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The University of Michigan, Ph.D., 1974
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STRATIGRAPHY, TECTONICS, AND HYDROCARBON POTENTIAL OF THE LOWER CRETACEOUS, COAHUILA SERIES, COAHUILA, MEXICO

by
Santiago Charleston

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Geology)
in The University of Michigan
1974

Doctoral Committee:

Professor L. I. Briggs, Co-Chairman
Professor C. I. Smith, Co-Chairman
Associate Professor D. B. Macurda
Associate Proffesor H. N. Pollack
Professor W. R. Tobler

This dissertation is dedicated with great respect and admiration to the following. The University of Michigan Alumni, whose work on the stratigraphy of northern Mexico has served as an inspiring encouragement to me.

Professor L. B. Kellum
Dr. R. W. Imlay
Dr. W. E. Humphrey
Professor C. I. Smith

Acknowledgements

I would like to express my deep gratitude to Dr. C. I. Smith and Dr. L. I. Briggs, co-chairmen of the dissertation for their encouragement and counseling. Dr. H. N. Pollack and Dr. D. B. Macurda supported and gave useful comments on the proper approach of this study.

I am greatly indebted to the Instituto Mexicano del Petróleo for financial support during the course of this study and to the following staff members of this institution for their invaluable assistance: Ing. Eduardo J. Guzmán, Sub-Director of Exploration, and Ing. Eduardo Rodríguez, Chief Geologist, who supported and gave constant encouragement for the completion of this work; Ing. Alfredo Guzmán and Ing. Baldomero Carrasco, who made helpful suggestions on carbonate petrography; and Ing. Guillermo de La Torre and Sr. Miguel Garcia, who were excellent field assistants. Dr. Abelardo Cantú kindly advised me in the identification of ammonites and Dr. M. Trejo identified the pelagic microfossils collected in the Menchaca Formation. Maria Elena Benavides and Gerardo Garcia helped with clerical work and drafting. Finally I would like to thank Dr. Federico Bonet for his advice and for allowing me to use the stratigraphic column from Cañon La Boca, Nuevo León.

I am particularly grateful to Ing. Francisco Viniegra, Exploration Manager, Petroleos Mexicanos; Ing. Arsenio Navarro, Exploration Superintendent at Reynosa, Tamaulipas, and Ing. Raul Gonzalez, Chief Geologist, for permitting me to use all the necessary well data and offering valuable and constructive criticism.

I would like to express my gratitude to Ing. J. Alfonso Zwanzinger, Ing. Gustavo Garcia, Ing. Romeo Garza, Ing. Pilar Zarate, Ing. Sergio Leyva and Ing. Sergio Salinas, all staff geologists of Petroleos Mexicanos at Reynosa, Tamaulipas, for sharing with me many moments of useful discussions in the field.

I am indebted to my friend, Gerald R. Paulson, for all his advice and especially to his wife, Christina, for her patience and suffering during the typing of the final manuscript.

During the course of the field seasons, I was greatly pleased to have been visited by Mr. W. E. Bloxsom, and Dr. F. E. Lozo, Shell Development Company. Their experience and comments on this investigation were always welcomed.

Special gratitude to my wife, Rosita, and the rest of my family for their encouragement. Their cheerful spirit was always a great incentive during the completion of this dissertation.

Last but not least, I would like to make public my recognition to Professor Emeritus L. B. Kellum, Department of Geology and Mineralogy, The University of Michigan for his moral support and for inspiring me with his enthusiasm and intimate knowledge of the geology of northern Mexico.

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INTRODUCTION

The general stratigraphic arrangement of the Coahuila Series has been known for several years, but detailed lithologic descriptions, interpretation of environments of deposition and tectonic processes, remained partially unresolved. The results of this study should provide that needed detail and lead to a better understanding of the Neocomian and Early Aptian associated sedimentary facies, their correlation and depositional framework.

Academic interest in these sediments has been spurred by an ever increasing need for additional hydrocarbon supplies in the region, and by recent "shows" encountered in some formations of the Coahuila Series. Exploratory drilling for hydrocarbons in carbonate formations of any age is difficult, and this additional case study should extend and clarify conceptual models developed during recent years.

LOCATION, AND FIELD AND LABORATORY PROCEDURE

The area studied (Fig. 1) includes most of the State of Coahuila, Mexico and parts of the State of Nuevo Leon, covering a total of 200,000 square kilometers.

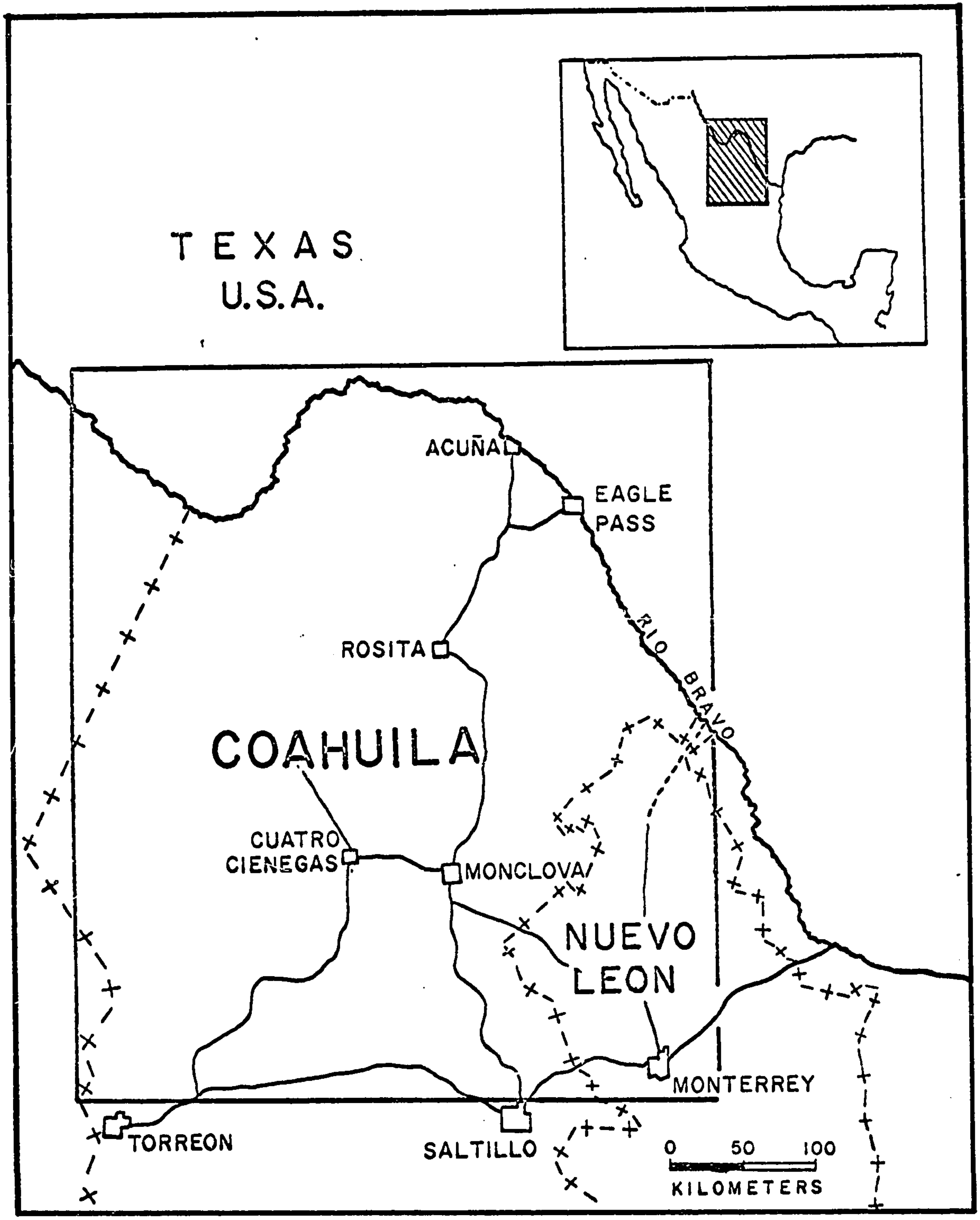


Figure 1: Location map of the area investigated.

A total of 19 stratigraphic sections (Fig. 2) were measured and many other places also were visited where sediments of the Coahuila Series are known to be present. Sections to be measured were selected with the aid of aerial photographs, literature references, and reconnaissance trips. Most of the sections were measured using a hand-level or a Jacob Staff, except where structural or topographic conditions presented problems for this type of procedure, plane table traverses were utilized.

A statistically valid description for the construction of facies variability maps necessitated a stratified sampling scheme for each section or subpopulation. This sampling stratification was achieved utilizing the concept of sedimentation unit defined by Otto (1938, p. 575) as follows:

> "The sedimentation unit at any sampling point is that thickness of sediment which was deposited under essentially constant physical conditions."

Petrographic descriptions of carbonate rocks utilized the classification of Dunham (1962), while Folk's (1969) classification was used for the description of terrigenous rocks. The descriptions of porosity and diagenesis utilized the classification of Choquette and Pray (1970). This data together with other field, structural and paleontologic data were transferred to specially designed numerically coded sheets (Appendix A). The data from these sheets were transferred onto computer cards and later retrieved for computers to prepare the necessary lithofacies maps.

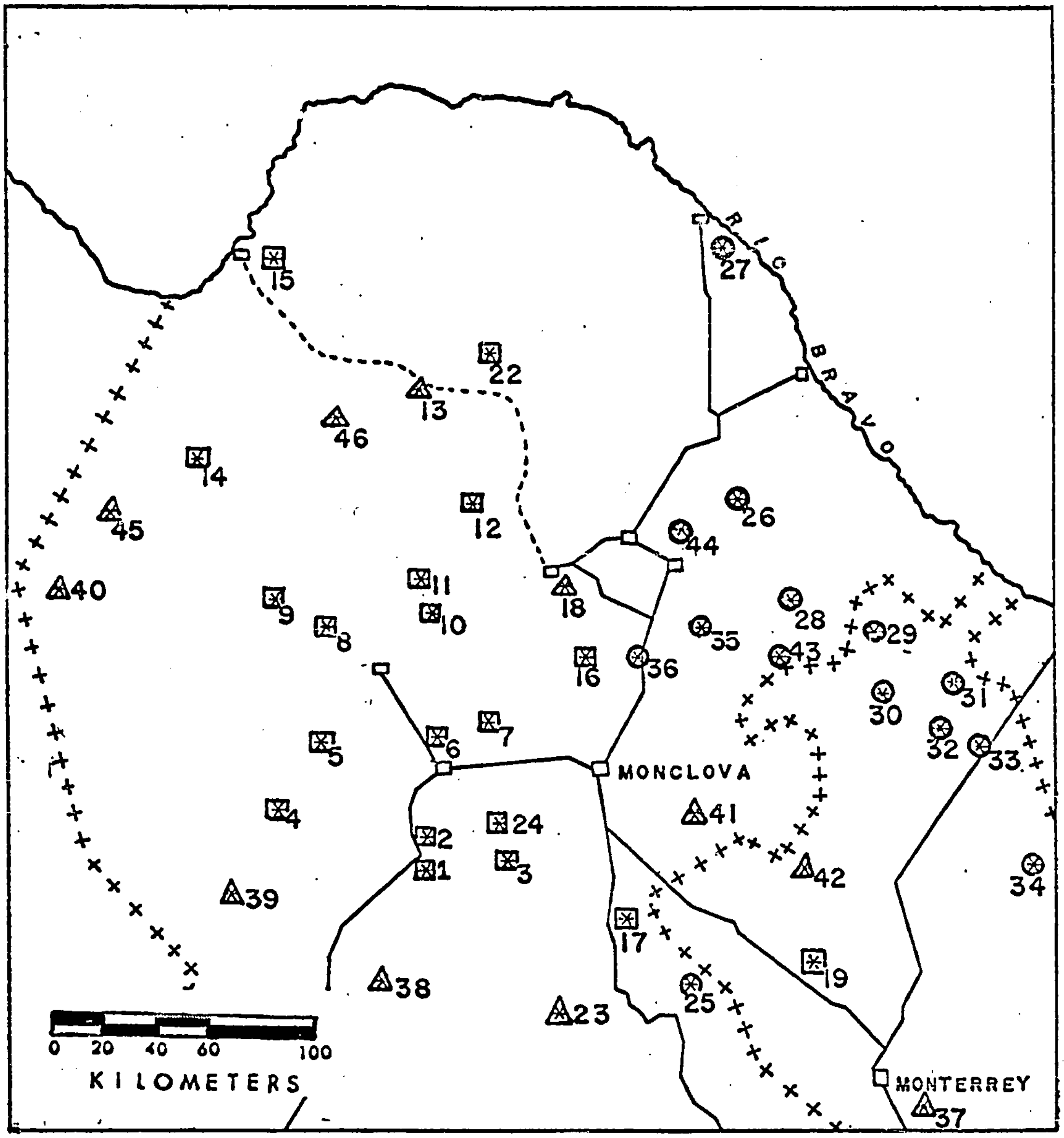


Figure 2: Location of stratigraphic sections and wells. (Names on pages 6 and 7).

⊠ Section measured and described here after.

△ Section visited.

⊗ Well.

LIST OF MEASURED SECTIONS

1. Southern Flank of Sierra de San Marcos
2. Northern Flank of Sierra de San Marcos
3. Potrero de Barril Viejo
4. Sierra Colorada
5. Sierra de la Madera
6. Potrero de la Virgen
7. Potrero de Menchaca
8. Potrero de La Mula
9. Sierra El Fuste
10. Potrero de Padilla
11. Potrero del Berrendo
12. Cañon de La Alameda*
14. Sierra del Pino
15. Sierra del Carmen
16. Potrero de Oballos
17. Potrero de la Gavia
19. Potrero de Minas Viejas
22. Sierra El Cedral*
24. Potrero de Agua Chiquita

*Sections measured with C. I. Smith, W. E. Bloxsom, Q. C. Hebrew, W. J. Cook, C. C. Rust and E. A. Shinn.

LIST OF VISITED SECTIONS

18. Sierra Hermosa de Santa Rosa

23. Sierra de La Paila

37. Cañon de La Boca*

38. Sierra de Los Alamitos

39. Sierra de Las Delicias

40. Sierra Mojada

41. Sierra de Pajaros Azules

LIST OF WELLS

25. Anhelo No. 1

26. Peyotes No. 2-A

27. Chupaderos No. 1

28. La Perla No. 1

29. Garza No. 1

30. Reforma No. 1

31. Camarón No. 101

32. Anáhuac No. 2

33. San Ambrosio No. 1

34. Lajillas No. 1

35. El Gato No. 1

36. Baluartes No. 1

43. Don Martín No. 1

44. Cloete No. 1

*Section measured by Bonet (1971)

PREVIOUS INVESTIGATIONS

The stratigraphy of the Early Cretaceous sediments in northern Mexico was greatly advanced by Emil Böse (1923), who established the concept of a pre-Mesozoic land-mass in the State of Coahuila. This investigation was later extended by Böse and Cavins (1927) and by Baker (1934), who made important tectonic and stratigraphic observations in the Valle de la Babia and discovered the unconformity between the Late Paleozoic schists and the Early Cretaceous conglomerates outcropping at the base of the escarpment of Sierra del Carmen.

The collections and geological observations gathered by Mulleried (1927), Hare and Kellum (who at that time were employed by a private oil company) were used by Burckhardt (1930, p. 143) to describe the lithology and fossil content of the Neocomian sediments in Potrero de Barril Viejo, southeast of Cuatro Cienegas, and in Potrero de La Gavia, south of Monclova.

The work initiated by Böse was continued by Kellum, Imlay and Kane (1936). These contributions form the basis of modern stratigraphic, paleontologic and paleogeographic concepts regarding the Early Cretaceous sediments of northern Mexico. The subsequent important work of Humphrey and Diaz (1956) established the present tectonic and stratigraphic terminology of the Mesozoic sediments of northern Mexico.

More recently, Krutak (1965) studied the terrigenous sediments of the Patula Arkose in the area of Sierra de la Gavia. Bishop (1966) and Smith (1970) described in detail the petrography and diagenesis of some of the Coahuila Series carbonate sediments.

Extensive mapping and geological information of the Early Cretaceous sediments have been obtained through the work by the geologists of Petroleos Mexicanos. These investigations were summarized recently by Navarro (1969) and Salinas (1969).

GEOLOGIC SETTING

Tectonic Development of the Sabinas Basin

Sedimentation of the Coahuila Series is directly dependent of the tectonic conditions prevailing in northern Mexico since Late Jurassic. Near the close of this period the Sabinas Gulf was an elongated embayment, separating the Tamaulipas and Coahuila peninsulas (Fig. 32). Connection of the Gulf with the open sea was through a relatively wide inlet in the southeast and through a small inlet in the northeastern portion. The sediments formed during this time were characterized by fine terrigenous argillaceous deposits along the margins of the gulf, which grade downdip into a sequence of evaporites and highly organic, bituminous shales.

The lithologic transition between Jurassic and Cretaceous sediments observed in the area is marked by the influx of a large volume of terrigenous sediments into the Sabinas Basin, but the effects of the Nevadian Orogeny were insignificant in comparison with some strong deformations present along the Cordilleran Geosyncline of North America and in some areas of northern Mexico. A satisfactory explanation for the influx of the great volume of terrigenous sediments in the Sabinas Basin during Early Cretaceous is at the moment very speculative. It could be related to a relatively rapid epeirogenic movement of the continental elements accompanied by normal faulting along their margins and a rapid rate of subsidence of the basin (Fig. 3-A). A similar type of mechanism was responsible for the deposition of the Triassic sediments in Southern Coahuila (Cserna, 1970) and the arkosic wedges of Central Appalachians (Pelletier, 1958; Meckel, 1967).

After the uplift of the continental elements the erosive processes obliterated the topographic irregularities. This produced a decrease in size of the terrigenous sediments brought into the basin (Fig. 3-B). Rapid transgression of the sea promptly flooded the higher topographic areas during Early Aptian and laid a thick sequence of calcareous strata upon the older clastic sediments (Fig. 3-C). At the end of this stage, sedimentation of the Coahuila Series terminated abruptly in the entire northern portion of Mexico and southeastern United States owing to either a regional epeirogenic uplift or an eustatic drop in sea level (Smith, 1970, p. 30). This resulted in the rapid and widespread deposition of the argillaceous La Peña Formation. After this brief episode of tectonic instability, sedimentation in the Sabinas Basin continued practically uninterrupted. A new broad calcareous platform in the Comanche Series was built on the foundations of the Early Aptian carbonate platform. During the last part of the Mesozoic, a renewed period of regional subsidence was accompanied by the deposition of flysch-type sediments, followed by the accummulation of a thick sequence of deltaic deposits at the very end of the Cretaceous.

At the beginning of the Tertiary, the Laramide deformation, influenced by the Pre-Cretaceous paleogeographic elements (Kellum et al, 1936, p. 430; Humphrey, 1956, p. 28), strongly compressed the sediments of the Sabinas Basin between the southern Coahuila Massif and the northern Coahuila - Texas Craton, thereby developing the numerous structures present in the Coahuila Marginal Folded Belt (Guzmán and Cserna, 1961). The northern and southern boundaries of this folded belt (Fig. 3-D) are characterized by the presence of asymmetrical anticlines, with the axial planes inclined toward the foreland blocks (Kellum, 1936, p. 1001; Humphrey, 1956, p. 29), and by high angle thrust faults with their axial planes also titled toward the land-masses.

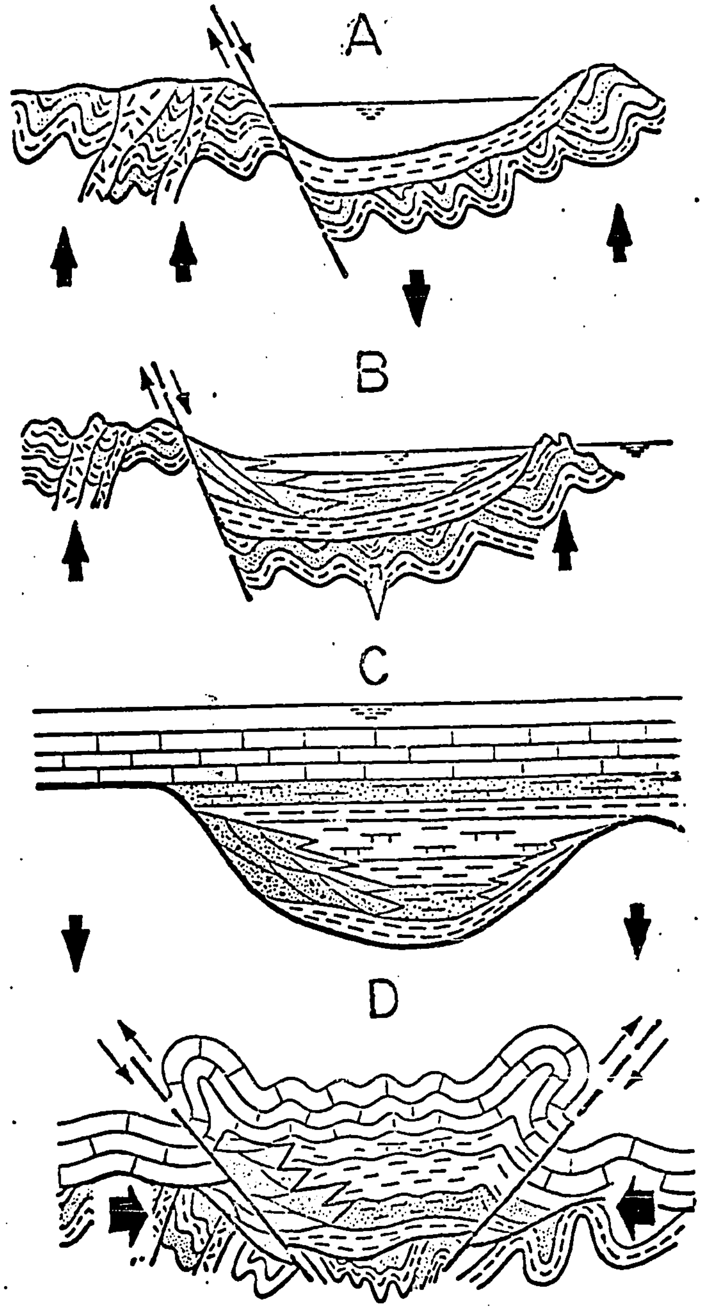


Figure 3: Diagrammatic tectonic development of the Sabinas Basin.

A. Normal Faulting and Subsidence (Early Neocomian)
B. Deposition of Arkose Wedges (Neocomian)
C. Continous Subsidence (Late Cretaceous)
D. Laramide Deformation (Early Tertiary)

STRATIGRAPHY

General Discussion

The basement rocks of Pre-Mesozoic age in the State of Coahuila consist of (1) Late Paleozoic schists outcropping near Boquillas del Carmen at the base of the escarpment of Sierra del Carmen (Flawn and Maxwell, 1958, p. 2245; Daugherty, 1963, p. 1747); (2) Isolated granitic stocks in the central portion of Potrero de La Mula; (3) Flysch deposits, shales, orthoquartzites, limestones, schists and granodioritic intrusives in the area of Las Delicias (King, 1934; Kelly, 1936), approximately 60 km. southwest of Cuatro Cienegas, Coahuila and along many deeply eroded canyons in the central part of Sierra de Tlahualilo (Kellum. 1936, p. 419); and (5) Schists, gneisses and granitic rocks encountered by some of the wells (Peyotes 2-A, La Perla No. 1, etc.) drilled by Petroleos Mexicanos along the eastern portion of the State. The distribution and lithology of all these Pre-Mesozoic rocks seems to have a very close relationship with the southern extension of the Ouachita - Marathon Structural Belt.

The Jurassic System generally consists of shales, evaporites and some calcareous units. These sediments outcrop along the interior valleys or "potreros" of breached anticlines. The rocks of the Cretaceous System are more extensively distributed and form the higher resistant portions of the mountain masses. This system has been divided into three series, which are (in ascending order). the Coahuilan, Comanchean and Gulfian. The first of these series is the subject of the present study.

The sediments included in the Coahuila Series range from typical continental terrigenous deposits to microcrystalline marine mudstones deposited along the deeper portions of the Sabinas Basin (Fig. 4). These strata were formed during the entire Neocomian and Early Aptian, an interval characterized by an extensive transgression of the sea over most of the North American continent.

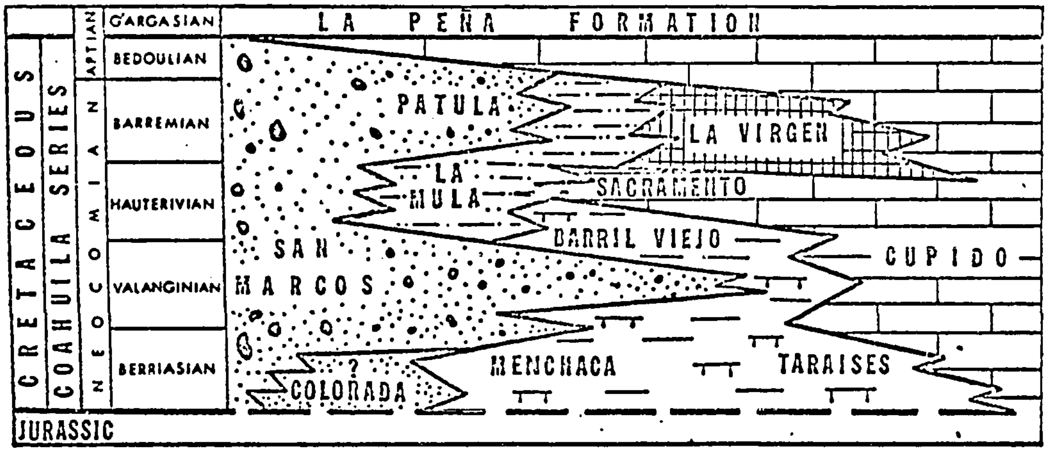


Figure 4: Schemmatic lithofacies distribution in the Coahuila Series.

Coahuila Series

Imlay (1940, p. 124) originally defined the Coahuila Series as a group, but he later (1944, p. 1005) regarded it as a chronostratigraphic unit with the rank of a series, and subdivided it into the Durango and Nuevo Leon groups.

The upper limit of the Coahuila Series was assigned by Imlay (1944) to the zone of *Dufrenoya texana* of Late Aptian in age. This biostratigraphic horizon is found in the sediments of La Peña Formation and equivalent units like the Otates Member in eastern Mexico and the Pearsall Formation in southeastern Texas. Taking in consideration that these units have a very extensive distribution and were deposited during a relatively short period of time, Humphrey (1949) suggested that the upper limit of the Coahuila Series is better represented by the sharp contact between the Cupido and La Peña formations (Plate 16). This criteria has been accepted by most stratigraphers, since the contact between these units is a very practical time stratigraphic horizon.

Durango Group

This group was originally proposed by Imlay (1944, p. 1007) to include all the lithologic units between the Nuevo Leon Group at the top and the Late Jurassic Zone of

Neocosmoceras, *Spiticeras* and *Himalayites* at the base. However, Humphrey and Diaz (1956, p. 152) modified the upper limit and based it on the presence of *Maderia*, *Mexicanoceras*, *Leopoldia* and *Acanthodiscus*, all of which were assigned to the Early Hauterivian. However, these interpretations are based exclusively on biostratigraphic criteria and, hence, unacceptable according to the Code of Stratigraphic Nomenclature, as was originally noted by Smith (1970, p. 16).

In the present study, the Durango Group is considered a lithostratigraphic unit restricted exclusively to the up-dip margin of the Sabinas Basin, where the unit includes the thick sequence of continental and marginal sediments in the basal portion of the Coahuila Series. It is limited at its base by the Sabinas Series and at its top by strata of the Nuevo León Group. Within the Durango Group are included the Colorada Formation, the Menchaca Formation, the San Marcos Arkose, the Barril Viejo Formation and the Taraises Formation.

Nuevo León Group

This unit was originally proposed by Imlay (1944, p. 1007) to include the sediments limited at the base by the lowest range of the ammonites *Pulchellia*, *Barrenites* and *Pseudohaploceras* and at the top by the zone of *Dufrenoya texana*.

In the present work, the Nuevo León Group is redefined to include the sediments above the Durango Group and below the Comanche Series. Although this interpretation is similar to that of Humphrey and Diaz (1956, p. 190), it does not utilize biostratigraphic criteria for defining the limits as was suggested by these authors.

Included within the Nuevo León Group are the Sacramento Formation, the terrigenous sediments of the Patula Arkose, the evaporites of the La Virgen Formation, the argillaceous strata of the La Mula Formation and the limestones of the Cupido Formation.

Toward the deeper portion of the Sabinas Basin, the Durango and Nuevo León groups are indistinguishable, and the entire Coahuila Series consists of an homogeneous sequence of basinal mudstones.

Menchaca Formation

Occurrence and Type Locality

The "Menchaca Limestone" was formally introduced by Kane (in Imlay, 1940, p. 122) for exposures along the Potrero de Menchaca, 25 km. northeast of Cuatro Cienegas, Coahuila. Here the more general name of "formation" is used since the unit not only contains limestones but fine terrigenous and argillaceous components as well. The formation occurs also in the potreros of Oballos, Agua Chiquita and La Virgen. In the Potrero de La Virgen sediments assigned to the Menchaca Formation are poorly exposed and their correlation very speculative at present.

Lithology and Facies Distribution

The maximum observed thickness of this unit is about 250 meters measured in the southeastern corner of Potrero de Menchaca, (Figs. 5 and 6). Here, as well as in Potrero de Oballos the formation is characterized by coarse to medium bedded, dark gray, shell fragment wackestones and mudstones, interbedded with dark gray, nodular marls with abundant Exogyra and ammonite fragments.

The upper contact of this unit with the San Marcos

Figure 5: Interbedded marls and limestones of the Menchaca Formation exposed in the southeastern corner of Potrero de Menchaca. The resistant white layers at the top correspond to the base of the San Marcos Arkose. View toward the southeast.

Figure 6: Nodular marls with abundant Exogyra in the Menchaca Formation, Potrero de Menchaca.

Arkose is transitional, and fossil evidence indicates that the Menchaca Formation is also lithologically transitional across the boundary between the Jurassic and Cretaceous systems; however, Humphrey and Diaz (1956, p. 169) restricted the Menchaca to the Early Neocomian (Berriasian - Valanginian) and assigned the lower part of the formation to La Casita Group of Late Jurassic in age.

On the basis of their stratigraphic position and fossil content, approximately 60 meters of sediments measured in the central part of Potrero de Agua Chiquita were assigned to the Menchaca Formation (Plate 17). The lower 28 meters consists of coarse grain subarkose and thick to medium bedded dark gray, conglomeratic dolomites with fragments up to the size of granules and small pebbles. Resting conformably on these sediments, are 19 meters of arenaceous shell fragment mudstones and dolomites, interbedded with arenaceous, shell fragment marls with abundant gastropods and Exogyra reedi. The upper 13 meters also consists of marls but with a larger percentage of terrigenous components.

In the central part of Potrero de La Virgen there is a small outcrop of thick to medium bedded, reddish brown, arenaceous dolomites and shell fragment wackestones. Humphrey and Diaz (1956) assigned these sediments to the Upper Jurassic base exclusively on their low position in the section. Although this interpretation could be correct, I prefer to correlate these strata with the upper part of the Menchaca Formation based on their lithologic similarity with the sediments described above in Potrero de Agua Chiquita.

The Menchaca Formation grades basinward into argillaceous deposits of the lower Taraises Formation (Fig. 4) and into the basinal mudstones of the lower Cupido Formation.

Age and Correlation

In the type localith and approximately 140 meters below the contact with the overlying San Marcos Arkose, the Menchaca Formation contains numerous ammonites of the genera *Spiticeras* and *Subthurmania*, and abundant large forms of *Exogyra reedi* (?). In about the same stratigraphic interval, Humphrey and Diaz (1956, p. 168) reported that Imlay identified *Spiticeras serpentinum* Burckhardt; *Spiticeras uhligi* Burckhardt; *Spiticeras binodum* Burckhardt; *Neocomites densestriatus* Burckhardt; *Berriasella* (?); *Cymatoceras*; *Exogyra reedi* Imlay; and *Exogyra puthnami* Imlay. This faunal association is very similar to the collection described by Burckhardt (1912) in San Pedro El Gallo, Durango and assigned by Humphrey and Diaz (1956, p. 169) to the Barriasian-Valanginian Stage. Trejo (verbal communication, 1971) based on a microscopic study of samples collected in the Menchaca Formation, also assigned this interval to the Berriasian - Valanginian. This interpretation was based on the reduced number of *Calpionella alpina* and the presence of *Remaniella cadischiana* with *Calpionellopsis simplex*.

In the lowermost portion of the same section, Trejo (op. cit.) identified a microfauna consisting of *Calpionella alpina*, *Tintinopsella carpathica*, *Calpionella elliptica*, and *Nannoconus bronnimani*, forms generally assigned to the top of the Tithonian. In Potrero de Oballos I failed to find identifiable ammonites, but similar microfossil data (Plate 1) apparently supports the assumption that the Menchaca Formation is lithologically trnasitional from Late Jurassic to Early Cretaceous.

Environment of Deposition

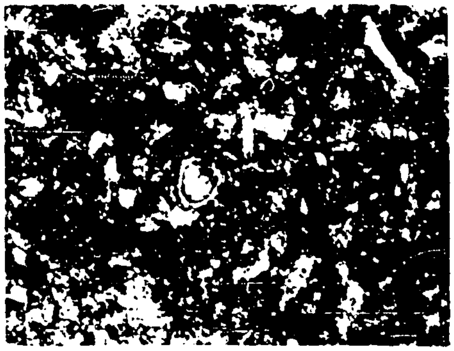
The sediments of this formation exposed in the potreros of Menchaca and Oballos were deposited in a relatively deep, low energy environment, characterized by numerous planktonic organisms and benthonic gastropods and mooluscs that constantly bioturbated the sediments. The mixed arkose, arenaceous mudstones and marls of this unit in Potrero

Plate 1

Photomicrographs of the Menchaca Formation in Potrero de Oballos, Sample CH966.

A, B, C, D and E. Recrystallized shell fragment lime mudstone with common calpionellids. Approximate magnification x100 (A, B, C, and D) and x200 (E).

PLATE 1



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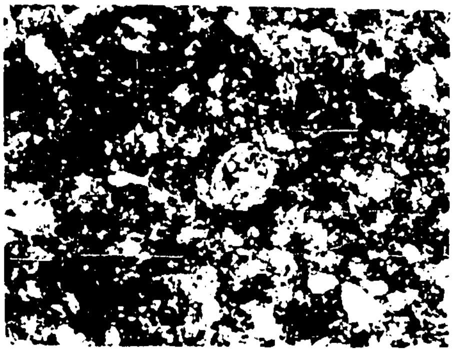

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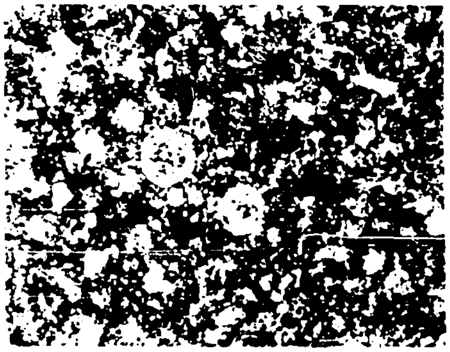

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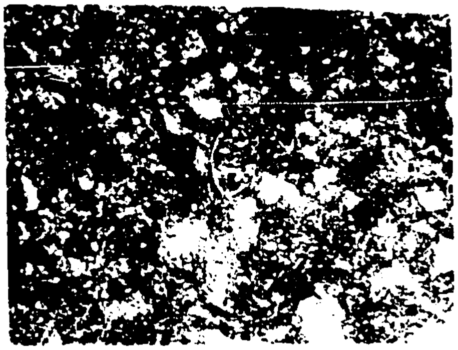

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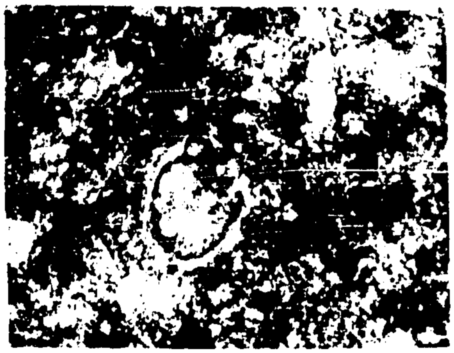


E

de Agua Chiquita, were deposited in a litoral environment characterized by the influx of continental terrigenous sediments brought into the basin by fluvial currents.

Taraises Formation

Type Locality

This lithostratigraphic unit was originally defined by Imlay (1936, p. 1111) from exposures in Taraises Canyon west of Parras, Coahuila. In this study, the Taraises was measured and described only in the central part of Potrero de Minas Viejas (Appendix B). Other sections were visited in Cañon Potrero in the Sierra de Bustamante and Grutas de Garcia and Huasteca Canyon, near Monterrey, Nuevo León.

Lithology

In Potrero de Minas Viejas, the thickness of the Taraises Formation is 300 meters. The lower part consists of thick-to medium bedded, gray mudstone, interbedded with some nodular shales. The upper part of the formation is more argillaceous. It consists of nodular marls with numerous molluscs and pyrite nodules, interbedded with thick to medium bedded, dark gray mudstones. In the area of Grutas de Garcia, Humphrey and Diaz (1956, p. 158) report a thickness of 492 meters for the Taraises Formation, which they divided into three members. The lower and upper members are predominantly limestones compared to the argillaceous middle member.

In the Huasteca Canyon, Vokes (1963) reported a total thickness of 290 meters for the Taraises Formation, divisible in two members, the lower member named by Piaggo (in Vokes, 1963, p. 139) the Nogales Member, consists of 40 meters of resistant, dark-gray to greenish, ridge-forming limestones, with a middle unit of soft shales. The unnamed upper member of the Taraises, consists of about 250 meters of a uniform sequence of argillaceous, fine grained, dense limestones with abundant organic matter and pyrite nodules.

Age

The fossil content of the Taraises Formation has been studied exhaustively by Imlay (1936, 1937, 1938) and Humphrey and Diaz (1956, p. 154-170). The formation contains a large number of ammonites of the genera Olcostephanus, Maderia, Mexicanoceras, Acanthodiscus, Leopoldia, and Valanginites. The presence of Olcostephanus in this faunistic association was considered by Imlay (1938, p. 152) to be indicative of a Late Valanginian and Early Hauterivian age.

In Huasteca Canyon, the age of the bottom of the Taraises Formation may be slightly younger. Vokes (1963, p. 138) reports the presence of Acanthodiscus, Leopoldia and Distoloceras, without Olcostephanus which according to Imlay (1938, p. 552) is indicative of an Early Huaterivian age. I found some forms of Leopoldia at this locality approximately 20 meters above the contact with Late Jurassic La Casita sediments. Therefore it seems that the Berriasian and Valanginian stages are absent or are greatly condesed in this locality.

Environment of Deposition and Facies Distribution

The Taraises Formation was deposited along the infraneritic and bathyal environments of the Sabinas Basin. The nodular shales and marls of this unit and equivalent argillaceous sediments of the Menchaca and Barril Viejo formations (Plate 18) form part of an elongated southeasterly oriented clastic wedge (Figs. 38 and 40) which began to develop during the Early Neocomian. This clastic wedge formed when the fine silts and clays derived from the emergent land-masses by-passed the conglomerates and conglomeratic sandstones of the San Marcos Arkose and were taken into the basin where they rapidly settled; however, a good percentage of the clays were kept longer in suspension and were transported by marginal currents into the external, deeper portions of the basin.

Colorada Formation

Occurrence and Type Locality

The type locality of this unit is the central part of the Sierra Colorada, 80 km. southwest of Cuatro Cienegas, Coahuila (Figs. 7 and 8) at the intersection of Sierra de la Fragua and Sierra El Venado. Although this is the only known outcrop of the Colorada Formation, its unique lithology and probable subsurface extent necessitate its separate designation as a new lithostratigraphic unit.

Lithology

The type section measured in the western escarpment of Potrero Colorado has an exposed thickness of 221 meters and was divided into two members (Appendix B). The base of the lower member (and of the formation) is not exposed and the total thickness cannot be determined. The 30 meters exposed consist of reddish, coarse to medium subarkose and orthoquartzites. At the top of this unit, there is a 5 meters thick conglomerate consisting of medium to large size pebbles of milky quartz and igneous and metamorphic rocks.

The basal 5 meters of the upper member, directly overlying the conglomerate consists of reddish, silt-size orthoquartzite with numerous mud-cracks (Fig. 11). On top of this unit and apparently conformable with it, there are approximately 186 meters of supermature, reddish, brittle orthoquartzite, with well-rounded and well-sorted, pitted, fine- to medium-size grains (Plate 2). This unit is characterized by spectacular Beta cross-stratification sets (Allen, 1963). Most of these sets are more than 5 meters in thickness (Figs. 9, 10, and 12).

Age and Correlation

The age of the Colorada Formation is uncertain because it is not fossiliferous, the bottom is not exposed and the contact with the overlying San Marcos Arkose shows a slightly angular unconformity, which could also be the effect of the cross-bedded nature of the Colorada Formation. Therefore if this contact is unconformable, the formation is probably Pre-Cretaceous in age, on the other hand if the contact is conformable the Colorada Formation is most probably Cretaceous in age.

Environment of Deposition

Textural properties of the Colorada Formation, together

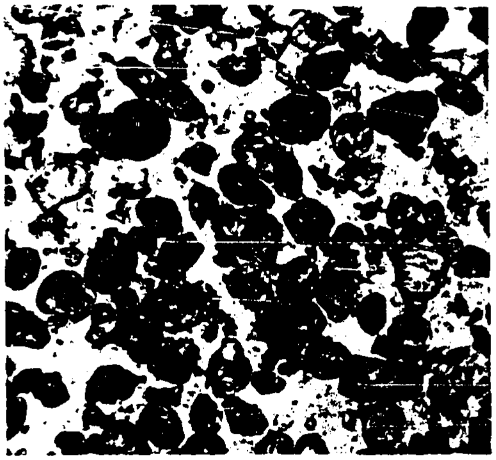
Plate 2

Photomicrographs of the Colorada Formation in the type locality of Sierra Colorada. Approximate magnification x30.

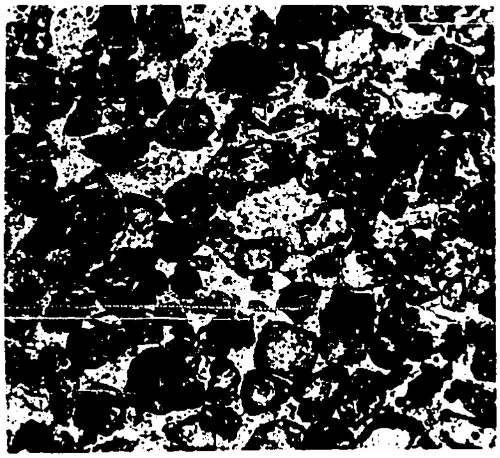
A, B, and C. Orthoquartzite with fine to medium (100 to 250 micron), well rounded and sorted grains. Sample CH186.

D and E. Orthoquartzite with frosted, well rounded and medium sorted grains. Sample CH188.

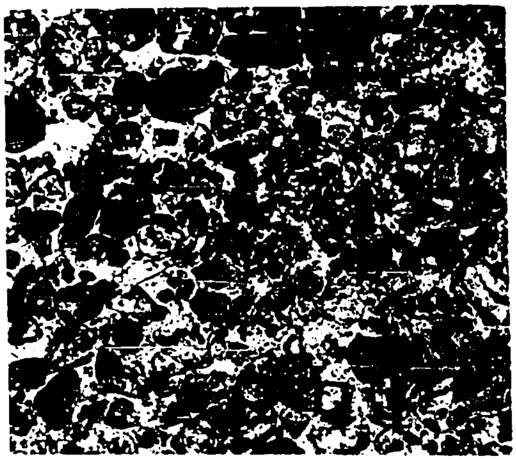
PLATE 2



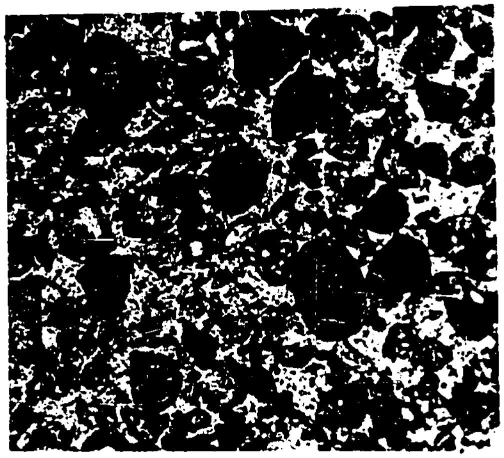
A



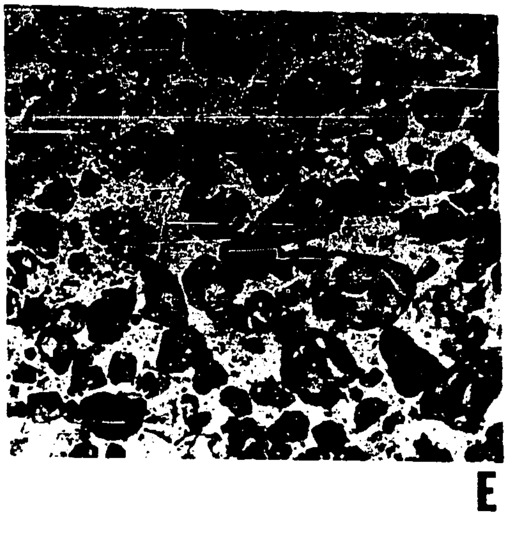
B



C



D



E

Figure 7: Eolian red sandstones in the Colorada Formation outcroping in the eastern wall of the Sierra Colorada.

Figure 8: Closer view of the eolian sandstones in the Colorada Formation.

