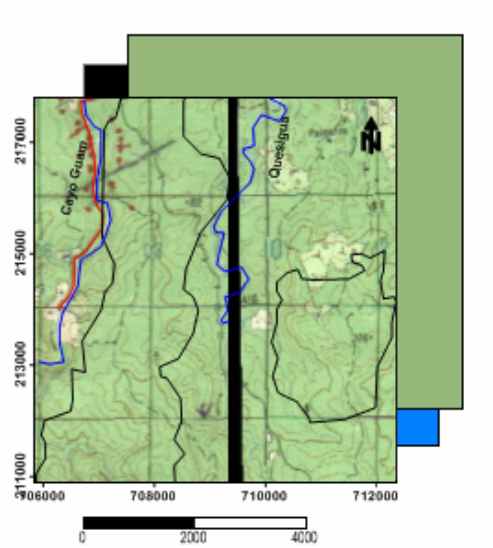

Tectonic study of the hydrographic basins "Cayo Guam and Quesigua"*

Ivanis Campos Girón

Carrera: Ingeniería Geológica.

Instituto Superior Minero Metalúrgico (Cuba).

Abstract: The main objective of this work is to characterize the hydrlgrafic basins of Cay Guam and Quesigua from the tectonic point of view. Parallel to this work, aerial photographic interpretation was carried out in order to identify the existing alignment and disjunctive structures. Preliminary information and field data were processed and interpreted; based on which diagrams, maps, graphics and tables were generated to allow the characterization of the hydrographic basins applying image processing and geologic mapping techniques.

Key words: Tectonic; hydrographic basin; Cayo Guam; Quesigua.

Estudio tectónico de las cuencas hidrográficas Cayo Guam y Quesigua

Resumen: El trabajo tiene como objetivo fundamental caracterizar tectónicamente las cuencas hidrográficas Cayo Guam y Quesigua. Paralelo al trabajo de campo se realizó la fotointerpretación aérea, con el objetivo de determinar las alineaciones y estructuras disyuntivas presentes. Se realizó el procesamiento e interpretación de la información preliminar y los datos del trabajo de campo, con los que se lograron realizar una serie de diagramas, mapas, gráficos y tablas; que permitieron la caracterización tectónica de las cuencas hidrográficas. Para la confección de estos se emplearon técnicas de procesamiento de imagen y la cartografía geológica.

Palabras clave: Tectónica; cuencas hidrográficas; Cayo Guam; Quesigua.

Introduction

The investigated region is geographically situated east of Moa, province of Holguín. It is bounded on the north by the Atlantic Ocean, on the south by the municipality of Yateras, on the east by the municipality of Baracoa and on the west by the municipalities of Sagua de Tánamo and Frank País, situated between X: 706 000 -712 350 according to the Lambert coordinates. The area is located on the Cuban Western Bloch; which is characterized by great complexity from the geologic and tectonic points of view as revealed by the seismic activity.

Major fault systems

According to previous investigations, it has been determined that there are 4 major fault systems in the region according to Rodríguez (1998) y Domínguez (2005), largely affecting the area. The origin of the first system is associated to the cessation of subduction as a result of collision of the insular arc with the continental margin onto which ophiolite assemblage are emplaced, for which the faults of this system are spatially and genetically related to the boundaries of mafic and ultramafic bodies. The faults of this system often appear to be hidden and cut off by younger systems as well as strong crusts of weathering developed in ophiolite assemblages. Most of these faults

are passive and their presence can be mainly observed by the aligned and abrupt contact among different lithologies.

The diploma work developed by Mailiy Barrera and Iván Barea in 2008 stated the existence of two faults belonging to this system; which had not been described or mentioned before: North and South Arc Faults. The inclusion of these faults to this system is attributed to its arc morphology; which corresponds to faults having low dip angles; which are developed under strong compressive conditions and due to the fact of coinciding with abrupt and curve contacts between gabbros and hyperbasites.

North Arc Fault: This structure has been proposed in previous investigations (Rodríguez, 1998) but it has not been characterized. This structure occurs in the shape of a concave arc to the south, in the direction of N34ºW and N60ºE to the westernmost and easternmost parts; respectively. This structure appears to be associated to the placement of ophiolite which generates a relief in the form of scales.

South Arc Fault: It occurs parallel to the North Arc Fault. This structure is semicircular in shape and it extends from the affluents of the Quesigua River into Potosí, and it is bordered by the same structures, with direction of N32ºW and N80ºE in its straightest ends.

Cay Guam Fault: It stretches from the top of the Cay Guam River to the affluent of the Quesigua River with a direction of N15ºW. It is cut off and displaced by a group of younger structures northeast and northwest.

Quesigua Fault: It develops through an arc with its concave portion heading east northeast; maintaining a direction of N10ºE in its northern part where it is straightest and of N40ºW to the south. It stretches from the coral reef up to intercepting Jiguaní River in the southeast of the working site.

