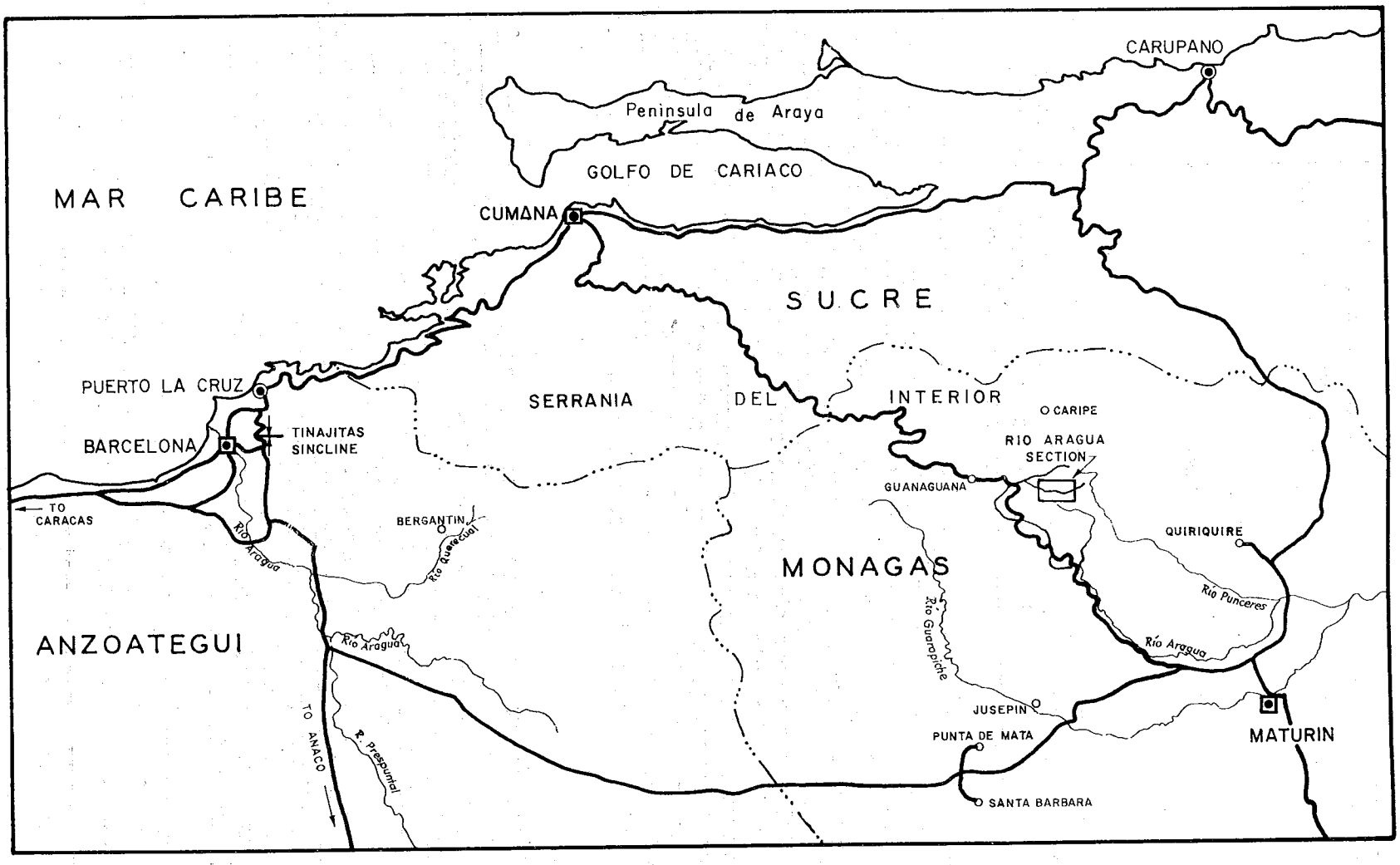


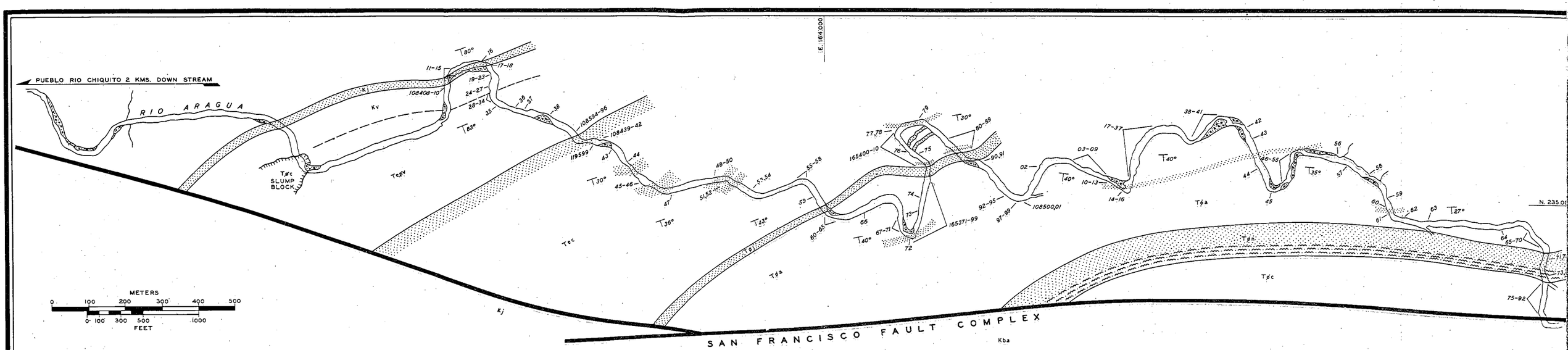
MAP OF A PORTION OF EASTERN VENEZUELA SHOWING THE LOCATION OF THE RIO ARAGUA SECTION

SCALE 1:1.000.000

0 10 20 30 40 50

KMS.

FIG. 1



MODIFIED AFTER R. HOWELL, JR., 1957

LEGEND

OLIGOCENE	
CARAPITA FM.	Tøc
NARICUAL FM.	Tøn
AREO FM.	Tøa
LOS JABILLOS FM.	Tøj
EOCENE	
CARATAS FM.	Tec
PALEOCENE & UPPER CRETACEOUS	
VIDOÑO FM.	Tep-v-Kv
UPPER CRETACEOUS	
SAN JUAN FM.	Kj
LOWER CRETACEOUS	
BARRANQUIN FM.	Kba

* SAMPLE NOS. 108408 TO 108592 WERE TAKEN CONSECUTIVELY GOING UPSTREAM. NOS. 108594 TO 108596 AND NOS. 165371 TO 165410 ARE LATER SPOT SAMPLES.

DIP AND STRIKE DATA AVERAGED FROM OBSERVATIONS IN RIVER BED.

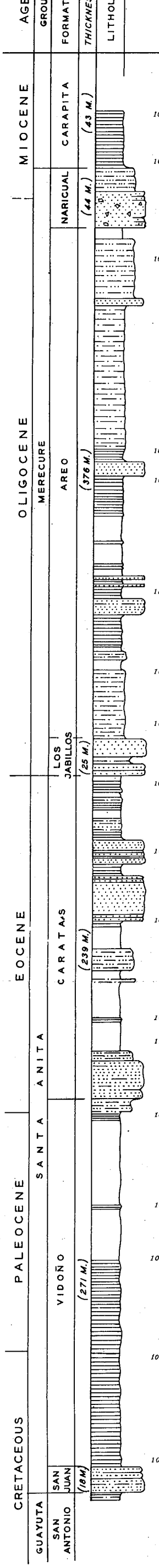
CREOLE PETROLEUM CORPORATION

GEOLOGIC MAP OF THE RIO ARAGUA SECTION

ORIGIN OF COORDINATES
MATURIN N. 200.000 E. 200.000

J. L. LAMB NOVEMBER, 1963

FIG. 2



DESCRIPTION

108590 Shale, gray, micaceous, calcareous, finely laminated, somewhat contorted; limestone nodules and skeins of calcite.

108575 Siltstone, black, with sandy layers, calcareous, carbonaceous, weathered.

Sandstone fine grained, quartzose, with bands of angular quartz pebbles, brown, fractured and folded

Conglomeratic sandstone with fine grained matrix, pebbles up to 10 mm., gray to black, slightly silty, hard

Siltstone, black, carbonaceous, calcareous, sandy, micaceous, hard, with nodules of brown limestone and calcite in fractures.

108565 Siltstone, gray to black, calcareous, carbonaceous, ferruginous, hard, sandy, massive.

Siltstone, gray to black, calcareous, carbonaceous, sandy, ferruginous, hard, massive, fractured.

