ARTICULO

PROBLEMS OF EOCENE CORRELATION IN LAKE MARACAIBO, VENEZUELA[1]

by G.A. Young[2]

Abstract

Correlation of the Eocene sediments in the area of Lake Maracaibo is difficult, because of rapidly changing lithic facies, and the designation of an appropriate stratigraphic nomenclature is hindered by several factors and the resulting problems that have been created. Poorly exposed outcrops and the varied facies changes are those factors primarily recognizable for the inadequate formational descriptions, usage of informal names, usage of private names by operating geologists, differences of opinion as to interpretation of informally named formations, and the application of published names, many of which were unsuitable, to all areas of the subsurface of Lake Maracaibo. The application of the B-C group nomenclature to areas of the Lake other than Tía Juana and Centro Lago is believed to be ill-advised and the disadvantages are considered to be: 1) the unit numbers have to be grouped together to fit the lithology (i.e. B-6/8); 2) the intermediate unit tops are often placed at relatively proportional intervals with the unfortunate intimation that the tops of the sand beds are correlative; 3) the correlation, being uncertain, necessitates the use of question marks before most numbers.

It is pointed out that major lithic units (magnafacies) do exist and that these extend, with persistent lithology, for considerable distances, crossing time lines, until they interfinger with other lithic units. For the Lake area, six units comprise the Eocene section: Paují shale, upper sand member of the El Mene formation, lower shale member of the El Mene, Misoa sandstone, upper shale member of the Trujillo formation and lower sandstone member of the Trujillo. Formal names are not proposed for these members (magnafacies) in this paper.

Resumen

La correlación de los sedimentos del Eoceno en el área del Lago de Maracaibo es muy difícil debido esencialmente a los rápidos cambios de facies líticas en esa región. La designación de una nomenclatura estratigráfica apropiada ha sido obstaculizada por varios factores adversos y por los problemas que estos han creado. La deficiencia de los afloramientos sumada a los cambios de facies son los factores adversos primordiales responsables por las descripciones deficientes de las formaciones. Esto ha dado lugar a una serie de procedimientos inadecuados tales como: El uso de nombres indebidos y de nomenclaturas privadas por parte de los geólogos operantes. Las diferencias de opinión surgidas en la interpretación de las descripciones de formaciones que han sido informalmente bautizadas. El uso de nombres ya publicados, muchos de los cuales son inadecuados para ser aplicados a todas las áreas del subsuelo del Lago de Maracaibo. Un ejemplo es el uso de la nomenclatura del grupo de

[1]Manuscript received 28 July 1961. Presented before the A.V.G.M.P. on 20 December, 1960 in Caracas and before the Soc. Geológica de Venezuela Occidental on 22 March, 1961 in Maracaibo. Published with the permission of the Mene Grande Oil Company.

[2]Geologist, Mene Grande Oil Company, Caracas.

arenas B-C para áreas del lago fuera de la región de Tía Juana y Centro Lago. Se cree que la práctica es inadecuada por las siguientes razones: a) Hay que agrupar varios números para que correspondan con la litología, por ejemplo, B-6/8. b) Los topes de las unidades intermediarias son puestos con frecuencia a intervalos relativamente proporcionales, asumiendo que los topes de las arenas son correlativos. c) Debido a que la correlación de estas arenas es dudosa, se recurre al uso de signos de interrogación acompañando a los números.

Se hace la advertencia de que sí existen unidades litológicas mayores (magnafacies) las cuales cruzan las líneas de tiempo, y las que se extienden por distancias considerables hasta interdigitarse con otras unidades vecinas.

En el Eoceno del Lago de Maracaibo hay seis unidades litológicas mayores (magnafacies) bien determinadas a saber:

1) Las lutitas Paují
2) El miembro superior arenáceo de la formación El Mene
3) El miembro inferior lutítico de El Mene
4) Las arenas Misoa
5) El miembro superior lutítico de la formación Trujillo
6) El miembro arenáceo inferior de la formación Trujillo

No se proponen nombres formales u oficiales para estas unidades en el presente trabajo.

Contents

Introduction

The designation of a stratigraphic nomenclature for the rock assemblages of Eocene age occurring in the Lake Maracaibo area is a difficult matter, both for the regional correlation of large units and for the local correlation of sand beds. Attempts to find a logical nomenclature that adequately describes the lithic units of the varied facies of the rock assemblages bog down because of a multiplicity of factors: poorly exposed outcrops, inadequate formational descriptions, usage of informal names, continuous facies changes and difficulties of correlation. Yet it would seem desirable to set up a system of nomenclature for Eocene sediments based upon the lithic units as they exist in the subsurface of the drilled areas of the Lake Maracaibo instead of attempting to conform to a system derived from inadequately defined formations found in outcrops.

It is the purpose of this paper to examine the problems concerning nomenclature and correlation within the Lake Maracaibo area and to suggest, as a partial solution for the problem, a lithological breakdown of the Eocene sequence into six major lithic units. Most of the discussion concerns the northeastern part of the Lake area (the Bolívar Coastal Fields, Ceuta, Centro del Lago and Lama areas) because these heavily drilled areas provide most of the subsurface data and because it is the area for which a good subsurface nomenclature is required.

Review of published nomenclature

The stratigraphic names applied to the Eocene sediments were given in the ordinary way; outcrops were examined, described and named. However, in the Maracaibo Basin, where only portions of the Eocene sediments are exposed, this obviously resulted in a piecemeal recognition of the sediments. To add to the difficulty, few of the type sections were published with detailed lists of lithologic units or with columnar sections, so that the arrangement of sands and shales within most of the sections are unknown.

Thus the names that were applied to the Eocene had only a gross significance at best, and the attempts to relate one outcrop area with another were also, necessarily, in a gross sense. With the penetration of the subsurface in Lake Maracaibo, there was a time-honored tendency to relate the newly discovered sections to the names from the outcrop areas. Since the stratigraphic position of the local sequence could not be determined exactly, the names could only be used to demonstrate a generalized relationship (usually based upon biostratigraphic correlation) with the outcrop rocks.

Many articles have been written attempting to correlate outcrop with outcrop and outcrop with subsurface. Among the many comprehensive articles, I should like to mention several important ones: Sutton (1:1946) compiled information on all the formations in the Maracaibo Basin, with data on lithology, distribution, age and correlation; he did not provide columnar sections or electric logs. The staff of the Caribbean Petroleum Company (2:1948) described eleven fields in the Maracaibo Basin in some detail, but for the main part, did not propose formal stratigraphic names for the sections shown. Schaub (1948) pointed out and discussed some of the difficulties hampering correlation, and some differences of opinion with Sutton. González de Juana (3:1951) ably summarized information on the gross correlations. Mencher et al. (4:1951) provided resumés on the stratigraphy and structure of major fields. The B-group nomenclature for the Bolívar Coast Fields was published for the first time, on a diagrammatic cross-section (p. 737), but without explanation. The

