Geological Report No. 31

GEOLOGY OF THE LLANOS FRONT RANGES

IN THE

TAMARA-TEN REGION AND NEAR LABRANZAGRANDE (BOYACA)

By P. Hess

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Tame, November 1938.

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Earlier reports:

G.R.No.7, Hubach, Renz and Valencia, Geological Reconnaissance of the front ranges of the Eastern Cordillera in Boyacá.

Hubach, Monthly Report over April 1938.

Hubach and Morgan, Explanation of the Cross Section Yopal-Puente Reyes, September 1-6, 1938.

G.R.No.21, R. Wheeler, Río Cravo Sur-Río Niscota

P. Hess, Monthly Report March-April 1938

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GEOLOGY OF THE LLANOS FRONT RANGES IN THE TAMARA-TEN REGION AND NEAR LABRANZAGRANDE (BOYACA)

By P. Hess

A. INTRODUCTION

Field work has been done between June first and September 30th, 1938, and has been hindered considerably by heavy rains.

Between the first and 12th of June, the writer studied the Cretaceous stratigraphy near Labranzagrande and El Morro, where Hubach and Renz had worked before. On the 19th of June he began working in the Ten region, where Dr. Hubach introduced him into the geology of the Río Casanare section and on the first of August he proceeded into the Támara region. The geological studies in the region of Támara and Ten comprise the structures West of the Nunchía syncline in the area between Río Pauto in the South and Quebrada Guaraque (a northern tributary to Río Ariporo) in the North and form the northern continuation of the writer's earlier studies in the Nunchía region (see report March-April 1938).

The results of the writer's monthly reports over June and July 1938 are compiled in the present report.

B. STRATIGRAPHY

Generally speaking, the front ranges between Río Cravo Sur and Río Casanare can be divided into Hubach's Tauramena and Medina Belts (see G.R.No.7). The Tauramena Belt comprises the hills and mountain ranges which follow the border of the Llanos plain and which are formed of Tertiary sediments; the main structural feature of the Tauramena Belt is the broad Nunchía syncline. The higher mountain ranges West of the Tauramena Belt, where Cretaceous sediments are exposed, constitute the Medina Belt, which is composed of a number of complicated anticlines.

The sequence which has been studied in the Támara-Ten region reaches from the Quaternary down into the middle Guadalupe (Abrupta series). In the El Morro-Labranzagrande area exposures reach down into the lower Villeta (Fómeque series).

Changes of facies occur principally in a SE-NW direction, that is to say, perpendicular to the general strike. The thickness of the Cretaceous and the Limbo series particularly seems to increase rapidly toward the West.

Figure 1 gives a synopsis of the stratigraphical subdivisions dealt with in this report.

In most cases and especially in the Cretaceous the thicknesses have been estimated only because it would have cost too much time to measure sections in the deep gorges which are impassable in many places.

1) Fómeque Series (Lower Villeta, Upper Hauterivian to Albian, according to Hubach).

The Fómeque series is exposed in the core of the Siamá and the Labranzagrande anticlines. There it consists of black, sandy shales which are partly micaceous, sometimes pyritic and sometimes slightly calcareous and which contain ferruginous limestone concretions, sometimes also marly sandstone layers. Thickness: 600-800 metres (?).

In the Quebrada Santos (between El Morro and Labranzagrande) Dr. Hubach has found marine fossils in this series, namely, Ammonites, Trigonia and fish remains (see report Hubach-Morgan, P.R. Aug.-Sept.1938).

2) Une Series (Middle Villeta, Cenomanian?, according to Hubach).

The Une series forms both flanks of the Siamá and of the Labranzagrande anticline, also the Yopos syncline. Its thickness is about 600-800 metres or more. It consists mainly of thick layers of hard, quartzitic sandstone of light gray colour. These sandstones vary between fine, medium and coarse grain and are often crossbedded. Frequently the weathered sandstone shows rusty brown dots in the interior and often it is covered by a greenish yellow film of sulphur. Viewed from the side, the sandstone layers appear finely striped by dark zigzag lines which follow the bedding planes ("Drucksuturen").

The sandstone layers are separated by layers of gray to black shales which are generally micaceous, often sandy and locally pyritic, sometimes containing many small, black concretions. Usually these shales are coaly, at times grading laterally into coal. It seems that the shales are best developed in a certain zone somewhere in the middle of the Une series.