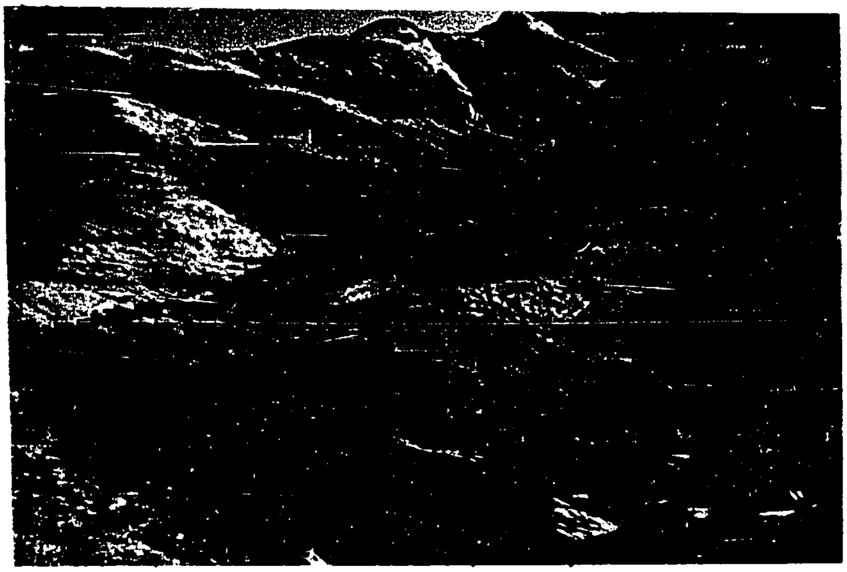


Figure 9: Large scale Beta cross-bedding in the Colorada Formation, Sierra Colorada.

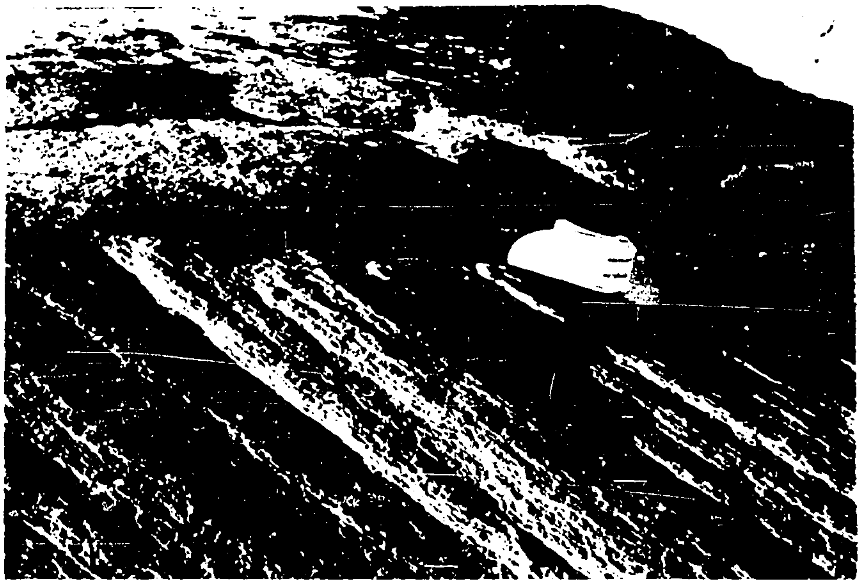


Figure 10: Planar erosional surface in the large scale Beta cross-bedding of the Colorada Formation, Sierra Colorada.

Figure 11: Mud-cracks at the base of the Colorada Formation, Sierra Colorada.

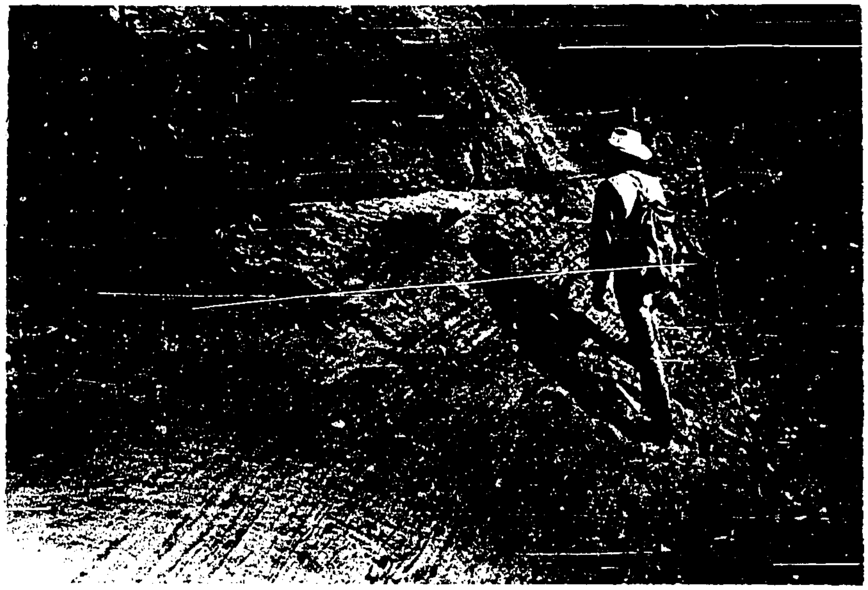


Figure 12: Large scale Beta cross-bedding in the Colorada Formation, Sierra Colorada.

with the large scale cross-bedding, strongly suggest deposition in a desert environment. The Beta cross-stratification sets resemble the cross-bedding found in the Navajo Sandstone of Arizona (Hack, 1941; Pettijohn and Potter, 1964), also interpreted as desert dune deposits.

Supplementary evidence for the deposition of this unit in an arid environment are the mud-cracks at the base of the upper unit and the typical red color from which the formation takes its name. The red color is from abundant hematite coating the grains and in the matrix. Recent studies (Walker, 1967, p. 354) conclusively demonstrated that red beds can be formed as an in-situ alteration of iron-bearing detrital grains, in hot arid or semi-arid climates.

San Marcos Arkose

Occurrence and Type Locality

The San Marcos Arkose was named by Kane (in Imlay, 1940, p. 121) for exposures in the large Potrero de San Marcos located 30 km. southeast of Cuatro Cienegas. The southernmost exposure of this unit was found in the eastern escarpment of Sierra Colorada, about 50 km. west of the type locality. Northeastward of this site the Arkose thins out and forms a clastic wedge that extends toward the central part of Sierra de La Madera and toward the potreros de Barril Viejo, Agua Chiquita and Menchaca (Plate 17). The northernmost outcrop of the arkose wedge was found in the central part of Potrero de Padilla.

Lithology

In Potrero de San Marcos, the total thickness of the Arkose is 744 meters and it may be divided into three members (Appendix B). The lower member is 80 meters thick and consists of reddish, very thick-to thick-bedded arkosic and subarkosic conglomerates. Grain size ranges from small pebbles up to small and medium cobbles (Fig. 13); channel fill and large scale cross-stratification are common. The middle unit has a total thickness of 510 meters and is made up predominantly of reddish, angular, poorly-sorted, coarse to very coarse arkoses and subarkoses (Plate 3). These are interbedded with conglomeratic subarkoses with grain size ranging from granules up to medium and large pebbles. The upper member of the San Marcos Arkose is made up of 154 meters of thick to medium-bedded, slightly conglomeratic (large pebbles) arkose.

In Sierra Colorada the thickness of the San Marcos Arkose is 302 meters. Although the section here was also divided into three units they are very much different from the three described at Potrero San Marcos. The lower member is a sequence of reddish, coarse-to medium-bedded, subarkosic siltstones with some mudballs and small-scale cross-bedding. The middle member consists of 193 meters of reddish, coarse-to medium-bedded, poorly sorted, angular, coarse sand-size, conglomeratic subarkose with numerous interbeds of cross-bedded, channel filling arkosic and subarkosic conglomerates (Fig. 14) formed by medium and large pebbles of quartz and igneous and metamorphic rocks. The upper member of the section is formed of dolomitized subarkoses and othoquartzites.

At Potrero de Agua Chiquita the thickness of this formation decreases to only 67 meters. It is made up of thick-to medium-bedded, cross-bedded, coarse to medium orthoquartzites

Plate 3

Photomicrographs of the San Marcos Arkose in Potrero de San Marcos. Approximate magnification x30:

Q=quartz, F = potassium-feldspar, P = platgioclase, M = mica, and C = chert.

A. Coarse grain arkose, cemented by calcite. Sample CH51.

B. Arkose with very coarse grains, partially cemented by calcite. Sample CH59.

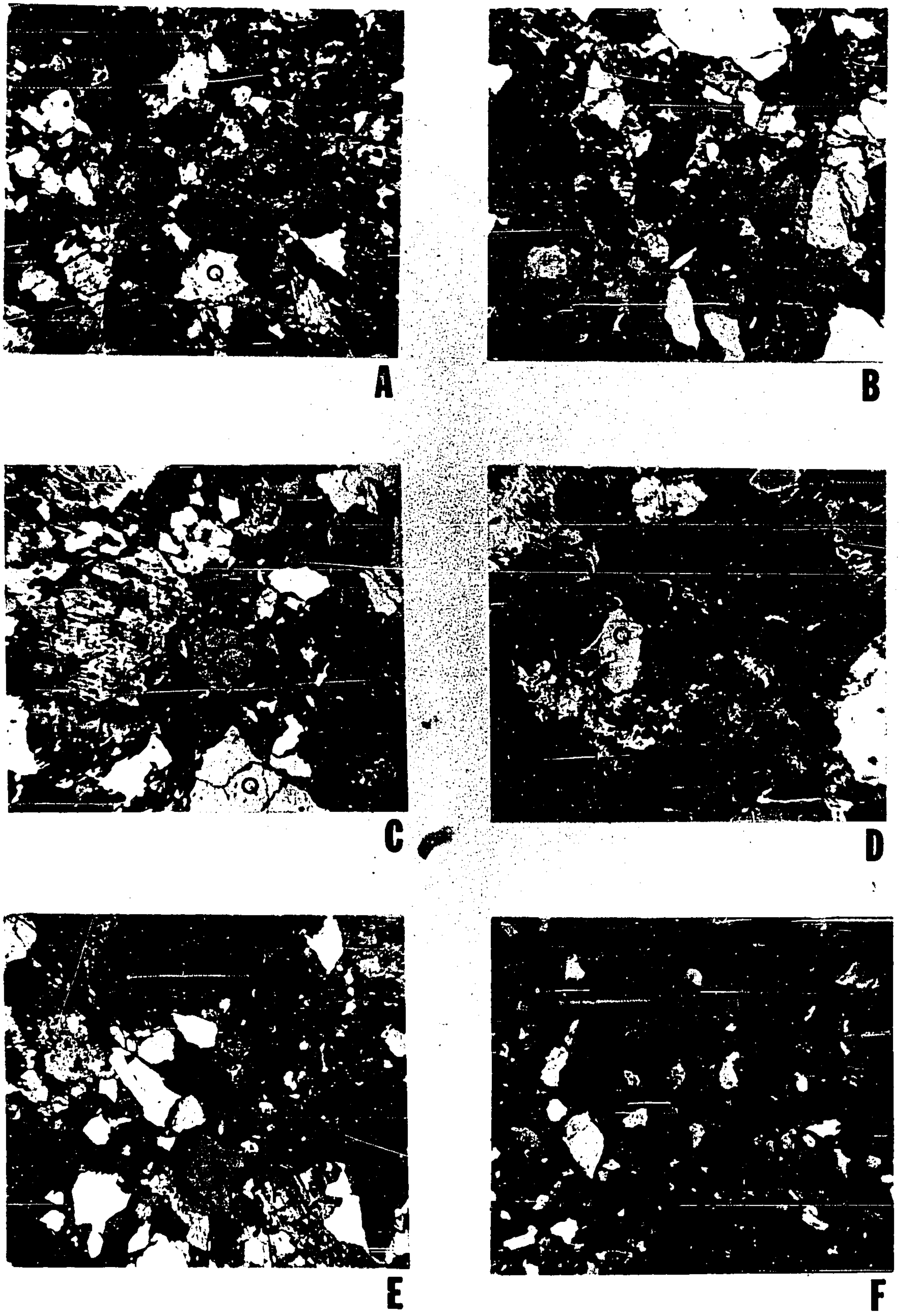
C. Subarkose with abundant hematite in the matrix (black grains). Cemented by calcite. The large grain of feldspar is an altered microcline. Sample CH59.

D. Arkose with abundant altered feldspar grains and hematite. Sample CH62.

E. Very coarse arkose with abundant altered microcline and plagioclase. Calcite cement. Sample CH63.

F. Very dolomitized subarkose. Sample CH68.

PLATE 3



and subarkoses with subrounded, medium sorted grains.

In Potrero de Menchaca the thickness of the San Marcos is 159 meters, consisting of conglomeratic coarse arkose and subarkoses with numerous well rounded small pebbles. The upper part of the section has 68 meters of thick bedded, dark gray, coarse to medium sand size grains, dolomitized subarkoses (Plate 4), interbedded with some beds of nodular shales. This unit is also characterized by the presence of large scale Epsilon cross-bedding.

The thinnest sections of San Marcos Arkose was found in the Potrero de Padilla. In this locality the San Marcos consists of 57 meters of shales, interbedded with thin-bedded, poorly sorted, subangular, coarse to medium orthoquartzites and subarkoses. There are a few conglomeratic intervals formed by granules and small and medium pebbles with some fragments up to small cobble in size.

In Potrero de Barril Viejo the terrigenous sediments of the San Marcos Arkose underlie shales and marls of the Barril Viejo Formation. The lower contact of the Arkose is not exposed, and only about 13 meters of the formation outcrop in the central part of the potrero. Humphrey and Diaz (1956, p. 173) reported a thickness greater than 1000 meters for the San Marcos Arkose based on data from the Ohio-Mex

Plate 4

Photomicrographs of the San Marcos Arkose in Potrero de Menchaca. Approximate magnification x30.

Q = quartz, F = potassium-feldspar, P = plagioclase, M = mica, and C = chert.

A. Very coarse subarkose, partially cemented by calcite (lower left corner). Sample CH522.

B. Subarkose with numerous grains of quarts with undulated extinction. Sample CH523.

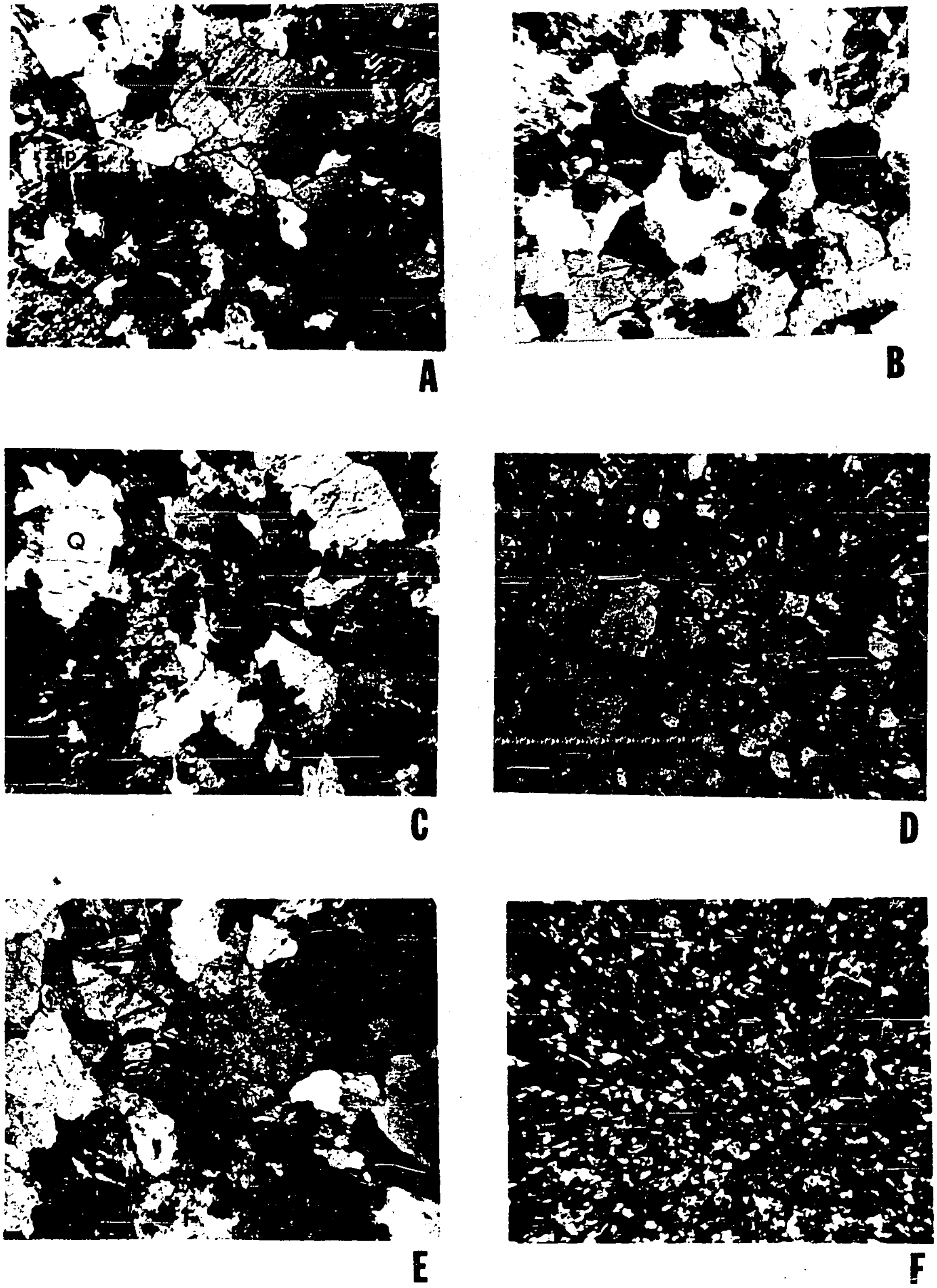
C. Coarse grain arkose, cemented by calcite. Sample CH525.

D. Dolomitized subarkose. Sample CH526.

E. Coarse grain arkose with abundant altered plagioclase grains. Sample CH527.

F. Very dolomitized subarkose. Sample CH528.

PLATE 4



San Marcos #2 wildcat drilled in 1928. This thickness may be in error as a result of partial repetition of the section in the well on the overturned limb of the anticline.

Stratigraphic Relationship

No fossils have been found in the San Marcos Arkose and determinations of age and facies relationships must be based entirely on its physical properties and spatial distribution.

In Potrero de San Marcos the upper contact of the Arkose is lithologically transitional with the limestones of the Cupido Formation. The lower contact is not clearly exposed. However, on the south side of the potrero a small overturned section of Jurassic shales and marls grades into a reddish conglomerate composed of unsorted, medium to large size boulders. Presumably this unit belongs to the lowermost portion of the San Marcos Arkose. In potreros de Menchaca and Agua Chiquita, the San Marcos Arkose overlies the Menchaca Formation and underlies the Barril Viejo Formation as noted by Kane (in Imlay, 1940, p. 122). Toward the central part of the Sabinas Basin the San Marcos Arkose thins out and in the Potrero de Oballos the arkosic sediments are absent.

The stratigraphic relationship of the San Marcos Arkose

Figure 13: San Marcos Arkose conglomerate consisting of subrounded large pebbles and small cobbles. Potrero de San Marcos.

Figure 14: Channel filling in the San Marcos Arkose, Sierra Colorada.

described above shows that in the type locality the time interval for the deposition of this unit may cover most of the Neocomian and perhaps some of Early Aptian. The Arkose thins out basinward and forms a clastic wedge (with a regressive offlap at the base and transgressive onlap at the top) which was probably developed during Late Berriasian to Early Valanginian.

Environment of Deposition

Comparison of textural and compositional properties of the San Marcos Arkose with recent terrigenous sediments (Walker, 1967; Pettijohn and Potter, 1964; Allen. 1965; Visher, 1965) and with similar clastic wedges found in the geologic record (Meckel. 1967; Schenk, 1967; Boggs, 1964; Hubert, 1960) strongly suggest a continental and a transitional environment of deposition.

Variation in thickness of the San Marcos from more than 744 meters in the type locality along the southwestern margin of the basin to only 57 meters toward the northeast in the central part of Potrero de Padilla, indicates a very rapid rate of subsidence along the margins of the basin. This drastic downwarping was probably controlled by the presence of a normal fault or fault system running parallel to the edges of the continental elements (Fig. 3). Similar tectonic conditions have been proposed to explain the deposition of Triassic sediments in northern Mexico (Cserna,1970), northeastern United States and in the Early and Middle Pennsylvanian arkosic wedges (Pelletier, 1958; Meckel, 1967) of the central Appalachians.

At the type locality, Sierra Colorada, Sierra de La Madera and Potrero de Barril Viejo, the large pebbles and boulders found in the conglomeratic facies of the San Marcos Arkose together with the presence of deep, entrenched conglomerate filled channels, suggest that these sediments were deposited in alluvial fans (Eckis, 1928; Beaty, 1963; Denny, 1965) located along the piedmont aprons of the topographically uplifted crystalline massifs.

The finer sandstones and siltstone facies of the San Marcos Arkose containing coarse channel fill and abundant cross-stratification is suggestive of deposition along an extensive marginal alluvial plain (Allen, 1965; Friend, 1965) by means of numerous braided streams.

In the area of potreros de Menchaca and Agua Chiquita, the Epsilon cross-bedding of the San Marcos Arkose and the presence of well rounded and sorted, small pebbles and granules in the conglomerates indicate a litoral or marginal marine environment of deposition of the Arkose.

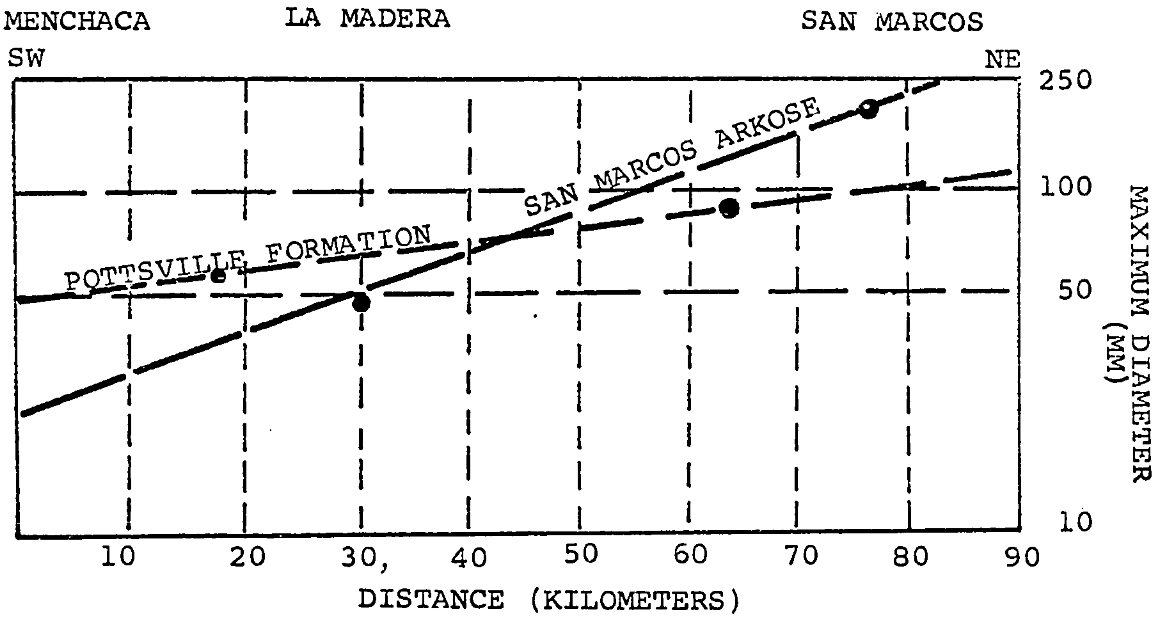


Figure 15: Pebble size distribution in the San Marcos Arkose and in the Pottsville Formation (Meckel, 1967, p. 237).

With the assumption of an initial maximum pebble size of 250 mm (Meckel, 1967, p. 237), a size-distance function for the average maximum pebble size distribution of the conglomeratic units of the San Marcos Arkose (Fig. 15), shows that the pebble size distribution gradient of this unit is greater than that obtained by Meckel for the Pottsville Formation. This difference probably reflects the fact that the conglomerates of the San Marcos Arkose are composed of igneous and metamorphic rocks, whereas those of the Pottsville Formation are almost entirely of vein quartz and orthoquartzites.

Fig. 15 can also be used to estimate the distance to the edge of the basin (Pelletier, 1958; McDowell, 1957). According to this method of interpretation the position of the basin edge relative to the San Marcos Arkose was located about 20 km. southwest of Potrero de San Marcos in the area of Sierra de los Alamitos. However a more reliable indicator for the position of the source area is the lithofacies maps (Figs. 37, 38 and 39) which illustrate that the source area for the arkosic clastics is not only the region of Sierra de los Alamitos, but a more extensive portion of the southern end of the Coahuila Peninsula as well.

Barril Viejo Formation

Occurrence and Type Locality

The type locality of the Barril Viejo is in the central part of Potrero de Barril Viejo, approximately 40 km. southeast of Cuatro Cienegas, Coahuila (Kane in Imlay, 1940, p. 121). The formation is well exposed in potreros de Menchaca, Agua Chiquita, Oballos, Padilla and Sierra de La Gavia. The maximum thickness of the Barril Viejo Formation is 351 meters. measured in the northwestern corner of Potrero de Oballos (Appendix B). From there it thins gradually toward the southwest and is absent in Potrero de San Marcos.

Lithology

The Barril Viejo Formation generally consists of nodular marls and shales, interbedded with shell fragment wackestones and mudstones (Fig. 16); pelecypods, gastropods, annelid tubes, echinoids, and solitary corals are common and some ammonites have been found. The unit weathers to form a characteristic topographic slope (Fig. 17) below the resistant bench forming dolomitic beds of the Sacramento Formation that overlie it.

In the central part of Potrero de La Gavia, the Barril Viejo underlies with a transitional contact, the coarse

Figure 16: Nodular marl with abundant Exogyra, pelecypods and gastropods, Barril Viejo Formation, Potrero de Agua Chiquita.

Figure 17: Shales and limestones in the Barril Viejo Formation, central part of Potrero de Agua Chiquita. The resistant layers in the upper part are the dolomites of the Agua Chiquita Member (Sacramento Formation). View toward the south.

terrigenous sediments of the Patula Arkose. The basal 40 meters of the formation, consist of medium-to thin-bedded, calcareous orthoquartzites and shell fragment mudstones, interbedded with nodular shales and marls. The upper 117 meters are medium-to thin-bedded very arenaceous, shell fragment, oolite grainstones (Plate 5), interbedded with siltstones and orthoquartzites.

W. G. Kane (in Imlay, 1940, p. 21) proposed the name of "Padilla Limestone" for the unit overlying the San Marcos Arkose in the central part of Potrero de Padilla thus correlating it with the striking ridge-forming limestones and dolomites recognized elsewhere in the area. However the lithology and fossil content of Kane's "Padilla Limestone" in its type locality is very similar to the typical facies of the Barril Viejo Formation as described above. Therefore, in order to avoid future stratigraphic complications, I propose to withdraw from the stratigraphic nomenclature the name "Padilla Limestone", replacing it by the name of Sacramento Formation described below. Humphrey and Diaz (1956, p. 178) redefined the Barril Viejo Formation at the type locality, in the following manner:

> "The Barril Viejo Formation, therefore is here redefined to include sediments in its type locality previously referred to as the "Padilla Limestone" by Imlay as well as to include higher

Plate 5

Photomicrographs of the Barril Viejo Formation in Potrero de La Gavia. Magnification approximately x30 unless otherwise stated.

A. Gastropod shell fragment, oolite grainstone. Sample CH89.

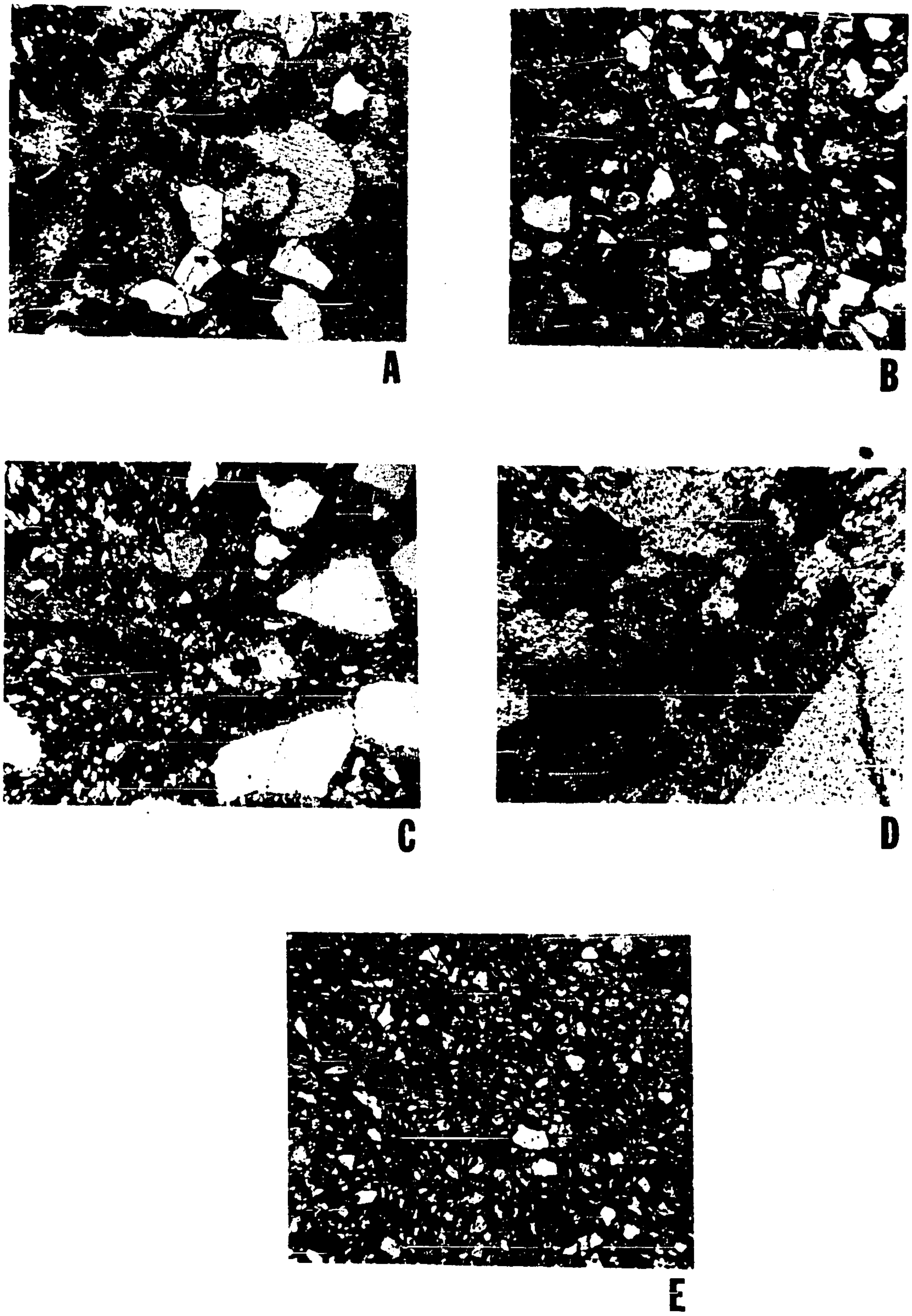
B. Oolitically coated quartz grain, shell fragment grainstones. Sample CH103.

C. Arenaceous, shell fragment, oolite grainstone; quartz grains with a fibrous calcite rim. Altered plagioclase with an opaque mineral in the center of the photograph. CH95.

D. Closer view of above, showing fibrous calcite cement around a quartz grain. Approximate magnification x120.

E. Subarkose with abundant hematite in the matrix. Sample CH107.

PLATE 5



> strata below the Patula Arkose, which were apparently unreported to Imlay and possibly not observed by Kane."

I do not consider this definition appropriate because Kane's "Padilla Limestone" (Sacramento Formation) is a very distinctive interval, separating the Barril Viejo Formation below from the Patula Arkose above.

Age

The faunal content of the Barril Viejo Formation has been studied by Imlay (1940) from collections made by L. B. Kellum, W. G. Kane, T. S. Jones and himself, in several places near the area of Cuatro Cienegas, Coahuila. The following is a list of the more significant:

Solitary corals

"Terebratula" coahuilensis Imlay

Cucullaea grabrielis var. fraterna Imlay

Pinna

Exogyra reedi Imlay

Pecten

Syncyclonema

Neithea biangulata Imlay

Prohinnites ordoñezi Imlay

Plicatula unbonata Imlay

Lucina kellumi Imlay

Pholadomya

Harpagodes americanus Imlay

Natica

Leopoldia crassicostata Imlay

Leopoldia victoriensis Imlay

Leopoldia truncata Imlay

Acanthodiscus magnificus Imlay

Acanthodiscus cf. *radiatus* Bruguiere

Dichotomites multicostatus Imlay

Imlay (1940, p. 133) considered the presence of *Leopoldia* and *Acanthodiscus* to represent the Early Hauterivian and correlated this unit with the upper member of the Taraises Formation. Humphrey and Diaz remeasured and described Imlay's sections and they also considered the formation to be Early Hauterivian in age. In the course of this study, a poorly preserved fragment of an ammonite of the genus *Olcostephanus* was found in the Potrero de Agua Chiquita. According to Imlay (1938, p. 550) this would indicate an Early Hauterivian - Late Valanginian age for the marls and shales of the Barril Viejo Formation.

Correlation and Evironment of Deposition

The Barril Viejo Formation occurs in a wide elongate belt, roughly parallel to the southern end of the Coahuila Peninsula. Stratigraphic and geographic distribution of the Coahuila Series sediments (Plates 18 and 19) indicate that the Barril Viejo Formation is a transgressive unit equivalent to the marls and shales of the upper member of the Taraises Formation and the lower microcrystalline mudstone facies of the Cupido Formation deposited in the external part of the basin.

Sedimentation of the Barril Viejo Formation in the type locality and in potreros of Agua Chiquita, Menchaca, Padilla and Oballos, took place in a relatively tranquil environment, where bottom dwelling, burrowing gastropods and pelecypods disturbed the muddy bottom sediments. However, the lithology and diagenetic characteristics of this unit in Potrero de La Gavia, suggest a litoral or marginal marine environment, subject to the effects of waves and currents.

Sacramento Formation

Occurrence and Type Locality

The type locality of this formation is in the central part of Potrero de Agua Chiquita, approximately 5 km. southwest of Sacramento, Coahuila. The striking ridge-forming sediments of this unit are also found in the potreros of Barril Viejo, Menchaca and Oballos.

Previously the name "Padilla Limestone" was applied by Kane to this formation elsewhere. However, the use of this name as noted earlier should be discarded in order to avoid future stratigraphic complications.

Lithology

The Sacramento Formation is divided into two members. The lower is called the Agua Chiquita Member for exposures in the Potrero of Agua Chiquita (Plate 20), and the upper is named the Oballos Member for outcrops in the northwestern corner of Potrero de Oballos.

Agua Chiquita Member

This member conformably overlies the shales and marls of the Barril Viejo Formation and outcrops extensively in the potreros of Menchaca, Agua Chiquita, Barril Viejo and Oballos. It forms a very striking and resistant scarp (Figs. 18, 19 and 20) surrounding the central part of the potreros. At the type locality, the Agua Chiquita Member consists of 59 meters of dark gray, thick to very thick bedded, coarse grained dolomite, formed by a very tight mosaic of dolomite crystals with occasional ghosts resembling mollusc shell fragments or intraclasts (Plate 6). In Potrero de Menchaca, the lithology and thickness of this member is very similar to that of the type section but shows in the upper part numerous relict fragments of rudimentary rudistids, resembling monopleurids. In Potrero de Oballos the Agua Chiquita Member is not dolomitized. It consists of thick-bedded, dark gray, intraclast, mollusc shell fragment wackestones. The upper part contains some beds of mollusc and algal fragment grainstones (Plate 7) with numerous shells of monopleurids and toucasias.

Dolomitization of this member is very closely related to the spatial distribution of the overlying evaporites in the La Virgen Formation (Figs. 21, 22 and 41). This factor suggests that the dolomitization could be the effect of Mg-rich solutions percolating down from the evaporites above.

Plate 6

Photomicrographs of dolomites in the Agua Chiquita Member (Sacramento Formation) in the type locality of Potrero de Agua Chiquita. Approximate magnification x30.

A and B. Coarse grain dolomite (100 to 300 micron) Sample CH284.

C. Dolomite with numerous "ghosts" resembling shell fragments. Sample CH285.

PLATE 6

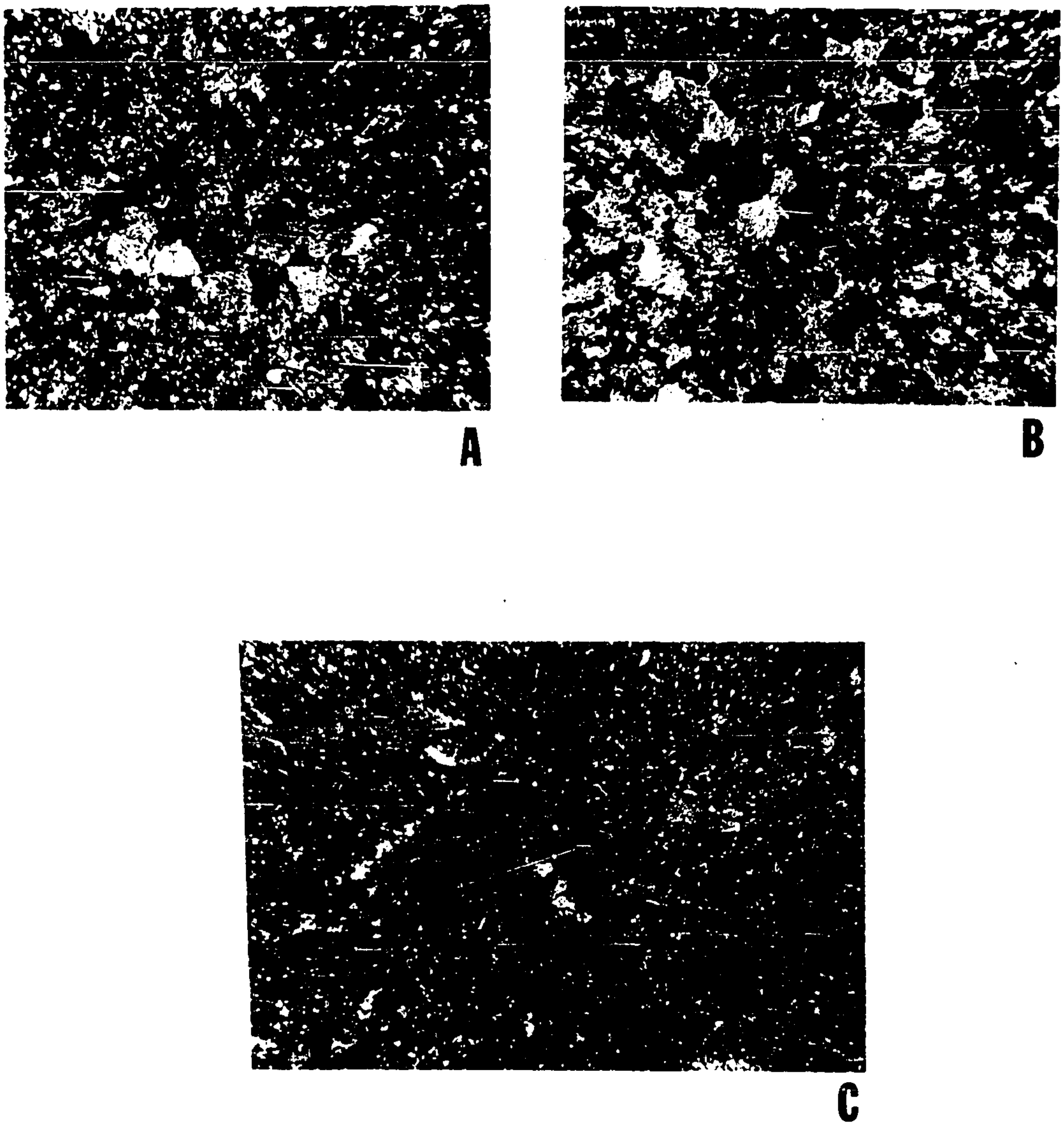


Plate 7

Photomicrographs of the lithofacies of the Agua Chiquita Member in Potrero de Oballos. Magnification approximately x30 unless otherwise stated.

A. Recrystallized, intraclast, shell fragment grainstone. Sample CH985.

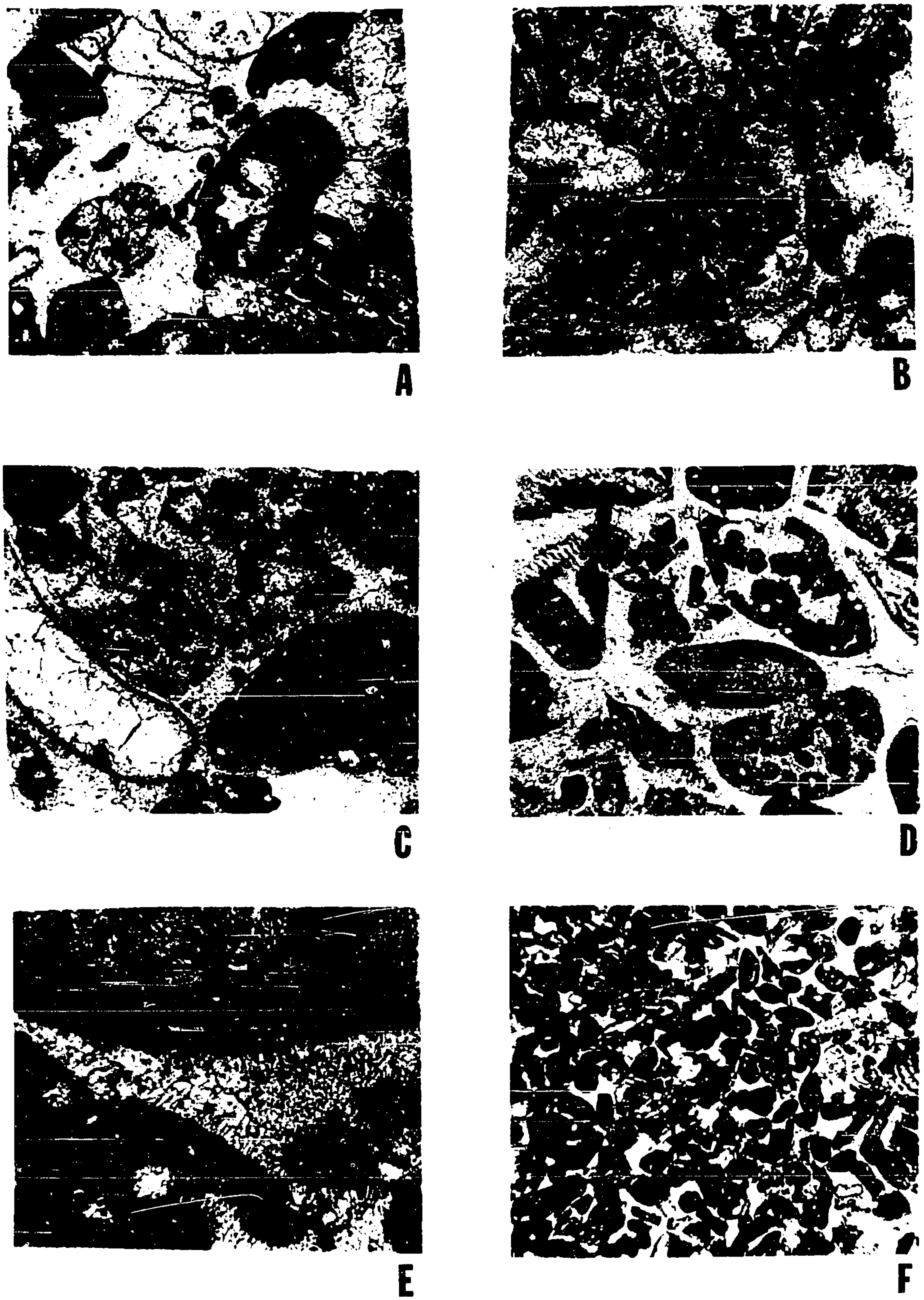
B and C. Same as above showing some intraclasts completely recrystallized.

D. Foraminifera, intraclast grainstone; large coral fragment in the right, and dasycladacean algal fragment in the upper left. Sample CH986.

E. Same as above, showing the rim of calcite cement around the intraclasts. Approximate magnification x125.

F. Oolite, pellet grainstone. Sample CH987.

PLATE 7



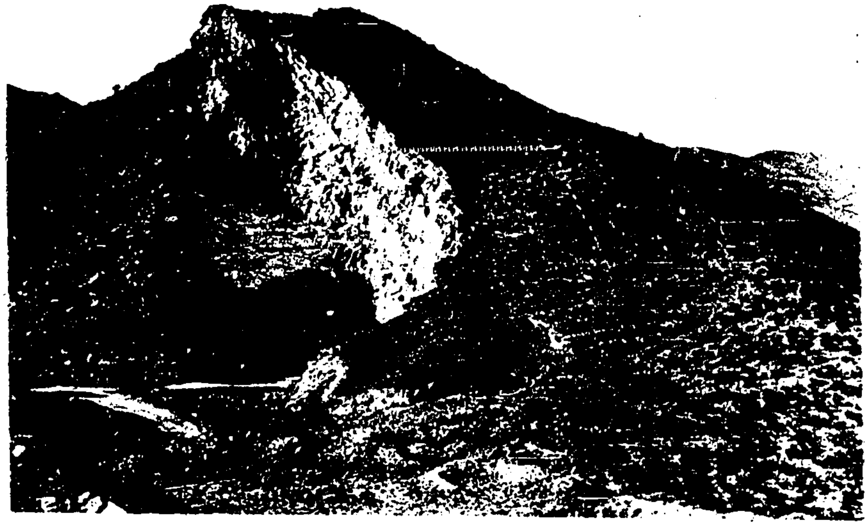


Figure 18: Quarry in the dolomites of the Agua Chiquita Member, central part of Potrero de Agua Chiquita. View toward the north.

Figure 19: Ridge-forming dolomites of the Agua Chiquita Member (darker interval) around the central part of Potrero de Menchaca. View toward the northwest.

Oballos Member

The type locality of this member is the northwestern corner of Potrero de Oballos. It consists of thick-to medium-bedded, nodular marls, interbedded with medium-bedded, ostracod, foraminifera wackestones (Plate 8). In other localities where this member is found, the lithology is very similar, the only significant difference is in Potrero de Barril Viejo where there are some beds of thick-bedded, arenaceous, oolite and intraclast grainstones. The thickness of the Oballos Member ranges from 101 meters in the type locality to only 46 meters in the central part of Potrero de Barril Viejo.