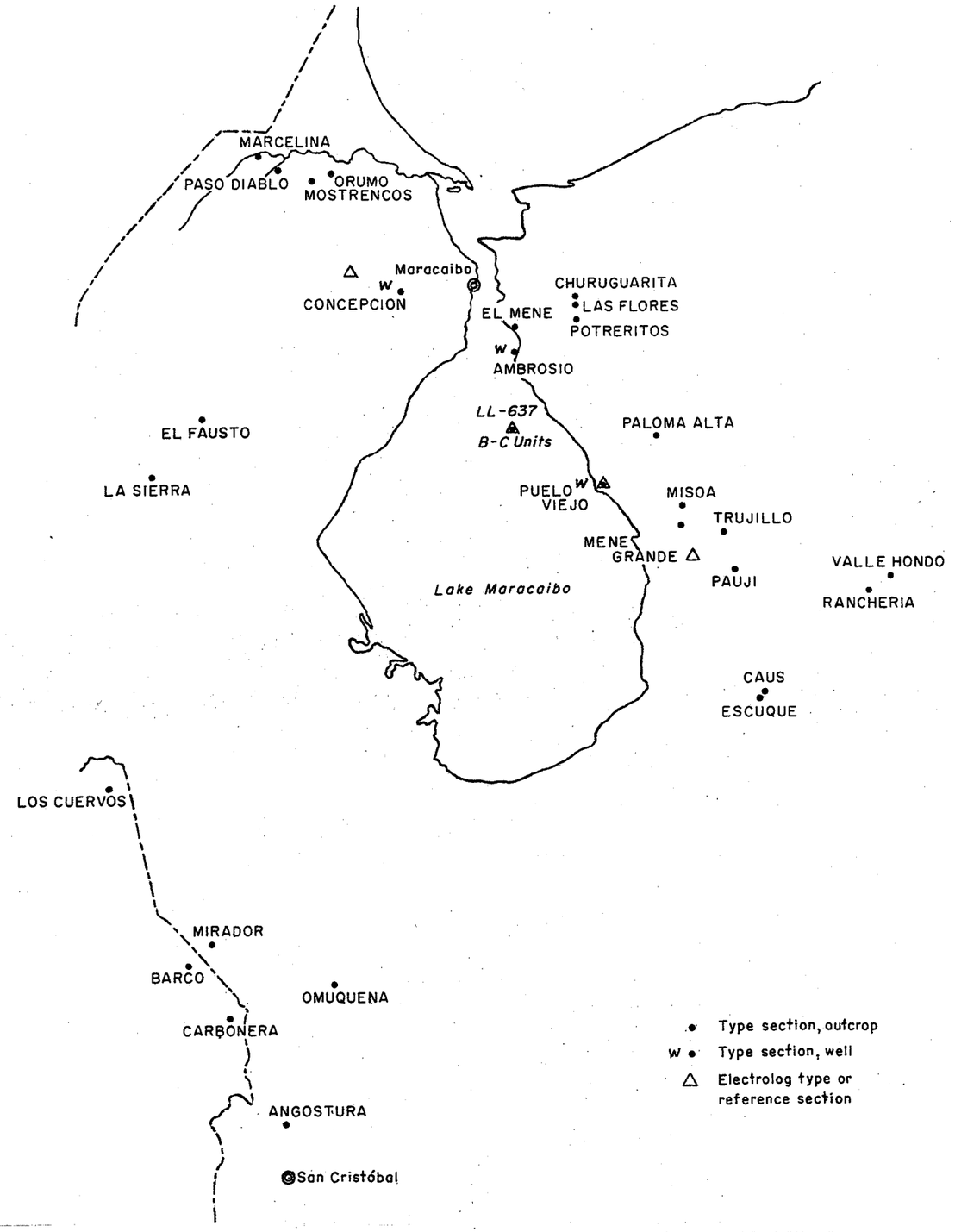


Fig. 1. Young. Location of Eocene type localities.

paper by Young et al. (5:1956) contained an electric log type section for the Eocene in the Lake area, showing the B- and C-sand group nomenclature (p. 80)[1], as well as the electric logs of partial Eocene sections in La Paz (p. 65) and Mene Grande (p.76) fields. Miller et al. (6:1958) display a very good correlation chart for Eocene sediments. Miller also discusses the stratigraphy as related to paleoecology of environments and provides a contour and isopach map of the Eocene. Borger and Lenert (7:1959) show the same B- and C-sand group type section as Young et al. but slightly modified.

These papers have been mentioned to show the range of the more recently published material covering the Maracaibo Basin and to illustrate how little has been published about the detailed stratigraphy of the subsurface in the Lake Maracaibo area.

Eocene formational names

The distribution of Eocene type localities and reference sections is shown on Figure 1. The Las Flores and Potreritos formations (1: pp.1675-1683), named from outcrops in the northeast of District Bolívar, were used to designate subsurface sections, but were dropped by most companies because of the ambiguity of the terms. The El Mene formation (8: p.93), defined from an outcrop extending along the Lake shore, has been used, mainly by the Mene Grande Oil Co., to designate the Eocene sediments overlying the Misoa formation in the subsurface. The Ambrosio formation (8: p. 95) was named from the village of Ambrosio although the type section is in wells of the Ambrosio field but there is no type log, electric log nor columnar section for this thin Eocene section penetrated by the wells in the Icotea syncline. The Pueblo Viejo formation (2: p. 525) is represented by a type electric log (8: p.532) and can be recognized easily in the subsurface of the Pueblo Viejo area. The Misoa (9: p. 678) and Trujillo formations (10: p.175-6) are the formation names used principally in the subsurface by most workers, but even though they have been discussed in many publications, the lithology has never been described in detail. Only a representative columnar section and an electric log of the uppermost part have been published. The Paují formation (11: p.242) is probably the best known of the Eocene formations and columnar sections and electric logs have been published. The descriptions of the formations that outcrop around the southern part of the basins, formations such as Ranchería (12), Valle Hondo (13: p. 479), Caus (11: p.238), Escuque (12), Carbonera (14: p.1196), Omuquena (1: p.1673), etc., all indicate the facies changes that have taken place in the basin, but these formations are too distant to have any effect upon the Eocene nomenclature to be applied in the Lake area.

In the northern Mara area, the formations Orumo (8: p.93), Mostrencos (8: p. 91) and Paso Diablo (8: p. 90) were named from outcrops that represent the lower part of the Eocene section; however, the exact correlation with the rock sequence in the central Lake is still controversial. The Concepción formation (2: p. 588), applied to the Eocene sequence in the wells of Concepción field, is represented by an electric log (2: p. 586) and a generalized columnar section. This formation name has been used principally by Shell for the C-sand group in the Lake area.

---

[1]The electric log type section for B- and C-units was prepared by F.W. Johnson, Chief Geologist of the Creole Petroleum Corp. The limits of the units have been modified slightly by Borger and Lenert, also with the Creole Petroleum Corp.

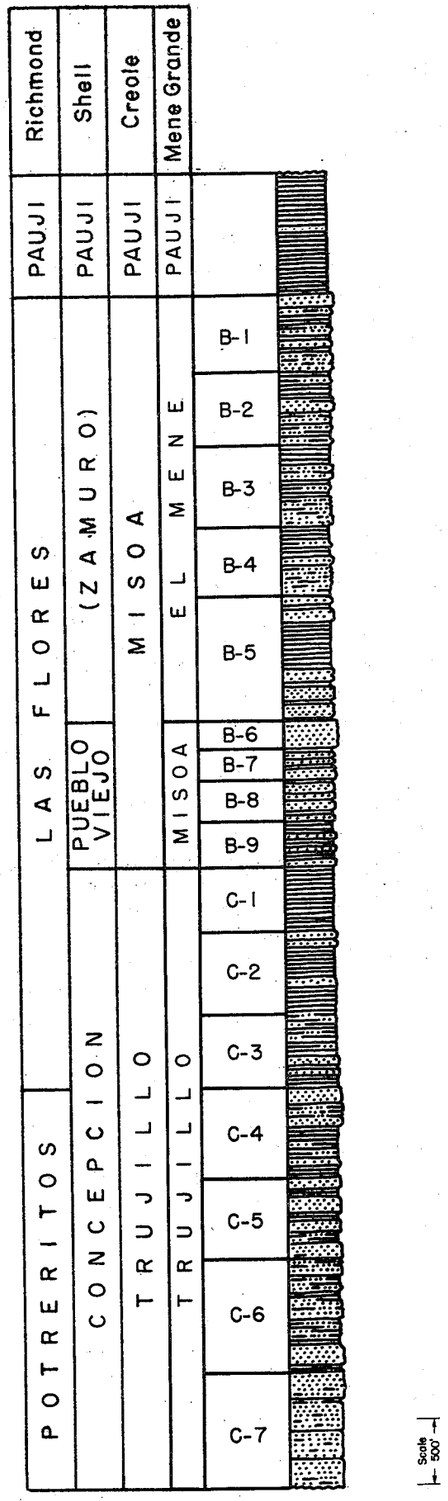


Fig. 2. Young. Columnar section of the Eocene sediments in the Lake Maracaibo area.

Problems of nomenclature

There are many problems that arise when one tries to adhere to the published nomenclature. Some problems are inherent in the nomenclature and others are due to lack of data and the consequent differences of interpretation and opinion. Some of the more obvious problems can be listed, as follows:

1. Many of the formations that have been described from outcrops do not have accurate nor detailed columnar sections, nor cross-sections for detailed correlation. Many formations do not have type sections nor type logs.

2. Some of the formations have been named from inadequately exposed sections; in some cases the top and/or bottom sections of the formation were unknown at the time the formations were named. Consequently, thicknesses of the sections as well as the types of formational contacts and the names of the adjacent formations had to be assumed. Obviously, complete and detailed information as to the lithic character of these formations was unknown, and in many cases, is still unknown.

3. In general, the lithologies of the outcropping formations, being several kilometers distant, are not representative of the lithologic sequences found in the subsurface sections present in the Lake Maracaibo area due to the rapid lateral facies changes that took place during the deposition of the Eocene.

4. Due to the conditions mentioned above, there has always been considerable difference of opinion as to the relationships of subsurface units, such as the B and C groups, the Pueblo Viejo formation, etc., to the outcrop formations. The differences of opinion among four of the operating oil companies are illustrated by Figure 2. These differences are difficult to reconcile and even if the solution were to be found, habits of usage and the correlations listed on thousands of logs tend to bind the operating geologists to the nomenclatures to which they are accustomed. This then is a major problem and one requiring a decision among the operating companies. If possible the proper formations for the rock assemblages in the Lake should be determined; however, since that does not seem to be feasible with the present extent of our knowledge, it would be proper to assign new formational names based upon the lithologic units as we know them.

5. In addition to difficulties in correlation of formational nomenclature, it is also difficult to correlate sand and shale beds within formations or even within members. Borger and Lenert (7) summarized the problem of correlation precisely: "The Trujillo formation has been subdivided rather arbitrarily into seven members; namely the C-7-X through C-1-X (from bottom to top). Due to the lack of diagnostic fossils and fairly rapid lateral changes in sand development, the subdivision of the Trujillo by the electric log is often difficult to make without a tie-in to either the overlying B-6-X sandstone or the underlying Guasare formation." To reiterate, the C-X units (and the B-X units as well) have been assigned arbitrarily; they are not based upon group differences in lithologies, but rather they are units of more or less equal thickness, the tops of which are placed on prominent or convenient sand beds that appear to have appreciable lateral extent (see Fig. 3).