El Medio Fault: It extends from the north of the Semillero river to the Quesigua river with a direction of N40ºE. It is dislocated by a younger structure from north-south in its northern part. Based on the criteria taken into account in this investigation, it can be corroborated that the structure proposed in previous investigations is a strip-slip.

Morphotectonic blocks and microblocks present in the investigated area

According to previous investigations, the investigated area is located in three morphotectonic blocks. The blocks are as follows: El Toldo, Cayo Guam and Cupey

(Rodríguez, 1998). In subsequent investigations, the latter has been divided into six morphotectonic blocks based on the characteristics of the main active faults present in the area.

Cayo Guam Block: It occupies a small portion of the investigated area. It is in the shape of wedge between the block El Toldo and the microblock El Gallito. This block is bounded by Cayo Guam´s and Quesigua´s faults (Rodríguez, 1998); which are cut off and displaced northeast and northwest. This block acts as an intermediate descending step in relation to El Toldo block.

The morphometric values vary from 50 to 300 meters in the area, being highest to the southern portion, reaching more than 350 meters. This is the case of the maps of isobasites of the order of two and three.

The main tectonic structures crossing this block are to the northeast and cutting off limit faults of blocks for the most part, However, according to the investigations carried out on the western and eastern margins of the Cay Guam and Quesigua rivers, two northeasterly directions were identified: one being N5ºE and the other one N78ºE. The only prevailing northwesterly direction was the northeast of Monte Lejo; which can be conditioned by a structural knot formed when two northeastern systems and one north-southern system cross each other.

The fluvial network is quite dense. Its rivers flow in the form of a radius from the center of the block to the periphery. Low slopes are predominant, with values between 0º and 15º; however, the slopes in the south reach up to 40º.

Block El Toldo: This block having the greatest lifting movements is bounded by the Cay Guam block on the north and the Feni´s microblock on the east. It is bounded in its westernmost part by the Fault of Quesigua.

In the map of isobasite of the order of 2, a wide range of values from 100 to over 700 meters can be observed in this block. Contrasting morphometric values can be found in the border zone with the Cay Guam block. In the isobasite of the order of 3 the isobasas vary from 100 to 650 meters. The slopes mostly range between 10º-30º, having peak values of 50 o in the area bordering the Cay Guam block.

The fluvial network flows from south to north because the highest elevations are located in the south.

According to the data obtained from the residual relief maps, this block has a great amount of eroded rocks towards the central part. This can be corroborated by the results obtained from the other morphometric maps and specially the one of different orders where the isobasas have values between -50 up to 150 meters. This shows that its movement differs from that of Cay Guam. The fault of Cay Guam extending from its north side to its centre can be found among the structures cutting the block.

Cupey Block It is located in the westernmost area from the Quesigua Fault to the coordinate 721 000; which is taken as the conventional border of the investigated area.

The morphometric values of this block are variable. On the northern and Eastern parts, the isobasas of the second order are 50 to 150 meters, between 50 to 100 meters for the third order and beyond 300 meters in the south. The slopes are low to the north; however, high slopes can be observed in the south; where they reach up to 50º.

According to the morphometric data and varied behaviour of the Cupey block, it was concluded that it is divided into six microblocks: Cocalito, El Gallito, Cañete, El Feni, Jiguaní and La Teresa.

The microtectonic study revealed the differences between the north and the south of the Cupey block, from the El Medio Fault N40ºE; which divides the block into two sub-blocks with cracking heading N50ºW-N30ºW and N50ºE -N90ºE for the Cupey Northern Sub-block and Cupey Southern Sub-block; respectively. This together with some morphologic and field elements; such as, the rotation in the direction of the dividing lines and the existence and displacement of escarpment show that the Northern sub-block turned counter clockwise in respect of the southern block with an angle of approximately 30º.

El Gallito Microblock: It is, in the shape of a wedge, north of the studied area, between the Cay Guam Block and the Cocalito Microblock. The structures bordering this block that can be mentioned are: Quesigua and El Medio.

The lithologies characterizing it are the hyperbasites which take up a large area, the gabbros in its central part and the quaternary deposits to the north. Geomorphologically, two major landscapes are predominant in this area: mountainous and pre-mountainous low flattened and slightly dissected.

The morphometric values are quite regular; which range from 50 to 200 meters for the isobasites of the order of two; however, values were lower for the isobasites of the order of three and are more aligned to the structure; which is its western border.

The fluvial network is homogeneous. All its rivers flow from south to north.

The slopes are low, ranging from 0^0 to 10^0; however, in the south they reach up to 30^0.

Cocalito Microblock: It is situated between the microblocks El Gallito, El Feni and La Teresa. El Medio, Potosí and Arco Sur are among the structures bordering this block, which is cut off by the Northern Arc Fault.