Age and Correlation

The Sacramento Formation has yielded few reliable fossils. The Agua Chiquita Member has only a poorly preserved fauna of monopleurids, and the Oballos Member some benthonic gastropods and molluscs. The only fossil identified in this member were several forms of Choffatella (Plate 8) which has a very wide range. Bloxsom (1972, p. 25) reported it in the Upper Aptian sediments of northern Coahuila. Future detailed biostratigraphic analysis of this formation may provide a more reliable age, but at the moment its stratigraphic position, overlying the Barril Viejo Formation and underlying the shales of the La

Plate 8

Photomicrographs of the typical lithofacies in the Oballos Member (Sacramento Formation). Approximate magnification x30.

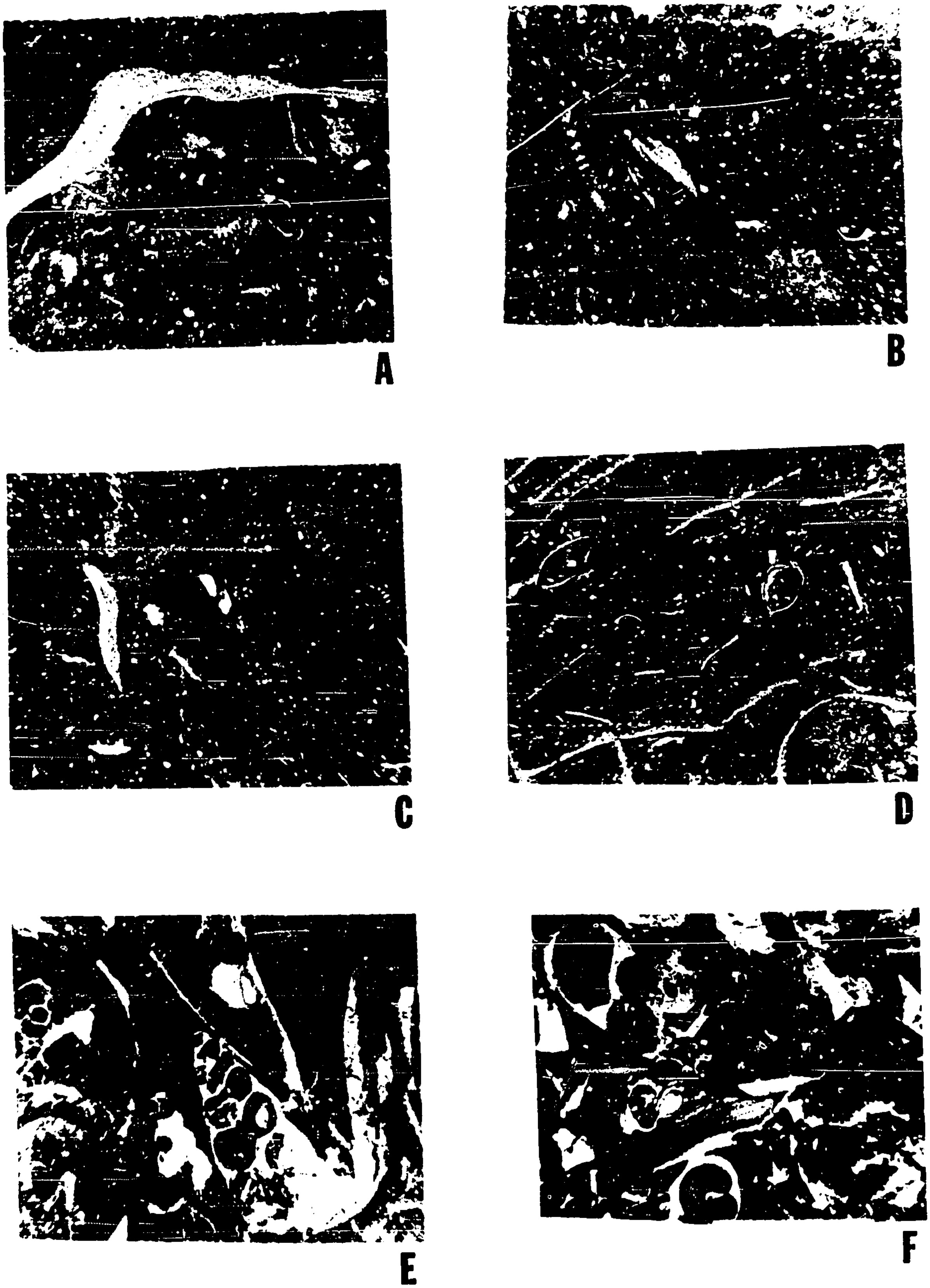
A. Mollusc shell fragment wackestone; Choffatella in the center. Potrero de Agua Chiquita. Sample CH298.

B and C. Shell fragment wackestone with Choffatella and unidentified biserial foraminifera. Potrero de Oballos. Sample CH988.

D. Ostracod, shell fragment wackestone. Potrero de Oballos. Sample CH990.

E and F. Gastropod shell fragment packestone with Turritella and Choffatella. Potrero de Oballos. Sample CH991.

PLATE 8



Mula Formation, places its age between the Late Hauterivian and Early Aptian.

Down-dip toward the central part of the basin the Sacramento Formation grades very rapidly into the platform carbonates of the Cupido Formation. (Plate 19). Toward the continental margin there is a facies change between the Sacramento and the coarse conglomeratic sandstones and conglomerates of the San Marcos Arkose.

Environment of Deposition

In most places the extensive secondary dolomitization of the Agua Chiquita Member has obscured sedimentary textures and grains critical to the interpretation of the depositional environments. However, it seems probable that during this time, the Sabinas Basin was momentarily stabilized and the volume of fine terrigenous sediments decreased considerably, promoting the deposition of calcium carbonate material in a clear, shallow, fairly agitated environment. This environment was also conducive to a scanty development of some very small and rudimentary rudistid colonies. Apparently this condition changed after another local transgression developed, leading to the deposition of the Oballos argillaceous sediments in a shallow, quiet environment, characterized by the proliferation of mud-dwelling gastropods and pelecypods.

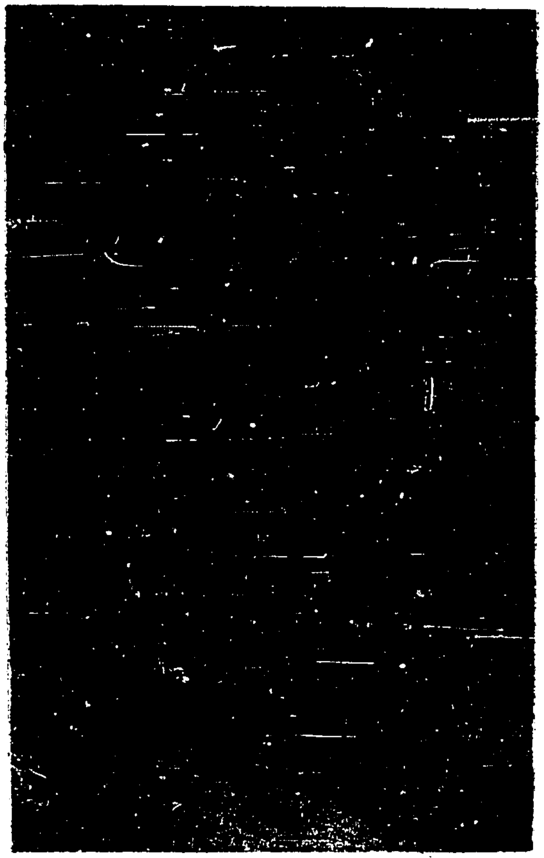


Figure 20: Resistant arenaceous dolomites in the Agua Chiquita Member in the eastern flank of Potrero de Barril Viejo.

La Virgen Formation

Occurrence and Type Locality

The name "La Virgen Gypsum" was given by Humphrey and Diaz (1956, p. 256) to the evaporites exposed in the western side of Potrero de la Virgen, about 10 km. northeast of Cuatro Cienegas, Coahuila. I prefer to use the broader name of La Virgen Formation due to the lithologic variability of this unit.

La Virgen Formation was originally described by Kane (in Imlay, 1940, p. 121) who correlated it with the Cuchillo Parado Formation of northeastern Chihuahua. The evaporites and associated limestones and siltstones of this formation outcrop in the northwestern margin of the Sabinas Basin. The southeastern most exposure was found in the central part of Potrero de Lamadrid, 20 km. east of Cuatro Cienegas. From this locality the evaporites extend northward and outcrop in potreros of La Virgen, Padilla El Berrendo and Sierra del Oregano. Although some evaporites apparently equivalent to La Virgen were encountered in the Peyotes 2-A well (Appendix C), northeast of this region, the general trend of evaporite distribution is definitely westward (Figs. 21 and 22) toward the area of Potrero de La Mula, Sierra del Fuste, Sierra del Pino, Sierra del Corazón (Garza, 1970, p. 53) and probably into Chihuahua.

The La Virgen Formation is subdividable in most places into three members; a predominantly calcareous interval in the middle with evaporitic units below and above. In the type locality (Fig. 23), the lower contact of this formation is covered by recent alluvial sediments. The section measured in the eastern side of the potrero was 449 meters thick in comparison with 535 meters reported by Humphrey and Diaz (1956, p. 259) in the western flank. The lower unit has a thickness of 162 meters and is formed by alternating beds of gypsum and thin-bedded shell fragment mudstones. The middle unit is 43 meters thick. It is predominantly calcareous and consists of thick-bedded, mollusc fragment packstones, grainstones and mudstones, with a small interval of gypsum in the middle part. In the upper unit, gypsum predominates over the shell fragment mudstones and wackestones. The contact with the overlying Cupido Formation is transitional.

In Potrero de la Mula, the evaporites of the La Virgen outcrop extensively along the northern flank. They overlie reddish siltstones and conglomerates assigned to the San Marcos Arkose and underlie the shallow water calcarenites of The Cupido Formation. A section measured in the eastern flank

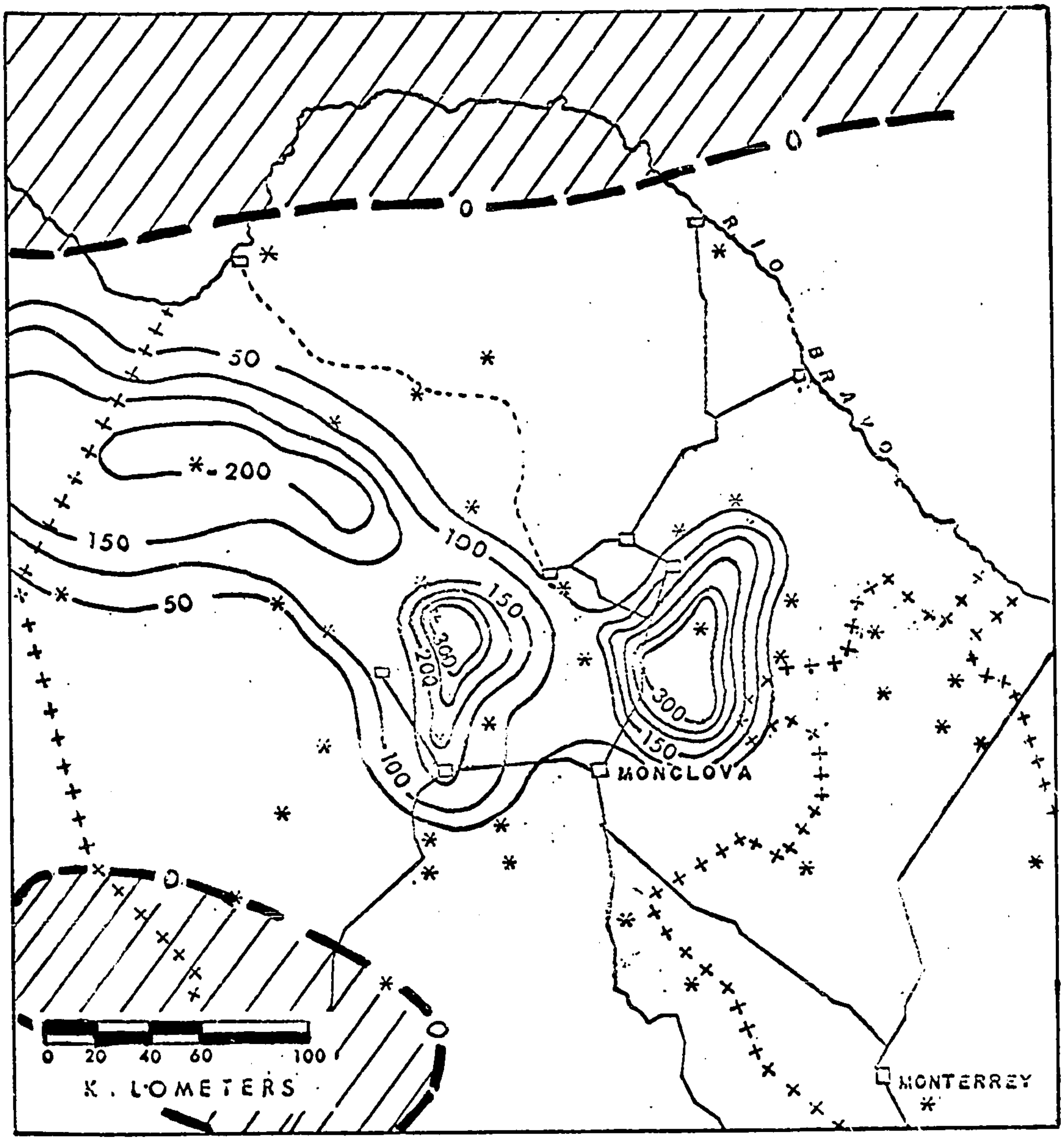


Figure 21: Isopach evaporite map of the Coahuila Series. The ruled area in the north corresponds to the Texas Craton, and in the south to the pre-Mesozoic igneous and metamorphic rocks of the Coahuila Island.

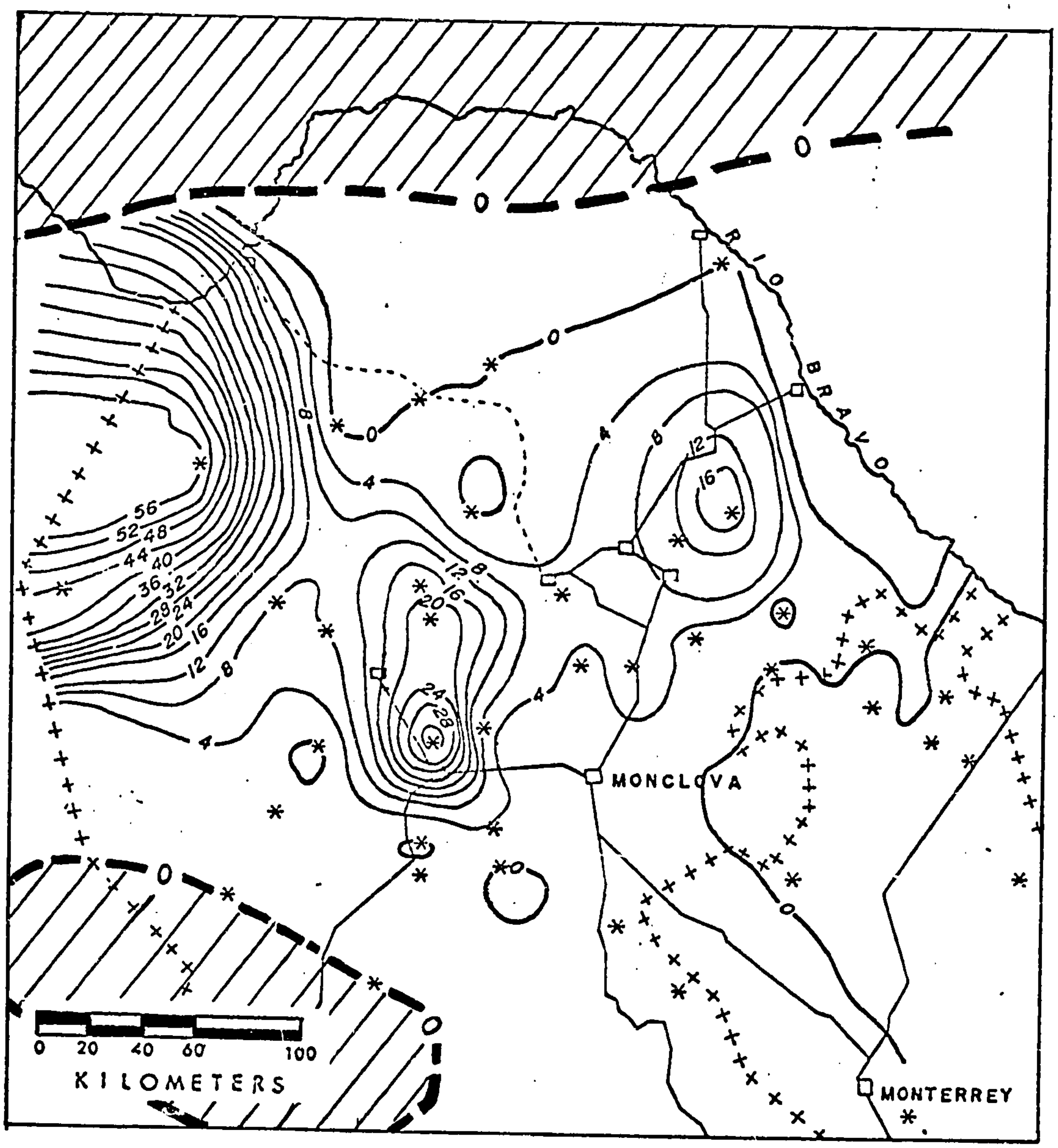


Figure 22: Evaporite percentage map of the Coahuila Series. The ruled area in the north corresponds to the Texas Craton and in the south to the Coahuila Island.

of the potrero (Plate 21) was 404 meters thick. The formation here is also tripartite with a resistant, cliff-forming interval of dolomitized, oolite grainstones and wackestones, forming a medial wedge between two gypsum units.

The La Virgen Formation outcrops very extensively in the central part of potreros del Berrendo and Padilla. In the latter locality the middle member consists of 113 meters of thick-to medium-bedded micrites and several intervals of shell fragment, miliolid grainstones and packstones. The lower and upper members have a total thickness of 401 meters. They are formed by gypsum interbedded with medium-to thin-bedded micrites.

In Sierra del Fuste, approximately 15 km. northwest of Potrero de La Mula, La Virgen Formation consists of 146 meters of gypsum interbedded with fine terrigenous sandstones and siltstones. The lower part of this unit contains thin layers of gypsum and siltstones resembling the "enterolithic gypsum" described by Christopher et al. (1969, p. 858) in the sabkhas of the Persian Gulf.

Age and Correlation

The most common fossils found in La Virgen Formation are frequently oriented small forms of *Turritella* (Fig. 24), and

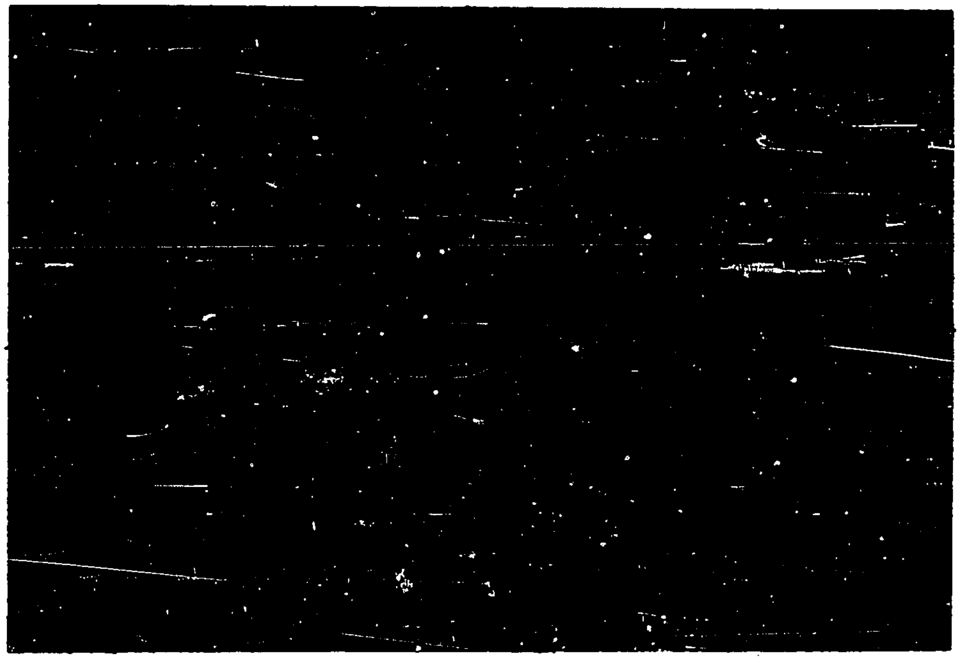


Figure 23: Evaporites of the La Virgen Formation at the type locality. The dark line corresponds to the contact between the Cupido and La Peña formations. Eastern flank of Potrero de La Virgen.

pelecypods like Exogyra. Although these fossils are quite abundant in some intervals, they are not suitable for a refined biostratigraphic zonation. In general I agree with Humphrey and Diaz (1956, p. 244) who considered that the La Virgen Formation represents most of the Barremian, since the evaporites underlie the limestones of the Cupido Formation.

In the northeastern corner of Chihuahua, Burrows (1910, p. 95) reported a sequence of evaporites and assigned them to the Cuchillo Parado Formation. Imlay (1944, p. 1185) determined that this unit is Early Albian to Early Aptian in age. More recently, Humphrey and Diaz (1956, p. 246-249) proposed the restriction of the Cuchillo Parado Formation to include evaporite strata older than Late Aptian, overlying the terrigenous sediments of Las Vigas Formation. Possibly part of the Cuchillo Parado Formation of Chihuahua is correlative with the evaporites of the La Virgen Formation in Coahuila. Further detail work on the area will clarify this interpretation.

The stratigraphic cross-sections and lithofacies maps (Plate 18 and Fig. 41) suggest that the evaporites of La Virgen correspond to a facies change of typical epineritic sediments, grading toward the down-dip side of the basin into marine deposits of the Cupido and La Mula formations. Toward the interior portion of the shelf, the evaporites change facies again into the continental terrigenous sediments of the Patula and San Marcos Arkose.

Environment of Deposition

The mechanism of evaporite deposition has been studied by many workers. Scruton (1953), Sloss (1953) and Borchert (1963) suggested important hypotheses that account for the accummulation of evaporites in the geologic record. Most of these explanations are related to climatological conditions, subsidence and mechanical processes prevailing in the depositional sites.

The petrographic character, paleogeography, and associated lithologies of the La Virgen Formation indicate that deposition took place in two main environments during a period characterized by a constant subsidence along the margins of the Coahuila Island and by much warmer climatological conditions.

The massive gypsum interbedded with dolomitized wackestones and grainstones in the lower and upper members of the La Virgen Formation was probably deposited in marginal lagoons, partially separated from the main sea by an oolite barrier or other topographic obstacle. However the most important environment of deposition of the La Virgen Formation was the supratidal flats and continental"sabkhas" developed along the margins of the lagoons. The paleogeographic data indicate that during deposition of the La Virgen, the physiographic and hydrologic conditions of the area were suitable for the development of broad, extended coastal flats or "sabkhas" (Kinsman, 1969, p. 832) marginal to the lagoons. Evaporitic accummulation occurs in the sabkhas by processes of alternating flooding by storm waters and evaporation. After the storm flooding replaces interstitial water lost by the evaporation, the pore-fluid becomes highly concentrated and could move upward by the effect of evaporite pumping as was suggested by Hsu and Siegenthaler (1969, p. 17). When the brine reaches the necessary salinity, gypsum or anhydrite is formed in the capillary zones of the exposed sabkhas. The deposits are in the form of irregular-shaped nodules (Maiklen et al., 1969) or adopt very contorted forms called enterolithic bedding (Shearman and Fuller, 1969, Christopher, et al., 1969), due to the similarity to human intestines. Similar contorted laminations of siltstones and gypsum and stringers of nodules (Fig. 25) have been identified in some intervals of the La Virgen Formation.

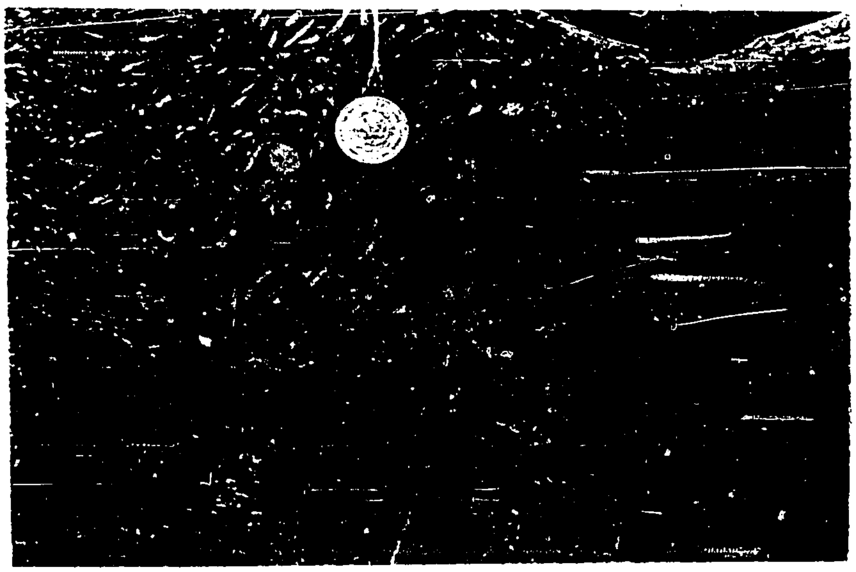


Figure 24: Limestone with abundant oriented Turritella (indicated by the arrow) in the La Virgen Formation, northeastern corner of Potrero de La Mula.

Figure 25: Stringers of calcite nodules, probably replacing gypsum or anhydrite insubarkosic sandstones and siltstones of the La Virgen Formation, southeastern corner of Potrero de Menchaca.

La Mula Formation

Occurrence and Type Locality

Imlay (1940, p. 122) designed the Potrero de La Mula, 30 km. northwest of Ocampo, Coahuila, as the type locality for this formation. Kane (in Imlay, 1940, p. 121) originally named this unit "La Mula Shale"; however, Humphrey and Diaz (1956, p. 229), considering that the unit does not exhibit lithologic homogenity, changed it to the more general name of "La Mula Formation".

The La Mula Formation was measured in potreros de Padilla, Oballos, Menchaca, and Agua Chiquita (Appendix B). On the basis of their stratigraphic position some sediments were assigned to this formation in Sierra del Fuste, Sierra del Carmen, Valle El Infante, Cañon de La Alameda, Potrero de Barril Viejo and Sierra de La Gavia.

Lithology

A distinctive characteristic of this unit is the presence of shales in the lower part (Fig. 26), overlain by predominantly calcareous sediments of the upper part. In Potrero de Padilla, the lower member is 154 meters thick and consists of reddish and greenish fissile shales. The upper member contains 420 meters of medium-to thin-bedded, arenaceous, shell fragment mudstones, interbedded with shell fragment wackestones and grainstones. In Potrero de Oballos, the basal portion of La Mula Formation is only 73 meters in thickness and is composed of shales interbedded with thin-bedded mudstones. The middle and upper part of the formation consist of 486 meters of thick-to medium-bedded mudstones and some intervals of shell fragment, miliolid grainstones and packstones. There are also several units composed of collapse breccias (Fig. 27) and highly contorted mudstones with calcite pseudomorphs (Plate 9) replacing gypsum or anhydrite.

In Potrero de Agua Chiquita, the lower shale member has a thickness of 200 meters. The upper member is also predominantly calcareous and consists of 100 meters of medium-to thin-bedded, shell fragment mudstones.

Age and Correlation

La Mula Formation generally underlies shallow calcareous limestones of the Cupido Formation and is laterally equivalent to the microcrystalline mudstones of the Cupido Formation deposited on the deeper portions of the external basin. Toward the shallower and marginal parts of the shelf, the La Mula Formation grades into the terrigenous sediments of the

Figure 26: Fissile shales in the La Mula Formation, interbedded with thin bedded limestones, central part of Potrero de Agua Chiquita.

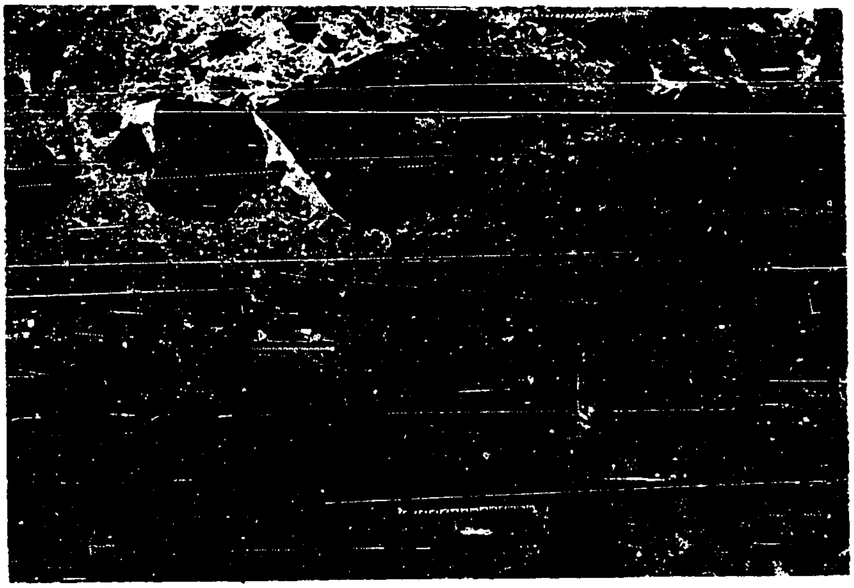


Figure 27: Collapse breccia in the La Mula Formation, southeastern corner of Potrero de Menchaca.

Plate 9

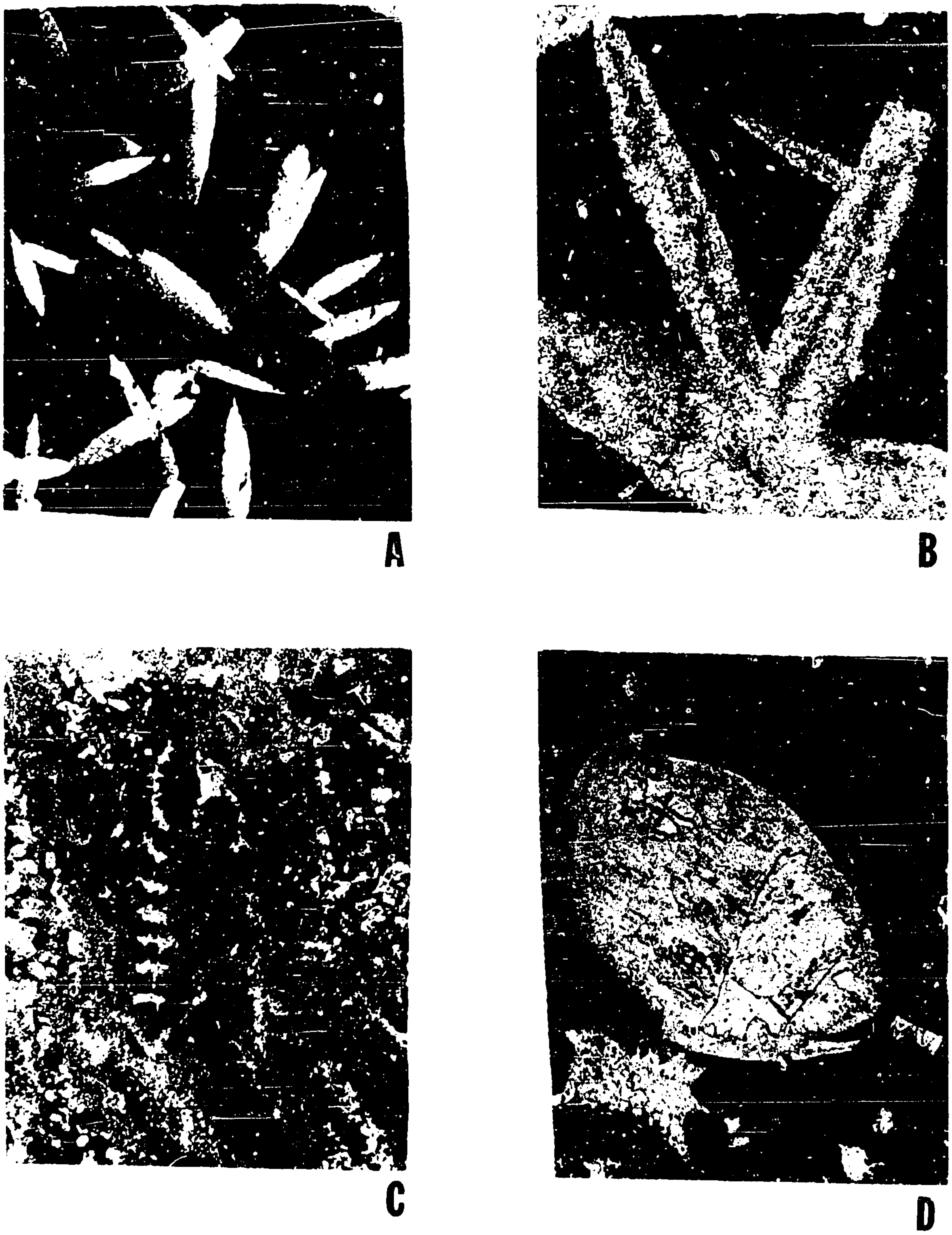
Photomicrographs of the La Mula Formation in Potrero de Oballos.

A and B. Mudstone with calcite pseudomorphs after gypsum or anhydrite. Sample CH1007. Approximate magnification x15 (A) and x30 (B).

C. Mudstone with Choffatella. Sample CH998. Approximate magnification x30.

D. Mudstone with a recrystallized ostracod (?). Sample CH1015. Approximate magnification x120.

PLATE 9



Patula Arkose and into the evaporites of La Virgen Formation (Plate 17). This spatial distribution suggests (Imlay, 1940, p. 1033) that La Mula Formation was deposited during the entire Barremian and perhaps part of the Early Aptian.

Environment of Deposition

The basal shales and calcareous siltstones of the La Mula Formation were deposited in the shallow interior portions of the shelf during a time characterized by the influx of fine terrigenous sediments derived from the adjacent continental elements. After the influx of clays and silt decreased considerably, the sedimentation pattern changed drastically such that the argillaceous units formed in the lower part of La Mula are overlaid by mudstones and shell fragment wackestones and packstones of the upper part of the formation.

Patula Arkose

Occurrence and Type Locality

The type locality (Kane; in Imlay, 1940, p. 122) of this unit is the central part of Potrero de La Gavia, 20 km. south of Monclova, Coahuila. From this site, the arkosic sediments extend in a northwesterly direction toward the area of Potrero de Barril Viejo.

Lithology

In Potrero de La Gavia the total thickness of the Patula Arkose is 927 meters (Appendix B). The lowermost 445 meter consist of reddish, thick-to medium-bedded, silt size subarkoses and orthoquartzites. The overlying 243 meters consist of reddish, nodular, subarkosic siltstones, interbedded with poorly sorted, angular conglomeratic (granules), coarse subarkoses and arkoses with few fragments up to the size of large cobbles. The upper 33 meters of this interval consist of reddish, very thick-to thick-bedded, conglomeratic orthoquartzites and subarkoses. The conglomeratic fragments are composed mainly of milky quartz and a few metamorphic and igneous rocks. The upper 239 meters of the Patula are reddish, nodular, arkosic and subarkosic siltstones, interbedded with thick-to medium-bedded, subangular, medium sorted, granular conglomeratic subarkoses and arkoses (Plate 10), some conglomeratic intervals have fragments ranging in size from granules to small and medium pebbles.

In Potrero de Barril Viejo, the terrigenous sediments of the Patula Arkose have a thickness of 398 meters. The lower 205 meters of the section consists of light reddish, thick-bedded, subangular, poorly sorted, coarse to medium sand size, subamture subarkose, interbedded with medium-to thin-bedded, subarkosic siltstone. There are some intervals with numerous granule size fragments and some beds of nodular siltstones and shales. The upper 193 meters are formed by a very thick-to thick-bedded, slightly conglomeratic and conglomeratic subarkoses and litharenites. The conglomeratic fragments are formed mainly by granules and large pebbles, although there are also a few fragments up to the seize of large cobbles.

Age and Correlation

At the type locality, the Patula Arkose underlies the limestones of the Cupido Formation and overlies the shales and marls of the Barril Viejo Formation. Both contacts are transitional. Toward Potrero de Barril Viejo, the arkosic

Plate 10

Photomicrographs of the Patula Arkose in the type locality of Potrero de La Gavia. Approximate magnification x30.

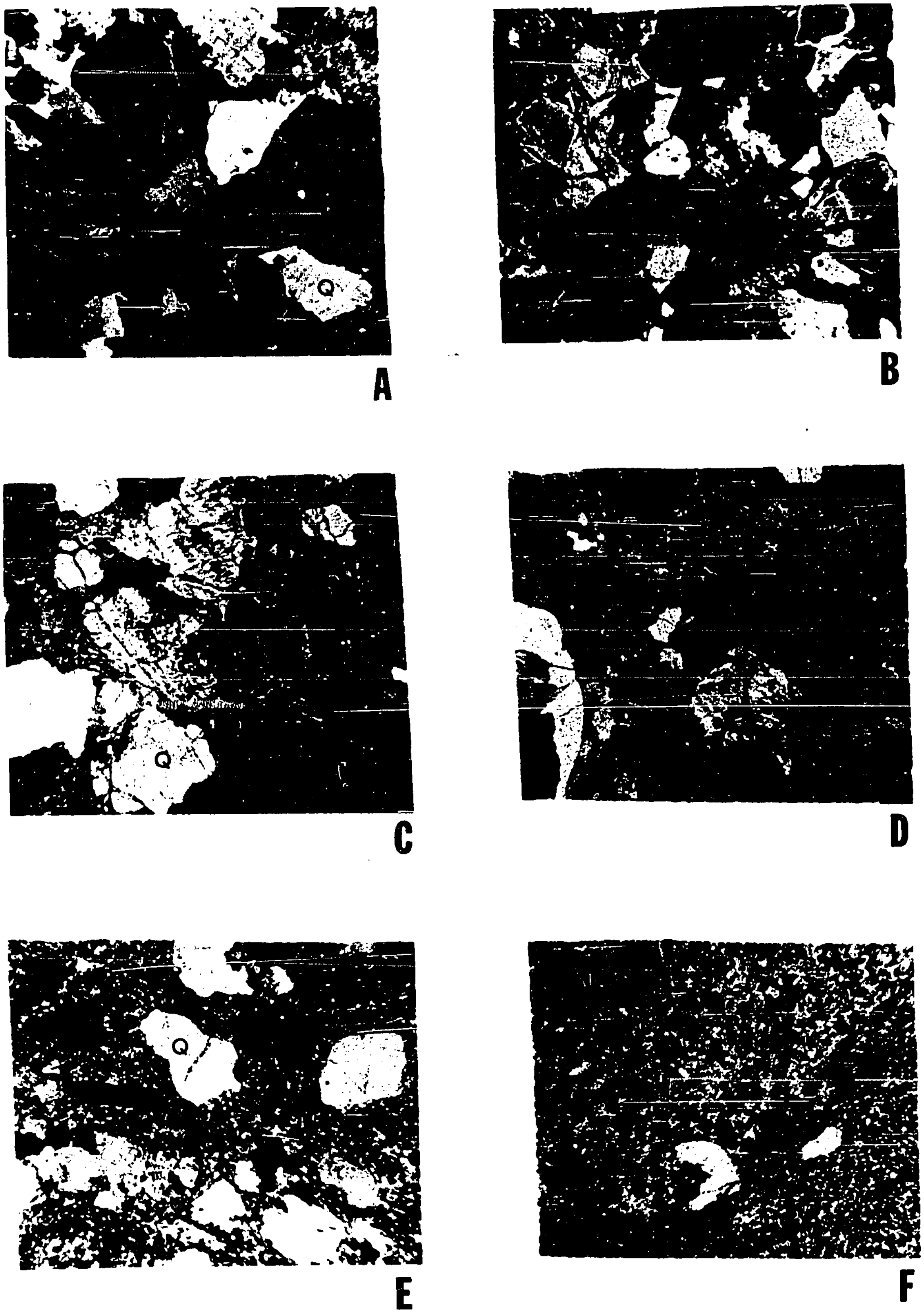
Q = quartz, F = potassium-feldspar, P = plagioclase, M = mica, and C = chert.

A, B, and C. Very coarse arkose, slighltly cemented by calcite; abundant microcline and altered plagioclase. Sample CH138.

D. Medium to coarse arkose; some mica grains and abundant feldspars. Sample CH135.

E and F. Dolomitized subarkose. Sample CH144.

PLATE 10



debris of this unit forms a clastic wedge between the Cupido and the Sacramento Formation. This spatial relationship implies that the deposition of the Patula Arkose took place from Late Hauterivian and throughout the entire Barremian stage.

The stratigraphic and spatial distribution of the Patula Arkose indicate that this unit is an upper tongue of the San Marcos Arkose (Plate 19) which extended farther eastward from the southern end of the Coahuila Peninsula. Toward the north and northwest the Patula changes facies very rapidly to the La Mula Formation. Toward the eastern part of the basin, the deltaic sandstones and siltstones of this formation are replaced by the carbonates of the Cupido Formation.

Environment of Deposition

Lithofacies maps (Figs. 39 and 40) of the Neocomian sediments, and textural properties of the Patula, indicate that this arkose was deposited on an elongated alluvial plain. Terrigenous sediments were constantly transported eastward to the margins of the plain, where deposition of the arkosic sands and siltstones developed a progradational deltaic system.

Other environments present during the deposition of the Patula Arkose were the alluvial fans and channels, the sites in which most of the conglomerates were deposited

The lithofacies distribution of the Patula Arkose also suggests that the source area was located toward the west of Potrero de la Gavia, around the area of Sierra de Las Delicias and Sierra de los Alamitos. Krutak (1965, p. 517) concluded from cross-bedding data that the major source area for the Patula Arkose was near Potrero de La Mula. This interpretation does not agree with the lithofacies distribution and with the paleogeographic and stratigraphic data, which show that the area of Potrero de la Mula during most of the Neocomian was a restricted and isolated portion of the basement, having a very local influence on the sedimentological framework of the Coahuila Series.

Cupido Formation

Type Locality

The Cupido Formation is a major mountain and cliff-forming unit, extensively distributed over most of northern Mexico. This formation was proposed by Imlay (1937, p. 606) for exposures along the northern wall of Cañon del Mimbre, in the middle part of Sierra de Parras, 60 km. southwest of Parras, Coahuila. More recently, Humphrey (1949, p. 103) redefined the Cupido Formation to include the lower limestone member of Imlay's La Peña Formation. This usage has been extended and accepted throughout northern Mexico by most stratigraphers.

Lithology and Thickness

The Cupido Formation is missing by onlap on the southern extension of the Texas Craton and on the Pre-Mesozoic metamorphic and granitic rocks cropping out near Valle de Las Delicias, in the southern end of the Coahuila Peninsula (Plate 19). From these areas the unit gradually increases in thickness southward and eastward toward the central part of the Sabinas Basin, and along the eastern margin of the State of Coahuila it is close to 1000 meters (Fig. 28) thick.

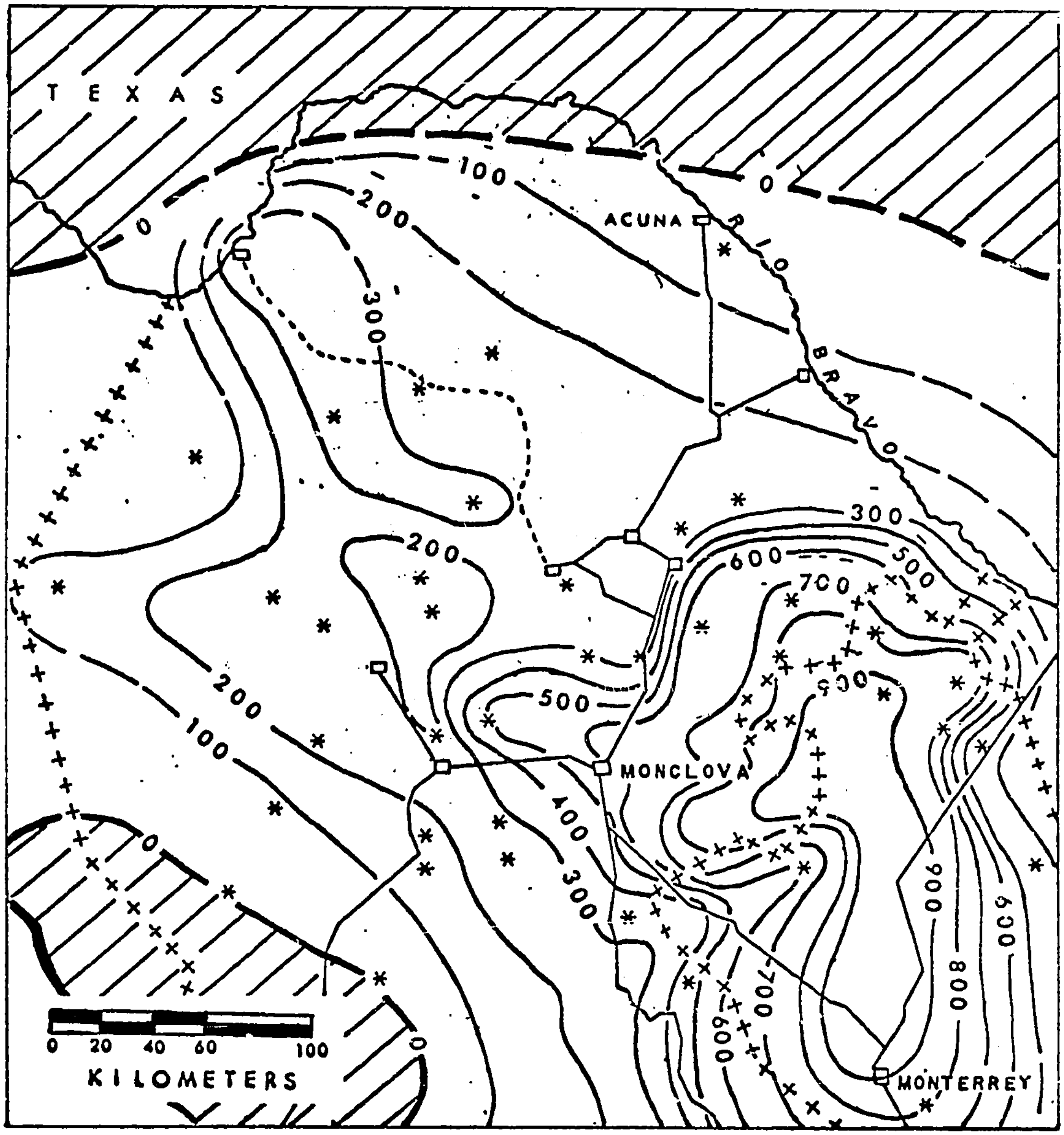


Figure 28: Isopach map of the Cupido Formation. The ruled area in the north correspond to the Texas Craton and in the south to the pre-Mesozoic igneous and metamorphic rocks of the Coahuila Island.