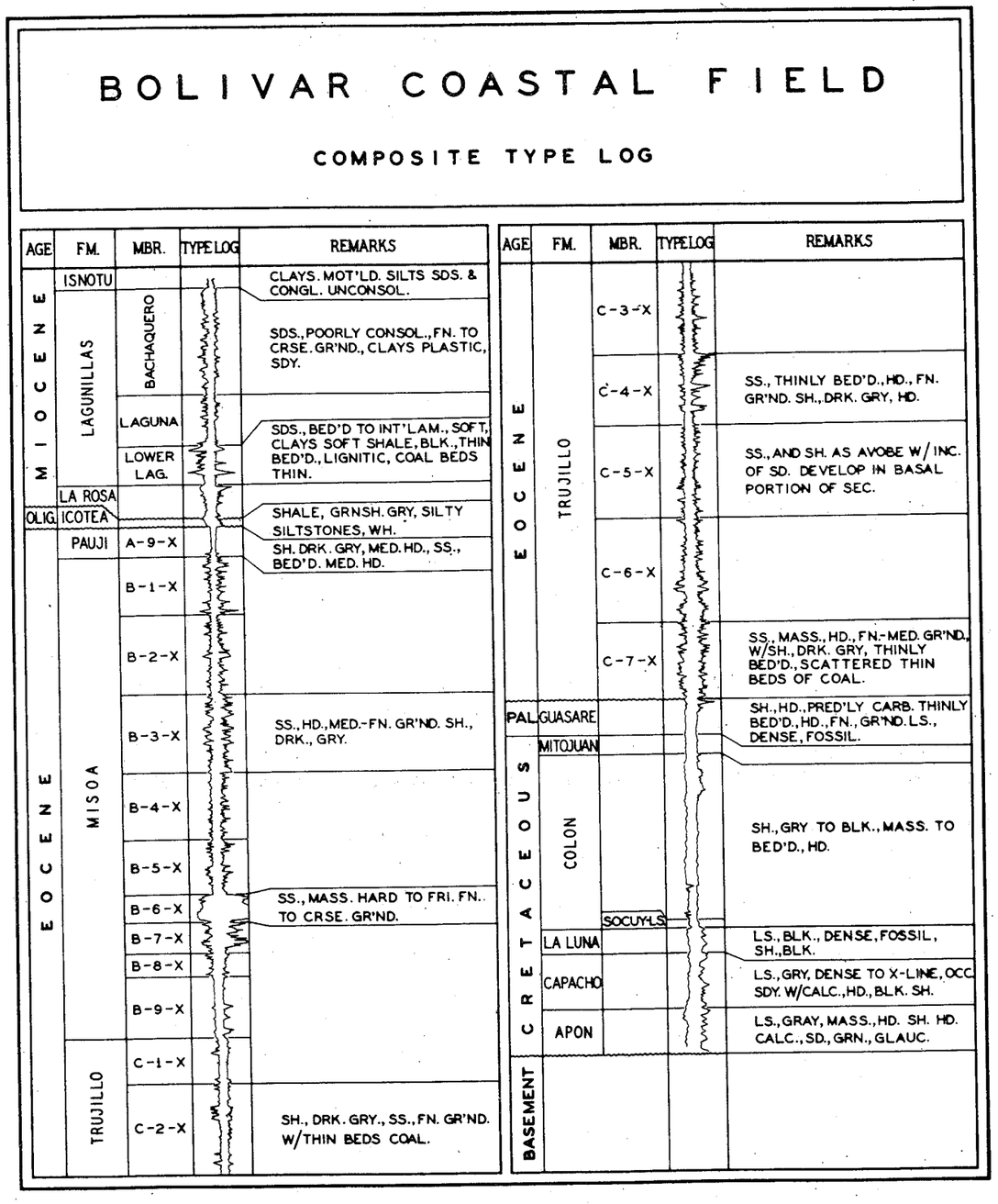


Fig. 3. Young. Electrolog showing B-X and C-X units, Tia Juana lake area (after Borger and Lenert; 7, p.244)

6. The B-C group units, which have proven to be of considerable convenience in the Tía Juana area, have been extended, or attempts have been made to extend them, over the entire Lake area; however, each worker has extended or correlated these units in a different way. Some have interpreted the general thinning of the Eocene sequence to the south and to the west as having taken place through the gradual thinning of each B and C unit. Some believe that most of thinning takes place in certain of the units; for example, the B-3, C-1, C-3, whereas other units, although they thin slightly, maintain their thicknesses in proportion to the others. Others believe that some of the thinning is accomplished by non-depositional hiatuses or by actual erosional hiatuses. There is no doubt that the correlation is difficult. Nevertheless, it is also apparent that certain B and C tops are persistent, and that other intermediate B and C tops are only spaced conveniently between those markers. Thus the B and C units are really used, outside of the type area, as one would use a yardstick to subdivide the major lithic assemblages.

7. This problem then poses a question of nomenclatural procedure: Should a nomenclature, adapted to the stratigraphic sequence in one area of the Lake Maracaibo, be forcibly applied to the rock assemblages in other areas of the Lake, even if it is not necessarily suitable for lithologic subdivision of the sequence except perhaps on a gross scale?

Problems in the application of the B-C nomenclature

To illustrate the problem of the application of the B-C group nomenclature, a north-south section along the coast from the Tía Juana area to the Ceuta area is shown by Figure 4. Over a distance of 30 kilometers, there is considerable thinning that amounts to over 4000 feet in the Trujillo formation alone. If we consider that all the B and C units thin more or less equally, then we must interpolate the tops of the "weaker" units into the major subdivisions. For example, the top of the C-4, which represents the top of the predominantly sandy section of the lower Trujillo formation, is discernible in both the Pueblo Viejo and Ceuta areas, but, whereas the C-4 to C-7 section of Pueblo Viejo may be divided into units that somewhat resemble the type units, any such subdivision in the Ceuta area is purely fanciful. The same applies to the other major rock divisions: within the B-6 to B-9, the tops of the "weaker" units are placed wherever there are convenient shale breaks separating the adjacent sand. Within the C-1 to C-3 shale grouping, the C-2 is placed on the top of a convenient sand near the required thickness for the C-1.

Protagonists of the hiatus theory utilize the erosional disconformities to explain additional or extraneous thickening or thinning of the section; for example, a hiatus at the base of the B-9 would explain why the C-1 is thicker than it should be in cases where the "C-2" sand appears to be low in the section, or conversely, explain why the C-1 unit is thin if the C-2 sand is apparently high in the section.

Without doubt, all of these concepts have some bases and it is believed that, within local areas, some of these units can be shown to thin equally or at the same rate, that some selected intervals do seem to thin at a greater rate than others, and that some units are thinned by erosion or non-deposition.

Moreover, in an attempt to piece together the paleoecology of the Maracaibo basin as a whole, it becomes obvious that the entire area was not covered by the same environment at the same time. Thus, for example, the environment in which the

