The presence of Bolivina explicata in its microfaunas suggests a late Coniacian age for the Tres Esquinas Member, and this accords with the accepted ages of the beds above and below it.

NAZARET FORMATION, Guajira Península

Otto Renz (1960, p. 337) has described an unnamed formation of Upper Eocene age in the northeastern part of the Guajira Península. The name Nazaret Formation is here proposed for this unit, since its description is based on outcrops in the vicinity of the village of Nazaret and no other locality is mentioned.

Renz' brief description is freely translated as follows:

"During the Upper Eocene the sea invaded the northern part of the península and transgressed along the northeastern edge of the Serranía de Macuire. Wholly marine Upper Eocene deposits are found there lying discordantly on gneiss and Cretaceous sediments.

"The best outcrops of Upper Eocene sediments are observed at 14 and 2 kilometers northwest of Nazaret and 1 kilometer northwest and 5 kilometers east of the same place.

"These sediments start with a basal conglomerate of variable thickness made up of rounded pebbles of gneiss and Cretaceous rocks. This conglomerate is followed by light brown limestones, partly sandy, containing abundant fragments of Lithothamnium, a rich fauna of larger foraminifera, and mollusks. Lenses and thin layers of rounded pebbles appear between the beds of limestone. The thickness of the limestone is from 60 to 100 meters.

"In all the outcrops the Upper Eocene sediments seem to lie unconformably below Miocene beds."

Renz includes a small-scale locality map (Fig. 2) and lists fossils indicative of Upper Eocene age. His description is considered adequate for defining a new formation, though a specific type section should be designated at some future date.

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ARTICULO

STRATIGRAPHIC ASPECTS OF THE MINERALOGY OF SOME VENEZUELAN CLAYS[1]

By Manuel Rivero Palacio[2]

The Instituto Venezolano de Investigaciones Tecnológicas e Industriales is carrying on a general survey of the clay deposits of Venezuela with the object of evaluating their possible technological use.

The samples are collected by a field geologist, Mr. Charles Jefferson, from those outcrops which obviously show a large amount of such material. These samples are sent to the laboratory, duly tagged with geographical position, lithologic description, and age. This latter is ascertained from published maps, or by the personal experience of Mr. Jefferson.

The samples, as received from the field, undergo a series of standard tests described in a publication of the Instituto Venezolano de Investigaciones entitled "Arcillas Industriales - Parte No. 1 - Bases Técnicas." Among these tests are the determination of the mineralogy of the clay by X-ray diffraction, aided, if necessary, by differential thermal analysis, thermal balance, and in some cases chemical analysis.

From the beginning, it was obvious that the mineralogical composition of the clays brought out interesting stratigraphic relationships quite apart from the possible technological use. To demonstrate these stratigraphic relations, the author has prepared this paper. It is hoped the reader keeps in mind that the principal purpose for which the samples were collected and studied was quite different from the purpose of the present paper. The original study was made to evaluate possible technological uses of clays, whereas this paper considers the stratigraphic relationships that were observed while carrying on the other work.

To help the reader keep this point in mind, the number of samples studied belonging to any one formation will always be mentioned, so that one may draw his own conclusions with respect to the validity of any idea advanced by the author. In other words, the author is very much aware of the fact that this study is very lacunary and incomplete; and it is offered more to show what can be done with the method, than as a contribution to the knowledge of the stratigraphy of Venezuela.

The X-ray work was done in the laboratory of the Instituto Venezolano de Investigaciones Científicas with a Phillips X-ray unit equipped with goniometer and electronic recorder. Preferred orientation has been used throughout with a scanning speed of 1° or 2° per minute, a copper X-ray source with a nickel filter at 40 KV and 17 MA, and a Geiger Counter. Scattering and diverging slits are 1°; receiving slits are .006 in. This instrument was operated by Antonio Busolo, to whom I wish to express my thanks.

Throughout the work subjective words like abundant and scarce, or low and high, have been used rather than numerical quantities. The writer does not have as yet

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enough experimental data to be able to calibrate the results of the instrument; and the use of numerical data might tend to give a misleading idea of the accuracy of the work.