Well preserved plant remains of the genera Equisetum and Weichselia occur frequently in the shales. A fossil horizon containing lamellibranchs and gastropods is exposed above the Mantas overthrust on the El Morro-Labranzagrande trail. The plant remains have shiny graphitic skins and the coals give the impression of being somewhat anthracitic or graphitic, which makes the writer believe that the Une series of the Labranzagrande and the Siamá anticline is slightly metamorphosed.

3) Chipaque and Albarracín Series (Upper Villeta and Lower Guadalupe)

A thick sequence of shales is exposed between the Une series and the Abrupta series in the Colorada syncline north of Labranzagrande. According to Hubach, the lower part of this sequence represents the Chipaque series and its upper part the Albarracín series. (See Hubach-Morgan, op.cit.). The sequence consists of bluish grey to dark grey shales with thin intercalations of dark grey, fine grained sandstone. There occur also striped shales and sandstones.

At Casa Contento (1260 metres) a layer of 2 metres of bituminous limestone full of lamellibranchs crops out (see Encl.II). Higher up two limestone layers of the same sort are exposed at 1380 and 1520 metres, respectively, but the upper one does not contain any fossils. Taking the

limestone of Casa Contento as marking the Chipaque-Albarracín contact, the thickness of the Chipaque series is estimated as 400-500 metres (?) and that of the Albarracín series as 300-400 metres (?).

4) Abrupta Series (Middle Guadalupe, Coniacian, according to Hubach).

The presence of intercalations of hard, bluish-grey shale, of sandy, fossiliferous limestone and of chert distinguish the Abrupta series from the Túnel series. Good exposures have been observed at the Tablon of Labranzagrande (Encl.IVc) and in the core of the Gore-Muchilera anticline on Río Ariporo (Encl.Va). The thickness exposed in the Muchilera anticline is 200-300 metres and on the Tablon about 200 metres.

The series consists of massive layers of hard, quartzitic sandstone, usually light grey and fine grained, alternating with layers of oyster-bearing, sandy limestone and with layers of hard, bluish-grey shale which sometimes have a striped appearance. On the Muchilera anticline the limestones are bituminous and contain different kinds of lamellibranchs besides the oysters. The shales contain a fossil horizon in the Muchilera anticline with lamellibranchs, pholads, corals and fish teeth. Fish remains occur also at the Tablon (Encl.IVc).

5) Túnel Series (Upper Guadalupe, Coniacian, according to Hubach).

The Túnel series is well exposed in the core of the Morro anticline near El Morro, where it has a thickness of about 300-400 metres.

It consists of massive, sugary sandstones of white or light grey colour. These sandstones are fine, medium or coarse grained and sometimes they contain layers with small quartz pebbles. Crossbedding is frequent. Usually the Túnel sandstones are harder than the Limbo sandstones, but friable, porous sandstones of the Limbo type have also been observed in the Túnel series. The bedding of the sandstone layers is indicated by grey or reddish brown lines, but these lines are straight, not zigzag, as in the Une sandstones.

Somewhere in the middle of the Túnel series shaly layers occur which vary between grey shale with plant remains, hard bluish-grey shale and striped shale with ferruginous limestone concretions. The shales contain ripplemarked sandstone layers with ophiurids.

6) Limbo Series (Probably Tertiary, has been considered as Cretaceous)

This series always consists of a lower shale member, the Limbo shales, and a higher sandstone member, the Limbo sandstones.

The Limbo shales are of grey colour and are often ferruginous, sometimes containing limestone concretions or thin layers of hard, ferruginous limestone weathering with a reddish brown colour. Layers of sandy shales with plant remains occur, also intercalations of fine grained, hard, greenish-grey sandstone. Commercial coal layers have been observed in Quebrada Apure (tributary to Río Ariporo), in Quebrada Gore (on the Gore anticline) and on the El Morro anticline. Thickness 100-200 metres. The Limbo shales seem to correspond to the Guaduas formation (see report Hubach-Morgan).

The Limbo sandstones are well exposed on the Gore-Muchilera anticline and at Peña Negra. They are soft, porous and sugary and their

grain varies between from fine to very coarse; even layers of small and well rounded quartz pebbles occur. The sandstones are striped like those of the Túnel series, but unlike the Une sandstones. Thickness: 250-350 metres. An intercalation of grey shale is present in the upper part of the sandstone series.