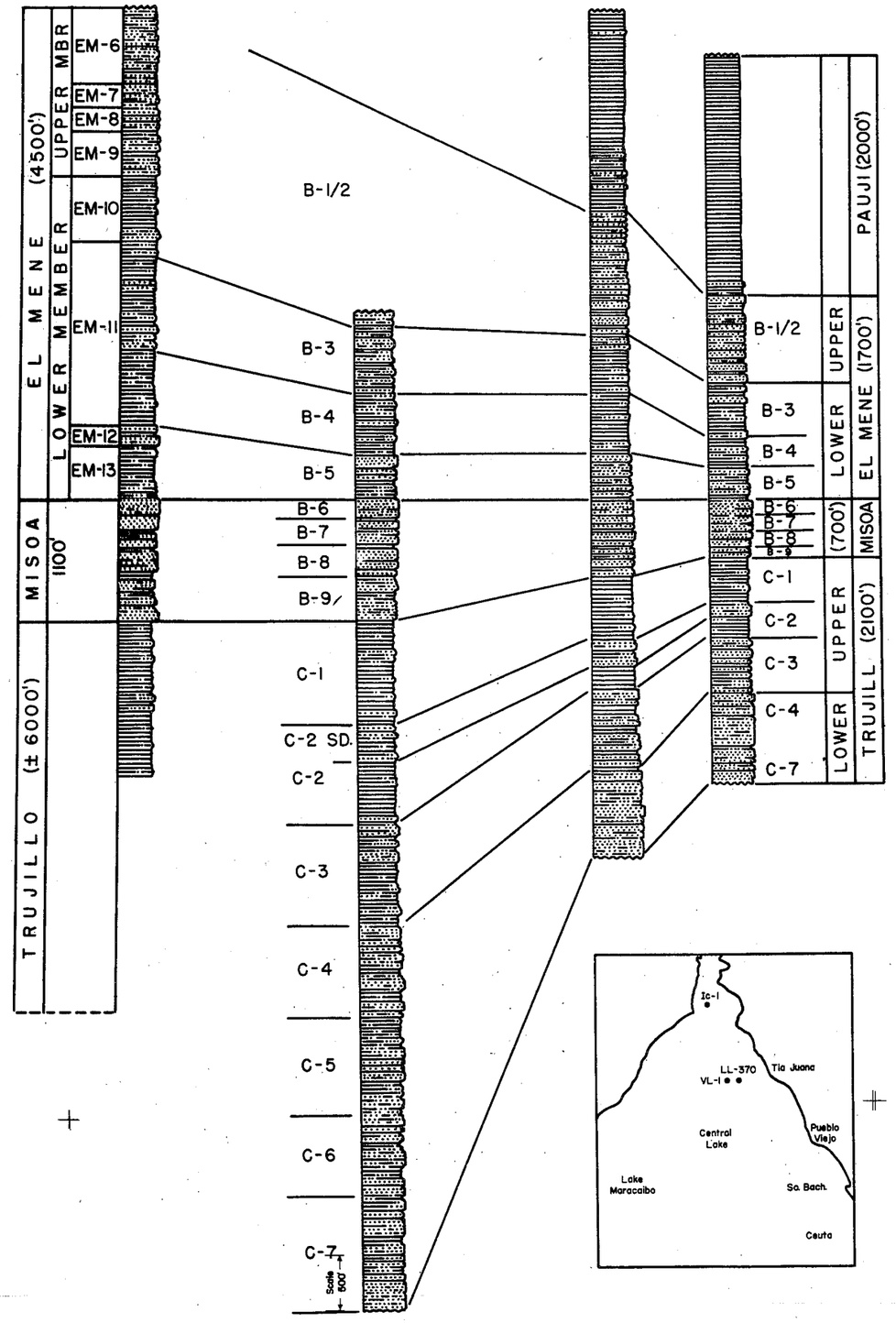


Fig. 4. Young. Columnar sections along the Bolivar Coastal Fields. The concept of more or less equal thinning of the B and C units is illustrated on section from Tia Juana southward to Ceuta.

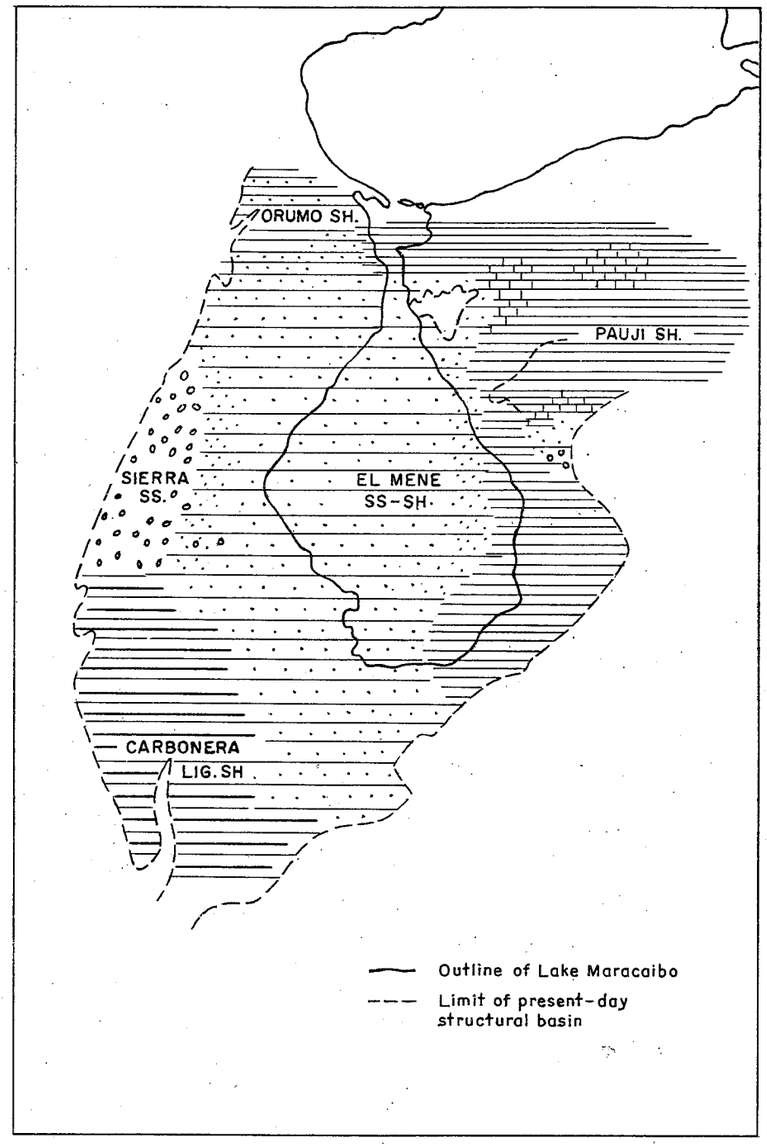


Fig. 5. Young. Lithofacies map of the Eocene during the deposition of the lower member of the El Mene formation.

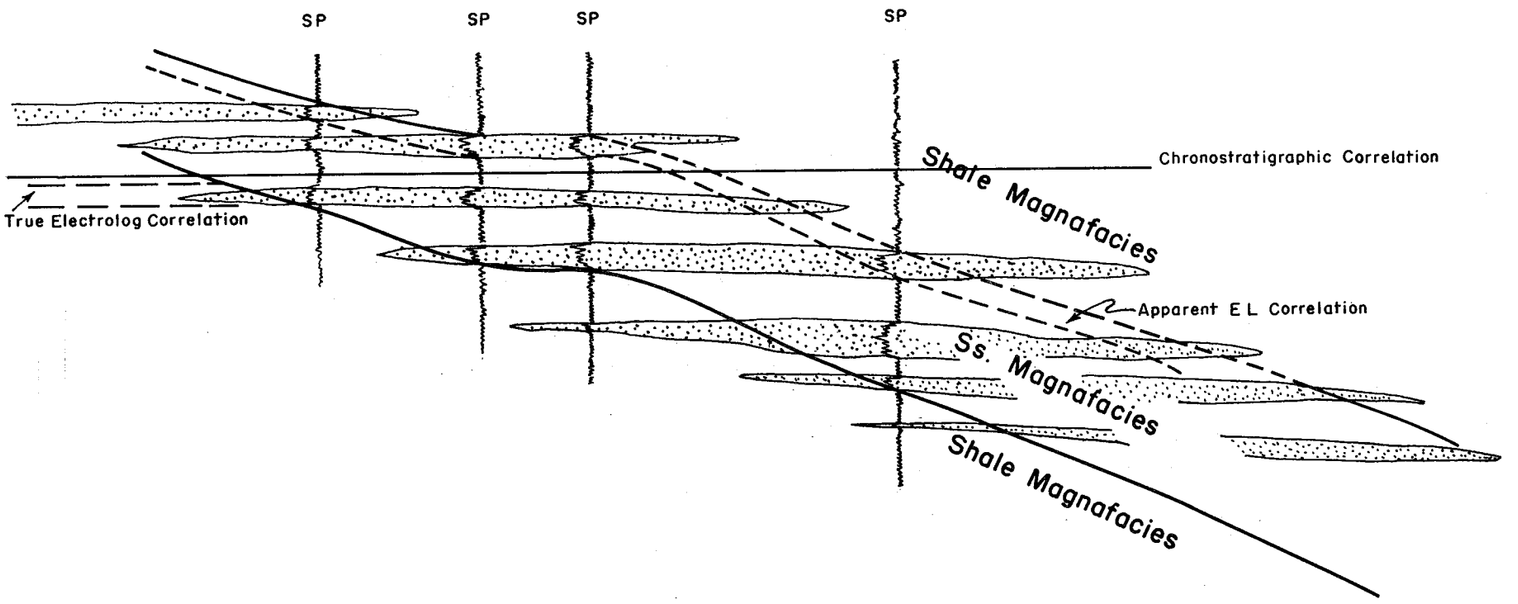


Fig. 6. Young. A diagram illustrating the relationship between a sandstone magnafacies and the chronostratigraphic correlation. Electric log correlation may be either a true lithic correlation, if the well control is sufficiently close, or may only appear to be a true correlation. As shown in the sketch, the EL always shows three major sands to be present, regardless of whether or not they are the same sands.