The relative abundance of minerals in any sample is given as the relative intensities of their main reflections. This may at times lead to misinterpretation, particularly if the same pattern has, for instance, poorly crystallized kaolinite and highly crystalline quartz whose strong reflections overshadow the kaolinite reflections, thus masking their relative proportions. This is an inherent weakness of the method when used for quantitative estimations.

The term "high" intensity is used when the main reflections of a mineral go off the paper or nearly so; "low" intensity, when they are smaller than about 30 units above the noise line; and of course, medium, in between these limits. The same scale setting has been used throughout the work so that direct comparions can be made between patterns. No appreciable drift has been observed in the instrument in the course of the work.

One almost universal component of clays is quartz. The main line of quartz (101) coincides with the usually very strong third order reflection of illite. Therefore, in the presence of illite it is impossible to detect small amounts of quartz. Since illite is present in almost all the samples, the (100) line, which is 1/3 the size of (101) has been used to judge the presence of quartz. When this line is absent, it is concluded that the sample is quartz free, which, of course, may not be true. However, we have prepared artificial mixtures of quartz and kaolinite which tend to show that the error is of the order of about 5%.

The area covered by the samples studied takes in a good part of Western Venezuela: west from the meridian of Caracas but with very large blank spaces within this area, such as Western Zulia, Táchira, Mérida and most of Trujillo, Southern Guárico, etc.

As far as possible, the writer gives towns and roads as geographical references. Therefore, a good road map of this area, such as those published by the oil companies, is enough to guide the reader through this work.

It must be kept in mind that the description of composition given here, is not the type of description that a petrographer may wish. The composition given here refers to the fine particle size. Anything coarser than, say 50 microns, settles out in the process of preparing the sample. So, when it is said that the quartz content of a sample is "low", it may contain grains of quartz visible to the naked eye; but, it is low in quartz of grain size of the same order as the clay particles.

CRETACEOUS

Río Negro Formation

Three samples belonging to this formation have been examined. Two of them come from the La Cuchilla region in Trujillo and one from the highway between San Pedro and Carora in Lara. The intensity of these patterns is high. Their main constituent is illite with some kaolinite and varying amounts of pyrophyllite. The latter's presence in one sample is doubtful, but it is the main constituent in another sample and sufficiently abundant in the third for positive identification. All of them contain quartz in moderate quantities.

Aguardiente Formation

The next younger Cretaceous formation from which we have samples, is the Aguardiente. Twenty-three samples have been received belonging to this unit, most of which come from an area centered around Bobare in the State of Lara. Others come from the Pan American highway, south of Puente Torres in Lara, from along the Lara-Zulia highway, and from the highway between Mitón and Torococo in the State of Trujillo.

This group of samples has a very well-defined mineralogy that is remarkably consistent. Their main constituents are illite and pyrophillite in about equal proportion (i.e. equal intensity peaks), but at times one or the other may be slightly more abundant. Typically the intensity is high, but in one sample pyrophyllite had medium intensity.

Kaolinite constitutes a minor component in varying proportions and occasionally may reach the same relative abundance of the other two components.

The quartz content varies from abundant to entirely absent, but in general the quartz content is low.

The specimen from the highway between Mitón and Torococo in Trujillo (INV-130), from an outcrop 2 Km. west of Mitón, differs from the others in that it does not contain pyrophyllite, is high in kaolinite and low in illite. Judging purely on mineralogical basis, it seems that this sample does not belong in the Aguardiente formation. However, it is possible that the Aguardiente formation may present a greater variability than the few specimens examined to date seem to indicate.

Colón Formation

(To date no samples have been collected from the Capacho or La Luna formations.)

Five samples belonging to the Colón formation were studied. Four come from the area of Barbacoas-Humocaro Bajo in the State of Lara, two black and two grey shales. The other sample comes from the Cuicas-El Helechal road in the same State and is a black shale.

The main constituent of these shales is illite with very small amounts of kaolinite. In one sample doubtful attapulgite, and in another doubtful halloysite were observed. The content of quartz is very high, being perhaps the main constituent in one of them.

Unlike the other formations of the Cretaceous, the intensity given by the patterns of the Colón samples is low. This tends to throw one's estimates of the relative amounts of quartz out of proportion: because, while the clay minerals may lose intensity for a variety of reasons, the quartz tends to keep its high crystallinity and thereby its high intensity reflections, thus influencing the estimations towards higher proportions of quartz. It is quite possible that the reason for the low intensities of these patterns is the presence of much amorphous aluminous silicate such as allophane.