Siltstone, gray to black, calcareous, carbonaceous, sandy, ferruginous.

Siltstone, gray to black, carbonaceous, calcareous, micaceous, sandy, ferruginous, hard.

108555 Shale, black, calcareous, carbonaceous micaceous, ferruginous, laminated, hard contorted

108513 Shale, purple to black, very micaceous, silty, soft, ferruginous, fractured and folded

Shale, black, carbonaceous, slightly calcareous, silty, with minor folds

Shale, black, carbonacrous, calcareous, siliceous, silty in streaks.

Shale, black, carbonaceous, micaceous, cherty, hard, resistant.

165370 Shale, gray, sandy, calcareous, ferruginous, hard, weathering gray.

Shale, black, micaceous, cherty, ferruginous, carbonaceous, laminated, slightly silty, hard, fractured.

Shale purple to black, micaceous, silty soft ferruginous, fractured and folded

Siltstone, sandy, dark gray, hard, slickensided, gray-weathering.

165379 Siltstone, sandy purplish gray, calcareous hard, gray-weathering.

Siltstone, sandy, gray, calcareous hard, weathering to light gray.

165398 Sandstone, fine grained, subangular, gray, well sorted, quartzose, micaceous, silty, hard, ferruginous, massive

Siltstone, very sandy, calcareous hard, gray, weathering to light gray.

108484 Shale, gray to black, silghtly silty, micaceous, carbonaceous, cherty, laminated

Shale, gray to black, calcareous, silty, micaceous, laminated, ferruginous

Siltstone, sandy and argillaceous, calcareous, weathering to light gray.

Sandstone, fine to medium grained, quartzose, cinnamon brown, micaceous, ferruginous, soft, fractured, weathered.

10845 Sandstone, fine grained, quartzose, well sorted, micaceous, calcareous, coaly, hard, massive and fractured.

Sandstone, fine grained, quartzose, micaceous, gray slightly calcareous, massive, hard, fractures filled with calcite

Limestone, fine textured, gray to cinnamon brown, silty to sandy, thick bedded, fractured.

108446 Siltstone, gray to black, carbonaceous, sandy hard, fractured.

Siltstone, greenish gray, calcareous, glauconitic, micaceous, shaly and thin bedded

108443 Shale, gray, calcareous, carbonaceous, laminated, ferruginous

119599 Sandstone, medium grained, quartzose, well sorted, gray to brown, micaceous, ferruginous, massive, slightly shaly

Siltstone purplish gray to red, micaceous, calcareous, partly covered

108594

108438 Shale, gray to gray-brown, laminated ferruginous, locally calcareous, soft, weathered.

108437 Shale, black, carbonaceous, cherty, hard ferruginous, laminated, pyritic, and veined with calcite.

Shale gray to black, carbonaceous, calcareous, micaceous, laminated with calcite in fractures.

Shale, black, carbonaceous, cherty, ferruginous, laminated, soft, pyritic and veined with calcite

108430

Shale, gray to purple, cherty, very silty, micaceous, ferruginous with sandstone in thin layers, weathered

Shale, black, carbonaceous, cherty, hard, ferruginous, laminated, pyritic and veined with calcite. Thin sandstones developed along strike

108365 Sandstone, fine to medium grained, well sorted, quartzose, gray to brown, arkosic, ferruginous, hard contains lenticular siltstones.

Siltstone, purple to black, shaly, cherty, micaceous, hard, sandy thin bedded

FIG-3

STRATIGRAPHIC SECTION ALONG RIO ARAGUA

11 KMS. TO EAST OF GUANAGUANA. EDO. MONAGAS

SCALE 1:2000

INTERPRETED BY: R. H. HOWELL JR., H. ROSALES & J. LAMB

(especially on Río Aragua), yet the Vidoño-Caratas-Los Jabillos sequence there is readily correlated with the Río Querecual type section by way of numerous intervening river sections along the mountain front. On these correlation sections no evidence is seen, such as irregular changes of thickness or angular relationships, which supports the concept of a break in the sequence, hence the Vidoño-Caratas and Caratas-Los Jabillos contacts are considered conformable.