In the area of Cañon La Boca, Sierra de la Silla, near Monterrey, Nuevo León, Bonet (personal communication) measured 830 meters of a monotonous sequence of microcrystalline mudstones, equivalent to the entire Coahuila Series (Neocomian to Early Aptian). In this work, these sediments are recognized an independent lithofacies within the Cupido Formation; however, in the subsurface of eastern Mexico, similar stratigraphic and lithologic strata are given the name of Lower Tamaulipas Formation.

From Cañon La Boca, which is located on the margin of the Sabinas Basin, the lithologic variability of the Cupido Formation increases toward the northwest where it consists of a complex array of interfingering carbonate lithofacies (Fig. 30).

In Potrero de Minas Viejas, the lower microcrystalline mudstones of the Cupido Formation are 617 meters thick. The upper 286 meters of the formation consist of a thick-bedded, Toucasia and caprinid boundstone overlain by thick-to medium-bedded shell fragment, miliolid mudstones and wackestones.

In the area of Sierra de La Gavia, Barril Viejo, San Marcos, Sierra de La Madera and Sierra Colorada (Appendix B), the limestones of the Cupido Formation overlie terrigenous sediments of the Patula and San Marcos. The basal part of the unit consists of a transgressive sequence of thick-to medium-bedded, arenaceous dolomites, associated with algal stromatolites and cross-bedded, oolite grainstones. The upper part of the unit generally consists of thick-to medium-bedded, miliolid, shell fragment mudstones and wackestones with serpulid tubes and several intervals containing Toucasia and Monopleura biostromes.

In Potrero de Agua Chiquita, the Cupido Formation has a thickness of 290 meters. Most of the unit is formed by alternating serpulid tube mudstones and shell fragment wackestones and packstones with several beds of collapse breccia.

In the area of Potrero de Menchaca, the Cupido Formation is 599 meters thick. The section is divisible into three different parts. The lower part, 175 meters thick consists of thick-to medium-bedded, fissile shales, interbedded with thick-to medium-bedded, shell fragment, pellet mudstones. There is a 6 meters thick interval of massive gypsum, associated with algal stromatolites and thick-bedded, pellet, shell fragment packstones with numerous Turritella. The middle member of the Cupido Formation is composed of 55 meters of highly bituminous, very dark shales, interbedded with medium to thin-bedded, dark mudstones. The upper member is predominantly calcareous in nature and has a total thickness of 369 meters. The lower portion consists of thick-bedded, shell fragment mudstones, interbedded with thin units of shales, and there is an interval of cross-bedded, oolite grainstone at the base. In the lower middle part of this interval there is a 50 meter thick collapse breccia. The uppermost 200 meters of this member is composed of thick-bedded, miliolid, shell fragment mudstones and intraclast, pellet, shell fragment grainstones and packstones. There are also several units with numerous rudistids resembling Monopleura. Approximately 12 meters below the contact with La Peña Formation there is a caprinid boundstone with corals and many other rudistids.

The section of the Cupido Formation measured at the northwestern corner of Potrero de Oballos also shows a tripartite subdivision. The total thickness of the unit is 329 meters. At the base of the lower member there is a 60 meter sequence of thick-to medium-bedded, shell fragment, miliolid grainstone overlain by miliolid mudstones and wackestones. The middle member is mostly a 60 meter collapse breccia, interbedded with intraclast, shell fragment wackestones. The upper member is 109 meters thick and consists of miliolid wackestones with common Orbitolina and a caprinid and Monopleura boundstone near the top.

In the central part of Potrero del Berrendo the total thickness of the Cupido Formation is only 134 meters. The unit is here named the El Berrendo Member due to its unique lithology formed by a continuous sequence of very dark to black bituminous mudstones with few scattered fragments of serpulids and ostracods. In the central part of Potrero de Padilla, the Cupido Formation is only 126 meters thick. It is divided in two members, the lower member consists of miliolid, ostracod mudstones, and the upper member of highly bituminous, serpulid mudstones.

At the base of the escarpment of Sierra del Carmen 30 km. east of Boquillas, the Cupido Formation has a thicknes of 324 meters. The lower part consists of arenaceous mudstones and thick-bedded, intraclast, miliolid, algal fragment packstones. Overlying this part there are 80 meters of shales interbedded with arenaceous mudstones and oolite, shell fragment grainstones and packstones. Most of the limestones in the upper 170 meters of the section are oolite, mollusc fragment grainstones.

Lithofacies Subdivision

During the last decade, the field of carbonate petrography has gained an enormous amount of information from the investigations carried out in many recent carbonate sedimentary environments. Important contributions in the

Bahamas and Florida shelves (Illing, 1954; Ginsburg, 1956-57; Cloud, 1961; Shinn, Ginsburg and Lloyd, 1965; Newell and Rigby, 1957; Purdy, 1963) in the Yucatan shelf (Logan et al, 1959; Hoskin, 1962; Bonet, 1971) and in the northern part of Australia (Fairbridge, 1950; Logan et al., 1970) have provided numerous models and important criteria, that enhance the recognition of carbonate environments of deposition in the geologic record.

In the thick carbonate sequence of the Cupido Formation, there are numerous lithofacies assembled in a very complex interfingering spatial distribution. The following broad lithofacies subdivisions are recognized:

1.- Arenaceous Dolomite Facies.
2.- Oolitic Grainstone Facies
3.- Skeletal Mud/Wackestone Facies
4.- Bituminous Laminated Mud Facies
5.- Evaporite Facies
6.- Stromatolite Facies
7.- Rudistid Boundstone Facies
8.- Microcrystalline Mudstone Facies

In order to distinguish the different environments of deposition in which all these lithofacies were formed, it was considered appropriate to use the model illustrated in the following diagram:

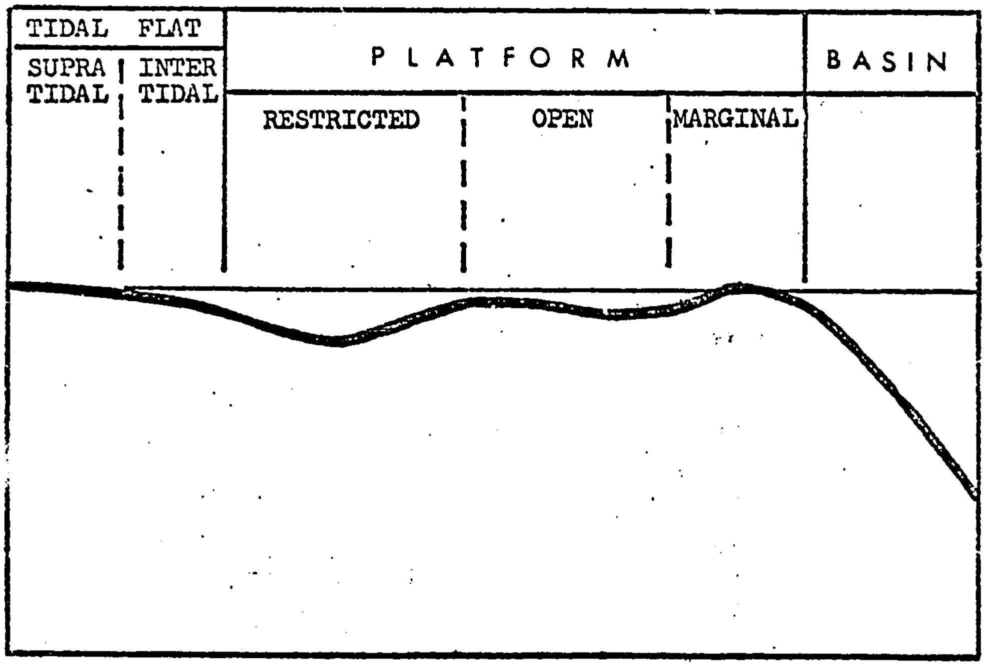


Figure 29: Environments of deposition of the Cupido Formation.

1.- Arenaceous Dolomite Facies

This lithofacies includes the basal transgressive units of the Cupido Formation. It consists of arenaceous dolomites frequently associated with stromatolitic features (Plate 11). The depositional environment of this facies is interpreted to have been on tidal flats along the litoral margin of the shelf.

2.- Oolitic Grainstone Facies

Within this lithofacies are included an array of grain-

Plate 11

Photomicrographs of the Arenaceous Dolomite Lithofacies of the Cupido Formation. Approximate magnification x35.

A. Slightly dolomitized, arenaceous mudstone. Sierra del Carmen. Sample CH1110.

B. Arenaceous, miliolid, shell fragment wackestone. Sierra Colorada. Sample CH346.

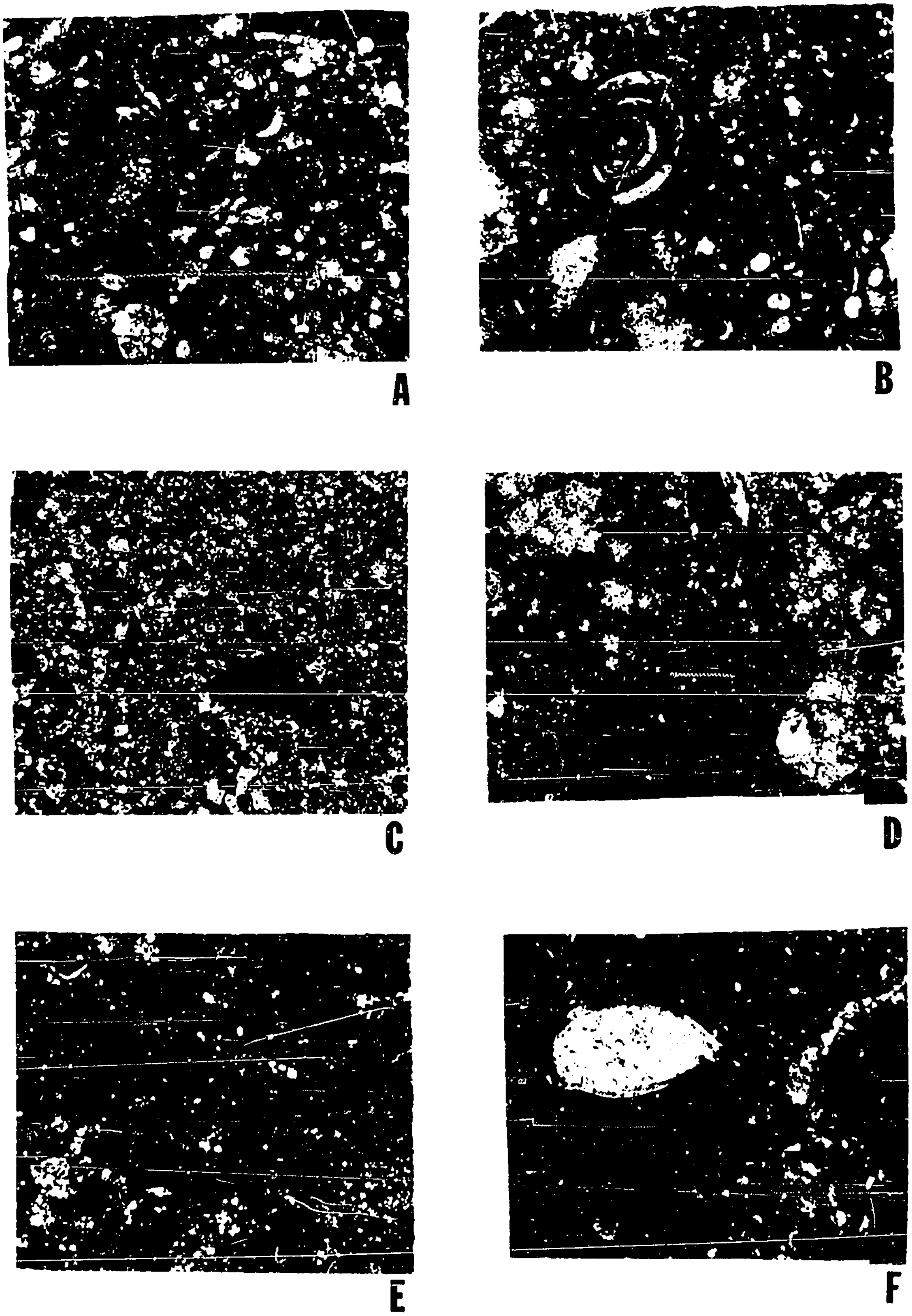
C. Arenaceous dolomite with good intercrystalline and vuggy porosity. Sierra Colorada. Sample CH336.

D. Arenaceous, dolomitized mudstone. Sierra Colorada. Sample CH346.

E. Arenaceous, slightly dolomitized mudstone.

F. Arenaceous mudstone with a pelecypod cross-section. Sierra Colorada. Sample CH346.

PLATE 11



supported carbonate rocks in which the predominant grains are oolites, well-sorted intraclasts, miliolids and algal fragments (Plate 12 and 13). The grainstones show frequently large scale planar cross-bedding. The environment of deposition of this facies (Illing, 1954; Newell and Rigby, 1957) was probably an open platform environment, characterized by extremely agitated water due to the effects of tidal currents and waves.

3.- Skeletal Mud/Wackestone Facies

Rocks of this lithofacies make up a large portion of the Cupido Formation. The skeletal debris is predominantly mollusc, echinoderm and serpulid fragments (Plate 14) intimately mixed in the mud-matrix.

The abundance of clay-size carbonate matrix in this facies and the grain components are correlative with an open marine but protective environment in which the mechanical processes present could not winnow out the fine calcareous sediments.

4.- Bituminous Laminated Mud Facies

This lithofacies is characterized by thin-to very thin-bedded, bituminous, very dark to black mudstones with a few shell fragments and ostracods in the highly organic calcareous matrix (Plate 15). This facies was named above the El Berrendo

Plate 12

Photomicrographs of the Oolitic Grainstone Lithofacies of the Cupido Formation in Sierra del Carmen.

A. Intraclast, shell fragment packstone; large grain of dasycladacean algae in the middle. Approximate magnification x30.

B. Arenaceous, oolite grainstone. Sample CH1125. Approximate magnification x20.

C. Oolite grainstone. Sample CH1129. Approximate magnification x30.

D. Oolite grainstone. Sample CH1132. Approximate magnification x30.

E. Oolite, shell fragment grainstone; sporangial segment in the middle.

F. Oolite grainstone with good intergranular porosity. Sample CH1142. Approximate magnification x35.

PLATE 12

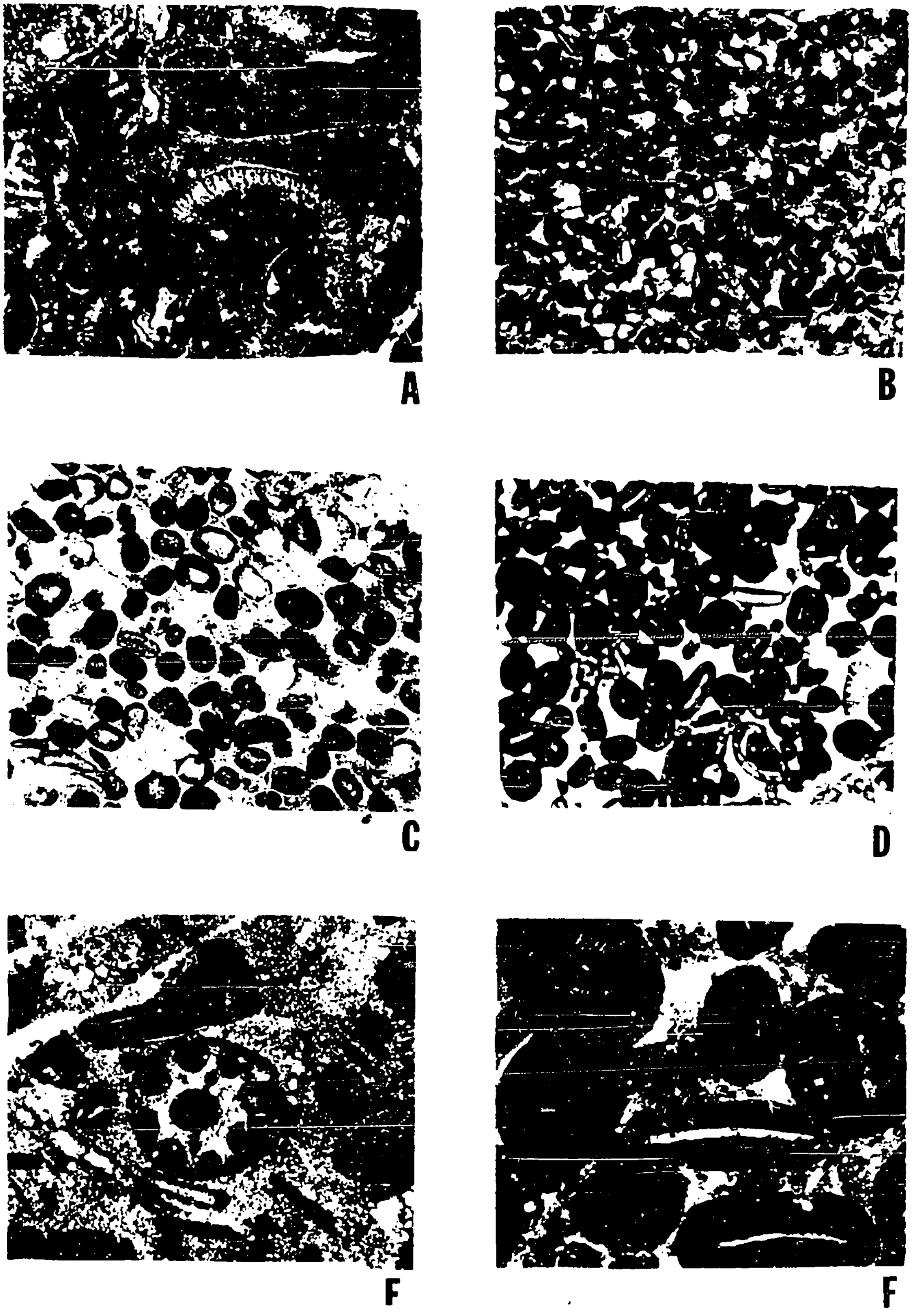


Plate 13

Photomicrograph of the oolitic grainstone lithofacies of the Cupido Formation in Potrero de Oballos.

A. Intraclast, shell fragment grainstone; unidentified foraminifera in the center. Sample CH1016. Approximate magnification x30.

B. Intraclast, foraminifera grainstone, sporangial disc of green algae (?) in the lower center. Sample CH1016. Approximate magnification x30.

C. Miliolid, intraclast grainstone. Sample CH1018. Approximate magnification x16.

D. Same as above with an amplified sporangial disc of green algae (?). Approximate magnification x120.

E and F. Oolite grainstone. Sample CH1023. Approximate magnification x30.

PLATE 13

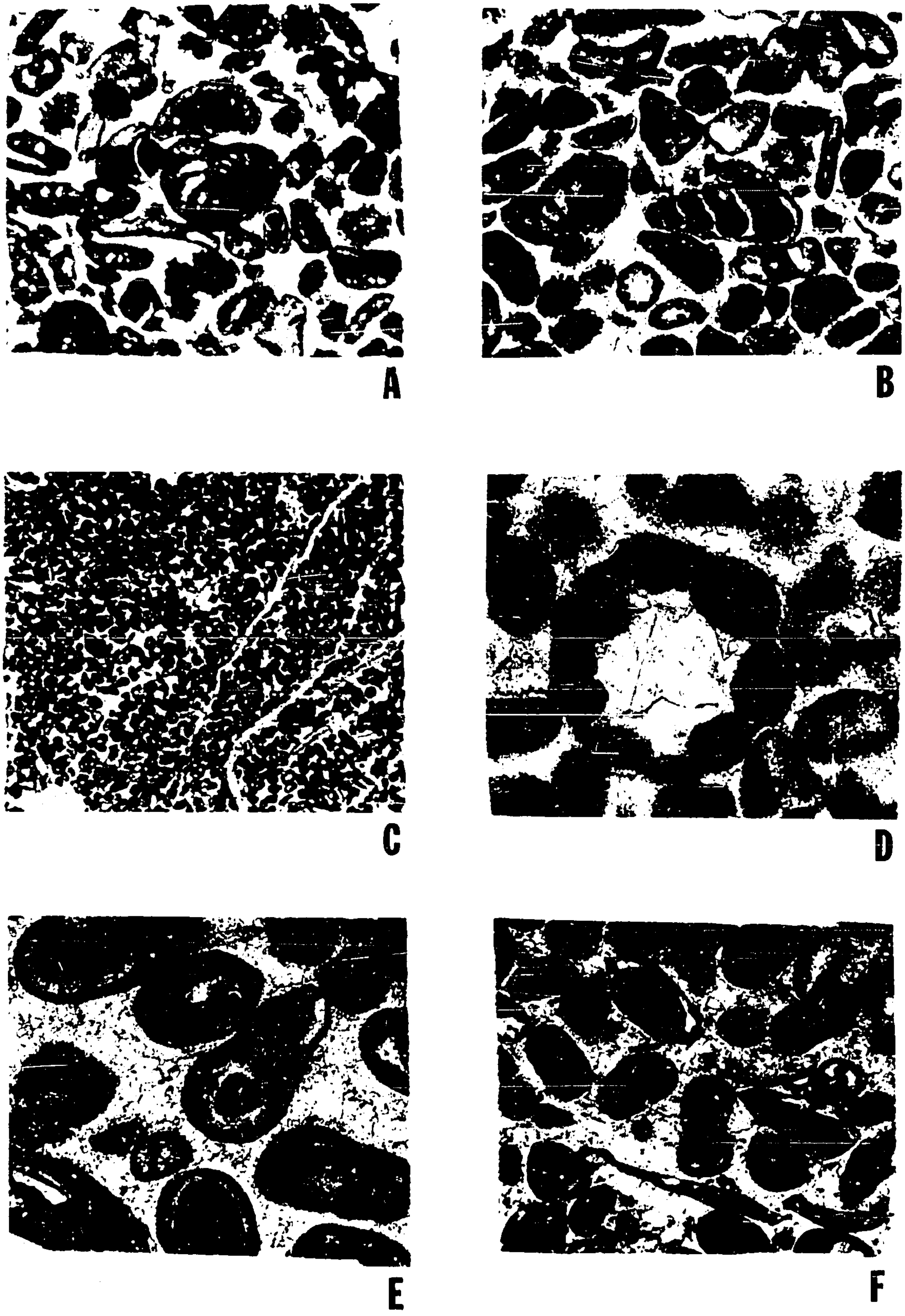


Plate 14

Photomicrograph of the typical skeletal mudstone - wackestone lithofacies of the Cupido Formatior in Potrero de Oballos.

A. Shell fragment mudstone; cross-section of an ostracod in the middle. Sample CH1014. Approximate magnification x50.

B. Same as above. Approximate magnification x35.

C and D. Foraminifera, echinoderm fragment wackestone. Sample CH1040. Approximate magnification x30.

E. Mudstone with Orbitolina. Sample CH1041. Approximate magnification x30.

F. Longitudinal section of Orbitolina. Sample CH1041. Approximate magnification x35.

PLATE 14

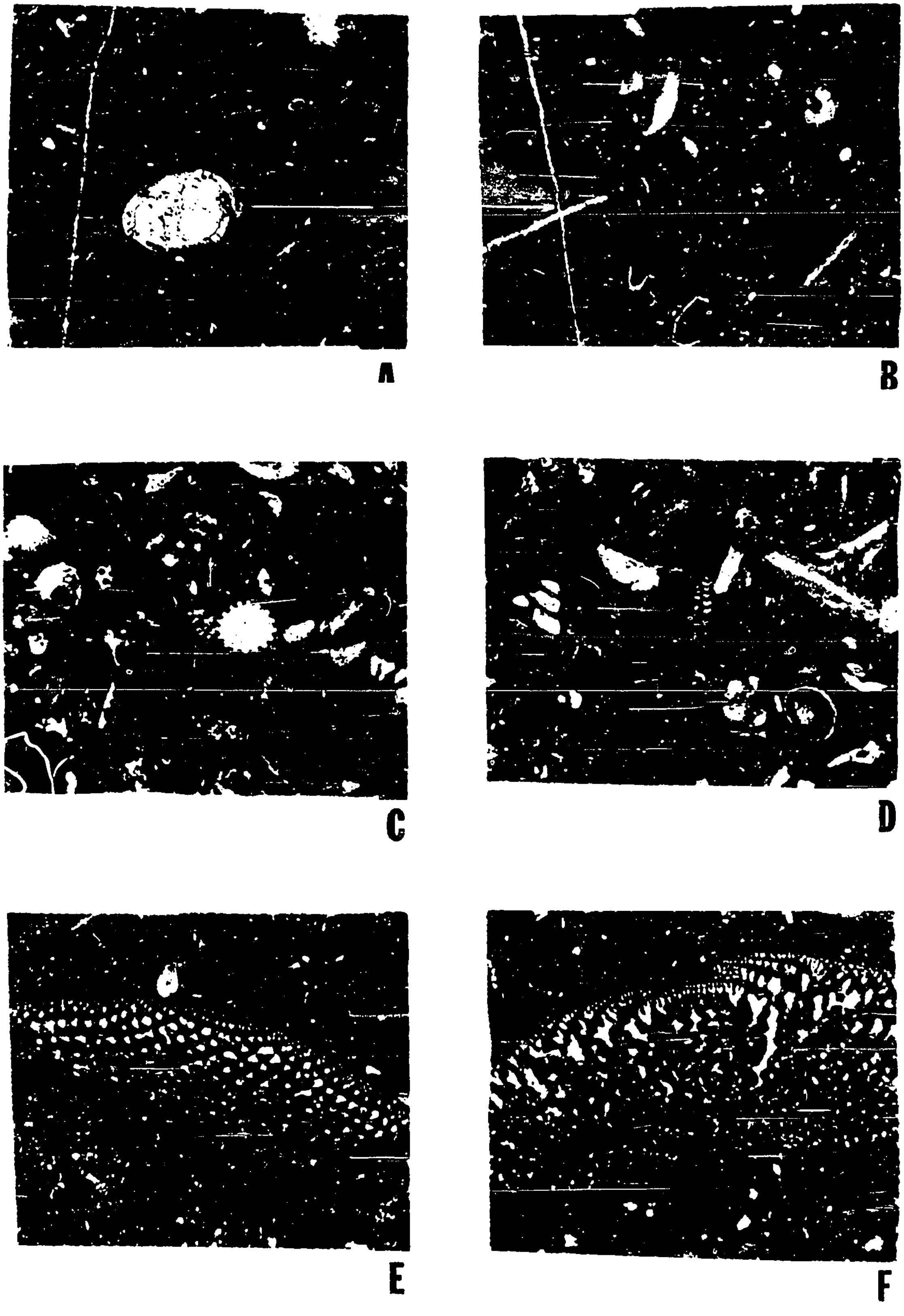


Plate 15

Photomicrographs of the bituminous laminated mudstone lithofacies (El Berrendo Member) of the Cupido Formation in Potrero de Padilla.

A. Mudstone with a cross-section of an ostracod (?). Sample CH883. Approximate magnification x30.

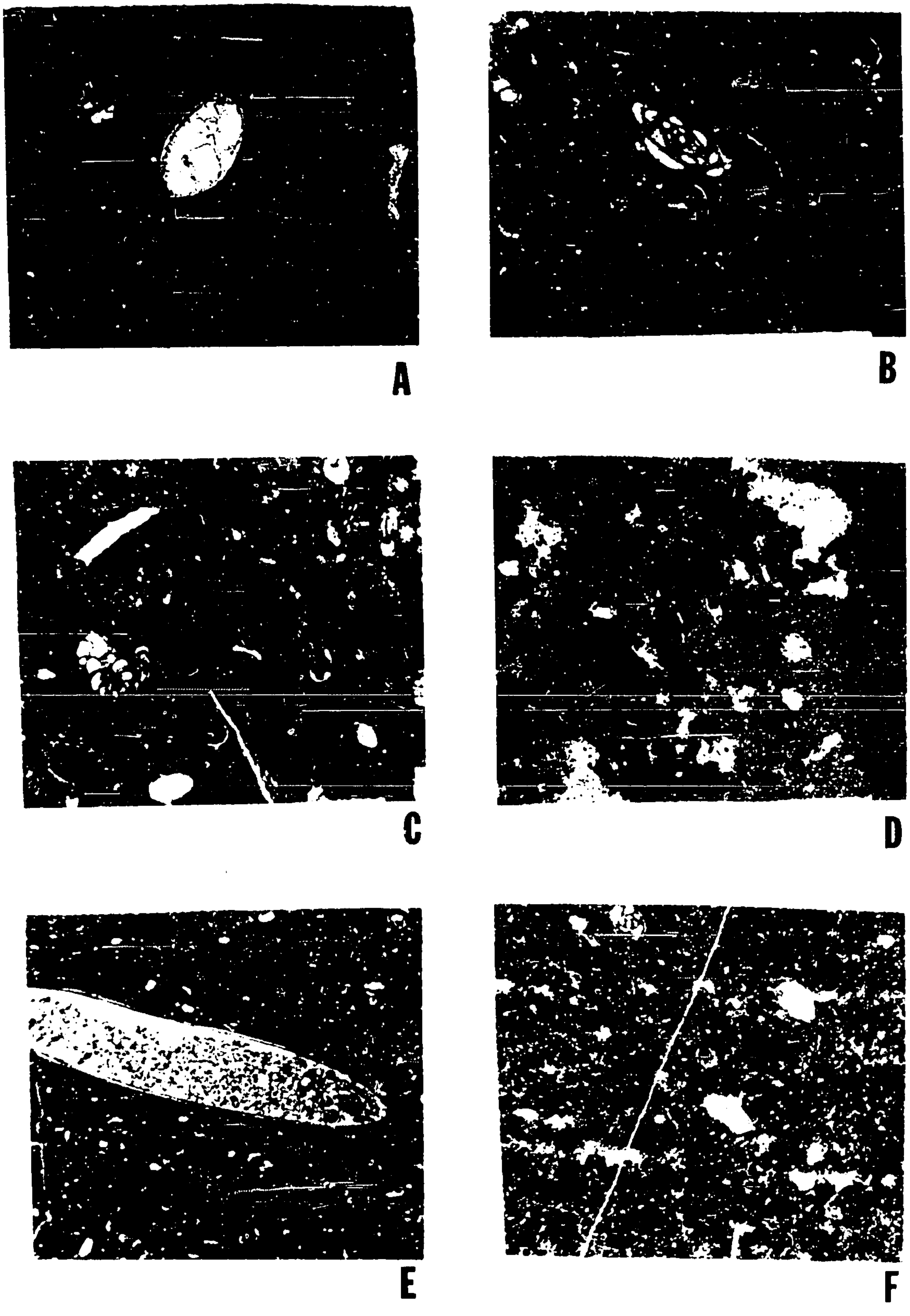
B and C. Miliolid, shell fragment mudstone. Sample CH883. Approximate magnification x30.

D. Recrystallized mudstone. Sample CH886. Approximate magnification x30.

E. Recrystallized mudstone with an oblique section of a serpulid tube. Sample CH887. Approximate magnification x125.

F. Recrystallized, shell fragment mudstone. Sample CH877. Approximate magnification x30.

PLATE 15



Member after the excellent outcrops found along the central part of Potrero del Berrendo, northeast of Cuatro Cienegas, Coahuila. Most probably this lithofacies resulted from deposition in a shallow, protected and restricted euxinic environment.

5.- Evaporite Collapse Breccia Facies

The evaporites are intimately associated with the bituminous, laminated mud facies of the Cupido Formation. It is characterized by the presence of thin gypsum stringers or structural features like contorted bedding, net work structures or collapse breccia that are closely related to the former presence of evaporites. This lithofacies represents an intermediate stage between the calcareous strata of the Cupido Formation and the laterally equivalent evaporitic beds of the La Virgen Formation.

The most characteristic feature of this lithofacies is the presence of collapse breccias resulting from ground water leaching of evaporites. Excellent examples can be seen in Potrero de Oballos and Potrero de Agua Chiquita. The environment of deposition of this facies was a very shallow, restricted, saline environment.

A similar biohermal reef-trend in the subsurface of Louisiana, U. S. A. was described by White and Sawyer (1966, p. 214) at the top of the Sligo Formation (subsurface equivalent to the Cupido Formation in Louisiana and Texas). From there the reef-trend apparently extends in a southwesterly direction along the south flank of the San Marcos Arch and continues across southeastern Texas and into Mexico. Rogers (1967, p. 56) indicates that the position of the platform edge in southeastern Texas is located some miles north of Pescadito dome, Webb County, approximately 40 kilometers northwest of Laredo, Texas.

Drilling by Petroleos Mexicanos has demonstrated that the Cupido reef-trend continues into Mexico. Some of the wells drilled in the northern part of Nuevo Leon (Anahuac #2, Camaron #101, etc.) encountered the rudistid boundstone lithofacies near the top of the Cupido Formation (Appendix D). Further fieldwork by the Northeastern Exploration District of Pemex (Tovar, 1965) indicates that the reef-trend emerges on the surface along the northern end of Sierra de Gomas and continues through the northwestern site of Sierra de Minas Viejas, across the central portion of Sierra del Fraile and to the northern part of Sierra de La Silla near Monterrey. From this point the Cupido reef-trend swings to the west-southwest, passing through the area of Cañon de la Huasteca

6.- Stromatolite Facies

In this lithofacies are included the finely laminated algal stromatolites and closely related structures (birdseyes, mud-cracks, dolomite crusts, gypsum or anhydrite pseudomorphs, etc.) commonly present in these rocks. In general this facies is more common toward the up-dip margin of the shelf where it overlies the basal transgressive units of the Cupido Formation. The depositional site of this facies was probably very shallow marine environments, subjected to periodic aerial exposure along the supratidal and intertidal flats.

7.- Rudistid Boundstone Facies

This facies is characterized by carbonate rocks formed by organically bound rudistids (Caprinuloidea, Toucasia, Monopleura) and associated skeletal, coral and algal components.

The presence of reef-building organisms in this lithofacies indicate a very shallow environment, with clear warm sea waters and vigorous wave and current action. These conditions prevailed along the eastern margin of the platform during most of the Neocomian and Early Aptian and along the interior portions of the platform where isolated rudistid build-ups developed in late Early Aptian.

located along the southern limit of the area studied in this investigation.

According to Diaz (verbal communication), beyond Cañon de la Huasteca, the Cupido reef-trend continues in a southern direction and outcrops in the area of Galeana, Nuevo León. However recent fieldwork by Garcia (1971) suggests that beyond Cañon de la Huasteca, the reef-trend parallels the west - southwest trend of the Sierra Madre Oriental and passes directly south of Saltillo, Coahuila.

The rudistid boundstone facies in the calcareous platform interior, formed near the end of Cupido sedimentation during a time that the platform stabilized and permitted a scanty local development of rudistid bioherms and biostromes. These isolated reefs contrast markedly with the continuous rudistid bioherms along the platform margin. Only in potreros of Oballos and Menchaca are there well developed caprinid bioherms. In the other Cupido sections where the rudistids are present, they are *Toucasia* and *Monopleura* biostromes.

8.- Microcrystalline Mudstone Facies

This distinctive lithofacies of the Cupido Formation outcrops extensively along the eastern limit of the area. It consists of massive-to thick-bedded microcrystalline mudstones, generally associated with chert nodules, well developed stylolites, planktonic foraminifera, radiolarians, ostracods, and calcispherules. In the section measured in the southern flank of Sierra de Minas Viejas (Appendix B) the lower 600 meters of the Cupido Formation have this lithofacies. Other exposures of the microcrystalline mudstones are found in Sierra de Picachos, 75 km. northeast of Monterrey, Nuevo León. (Bishop, 1966) and in the central portion of Sierra de La Silla (Bonet, 1971) 30 km. southeast of Monterrey. In these localities the mocrocrystalline muds range from 400 to 800 meters in thickness.

The environment of deposition of the microcrystalline mudstone facies corresponds to the outer margin of the platform where the high energy processes were subdued and the clay-size carbonate particles transported from the shallow water shelf (Bishop, 1966, p. 334) quietly settled out along with planktonic skeletal constituents.

Spatial Distribution of Lithofacies and Correlation

Sedimentation of the Cupido Formation throughout the Neocomian and Early Aptian, records a complete sequence of carbonate lithofacies (Fig. 30) deposited within a complex array of environments.

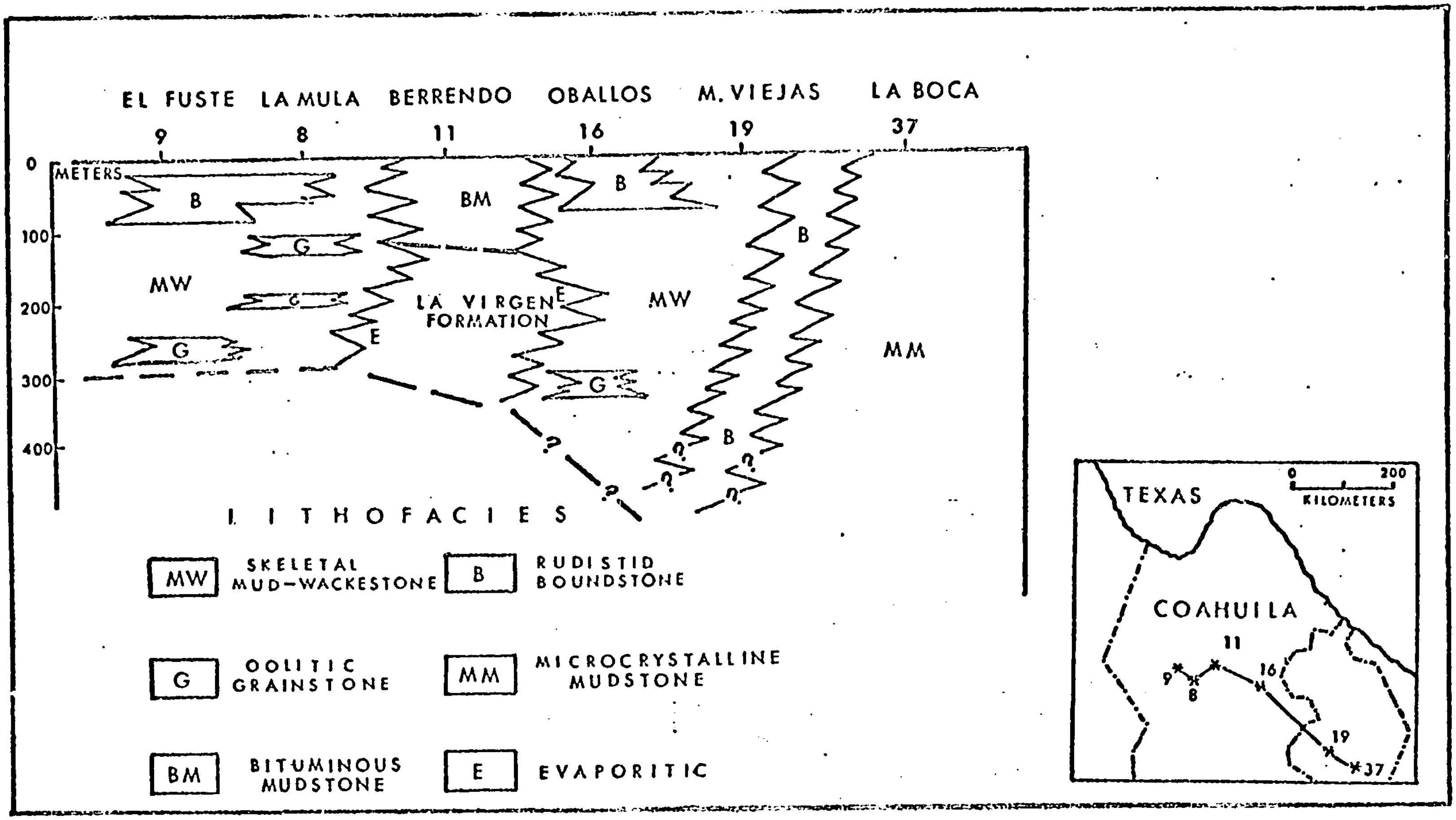


Figure 30: Carbonate lithofacies in the Cupido Formation from Sierra del Fuste to Cañon La Boca.

During the early sedimentation of the Coahuila Series the continental and marginal environments of the shelf were characterized by the deposition of terrigenous sediments; whereas, in the external portion of the basin carbonate muds were deposited in a relatively deep water environment.

Continuous transgression of the sea over the continental highland was accompanied by a correspondant decrease of clastic sediments brought into the basin and by an onlap of the basal transgressive lithofacies of the Cupido Formation over the underlying terrigenous and argillaceous sediments.

Near the end of the Coahuilan sedimentation, the numerous carbonate lithofacies of the Cupido were widely distributed over an extensive carbonate platform. In the shallow, open environments of the platform, which was continuously agitated by mechanical processes, oolite grainstones and packstones were deposited. Seaward, in the more protective environments, sediments were characterized by skeletal mudstones and wackestones. The complex vertical and spatial distribution of the grain-supported and mud-supported carbonates of the Cupido Formation suggest that the overall transgression of the sea was interrupted by periods of local regressions (Smith, 1970, p. 31), probably resulted from a variety of factors, like tidal flat progradations, eustatic variation or tectonic instability of the platform.

In the shallow outer margin of the platform currents and waves brought nutrients that promoted the development of rudistid bioherms. A delicate balance between the organic productivity of these colonies and the rate of subsidence along the platform margin induced a continuous porgradation of the reefs over the microcrystalline mudstones deposited in the deeper, external basin (Plates 18 and 19). This type of progradational reef-growth is similar to the Comanchean prograding reef-trend studied by Smith (1971) and Bloxsom (1972) in the northern part of Coahuila.

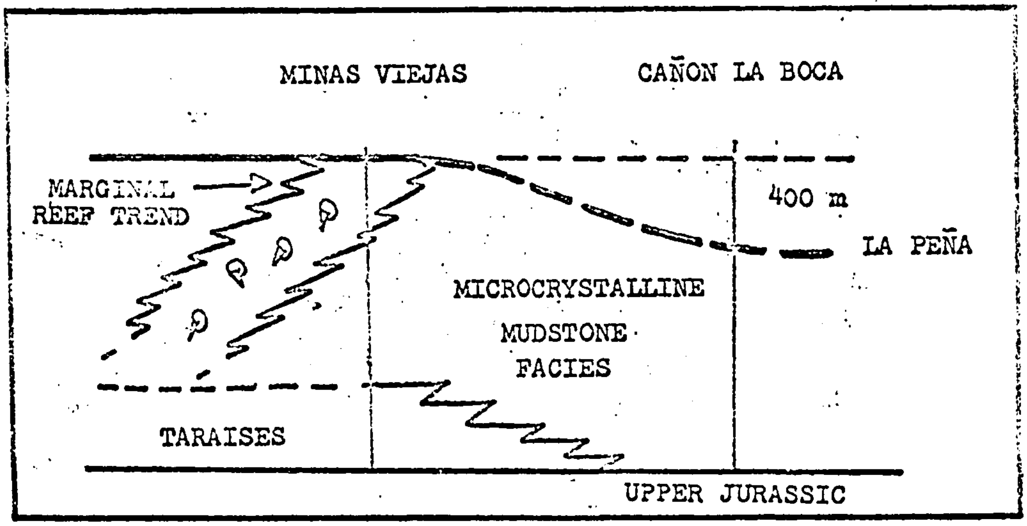


Figure 31: Diagrammatic stratigraphic cross-section of the Cupido Formation.

A difference of 400 meters in thickness between the shallow water platform facies and the deeper basinal facies (Fig. 31) suggest that the rates of deposition along the platform were greater than in the basin. This figure may also be a good approximation of the relief of the Cupido carbonate platform at the end of the Early Aptian.

Shallow restricted saline environments developed along the interior portion of the platform in response to slower rates of subsidence, together with climatological and hydrological conditions resulted in the deposition of evaporites and highly organic mudstones. Restriction was probably related to the formation of local rudistid bioherms, oolitic shoals or local islands that isolated the interior part of the platform. This arrangement is remarkably similar to the condition existed during the development of the Middle Albian McKnight Formation (Smith, 1971, p. 101) in the central portion of the Maverick Basin.

HISTORICAL DEVELOPMENT OF THE COAHUILA SERIES

General Statement

During the Late Jurassic the paleogeography of northern Mexico was dominated by the Coahuila and Tamaulipas peninsulas (Fig. 32). These continental elements were the southern extension of stable interior portions of North America. A continuous extension of the Coahuila Peninsula during this time is well supported by the available stratigraphic information. However, well data in the area occupied by the Tamaulipas Peninsula suggests that this land mass was breached along the present northern portion of the State of Nuevo Leon.