At this point it seems desirable to pause and try to visualize the picture that emerges from the study of the mineralogy of 31 samples of Cretaceous clays.

Admittedly the picture is very much distorted; however, the author feels that the presentation of such a picture is interesting, to point out what can be done with the method. The conclusions offered are in the spirit of "points to disagree with" in future research.

The one mineral that we find makes up the bulk of these sediments, is illite. The rocks eroded to produce such large quantities must have been very rich in mica, such as a mica schist. The presence of large quantities of pyrophyllite in these two formations suggests even more strongly the metamorphic character of the source rock.

The fact that in both the Rio Negro and Aguardiente the intensities are high, suggests that the material making up these sediments was not submitted to long weathering processes and thus was not degraded.

Towards the close of the Cretaceous, during Colón time, the intensities of the patterns of this formation tends to indicate that the degrading process was more active; perhaps due to long weathering and transportation.

The absence of pyrophyllite towards the close of the Cretaceous, during the Colón time, points toward a change of the source of sediments.

EOCENE

Trujillo Formation

Ascribed to this formation are five samples:

One from around El Tocuyo)
Two from around Guárico) State of Lara
Two from around Cúicas) State of Trujillo

There is a great deal of variation in the mineralogy of these samples. The one from El Tocuyo, as well as one from Guárico, are composed of illite and kaolinite with abundant quartz and low intensity. These look like Colón.

The other from Guárico (INV-58), 9 Kms. S.W. of Guárico, on the new highway Guarico-Hda. Berlin, has pyrophyllite and illite as main components with a predominance of pyrophyllite, very little quartz, and high intensity. The mineralogy of this sample strongly suggests the Aguardiente formation. However, if the field classification is correct (and the field man thinks it is), it means that this remarkably striking mineralogical assemblage extends into the Eocene. More samples from this area would be desirable to check this point.

The two samples from the Cúicas area look very much alike, but differ from the rest. Lithologically they are black shales. The main mineral is kaolinite with a little illite and chlorite and abundant quartz. There is also an unidentified mineral which forms a combined peak with illite (001), at about 11.9 Å. The intensity is low.

The large variation in the mineralogy of the Trujillo formation is difficult to explain. If the areas from which the samples come were far apart, much variation would be expected; but, from areas reasonably close like El Tocuyo and Guárico, more similarity would be expected. Of course, it must be born in

mind that with so few samples, a clear picture of the range of variation of a formation cannot be drawn. However, judging solely by mineralogical aspects of the samples examined, one cannot help but feel that beds of different ages have been lumped together in this formation.

Misoa Formation

One sample of this formation near Mene de Mauroa is composed of kaolinite with a little illite and still smaller amounts of chlorite. The intensity is low and quartz is abundant. This sample is undistinguishable from those of the post-Eocene formations of Falcón.

Churuguarita Formation

The four samples we have of this formation come from the extreme western part of Falcón. They display low-intensity kaolinite with some illite, doubtful chlorite, and abundant quartz. The low-intensity kaolinite is typical of most of the Eocene formations.

Mene Grande Formation

The three samples available from the State of Zulia, Bolívar District, are composed of kaolinite with a little illite and abundant quartz. As a very minor component one sample has chlorite, and another an expanding material, and the third has nothing above the spacing of illite. One sample has low intensity and, therefore, is indistinguishable from the younger Tertiary formations of Falcón. In the other two, the kaolinite has a high intensity, which feature could help in distinguishing it from the post-Eocene in some areas.

Jarillal Formation

Two samples of this formation from the State of Falcón, about 30 Kms. N. of Churuguara, gave patterns of exceptionally low intensity, composed of kaolinite and illite with abundant quartz and gypsum. The intensity is so low that the identification of most peaks is doubtful. These cannot be distinguished from the post-Eocene formations.

Guárico Formation

The only sample of this formation, collected near El Pao in the State of Cojedes (INV-297), is a brown shale. Its components are chlorite with a little illite and abundant quartz. The specimen in its natural state gives low intensity reflections very similar to the Guarumen Group of that area. However, when washed through a No. 200 sieve, the chlorite gives medium intensity, thus presenting a sharp contrast with the Guarumen Group.