It is concluded that the fossiliferous Caratas in the east and the barren Caratas in the west represent the same time interval, late Lower to Middle Eocene, and their faunal differences represent differences in basinal position. To the west the Caratas, inclusive of the Tinajitas Member, consists mainly of inshore facies with sparse and undiagnostic faunas. To the north and east a deeper marine environment is represented by interbedded shales with well preserved planktonic foraminifera, and the Tinajitas reefal facies has disappeared. In addition to Río Aragua, this deeper environment is developed on the nearby ríos Guarapiche and Punceres and also in the subsurface of the Quiriquire oilfield. These localities lie approximately on a WNW-ESE trend which probably parallels the depositional strike of the Caratas.

The Los Jabillos-Areo sequence likewise develops deeper marine character from west to east, the sandstone units thinning and the shales becoming more richly foraminiferal. A curious local feature is that on Río Aragua the post-Vidoño strata are appreciably shalier and much more fossiliferous than on Río Guarapiche, slightly to the northwest[4]. This appears anomalous, as the latter section would reasonably seem to be the more basinal of the two. The explanation is that the San Francisco Fault between the two localities is a right-lateral wrench fault, as is shown by structural offset of the Cretaceous formations and displacement of Caratas isopachs and facies trends along the fault. The Río Aragua section has been displaced to the southeast, hence despite its present position it represents the most basinward development of the Eo-Oligocene formations preserved in the Serranía del Interior.

LITHOSTRATIGRAPHY OF THE RIO ARAGUA SECTION (see text-Figure 3)

The San Juan Formation, although only 18 meters thick in this area, forms very prominent ridges which can be traced with facility in the field and on the aerial photographs. It is dominantly a fine-grained quartzose sandstone.

The Vidoño Formation is mostly covered in the upper portion; the exposed, lower part is a dark gray shale, much the same as it appears cropping out throughout the Serranía del Interior from the Tinajitas Syncline to northern Monagas. Its thickness is 271 meters.

The Caratas Formation contains sandstones and siltstones as in its type area, but the presence of several thick shales makes it a less massive unit than is typical to the west. Further differences are that glauconite is scarce and no limestones of the Tinajitas Member are present at the top of the Caratas interval. The Caratas thickness on Río Aragua is 239 meters.

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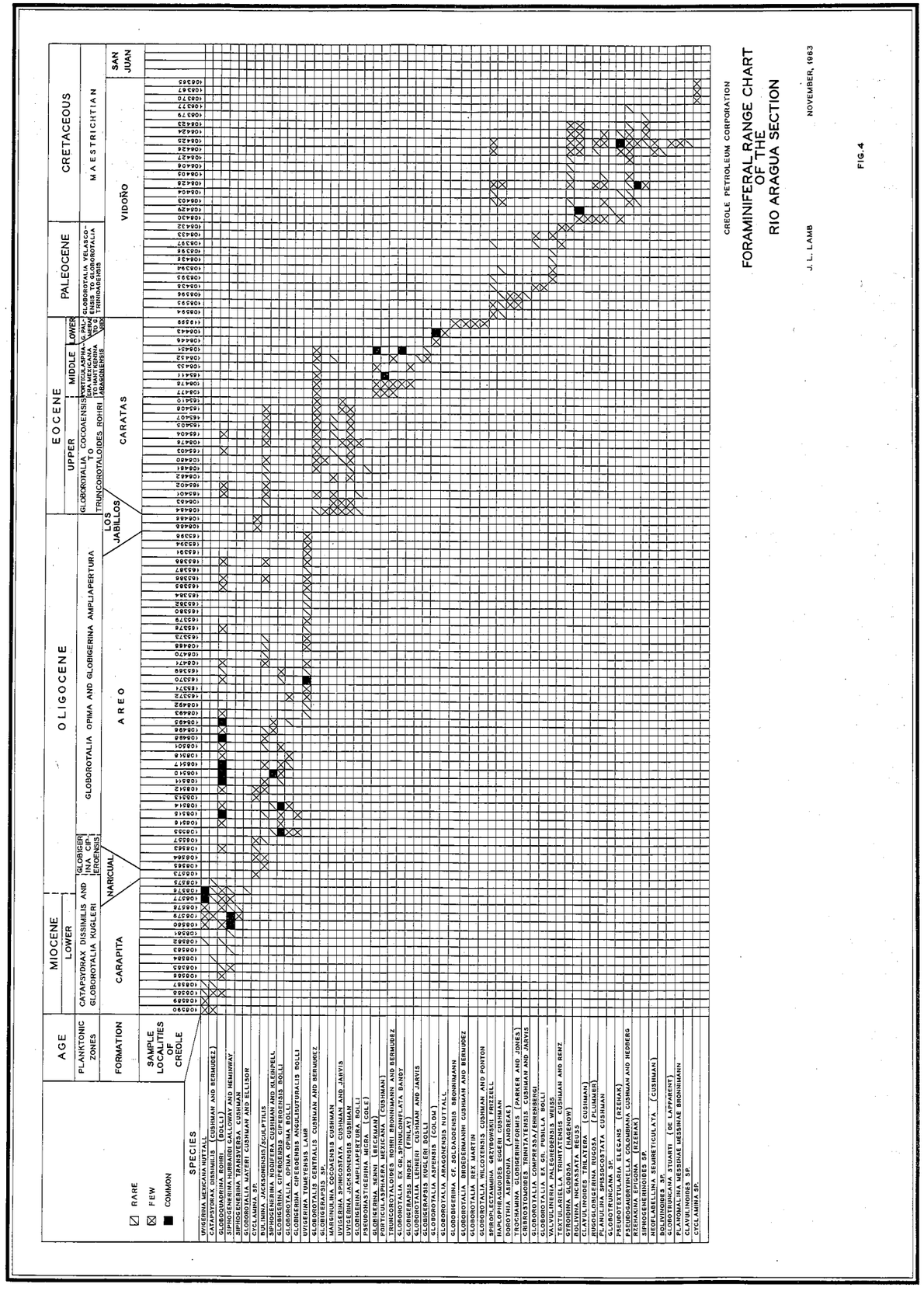
4 Compare text-Figure 3 of present paper with Figure 5 of Salvador and Rosales, 1960.