This block has outcrops of hyperbasites mainly, which occupy a large area. Geomorphologically, two major landscapes are predominant in the area> mountains and pre/mountains, low flattened and slightly dissected.

The map of the isobasites of the order two shows morphometric values between 50 and 250 m, and are higher towards the southern part of the microblock, where there are contrasting changes in the isobasas at short distances. However, the pattern is not the same in the older map of isobasites. These are parallel to the El Medio Fault. In turn, they contrast with the Quesigua structure, which are between 50 to 200 m. The isobasites have a similar pattern in the map of difference of orders although a negative relief anomaly can be observed in the south. It can reach up to -50 m, which is associated with the differentiated microblock movements.

A higher degree of river bed erosion can be clearly observed in the residual map of the order two towards the south of the microblock; which indicates that it is increasing. Likewise, the map of isobasite of the order three indicates a greater riverbank depth.

El Feni Micrioblock: It is situated in the shape of a wedge between El toldo and La Teresa and Cocalito microblocks and this is the largest microblock in the entire area of study. It is located between the Quesigua and Potosi bordered by the Southern Arc Fault in the north.

It is mainly made up of gabbros although it contains hyperbasites in the south-estern part. The western border of the microblock is made up of a linear contact between the two lithologies.

The fluvial network is mostly dendritic. Quesigua and Potosí rivers are in the northwestern and northeastern parts, flowing south north, with the exception of the Feni which is southeast. The map of isobasites of the order two are indicates morphometric values of 100 to 450 m and above towards the east. The isobasas are parallel to the structure, bordering on it to the east west. By contrast, the isolines are perpendicular to the bordering structures in the third order except for the southwest part of the microblock.

In the residual relief maps the pattern is similar in the entire area. Erosion tends to be more extensive to the south. The prevailing slopes in this block range from 0º-10º. There are slopes above 30º in the central and southern parts.

Cracking measurement analysis and interpretation

A total of 753 deposit elements in six outcrops were measured for the cracking analysis and interpretation.

Análisis e interpretación de las mediciones de agrietamiento

Para el análisis e interpretación del agrietamiento se midieron un total de 753 elementos de yacencia en seis afloramientos.

The rosette plot in Figure 1 shows that cracking occurs NW and NE mainly, the latter is the most prevalent in the studied area, N40ºE, E-W, and secondarily N30ºE and N60ºE. In the NW less frequent directions are N15ºW, and secondarily associated are N30ºE and N60ºE. This can reflect a gradual change in the main direction of the stresses that affected the region. Three major cracking families and corresponding deposit elements are represented in the contour and drawing plots; respectively.

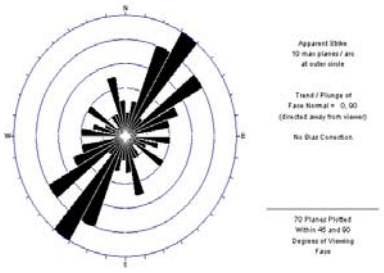

Figure 1. Rosette Plot Cay Guam A1.

As shown in the rosette plot (Figure 2), the main cracking directions are N35ºE, N45ºE as secondary, N75ºW represented as less frequent directions and NS with a small representation.

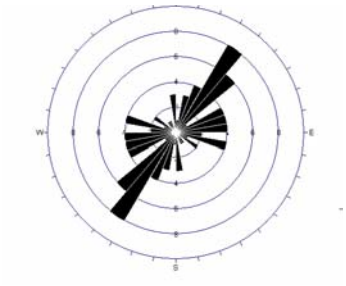

Figure 2. Rosette Plot Cay Guam A2

As shown in the rosette plot (Figure 3), the main cracking directions are E-W, N45ºW and N35ºW as associated; which can be attributable to the drawings of the enjambment of tectonic structures that affected the region. This system is classified as a possible oversliding fault. This process is also reflected in Quesigua outcrop rosette plots A2 and A3. It is less representative in A2. The three major cracking families and the corresponding deposit elements are represented in the contour and drawing plots; respectively.

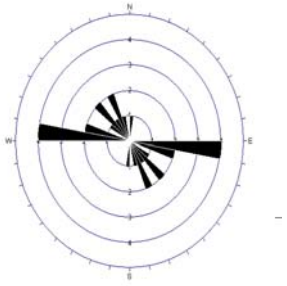

Figure 3. Rosette Plot Cay Guam A1.

As shown in the rosette plot (Figure 4), three maximum frequencies of appearance with the morphoalignments. The first is N25ºE; which is the main cracking direction, the second is N35ºE and the third one is N55ºE; which are mainly related to the slope and fluvial network alignments present in the SW of the area and with the system of faults affecting the region.