Sedimentation of the Coahuila Series is characterized by three different phases or stages of deposition. During the initial phase at the beginning of the Neocomian (Berriasian to Early Hauterivian) great volumes of arkosic sediments were deposited from the continental highlands. The intermediate phase, which would include approximately the time interval between Late Hauterivian to Late Barremian, is marked by the deposition of a thick sequence of evaporites in the interior portion of the Sabinas Basin. The last stage, covering most of the Early Aptian, displays a regional encroachment and transgression of the Lower Cretaceous seas over the land masses, as well as the development of a very extensive

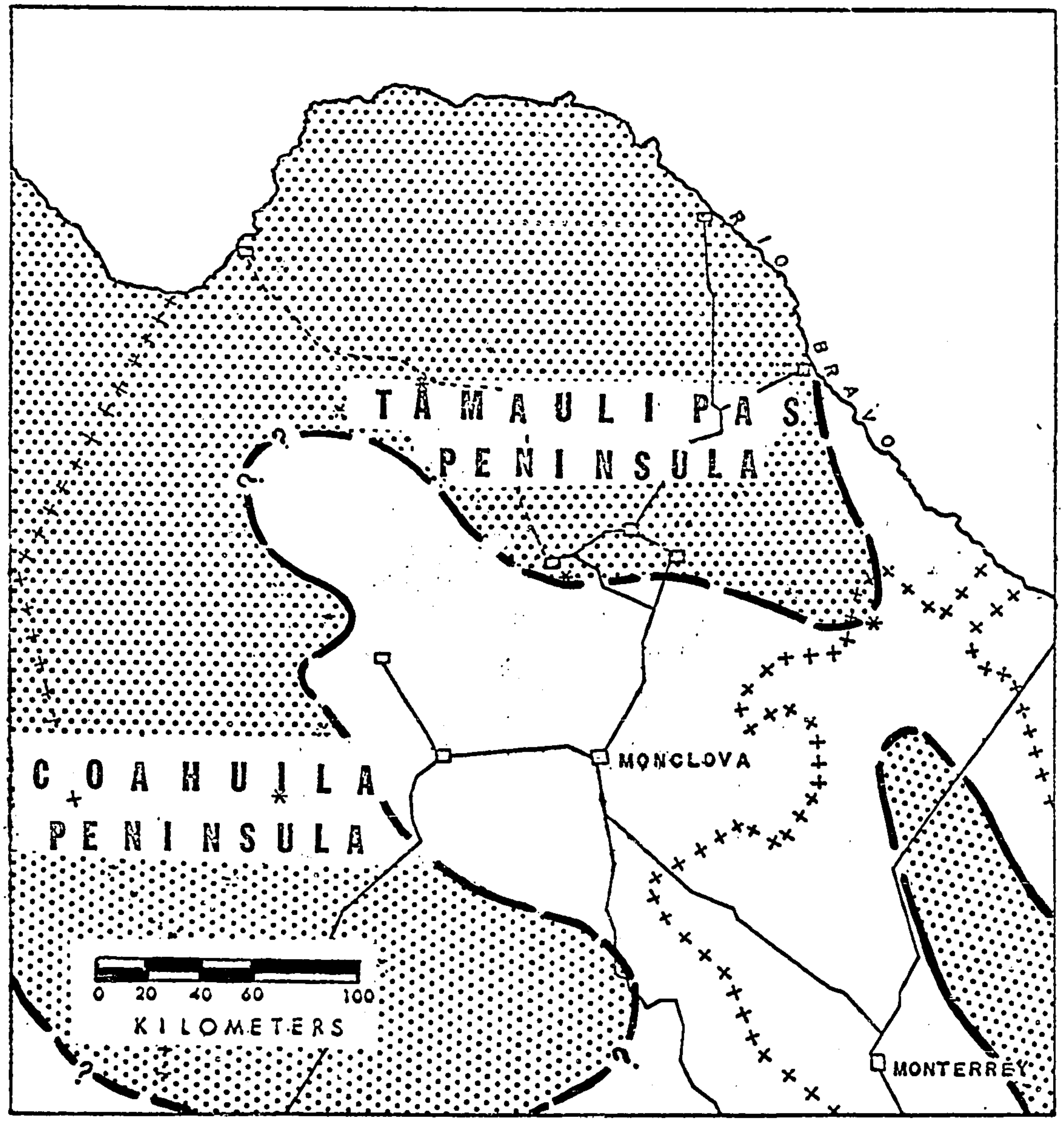


Figure 32: Paleogeographic map of northern Mexico during Late Jurassic.

carbonate platform.

Initial Phase of the Coahuila Series

After the deposition of the marls and limestones of the Menchaca Formation in the interior portions of the Sabinas Basin during Late Jurassic and Early Cretaceous, the Coahuila Peninsula was subjected to an episode of tectonic disturbance characterized by the appearance of normal faulting and uplift along its margins. Rapid erosion of the Coahuila fault blocks produced the thick volume of arkosic conglomerates and conglomeratic sandstones of the San Marcos Arkose. These sediments were rapidly deposited in the stream channels and piedmont alluvial fans. Paleogeographic conditions and distribution of the coarse clastic sediments (Fig. 33) indicates that the source areas were the Tamaulipas Peninsula (Texas Craton) to the north and the southern part of the Coahuila Peninsula to the south.

Altough sedimentation was uninterrupted in the basin from the Late Jurassic to Early Cretaceous, the wedge of the San Marcos Arkose that overlies the Menchaca Formation, suggests the appearance of a local regression of the sea at the beginning of the Neocomian. As the influx of coarse clastic debris decreased during the Late Valanginian to the Early

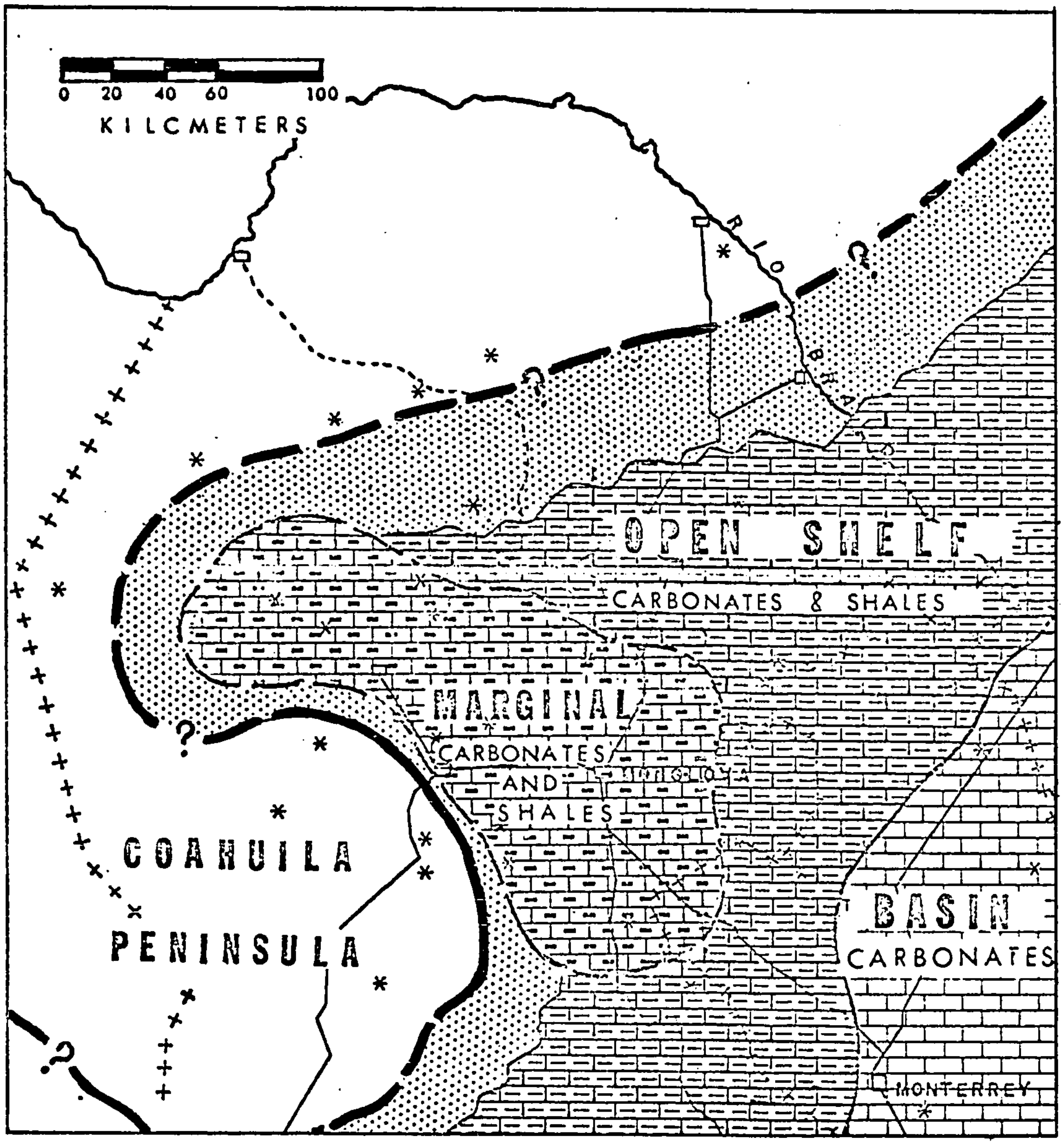


Figure 33: Paleogeography and environments of deposition of the Coahuila Series from Berriasian to Early Hauterivian stage (Menchaca Formation, San Marcos Arkose, Barril Viejo Formation and Lower Cupido Formation).

Hauterivian, the sea again transgressed the adjacent land masses, leading to deposition of the highly fossiliferous shales and marls of the Barril Viejo Formation. During this time, a good percentage of the fine silt and clay fractions suspended in the water was transported by the prevailing marginal cuurents into the external parts of the basin and deposited together with the calcareous sediments of the Taraises Formation; however, the outer portion of the shelf was characterized by a continuous deposition of the relatively deeper water microcrystalline mudstones of the lower Cupido Formation.

Intermediate Phase of the Coahuila Series

The beginning of this phase is marked by a period of temporary tectonic stability of the basin, followed by the deposition of the limestones and marls of the Sacramento Formation. This stability was interrupted by a renewed epeirogenic uplift along the southern end of the Coahuila Peninsula accompanied by the deposition of coarse terrigenous clastics of the Patula Arkose along an easterly oriented (Fig. 34) progradational deltaic wedge. During this time, the fine silt and clay that by-passed the depositional site of the continental and litoral coarse clastic debris were transported into the interior environments of the open shelf

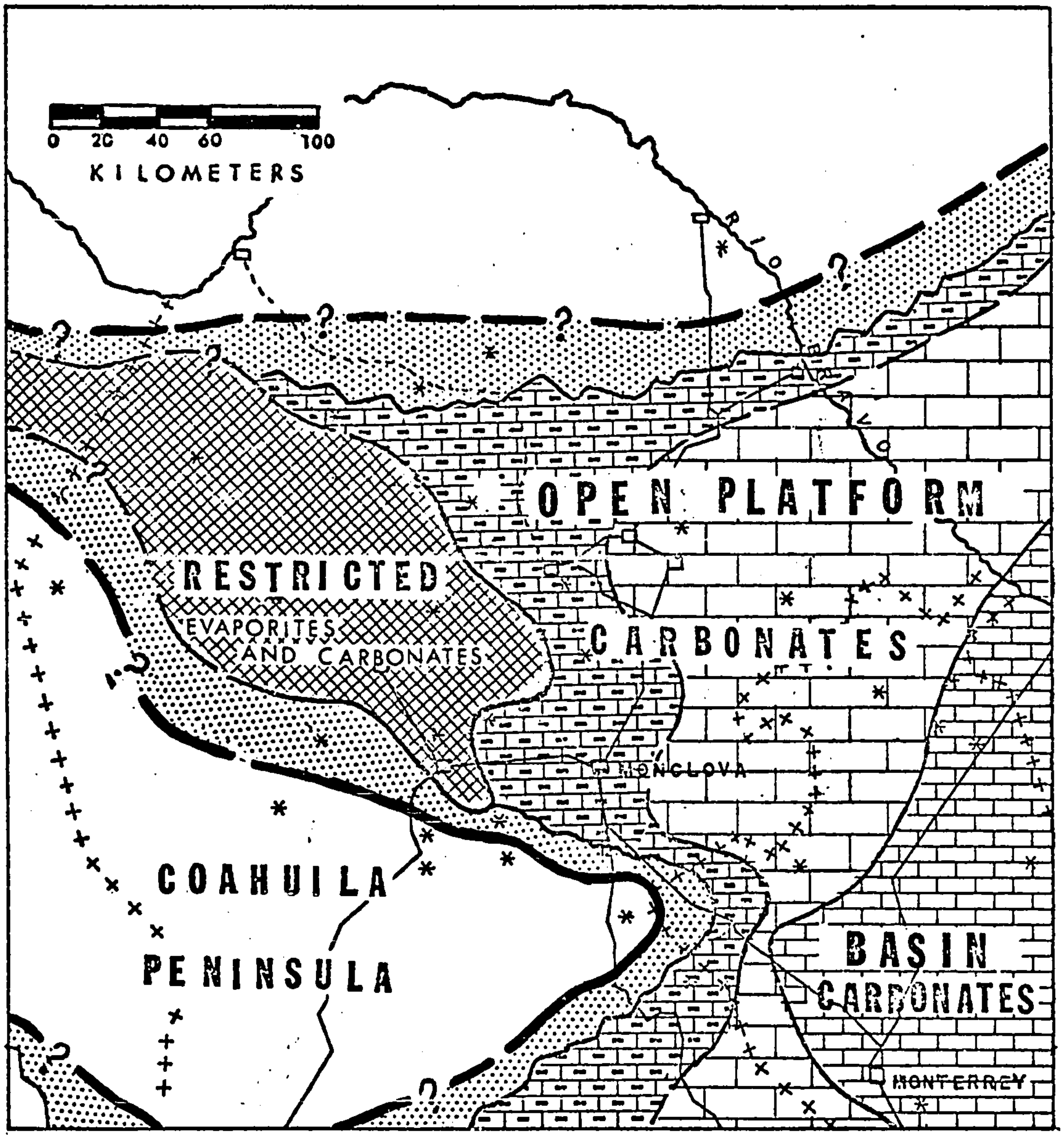


Figure 34: Paleogeographic map and environments of deposition of the Coahuila Series during the Barremian stage (Sacramento Formation, Patula Arkose, La Virgen Formation, La Mula Formation and Upper Cupido Formation).

to form the argillaceous sediments of the La Mula Formation.

In this stage the central part of the Coahuila Peninsula was breached leaving the southern end as an island (Fig. 34). Appearance of local shoals or barriers along the western litoral margin of the basin, together with suitable climatological and hydrological conditions were responsible for the development of restricted, saline environments leading to the deposition of La Virgen evaporites and related carbonates in the marginal lagoons, and on the marine and continental sabkha-type environments of deposition.

During this stage, the external portions of the basin continued to be characterized by deposition of the deep water microcrystalline mudstone lithofacies of the Cupido Formation.

Final Depositional Phase of the Coahuila Series

In this stage the continuous transgression of the sea completely covered the middle part of the ancestral Coahuila Peninsula (Fig. 35). The shore line over the Texas Platform moved farther north, maintaining parallelism with the previous Late Neocomian position.

Although terrigenous sediments were still derived from

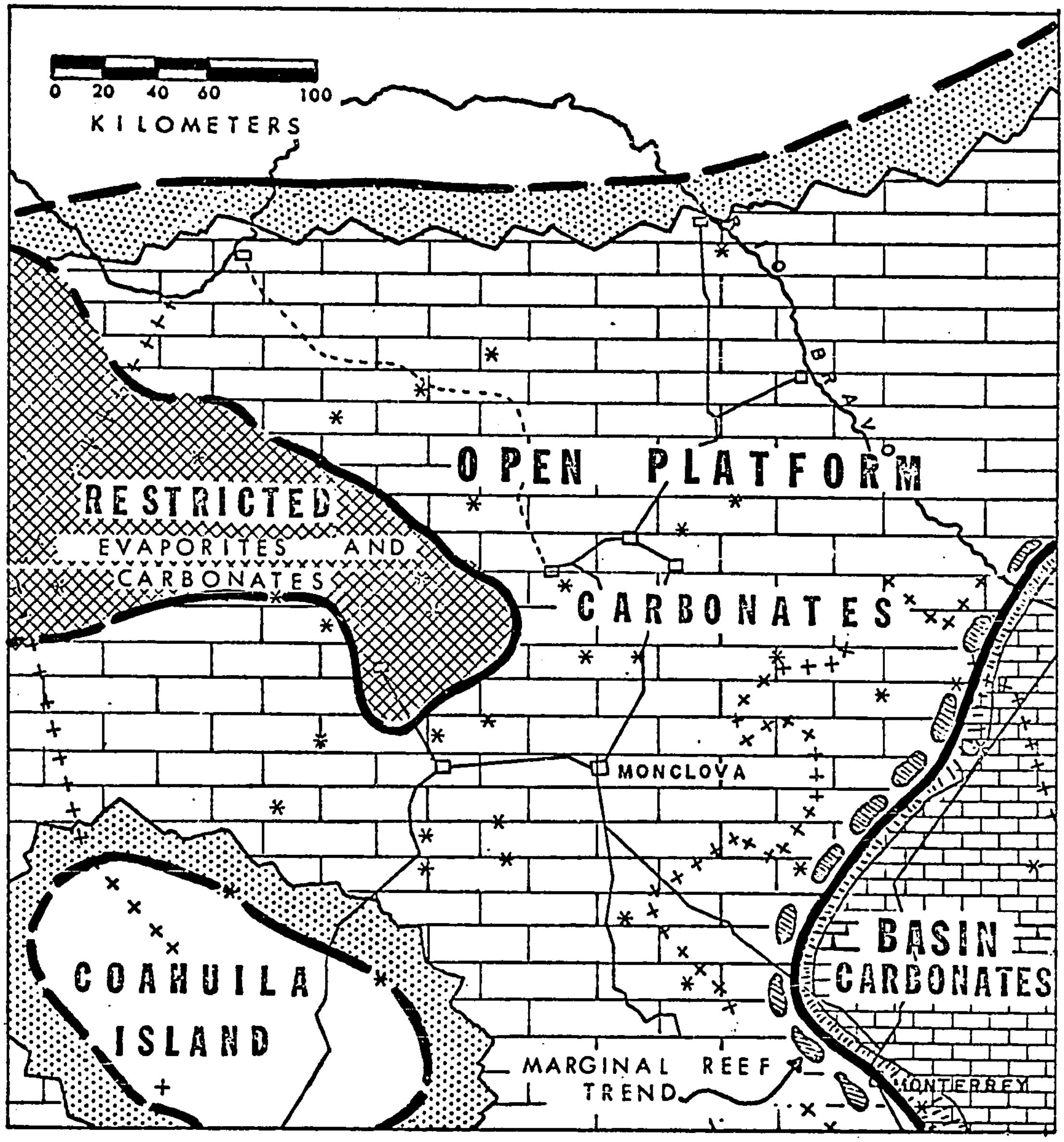


Figure 35: Paleogeographic map and environments of deposition of the Coahuila Series during Early Aptian (La Virgen and Upper Cupido Formation).

the land masses during the early portion of this phase, most of the sedimentary sequence consists of thick carbonate rocks included in the Cupido Formation. These sediments were deposited along the extensive calcareous platform developed in northern Mexico during Early Aptian. The numerous lithofacies members of the Cupido deposited on the platform consists of basal transgressive dolomitic sands, and supratidal dolomites, overlain by a complex interfingering array of bioclastic, oolitic grainstones and packstones deposited in the open high energy environments of the platform and shell fragment, miliolid mudstones to wackestones, which originated in more protective environments shielded from strong wave and current processes.

In the eastern margin of the platform (Fig. 35), clear, shallow, agitated waters promoted the development of a continuous reef-trend. A delicate balance between the rate of subsidence of the platform margin and the organic productivity of the rudistid bioherms produced a continuous progradation of the reef banks over the microcrystalline mudstones of the Cupido Formation deposited in the deeper external basin. Differences in thickness between the shallow carbonates of the platform and the deeper water mudstones of the basin suggest that the bathymetric difference between them was close to 400 meters.

In the landward interior margin of the shelf, the hydrological and climatological conditions were more drastic than in the previous stages, and deposition of La Virgen evaporites extended over a larger area (Fig. 35). In some portions of these environments, restricted euxinic conditions in the marginal lagoons led to the deposition of highly organic bituminous mudstones, which are recognized as an independent lithofacies unit (El Berrendo Member) of the Cupido Formation.

GENERALIZED LITHOFACIES DISTRIBUTION OF THE COAHUILA SERIES

Throughout Early Neocomian, the ancestral Gulf of Mexico transgressed very rapidly over the Pre-Cretaceous physiographic elements then present in northern Mexico. Near the end of the Coahuilan sedimentation, the Tamaulipas Peninsula was completely covered by the sea, and the southern extension of the Coahuila Peninsula was breached along the middle portion leaving the southernmost end of it as an isolated island. During the deposition of the Coahuila Series, the Sabinas Basin was subject to constant rapid subsidence, where close to 2200 meters of continental and marine sediments accummulated (Fig. 36) in the central portion of the basin.

Large volumes of coarse, arkosic sediments derived from the Texas Craton to the north and from the Coahuila Island in the south (Figs. 37 and 38) were rapidly deposited in alluvial fans and spread out on the marginal alluvial plains by fluvial currents. A considerable volume of the terrigenous sediments were also transported eastward by fluvial currents to form the striking progradational deltaic wedge south of Monclova (Figs. 39 and 40). Although quite speculative, Smith (1971, p. 75) estimates that the topographic relief of the continental highlands was between 500 and 600 meters in the Texas Craton

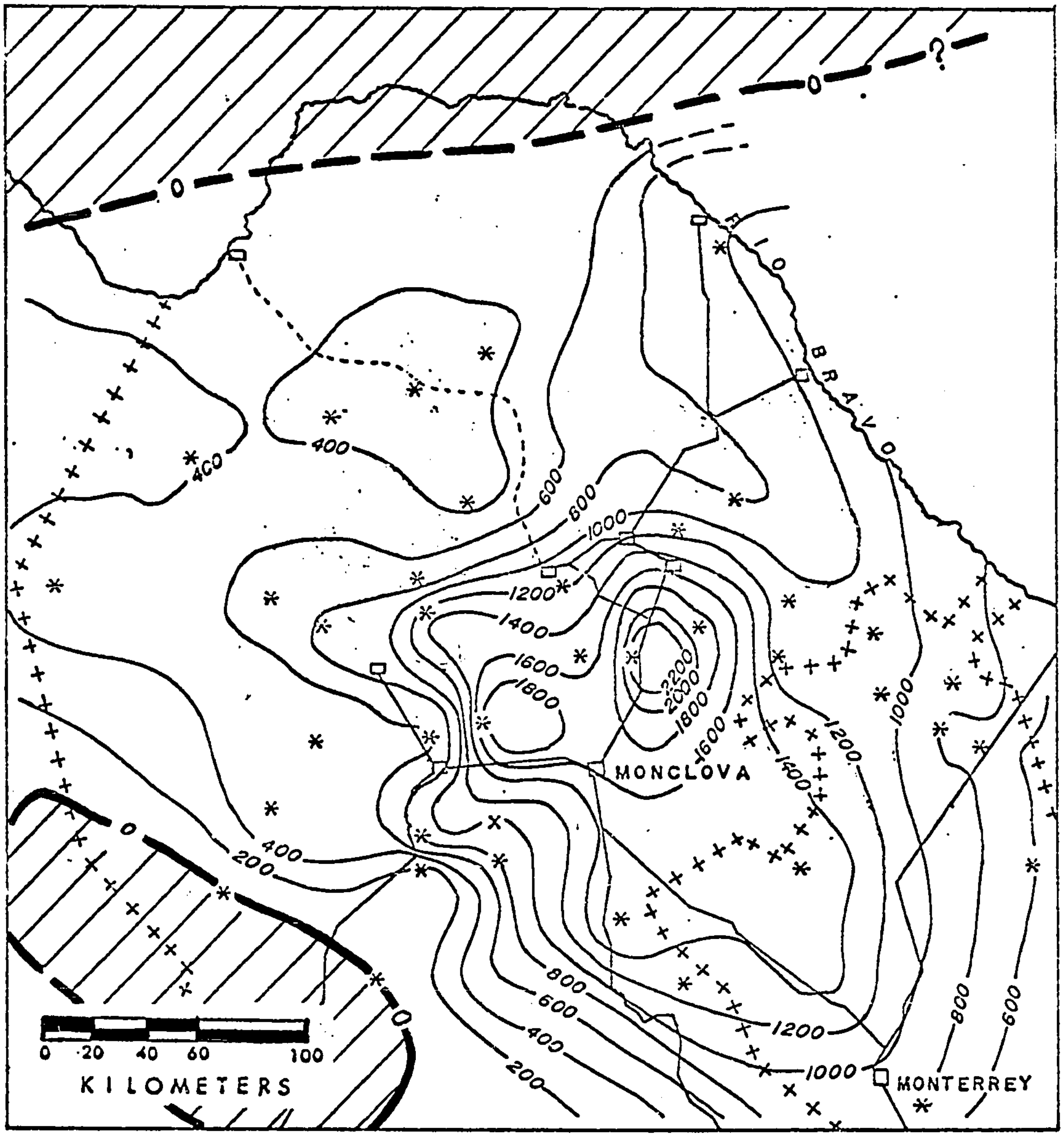


Figure 36: Isopach map of the Coahuila Series. The ruled area in the north correspond to the Texas Craton and in the south to the pre-Mesozoic igneous and metamorphic rocks of the Coahuila Island.

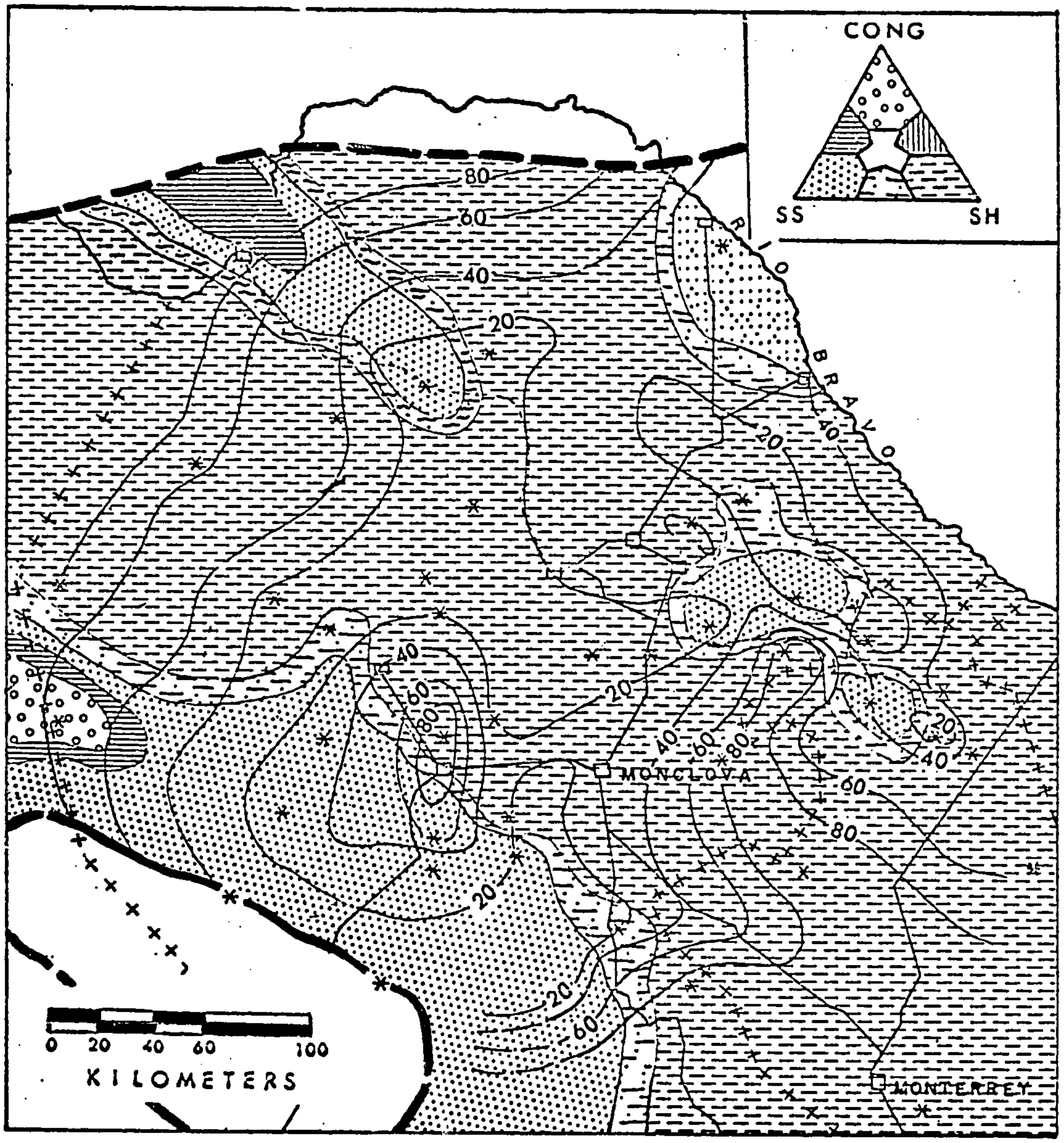


Figure 37: Pelto's D-Function map of the terrigenous sediments in the Coahuila Series. Contours represent differences in the degree of mixing of the components (Sand, Shale and Conglomerate) present in the sections.

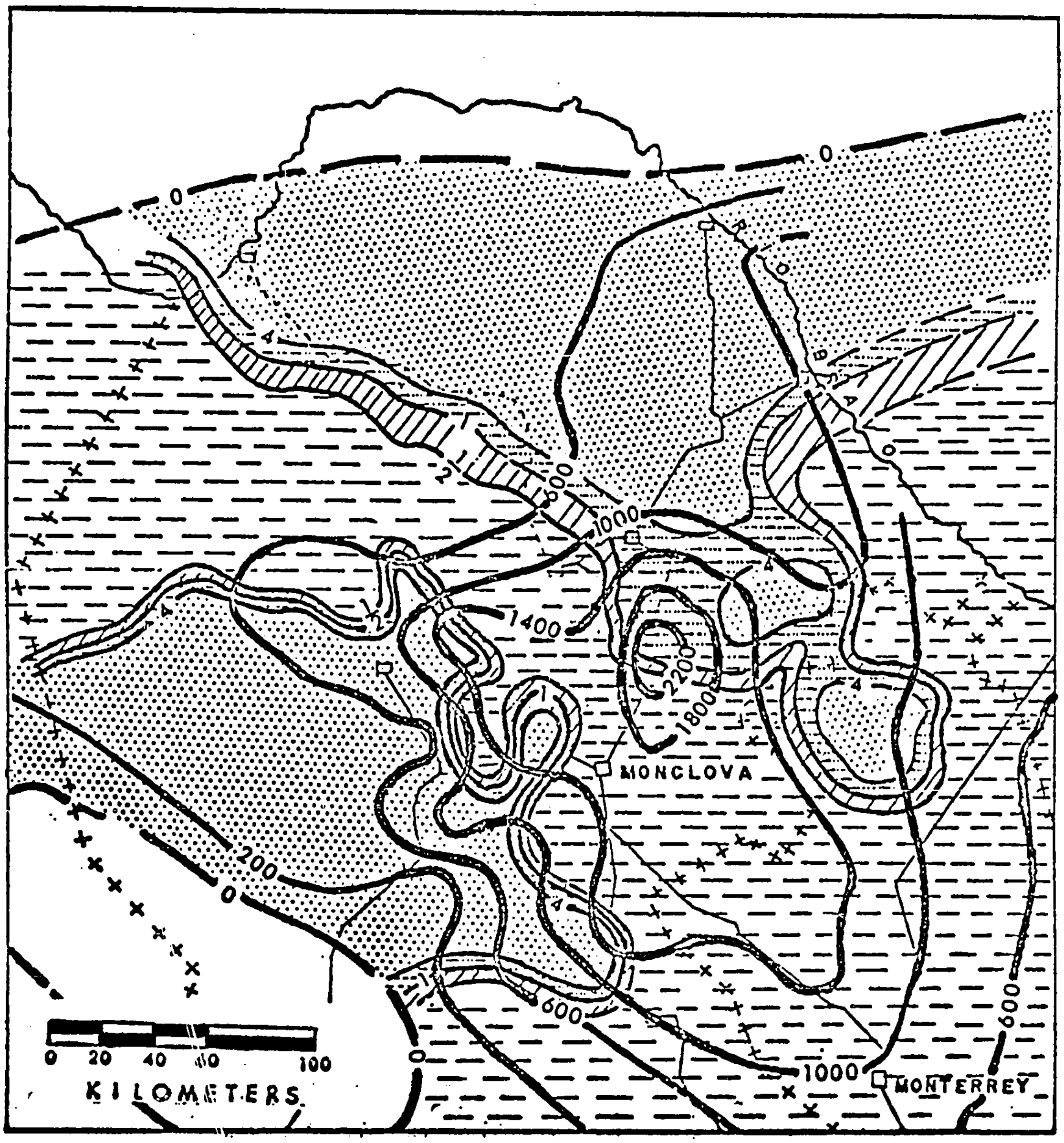


Figure 38: Isopach and sandstone-shale ratio map of the Coahuila Series.

800 isopach.

4 sandstone-shale ratio.

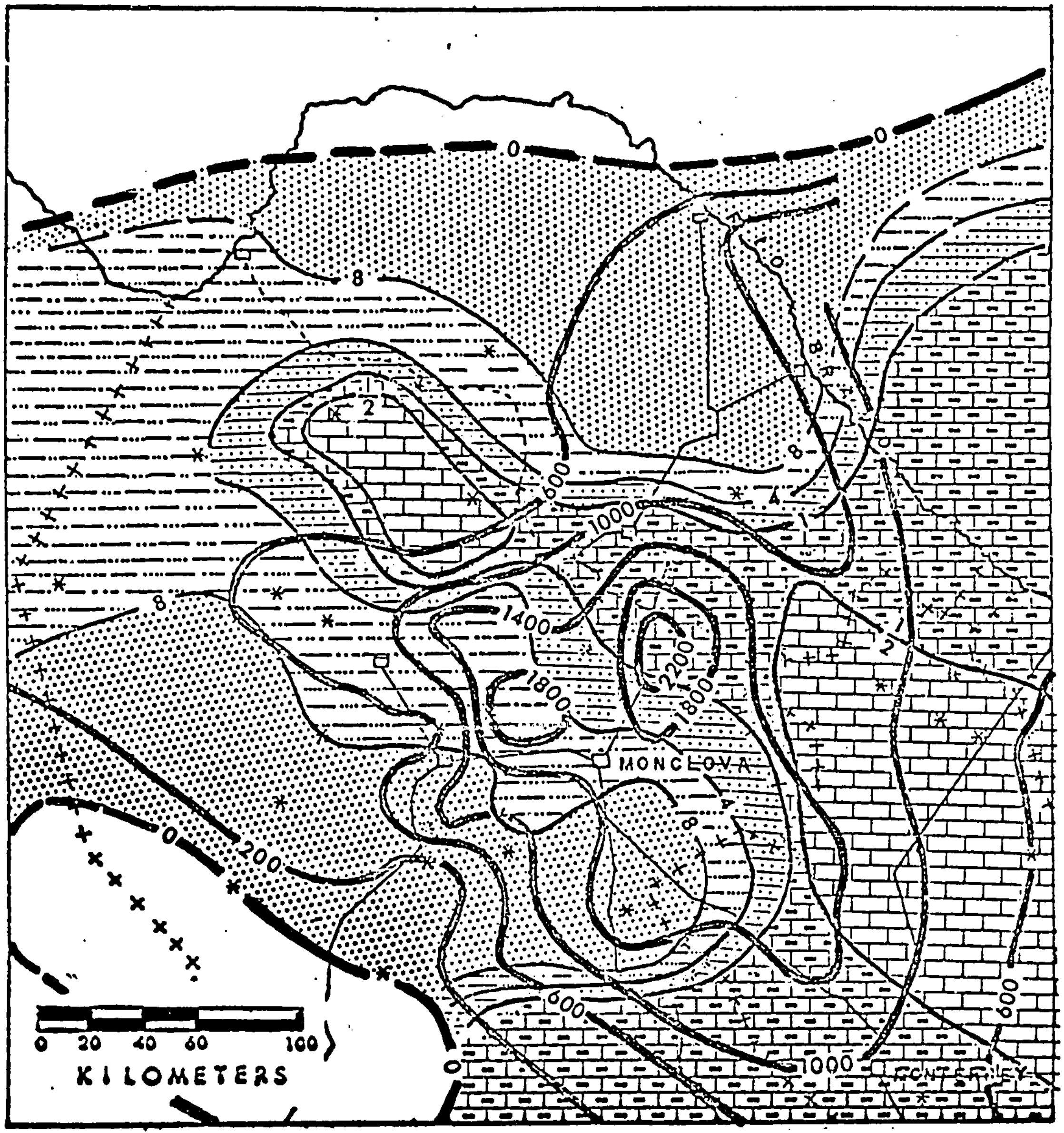


Figure 39: Isopach and clastic ratio map $(\frac{\text{Sand+Shale}}{\text{Lst+Dol+Gypsum}})$ of the Coahuila Series.

600 isopach.

4 clastic ratio.

and 300 to 400 meters in the southern end of the Coahuila Peninsula.

The finer silt and clay clastic sediments derived from the land masses by-passed the coarse apron of terrigenous arkoses and were transported into the epineritic environment of the basin (Fig. 41); however, a large percentage of the clays, kept in suspension longer were transported to the external edge of the shelf.

On the western interior portion of the shelf, slow rates of subsidence and the development of shoals or barrier islands, which practically isolated the marginal environments, led to the deposition of a thick sequence of evaporites (Fig. 41) and related sediments along the restricted lagoons and continental and marine sabkha-type environments.

Contrasted to the numerous lithofacies formed on the western side of the basin, the eastern side was characterized by a constant deposition of carbonate sediments (Figs. 39, 40 and 41) along a very extensive calcareous platform that began to form during Early Neocomian. On the shallow portions of the open platform the sediments consist of a complex framework of grain-supported oolitic, shell fragment, intraclast grainstones and packstones, and shell fragment, miliolid mudstones and wackestones deposited in the more protective

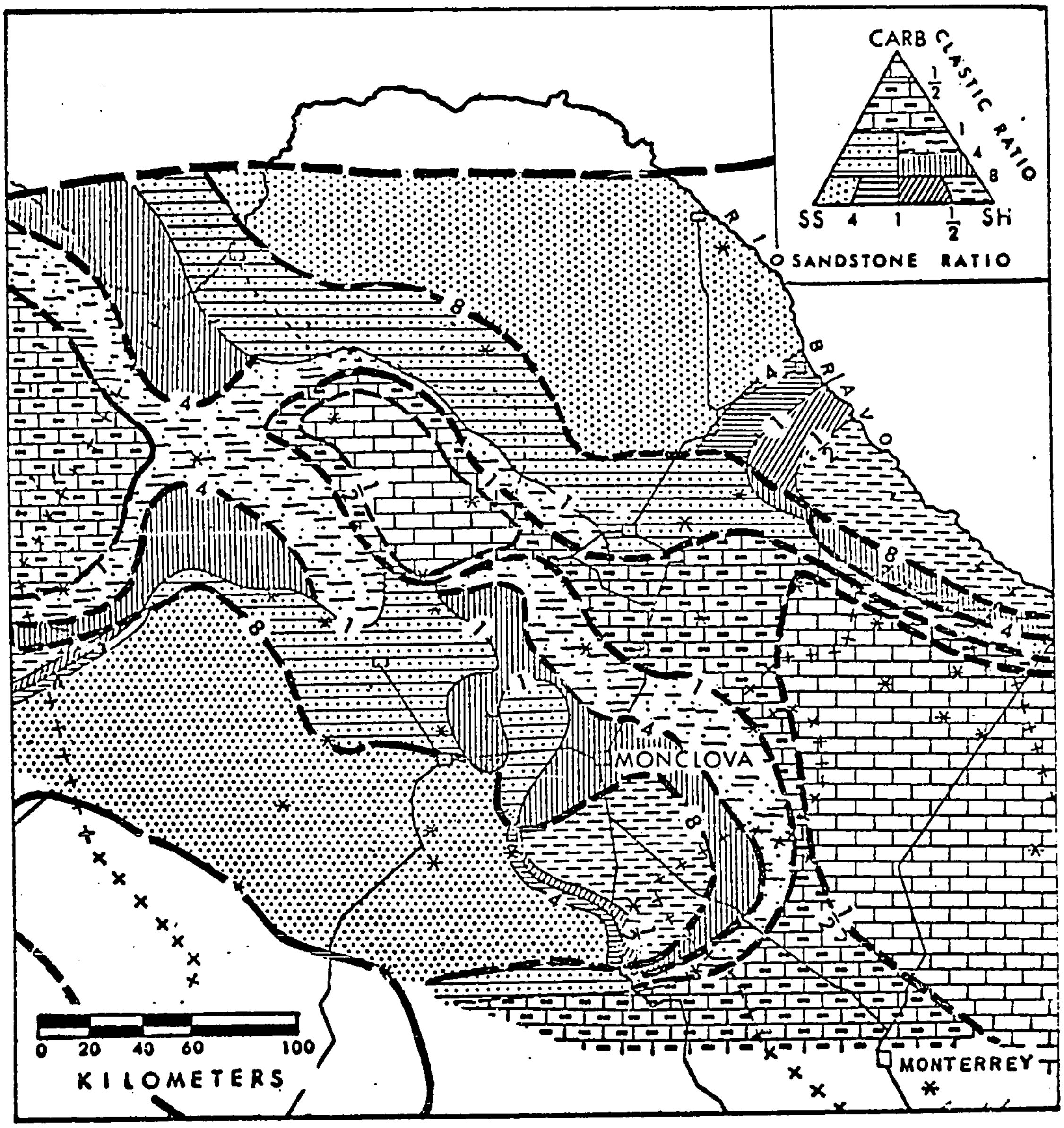


Figure 40: Clastic and sandstone-shale ratio map of the Coahuila Series.

▬ ▬ 4 ▬ ▬ clastic ratio

— 1 — sandstone-shale ratio

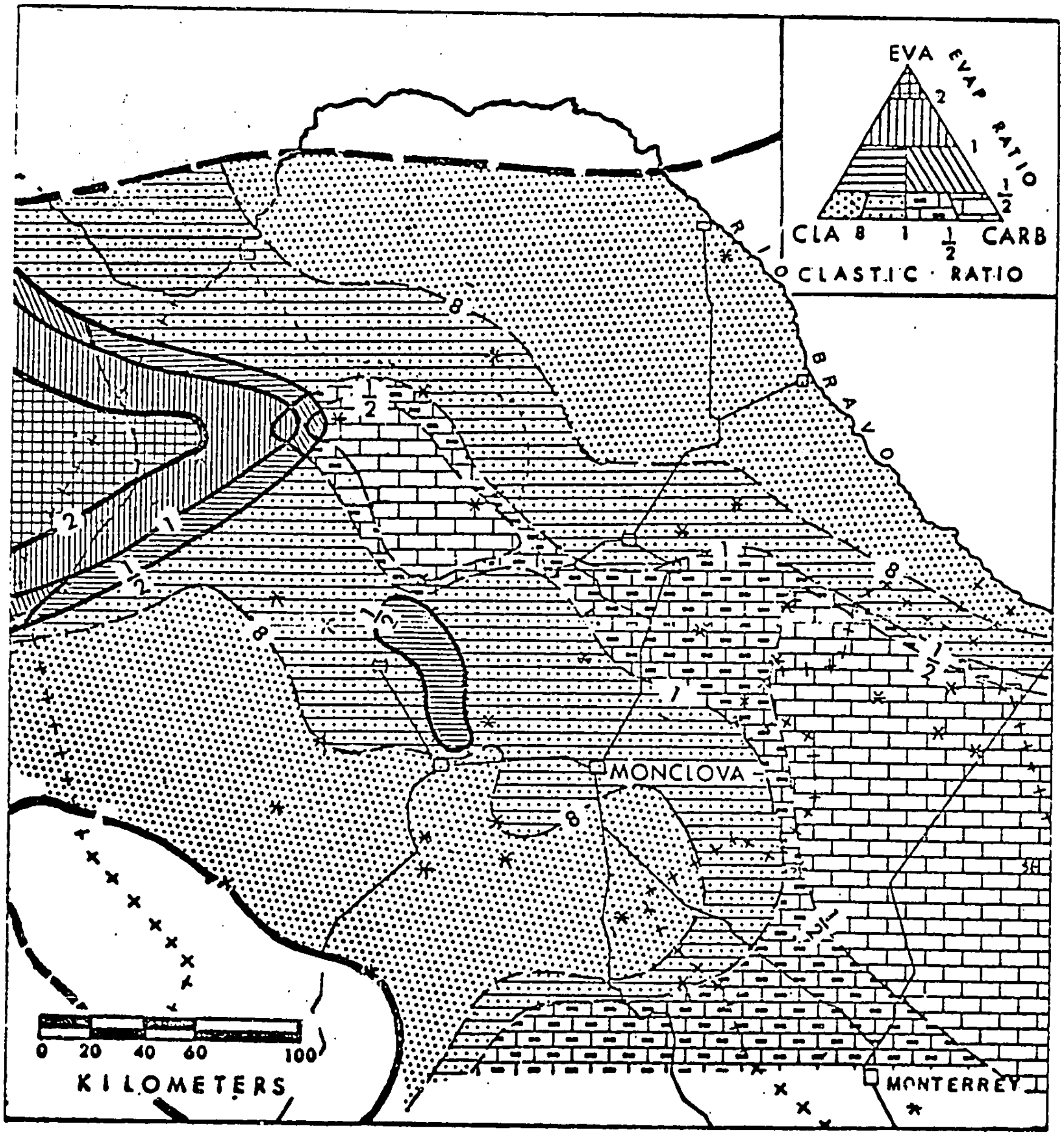
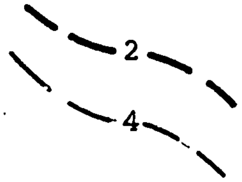


Figure 41: Clastic and evaporite ratio map ($\frac{\text{Gypsum}}{\text{Lst+Dol+Sand}}$) of the Coahuila Series.



evaporite ratio

clastic ratio

sites. Along the platform margin, the higher energy processes strongly oxygenated the waters and brought great amounts of nutrients that contributed to the development of rudistid bioherms and other symbiotic organisms. By the end of Early Aptian these rudistid colonies were forming a continuous marginal reef-trend, which prograded over the microcrystalline mudstones deposited in the contiguous oceanic basin.

ECONOMIC IMPORTANCE OF THE COAHUILA SERIES

The hydrocarbon potential of the Coahuila Series is directly related to the presence of hydrocarbon source beds, the tectonic history of the region, the distribution of lithofacies and the diagenetic properties of the sediments.