The Los Jabillos Formation is only 25 meters thick in this section, which is a mere basinal remnant of the development of more than 200 meters of sandstone found at the type section on Cerro Los Jabillos near Río Querecual. It is recognized here as being a fine-grained, quartzose sandstone intervening between siltstones and shales of the Caratas and Areo formations.

The Areo Formation of the Río Aragua is composed largely of gray, highly microfossiliferous siltstone and dark shale and is 376 meters thick. The upper part is sandy siltstone, which passes upward into the Naricual (?) sandstones.

The Naricual (?) Formation. In transitional contact between the upper Areo siltstones and the overlying Carapita shales is a 44-meter interval of hard conglomeratic sandstone capped by sandy siltstone. From its position, this is tentatively identified as a basinal remnant of the Naricual Formation, with none of the diagnostic features seen in the thick developments farther west.

An entirely different possibility is that this bed represents a tongue of clastic sediments rooted in the north flank of the basin, genetically related to the Nariva Formation of Trinidad. The conglomeratic texture is difficult to explain if it represents a shaled-out remnant of the Naricual.

The Carapita Formation is only represented by a thin sliver along the San Francisco Fault (see text-Figure 2) and the great bulk of the formation has been destroyed by faulting and erosion. The few meters preserved consist of gray, highly foraminiferal, somewhat contorted shales.

BIOSTRATIGRAPHY

The extensive outcrops of fossiliferous Caratas and Areo shales along the Río Aragua are unparalleled elsewhere in the Serranía, although better exposed and more fossiliferous Vidoño shale sections are known from a number of other localities. While most of the species listed on the faunal chart (text-Figure 4) are readily identifiable[5] and fairly abundant, many other species have been fragmented and contorted by incipient metamorphism, to the point of rendering identification difficult. For this reason the writer has selectively included only those species that have some proven biostratigraphic value and are readily identifiable. Species of nondescript or seldom encountered taxa have not been included in this discussion. It is expected that more detailed sampling and reprocessing of material by future workers will add to this faunal list, especially in the Vidoño shale interval.