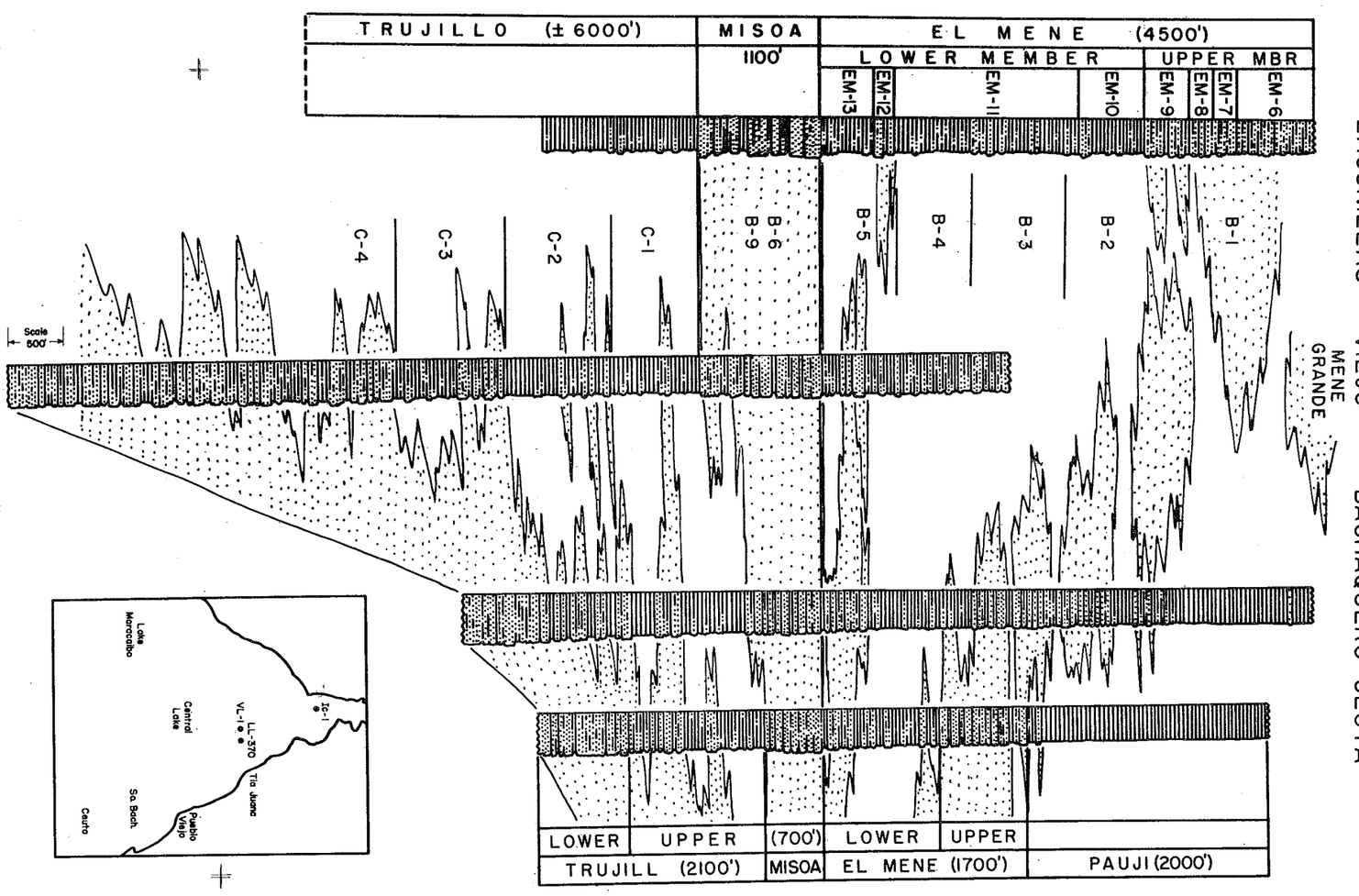


Fig. 7. Young. Columnar sections along the Bolívar Coastal Fields showing an extreme version of the concept that the thinning of the Eocene section is a function of rapid facies changes and that the major

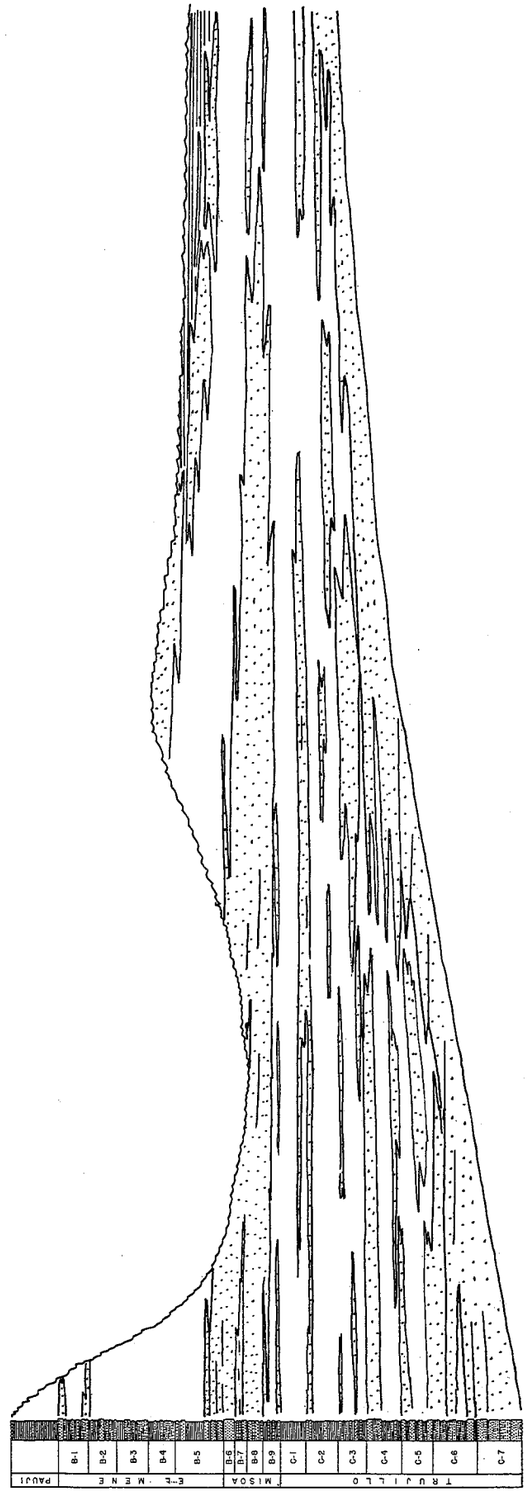


Fig. 8. Young. Diagrammatic section from Tía Juana (Lake) to the Andes showing the changes in lithofacies (magnafacies).

B-3 unit of Tía Juana was deposited does not appear to have extended over the Lake area at one time (see Fig. 5). Rather, as one would expect, there were many and varied environments present, from the continental fans of the La Sierra formation (8: p. 89) in the west to the marine reefs of the Paloma Alta formation (15: p.115) in the east.

Thus it is the contention of the author that the thinning of the major rock assemblages is a function of the rapid continuous facies changes and that the major lithologic units are essentially magnafacies[1] (see Fig. 6). The upper member of the El Mene formation (Meneg nomenclature) constitutes a major rock assemblage that can be traced from Tía Juana to Ceuta, but it is felt that some of the apparent lateral changes and differences in sand ratios and sand characteristics are due to the presence of different sandstone beds, of different ages, being progressively added and grouped into the lithic unit to form a magnafacies (Fig. 7). An attempt to trace the chronologic deposition during any instant of time would show a continuous change of lateral lithologic and faunal facies; for example, the EM-10 (or B-2) in Tía Juana (shore) is a lignitic shale, which contains a Trochammina inflata marsh fauna, that was deposited contemporaneously with some part of the B-1, poorly sorted sandstones containing outer bar Quinqueloculina - Textularia faunas, and farther south, with some part of the Paují formation, black shales containing neritic marine faunas. Thus chronologic deposition lines pass through various magnafacies (shown by Fig. 5).

In the center part of the Lake Maracaibo, one encounters similar types of facies changes (Fig. 8). In the type area - the Tía Juana Lake area - the B and C units show distinguishable lithic characteristics. However, to the south in the northern Central Lake area, the B-6/B-8 sands have merged, a thick sand appears near the C-1/C-2 contact and the C-4/C-7 section is considerably thinner. The B-C nomenclature can still be applied, but one should consider carefully whether or not the denomination of the tops of the weaker units (i.e. B-7 or B-8 sands) are really correlation points or just convenient shale breaks or sand tops that occur at about the right place in the section.

Farther south in the Central Lake area, the Eocene section can be subdivided lithically into five assemblages: an upper massive sand group, a massive shale and siltstone group, another massive sand group, a predominantly shale group with intercalated sand beds, and a basal massive sand sequence. Again the B-C nomenclature has been applied, but now the correlation is more difficult. The upper sand group, because it is above a shale group that overlies the B-6, has been called variously B-1, B-2, B-3, and B-1/B-3. The shale group, depending upon the ideas of each worker, is called B-3/B-5, B-2/B-5 and so on to fit with the overlying and underlying sand sections. The next lower sand section, which includes the B-6, can no longer be subdivided logically even by the most avid of splitters, and so is generally called B-5/B-8 or B-6/B-9, etc.

This jumble of numbers can hardly be called a nomenclature: it is only an uncertain grouping of lithic features that appear to simulate a correlative relationship to the type section of the B-C units. But it is not a nomenclature that suits the rock assemblages. It does not utilize the best correlative features of the sediments nor does it group the lithologies so as to form properly defined lithologic members.

[1] A term proposed by Caster (16: p. 19) to distinguish each major group of deposits that represent a particular environment of deposition and maintain a similar lithology. It irregularly transgresses time stratigraphic lines and it shifts in geographic placement.

The foregoing comments are not meant to disparage the use of the B-C nomenclature in areas where it can be applied readily and with sense, but rather to point out the futility of trying to apply a nomenclature that does not fit the section. The disadvantages of using the B-C units in areas such as southern Central Lake and Ceuta are several: 1) The unit names (or numbers) have to be grouped together to accommodate the lithology (i.e. B-6/B-8, as mentioned above); 2) the unit tops are not placed on true correlation points but on some conveniently located sand or shale bed, with the unfortunate intimation that the tops are correlative; 3) the correlation, being uncertain, necessitates the use of question marks before most unit names (i.e. ?C-5, ?C-6, ?C-7) or blank spaces on most logs between major correlation points (i.e. top C-4 to base C-7). Because of this uncertainty, the names as applied to any section are in a continual state of flux, since they are changed with each later and "better" correlation when compared with sections from more recently drilled wells nearer to the type-section area.