Units considered as suitable hydrocarbon source beds have been identified in several formations of northern Mexico. The Late Jurassic bituminous shale of the La Casita Group, cropping out in the Monterrey area, is an example. Other sediments with the same attributes have been identified in the La Peña Formation and in the McKnight Formation described by Smith (1970, p. 87) in northern Coahuila. In the Neocomian and Early Aptian section, the units considered to be potential source beds are the middle part of the Menchaca Formation, some shale beds of the La Mula Formation, and the highly bituminous micrites of the El Berrendo Member (Cupido Formation) in Sierra del Berrendo and Potrero de Padilla.

The history of the Sabinas Basin is that of a very extensive region subjected to a constant subsidence since the Late Jurassic and through all the Cretaceous Period. Under these circumstances it is possible that some of the highly organic sediments deposited in the basin were placed in the proper conditions of temperature and pressure to initiate the formation of early hydrocarbons even before the areas were strongly affected by the Laramide Orogeny during the Late Cretaceous and Early Tertiary. After the first hydrocarbons were formed, compaction of the sediments caused them to either migrate back to the surface or to accummulate in suitable stratigraphic or structural traps (Fig. 42-A). These traps were affected by many factors, mainly the variability of porosity in the lithofacies framework of the Coahuila Series.

Later folding, fracturing and erosion of the Coahuila Series complicated substantially the original picture of hydrocarbon distribution (Fig. 42-B). Intense Laramide folding in northern Mexico, followed by breaching of the anticlines has left the most resistant but highly fractured limestones of the Cupido Formation in the higher parts of these structures. The hydrocarbons previously accummulated in this unit have been flushed by meteoric waters (Fig. 42-C) except those areas isolated by stratigraphic or tectonic features that act as barriers for the movement of ground water within the sediments.

Stratigraphically influenced barriers are present in the area that corresponds to the depositional site of the La Mula, Barril Viejo and Menchaca formations. These argillaceous units act as a seal for the rest of the formations below. The results obtained in the well Buena Suerte #1

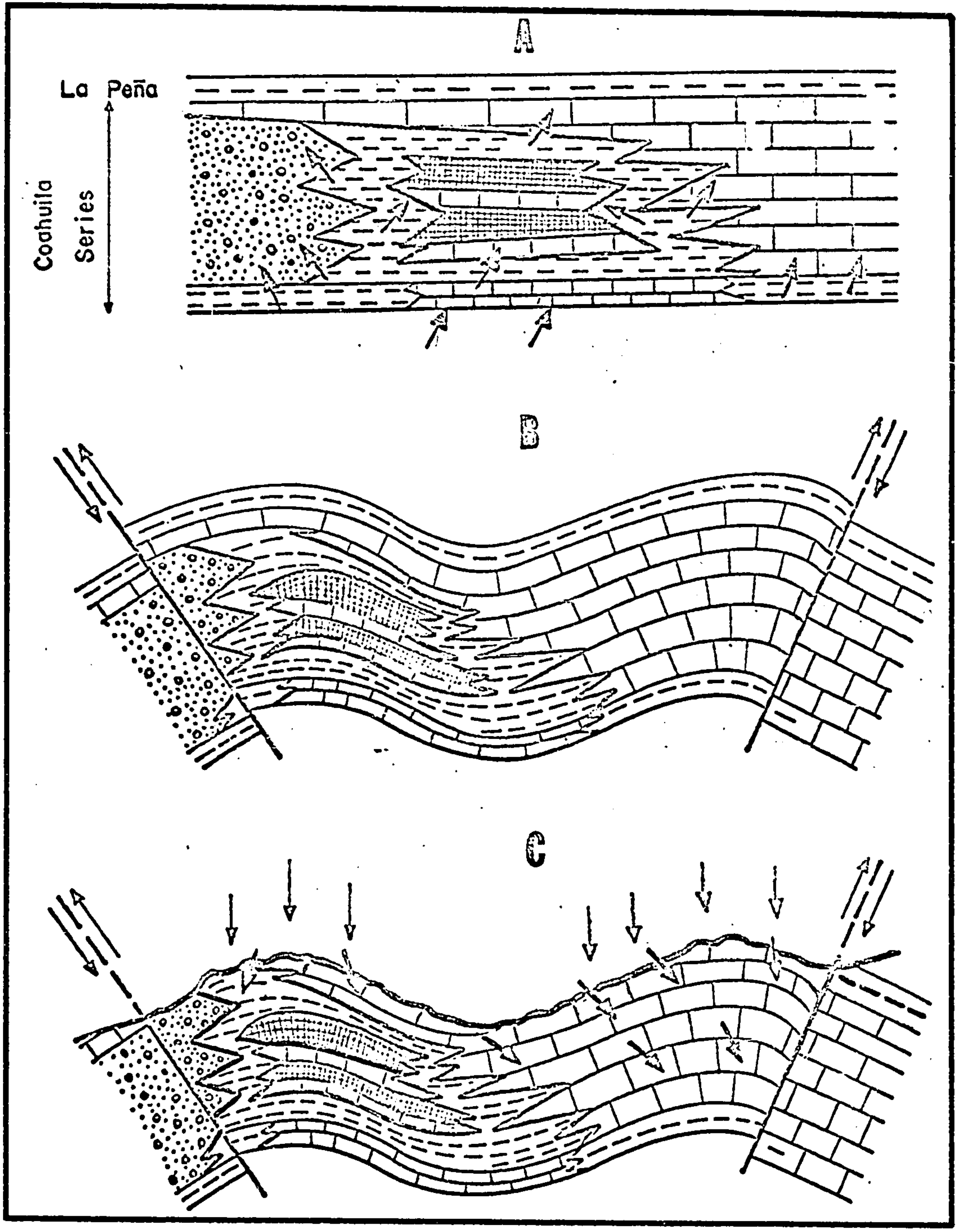


Figure 42: History of migration of hydrocarbons in the Coahuila Series.

A. Early migration of hydrocarbons.

B. Entrapment of hydrocarbons after the Laramide deformation.

C. Leaching and final entrapment.

drilled by Pemex, northwest of Monclova, support this interpretation, since drilling reported traces of oil in some calcareous intervals of the La Virgen and Menchaca formations.

An area apparently isolated by tectonic conditions is the northeastern corner of the State of Coahuila where the presence of high angle reverse faults has prevented flushing of hydrocarbons by water migrating from west to east through the limestones of the Coahuila Marginal Folded Belt to the south. Several Pemex wells drilled in the northern block showed indications of hydrocarbons in the fractured limestones of the Cupido Formation; whereas, wells drilled on the southern flank of the fault blocks contained no hydrocarbons.

Under these circumstances, future exploration for oil in the Coahuila Series of northern Mexico should be oriented toward the following regions.

1.- The central portion of the Sabinas Basin which includes the depositional site of the impermeable shales of the La Mula Formation and other argillaceous units like the Barril Viejo and Menchaca formations. All these sediments act as protective seals that prevent flushing of porous carbonates below.

Since the shales of the La Mula Formation grade into the evaporites of La Virgen Formation, it is important to consider the last unit a prime target for future oil exploration, specially the porous, oolitic grainstones, mudstones and dolomites, interbedded with protective seals of gypsum intervals.

2.- The second prime area for petroleum explorations is the northeastern corner of Coahuila, where high angle reverse faults may provide a barrier to ground water migration. The rocks of interest in this area correspond to the grain supported calcareous skeletal mud/wackestone and rudistid boundstone lithofacies of the Cupido Formation.

CONCLUSIONS

Preliminary stratigraphic investigation of the Early Cretaceous Coahuila Series in northern Mexico provides the necessary information leading to a better understanding of the spatial and geographic distribution of these sediments, their tectonic history and economic petroleum potential.

The sediments of the Coahuila Series consist of a complex interfingering array of continental and marine lithofacies deposited in a typical intracratonic basin. The lithologic character and stratigraphic distribution of the series are a response to the tectonic conditions prevailing in the basin, and to the variability of the biological and physical processes present in the environments of deposition. The most important events recorded during the Coahuilan sedimentation are as follows:

(1) Epeirogenic uplift of the Coahuila Peninsula followed by a local regression of the sea and the deposition of a thick arkosic wedge (San Marcos Arkose as an offlap sequence over the Menchaca Formation).

(2) Transgression and onlap of the arkosic debris by shallow water shales and limestones (Barril Viejo and Sacramento formations).

(3) Continuous subsidence and breaching of the middle part of the Coahuila Peninsula and deposition of evaporites in the western margin of the shelf (La Virgen Formation) grading basinward into shallow argillaceous sediments (La Mula Formation) and then into deeper water limestones (Lower Cupido Formation). During this time local epeirogenic uplift of the southern end of the Coahuila Peninsula led to the development of an easterly oriented clastic wedge (Patula Arkose).

(4) Continuous transgression and subsidence with a progressive onlap of the underlying sediments by shallow water limestones (Upper Cupido Formation), and progradation of the rudistid reef-trend in the platform edge over deeper water limestones.

Coahuilan sedimentation came to an end when a reginal epeirogenic uplift (or an eustatic change in the sea level) was followed by the widespread deposition of the argillaceous sediments of La Peña Formation that blanket the Coahuilan sediments and prevent continued growth of the rudistid reefs in the platform margin.

The hydrocarbon economic potential of the Coahuila Series is dependent of the tectonic history of the area and the stratigraphic and diagenetic conditions of the sediments. Present geomorphologic and hydrologic conditions of northern Mexico show that hydrocarbons previously accummulated in structural or stratigraphic traps of the Coahuila Series have been flushed by fresh-water, with the possible exceptions of those sites protected by impermeable seals or by the presence of tectonic barriers. Therefore, future exploration for oil reservoirs in the sediments should be concentrated in (1) the central part of the Sabinas Basin where impermeable marine shales (Menchaca, Barril Viejo and La Mula formations) act as a protective seal for the lower units; and (2) the northeastern corner of the state, which apparently has been isolated by regional faulting.

APPENDICES

APPENDIX A

Coded Sheets and Computer Programs.

Tables 1 and 2 show the coded sheets that were designed to transfer all the petrographic, structural and diagenetic data onto standard IBM cards. A computer program called PRINT was used to print all the numeric data in the form shown in Charts 1 and 2. Another FORTRAN program called LITHO was written. This program performs all the operations required to obtain thicknesses, ratios and percentages of the lithologic components present in the measured sections. The program can be set to include data from an entire section or from any particular segment of it.

TABLE 1

ST.		X							Y							SEC. NUM		BOTTOM OF INTERVAL							TOP OF INTERVAL						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	21	32

SEDIMENT. UNIT	33	34	35	36	37

INTERNAL BEDDING	C	48 49	50 51	52 53	54 55
Massive	01				
Nodular	02				
Cross-lam.	03				
Alp. - Xlam	04				
Bet. - Xlam.	05				
Gam. -Xlam.	06				
Eps. - Xlam.	07				
Zet. - Xlam.	08				
Eta. - Xlam.	09				
The. - Xlam.	10				
Iot. - Xlam.	11				
Kap. - Xlam.	12				
Lam. - Xlam.	13				
Mu. - Xlam.	14				
Nu. - Xlam.	15				
Xi. - Xlam.	16				
Omi. -Xlam.	17				
Pi. - Xlam.	18				
Slump str.	19				
Burrowing	20				
Bioherm	21				
Biostrome	22				
Graded bed	23				
Thick lam.	24				
Thin lam.	25				
Imb. bedd.	26				
Sand dike	27				
Brec. dike	28				
Recryst.	29				
Fissile	30				
Nodular	31				
Slaty	32				

GRAIN SHAPE	C	72	73
Angular	1		
Subangular	2		
Subrounded	3		
Rounded	4		
	5		

THICKNESS	C	38 39	40 41	42 43	44 45
V. thick bedded	01				
Thick bedded	02				
Med. bedded	03				
Thin bedded	04				
V. thin bedded	05				
Thick laminated	06				
Thin laminated	07				
Continuous beds	08				
Discont. beds	09				

BEDDING SURF. STRUCTURES	C	56 57	58 59	60 61	62 63
Symm. ripp. mark	01				
Asym. ripp. mark	02				
Bored surface	03				
Current marks	04				
Organ. markings	05				
Mud-cracks	06				
Fucoids	07				
Load structure	08				
Rain drops	09				
Trails	10				
Tracks	11				
Footprints	12				
	13				
	14				

SORTING	C	74	75
Well sorted	1		
Medium sorted	2		
Poorly sorted	3		
	4		

	76	77	78	79
CARD NUMBER				

MATURITY	C	46	47
Inmature	1		
Submature	2		
Mature	3		
Supermature	4		

	C	64	65	66	67
Gradat.	1				
Sharp	2				
Ang. unc.	3				
Disconf.	4				
Nonconf.	5				
Diastem.	6				
	7				
	8				

COLOR	C	68 69	70 71
Light	1		
Dark	2		
White	3		
Gray	4		
Black	5		
Red	6		
Brown	7		
Yellow	8		

CARD TYPE	C	80
Field descript	1	
Lab. description	2	
Grain Size Anal.	3	
Statistic. Anal.	4	
	5	
	6	
	7	

DATE	M		D		Y	

SAMPLE					

TABLE 2

GRAIN SIZE		1 2	3 4	5 6	7 8
Boulder	01				
L. cobble	02				
S. cobble	03				
VL. pebble	04				
L. pebble	05				
M. pebble	06				
S. pebble	07				
Granule	08				
VC. sand	09				
C. sand	10				
M. sand	11				
F. sand	12				
VF. sand	13				
Silt	14				
Clay	15				
	16				

LITHOLOGY	C	43 44	46 47	49 50
Mudstone	01			
Wackestone I	02			
Wackestone II	03			
Packstone	04			
Muddy	05			
Grainstone	06			
Boundstone	07			
Shale	08			
Marl	09			
Siltstone	10			
Clay	11			
Sandstone	12			
Orthoquart.	13			
Litarenite	14			
Arkose	15			
Subarkose	16			
Feld.Litaren.	17			
Sublitarenite	18			
Lit. Arkose	19			
Conglomerate	20			
Breccia	21			
Dolomite	22			
Anhydrite	23			
Gypsum	24			
Chert. nodul.	25			
Igneous rock	26			
Metam. rock	27			
Schist	28			
	29			
	30			
	31			

GRAIN COMPONENTS						
FIRST LITHOLOGY		9 10	12 13	15 16	18 19	21 22
SECOND LITHOLOGY		24 25	27 28	30 31	33 34	36 37
Intraclast	01					
Rock fragment	02					
Oolites	03					
Pellets	04					
Miliolids	05					
Orbitolina	06					
Globigerina	07					
Foraminifera	08					
Shell fragment	09					
Coated grains	10					
Coated oolite	11					
Mica	12					
Biotite	13					
Moscovite	14					
Quartz	15					
Feldspar	16					
Orthoclase	17					
Plagioclase	18					
Olivine	19					
Pyroxene	20					
Mafic mineral	21					
Felsic mineral	22					
Pyrite	23					
Hematite	24					
Pisolite	25					
Igneous rock	26					
Metamorph.rock	27					
Chert	28					
Calc. nodules	29					

PERC. OF GRAIN COMP.									
11	14	17	20	23	26	29	32	35	38

LITH %		
45	48	51

	39
NUM. OF LITH.	

LITHOLOGIC RELAT.	C	40	41
Interbedded	1		
Mixed vertically	2		
Mixed laterally	3		
Superimposed	4		

TEXTURAL GROUPS	C	42
Slightly nglom.	1	
Conglomeratic	2	

FIRST LITH.	C	52 53	55 54	58 59	61 62
SECOND LITH.	C	64 65	67 68	70 71	73 74
Foram.	01				
Globig.	02				
Orbitol.	03				
Dictyoc.	04				
Pelag.F.	05				
Gastrop.	06				
Turrit.	07				
Pelecip.	08				
Pecten.	09				
Brachiop.	10				
Ostrea	11				
Echinoid	12				
Coral	13				
Cladoph.	14				
Alectr.	15				
Chondr.	16				
Gryphea.	17				
Exogyra.	18				
Rudistid	19				
Toucas.	20				
Monopl.	21				
Caprinid	22				
Radiolit.	23				
Algae	24				
Tylostom	25				
Ammon.	26				
Serpula	27				
Pholado	28				
Stromat.	29				
	30				
	31				
	32				

FOSSIL FREQUENCY							
54	57	60	63	66	69	72	75

	80
CARD TYPE	

CARD NUMBER	76	77	78	79

SIERRA DEL CEDRAL

ST	X	Y	SEC	BASE	TOP	IND	UNI	THICKNESS	STRUCTURES			CONT	COLOR	MAT	SHA	CLA	NUM	TYPE
1	12.60	25.80	22	0.00	10.00	0	1	4 5	0 0 0 0	0 0 0 0	0 0	0000	67 0	20	30	20	2701	1
1	12.60	25.80	22	10.00	17.94	0	2	0 0	5 0 0 0	30 0 0 0	0 0	2000	67 6	00	00	00	2703	1
1	12.60	25.80	22	17.94	55.70	0	3	5 4	5 4 0 0	0 0 0 0	0 0	1000	67 6	00	00	00	2705	1
1	12.60	25.80	22	55.70	59.00	0	4	4 0	4 0 0 0	0 0 0 0	1 0	2000	417	00	00	00	2707	1
1	12.60	25.80	22	59.00	68.60	0	5	4 0	0 0 0 0	0 0 0 0	0 0	2000	17 0	00	00	00	2709	1
1	12.60	25.80	22	68.60	73.40	0	6	3 4	3 0 0 0	31 0 0 0	0 0	2000	14 4	00	00	00	2711	1
1	12.60	25.80	22	73.40	75.60	0	7	3 0	0 0 31 0	0 0 0 0	0 0	1000	4 0	00	00	00	2713	1
1	12.60	25.80	22	75.60	78.00	0	8	3 4	3 0 0 0	31 0 0 0	0 0	1000	414	00	00	00	2715	1
1	12.60	25.80	22	78.00	79.90	0	9	3 0	0 0 31 0	0 0 0 0	0 0	2000	14 0	00	00	00	2717	1
1	12.60	25.80	22	79.90	93.25	0	10	3 0	0 0 0 0	0 0 3 0	0 0	2000	14 4	00	00	00	2719	1
1	12.60	25.80	22	93.25	98.75	0	11	4 0	4 3 0 0	0 0 0 0	0 0	2000	414	00	00	00	2721	1
1	12.60	25.80	22	98.25	118.00	0	12	3 2	3 2 0 0	0 0 0 0	0 0	2000	4 4	00	00	00	2723	1
1	12.60	25.80	22	118.00	123.50	0	13	4 5	0 0 31 0	0 0 0 0	0 0	2000	24 0	00	00	00	2725	1
1	12.60	25.80	22	123.50	126.00	0	14	3 0	0 0 0 0	0 0 0 0	0 0	2000	4 0	00	00	00	2727	1
1	12.60	25.80	22	126.00	130.00	0	15	3 0	2 0 0 0	31 0 0 0	0 0	1000	4 4	00	00	00	2729	1
1	12.60	25.80	22	130.00	133.30	0	16	0 0	0 0 0 0	0 0 0 0	0 0	2000	0 0	00	00	00	2731	1
1	12.60	25.80	22	133.30	145.00	0	17	4 0	0 0 0 0	31 0 0 0	0 0	1000	4 0	00	00	00	2733	1
1	12.60	25.80	22	145.00	152.00	0	18	3 2	0 0 0 0	0 0 0 0	0 0	2000	4 0	00	00	00	2735	1
1	12.60	25.80	22	152.00	178.50	0	19	4 5	5 4 0 0	0 0 0 0	0 0	2000	4949	00	00	00	2737	1
1	12.60	25.80	22	178.50	181.50	0	20	3 0	3 0 0 0	31 0 0 0	0 0	2000	4 4	00	00	00	2739	1
1	12.60	25.80	22	181.50	183.00	0	21	0 0	0 0 0 0	0 0 0 0	0 0	1000	0 0	00	00	00	2741	1
1	12.60	25.80	22	183.00	185.50	0	22	4 3	3 0 0 0	31 0 0 0	0 0	1000	4 4	00	00	00	2743	1
1	12.60	25.80	22	185.50	191.00	0	23	0 0	0 0 0 0	0 0 0 0	0 0	1000	0 0	00	00	00	2745	1
1	12.60	25.80	22	191.00	197.10	0	24	3 4	3 0 0 0	0 0 0 0	0 0	2000	4 4	00	00	00	2747	1
1	12.60	25.80	22	197.10	210.00	0	25	4 0	0 0 0 0	0 0 0 0	0 0	2000	14 0	00	00	00	2749	1
1	12.60	25.80	22	210.00	219.00	0	26	3 2	0 0 0 0	0 0 0 0	0 0	2000	4 4	00	00	00	2751	1
1	12.60	25.80	22	219.00	231.10	0	27	3 0	3 0 0 0	31 0 0 0	0 0	1000	4 4	00	00	00	2753	1
1	12.60	25.80	22	231.10	232.10	0	28	2 0	0 0 0 0	0 0 0 0	0 0	2000	4 0	00	00	00	2755	1
1	12.60	25.80	22	232.10	237.00	0	29	3 0	0 0 3129	0 0 0 0	0 0	2000	4 0	00	00	00	2757	1
1	12.60	25.80	22	237.00	238.00	0	30	3 0	0 0 0 0	0 0 0 0	0 0	2000	4 0	00	00	00	2759	1
1	12.60	25.80	22	238.00	240.00	0	31	3 0	0 0 31 0	0 0 0 0	0 0	2000	4 0	00	00	00	2761	1
1	12.60	25.80	22	240.00	241.00	0	32	3 0	0 0 25 0	0 0 0 0	0 0	2000	4 0	00	00	00	2763	1
1	12.60	25.80	22	241.00	244.00	0	33	3 4	0 0 0 0	0 0 0 0	0 0	1000	4 0	00	00	00	2765	1
1	12.60	25.80	22	244.00	257.30	0	34	3 2	3 0 0 0	0 0 0 0	0 0	2000	4 4	00	00	00	2767	1
1	12.60	25.80	22	257.30	278.00	0	35	3 2	0 0 0 0	0 0 0 0	0 0	1000	24 0	00	00	00	2769	1
1	12.60	25.80	22	278.00	303.00	0	36	3 4	0 0 0 0	0 0 0 0	0 0	1000	24 0	00	00	00	2771	1
1	12.60	25.80	22	303.00	314.00	1	37	3 4	0 0 10 0	0 0 0 0	0 0	1000	4 0	03	00	00	2773	1

CHART 1

SIERRA DEL CEDRAL

GRAIN SIZE				GRANULOMETRY FIRST LITHOLOGY					SECOND LITHOLOGY					NL	LT	TG	LITHOLOGY FIR LIT	SEC LIT	THI LIT	FOSSILS	FIRST LITHOLOGY			SECOND LITHOLOGY			IND	NUM	TYPE
				F	F	F	F	F	F	F	F	F	F				P	P	P	F	F	F	F	F	F	F			
111	2	0	0	0	0	0	0	0	0	0	0	0	0	1	00	0	140	0	0	0	0	0	0	0	0	0	0	2702	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10	0	117	113	0	0	0	0	0	0	0	0	0	2704	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10	0	117	113	0	0	0	0	0	0	0	0	0	2706	1
0	0	0	0	0	0	0	0	0	90	0	0	0	0	2	10	0	18	12	0	0	0	0	0	0	0	0	0	2708	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	00	0	110	0	0	0	0	0	0	0	0	0	0	2710	1
0	0	0	0	90	0	0	0	0	0	0	0	0	0	2	10	0	24	96	0	0	0	0	0	0	0	0	0	2712	1
0	0	0	0	90	0	0	0	0	0	0	0	0	0	1	00	0	20	0	0	63	0	0	0	0	0	0	0	2714	1
0	0	0	0	90	0	0	0	0	0	0	0	0	0	2	10	0	24	96	0	63	0	0	0	0	0	0	0	2716	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	00	0	90	0	0	0	0	0	0	0	0	0	0	2718	1
0	0	0	0	90	50	30	0	0	90	50	30	0	0	2	10	0	25	69	0	0	0	0	0	0	0	0	0	2720	1
0	0	0	0	90	0	0	0	0	0	0	0	0	0	2	10	0	19	21	0	0	0	0	0	0	0	0	0	2722	1
0	0	0	0	90	0	0	0	0	40	30	0	0	0	2	10	0	28	62	0	0	0	0	0	0	0	0	0	2724	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	00	0	10	0	0	0	0	0	0	0	0	0	0	2726	1
0	0	0	0	50	90	0	0	0	0	0	0	0	0	1	00	0	20	0	0	0	0	0	0	0	0	0	0	2728	1
0	0	0	0	90	0	0	0	0	0	0	0	0	0	2	10	0	21	99	0	0	0	0	0	0	0	0	0	2730	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	00	0	29	0	0	0	0	0	0	0	0	0	0	2732	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10	0	13	117	0	0	0	0	0	0	0	0	0	2734	1
0	0	0	0	30	90	0	0	0	30	90	0	0	0	2	10	0	28	62	0	0	0	0	0	0	0	0	0	2736	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10	0	17	113	0	0	0	0	0	0	0	0	0	2738	1
0	0	0	0	30	90	0	0	0	0	0	0	0	0	2	10	0	68	92	0	0	0	0	0	0	0	0	0	2740	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	00	0	290	0	0	0	0	0	0	0	0	0	0	2742	1
0	0	0	0	90	0	0	0	0	0	0	0	0	0	2	10	0	22	98	0	0	0	0	0	0	0	0	0	2744	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	00	0	290	0	0	0	0	0	0	0	0	0	0	2746	1
0	0	0	0	90	0	0	0	0	90	30	0	0	0	2	10	0	27	63	0	0	0	0	0	0	0	0	0	2748	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	00	0	10	0	0	0	0	0	0	0	0	0	0	2750	1
0	0	0	0	50	90	0	0	0	90	30	0	0	0	2	10	0	28	62	0	0	0	0	0	0	0	0	0	2752	1
0	0	0	0	90	0	0	0	0	0	0	0	0	0	2	10	0	12	18	0	172	82	0	0	0	0	0	0	2754	1
0	0	0	0	90	0	0	0	0	0	0	0	0	0	1	00	0	220	0	0	0	0	0	0	0	0	0	0	2756	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	00	0	19	0	0	0	0	0	0	0	0	0	0	2758	1
0	0	0	0	90	0	0	0	0	0	0	0	0	0	1	00	0	20	0	0	0	0	0	0	0	0	0	0	2760	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	00	0	19	0	0	0	0	0	0	0	0	0	0	2762	1
0	0	0	0	90	0	0	0	0	0	0	0	0	0	1	00	0	10	0	0	290	0	0	0	0	0	0	0	2764	1
0	0	0	0	50	90	0	0	0	0	0	0	0	0	1	00	0	20	0	0	0	0	0	0	0	0	0	0	2766	1
0	0	0	0	50	40	10	0	0	90	0	0	0	0	2	10	0	64	26	0	274	0	0	0	0	0	0	0	2768	1
0	0	0	0	50	100	90	0	0	0	0	0	0	0	1	00	0	20	0	0	113	0	0	0	0	0	0	0	2770	1
0	0	0	0	90	0	0	0	0	0	0	0	0	0	1	00	0	20	0	0	0	0	0	0	0	0	0	0	2772	1
0	0	0	0	50	90	0	0	0	0	0	0	0	0	1	00	0	20	0	0	254	84	0	0	0	0	0	1	2774	1

CHART 2

COMPUTER PROGRAM CALLED <u>LITHO</u> USED TO OBTAIN THE FOLLOWING PARAMETERS FROM THE MEASURED SECTIONS:

ESTOT = TOTAL THICKNESS OF SECTION
ETCAR = TOTAL THICKNESS OF CARBONATES
ETDOL = TOTAL THICKNESS OF DOLOMITES
ETLUT = TOTAL THICKNESS OF SHALES
ETARE = TOTAL THICKNESS OF SANDSTONES
ETEVA = TOTAL THICKNESS OF EVAPORITES
POCAR = PERCENTAGE OF CARBONATES
POLUT = PERCENTAGE OF SHALES
PORAR = PERCENTAGE OF SANDSTONES
PEVAP = PERCENTAGE OF EVAPORITES
RACLA = CLASTIC RATIO (ETARE + ETLUT/ETCAR + ETEVA)
RAZAR = SANDSTONE RATIO (ETARE/ETLUT)

```
      INTEGER  SEC(30),SECC
      REAL NUS(30),NU
      DIMENSION POLIT(10),LIT(10),ABS(30),ORD(30),ESTOT(30),ETCAR(30),ET
     1LUT(30),ETARE(30),ETEVA(30),POCAR(30),POLUT(30),PORAR(30),PEVAP(30
     2),RAZEV(30),RACLA(30),RAZAR(30),ESPUS(30),ETCAL(30),ETCON(30),ETDO
     3L(30),ETIME(30),ETCUB(30),POCON(30),PODOL(30)
      WRITE(5,100)
  100 FORMAT(1H1,3HSEC,3X,1HX,5X,1HY,4X,5HESTOT,3X,5HETCAR,3X,5HETDOL,2X
     1,5HETLUT,1X,5HETARE,3X,5HETEVA,2X,5HETCUB,1X,5HPOCAR,1X,5HPOLUT,1X
     2,5HPORAR,1X,5HPEVAP,1X,5HRAZEV,1X,5HRACLA,1X,5HRAZAR,2X,3HNUS,2X,5
     3HESPUS /)
      J=0
  130 ESTO=0.0
      ETCA=0.0
      ETDO=0.0
      ETAR=0.0
      ETLU=0.0
      ETEV=0.0
      ETIM=0.0
      ETCO=0.0
      ETCU=0.0
      NU=0.0
  102 READ(8,103)X,Y,SECC,BASE,CIMA,IND,NL,(LIT(I),POLIT(I),I=1,NL)
  103 FORMAT(2X,F7.0,F7.0,I2,F7.2,F7.2,I1/38X,I1,3X,3(I2,F1.0))
      NU=NU+1
      ESUS=CIMA-BASE
      ESTO=ESTO+ESUS
   10 DO 15 I=1,NL
      IF(POLIT(I))18,19,18
   18 ESP=ESUS*POLIT(I)/10
      GO TO 4
   19 ESP=ESUS
    4 IF(LIT(I)-7)50,50,51
   51 IF(LIT(I)-8)52,60,52
   52 IF(LIT(I)-9)53,50,53
   53 IF(LIT(I)-10)54,60,54
   54 IF(LIT(I)-11)55,60,55
   55 IF(LIT(I)-19)70,70,56
   56 IF(LIT(I)-20)57,80,57
   57 IF(LIT(I)-21)58,90,58
```

```
PAGE   2

   58 IF(LIT(I)-22)59,104,59
   59 IF(LIT(I)-24)90,90,61
   61 IF(LIT(I)-25)70,70,63
   63 IF(LIT(I)-28)106,106,65
   65 IF(LIT(I)-29)108,108,67
   67 GO TO 70
   50 ETCA=ETCA+ESP
      GO TO 15
   60 ETLU=ETLU+ESP
      GO TO 15
   70 ETAR=ETAR+ESP
      GO TO 15
   80 ETCO=ETCO+ESP
      GO TO 15
   90 ETEV=ETEV+ESP
      GO TO 15
  104 ETDO=ETDO+ESP
      GO TO 15
  106 ETIM=ETIM+ESP
      GO TO 15
  108 ETCU=ETCU+ESP
   15 CONTINUE
      IF(IND-1)102,110,102
  110 J=J+1
      ABS(J)=X
      ORD(J)=Y
      NUS(J)=NU
      ESTOT(J)=ESTO
      ETCAL(J)=ETCA
      ETLUT(J)=ETLU
      ETARE(J)=ETAR
      ETCON(J)=ETCO
      ETEVA(J)=ETEV
      ETDOL(J)=ETDO
      ETIME(J)=ETIM
      ETCUB(J)=ETCU
      ETCAR(J)=ETCAL(J)+ETDOL(J)
      POCCN(J)=ETCON(J)/ESTOT(J)
      POCAR(J)=ETCAR(J)*100/ESTOT(J)
      PODOL(J)=ETDOL(J)/ESTOT(J)
      POLUT(J)=ETLUT(J)*100/ESTOT(J)
      PORAR(J)=ETARE(J)*100/ESTOT(J)
      RACLA(J)=(ETARE(J)+ETLUT(J)+ETCON(J))/(ETCAR(J)+ETEVA(J))
      PEVAP(J)=ETEVA(J)*100/ESTOT(J)
      RAZEV(J)=ETEVA(J)/ETCAR(J)
      RAZAR(J)=ETARE(J)/ETLUT(J)
      ESPUS(J)=ESTOT(J)/NUS(J)
      SEC(J)=SECC
      WRITE(5,120)SEC(J),ABS(J),ORD(J),ESTOT(J),ETCAR(J),ETDOL(J),ETLUT(
     1J),ETARE(J),ETEVA(J),ETCUB(J),POCAR(J),POLUT(J),PORAR(J),PEVAP(J),
     2RAZEV(J),RACLA(J),RAZAR(J),NUS(J),ESPUS(J)
  120 FORMAT(1H0,1X,I2,1X,F5.2,1X,F5.2,1X,F7.2,1X,F7.2,1X,F6.2,1X,F6.2,1
     1X,F6.2,1X,F6.2,1X,F6.2,1X,F5.2,1X,F5.2,1X,F5.2,1X,F5.2,1X,F5.1,1X,
     2F5.1,1X,F5.1,1X,F4.0,1X,F6.2)
      GO TO 130
      END
```

COMPUTER PROGRAM CALLED PRINT UTILIZED TO PRINT ALL THE NUMERIC DATA FROM THE FIELD AND LABORATORY DESCRIPTIONS.

```
      INTEGER ES,SEC,USE,EST(10),ESI(10),ESE(10),CONT(10),COL(10),MAD(10
     1),FOR(10),CLA(10),TIPO
  302 LIN=0
      WRITE(5,107)
  107 FORMAT(1H1)
      WRITE(5,100)
  100 FORMAT( 1H0,1X,2HES,4X,1HX,6X,1HY,4X,3HSEC,4X,4HBASE,4X,4HCIMA,1X,
     13HIND,4X,3HUSE,2X,6HESTRAT,3X,3HEST,1X,3HINT,3X,3HEST,1X,3HEXT,2X,
     24HCONT,2X,5HCOLOR,1X,3HMAD,1X,3HFOR,1X,3HCLA,2X,3HNUM,1X,4HTIPO)
  300 READ(8,101) ES,X,Y,SEC,BAS,CIM,IND,USE,(EST(I),I=1,4),(MAD(I),I=1,
     12),(ESI(I),I=1,4),(ESE(I),I=1,4),(CONT(I),I=1,4),(COL(I),I=1,2),(F
     2OR(I),I=1,2),(CLA(I),I=1,2),NUM,TIPO
  101 FORMAT(I2,2F7.2,I2,2F7.2,I1,I4,4I2,2I1,4I2,4I2,4I1,2I2,2I1,2I1,I4,
     1I1)
      WRITE(5,102) ES,X,Y,SEC,BAS,CIM,IND,USE,(EST(I),I=1,4),(ESI(I),I=1
     1,4),(ESE(I),I=1,4),(CONT(I),I=1,4),(COL(I),I=1,2),(MAD(I),I=1,2),(
     2FOR(I),I=1,2),(CLA(I),I=1,2),NUM,TIPO
  102 FORMAT(1X,I2,1X,2F7.2,2X,I2,2X,F7.2,1X,F7.2,2X,I1,3X,I4,1X,2I2,1X,
     12I2,1X,2I2,1X,2I2,1X,2I2,1X,2I2,1X,4I1,2X,2I2,3X,2I1,2X,2I1,2X,2I1
     2,1X,I4,4X,I1)
      IF(IND-1)303,302,300
  303 LIN=LIN+1
      IF(LIN-50)300,302,300
      END

      INTEGER TG(10),CGR(10),RELI(10),LIT(10),GT,FOS(10),TIPO
  305 LIN=0
      WRITE(5,103)
  103 FORMAT(1H1)
      WRITE(5,104)
  104 FORMAT(1H0,1X,6HTGRANO,6X,25HG R A N U L O M E T R I A,5X,2HNL,1X,
     12HRL,1X,2HGT,1X,17HL I T O L O G I A,8X,13HF O S I L E S,6X,3HIND,
     22X,3HNUM,3X,4HTIPO/14X,7HPRIMERA,11X,7HSEGUNDA,15X,3HPRI,2X,3HSEG,
     32X,3HTER,7X,7HPRIMERA,6X,7HSEGUNDA/13X,9HLITOLOGIA,9X,9HLITOLOGIA,
     414X,13HLIT  LIT  LIT,6X,9HLITOLOGIA,4X,9HLITOLOGIA/13X,5('F  '),2X
     5,4('F  '),1HF,13X,11HP    P    P,6X,4('F  '),1X,3('F  '))
  301 READ(8,106) (TG(I),I=1,4),(CGR(I),I=1,10),NL,(RELI(I),I=1,2),GT,(L
     1IT(I),I=1,3),(FOS(I),I=1,7),IND,NUM,TIPO
  106 FORMAT(4I2,10I3,I1,2I1,I1,3I3,7I3,2X,I1,I4,I1)
      WRITE(5,105)(TG(I),I=1,4),(CGR(I),I=1,10),NL,(RELI(I),I=1,2),GT,(L
     1IT(I),I=1,3),(FOS(I),I=1,7),IND,NUM,TIPO
  105 FORMAT(1X,2I2,1X,2I2,1X,5I3,2X,5I3,1X,I1,2X,2I1,2X,I1,2X,I3,2X,I3,
     12X,I3,4X,4I3,1X,3I3,5X,I1,2X,I4,5X,I1)
      IF(IND-1)306,305,301
  306 LIN=LIN+1
      IF(LIN-50)301,305,301
      END
```

APPENDIX B

Location and Description of Measured Sections.

The approximate location of the measured sections is shown in Fig. 43 and the exact location of each section with its description. A lithologic column accompanies the description of each section. The lithologic symbols utilized are illustrated in the following chart:

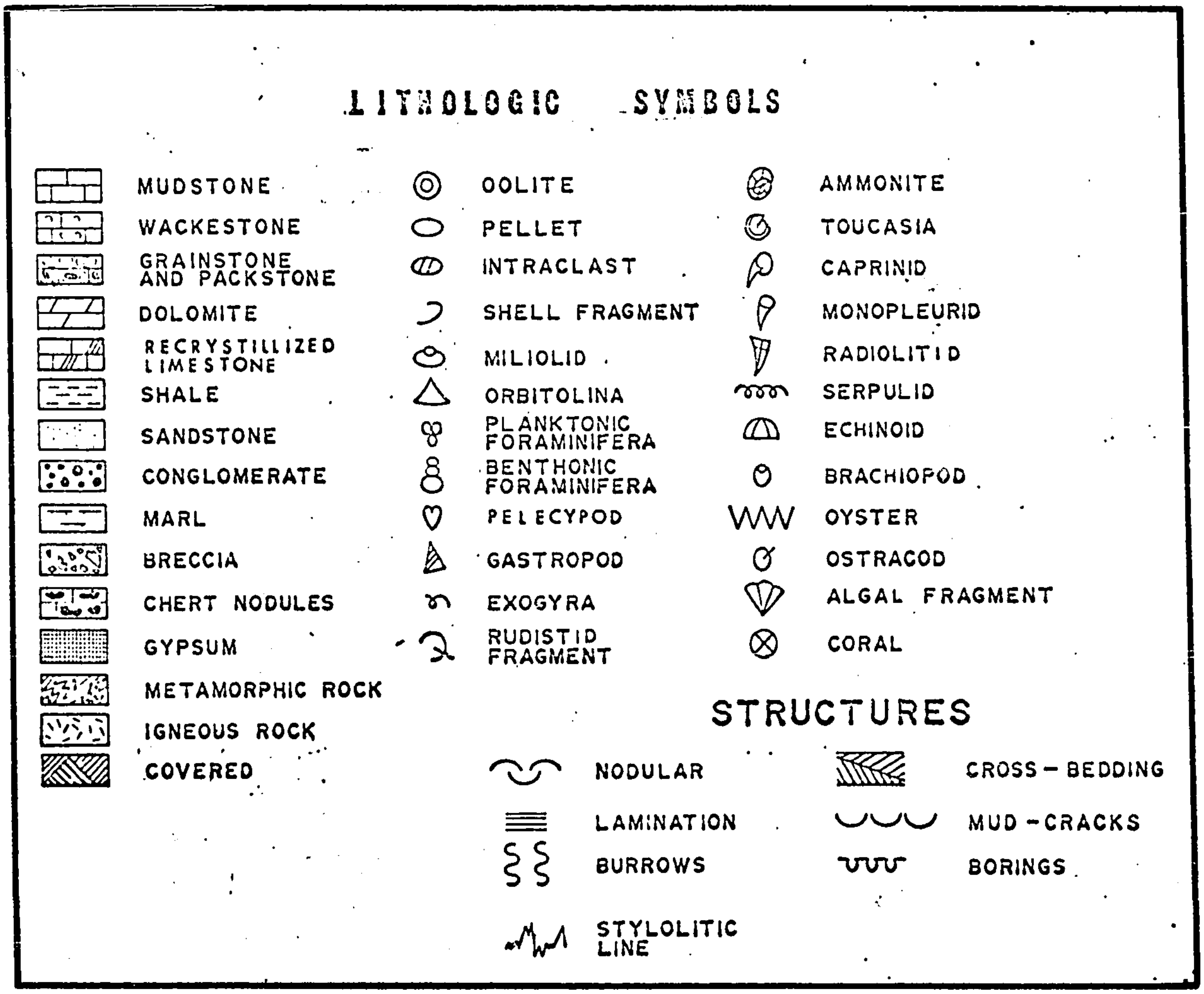


Chart 3: Lithologic and structural symbols.

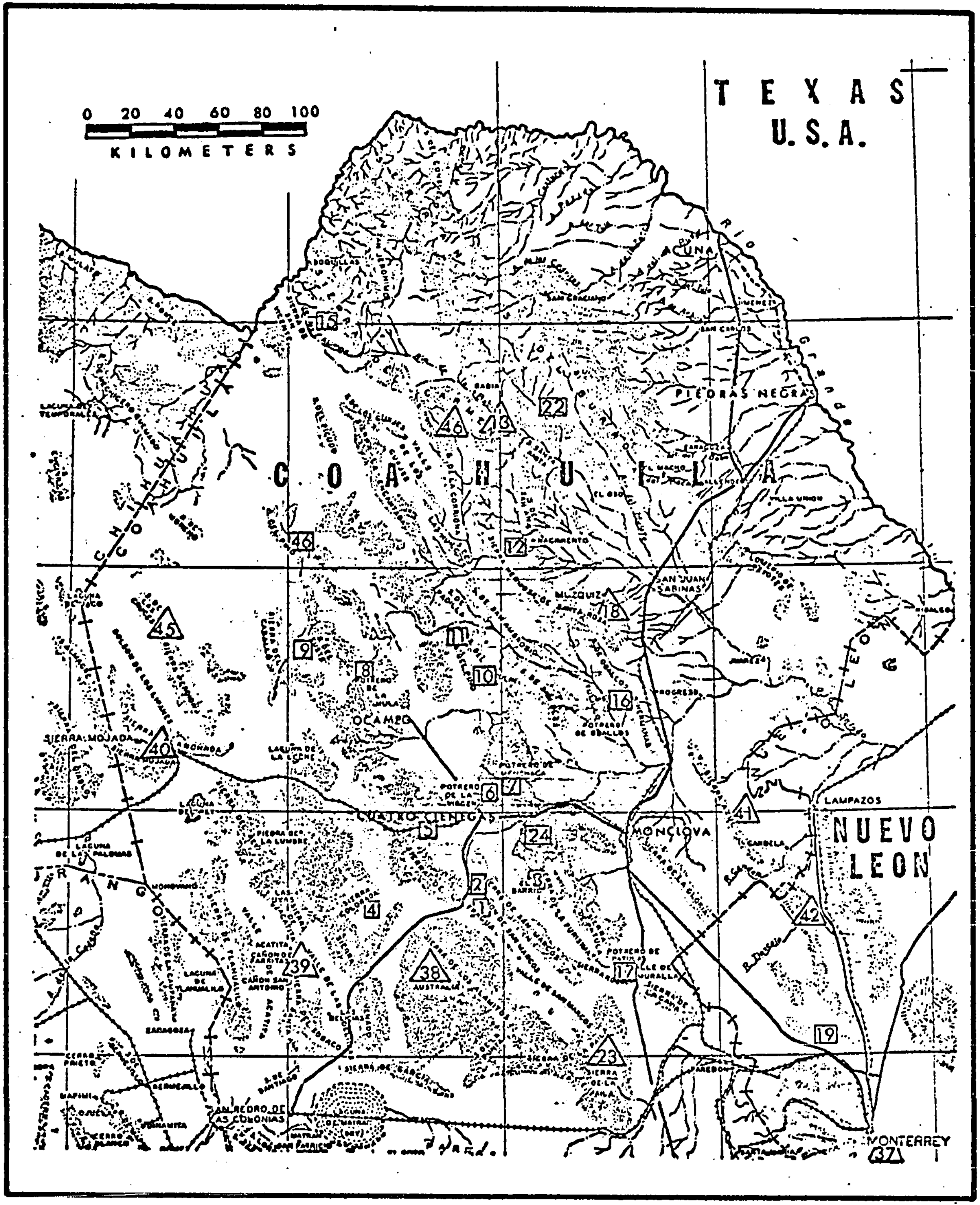


Figure 43: Location map of the stratigraphic sections (modified after Kellum, 1936).

☐ Section measured and described.

△ Section visited.

POTRERO DE SAN MARCOS

SECTION 1

Southern flank of Potrero de San Marcos,
near an abandoned mine.