Previous biostratigraphic studies of the Santa Anita and Merecure groups are limited to a short paper by Cushman (1947) describing a Paleocene-Cretaceous fauna collected by H.D. Hedberg from the Vidoño shale in the Barcelona-Bergantín region; the Paleocene-Lower Eocene Vidoño faunas published by Stanley (1960) from the Alcabala Section near Puerto La Cruz; and the definitive work by Renz (1962) on the type section of the Santa Anita and Merecure groups on the Río Querecual. Renz lists a Cretaceous-Paleocene-Lower Eocene fauna from the Vidoño-Lower Caratas and a previously unrecorded Upper (?) Eocene fauna from the Tinajitas. Many of the Vidoño species listed by these authors are also present in the Vidoño Formation of the Río Aragua, and their faunal

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5 Acknowledgement: Dr. Hans M. Bolli kindly assisted in identifying the Paleocene and Lower Eocene planktonic foraminifera.

lists are longer than the writer's. The Upper (?) Eocene interval noted by Renz in the Tinajitas is difficult to correlate precisely with the Río Aragua section, as he indicates uncertainty about the identification of several species, but it shows certain faunal affinities to the upper parts of the Caratas interval.

As to published faunal data on stratigraphically higher formations in eastern Venezuela: Hedberg and Pyre (1944, p. 19) noted a fauna of Nonion sp. and Uvigerina "of the cocoaensis type" in the Los Jabillos-Areo interval in both western and eastern parts of the Serranía. The so-called "Carapita" microfauna described by Franklin (1944) from the vicinity of Río Orégano, State of Anzoátegui, was obviously taken from the Areo Formation. Franklin describes Bulimina sculptilis Cushman and Globigerina concinna d'Orbigny (= G. ciperoensis Bolli), which are not known to range above the Areo Formation in eastern Venezuela. Unfortunately his locality description is so vague that the writer has been unable to locate his outcrops on available maps. Nevertheless, his inferred correlation of the fauna with the Alazán of México and the Finca Adelina of Cuba is in accordance with the writer's views.

Lastly, Hedberg (1937) described a fauna from the type area of the Carapita Formation, which lies along a tributary of the Río Querecual. His fauna is representative of a shallow to deep marine biofacies, and is believed to be of Catapsydrax dissimilis zone age. However, his section is considered to be badly faulted and the faunal sequence there is not entirely clear.

Cretaceous (Maestrichtian)

The lower Vidoño shale carries an Upper Cretaceous microfauna, which includes the following species:

Rugoglobigerina rugosa (Plummer)
Pseudotextularia elegans (Rzehak)
Globotruncana stuarti (De Lapparent)
Planomalina messinae messinae (Bronnimann)
Neoflabellina semireticulata (Cushman)
Siphogenerinoides sp.
Pseudogaudryinella columbiana Cushman and Hedberg

Throughout the Serranía del Interior the late Cretaceous microfaunas of the lower Vidoño are equally as abundant, or more so, as those of the Río Aragua. Renz (1962, plate I) lists some 121 species from the lower Vidoño on Río Querecual, including most of those listed here.

Paleocene (Globorotalia velascoensis Zone down to G. trinidadensis Zone). The Cretaceous-Paleocene contact falls within the lower Vidoño shale, where the copious Upper Cretaceous fauna is replaced by an impoverished Lower Paleocene assemblage. Due to indurated preservation in this interval the small planktonic species are identified less precisely than the calcareous and arenaceous benthonics. The species which characterize the lower part of the Paleocene are:

Globorotalia ex gr. pusilla Bolli
Globorotalia compressa/ehrenbergi (?= G. pseudobulloides (Plummer))
Valvulineria palegredensis Weiss

The upper portion of the Vidoño is mostly covered, but some outcrops were found that contain exclusively arenaceous assemblages, including the species:

Spiroplectamina grzybowskii Frizzell
Haplophragmoides eggeri Cushman
Dorothia asiphonia (Andreae)
Trochammina globigeriniformis (Parker and Jones)
Cribrostomoides trinitatensis Cushman and Jarvis

Although not precisely diagnostic in an age sense, these arenaceous species are common to the upper Vidoño shale of other sectors and are often found in association with late Paleocene planktonic foraminifera.

Lower Eocene (Globorotalia palmerae Zone down to G. rex Zone). Early efforts by the writer to find a Lower Eocene fauna on the Río Aragua were mostly directed towards the upper Vidoño shale, as both Stanley (1960) and Renz (1962) reported Lower Eocene faunas from this horizon in their respective areas. However, later spot-sampling recovered a Lower Eocene fauna immediately above the basal massive Caratas sandstone (sample 119599). This assemblage is quite similar to the Lower Eocene (G. rex Zone) horizon of Renz on the Río Querecual. The key planktonics identified from this sample are:

Globorotalia rex Martin
Globorotalia broedermanni Cushman and Bermúdez
Globorotalia wilcoxensis Cushman and Ponton

Benthonic species were rare to absent in this sample.

