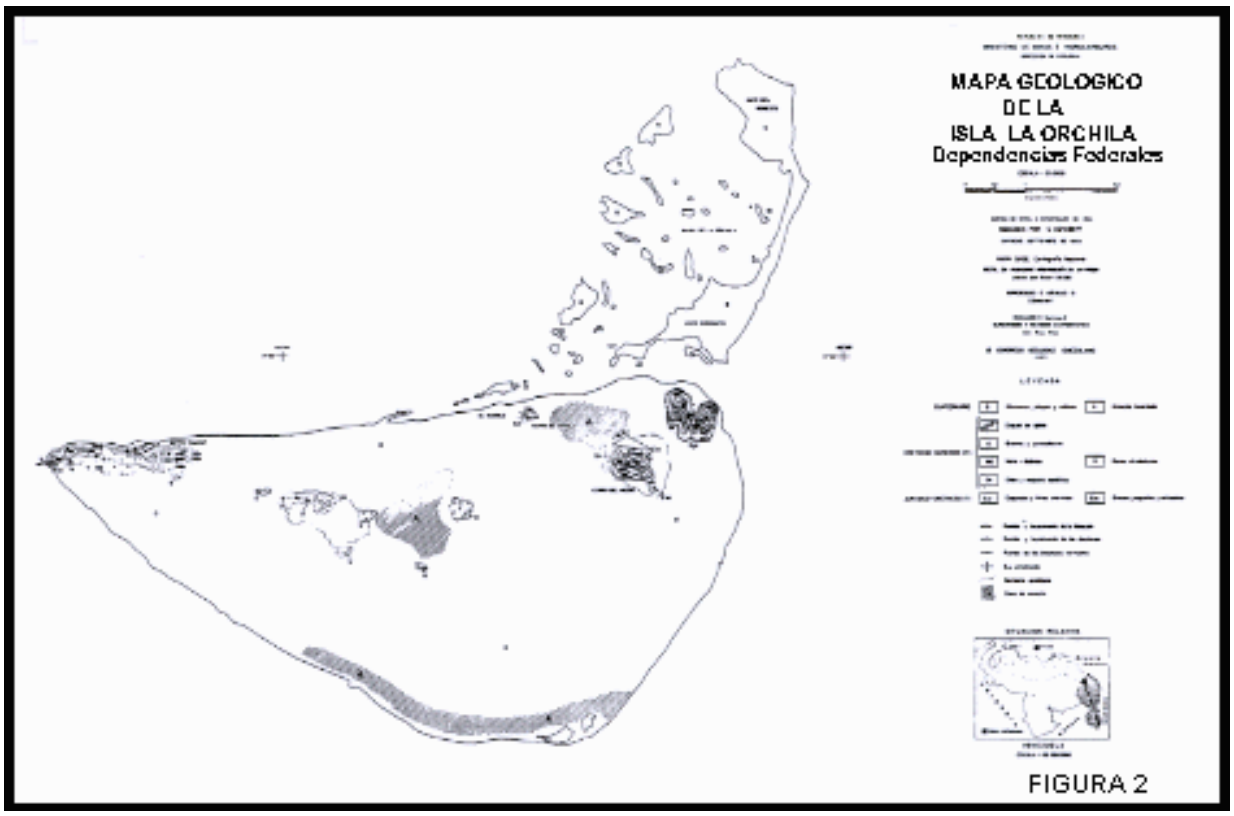

FIGURA 2

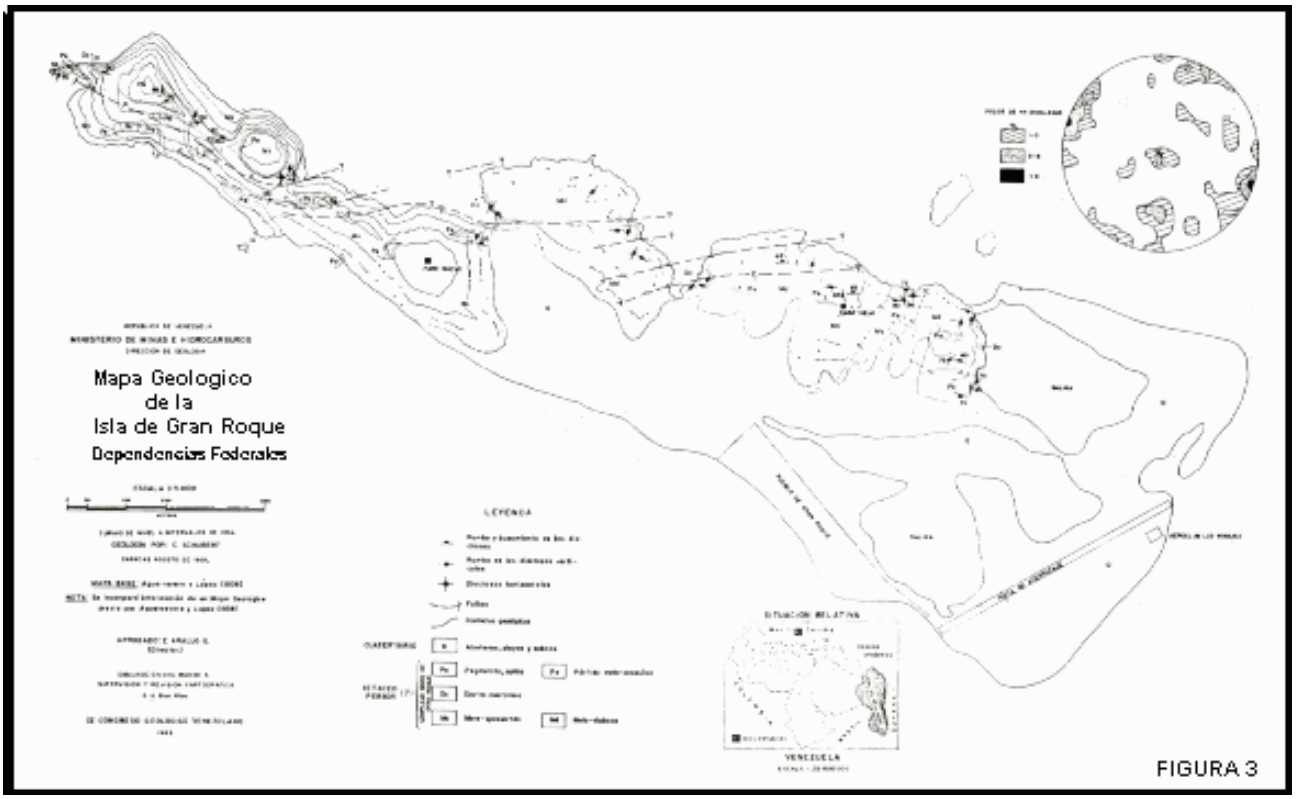

FIGURA 3

GRANITIC AND ALKALINE APLITES

These rocks crop out as dikes of variable thickness (a few centimeters to 1 m. or more), which are intrusive into all the rocks described previously (meta-diabase, meta-spessartite and quartz-diorite). They are most abundant in the western hill (Fig. 3), although there are some in the eastern hill.

The rock is phaneritic, fine-to medium-grained, equigranular and massive. Its color varies from white to light brown, depending on the state of alteration of the rocks. Under the microscope the texture is equigranular and granitoid, the grains are allotriomorphic, and do not show preferential orientation.

Mineralogy: the minerals present in this rock are: potash feldspar (perthite), 43% (40 - 60%); quartz, 36% (35 - 46%); plagioclase, 19% (5 - 35%); biotite, 1%; secondary accessories are: chlorite, pistacite, sphene and opaques.

GRAPHIC PEGMATITE

The pegmatite is found forming dikes of variable thickness (a few centimeters to 1 m. or more), and as a long and thick body in the western part of the western hill. These are intrusive into the meta-spessartite. The rock is phaneritic, coarse-grained, massive, and slightly altered. Its color varies between white, dirty pink and light brown. They are generally associated with the aplite dikes described previously. Under the microscope the texture is pegmatitic with graphic intergrowths of perthite and quartz; less frequently one finds myrmekitic intergrowths.

Mineralogy: the most common minerals are: potash feldspar, quartz, plagioclase; biotite and hematite are accessories.