Four major cracking families and the corresponding deposit elements are represented in the contour and drawing plots; respectively.

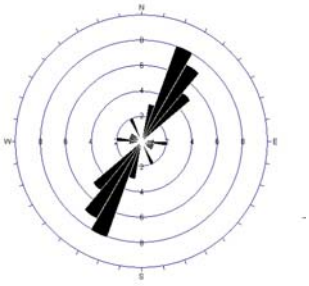

Figure 4. Rosette Plot Cay Guam A2.

As shown in the rosette plot (Figure 5), the main cracking directions are N50ºE and secondarily associated are N20ºE, N75ºE and towards NW, N65ºW dominating and N35ºW with a small representation. This might be related with a transform fault that displaced the contacts with the sliding mantle. Five major cracking families and the corresponding deposit elements are represented in the contour and drawing plots; respectively.

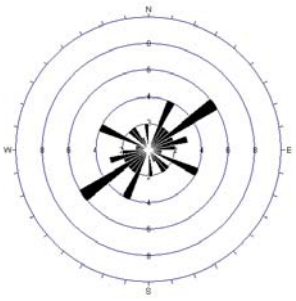

Figure 5. Rosette Plot Quesigua A3.

After analysing and interpreting measurement results based on rosette plots, stress diagrams and Wulff falsilla, the main stress directions which resulted in the faulting of rocks, as can be observed in Figure 6.

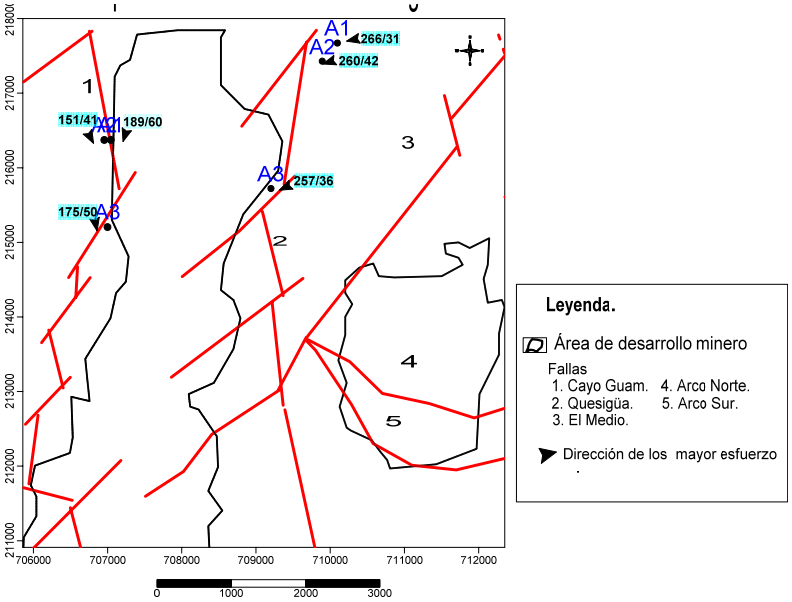

Figure 6. Tectonic Map of the Area of Study shows the Directions of Tectonic Stresses, Scale 1: 25 000.

Conclusions

Based on the interpreted field data and the information obtained from the methods used in the investigation, the results are as follows:

The investigated area is characterized by predominance of disjunctive structures; which took place in four different geotectonic periods conditioned by regional events that have affected the Cuban Eastern Block.

The main directions of the existing structures in the investigated area are northeast, northwest, and predominantly N40ºE and N15ºW.

The main directions of major stresses were established; which are associated to the structures present in the area of study. The main stresses of Cay Guam Fault are 151/54, 189/60 and 175/50 in different locations, coinciding with the north-westerly direction of the fault.

The major stresses of Quesigua Fault are 266/31, 260/42, 257/36 in different outcrop locations, coinciding with the north-easterly direction of the fault.

Tectonic displacement affecting the rocks of the area is to the northeast and northwest.

Bibliographical references

BARRERA, M. & BAREA, I. 2008: Estudio morfotectónico del área enmarcada por las concesiones mineras La Delta, Cantarrana y Santa Teresita para el establecimiento de los dominios geomorfológicos. Trabajo de diploma en opción al título de ingeniero geólogo. Instituto Superior Minero Metalúrgico. Moa.

DOMÍNGUEZ, L. 2005: Morfotectónica del área comprendida entre el poblado de Yamanigüey y la ciudad de Baracoa con vista a la planificación turística. Tesis de maestría. Instituto Superior Minero Metalúrgico. Moa.

RODRÍGUEZ, A. 1998: Estudio morfotectónico de Moa y áreas adyacentes para la evaluación de riesgos de génesis tectónica. Instituto Superior Minero Metalúrgico. Moa.

* Tutored by: Dra. Alina Rodríguez Infante and Ing. Iván Barea Pérez.