7) Carbones Series

The section is well exposed on the Río Ariporo, where it has been studied more in detail. There the series consists mainly of greenish grey or grey shales which are partly sandy, often nodular, sometimes ferruginous and always exceedingly fissile. Intercalations of shaly coal are frequent, sometimes containing crystals of gypsum and covered by a crust of sulphur (?); it seems that the coal layers are concentrated especially in the middle part of the series. A few layers 1-1½ metres thick of hard, fine grained sandstone are present, sometimes limey, well bedded and frequently bearing ripple marks. Often the shales have a striped appearance, caused by thin sandstone beds, and such striped shales grade frequently into striped sandstone; sandstone layers of this sort are hard and often limey; locally they are replaced by sandy limestone. Occasionally there occur layers of yellow weathering, grey limestone, 10 to 30 centimetres thick, and often lenticular, which are apt to pass laterally into large limestone concretions. Ferruginous limestone concretions of all sizes are dispersed irregularly throughout the whole Carbones series.

Intercalations of red shales have been observed on the Río Charte and near El Morro. Gypsum occurs in the shales on the Río Ariporo, near Támara and El Morro. Very thin layers of ferruginous limestone, weathering with a reddish brown colour, are frequent on Río Tocaria , Río Cravo Sur and Río Charte.

Plant remains are frequent in the whole Carbones series, especially in sandy shales; they are best preserved in the shaly coal and in the shales.

Dr. Hubach has observed an important fossil horizon on the Río Ariporo and the writer has collected material for palaeontological examination at this locality which is indicated on enclosure X. Similar outcrops have been observed about 100 metres farther upstream and about 1 km farther downstream; presumably the stratigraphical level is the same in all three places, repeated structurally.

The thickness of the Carbones series is estimated to be about 600-800 metres, but these figures are not dependable due to intensive imbrication and thrusting; Wheeler mentions about 1300 metres from Río Payero (G.R.No.21).

8) Diablo Series (including the Charte Series)

It has been agreed to include the sediments known as the Charte series under the designation "Diablo Series". The Diablo Series, in the new sense, can be subdivided into four members which are characterised, respectively, from bottom to top, by sandstone, shale, sandstone and again shale. The two lower members correspond to what the writer has called "Diablo" in his September report. The three upper members correspond to what Renz has called the lower, middle and upper Diablo, in his October report.

The lower sandstone member is exposed in Quebrada Guáymara (tributary of Río Ariporo), in the Sabana El Yopo and near Chitagote (Támara-Ten trail) and in the east flank of the Támara anticline, between Támara and a point south of Río Pauto. It consists of massive layers of hard sandstone, alternating with layers of grey shale. The sandstones are fine to very coarse grained and often crossbedded; they are porous like the Limbo sandstones. Plant remains and a few thin beds of coal are present in the shales. The thickness is about 150 metres.

The lower shale member consists mainly of hard shales which are sometimes grey, sometimes mottled red and grey. These shales contain intercalations of fine grained sandstone of light brown colour, which is either hard or soft and porous, and also limestone concretions. The lower shale member contains a horizon with marine fossils: foraminifera, lamellibranchs (badly preserved), fish remains and sponges (?). Presumably, this level corresponds to Renz's Turuba fossil horizon.

The two upper members of the Diablo series have not been studied in detail. Like the lower members, they consist of an alternation of shales and sandstones in which the sandstones predominate in the upper sandstone member and at the top of the upper shale member.

All three upper members of the Diablo series are exposed in the west flank of the Nunchía syncline. Together they are approximately 1200 metres thick in the region of Támara.

9) Caja Series

The Caja series crops out in the Nunchía syncline. Near Cerro Zamaricote it is 2800 m thick. It is composed of sandstone layers between 1/2 and 3 metres thick which are separated by layers of shale.

The sandstones are soft and porous, of red or reddish brown colour and usually fine or medium grained; sometimes they are coarse and contain poorly rounded pebbles of quartz, black chert and sandstone. The shales are sandy and often grade into shaly sandstone; their colour is red or mottled red and grey.

10) Farallones Series

The Farallones series is exposed on Cerro Zamaricote in a thickness of about 1000 metres. It can be subdivided into a Lower and an Upper group. The sediments described in the writer's September report as Upper Caja are designated in the present report as Lower Farallones, after discussing the problem with Dr. Hubach.