On Río Querecual Renz lists Globigerina soldadoensis Bronnimann, a Lower Eocene planktonic species, as occurring in the Caratas above his Globorotalia rex Zone of the Vidoño. He therefore takes this occurrence as the top of the Lower Eocene. The writer has also encountered this species interval in the Caratas from other localities in the Serranía, but has not yet found it in the Río Aragua. It is more than likely present and probably will be found with more sampling.

Middle Eocene (Porticulasphaera mexicana Zone down to Hantkenina aragonensis Zone). Paleontologists of the Creole Petroleum Corporation have realized for some time that the Caratas Formation is, in part, Middle Eocene. The Caratas sections cropping out along the Río Guarapiche and Río Punceres have yielded typical or normal Middle Eocene assemblages, so it was no surprise to also find them in the intervening Río Aragua sector. Much of the credit for the discovery of these localities goes to Hugo Rosales for his careful sampling. The diagnostic species encountered are:

Globigerina senni (Beckman)
Porticulasphaera mexicana (Cushman)
Truncorotaloides rohri Bronnimann and Bermúdez
Globorotalia ex gr. spinuloinflata Bandy
Globigerapsis index (Finlay)
Globorotalia lehneri Cushman and Jarvis
Globigerapsis kugleri Bolli
Globorotalia aspensis (Colom)
Globorotalia aragonensis Nuttall

The above list includes both early and late Middle Eocene planktonic species, and benthonic species are very scarce. However, the late Middle Eocene Truncorotaloides rohri Zone was not recognized in this section and it is probably included in the Upper Eocene portion of the overlying interval. This zone is very difficult to recognize, especially if the name-fossil is absent above the extinction of P. mexicana, as it seems to be here. The upper limits of the Middle Eocene, in the Serranía, are more often characterized by presence of the G. spinuloinflata-group or P. mexicana.

Upper Eocene (Globorotalia cocoaensis Zone down to approximately the Truncorotaloides rohri Zone). The more diagnostic species from the Upper Eocene portion of the Caratas are:

Globorotalia centralis Cushman and Bermúdez
Globigerina ampliapertura Bolli
Pseudohastigerina micra (Cole)
Globigerapsis sp.
Marginulina cocoaensis Cushman
Uvigerina spinicostata Cushman and Jarvis
Uvigerina jacksonensis Cushman
Bulimina jacksonensis/sculptilis

The Upper Eocene genus Hantkenina, although not encountered in this section, has been found at a similar stratigraphic horizon in the Quiriquire Field.

In other sectors the Upper Eocene part of the Caratas is often characterized by a calcareous and/or limestone facies often containing orbitoids, which is the Tinajitas Member of the Caratas Formation as defined by Salvador (1964). No orbitoids (or limestones) have been found at this level in the Río Aragua section, therefore the Tinajitas Member cannot be recognized here. This is not surprising as the Caratas Formation in this basinal position has a decidedly more marine biofacies aspect than in the more southerly sectors.

Oligocene (Globorotalia kugleri Zone down to Globigerina ampliapertura Zone). Bolli (1957, p. 99; 1959, p. 631, 634) suggested, without documentation, that the Oligocene-Miocene boundary in the Caribbean area corresponds to the contact between the Globorotalia kugleri Zone (below) and the Catapsydrax dissimilis Zone (above). Stainforth (1960) analyzed the stratigraphic occurrences of certain species of planktonic foraminifera within the Oligo-Miocene faunal succession of Europe, and drew analogies with the planktonic zonation of the Caribbean area. He found conflicting evidence regarding placement of the Oligocene-Miocene boundary in the mid-American Tertiaries, but one of his two alternative choices was the base of the C. dissimilis Zone. Subsequently the subject was further ventilated in a published discussion between Renz and Stainforth (1961), wherein the latter gave practical reasons for adopting the indicated datum. Still later this placement of the Oligocene-Miocene boundary received "official" approval in Venezuela when it was incorporated on the stratigraphic chart sponsored by the Ministerio de Minas e Hidrocarburos and the principal oil companies (Soc. Ven. Ing. Pet., 1963; p. 188: see also A.V.G.M.P., Bol. Inf., vol. 6, no. 11, 1963).