CUPIDO FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
11		Thick-bedded mudstone.	2.00
10		Very thick-to thick-bedded, oyster shell fragment packstone.	8.00
9	CH17	Very thick-bedded mudstone.	9.00
8	CH16	Very thick-bedded, shell fragment wackestone.	6.00
7	CH15	Very thick-to thick-bedded mudstone.	18.00
6	CH14	Thick-bedded, oolite grainstone.	3.00
5	CH13	Very thick-bedded mudstone.	15.00
4	CH12	Thick-bedded, oolite, shell fragment wackestone.	16.00
3	CH11	Thick-bedded, intraclast wackestone.	3.00
2	CH10 CH9	Thick-bedded, dolomitized, arenaceous, shell fragment wackestone.	10.00
1	CH8 to CH3	Medium-to thin-bedded, calcareous, fine grained orthoquartzite.	30.00

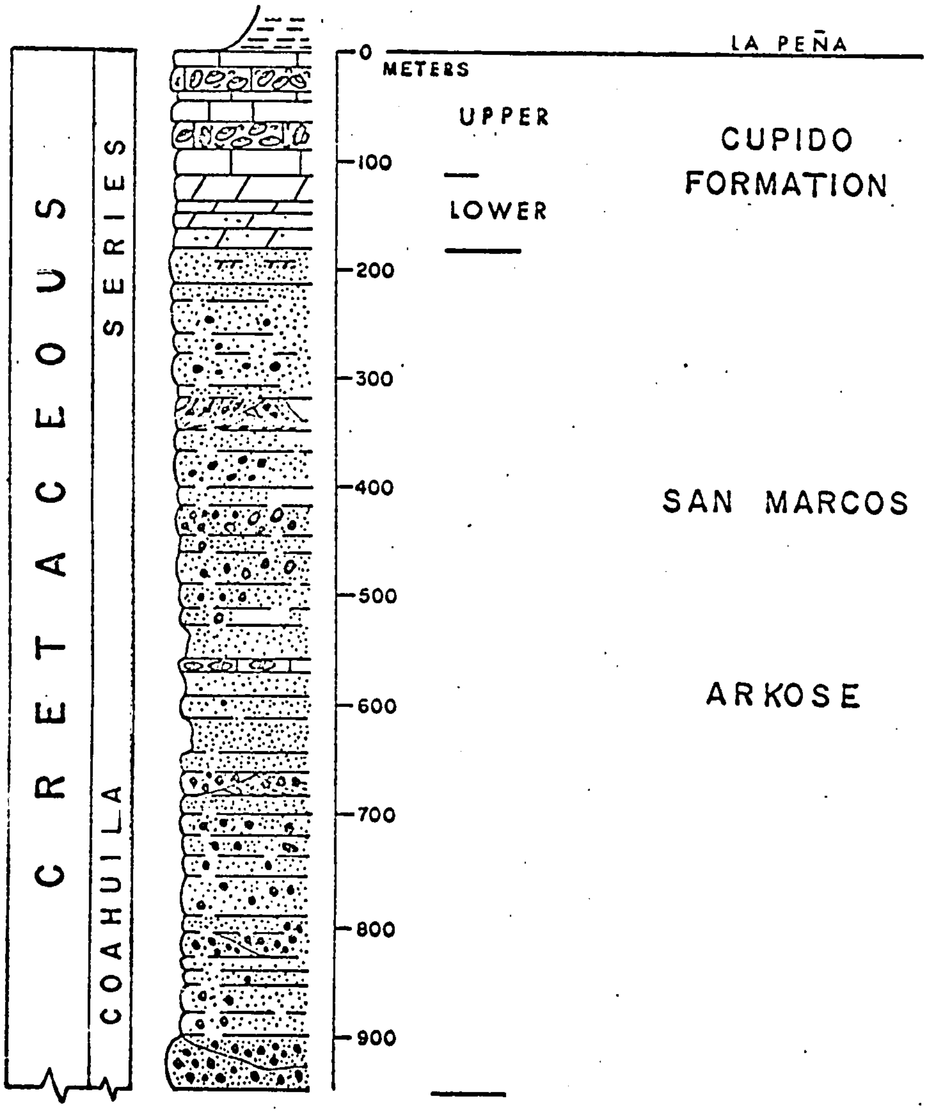
(Base of section not exposed)

Total Thickness 120.00

Total Thickness of Section 120.00

POTRERO DE SAN MARCOS

2



POTRERO DE SAN MARCOS

SECTION 2

Measured in the northwestern corner of Potrero de San Marcos, approximately 6 Km. north of an abandoned candelilla camp.

CUPIDO FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
41	CH85	Thick-bedded mudstone.	6.40
40	CH84	Thick-bedded, gray, pelecypod and gastropod shell fragment, miliolid, intraclast grainstone; few Toucasia.	12.60
39	CH83	Thinly laminated, dolomitized, algal stromatolite.	4.40
38		Thick-bedded mudstone.	6.30
37	CH82 CH81	Very thick-to thick-bedded, light gray, pelecypod, shell fragment, miliolid wackestone; abundant oysters in the lower part.	10.30
36	CH80	Thick-bedded, light gray, recrystallized, pellet mudstone.	5.20
35	CH79	Thick-bedded, light gray, slightly arenaceous dolomite.	10.90
34	CH78	Very thick-to thick-bedded, dark, coarse grain dolomite.	20.60
33	CH77	Very thick-bedded, gray, miliolid, mollusc shell fragment, echinoderm shell fragment wackestone.	8.00
32		Thick-to medium-bedded, light gray, thinly laminated, slightly dolomitic mudstone.	12.80

UNIT	SAMPLE	LITHOLOGY	METERS
31	CH76	Medium-to thin-bedded, light gray, very dolomitized, arenaceous mudstone; asymmetric ripple marks.	6.30
30	CH75	Thick-to very thick-bedded, light gray, fine grain dolomite; few medium quartz grains; good intergranular porosity.	40.40
29	CH70	Very thick-bedded, well sorted, mature orthoquartzite with calcite cement.	3.00
28	CH69	Thick-bedded, gray, very arenaceous, fine grain dolomite.	5.30
27	CH68	Thick-bedded, light gray, medium sorted, dolomitic orthoquartzite.	15.50
		Total Thickness	168.00

SAN MARCOS ARKOSE

UNIT	SAMPLE	LITHOLOGY	METERS
26		Covered interval.	8.00
25	CH67	Thick-bedded, light gray, slightly conglomeratic (granules), very coarse arkose; angular, poorly sorted grains.	25.00
24	CH66	Thick-to medium-bedded, reddish, slightly conglomeratic (granules and large pebbles), coarse arkose with subangular, poorly sorted grains; few fragments have the size of medium to small cobbles.	73.00
23	CH65	Thick-bedded, reddish, conglomeratic (granules and large pebbles), coarse subarkose; poorly sorted, subangular grains; some small cobbles.	48.00
22		Covered interval.	14.50
21		Thick-bedded, reddish, conglomeratic (granules and small pebbles), arkose; few large cobbles.	3.00

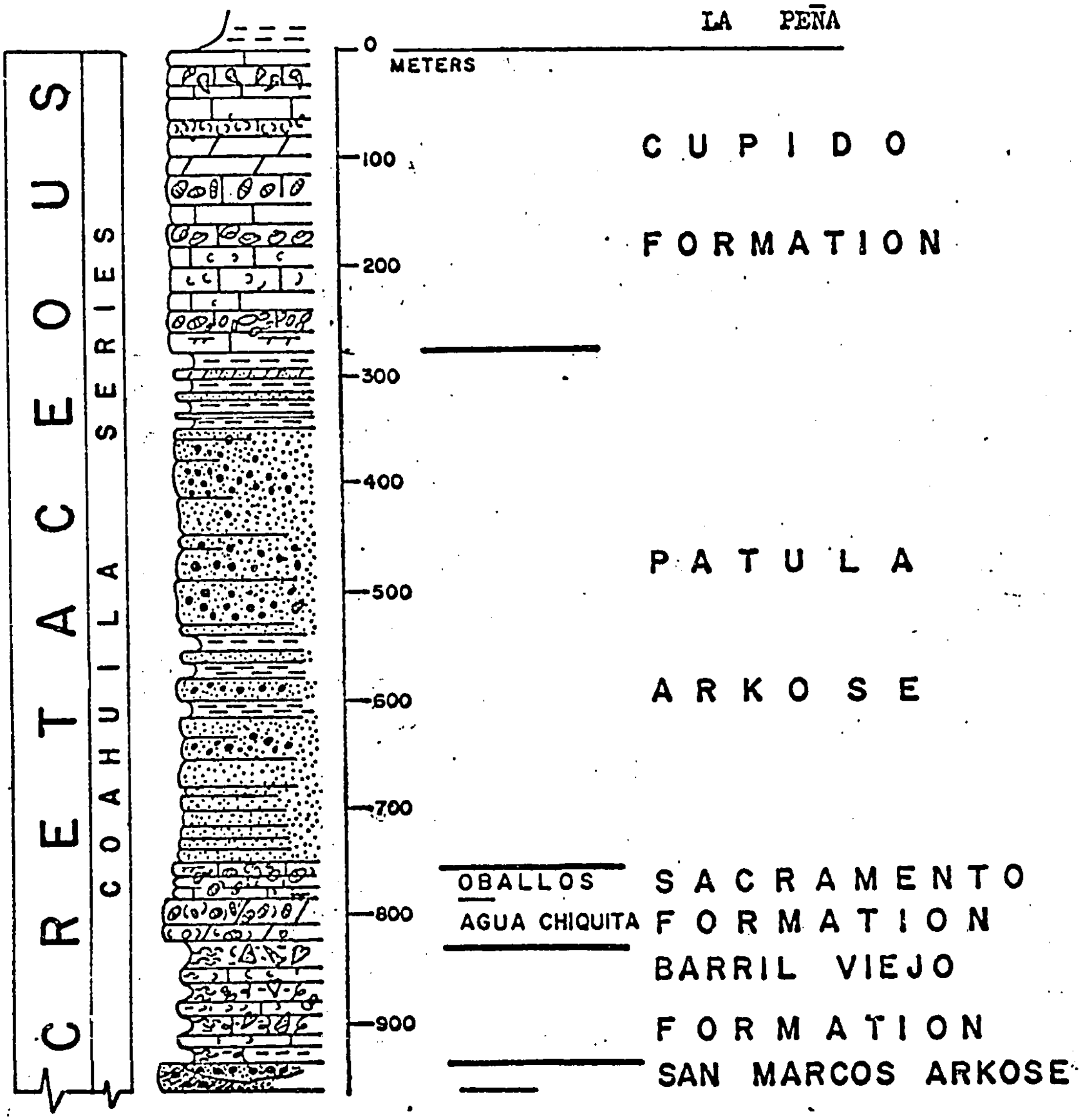
UNIT	SAMPLE	LITHOLOGY	METERS
20	CH64	Thick-to medium-bedded, reddish, conglomeratic (large pebbles and granules), coarse subarkose; subangular, poorly sorted grains, interbedded with thin beds of arkosic siltstone.	84.00
19	CH63	Very thick-bedded, reddish, conglomeratic (large pebbles), very coarse arkose; subrounded, poorly sorted grains.	4.00
18	CH62 to CH60	Thick-to medium-bedded, slightly conglomeratic (granules and large pebbles), coarse to very coarse arkose; angular, poorly sorted grains, interbedded with reddish, siltstone.	41.00
17	CH59	Thick-to medium-bedded, reddish, slightly conglomeratic (granules), coarse subarkose; angular, poorly sorted grains, interbedded with reddish siltstone.	41.00
16	CH58	Thick-bedded, gray, very arenaceous, recrystallized mudstone; abundant lenses of calcite.	2.00
15	CH57 CH56	Thick-bedded, cross-bedded, reddish, coarse arkose; angular, poorly sorted grains; calcite cement; some vuggy porosity.	56.00
14		Thick-bedded, calcite nodules, very arenaceous mudstone.	2.00
13	CH54	Medium-to thick-bedded, reddish, conglomeratic, arkose; poorly sorted, angular grains; interbedded with reddish, silty, immature subarkose.	40.00
12	CH52 to CH50	Thick-bedded, reddish, coarse to very coarse subarkose; angular, poorly sorted grains; poor intergranular porosity; there is an interval of reddish conglomerate, formed by small pebbles and granules.	102.00

UNIT	SAMPLE	LITHOLOGY	METERS
11	CH49 to CH45	Thick-bedded, red, granular conglomeratic subarkose; angular, poorly sorted grains; small scale planar cross-bedding.	35.00
10	CH44 CH43	Medium-to thin-bedded, reddish, arkosic siltstone interbedded with medium bedded, red, slightly conglomeratic (granules), coarse subarkose with angular, poorly sorted grains.	26.50
9	CH42 CH41	Medium-to thin-bedded, reddish, poorly sorted subarkose.	15.80
8	CH40	Thick-to medium-bedded, reddish, slightly conglomeratic (fine pebbles), submature arkose.	19.00
7	CH39	Thick-bedded-to medium-bedded, reddish, fine arkose; subangular, medium sorted grains.	11.50
6		Covered interval.	12.00
5	CH38 CH37	Very thick-to thick-bedded, red, arkosic, granular conglomerate, interbedded with reddish, immature arkose.	33.00
4		Thick-bedded, red, medium and small pebble arkosic conglomerate, interbedded with granular, poorly sorted, coarse subarkose.	16.00
3	CH36 CH35	Thick-to medium-bedded, red, slightly conglomeratic (small pebbles), coarse arkose; angular, poorly sorted grains; small scale planar cross-bedding.	19.00
2		Thick-to medium-bedded, red, conglomeratic (large pebbles), arkose; large scale planar cross-bedding.	6.00
1	CH34	Thick-bedded, red, small pebble arkosic	

UNIT	SAMPLE	LITHOLOGY	METERS
	CH33	conglomerate; some fragments have the size of large cobbles.	6.70
		(Base of section not exposed)	
		Total Thickness	744.00
		Total Thickness of Section	912.00

POTRERO DE BARRIL VIEJO

3



POTRERO DE BARRIL VIEJO

SECTION 3

This section was measured in the eastern flank of Potrero de Barril Viejo, 2 Km south of the abandoned well San Marcos # 2.

CUPIDO FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
63	CH281	Very thick-bedded, dark gray, shell fragment wackestone.	10.00
62	CH282	Thick-bedded, shell fragment packstone with Monopleura.	3.50
61	CH283	Very thick-to thick-bedded, mollusc shell fragment mudstone.	10.00
60	CH284	Very thick-bedded, dark gray, shell fragment, coarse grain dolomite.	6.00
59	CH285	Thick-bedded, shell fragment packstone with Monopleura.	3.00
58	CH286	Very thick-bedded, miliolid, shell fragment wackestone.	5.00
57		Very thick-to thick-bedded, shell fragment mudstone.	11.00
56	CH287	Thick-bedded, oyster shell fragment wackestone.	2.00
55	CH288	Very thick-bedded, miliolid, oolite grainstone.	6.00
54	CH289	Thick-to medium-bedded, slightly recrystallized, miliolid mudstone; chert nodules in the upper part.	11.00
53	CH290 to CH293	Thick-bedded, dark gray dolomite; chert nodules in the upper part.	27.50

UNIT	SAMPLE	LITHOLOGY	METERS
52	CH294	Very thick-bedded, gray, shell fragment, intraclast, pellet grainstone.	3.50
51	CH295	Very thick-to thick-bedded, slightly dolomitic, light gray, pellet mudstone.	20.00
50	CH280	Very thick-to thick-bedded, light gray mudstone.	16.50
49	CH279	Thick-bedded, light gray, shell fragment packstone.	2.50
48	CH278 to CH276	Very thick-to thick-bedded, recrystallized, light gray, shell fragment mudstone.	31.50
47	CH275	Very thick-bedded, light gray, shell fragment, miliolid, oolite grainstone.	6.50
46	CH274	Very thick-bedded, recrystallized, shell fragment wackestone.	20.50
45	CH273 to CH271	Very thick-bedded, gray, oolite, algal fragment, pellet grainstone.	12.50
44	CH270 to CH268	Very thick-bedded, gray, oyster shell fragment grainstone.	10.00
43		Thick-bedded, gray mudstone.	8.50
42	CH267	Thick-to medium-bedded, dark gray, intraclast, shell fragment wackestone.	10.00
41	CH266	Very thick-bedded, dark gray, intraclast, shell fragment grainstone.	5.50
40		Medium-bedded, dark gray, shell fragment wackestone, interbedded with nodular, pelecypod shell fragment marl.	21.00
39	CH265	Medium-bedded, dark gray, algal fragment, shell fragment, oolite grainstone.	2.00

UNIT	SAMPLE	LITHOLOGY	METERS
38		Thick-bedded, dolomitic mudstone.	5.50
37	CH264	Thick-to medium-bedded, arenaceous, fine dolomite.	9.00
		Total Thickness	280.00

LA MULA FORMATION

36	CH263	Medium-to thin-bedded, dark gray, slightly recrystallized, arenaceous mudstone, interbedded with shale.	17.50
35	CH262 to CH260	Thin-to very thin-bedded, gray, slightly recrystallized, shell fragment, arenaceous mudstone, interbedded with shale.	45.50
		Total Thickness	63.00

PATULA ARKOSE

34	CH259 CH258	Very thick-bedded, coarse subarkose, interbedded with shale.	16.00
33	CH257	Medium-to thin-bedded, greenish-gray, slightly granular conglomeratic, coarse subarkose; subrounded, medium sorted grains; some intergranular porosity.	28.50
32	CH256	Thick-to medium-bedded, greenish, slightly conglomeratic (large pebbles), coarse arkose; poorly sorted, subangular grains.	8.50
31		Thick-to medium-bedded, slightly conglomeratic (granules), very coarse arkose with subangular, poorly sorted grains.	16.00
30		Thin-to very thin-bedded, light gray, fine orthoquartzite with good sorted, subrounded grains, interbedded with shale.	16.00
29		Covered interval.	12.00

UNIT	SAMPLE	LITHOLOGY	METERS
28	CH255	Thick-to medium-bedded, light gray, medium subarkose with angular, medium sorted grains.	5.00
27	CH254 CH253	Very thick-to thick-bedded, light gray, conglomeratic (large pebbles and small cobbles), coarse subarkose with subangular, poorly sorted grains; large scale planar cross-bedding and channel filling.	91.00
26	CH252 CH251	Thick-bedded, light gray, very coarse arkose with poorly sorted, angular grains, interbedded with very sandy shale.	22.00
25	CH250	Thick-to medium-bedded, light, coarse subarkose with subrounded, poorly sorted grains, interbedded with slightly nodular, argillaceous siltstone; medium intergranular and intragranular porosity.	24.00
24	CH249	Thick-bedded, conglomeratic (granules and some medium and large pebbles) very coarse subarkose with angular, poorly sorted grains.	2.00
23	CH248 CH247	Thick-bedded, light red, slightly conglomeratic (granules and small pebbles) coarse subarkose with angular, poorly sorted grains.	19.00
22		Medium-bedded, reddish, immature, coarse subarkose, interbedded with slightly nodular, arkosic siltstone.	20.00
21	CH246 CH245	Very thick-to medium-bedded, light red, coarse to medium subarkose with poorly sorted, angular grains; small scale planar cross-bedding in the upper part.	22.00
20	CH244 CH243	Thick-to medium-bedded, reddish, coarse subarkose with angular, poorly sorted grains.	32.00

UNIT	SAMPLE	LITHOLOGY	METERS
19	CH242 CH241	Thick-to medium-bedded, reddish, fine subarkose with subangular, poorly sorted grains; some intergranular porosity.	30.00
18	CH240 to CH234	Medium-to thin-bedded, fine to coarse subarkose with subangular, poorly sorted grains, interbedded with arenaceous shale; good intergranular porosity in the sandstone.	34.00
		Total Thickness	398.00

SACRAMENTO FORMATION

OBALLOS MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
17	CH233	Medium-to thin-bedded, dark gray, arenaceous mudstone, interbedded with shale.	29.00
16	CH232	Thick-bedded, arenaceous dolomite.	3.00
15	CH231	Medium-to thin-bedded, arenaceous dolomite.	4.00
14	CH230	Medium-bedded, dark gray, shell fragment, intraclast grainstone; strongly dolomitized.	10.00

AGUA CHIQUITA MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
13	CH229 CH228 CH227	Thick-bedded, dark gray, dolomitized, intraclast, oolite, very arenaceous grainstone; medium intercrystalline porosity.	10.00
12	CH226 CH225	Massive, dark gray, dolomitized, oolite, shell fragment, intraclast grainstone.	12.00
		Total Thickness	68.00

UNIT	SAMPLE	LITHOLOGY	METERS
BARRIL VIEJO FORMATION			
11		Gray shale.	14.50
10	CH224	Medium-bedded, dark gray, shell fragment, intraclast, arenaceous wackestone, interbedded with shale.	10.50
9	CH223 CH222	Arenaceous, nodular marl with abundant *Exogyra*.	8.00
8	CH221 CH220 CH219	Medium-bedded, arenaceous, shell fragment dolomite, interbedded with marl; abundant *Exogyra*.	9.00
7	CH218 CH217	Thick-to medium-bedded, light, medium orthoquartzite with medium sorted, subangular grains; extensive dolomitization; some quartz grains show strong undulated extinction.	7.00
6	CH216	Thin-bedded, dark gray, arenaceous, shell fragment grainstone, interbedded with marl; abundant *Exogyra* and many other pelecypods, gastropods and solitary corals.	10.50
5	CH215	Medium-bedded, dark gray, dolomitized, shell fragment orthoquartzite, interbedded with marl; common *Exogyra*.	14.00
4	CH214 CH213 CH212	Medium-bedded, dark gray, very dolomitized orthoquartzite, interbedded with shale; common pelecypods and gastropods.	11.00
3	CH211 CH210	Thin-bedded, yellowish weathering, fine subarkose with subangular, medium sorted grains.	7.50
2		Covered interval.	29.00
		Total Thickness	121.00

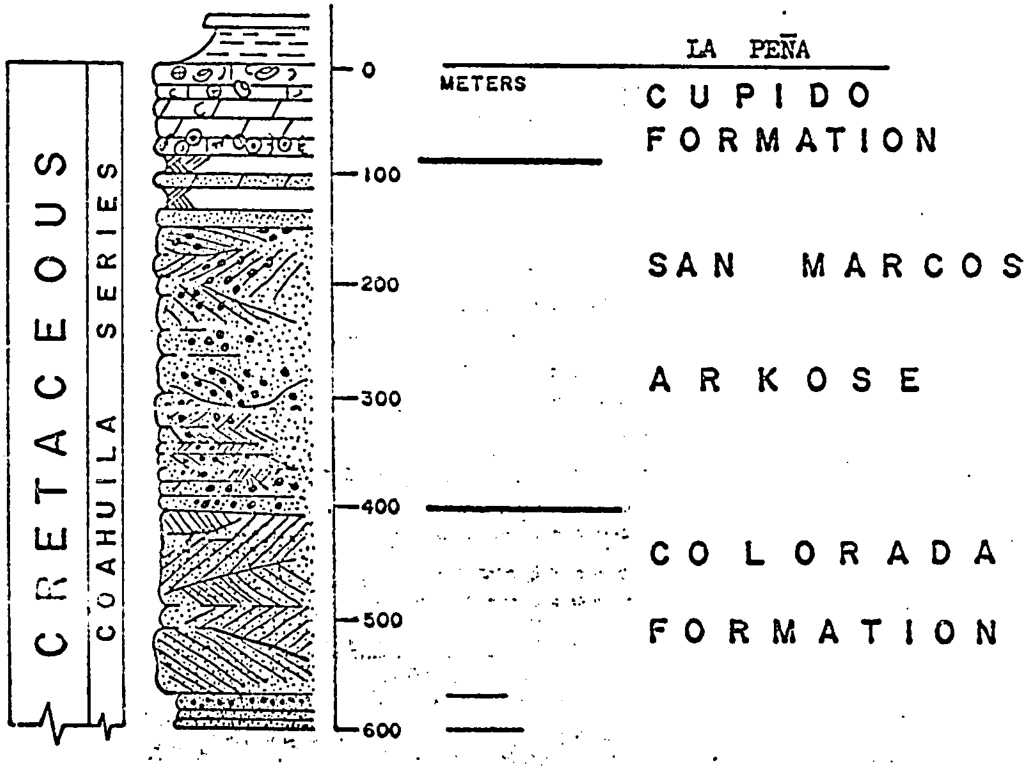
UNIT	SAMPLE	LITHOLOGY	METERS
SAN MARCOS ARKOSE			
1	CH298	Conglomeratic (granules with some medium and large cobbles), coarse subarkose with angular, poorly sorted grains.	13.00
		(Base of section not exposed)	

Total Thickness 13.00

Total Thickness of Section 943.00

SIERRA COLORADA

4



SIERRA COLORADA

SECTION 4

Northern flank of Potrero Colorado,
approximately 20 Km. northwest
of Rancho San Fernando.

CUPIDO FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
30	CH351 CH350	Very thick-to thick-bedded, echinoderm, shell fragment, miliolid mudstone to wackestone.	15.50
29	CH349 CH348	Thick-bedded, greenish-gray, shell fragment mudstone.	7.50
28	CH347	Medium-bedded, gray, miliolid, echinoderm fragment, intraclast grainstone.	5.00
27	CH346	Thick-to medium-bedded, shell fragment, dolomitic mudstone.	7.50
26	CH345 CH344	Thick-to medium-bedded, light gray, mollusc fragment, intraclast wackestone.	7.00
25	CH343 CH342 CH341	Thick-to medium-bedded, gray dolomite; medium intercrystalline porosity.	12.50
24	CH340	Thick-bedded, gray, slightly dolomitized mudstone.	6.50
23	CH339 to CH336	Medium-to thin-bedded dolomite; excellent vuggy and intercrystalline porosity.	10.50
22	CH335	Medium-bedded, reddish-brown weathering, oolite, algal fragment, intraclast grainstone; medium intergranular porosity.	6.00
		Total Thickness	78.00

UNIT	SAMPLE	LITHOLOGY	METERS
SAN MARCOS ARKOSE			
21		Covered interval.	5.00
20	CH334	Thick-bedded, slightly arenaceous dolomite; excellent vuggy and intercrystalline porosity.	2.50
19		Covered interval.	5.00
18	CH332	Medium-bedded, reddish-brown weathering, dolomitized subarkose; well sorted, angular grains.	2.50
17		Covered interval.	11.00
16		Thick-to medium-bedded, dolomitized orthoquartzite; well sorted, subangular grains; large scale festoon cross-bedding.	6.00
15	CH331 CH330	Thick-to thin-bedded, very arenaceous dolomite.	6.00
14	CH329 CH328 CH327	Very thick-to medium-bedded, light, submature arkose; angular, poorly sorted grains; calcite cement partially replaced by dolomite; good intergranular porosity.	25.00
13	CH325 CH324	Thick-bedded, reddish, slightly conglomeratic (granules and small pebbles), coarse submature subarkose; subrounded, poorly sorted grains; small scale planar cross-bedding.	8.00
12		Very thick-bedded, reddish, conglomeratic (granules and medium pebbles), coarse subarkose; subrounded, poorly sorted grains; channel filling in the lower part.	24.00
11	CH323	Thick-bedded, dolomitized subarkose; numerous calcite nodules.	2.00

UNIT	SAMPLE	LITHOLOGY	METERS
10	CH322 CH964	Very thick-to thick-bedded, arkosic conglomerate, composed by large and medium size pebbles of milky quartz, igneous and metamorphic rocks; presence of fluvial channels; matrix formed of coarse grains of quartz and feldspar; calcitic and dolomitic cement.	67.00
9	CH963	Very thick-to medium-bedded, brownish-red, conglomeratic (small pebbles and some large cobbles) coarse subarkose; poorly sorted, angular grains.	33.00
8	CH962	Thick-to thin-bedded, conglomeratic (granules and pebbles) coarse subarkose; angular, poorly sorted grains; large scale cross-bedding.	60.00
7		Thick-to medium-bedded, reddish, arkosic siltstone.	14.00
6		Covered interval.	7.00
5	CH961 CH960	Thick-to medium-bedded, reddish, arkosic siltstone; numerous mudballs.	24.00
		Total Thickness	302.00

COLORADA FORMATION

UPPER MEMBER

4	CH390 to CH386	Very thick-bedded, reddish, fine to medium orthoquartzite formed by very well sorted, well rounded grains; very large scale Beta cross-stratification sets.	186.00
3		Medium-to thin-bedded, reddish, siltstone; mud-cracks.	5.00

LOWER MEMBER

2	CH305	Thick-bedded, reddish conglomerate formed by large and medium pebbles and some small cobbles of milky quartz and igneous rocks.	5.00

UNIT	SAMPLE	LITHOLOGY	METERS
1	CH304 CH303 CH302	Thick-to medium-bedded, reddish, coarse subarkose; subangular, poorly sorted grains.	25.00

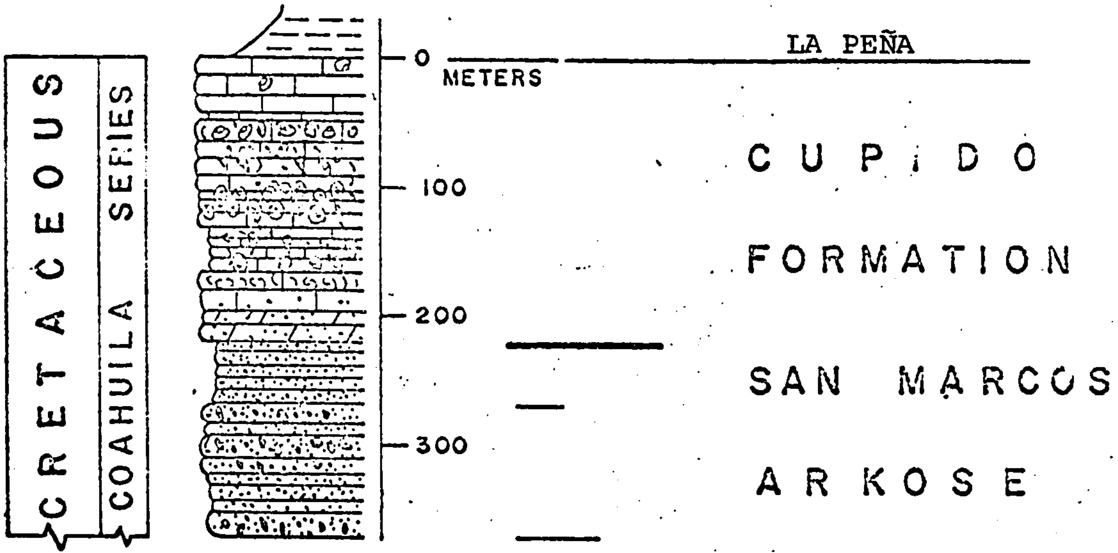
(Base of section not exposed)

Total Thickness 221.00

Total Thickness of Section
601.00

SIERRA DE LA MADERA

5



SIERRA DE LA MADERA

SECTION 5

Southern flank of Sierra de la Madera, approximately 20 km west of Cuatro Cienegas, Coahuila, near an abandoned mine.

CUPIDO FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
57	CH394	Thick-to medium-bedded, light, shell fragment wackestone.	1.53
56	CH393	Very thick-bedded, reddish-weathering, miliolid mudstone.	23.67
55	CH392	Thick-bedded, gray, shell fragment, miliolid mudstone.	3.15
54		Very thick-bedded, rudistid shell fragment wackestone.	0.95
53	CH391	Very thick-to medium-bedded, light gray, miliolid, shell fragment mudstone.	5.05
52	CH390	Very thick-bedded, shell fragment wackestone with Monopleura.	2.15
51		Thick-bedded, gray, miliolid, shell fragment mudstone.	1.90
50	CH389	Very thick-bedded, reddish weathering, shell fragment grainstone.	3.60
49		Thin-bedded, slightly arenaceous mudstone.	2.10
48		Very thick-to thick-bedded, recrystallized mudstone.	4.20
47	CH388	Thick-bedded, shell fragment, oolite wackestone to packstone.	5.75
46	CH387 CH386	Very thick-to thick-bedded, gray, recrystallized mudstone; chert nodules in the middle part.	13.75

UNIT	SAMPLE	LITHOLOGY	METERS
45		Thick-bedded, gray, oolite, shell fragment grainstone.	3.05
44	CH385	Very thick-to thick-bedded, shell fragment, miliolid mudstone.	6.55
43		Very thick-bedded, oyster shell fragment wackestone.	0.75
42		Thick-bedded, shell fragment, miliolid mudstone to wackestone; burrowing in the middle part.	10.00
41	CH384	Thick-bedded, pellet, shell fragment wackestone.	2.65
40	CH383 CH382	Thick-to thin-bedded, shell fragment, miliolid mudstone to wackestone.	6.30
39	CH381	Thick-bedded, light-gray, oolite, shell fragment mudstone.	2.10
38		Thick-bedded, shell fragment, oolite grainstone.	5.25
37	CH380	Thick-to medium-bedded, shell fragment, miliolid wackestone.	3.15
36	CH379	Thick-bedded, light gray, miliolid, recrystallized mudstone.	12.60
35	CH378	Thick-bedded, miliolid mudstone.	2.20
34	CH377	Thin-bedded, yellowish-weathering, arenaceous mudstone.	2.70
33		Thick-bedded, dark gray, shell fragment, oolite wackestone.	4.30
32		Very thick-bedded, shell fragment wackestone with <u>Monopleura</u> (?); chert nodules in the lower part.	2.00
31	CH376	Thick-bedded, light gray, shell fragment wackestone.	5.25

UNIT	SAMPLE	LITHOLOGY	METERS
30	CH375	Thick-to medium-bedded, shell fragment, oolite mudstone.	2.10
29	CH374	Thick-to medium-bedded, gray, shell fragment wackestone.	2.10
28		Medium-bedded, light gray, recrystallized mudstone.	4.20
27	CH373	Thick-to medium-bedded, light gray, oolite grainstone.	1.25
26		Thick-to medium-bedded mudstone.	3.05
25	CH372	Medium-bedded, very thinly laminated, algal stromatolite.	0.60
24		Medium-bedded, light gray mudstone.	3.65
23	CH371	Very thick-bedded, shell fragment grainstone.	2.50
22		Very thick-bedded, oolite, shell fragment wackestone.	2.90
21	CH370	Very thick-bedded, oolite grainstone.	1.70
20	CH369	Thick-bedded, gray, shell fragment mudstone.	2.30
19		Very thick-to thick-bedded, recrystallized mudstone.	4.20
18		Very thick-bedded, dark gray, dolomitic mudstone.	4.20
17	CH368	Medium-bedded, oolite, pellet grainstone.	1.80
16	CH367 CH366 CH365	Thick-to medium-bedded, recrystallized, arenaceous, shell fragment mudstone.	20.80
15	CH364	Thick-bedded, light gray, arenaceous, shell fragment, oolite wackestone.	9.80

UNIT	SAMPLE	LITHOLOGY	METERS
14	CH363 CH362	Thick-to medium-bedded, arenaceous, dark gray, shell fragment dolomite.	6.20
		Total Thickness	210.00

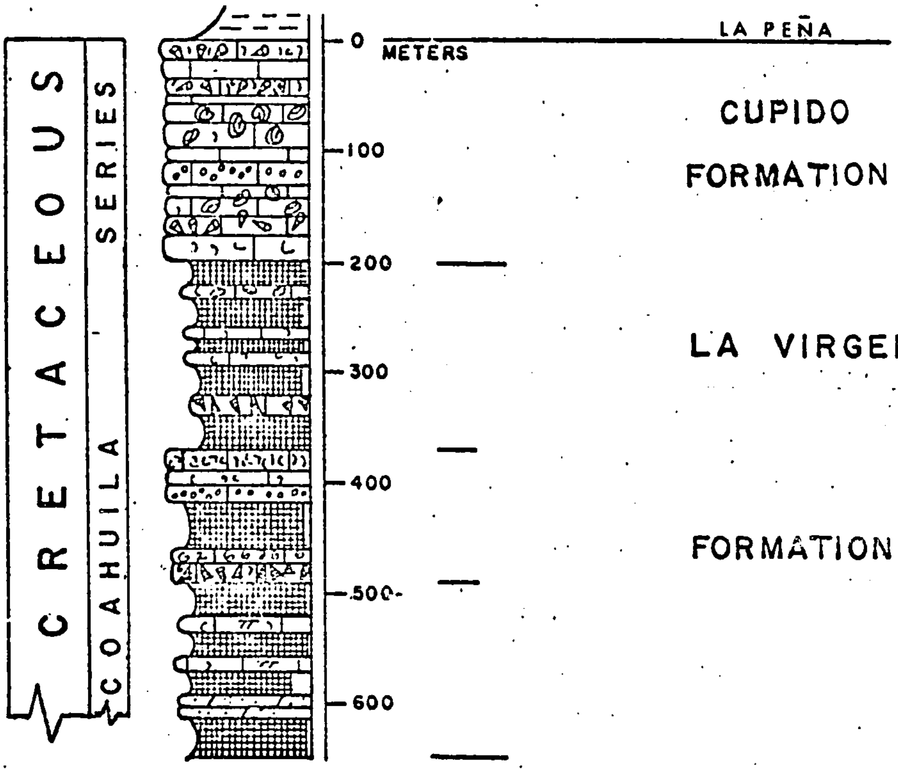
SAN MARCOS ARKOSE

13	CH361	Medium-to very thin-bedded, fine orthoquartzite; rounded, well sorted grains.	28.00
12	CH360	Thick-to medium-bedded, reddish, fine to medium arkosic siltstone.	2.30
11	CH359	Thick-to medium-bedded, reddish, medium, submature arkose; subrounded, medium sorted grains.	21.60
10	CH358	Medium-to thin-bedded, light, very coarse arkose with subangular, medium sorted grains.	6.40
9	CH357	Very thick-to thick-bedded, slightly conglomeratic (granules and medium pebbles) coarse arkose with subangular, medium sorted grains.	21.40
8		Covered interval.	2.40
7		Thick-to medium-bedded, reddish, conglomeratic (large to medium pebbles), coarse subarkose with subangular, poorly sorted grains.	9.40
6		Very thick-bedded, slightly conglomeratic (medium pebbles), very coarse subarkose; medium sorted, subangular grains.	3.30
5		Very thick-to thick-bedded, coarse arkose.	9.90
4	CH356	Medium-bedded, light, coarse arkose with medium sorted, subangular grains.	9.50
3		Very thick-bedded, light, coarse arkose with medium rounded, medium sorted grains; abundant malaquite and azurite.	2.40

UNIT	SAMPLE	LITHOLOGY	METERS
2	CH355	Thick-to medium-bedded, light, coarse arkose with medium sorted, subangular grains.	18.25
1	CH354	Very thick-bedded, brownish-red, conglomeratic (large pebbles and some small cobbles) coarse subarkose with angular, medium sorted grains.	<u>12.15</u>
		(Base of section not exposed)	
		Total Thickness	147.00
		Total Thickness of Section	357.00

POTRERO DE LA VIRGEN

6



POTRERO DE LA VIRGEN

SECTION 6

Eastern flank of Potrero de La Virgen,
approximately 12 Km. northeast of
Cuatro Cienegas, Coahuila.

CUPIDO FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
39		Very thick-bedded, shell fragment wackestone with Monopleura.	5.00
38	CH349 CH348	Very thick-to thick-bedded, gray, miliolid mudstone.	33.00
37		Thick-bedded, miliolid wackestone.	6.00
36	CH347	Very thick-bedded, shell fragment wackestone to packstone with numerous Monopleura.	8.00
35		Very thick-bedded, miliolid mudstone.	18.00
34		Very thick-bedded, shell fragment wackestone with Toucasia.	4.00
33		Very thick-to thick-bedded, shell fragment, miliolid mudstone.	19.50
32	CH346	Very thick-bedded, shell fragment wackestone with Toucasia.	2.50
31		Thick-bedded, miliolid wackestone.	6.50
30		Very thick-to thick-bedded, shell fragment, miliolid mudstone.	27.50
29	CH344	Thick-bedded, shell fragment, pellet grainstone.	2.00
28		Very thick-to thick-bedded mudstone.	8.50
27	CH343	Thick-bedded, thinly laminated, algal stromatolite.	3.00

UNIT	SAMPLE	LITHOLOGY	METERS
26	CH342	Very thick-to medium-bedded, shell fragment, miliolid wackestone with chert nodules in the top.	6.50
25	CH341	Very thick-bedded, shell fragment, miliolid mudstone to wackestone.	6.00
24	CH340	Very thick-to medium-bedded, slightly recrystallized mudstone.	15.00
23	CH339	Very thick-bedded, oolite grainstone.	2.50
22		Thick-bedded, shell fragment mudstone.	1.50
21	CH338	Very thick-bedded, shell fragment wackestone with <u>Monopleura</u>.	4.00
20	CH337 CH336	Very thick-to thick-bedded, shell fragment mudstone.	21.00
		Total Thickness	200.00

<u>LA VIRGEN FORMATION</u>

<u>UPPER MEMBER</u>

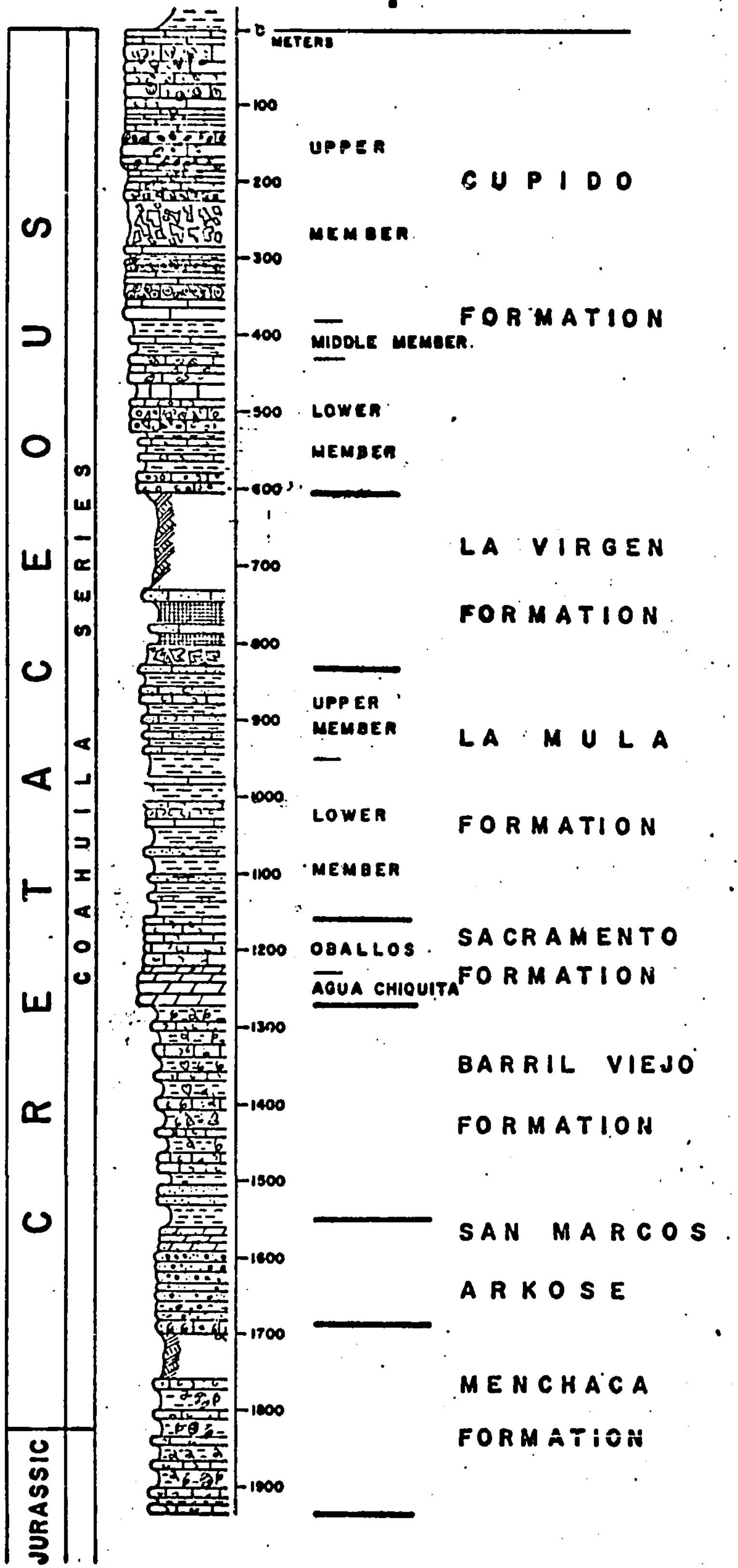
19		Covered interval.	19.00
18	CH335 to CH332	Thick-bedded gypsum, interbedded with medium to thin bedded, miliolid mudstone.	83.00
17	CH331 CH330	Thick-to thin-bedded, intraclast, shell fragment mudstone.	22.50
16	CH329 to CH325	Gypsum interbedded with thin beds of shell fragment mudstone and wackestone; upper part has numerous, oriented, small <u>Turritella</u>.	56.00

UNIT	SAMPLE	LITHOLOGY	METERS
MIDDLE MEMBER			
15	CH324 CH323 CH322	Thick-to thin-bedded, dark gray, shell fragment mudstone, interbedded with shales.	31.00
14		Thinly laminated, shell fragment mudstone.	9.50
13	CH321	Very thick-bedded, shell fragment, pellet grainstone.	2.50
LOWER MEMBER			
12	CH320	Gypsum, interbedded with thin bedded, dolomitized, shell fragment mudstone.	33.00
11	CH319	Thin-bedded, mollusc shell fragment packstone.	6.50
10	CH318 CH317	Thin-bedded, shell fragment mudstone, interbedded with shale; common <u>Turritella</u> in the middle.	14.00
9	CH316	Medium-to thin-bedded, shell fragment wackestone; abundant <u>Turritella</u> in the upper part.	10.00
8		Gypsum, interbedded with mudstone.	6.00
7	CH314	Medium-bedded, pellet grainstone.	2.00
6		Thin-bedded, recrystallized mudstone.	4.00
5	CH313 CH312	Gypsum, interbedded with thin bedded, slightly dolomitized, shell fragment mudstone.	31.00
4	CH311	Thin-bedded, shell fragment wackestone.	2.00
3	CH310	Very thin-bedded mudstone.	10.00
2	CH309	Medium-bedded, mollusc shell fragment packstone.	2.00

UNIT	SAMPLE	LITHOLOGY	METERS
1	CH308 to CH300	Gypsum, interbedded with thin bedded, slightly dolomitized, shell fragment mudstone to wackestone.	105.00
		(Base of section not exposed)	
		Total Thickness	449.00
		Total Thickness of Section	649.00

POTRERO DE MENCHACA

7



POTRERO DE MENCHACA

SECTION 7

Measured in the southeastern corner of Potrero de Menchaca, along the Arroyo de Lamadrid.