The Lower Farallones contains red and brown mottled sandy shales and shaly sandstones, dark grey sandy clays with plant remains and pyritic lignite, dark grey, coarse sandstones with numerous small pebbles of black chert, and finally conglomerates composed of rocks comparable to the rocks of the Une, Abrupta and Túnel series. On Quebrada Curuché the contact of Lower and Upper Farallones is unconformable. The thickness of the Lower Farallones has been measured as 350 metres.

The Upper Farallones forms the top of Cerro Zamaricote. It consists mainly of coarse conglomerates with boulders of Cretaceous rocks and contains intercalations of sandy shales and shaly sandstones. Near the base dark grey, soft sandstones have been observed which contain layers with

poorly rounded pebbles of black chert. A thickness of 700 metres has been measured.

11) San Pedro Terrace

The terrace of the Tablon Alto and the Tabloncito (Támara-Socha trail) is composed of sand and gravel which contain very large boulders of Cretaceous and Tertiary rocks: Une sandstone, Abrupta limestone, Abrupta sandstone, Abrupta chert, Túnel sandstone, Limbo sandstone, etc. These terrace deposits may be about 100 to 150 metres thick. They rest unconformably on the older formations but they are themselves folded gently.

C. PALAEONTOLOGY

Fossil plants have been collected in the Une, Limbo, Carbones and Farallones formation. Especially those collected in the Une series and in the Lower Farallones are well preserved so that there is some hope that their determination will be of use.

Lamellibranchs, corals and other fossils have been collected in the Une, Chipaque, Abrupta, Carbones and Diablo series.

Samples for micropalaeontological examination have been taken from the Túnel series up to the Caja series.

A sample taken by Hubach in the Carbones series on the Río Ariporo has been examined and described by Mr. Barker as follows:

" Discorbis mira Cushman — Lr.Miocene of Florida, also Recent.

Discorbis sp.aff.turbo d'Orbigny — Miocene to Recent.

Rotalia beccarii (Linné) var. — Uppermost Oligocene to Recent.

Elphidium sagrum (d'Orbigny) — Uppermost Oligocene to Recent.

Textularia candeina(d'Orbigny) — Lower Miocene to Recent

Textularia cf.gramen " — Oligocene to Recent.

Cassidulina chipolensis Cushman & Ponton - Chipola (Lr.Miocene)

Bolivina sp.indet.

Foraminifera are plentiful but all forms are very small and it appears to be a dwarfed fauna. Determination of all species is not possible at the present time as sieves ordered from The Hague have not yet arrived and the fauna is masked by shell fragments and detrital material (shaley fragments). Ostracods are abundant. The age on the evidence of the above species is considered to be lower Miocene (Chipola of Florida, Tuxpam of Mexico) but could perhaps be regarded as Oligo-Miocene as certain of the above species occur in the Uppermost Oligocene of Mexico (Poza Rica area). "

D. TECTONICS

a. TECTONICS OF THE TÁMARA-TEN REGION

The following structural zones have been distinguished in the Támara-Ten region (from East to West):

Llanos Plains

Cusiana Anticline } Tauramena Belt
Nunchía Syncline }

Cretaceous Front Ranges = Medina Belt

Only the Medina Belt has been investigated in detail and the following structural units have been recognised there (from East to West):

(1) Támara Anticline

(2) Gore-Muchilera Anticline

(3) Guayabal Anticline (Cueta Anticline on Río Tocaria)

(4) Trueno Overthrust

(5) Agua Blanca Anticline

1) Támara Anticline. - Coming from the South, the overthrust Cretaceous core of the Támara Anticline plunges toward the Río Pauto. From here on, Carbones beds form the crest which rises again and culminates between Cruz Verde and Támara. Then the axis plunges in Charte and Diablo beds up to Quebrada Guaseque and rises again to Río Ariporo where Carbones beds are exposed. With a sharp turn the anticline rises steeply toward Sabana Guanta and continues in Limbo beds into the Cordon de Ten.

Hubach showed the writer Abrupta beds thrust over Carbones beds on Río Casanare. This overthrust seems to begin north of Sabana Guanta, apparently in connection with a transverse fault (Quebrada Guaraque).

The east flank of the Támara anticline extends to the axis of the Nunchía syncline; consequently it is broad everywhere. The west flank is rather narrow up to Sabana Guanta but from there on it becomes broader toward Río Casanare.

West of the Támara axis another small anticline is present in the Carbones series near Támara; probably this is a secondary axis which might be considered as forming part of the Támara anticline.