POST-EOCENE FORMATIONS OF THE STATE OF FALCON

We have examined samples of clays described by the field geologists as belonging to the following formations:

Cerro Pelado	6	samples
Conglomerado de Coro	2	samples
Castillo	13	samples
Churuguara	9	samples
Agua Clara	3	samples
Patiecitos	2	samples
Caujarao	8	samples
Guayabal	3	samples
Querales	7	samples
Punta Gavilán	3	samples
Casupal	1	sample
Ojo de Agua	3	samples
Pegón	48	samples
Socorro	6	samples
Paraguaná	2	samples
Codore	10	samples
Urumaco	14	samples
Caujarao-Urumaco	3	samples
Total	137	samples

After such an impressive list of formations, the reader will brace himself, expecting wide changes of mineralogical composition and a broadside of names ending in "ite"; but, such is not the case. All the post-Eocene formations of Falcón examined to date, up to and including recent sediments, show a very monotonous mineralogical composition. So much so, that at times, when comparing the diffractometer charts of the 137 samples, it seemed that all of them might have come from the same outcrop, so little was the difference between patterns.

All the fine sediments of the above listed formations contain kaolinite, illite, and quartz; the latter is usually very abundant. For the most part, the intensity is low to very low, although at times some samples go to medium intensity and occasionally to high.

The presence of gypsum is quite common.

Most of the samples of the post-Eocene formations of Falcón present, in the zone of smaller Bragg angle than illite (001), a very high and wiggly noise line; that is, the peaks are not quite well developed, but more like unusually high fluctuations in noise level, leaving one in doubt as to their nature. It makes one suspect the presence of minerals of higher spacing, like chlorite or montmorillonite. However, only in very few samples could the presence of montmorillonite or chlorite be established, and they were in such small proportions as to be only of academic interest.

Features of interest found in some formations, though not considered characteristic of them, are as follows:

Castillo Formation

Two samples of the Castillo formation have very small amounts of pyrophyllite, so small as to make the presence of the mineral doubtful. However, if present, it may mean that some of the sediments of this formation might have been derived from the Cretaceous.

Ojo de Agua Formation

In one sample, the illite predominated over the kaolinite and small amounts of montmorillonite could be determined.

Codore Formation

In two samples chlorite was found in small proportions.

POST-EOCENE IN GENERAL

Betijoque Formation

Eight samples were collected in the State of Trujillo, from the north side of the Andes. The mineralogy is very similar to the post-Eocene of the State of Falcón; i.e. kaolinite, illite, and quartz. However, on the average, the intensities obtained were a little higher than those of the Falcón samples, and in some samples chlorite was in sufficient concentration for positive identification. In one of the samples a small amount of pyrophyllite was present.

Isnotú Formation

Four samples were collected, one in the vicinity of Betijoque, in the State of Trujillo, the others from the area of El Concejo-Quiroz in Zulia. These samples are composed of kaolinite, very little illite, and quartz. The intensities are medium to high. The higher intensities and the low illite content might be used to distinguish this formation from the post-Eocene of Falcón, but many more samples would be required to see if this small difference holds.

La Rosa Formation

Two samples from N.E. Zulia have been studied. Both are mottled clays. Their mineralogy is indistinguishable from the post-Eocene of Falcón.

Guarumen Group

This group includes three formations, namely Quebradón, Chaguaramas, and Batatal. No mineralogical differences were noted between these formations, so they will be described here as a group. In fact, no difference of consequence was found between this group and the post-Eocene formation of Falcón.

In all, 24 samples have been examined from an area extending from El Pao, in Cojedes, to Altagracia, in Guárico.

The minerals found were kaolinite, illite, and quartz. As in Falcón, the clays of this group present a much higher noise line in the zone of lower Bragg angle than illite (001). In some of the samples it could be seen that this high noise line was due to the presence of chlorite in small amounts; but in many

others, no mineral could be identified, and the high noise line was thought to be due, perhaps, to high iron content.

As an interesting feature in one sample, in the fraction smaller than 1μ, attapulgite was found as an important component; but, since this fraction represents only a very small percentage of the sample, attapulgite is a very small component.