Much of this uncertainty is due to the fact that these B and C groups have never been defined. No one knows if they are supposed to be chronologic units, strict electrolog units, or magnafacies (lithic) units. Each worker has followed his own idea and has extended the correlation accordingly.

These problems that have been pointed out, express the rather unfortunate status of our Eocene stratigraphy. If we were to name each lithic group in each area, then we possibly could have a perplexity of names that would obscure the regional stratigraphy and create unnecessary complications in the correlation of adjacent areas. If we continue to extend the use of the B and C units, we maintain our state of uncertainty and are committed to a bastardized type of nomenclature in outlying areas, such as Ceuta, even though we know well the entire Eocene sequence.

Major lithologic units of the Eocene

Although the Eocene stratigraphy is complex, with many variable, lateral interfingerings of lithologies, it is also evident that there are a few persistent assemblages of rocks, which appear to be magnafacies, that extend throughout the Lake area. It would seem plausible to unify our Eocene nomenclature and resolve the problem of the B-C groups, by utilizing these persistent lithologic units (magnafacies) which encompass lithologies of similar facies, in regional correlation and application. It is the suggestion of the author that a simple set of names be applied to these magnafacies and that they be considered as members (because they represent consistent lithologies) of the formational nomenclature. In this way each worker would know the type of units he is attempting to correlate. For example, he would know that the assemblage of sandstones underlying the Paují formation is always the same magnafacies (i.e., upper member, El Mene formation) and would not be faced with the uncertainty of whether or not the sandstones were the B-1/B-2 units (the B-2 top is usually meaningless) or a lateral facies of the B-3/B-4 shales.

A set of names for the major units has the advantage that they are not suggestive of the B-C correlation. Also, these major magnafacies units may be subdivided in each area according to the actual lithology present instead of by supposed correlation points.

The major rock assemblages of the Tía Juana (land) to Ceuta area can be described briefly as follows:

Description	% Sandstone	Thickness (Ceuta)	Informal Name
Shale assemblage: predominantly shale with a few intercalated sandstone beds.	5%	2100'+	Paují shale fm.
Sandstone and siltstone assemblage: predominantly thin bedded sandstone and siltstone interbedded with thin shale beds.	45%	800'	Upper Member El Mene fm.
Shale assemblage: mainly shale and siltstone with numerous intercalated sandstone beds, some up to 20 or 30 feet thick.	18%	950'	Lower Member El Mene fm.
Sandstone assemblage: dominantly sandstone, massive 30- to 100-foot beds, with a few thin-bedded shales.	60%	600'	Misoa fm.
Shale assemblage: predominantly shale with numerous intercalated sandstone beds, ranging from 5 to 60 feet thick.	15-20%	1250'	Upper Member Trujillo fm.
Sandstone assemblage: mainly massive sandstone and siltstone with numerous thin shale beds.	60%	1200'	Lower Member Trujillo fm.

The terms Upper and Lower have been mentioned as informal names to designate the members of the El Mene formation and the Trujillo formation as they are being discussed in this paper. (Actually, the terms are consistent with the divisions of the El Mene formation into upper and lower members designated in the Stratigraphic Lexicon, 17, p. 205.) It is not within the scope of this paper to propose formal names for these lithic units but rather to point up the fact that the units do exist. Any formal names should be proposed in accordance with the Code of Stratigraphic Nomenclature (Bull., A.A.P.G., vol. 45, no. 5, pp. 645-665) and should be accompanied by clearly described type sections or type wells with all available electric and radioactive curves and core data at a readable scale.

Use in reservoir work

Although these proposed units are especially suitable for regional work, the units were originally devised for reservoir and reserves work because the uncertainties of correlation have kept the sand electrolog nomenclature in a state of flux. In several cases the name of the objective sand on a drilling program had to be changed to another name upon completion and changed yet again the following year (on the basis of revised regional correlation) so that each year the production reports and reserve estimates were confused.

In these rather thick rock units, especially the El Mene Lower Member and the Trujillo Lower Member, the sand reservoirs may be designated by two methods: the

producing sand unit as defined by the discovery well for that particular reservoir, or as electrolog units of small groups of sand and shale beds that are persistent subdivisions of the major lithic unit.

In the discovery-well method, a sand reservoir that is being produced for the first time, for example, in the Lower Member, El Mene (abbr. EML), would be designated by that well; i.e. EML/75-Z-1X. As other sand reservoirs in the Lower Member are found to be productive, they would be designated by their respective discovery wells. Sands that are not productive are not named; as most of the sands are lenticular and not persistent over the distance of two or three locations, there is no need for names. However, with this method, one cannot distinguish, from the reservoir name alone, whether one sand reservoir is above or below another within the major lithic unit; nevertheless, it is a question of whether or not it makes any real difference. Structure and isopach maps would be drawn on the individual sand reservoirs for reserves calculations and reservoir studies.

Even if the limits of the B/C units were to be arbitrarily fixed at certain points within each field, the smaller sized B/C units would provide only a slightly better idea of relative stratigraphic position than does the use of the larger Upper and Lower members because each B and C unit also contains three or four prospective sand beds.

The problem of relative position can best be solved by means of a finely subdivided grouping of persistent beds, which would be set up in accord with the lithology of each field or area and named or numbered as desired. For example, in the Ceuta area, the Lower Member, El Mene, contains four productive horizons and the section contains nine minor lithic units, which can be numbered EML-1 to -9. The EML-1 unit is a shale (with little chance of the development of a sand bed) and EML-2 is a persistent sand (EML/75-Z-1X reservoir) over most of the Ceuta field. If a sand does develop in EML-1, or two sands develop in EML-2, these units can be further broken down by the decimal system; i.e., EML-1.1, EML-1.2, etc.

This system provides both names for any correlation points that may be desired and an exact sand reservoir nomenclature that describes the location of each sand in the section when combined with the discovery well; i.e. EML-2/75-Z-1X.

Use in regional correlation

Although this paper is concerned primarily with the Eocene sequence in the northeastern part of the Lake Maracaibo area, the proposed magnafacies units can be extended readily to other parts of the Maracaibo Basin where they are gradually replaced by, or interfinger with, other lithic facies. As an example, the sandstone facies disappear toward the eastern part of the Basin and reefal limestone facies appear: the Río Grande/Paloma Alta limestones appear in the upper Paují and lower Mene Grande formations, the Cerro Venado limestone in the middle Paují and the Churuguarita limestones in the upper part of and overlying the Paují formation.

The extension of the proposed units to the west are depicted on the cross-section El Centro to Río Raya (Fig. 9), which shows the true thickness relationships of the members and formations. The age relationships and the lateral and vertical lithologic facies changes are illustrated diagrammatically on the Correlation Chart (Fig. 10). This chart is a synthesis of the author's concepts of the interplay of shifting lithologic environments of deposition during Eocene time.