2) Gore-Muchilera Anticline. - In Sabana Gore, West of Támara, an anticline formed by Limbo beds rises steeply from under Carbones beds and Alluvium. Its immediate northern continuation is covered by San Pedro gravels, but the anticline appears again on Río Ariporo where Abrupta beds are exposed. Northward the anticline becomes overthrust toward the East and continues rising to the vicinity of Quebrada Guaraque, where Abrupta beds are exposed. From there on it plunges toward the Río Casanare, rises again steeply north of that river and turns from North to Northeast. The steep or overthrust East flank is narrow whereas the West flank may be 4 kms wide or even more.

3) Guayabal Anticline. - West of the Gore-Muchilera anticline follows the Guayabal anticline which is similar to the former in every respect.

4) Trueno Overthrust. - The Trueno overthrust is a much larger feature than the thrusts observed in the Támara, Muchilera and Guayabal anticlines and it differs from them also because it seems that the overthrust series has been folded conformably with the underlying series after the thrusting movement had ceased.

This interpretation of the Trueno thrust is based on the observations near Río Pauto where it seems that the Cueta anticline above the thrust corresponds to the Guayabal anticline below the thrust and that the Sierra Capitán syncline above the thrust corresponds to the Guayabal-Gore syncline below the thrust.

Thus, it seems that the Trueno overthrust has overridden the Guayabal and the Gore-Muchilera anticline, the latter being represented by the Limbo sandstones of Quebrada Mochila; so it can therefore be compared to a "Nappe".

5) Agua Blanca Anticline. - West of the Trueno thrust and the Cueta anticline follows the Peña Negra syncline which continues in a southerly direction to Río Tocaria. The next western anticline, the Agua Blanca anticline, has been observed on the Támara-Socha trail only where it rises toward the north.

b. TECTONICS OF THE LABRANZAGRANDE REGION

The structural elements observed in the Cravo Sur section are the following (from East to West):

Morro Anticline

Mantas (Mosquera) Overthrust

Los Yopos Syncline

Labranzagrande Anticline

Colorada (Tablón) Syncline

Siamá (Cruz) Anticline

The Morro anticline exposes Abrupta, Túnel, Limbo and Carbones beds. It rises to the south and becomes overthrust near Río Charte (Report March-April 1938).

The Los Yopos syncline contains Chipaque shales in its core and the Une sandstones of its east flank are thrust over the Carbones shales of the west flank of the Morro anticline, forming thus the Mantas overthrust.

The Labranzagrande Anticline is an asymmetric structure containing Fómeque shales in its core.

The Colorada syncline exposes Túnel sandstones at the Tablón north of Río Cravo Sur. The syncline plunges in a southern direction and becomes overturned.

The Siamá anticline has been observed on the Labranzagrande-Sogamoso trail where Fómeque shales occur in its core. North of the trail its East flank is vertical and rising to the south, it becomes overturned.

c. GENERAL REMARKS CONCERNING FOLDING OF THE CRETACEOUS FRONT RANGES

Uniformity of the structural character. - As appears from the table (see below), the folded sequence contains two rigid sandstone members which are embedded in comparatively plastic shales. This alternation of rigid and plastic sediments is responsible for the following peculiarities of the front ranges:

(1) Only the two rigid members form large structural features.

(2) Overthrusts are frequent at the base of either one of the rigid members.

(3) Structural features formed by either one of the rigid members have the same character.

However, besides the uniform lithology of the folded sequence, folding forces, acting evenly over a large area, must have contributed to the equable character of the front ranges as the following observations demonstrate:

(1) Anticlines seem to continue over long distances without offsets or digitations; only one case has been found where an anticline seems to end definitely, namely the plunge of the Támara anticline on Río Payero.

(2) In most places the anticlines are either asymmetrical, overturned or overthrust and invariably the steep or overthrust flank is the East flank. (Fig.3)

(3) Axial culminations on the different anticlines lie in front of each other, in all anticlines except the easternmost, the Támara anticline.

(4) Axial rise of an anticline invariably goes together with gradual overturning and overthrusting. Figure 2 illustrates the gradual change from symmetric anticlines to overthrusts, which in some cases are comparable to "Nappes". (Fig.3)

Age of folding

The San Pedro gravels lie unconformably on the older sediments. No unconformity has been found in the older sediments, but to date it is not certain that none are present. For instance, the Limbo-Carbones contact might possibly be unconformable but as it is frequently disturbed by thrusting and usually not well exposed, the writer could not ascertain whether or not it is unconformable. Also in Quebrada Curuché the Upper Farallones seems to rest upon an erosional surface on Lower Farallones, but the writer is inclined to interpret this case as a purely local nonconformity.