In this fraction many of the samples show a rounded broad peak that goes from ±11.2 to 10.6 Å. This may indicate some kind of interlayering of attapulgite and chlorite.

El Pegón Formation

The 20 samples belonging to this formation were collected from the vicinity of Sanare, State of Lara. Probably, there are no two authors that agree as to the extent and age of these strata, but Jefferson (personal communication) claims that these beds rest unconformably on the Trujillo formation, and since he knows exactly the locality from which he collected the samples, his opinion is accepted implicitly, as in the rest of this work.

Of the post-Eocene formations studied until now, this is the only one that presents a distinctive mineralogy. It is composed of pyrophyllite and illite with small amounts of kaolinite. The quartz content is high; the intensity is low in most of the samples, but high intensity was shown by six samples.

This mineralogy strongly resembles that of the Aguardiente formation from which it could be distinguished by low intensity and high quartz content. However, the distinction on the basis of quartz content and intensity is extremely hazardous.

Granting the age of these beds as post-Eocene, the mineralogical ensemble points towards Aguardiente or Río Negro as the source material, because, in no other formation, has pyrophyllite been found in significant amounts.

Río Yuca Formation

Samples of this formation, 14 in all, were collected from road cuts on the highway between Guanare and Biscucuy, from Río Boconó, and from the Barquisimeto-Acarigua road.

The Río Boconó and Guanare-Biscucuy road samples are very similar. They give typical low to very low intensity patterns with kaolinite and/or chlorite, little illite, and very abundant quartz. To ascertain in these low intensity patterns, whether kaolinite alone, or chlorite alone, or both, are present, is a very difficult matter. However, in one sample high intensity kaolinite was found.

In two of these patterns, the main crystalline constituent is quartz with small amounts of chlorite, illite, pyrophyllite. These latter minerals are in such small concentration as to make their identification doubtful.

On the Barquisimeto-Acarigua road, four samples were collected; two give patterns very similar to those of Río Boconó, except that no chlorite is present. The other two give medium intensity patterns with kaolinite, illite, and

a reflection at 9.6 Å. In one of these two samples, the quartz is low and in the other completely absent.

The reflections at 9.6 Å with 2^{d} and 3^{d} order reflections at 4.79 and 3.21 Å, respectively, have not been identified as yet. However, the only other samples giving this reflection together with low quartz content, come from young sediments, recent, or maybe older, of the Nirgua Valley, which will be discussed later, and from a graphitic schist near Urachiche in the State of Yaracuy.

In general, the sediments of the Río Yuca formation are very similar to those of the Betijoque formation on the northwestern side of the Andes. Probably both formations had the same source.

Guatire Formation

In all, 25 samples of this formation were examined; 24 come from an area approximately bounded by the towns of Sta. Lucía, Cúa, Ocumare, and Sta. Teresa in Miranda State. The other sample comes from the vicinity of Guatire in the same State.

This formation has a very distinctive mineralogy. The principal component is vermiculite with very small amounts of illite and quartz. In many of the samples, the principal constituent is montmorillonite with small amounts of kaolinite, illite, and quartz. Almost all of these samples contain carbonate to a greater or lesser degree, and more often than not, only discernible by chemistry; that is, the calcite does not show in the X-ray pattern.

If both vermiculite and montmorillonite are present in one sample, the detection of each becomes very difficult; but moreover, when one is present in predominant proportion, it is very difficult to prove the absence of the other. The same is true of kaolinite and vermiculite. In the presence of the latter, it is almost impossible to be sure of the absence of the former.

The above remarks have a bearing on the point as to whether there are two distinct types of sediments; that is, one montmorillonitic and the other vermiculitic. The author does not believe so. For one thing, the final identification made in many of the samples was almost a toss-up; therefore, probably both were present; but in some others, there was a clear-cut, unequivocal indentification of one or the other of these two minerals. Obviously, when vermiculite is present, as already said, kaolinite is undetectable, and that is the reason why there is no kaolinite mentioned when vermiculite is identified and there is an apparent association of montmorillonite and kaolinite.

The writer thinks most probable that this formation is made up of both minerals in widely varying proportions and all through it there are small amounts of kaolinite and/or illite; however, one or both may be absent at times.