ANDESITIC META-LAVA

At one locality m the eastern end of the eastern hill, there is a dike approximately 5 m. thick of a porphyritic rock with an aphanitic matrix. Its color is brown to light gray, and it contains pink phenocrysts of irregular form. The rock is somewhat weathered and porous due to leaching. This dike is intrusive into the meta-diabase. At both contacts and within the porphyry there is a thin zone (30-50 cm.) of alteration. Under the microscope, the texture is porphyritic, with ideomorphic phenocrysts of medium- to coarse-grain size. The matrix is holocrystaline, pilotaxitic, and very fine-grained. It shows a flow texture.

Mineralogy: The rock consists of the following minerals: phenocrysts composed of plagioclase, hornblende and quartz; matrix consists mainly of plagioclase; apatite and hematite are accessories.

ORTHO-AMPHIBOLITE

Ortho-amphibolite occurs at one locality which corresponds to the contact between a quartz-diorite dike and the meta-spessartite, at the western end of the island. At the same time, it appears to be associated with a fault zone. The rock is aphanitic and shows good exfoliation. The texture is equigranular, fine-grained, with a tendency to form a mosaic texture. The grains show preferential orientation.

Mineralogy: the rock contains the following minerals: plagioclase, 55%; hornblende, 45%; opaques, 1%.

PHOSPHATIC ROCKS

At numerous localities, especially in the southern flank of the western hill, there are deposits of phosphatic material. At one locality approximately 200 m. north of the small islands at the southwest end of the island (Fig. 3), there was an extensive deposit, which has been mined and of which only remnants exist. The phosphatic material has a light green color, is amorphous, and occurs in veins throughout the country rock, generally the meta-spessartite. According to AGUERREVERE: and LOPEZ (1938) the phosphate deposits were produced by phosphatization of the country rock (meta-spessartite and pegmatite-aplite) due to the action of phosphoric acid derived from the guano. These solutions penetrated fractures and joints and replaced the rock from the outside to the inside.

Through thin section analysis it was determined that originally the phosphatic rocks were granitic rocks, in which the weathered feldespar were leached and replaced by phosphates. The phosphates occurs both as crystalline and amorphous material. Dhalite (carbonated calcium phosphate) is one of the anisotropic phosphates present. The only unaltered material remaining is quartz. It is intensely fractured and shows wavy extinction.

QUATERNARY DEPOSITS

At the eastern end of the eastern hill there are good examples of beach rock. It consists of a meta-diabase conglomerate cemented by a reddish-brown ferruginous and slightly calcareous material. This rock occurs mainly at sea level, but reaches elevations of 1 m. At the southern flank of the western hill there are terraces made up of meta-diabase and meta-spessartite conglomerates, at elevations of 3 to 5 m. above sea level. They are cemented by calcareous material with numerous coral fragments.

STRUCTURES

The most prominent structures in the rocks of Gran Roque are the joints. In Fig. 3 they are represented in a stereogram. As can be seen, there is a prominent vertical joint system that strikes N 18° E. In addition, there are three less prominent systems: N 62° W, vertical; N 88° W, 52 N; and horizontal.

Other structures are associated with igneous contacts. At the contacts between the quartz-diorite and the meta-diabase there are inclusions of the latter within the former. These inclusions or xenoliths have diverse forms, but are generally angular and occur near the contact (in some cases they are still connected to the country rock). They show concentric alteration zones. Apophyses of diorite penetrating the country rock (meta-diabase) were also observed; some of these continue as small dikes or veins.

In the quartz-diorite and andesitic meta-lava dikes, chill zones were observed. Near the contact, the dike rock has a progressively finer grain size, and at the contact it is completely aphanitic. At the highest part of the western hill there is an almost horizontal pegmatite dike which cuts the hill, producing an anular outcrop (Fig. 3). West of this locality, there is a roof-pendant, that is, a remnant of altered meta-spessartite belonging to the upper contact with the intrusive pegmatite.

The island is cut by several faults (Fig. 3). The topographic expression of these faults consists of incisions striking approximately N 70° - 80°E, which form small canyons in the inlet north of the village of Gran Roque and in the northern flank of the western hill. In one of these incisions a clear fault zone was found, which consists of approximately 1 m. of fault gouge between two vertical fault planes. No evidence of movement was observed. It is possible that the phosphate-rich zone at the southwestern flank of the island may be associated with one of several faults.

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[2] Intituto Venezolano Investigaciones Cientificas.

[3] Ministerio de Minas e Hidrocarburos.