By the preceding definition the Oligocene includes the four zones, in upward sequence, of Globigerina ampliapertura, Globorotalia opima opima, Globigerina ciperoensis ciperoensis and Globorotalia kugleri. On Río Aragua the Oligocene age of the Areo shales is indicated by presence of G. o. opima, G. c. ciperoensis and and G. c. angulisuturalis, but these planktonic species are not abundant enough to define zonal limits with exactitude. However, on the basis of subsurface sections at Quiriquire Field, the author has shown elsewhere (Lamb, 1964) that an evolutionary sequence of Uvigerinas and Siphogenerinas can be keyed to the planktonic zones. In particular, U. tumeyensis n. sp. is confined to the opima Zone, while S. nodifera ranges from the upper part of the opima Zone into the kugleri Zone. It has been noted elsewhere that Bulimina jacksonensis/sculptilis does not range above the ciperoensis Zone. By utilizing these benthonic forms as well as the plankton, it is concluded (see text-Figure 4) that:

1) the Globigerina ampliapertura Zone falls entirely within the Los Jabillos sandstone;

2) the Globorotalia opima opima Zone extends from the top of the Los Jabillos to at least as high as Sample 108,555, i.e., through the basal 215 meters of the Areo;

3) the Globigerina ciperoensis ciperoensis Zone is represented in the upper Areo;

4) the Globorotalia kugleri Zone is not identifiable in the section, in the absence of the name-fossil, buy may correspond approximately to the "Naricual" interval.

(The Oligocene age of the Areo on Río Aragua agrees with the writer's findings at the type section and elsewhere. Post-Eocene planktonic foraminifera, such as those recorded here, are consistently present down to the top of the Los Jabillos. At Quiriquire Field the Globigerina ampliapertura Zone extends down into the Caratas shales below the Los Jabillos sandstone. No confirmation has been encountered of the supposed presence of the Eocene genus Discocyclina in the Areo (Hedberg and Pyre, 1944, p. 19; Hedberg, 1950, p. 1197).

Miocene (Catapsydrax dissimilis Zone). The Lower Miocene fauna of the basal Carapita Formation reflects a deep-water, marine environment of deposition. Representative species of this interval are:

Uvigerina mexicana Nuttall
Catapsydrax dissimilis (Cushman and Bermúdez)
Globoquadrina rohri (Bolli)
Siphogenerina hubbardi Galloway and Heminway
Siphogenerina transversa Cushman
Globorotalia mayeri Cushman and Ellisor

Siphogenerina transversa is a benthonic marker-species which can be used to advantage for recognizing the Oligocene-Miocene boundary. Phylogenetic relationships (discussed by Lamb, op. cit.) indicate that this species is descended from Siphogenerina nodifera, which does not range above the Oligocene. Although S. transversa evolved from S. nodifera in late Oligocene time, it is safe to conclude that its occurrence above the extinction level of S. nodifera represents Miocene age. Presence of S. hubbardi tends to confirm Lower Miocene age. Uvigerina mexicana has never been recorded above the Catapsydrax dissimilis Zone.

The foraminifera are poorly preserved in this tectonically squeezed wedge of Carapita shale, and the small planktonic forms are especially difficult to identify. Presence of Globoquadrina rohri proves that the beds are no younger than the Catapsydrax dissimilis Zone. Normally this zone contains several planktonic species not present in the Oligocene zones below. Foremost among them is the Globigerinoides triloba-group, but Globoquadrina altispira and Globorotalia fohsi barisanensis also deserve mention. Taken at face value, the absence of these species in the list above might indicate a level within the Globorotalia kugleri Zone (Oligocene). However, in view of the Lower Miocene benthonic species noted, the writer prefers to attribute their apparent absence to the difficulties of identifying poorly preserved specimens.

CONCLUSIONS

The exposures of Lower Tertiary strata along the Río Aragua are as important as the more westerly exposures, such as those along the Río Querecual, which have received more attention in the literature. They should be recognized as the most basinward development yet found of the formations which crop out extensively along the south flank of the Serranía del Interior. As such they give the geologist an additional, critical reference point with which to evaluate the sedimentary history of this region. The highly fossiliferous nature of these beds enables the paleontologist to correlate the formational sequence of the Serranía with the standard Caribbean planktonic zones, as established in Trinidad (Bolli, 1957, and others). Deserving particular emphasis is the presence of rich microfaunas with species diagnostic of Middle Eocene age.

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