The composition of this formation suggests a volcanic origin: either direct decomposition of volcanic ash, or reworked material of volcanic origin.

Similar types of clay were found in the area between Pto. Cabello and Morón, which suggests that the so-called Recent or Morón is at least in part of the same age as Guatire. Do these beds indicate active volcanic activity in Pliocene or Pleistocene time, or are they reworked pyroclastics of older vulcanism? This writer does not know the answer, but in this connection it would be interesting to study the Tiara volcanics.

RECENT

Nirgua Valley

From the immediate vicinity of the town of Nirgua in the State of Yaracuy, 11 samples were collected from beds that seem to occupy the floor of the valley. They are of a bluish color and very plastic. They might possibly represent lake beds of Recent age or perhaps be older.

They are composed of kaolinite with smaller amounts of illite. The quartz content is low. Unlike most of the Recent samples studied, the intensity of the pattern of these beds ranges from medium to high.

In all these samples a mineral with spacing of 9.6 Å is present. In three samples we have a complete series of reflections up to 5th order, and in the rest either 2nd, 3rd, and 5th, or 3rd and 5th order; two contain only a 3rd order reflection. This mineral is not affected by glycolation and disappears by heating to 550° C.

Area between Pto. Cabello and Morón

Of the supposedly Recent sediments of this area, seven samples were examined and three types of clays were found. One type is represented by three samples very much like the post-Eocene of Falcón, consisting of low intensity kaolinite and illite, with abundant quartz. One of these samples comes from mottled clays interbedded with a conglomerate dipping steeply to the south.

The other type, represented by three samples, is made up principally of montmorillonite with small amounts of illite and chlorite or kaolinite. Quartz is either absent or present in moderate amounts. One lone sample which represents perhaps the soil of this area, gives a very low intensity pattern which appears to be made up entirely of chlorite with abundant quartz. The identification of the chlorite is far from certain. It could be vermiculite or montmorillonite, if so, it would belong with the previous type.

Such diversity of mineralogy suggests differences in age; but on the other hand, it must be kept in mind that this area receives drainage that cuts source rocks of igneous, metamorphic and sedimentary origin, with the sedimentaries differing widely in age. For this reason, in one particular area, a certain source rock might predominate giving rise to a certain type of clay; and at the same time, in a near-by area, a different source rock might give rise to another type of clay.

Valencia Lake

The samples of clays from the Valencia Lake region came from the pits of the various brick yards operating in the area; twelve samples were examined.

These clays consist of illite and chlorite, in equal proportions, or one or the other predominating. The quartz content varies from very low to absent.

The composition of these clays is interesting, inasmuch as it gives a picture of what type of clays results from the weathering of the metamorphic and igneous rocks of the coast ranges, or at least of the Coast Ranges from the meridian of, say, Valencia to that of Los Teques. Detailed work in this area among the metamorphics may prove very fruitful.

In connection with these recent sediments, as a point of general interest, I will mention that samples of diatomaceous earth have been examined: one from the city of Maracay from alongside the street to the Yacht Club, and the other from the stream of Los Guayos near Valencia. The pattern obtained from these samples, as it might be expected, is that of amorphous material. Obviously, the mineral making up the diatoms tests is opaline silica.

The same composition as the Valencia lake sediments has been found in samples collected from the banks of the Río Guárico at Camatagua and from the flood plain of the same river at Barbacoas. However, a sample from the banks of the Orituco River, where it crosses the road from Chaguaramas to El Sombrero, gave a composition like the sediments of the Guarumen Group. Unfortunately, these samples did not come to the laboratory by the regular way, and field determination of age was not made.

Two samples from the highway Tinaco-El Pao in Cojedes gave patterns of extremely low intensity, composed mostly of quartz; one with some kaolinite and the other with chlorite. The intensity was so low that the identification was not very sure.

The samples of Recent clays collected from the roads Coro-Maracaibo and Lara-Zulia all show the same mineralogical composition as described under the post-Eocene formation of Falcón.

Recent sediments from Lara

Six samples of Recent sediments were studied from this State, from a wide area centered around Barquisimeto, and one sample from the vicinity of Aragüe near Carora.