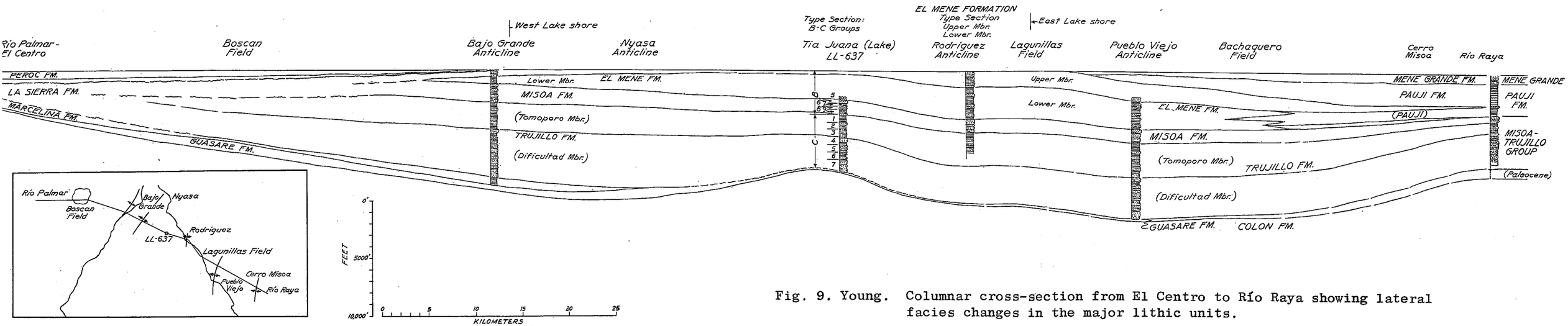
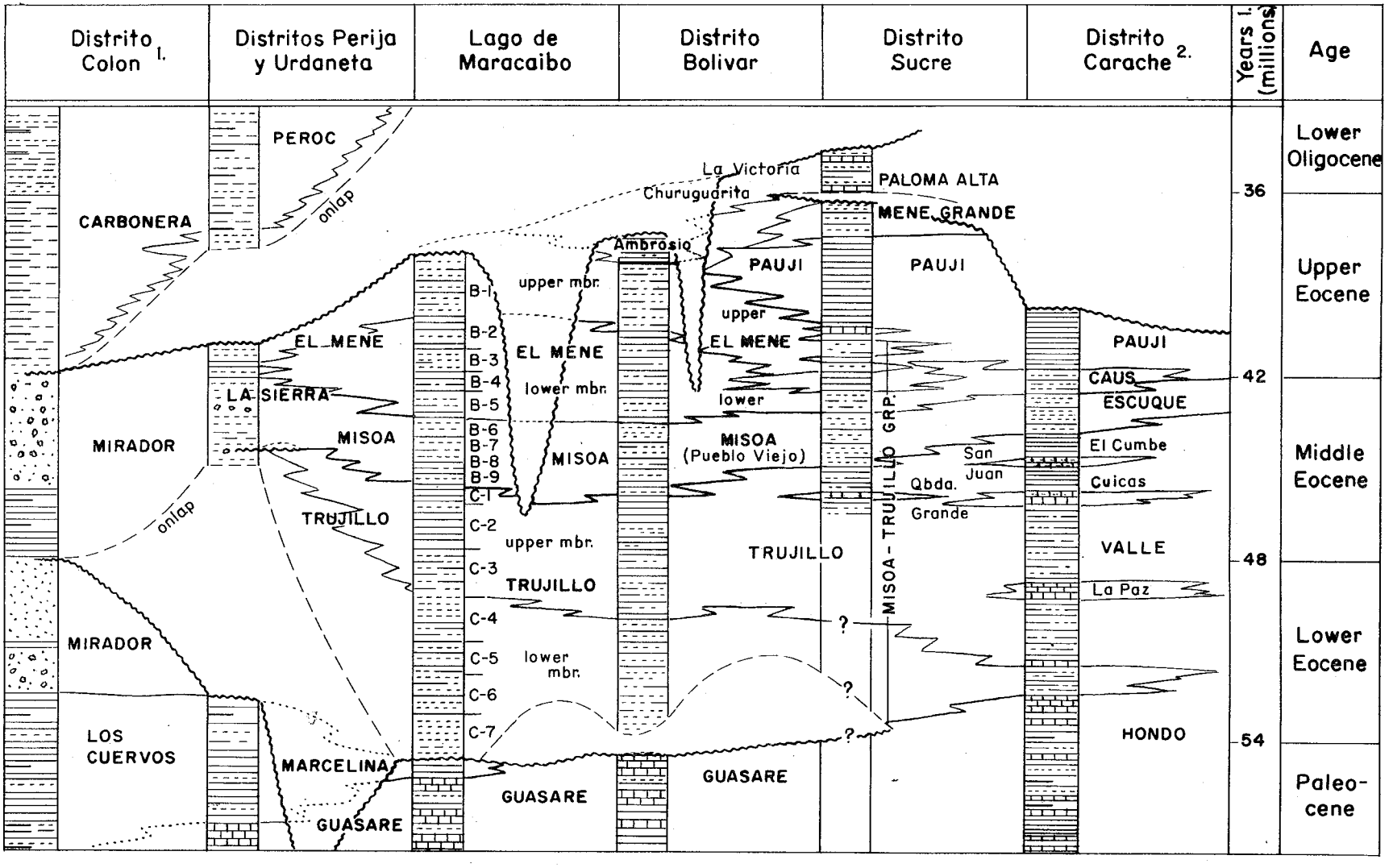


Fig. 9. Young. Columnar cross-section from El Centro to Río Raya showing lateral facies changes in the major lithic units.



1. After van der Hammen
2. After Salvador

Fig. 10. Young. Correlation chart illustrating diagrammatically the facies changes in Eocene sediments across a part of the Maracaibo Basin.

SUPPLEMENT

This paper was written originally as an introduction to a symposium on Eocene correlation which was to be given before the Asociación Venezolana de Geología, Minería y Petróleo. The purpose of this paper was only to point up the problems and to leave the solutions to the other papers of the symposium. However, as the symposium was never organized, the scope of the paper was extended slightly and it was presented by itself before the Asociación Venezolana de Geología, Minería y Petróleo in December 1960 and before the Sociedad Geológica de Venezuela Occidental in March 1961 with the idea of stimulating thought and discussion on the problems of Eocene stratigraphy. Mr. George De Coster of Creole, Maracaibo, presented an excellent discussion of the paper. A summary of the points made include the following:

1. "We (several Creole geologists in the Western Division Office and the Exploration Section) agree that Eocene correlations are unsatisfactory and that a concerted effort to improve them is desirable.

2. "We accept the basic concept of Mr. Young's lithostratigraphic subdivisions, but this scheme is not applicable over the whole Maracaibo basin without further modifications and additions.

3. "A type section should be designated for each lithostratigraphic unit, and its name should be derived from this type section (e.g. lease title or specific locality or feature).

4. "In some important details we disagree with the actual correlations presented by Mr. Young. These discrepancies need to be ironed out before any new scheme of nomenclature is adopted.

5. "Even though agreeing that the proposed nomenclature would assist regional geologists, we believe it would have little use for operations geologists and reservoir engineers, who need a nomenclature which will accommodate individual sands and packets of sands.

6. "For this last reason we believe a dual system of nomenclature of the Eocene is necessary. One system should embody the regional lithostratigraphic units envisaged by Mr. Young. The other system should refer to operational or electric-log units, essentially an improved version of the existing B-C nomenclature."

The last point, which is De Coster's solution, is quoted in full:

1. "We believe the subdivision of the Eocene into the B and C members is practical and applicable to at least the Cabimas, Tía Juana, Lagunillas and Central Lake areas. Mr. Young is correct in pointing out that these units should have been, or should be, formally named and described, and type wells chosen. The area in which these units would be applied should be defined. And it should be emphasized that these are electric-log units, not lithostratigraphic units, and that the extension of the correlations away from the type wells is on the basis of electric-log correlations. Separate systems of subdivisions should be established for South Lake, for Ceuta-South Bachaquero, and for the major areas in the Lake Maracaibo.

2. "Perhaps a dual system of subdivision of the Eocene is the answer, keeping very clearly in mind the nature of each of the two subdivisions. This dual system would include the following:

   a) "The subdivision of the Eocene of Lake Maracaibo into well defined lithostratigraphic units, area by area where the units maintain their homogeneity; and the lithostratigraphic correlation of these units from one area to the other. This complies with Mr. Young's proposal and his report would be a firm base for such a subdivision of the Eocene for the eastern Lake Maracaibo area.

   b) "The subdivision of the Eocene into sets of electric-log units which would be applicable to delineated field areas and which would be the principal stratigraphic tool for reservoir and subsurface geologists and engineers. These subdivisions would be carefully described and defined with type logs and type sections, and it would be clearly stated that these were electric-log units and would be correlated on this basis. The B and C members could be the system of subdivisions for the Tía Juana -- Lagunillas, etc. area - provided that they were carefully described and named, as suggested earlier."

Although there are minor differences, which can be resolved by discussions, there is general agreement that the Eocene can be subdivided into major lithologic units and that these units should be subdivided into a set of electric-log units that would be applicable to the different field areas.

REFERENCES

(1) SUTTON, F.A. (1946): Geology of Maracaibo basin, Venezuela; Am. Assoc. Petrol. Geol., Bull. vol. 30, no. 10, pp. 1621-1741.

(2) Staff of the Caribbean Petroleum Co. (1948): Oil fields of Royal Dutch-Shell group in western Venezuela; Am. Assoc. Petrol. Geol., Bull. vol. 32, no. 4, pp. 517-628.

(3) GONZALEZ DE JUANA, C. (1951): Introducción al estudio de la geología de Venezuela, Capítulo V: Las formaciones del Eoceno en los Andes venezolanos y en la subcuenca del Lago de Maracaibo; Bol. de Geol. (Venezuela), vol. 1, no. 3, p. 265-287.

(4) MENCHER, E., FICHTER, H.J., RENZ, H.H., WALLIS, W.E., RENZ, H.H., PATTERSON, J. M., and ROBIE, R.H. (1951): Resumen geológico, Capítulo I, pp. 1-80 en: Texto de las monografías presentadas en la Convención Nacional del Petróleo; Oficina Técnica de Hidrocarburos, Ministerio de Minas e Hidrocarburos (Venezuela).

(5) YOUNG, G.A., BELLIZZIA, A., RENZ, H.H., JOHNSON, F.W., ROBIE, R.H., and MAS VALL, J. (1956): Geología de las cuencas sedimentarias de Venezuela y de sus campos petrolíferos; Bol. Geol. (Venezuela), Pub. Esp. no. 2, 140 p.

(6) MILLER, J.B. EDWARDS, K.L., WOLCOTT, P.P., ANSGARD, H.W., MARTIN, R., and ANDEREGG, H. (1958): Habitat of oil in the Maracaibo basin, Venezuela; Habitat of Oil, A Symposium, A.A.P.G., pp. 601-640.

(7) BORGER, H.D., and LENERT, E.F. (1959): The geology and development of the Bolívar Coastal Field at Maracaibo, Venezuela; Asoc. Venez. Geol. Min. y Petrol., Bol. Inf. vol. 2, no. 9, pp. 237-256.

(8) HEDBERG, H.D. and SASS, L.C. (1937): Synopsis of the geologic formations of the western part of the Maracaibo basin; Bol. Geol. y Min. (Venezuela) vol. 1, no. 2-4, pp. 73-112 (English ed.).

(9) GARNER, A.H. (1926): Suggested nomenclature and correlation of the geological formations in Venezuela; Am. Inst. Min. Metall. Eng., Tr. pp. 677-684.