Therefore, relying on unconformities, there is no good reason to assume any folding until after deposition of the Farallones. The case is different, however, when we consider the material composing the Tertiary sequence of the Nunchía syncline. Here the Farallones series consists of conglomeratic sediments which prove that a mountain range existed in the vicinity during Farallones time and one can hardly go wrong in assuming that folding of the Cretaceous front ranges had already started at that date.

The San Pedro terrace which forms the high table mountains of Tablon Alto and Tabloncito is younger than the main folding. However, it has been folded, too, at some later date so that today it presents an undulating surface which corresponds exactly to the older structural features.

Based on these observations and considerations, one might give the following time table of folding:

I. Folding of the Cretaceous front ranges	:	Farallones
II. Strong folding of the whole region	:	San Pedro
III. Continuation of folding	:	Younger terraces

Some overthrusts (Mantas and Trueno) are difficult to understand if one does not assume the existence of at least two separate phases of folding. However, it is not possible at present to give these two phases definite places in the time table.

E. OIL INDICATIONS

Támara-Ten Region. - The fossiliferous limestones of the Abrupta series are bituminous and contain asphalt in fissures on Río Ariporo and Quebrada de la Tote in the Muchilera anticline. The abrupta series of the other anticlines has not been investigated. No other traces of oil have been observed.

Salt springs, springs with H_2S and hot springs with gas rise from the Túnel sandstones where the Río Pauto crosses the Támara anticline. The same sandstones furnish springs with salt and H_2S where the Río Ariporo crosses the Muchilera anticline; also, tepid springs have been observed there, near the Limbo-Carbones contact. According to local information, there are salt springs in the Sabana of Guayabal and on Río Ariporito, probably both on the Trueno overthrust.

Labranzagrande region. - No traces of oil have been observed. A hot spring rises from Une sandstone where Río Cravo Sur crosses the Siamá anticline. Farther West, on the Labranzagrande-Sogamoso trail, Hubach and Morgan have observed two salt springs with gas.

F. PROSPECTS

Possibilities for production in the Támara-Ten region. - The Cretaceous and Tertiary sequence contains many reservoir rocks and sealing formations; little is known, however, about the presence of source rocks.

Of all structures studied, the Támara dome of the Támara anticline seems to offer the best structural conditions as it is closed in Carbones and has a large drainage area.

There are several other anticlines in the vicinity of Támara which are closed in Carbones, but they are of small size and in most cases it is doubtful whether they reach down into the Cretaceous or constitute more than superficial irregularities.

The other anticlines in the Támara-Ten region are overthrust in most cases and usually open in the Abrupta series. They seem to offer possibilities for production from the Une sandstone, but they have not yet been studied sufficiently to enable the writer to evaluate their possibilities more in detail.

In the writer's opinion, it is doubtful whether commercial quantities of oil are available in the Támara-Ten region.

Properties in the Támara-Ten region

The Támara dome is rather densely populated. Farther West in the mountains population is scarce.

Part of the West flank of the Támara dome and all the land farther West lies in the Comunidad de Fuentes, belonging to the families Buitrago, Cordobas, Panquebas, Cuadras and others, with titles going back in part to 1828.

Tame, November 1938.

P. Hess.

Remarks to: "Geology of the Llanos Front Range in the Támara-Ten Region and near Labranzagrande(Boyacá)" - P.Hess

By H. Hubach

Page 1

Nomenclature: 1) The local names of the subdivisions of the Guadalupe, Villeta and Altogirón should be substituted by the appellations lower, middle, upper.

2) The Hague should regulate the use of the names "series, formations, stages," etc. Schuchert, for example, considers a series a larger unit than a formation. Other authors consider a formation larger than a series.

Changes of facies. - This viewpoint must be explained more in detail. The Cretaceous becomes more shaly and limy toward the West (Chicamocha Valley). The Guaduas (Limbo shale) evidently does not change much in that direction (toward Socha), the same as the lower part of the Bogotá (Cacho=?Limbo sandstone). The Carbones, the Caja and the Farallones have no equivalents toward the West (high East Cordillera).