The samples from the Barquisimeto area have one feature in common: namely, that all, except one, contain pyrophyllite in amounts varying from main constituent down to barely discernible. Indeed, the pattern of a sample from the road Barquisimeto-Acarigua could pass for a good Aguardiente formation pattern.

The other constituent accompanying the pyrophyllite in these samples is illite, thus enhancing the resemblance to Aguardiente. Kaolinite is also present in varying concentrations. In some samples chlorite is present.

The sample near Aragüe gave a pattern of extremely low intensity in which quartz seems to be the main component with a little kaolinite. Probably this sample contains considerable allophane.

It should be pointed out here that in the Barquisimeto area, in the course of this study, we have had the opportunity to examine both the source material, namely the Cretaceous, and the sediments resulting from them, namely the Quaternary. The source material contains pyrophyllite which, so far as known, is restricted to the Cretaceous, although there are some indications that it may extend into the Eocene. This source material, rich in pyrophyllite, has given rise to modern sediments also containing it, and in one case, the derived sediments are mineralogically indistinguishable from the source. The relationship between source and sediments is striking.

Falcón, as we have already pointed out, is another example of modern sediments mineralogically indistinguishable from the source rock, i.e. the post-Eocene formations.

Perhaps, the Nirgua Valley, in the State of Yaracuy, could illustrate this relationship, but not quite so strikingly, because the source rocks have not been studied

to any extent. It may be worthwhile pointing out, that the Recent sediments of this valley are strongly kaolinitic and, so far as the writer knows, the only place in Venezuela, outside of Bolívar, where reasonably well crystallized kaolinite is found, is in the metamorphic rocks surrounding this valley.

METAMORPHICS

Only seven samples have been examined of the metamorphic rocks of the Coast Ranges:

4 from the Nirgua Valley)
1 from the highway from Nirgua-Chivacoa) State of
1 from the highway from Nirgua-Tocuyito) Yaracuy
1 from the highway from Urachiche to Los Guamales)

The four samples from the Nirgua Valley are highly decomposed schist in which fairly well crystallized kaolinite was the main constituent, with small amounts of quartz and illite. Tow of these samples come from active pits.

The one from the Nirgua-Tocuyito road comes from a place 48 Kms. from Nirgua. It is a prominent outcrop due to its deep green color. Its main component is chlorite with many other minerals amongst which actinolite, tremolite, and metahalloysite seem to be present in that order of abundance.

The road from Nirgua to Chivacoa crosses an area with many limestone outcrops. One samples of these limestones has been collected, and its insoluble residue in hydrochloric acid was examined. The main constituent is illite, with smaller amounts of chlorite. Quartz may be present, but if so, in very small proportion. There is also an unidentified mineral with small reflection at 6.41 Å and 2nd order very intense at 3.20 Å.

The sample from the road from Urachiche to Los Guamales is a very decomposed graphitic schist. Its main constituent is illite with small amounts of kaolinite and abundant quartz. The graphite does not show in the X-ray patterns but comes out well in the D.T.A. curve. The 9.6 Å mineral, discussed in the Nirgua Valley sediments, is present in this sample.

SUMMARY

Summing up the salient features brought out by this study, we find that:

At least some of the lower Cretaceous (Río Negro and Aguardiente) is characterized by the presence of pyrophyllite.

Some of the upper Cretaceous (Colón) is strongly illitic with low intensity patterns.

Some of the Eocene is typically kaolinitic with small amounts of chlorite. There are some indications that it may contain pyrophyllite at times.

With the exception of the Pegón formation, north of Sanare, in the State of Lara, the post-Eocene formations of Falcón, north and south of the Andes (Betijoque and Río Yuca formations), south side of the Coast Ranges (Guarumen Group) are very similar, mineralogically speaking, characterized by kaolinite and illite with small proportion of chlorite.

In general, the Recent sediments have been found to be very similar to the older rocks studied in the same area.

The superficial clays of Lake Valencia are strongly chloritic. The origin of these sediments is not known, for no older rocks have been studied during the present work.

The Guatire formation (including beds found near Morón) presents the distinction of being the only formation outside of Guayana (see "Notas Mineralógicas de unas arcillas de Guayana", in "Geos" No. 8) in which montmorillonite and vermiculite have been found. The source rock is not known.