(10) TASH, G.E. (1937): Stratigraphy and paleontology of Mene Grande and vicinity; Bol. Geol. y Min. (Venezuela), vol. 1, no. 2-4, pp. 160-172 (English ed.).

(11) LIDDLE, R.A. (1928): The geology of Venezuela and Trinidad; J.P. Mac Gowan, Fort Worth, Texas, 552 p.

(12) SALVADOR, A. (1950): Stratigraphy of the Chejendé region, Venezuela; Ph. D. Thesis, Stanford University.

(13) CAUDRI, C.M.B. (1948): Note on the stratigraphic distribution of Lepidorbitoides; Jour. Paleont., vol. 22, no. 4, p. 473-481

(14) NOTESTEIN, F.B., HUBMAN, C.W., and BOWLER, J.W. (1944): Geology of the Barco Concession, Republic of Colombia, So. America; Geol. Soc. Am., Bull. vol. 55, no. 10., pp. 1165-1216.

(15) GORTER, N.E. and VAN DER VLERK, I.M. (1939): Larger foraminifera from central Falcón (Venezuela); Leidsche Geol. Mededeel., vol. 4, no. 2, pp. 94-122.

(16) CASTER, K.E. (1934): The stratigraphy and paleontology of northwestern Pennsylvania; Bull. Amer. Paleont., vol. 21, no. 71, pp. 1-185.

(17) SCHWARCK A., A.; Editor (1956): Stratigraphical Lexicon of Venezuela (English Edition); Bol. Geol. (Venez.), Spec. Publ. No. 1.

(18) VAN DER HAMMEN, T. (bull. 1958, art. 1960, issue 1961): Estratigrafía del Terciario y Maestrichtiano continentales y tectogénésis de los Andes Colombianos; Bol. Geol. (Col.), Serv. Geol. Nac., Vol. VI, Nos. 1-3, 1958.

(19) HABICHT, K. (1960): La sección de El Baño, Serranía de Trujillo, Edo. Lara; Memoria, III Congr. Geol. Venez., Bol. Geol., Publ. esp. no. 3, pp. 192-213.

(20) RAADSHOOVEN, B. van (1952): On some Paleocene and Eocene larger Foraminifera of western Venezuela; 3rd World Petrol. Congr., Sect. I, pp. 476-489.

ACKNOWLEDGEMENT

I should like to extend my thanks to Messrs. George De Coster and J.A. Richardson for their valuable comments and suggestions presented during the discussion before the Soc. Geológica de Venezuela Occidental. Thanks are also due Dr. H.H. Renz for his help and comments on the manuscript.

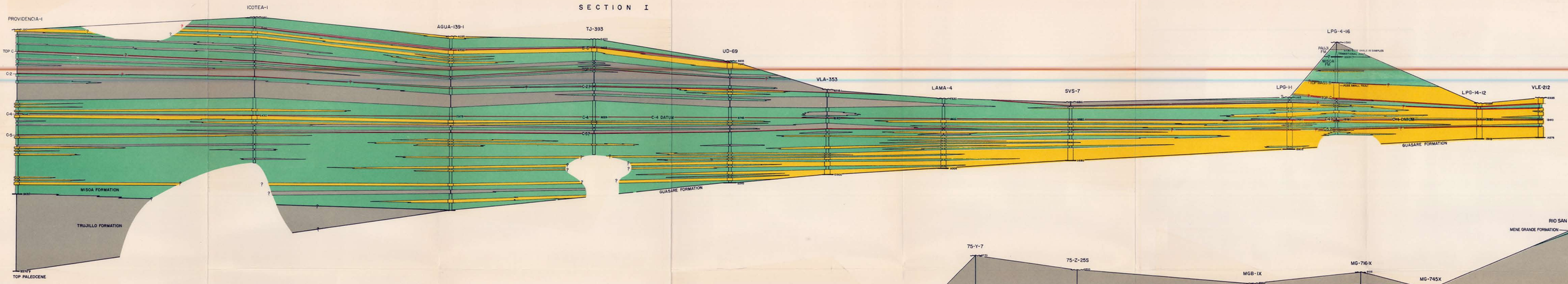
SCHEMATIC CORRELATION OF SUBSURFACE EOCENE LITHOLOGY

CONTRIBUTIONS OF THE A.V.G.M.P. MARACAIBO BASIN EOCENE NOMENCLATURE COMMITTEE

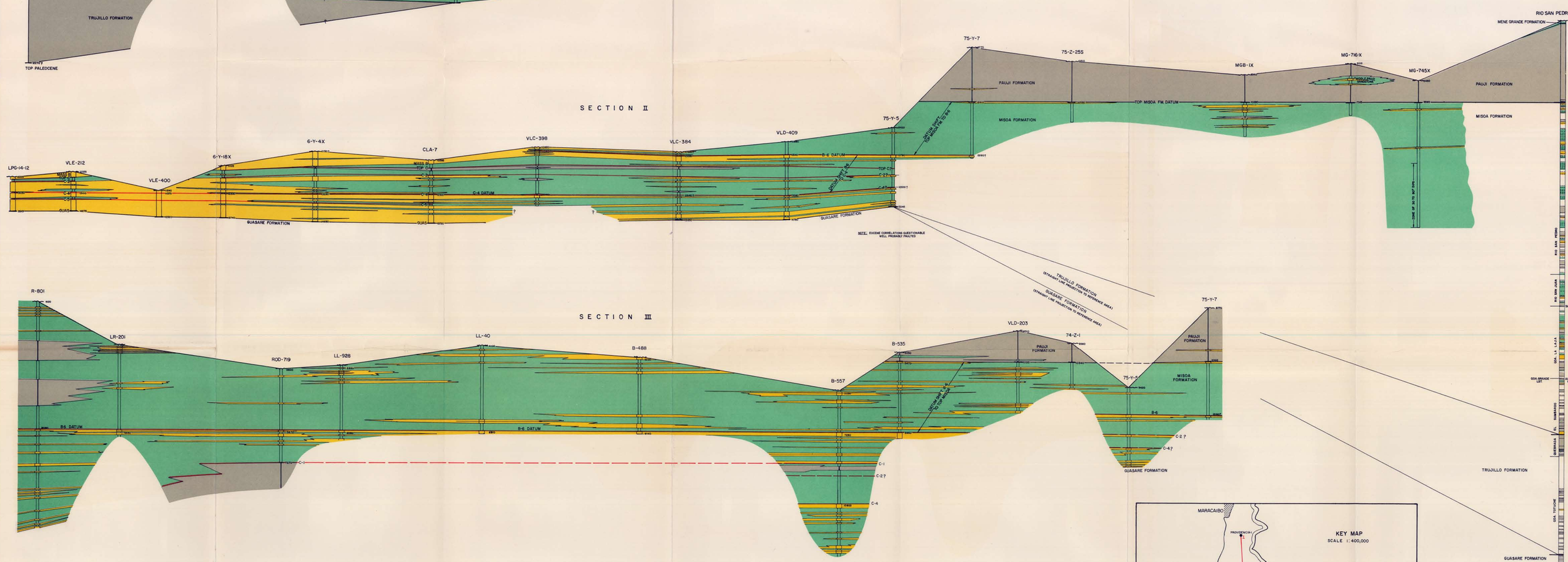
ARTICLE VII

PLATE I

SECTION I

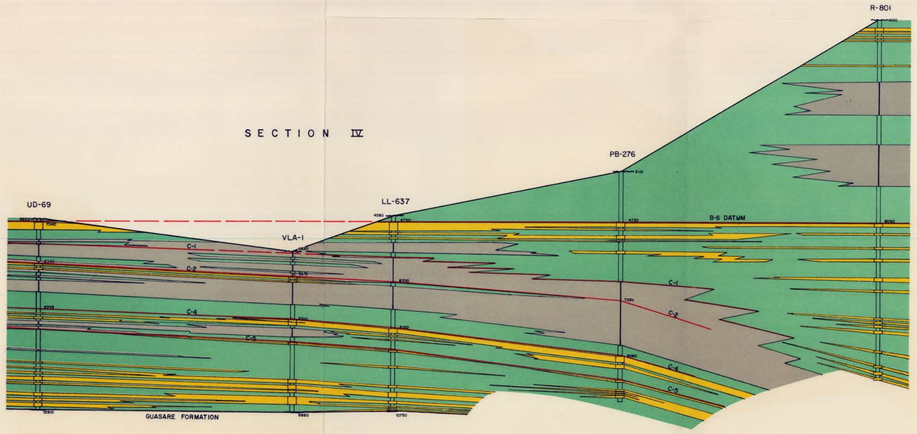


SECTION II



SECTION III

SECTION IV



LEGEND

GRAPHIC REPRESENTATION CODE

- SHALE INTERVAL
- ALTERNATING SANDSTONES, SILTSTONES & SHALES INTERPRETED FROM ELECTRIC LOGS-NO UNIT OVER 50'
- RATHER MASSIVE SANDSTONE-UNIT OVER 50'
- FORMATIONAL CONTACT
- UNCONFORMABLE CONTACT TOP EOCENE
- ELECTRIC LOG MARKER CORRELATION
- FACIES INTERPRETATION

TOPS ARE FROM 1:1000 ELEC LOG AND ARE PICKED TO NEAREST 5'

HORIZONTAL SCALE 1:100,000

VERTICAL SCALE 1:20,000

KEY MAP

SCALE 1:400,000