Changes of thickness. - The thickness of the Upper Cretaceous does not change visibly toward Sogamoso and the Chicamocha Valley. Exposures of the Lower Cretaceous at Labranzagrande indicate a larger thickness than in the Sogamoso-Chicamocha region, where the Lower Cretaceous is deposited on the East side of the Guantiva vector of the Santander massif. It rather seems that the line Labranzagrande-Sácama represents one geosyncline axis. From there toward the East (Guayana mass), the Cretaceous doubtless diminishes.

The Guaduas (Limbo shale) is less thick at the Llanos front than in the Chicamocha Valley. The Bogotá apparently is only rudimentarily deposited or preserved on the Llanos front, while it shows a large though varying development in the Chicamocha zone. The thick Carbones formation, the Caja and the Farallones are not developed West of the Llanos front. Along the front they represent an Upper Tertiary geosyncline.

A special reduction of the thickness of the formations older than Caja must be expected at the Corozal high, which may be interpreted as an old island mass.

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Fómeque. - Barker, as well as Fichter, recently examined the ammonites (Astieria type) from Quebrada Los Santos. They consider them Lower Barremian to Upper Hauterivian.

Une. - Weichselia indicates Lower Cretaceous (prae-Cenomanian); this plant lies in shales directly below the Une sandstone.

The anthracitic coal of the Une is not metamorphosed. Wherever this coal is present in the Une, it is anthracitic and no signs of metamorphism are indicated in the contiguous sediments.

Chipaque-Albarracín. - The upper limestone bed of the Casa Contento region must be taken as the top of the Chipaque, respectively as the boundary toward the Albarracín.

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Abrupta. - This level contains the highly varying species of Ostrea abrupta d'Orb., a typical fossil of the Upper Guadalupe(Monserrate) of the Chicamocha region, where it occurs, together with types of O.Nicaisei, from the top to the base of the Upper Guadalupe. It is certainly Coniacian.

Túnel. - Hess provisionally separated the Abrupta from the Túnel. Both represent the Upper Guadalupe (Coniacian).

Limbo. - Limbo shale and Limbo sandstone must be separated because the shale is a very close equivalent of the Guaduas of the Chicamocha (Socha), while the Limbo sandstone reflects the Cacho sandstone, viz., the basal member of the Bogotá.

Carbones. - We do not yet know exactly the base of the Carbones. Along the Ariporo, the Carbones is divided into a lower shale and an upper sandstone - shale member with ferruginous limestone concretions.

Diablo. - The name Charte-Diablo (Renz) should be applied to this "series". The Diablo commonly is less thick than the Charte.

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PALAEONTOLOGY.- As the Carbones is definitely Lower Miocene-Upper Oligocene, a transgression over the Limbo sandstone can be supposed.

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TECTONICS. - The Támara Anticline must be included in the Tauramena Belt; it is predominantly a Tertiary fold and lies East of the steep, chiefly Cretaceous ranges of the Medina Belt. The Mochilera Anticline represents the easternmost member of the Medina Belt. The axial thrust of this anticline seems to issue at the Ariporo (or even farther South), where it is indicated in the Carbones.

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Tectonics of the Labranzagrande Region. - Between the Los Yopos syncline and the Labranzagrande anticline, there is a steep, complicated zone.

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General Remarks. - This is an important contribution to the systematic order of the tectonics in Colombia. As to the uniformity of the structural features, the conclusions are derived from the surface.

It is possible that, for example, the imbrications of the Carbones also affect in the depth the Limbo, Tunel and Une sandstones.

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On the east side of the East Cordillera, the steeper, overturned and overthrust parts of the folds generally, but not invariably, lie on their east flanks. Where the Támara anticline crosses the Casanare River, its west flank is steeper than the east flank; north of the Cravo Sur, the Siamá anticline is overturned toward the West, while South of this river it is overturned toward the East.

Rules, as mentioned under 1-4, are well observed but they have some exceptions.

Age of folding. - Hess considers that the unconformable folding of the Medina Belt in the Támara-Ten region started earlier than in the Tauramena Belt; this is evidently exact. The scarcity of Caja (=?Tilatá) and ?lack of Farallones in the East Cordillera, the same as the conglomerates of the Farallones in the Tauramena Belt, prove it.

Though the Cretaceous-Tertiary sediments of the Tauramena Belt are conformable or practically conformable, the frequent increasing of sediments from the anticlines toward the synclines indicates that folding accompanied sedimentation.

The gentle San Pedro folds locally correspond to older ones but in the Casanare region, from Sácama to Corozal and north and south of this line, they are unconformable to older structures.

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