CUPIDO FORMATION

UPPER MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
103		Thick-bedded mudstone.	12.50
102	CH501	Very thick-bedded, caprinid boundstone.	24.00
101	CH500	Very thick-bedded mudstone.	17.00
100		Thick-bedded, shell fragment wackestone; abundant Monopleura.	3.00
99	CH499	Very thick-to thick-bedded, miliolid, shell fragment wackestone to packstone.	5.00
98		Thick-bedded, miliolid, shell fragment mudstone.	9.50
97	CH498	Thick-bedded, shell fragment wackestone; abundant Monopleura and Toucasia.	9.00
96	CH497	Thick-bedded, foraminifera, miliolid grainstone.	7.50
95		Very thick-bedded, shell fragment mudstone; few Toucasia.	11.00
94	CH496	Very thick-to thin-bedded mudstone.	25.00
93	CH495	Thin-bedded, shell fragment mudstone.	6.00
92	CH494 CH493	Medium-bedded, miliolid, shell fragment mudstone to wackestone; few Toucasia.	8.50
91	CH492 CH491	Very thick-bedded, shell fragment, miliolid mudstone.	18.50

UNIT	SAMPLE	LITHOLOGY	METERS
90		Thick-bedded, shell fragment wackestone; common <u>Monopleura</u>.	2.00
89	CH490 CH489	Very thick-to thick-bedded, intraclast, miliolid wackestone.	19.00
88		Thick-bedded, intraclast grainstone.	4.50
87	CH488 to CH481	Very thick-to thin-bedded, miliolid, shell fragment mudstone.	35.00
86	CH480	Thick-bedded, rounded intraclast grainstone.	2.00
85	CH479 to CH476	Thick-bedded, rounded intraclast wackestone to packstone.	6.50
84		Collapse breccia.	16.50
83		Covered interval.	8.50
82		Collapse breccia.	24.00
81	CH475 to CH473	Medium-bedded, dolomitized siltstone.	1.50
80		Medium-to thin-bedded, shell fragment, pellet packstone to grainstone.	2.50
79	CH472	Very thick-bedded, dolomitized, pellet wackestone.	2.00
78		Thin-bedded mudstone; interbedded with shale.	3.00
77		Covered interval.	23.50
76		Thin-bedded mudstone, interbedded with shale.	11.00
75	CH471	Very thick-to thick-bedded, silty mudstone.	17.00

UNIT	SAMPLE	LITHOLOGY	METERS
74	CH470	Thin-bedded, arenaceous, dolomitized, shell fragment wackestone, interbedded with shale.	10.00
73	CH469 CH468	Thick-bedded, dolomitized, shell fragment, oolite grainstone; medium intergranular porosity.	5.50
72		Very thick-bedded mudstone.	8.00
71	CH467	Thick-bedded, shell fragment, pellet packstone.	5.00
70	CH466	Thick-bedded, cross-bedded, shell fragment grainstone; excellent buggy porosity.	3.00
69		Thick-bedded mudstone.	5.50
BERRENDO MEMBER			
68	CH465	Thin-bedded, black to dark gray mudstone, interbedded with shale.	12.50
67	CH464 to CH461	Medium-to thin-bedded, black to dark gray, bituminous mudstone, interbedded with shale.	37.50
LOWER MEMBER			
66	CH460	Medium-bedded, algal fragment, shell fragment wackestone.	9.00
65	CH459	Thick-bedded, recrystallized, intraclast, shell fragment packstone.	2.50
64	CH458	Very thick-bedded, intraclast, miliolid mudstone.	11.50
63	CH457	Thick-bedded, miliolid, shell fragment grainstone.	6.00
62	CH456	Very thick-bedded, miliolid, oolite grainstone.	4.00
61		Collapse breccia.	4.50

UNIT	SAMPLE	LITHOLOGY	METERS
60		Covered interval.	12.50
59	CH455	Thin-bedded mudstone.	5.00
58		Medium-to thin-bedded mudstone.	11.00
57		Covered interval.	13.00
56	CH454	Thick-bedded, dolomitized, shell fragment grainstone.	6.50
55	CH453 CH452	Medium-bedded, shell fragment, miliolid mudstone.	3.00
54		Nodular marl.	3.00
53		Collapse breccia.	3.00
52	CH450	Medium-to thin-bedded, shell fragment, pellet mudstone, interbedded with shale.	28.50
51		Medium-bedded, silty mudstone, interbedded with shale.	18.00
50	CH449	Thick-to thin-bedded mudstone.	8.00
49		Algal stromatolite with a thin gypsum bed in the upper part.	6.00
48	CH448	Medium bedded, silty mudstone.	6.00
47	CH447	Thick-to medium-bedded, dolomitic, pellet, shell fragment wackestone.	16.00
		Total Thickness	599.00

LA VIRGEN FORMATION

46		Covered interval.	132.00
45	CH446 CH445	Thick-to thin-bedded, calcareous siltstone, interbedded with gypsum.	25.00
44	CH444	Gypsum, interbedded with recrystallized mudstone.	13.00

UNIT	SAMPLE	LITHOLOGY	METERS
43		Gypsum, interbedded with yellowish-weathering siltstone.	18.00
42		Thick-bedded, contorted, yellowish siltstone; common nodules of calcite pseudomorphs.	2.00
41		Collapse breccia.	35.00
		Total Thickness	225.00

LA MULA FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
40		Highly contorted, shell fragment mudstone.	2.00
39	CH443	Very thick-bedded, cross-bedded, oolite grainstone.	2.00
38	CH442 CH441	Contorted, yellowish, calcareous siltstone.	22.00
37		Medium-to thin-bedded, calcareous siltstone, interbedded with shale.	14.00
36	CH440 CH439	Contorted, yellowish-weathering, calcareous siltstone.	7.00
35		Medium-to thin-bedded mudstone.	5.00
34	CH438	Collapse breccia.	3.50
33		Medium-to thin-bedded, yellowish weathering, contorted siltstone; calcite nodules and "chicken-wire" structures.	6.50
32	CH437 CH436	Silty mudstone, interbedded with shale.	23.00
31		Thick-bedded, shell fragment mudstone, interbedded with nodular shale.	8.00
30	CH432 CH431 CH430	Thin-bedded, shell fragment mudstone.	18.00
29		Collapse breccia.	3.00

UNIT	SAMPLE	LITHOLOGY	METERS
28		Covered interval.	20.00
27	CH429 CH428 CH427	Medium-bedded, yellowish-weathering, calcareous siltstone, interbedded with shale.	50.50
26		Collapse breccia.	2.00
25	CH426 to CH423	Medium-to thin-bedded, shell fragment mudstone, interbedded with shale.	32.00
24	CH422 to CH419	Thin-bedded, yellowish-weathering, silty mudstones, interbedded with shales.	44.50
23	CH418 to CH414	Medium-to thin-bedded, silty mudstones, interbedded with shales; symmetric ripple marks in the middle.	69.00
22		Collapse breccia.	3.00
		Total Thickness	335.00

SACRAMENTO FORMATION

OBALLOS MEMBER

21	CH411 CH410	Very thick-to thick-bedded, dark gray, dolomitized, shell fragment mudstone.	37.00
20	CH409	Very thick-bedded, nodular, shell fragment wackestone; common gastropods and pelecypods, Harpagodes.	20.00

AGUA CHIQUITA MEMBER

19		Medium-bedded, dark gray, silty dolomite.	13.00
18		Very thick-to thick-bedded, dark gray dolomites; few Monopleura (?) in the upper part.	34.00
		Total Thickness	104.00

UNIT	SAMPLE	LITHOLOGY	METERS
BARRIL VIEJO FORMATION			
17		Thick-to medium-bedded, nodular shell fragment wackestone, interbedded with nodular marls; abundant gastropods, pelecypods and solitary corals.	136.00
16		Very thick-bedded, nodular marls; abundant brachiopods, pelecypods and gastropods.	50.00
15	CH540 CH539	Thick-to medium-bedded, shell fragment mudstones and wackestones, interbedded with nodular marl; abundant pelecypods and serpulid tubes.	61.00
		Total Thickness	247.00
SAN MARCOS ARKOSE			
14	CH538	Medium-bedded, reddish, conglomeratic (granules and small pebbles), coarse subarkose.	3.00
13	CH536	Thick-bedded, cross-bedded, coarse arkose; subangular, medium sorted grains.	9.00
12	CH535 CH534	Thin-bedded, silty mudstone, interbedded with shale.	14.00
11	CH533	Very thick-bedded, cross-bedded, conglomeratic (small pebbles and granules) coarse subarkose; subangular, medium sorted grains.	7.00
10	CH532 CH531	Very thick-to thick-bedded, dark gray, arenaceous dolomite.	35.00
9	CH530 to CH525	Very thick-to thick-bedded, cross-bedded, conglomeratic (small pebbles and granules), coarse to very coarse arkose; subrounded, medium sorted grains.	39.00

UNIT	SAMPLE	LITHOLOGY	METERS
8	CH524 to CH517	Very thick-bedded, conglomeratic (small pebbles and granules) coarse subarkose; subrounded, medium sorted grains.	52.00
		Total Thickness	159.00

MENCHACA FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
7	CH516 CH515 CH514	Medium-to thin-bedded, dolomitized arenaceous, shell fragment packstone, interbedded with nodular shales; common *Exogyra*.	23.00
6		Covered interval.	61.00
5	CH513	Thick-to medium-bedded, dark gray, shell fragment mudstone, interbedded with nodular marls; common *Exogyra*.	39.00
4	CH512	Thick-bedded, dark gray, shell fragment mudstone.	12.00
3	CH511 CH510	Thick-to medium-bedded, dark gray, ostracod, shell fragment mudstone, interbedded with nodular marl; abundant *Exogyra* some fragments of *Berriasella* (?); common tintinids resembling *Calpionella* and *Tintinopsella*.	35.00
2	CH509 to CH506	Thick-to medium-bedded, black to dark gray, shell fragment mudstone, interbedded with nodular marls; common *Calpionella* and *Exogyra*.	60.00
1	CH505 to CH502	Medium-to thin-bedded, dark gray, shell fragment mudstone, interbedded with shales; common authigenic quartz and *Exogyra*.	20.00
		(Base of section not exposed)	
		Total Thickness	250.00
		Total Thickness of Section	1919.00

SIERRA DEL FUSTE

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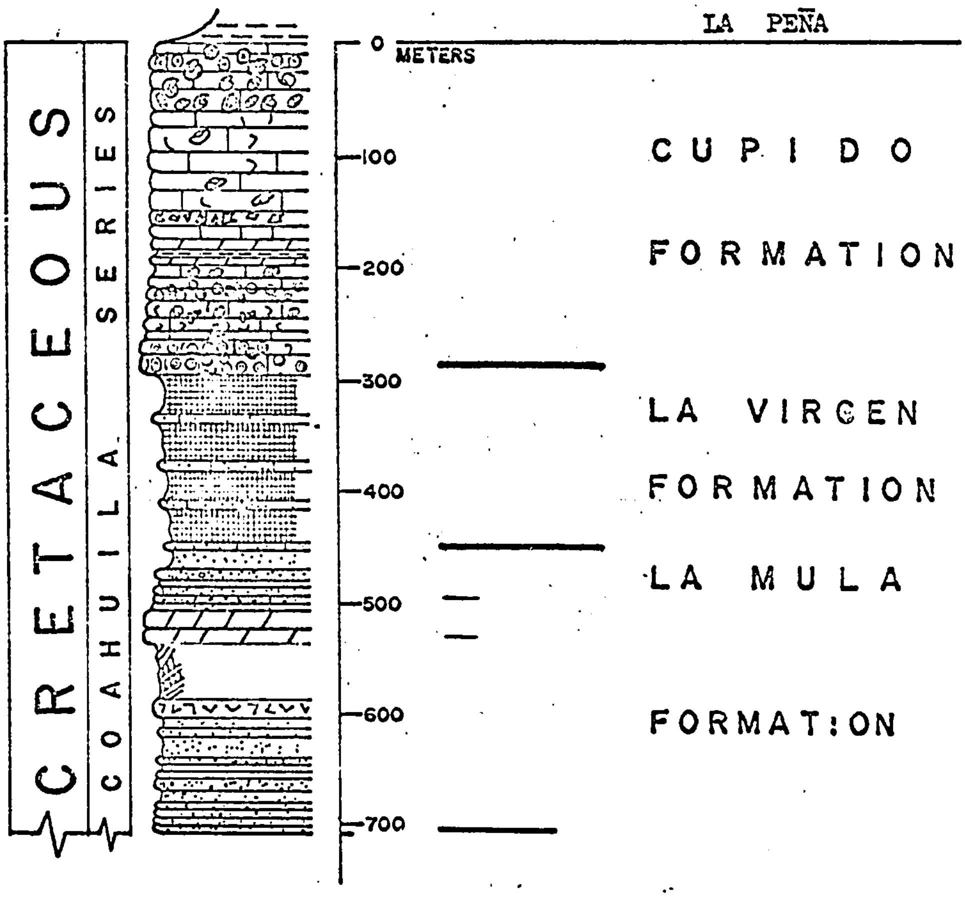


SIERRA DEL FUSTE

SECTION 9

Western margin of Sierra del Fuste,
about 8 Km. east of Rancho El Fuste.

CUPIDO FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
46	CH603	Very thick-to thick-bedded, light gray, intraclast, pellet, oolite grainstone.	14.50
45	CH602	Thick-bedded mudstone.	9.00
44	CH601	Very thick-bedded, shell fragment, intraclast wackestone; common <u>Toucasia</u>.	7.00
43		Thick-bedded mudstone.	2.00
42	CH600	Thick-bedded, shell fragment, pellet grainstone; common <u>Toucasia</u>.	6.00
41		Thick-bedded mudstone.	4.50
40	CH599	Thick-bedded, intraclast, oolite grainstone.	9.50
39	CH598	Very thick-bedded, shell fragment wackestone; few <u>Toucasia</u>.	4.50
38	CH597	Thick-bedded, miliolid mudstone.	12.00
37	CH596	Thick-bedded, intraclast, shell fragment wackestone.	4.00
36	CH595 to CH592	Very thick-to thick-bedded, miliolid mudstone.	59.00
35		Collapse breccia.	4.00
34	CH591	Very thick-bedded mudstone.	8.00
33		Covered interval.	5.00
32		Thick-to medium-bedded mudstone.	5.00

UNIT	SAMPLE	LITHOLOGY	METERS
31	CH590 CH589	Very thick-to thick-bedded, shell fragment, oolite grainstone.	11.00
30	CH588	Thick-bedded mudstone.	6.50
29	CH587	Medium-bedded dolomite, interbedded with nodular shale.	19.00
28	CH586	Thick-to thin-bedded, intraclast, annelid tube mudstone.	14.00
27	CH585 CH584	Very thick-bedded, shell fragment, intraclast wackestone; common *Toucasia*.	9.00
26	CH583	Very thick-bedded, intraclast, oolite grainstone.	13.00
25	CH582	Thick-bedded, miliolid mudstone.	10.00
24	CH581 CH580	Medium-bedded, intraclast, oolite wackestone.	18.00
23	CH579	Very thick-to thick-bedded, shell fragment, oolite grainstone.	3.50
22		Covered interval.	4.00
21	CH578	Thin-bedded, pellet grainstone; very dolomitized.	4.00
20	CH577 CH576	Medium-bedded, oolite grainstone.	9.00
19		Very thick-bedded mudstone.	4.00
18	CH574	Thin-bedded, intraclast wackestone.	1.00
		Total Thickness	280.00

LA VIRGEN FORMATION

17		Covered interval.	48.00
16		Gypsum, interbedded with thin bedded siltstone.	100.00

UNIT	SAMPLE	LITHOLOGY	METERS
15	CH572	Medium-bedded orthoquartzite, interbedded with shale.	37.00
14		Covered interval.	4.00
13	CH568	Gypsum, interbedded with medium to thin bedded, fine orthoquartzite.	31.00
12	CH567 to CH563	Medium-bedded dolomite, interbedded with shale.	30.00
11		Covered interval.	54.00
		Total Thickness	304.00

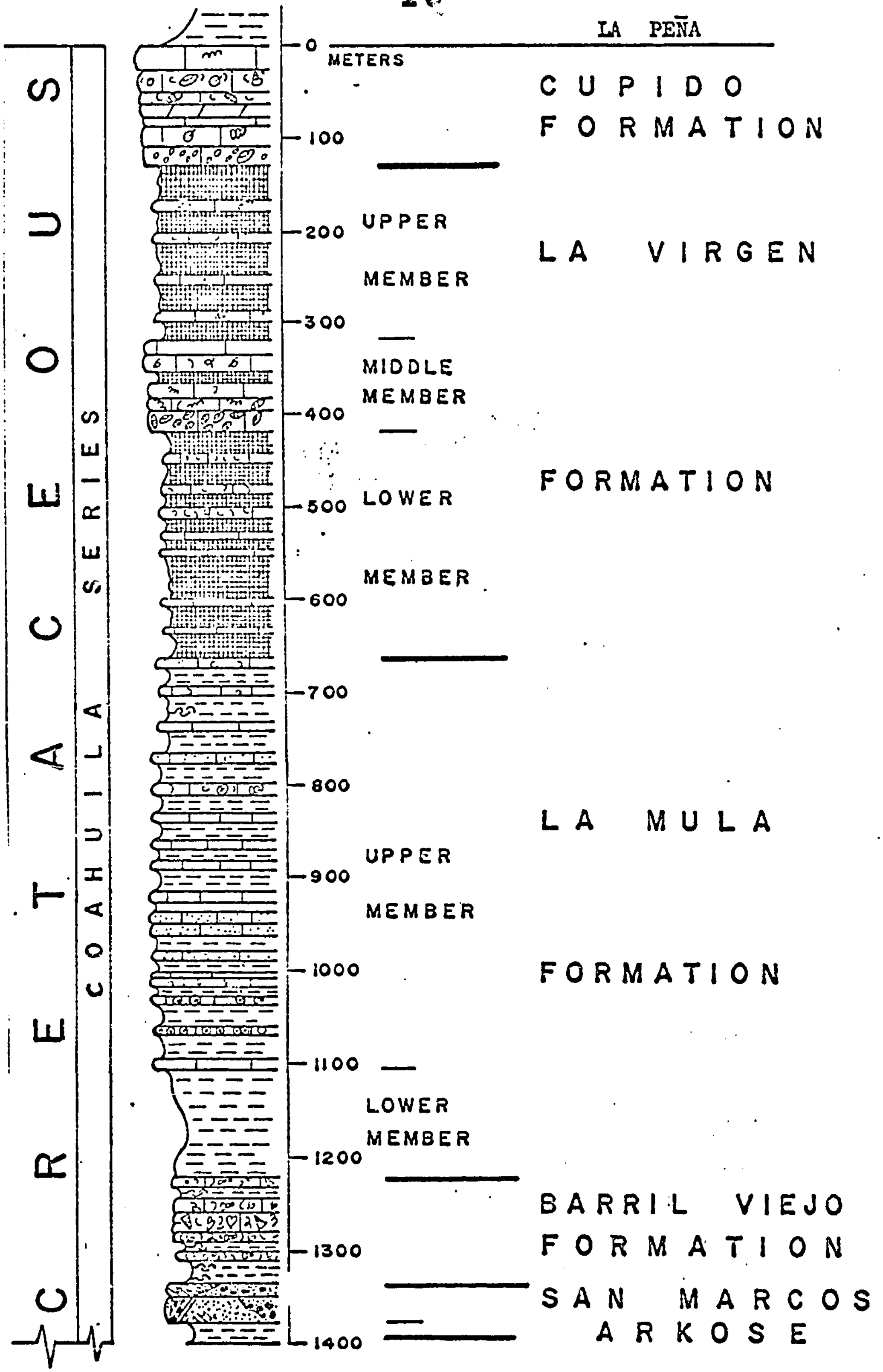
LA MULA FORMATION

10		Sill of igneous rock.	19.00
9		Covered interval.	11.00
8		Thin-bedded, medium orthoquartzite, interbedded with nodular siltstone.	58.00
7		Covered interval.	1.00
6		Thick-to medium-bedded, coarse subarkose.	2.00
5		Covered interval.	2.00
4	CH562	Medium-bedded, coarse orthoquartzite, interbedded with shale.	6.50
3	CH561	Thick-bedded, coarse orthoquartzite, interbedded with shale.	6.50
2	CH560 CH559	Very contorted, thin bedded, fine orthoquartzite, interbedded with very thin layers of gypsum.	13.00
1	CH558 CH557	Thin-bedded, fine orthoquartzite, interbedded with gypsum.	6.00

UNIT	SAMPLE	LITHOLOGY	METERS
		(Base of section not exposed)	
		Total Thickness	125.00
		Total Thickness of Section	709.00

POTRERO DE PADILLA

10



POTRERO DE PADILLA

SECTION 10

This section was measured in the northwestern corner of Potrero de Padilla, 3 Km. west of Puerto de Padilla.

CUPIDO FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
58	CH887 CH886 CH885	Thick-to medium-bedded, laminated, black to dark gray, pellet, annelid tube mudstone; middle part partially dolomitized.	52.50
57	CH884	Thick-bedded, oyster fragment, intraclast, annelid tube wackestone.	2.50
56	CH883 CH882	Thick-to medium-bedded, black to dark gray, shell fragment, intraclast, ostracod wackestone.	13.50
55	CH881	Thick-to medium-bedded, light gray, intraclast, shell fragment, algal fragment grainstone.	4.00
54	CH880	Thick-to thin-bedded, light gray, ostracod fragment, miliolid wackestone.	5.00
53		Thick-to medium-bedded, black dolomite.	7.50
52		Covered interval.	6.50
51	CH878 CH877	Medium-to very thin-bedded, black to dark gray, miliolid, foraminifera, ostracod mudstone; middle part has good vuggy porosity.	27.00
50	CH876 CH875 CH874	Thick-bedded, dark gray, mollusc shell fragment, pellet, miliolid, algal fragment grainstone; medium intergranular and intragranular porosity; few <u>Choffatella</u>.	7.50
		Total Thickness	126.00

UNIT	SAMPLE	LITHOLOGY	METERS
<u>LA VIRGEN FORMATION</u>			
<u>UPPER MEMBER</u>			
49	CH873	Gypsum, interbedded with thin-bedded, gray, shell fragment mudstone; few ostracods and <u>Choffatella</u>.	6.50
48	CH872 to CH868	Gypsum, interbedded with thin-bedded light gray, slightly argillaceous, intraclast, shell fragment wackestone and mudstone; <u>Choffatella</u> in the middle part.	155.50
<u>MIDDLE MEMBER</u>			
47		Thin-bedded, thinly laminated, black mudstone.	34.50
46	CH867 CH866 CH865	Medium-to thin-bedded, gray, shell fragment, annelid tube wackestone, interbedded with nodular, gray shale.	12.50
45		Gypsum.	20.50
44	CH864	Thick-to thin-bedded, black to dark gray, shell fragment mudstone.	24.50
43	CH863	Medium-bedded, dark gray, shell fragment, intraclast grainstone.	1.00
42	CH862 CH861 CH860	Thick-bedded, dark gray, shell fragment, annelid tube wackestone.	9.50
41	CH859	Thick-bedded, mollusc shell fragment, intraclast grainstone.	2.00
40	CH858	Thick-bedded, dark gray, intraclast, shell fragment grainstone.	3.00
39	CH857 CH856	Thick-to medium-bedded, coarse dolomite.	5.50

UNIT	SAMPLE	LITHOLOGY	METERS
LOWER MEMBER			
38	CH855 to CH851	Gypsum, interbedded with medium-to thin-bedded, dark gray, shell fragment, annelid tube, intraclast mudstone and wackestone.	79.00
37	CH850	Thick-bedded, bluish-gray, mollusc shell fragment, muddy grainstone.	3.00
36	CH849 CH848	Gypsum, interbedded with thick-to thin-bedded, yellowish-weathering, some quartz, argillaceous mudstone.	25.50
35	CH847	Thick-bedded, shell fragment mudstone.	2.00
34	CH846 CH845	Gypsum, interbedded with very thin-bedded, thickly laminated, yellowish-weathering, silty mudstone.	19.00
33	CH844 CH843	Thin-bedded, yellowish-weathering mudstone, interbedded with gray, nodular marl.	8.50
32	CH842	Medium-bedded, gray, shell fragment, miliolid, algal fragment grainstone; some intergranular porosity.	2.50
31	CH841	Thin-bedded mudstone, interbedded with nodular shale.	4.50
30	CH840 to	Gypsum, interbedded with thin-bedded, yellowish-weathering, slightly silty mudstone with excellent intragranular porosity.	95.00
		Total Thickness	514.00
LA MULA FORMATION			
29		Medium-to thin-bedded, bluish-gray, shell fragment mudstone, interbedded with nodular marl and shale.	55.80

UNIT	SAMPLE	LITHOLOGY	METERS
28	CH836 to CH833	Thin-to very thin-bedded, light gray mudstone, interbedded with fissile shale; abundant secondary quartz.	82.70
27	CH832	Medium-bedded, bluish gray, mollusc shell fragment, foraminifera, echinoderm fragment wackestone; common textularid foraminifera and Choffatella (?).	2.70
26		Very thin-bedded, bluish-gray mudstone, interbedded with fissile shale; good intergranular porosity.	16.00
25		Covered interval.	10.50
24	CH831 CH830	Thin-bedded, bluish-gray mudstone, interbedded with gray, fissile shale; presence of some gypsum in the lower part.	50.00
23	CH829	Thin-to very thin-bedded, bluish-gray mudstone, interbedded with light, fissile shale; lower interval with good intergranular porosity.	38.50
22	CH828 CH827 CH826	Very thin-to thin-bedded, yellowish-weathering mudstone, interbedded with fissile shale; common authigenic quartz.	50.50
21	CH825	Medium-bedded, shell fragment, algal fragment, foraminifera, intraclast grainstone; poor intergranular porosity.	1.00
20	CH824 CH823	Thin-to very thin-bedded, yellowish-weathering, thinly laminated, fine quartz grains, arenaceous mudstone.	18.00
19	CH822	Medium-bedded, bluish-gray, mollusc shell fragment, echinoderm fragment wackestone; few small gastropods.	2.00
18		Very thin-bedded, yellowish-weathering, silty mudstone, interbedded with bluish-gray, fissile shale.	19.50

UNIT	SAMPLE	LITHOLOGY	METERS
17	CH821	Medium-bedded, light gray, mollusc shell fragment grainstone.	2.00
16		Yellowish-weathering, fissile shale.	4.50
15	CH820	Medium-bedded, gray, oolite, mollusc shell fragment grainstone; medium intergranular porosity.	3.00
14	CH819 CH818	Very thin-to thin-bedded, yellowish-gray, silty mudstone, interbedded with light gray, fissile shale.	52.00
13	CH919 CH918	Medium-to thin-bedded, bluish, silty, echinoderm fragment, shell fragment mudstone, interbedded with yellowish-weathering, fissile shale.	10.50
LOWER MEMBER			
12	CH917 to CH913	Thick-to thin-bedded, red, nodular shale, interbedded with thin bedded, silty mudstone.	98.80
11	CH912 CH911 CH910	Medium-to thin-bedded, greenish, argillaceous, calcareous siltstone, interbedded with fissile shale.	12.00
10	CH908 CH905	Medium-to thin-bedded, reddish, calcareous siltstone, interbedded with greenish, fissile shale.	26.00
9	CH904	Medium-bedded, yellowish-weathering, angular, fine quartz grains, silty mudstone, interbedded with yellowish, fissile shale.	18.00
		Total Thickness	574.00
BARRIL VIEJO FORMATION			
8	CH903	Medium-to thick-bedded, dark gray and bluish-gray, shell fragment, echino-	

UNIT	SAMPLE	LITHOLOGY	METERS
		derm fragment, foraminifera, intraclast wackestone and packstone, interbedded with yellowish, fissile shales; common gastropods, pelecypods and *Choffatella*.	46.00
7	CH898 to CH888	Medium-bedded, bluish-gray, mollusc shell fragment, foraminifera, echinoderm fragment, ostracod fragment, algal fragment wackestone, interbedded with shell fragment, nodular marls; common gastropods, pelecypods and *Choffatella*.	39.50
6	CH935 CH934	Thick-to medium-bedded, bluish gray, shell fragment, intraclast, ostracod fragment wackestone, interbedded with nodular marl; presence of symmetric ripple marks in one of the beds.	10.00
5	CH933	Medium-bedded, yellowish, silty mudstone, interbedded with fissile shale.	7.50
		Total Thickness	103.00

SAN MARCOS ARKOSE

UPPER MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
4	CH932	Very thick-to thick-bedded, conglomeratic (small and large pebbles) coarse arkose.	23.50
3	CH931 CH930	Very thick-bedded, slightly conglomeratic (small pebbles) coarse arkose; angular, poorly sorted grains.	12.50
2	CH929 to CH924	Thick-bedded, conglomeratic (small pebbles) arkose; subangular, poorly sorted grains.	4.00

LOWER MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
1	CH923 CH922 CH921	Thin-bedded siltstone, interbedded with shales.	17.00

UNIT	SAMPLE	LITHOLOGY	METERS
		(Base of section not exposed)	
		Total Thickness	57.00
		Total Thickness of Section	1374.00

POTRERO DEL BERRENDO

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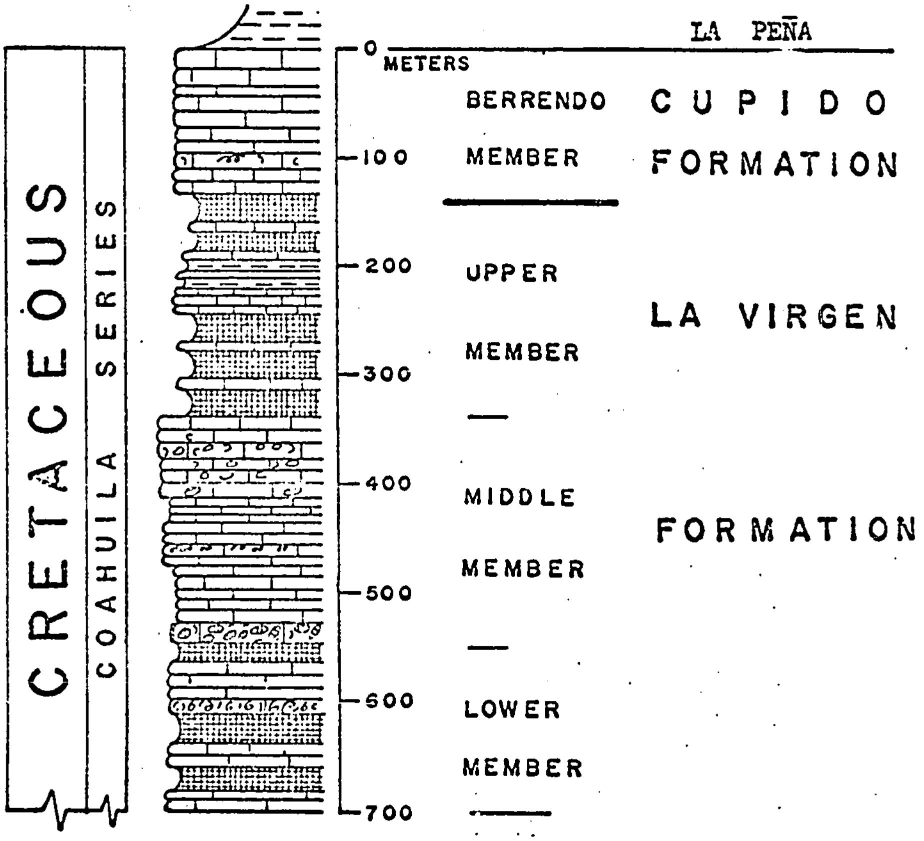


POTRERO DEL BERRENDO

SECTION 11

Section begins in the southern end of Potrero del Berrendo and continues along the eastern flank near Rancho El Berrendo.

CUPIDO FORMATION

BERRENDO MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
44	CH817	Thick-bedded, black mudstone.	7.00
43		Thin-to very thin-bedded, black mudstone, interbedded with marl.	9.50
42	CH816 CH815 CH814	Thick-to thin-bedded, black to dark gray mudstone.	38.00
41	CH813 CH812 CH811	Thin-to very thin-bedded, black to dark gray mudstone.	29.50
40	CH810	Thin-bedded, thinly laminated, black to dark gray mudstone, interbedded with dark, calcareous shales.	21.00
39	CH809 to CH804	Thick-to very thin-bedded, laminated, black to dark gray, annelid tube mudstone.	29.00
		Total Thickness	134.00

LA VIRGEN FORMATION

UPPER MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
38		Massive gypsum bed.	13.00
37		Thin-bedded, dark gray mudstone, interbedded with shales.	15.00

UNIT	SAMPLE	LITHOLOGY	METERS
36	CH803	Thick-bedded, black to dark gray mudstone.	13.00
35		Covered interval.	9.00
34	CH802	Thin-bedded, dark gray mudstone, interbedded with gypsum and shales.	5.50
33		Covered interval.	8.00
32		Thin-bedded, dark gray mudstone, interbedded with gypsum.	10.00
31		Covered interval.	6.50
30	CH801	Massive beds of gypsum, interbedded with thin-beds of dark gray mudstone.	27.00
29		Collapse breccia.	9.00
28		Covered interval.	32.00
27	CH800 to CH797	Thick-to thin-bedded, dark gray mudstone, interbedded with shales.	15.50
26	CH796 CH795	Massive bed of gypsum with some thin beds of shales and mudstones in the lower part.	51.00
25	CH794 to CH785	Very thick-to medium-bedded, gray to dark gray, pellet, miliolid, annelid tube mudstone.	64.50
24		Collapse breccia.	12.50
23		Covered interval.	10.50
22		Thin-to very thin-bedded mudstone; chert nodules in the middle part.	30.00
21	CH783	Medium-bedded, dark gray, shell fragment wackestone.	1.00

UNIT	SAMPLE	LITHOLOGY	METERS
20		Thin-bedded, argillaceous mudstone, interbedded with shales.	16.00
19	CH782	Very thick-to thick-bedded, shell fragment mudstone.	9.50
18	CH781	Very thick-bedded, shell fragment, intraclast wackestone.	4.50
17		Very thick-bedded, shell fragment mudstone.	6.50
16	CH780	Thick-to medium-bedded, intraclast, shell fragment packstone.	6.00
15	CH779	Thin-to very thin-bedded, dark gray mudstone.	9.50
14	CH778 CH777	Medium-to thin-bedded, dark gray, argillaceous mudstone.	11.50

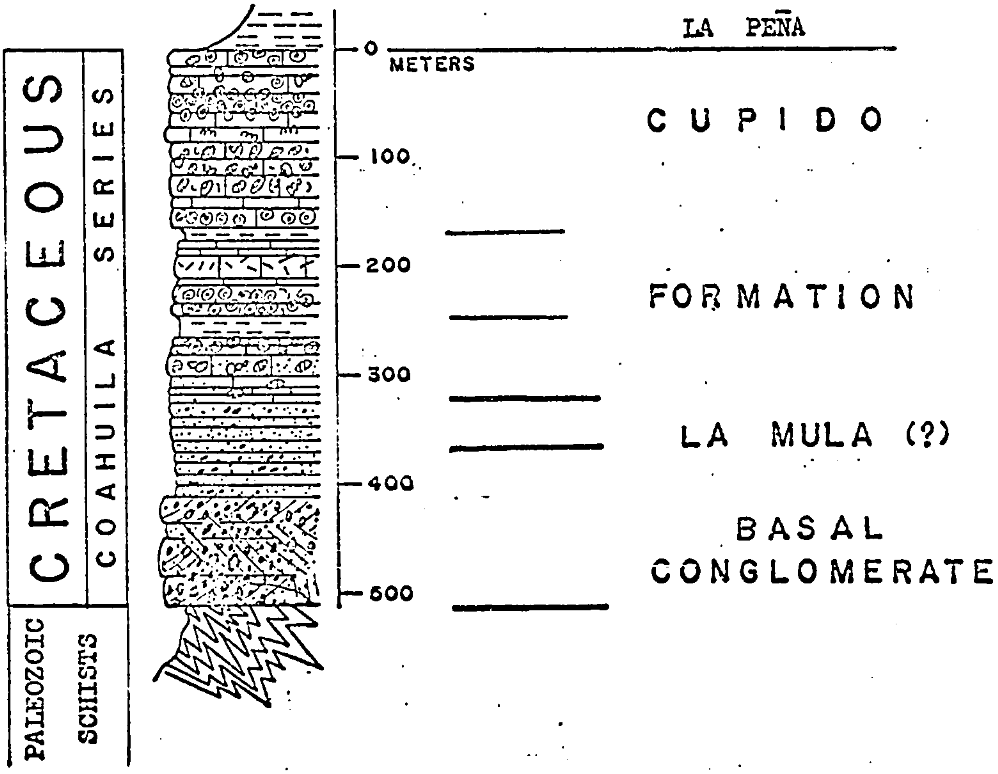
LOWER MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
12		Gypsum, interbedded with thin beds of argillaceous mudstone.	10.50
11		Covered interval.	5.00
10	CH775 CH774	Thin-to very thin-bedded, slightly argillaceous mudstone.	18.00
9	CH773	Medium-to thin-bedded mudstone.	6.50
8	CH772 CH771	Thick-to medium-bedded, shell fragment wackestone.	8.00
7	CH770	Gypsum, interbedded with thin-bedded mudstone.	23.00
6	CH769	Medium-bedded, shell fragment wackestone.	2.00
5	CH768 CH767 CH766	Massive beds of gypsum, interbedded with thin-bedded, dark gray mudstone.	59.00

UNIT	SAMPLE	LITHOLOGY	METERS
4	CH765	Thick-to medium-bedded dolomite.	4.50
3	CH764 CH763	Thick-to thin-bedded, dark gray, shell fragment mudstone.	10.00
2	CH762	Medium-bedded, intraclast, shell fragment wackestone.	8.00
1		Gypsum, interbedded with arenaceous mudstone.	7.50
		(Base of section not exposed)	
		Total Thickness	559.00
		Total Thickness of Section	693.00

SIERRA DEL CARMEN

15



SIERRA DEL CARMEN

SECTION 15

Western flank of the escarpment of
Sierra del Carmen, near an abandoned
mine, approximately 13 Km. east of
Boquillas del Carmen.

CUPIDO FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
41	CH1152	Very thick-to thick-bedded, oolite, algal fragment, foraminifera grainstone.	13.00
40	CH1151	Very thick-bedded, oolite grainstone.	4.00
39		Very thick-bedded, gray, burrowed, shell fragment mudstone.	5.00
38	CH1150 CH1149 CH1148	Very thick-to thin-bedded, gray, intraclast, oolite grainstone; poor intergranular porosity.	23.00
37	CH1147	Very thick-bedded, intraclast, shell fragment, echinoderm fragment grainstone.	2.50
36	CH1146	Very thick-to medium-bedded, gray, intraclast, shell fragment wackestone.	8.50
35	CH1145	Very thick-bedded, shell fragment, miliolid, oolite grainstone.	2.50
34	CH1144	Very thick-bedded, light gray, arenaceous mudstone.	2.50
33	CH1143 CH1142	Very thick-bedded, miliolid, intraclast, oolite grainstone.	5.00
32		Medium-to thin-bedded, argillaceous, shell fragment mudstone.	5.00
31	CH1141	Very thick-bedded, intraclast, oolite grainstone.	2.50
30	CH1140	Very thick-to thick-bedded, gray, miliolid, intraclast, foraminifera packstone.	7.50

UNIT	SAMPLE	LITHOLOGY	METERS
29	CH1139 CH1138	Very thick-bedded, dark gray, foraminifera, miliolid, shell fragment wackestone; common <u>Choffatella</u>.	13.50
28	CH1137	Thick-bedded, shell fragment, oolite packstone.	3.00
27	CH1136 CH1135	Medium-bedded, gray, shell fragment, intraclast, oolite grainstone.	6.00
26	CH1134	Medium-bedded, arenaceous mudstone.	3.00
25	CH1133	Very thick-bedded, dark gray, intraclast, miliolid, oolite grainstone.	4.50
24	CH1132	Medium-bedded, dark gray, yellowish-weathering, miliolid, intraclast, oolite grainstone.	6.50
23	CH1130	Thin-bedded, gray, shell fragment mudstone; numerous gypsum crystals.	15.00
22	CH1129	Thick-to medium-bedded, yellowish-weathering, shell fragment, oolite grainstone.	8.00
21		Covered interval.	17.00
20	CH1128	Very thin-bedded, greenish, miliolid, oolite wackestone.	6.50
19	CH1127	Medium-bedded, greenish-gray, shell fragment, oolite grainstone.	6.50
18		Sill of igneous rock.	24.00
17	CH1125	Medium-to thin-bedded, greenish-gray mudstone, interbedded with fissile shale.	14.00
16	CH1124 CH1123 CH1122	Medium-to thin-bedded, yellowish-weathering, algal fragment, oolite packstone; some intergranular porosity.	19.00
15	CH1121 CH1120 CH1119	Very thick-to thin-bedded, gray, echinoderm shell fragment, algal fragment, oolite grainstone; medium inter and intragranular porosity.	10.00

UNIT	SAMPLE	LITHOLOGY	METERS
14	CH1118	Medium-to thin-bedded mudstone.	5.00
13	CH1117 CH1116	Medium-to thin-bedded, calcareous siltstone, interbedded with fissile shale.	28.00
12	CH1113	Medium-bedded, intraclast, oolite grainstone.	3.00
11	CH1112	Medium-bedded, dark gray, yellowish-weathering, ostracod, shell fragment wackestone.	6.00
10	CH1111	Medium-to thin-bedded, yellowish-weathering, pellet, shell fragment, arenaceous mudstone.	23.50
9	CH1110 CH1109	Thick-to medium-bedded, yellowish-weathering, shell fragment, foraminifera, algal fragment packstone; few ostracods; some intergranular porosity.	15.00
8	CH1108	Medium-bedded, yellowish-weathering, shell fragment, arenaceous mudstone; few ostracods.	6.00
		Total Thickness	324.00

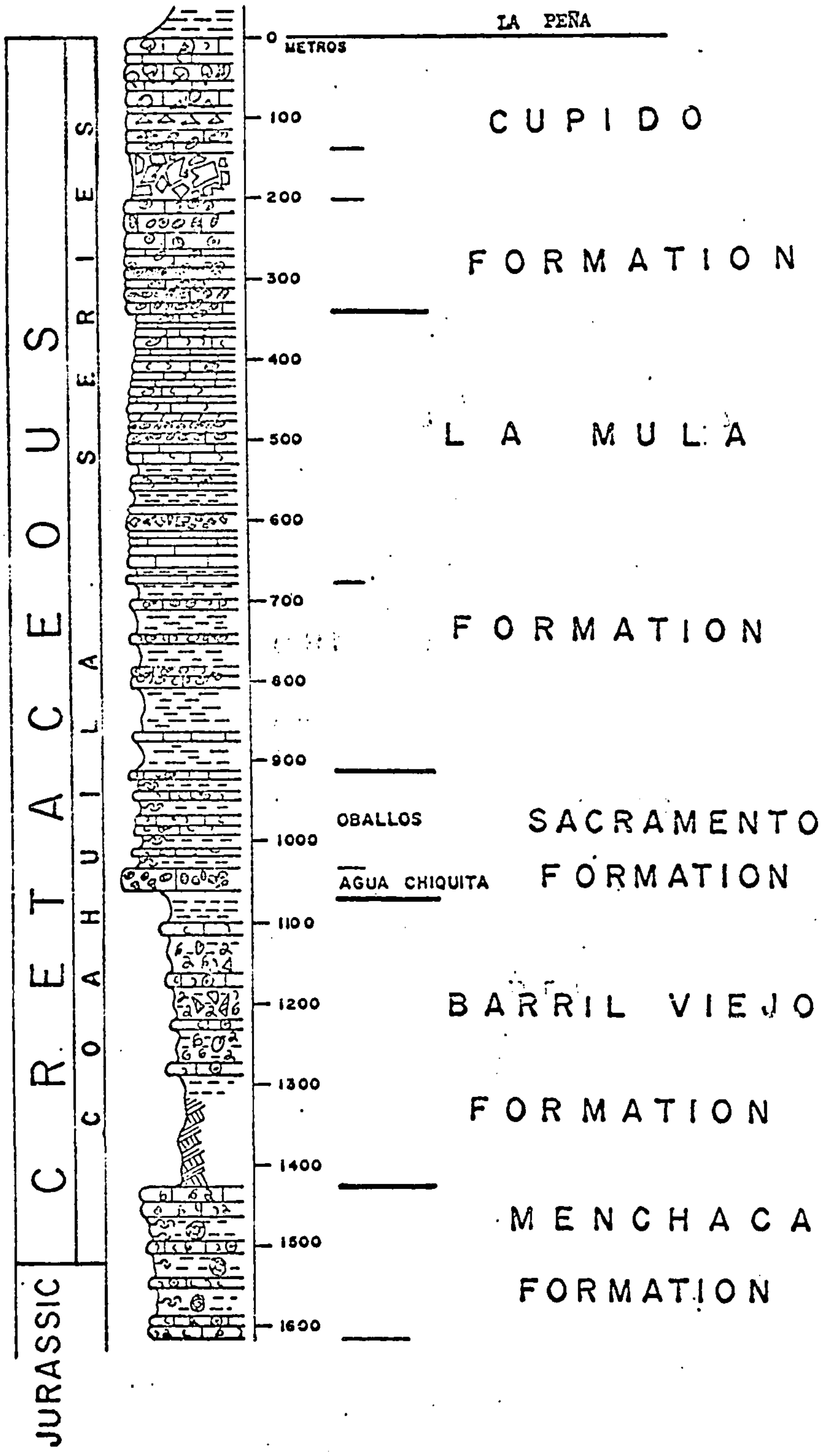
LA MULA FORMATION (?)

7	CH1107	Medium-to thin-bedded, fine orthoquartzite; angular, well sorted grains.	12.00
6	CH1106	Medium-to thin-bedded, fine sublitarenite; well sorted, subrounded grains; abundant chert.	11.00
5	CH1105 CH1104	Thick-to thin-bedded, reddish-brown, slightly conglomeratic (small pebbles and granules), medium sublitharenite.	54.00
		Total Thickness	77.00

UNIT	SAMPLE	LITHOLOGY	METERS
<u>BASAL CONGLOMERATE</u>			
4	CH1103	Thick-bedded, reddish, slightly granular conglomeratic, coarse litharenite; large scale planar cross-bedding.	5.00
3	CH1102	Very thick-bedded, reddish, large pebbles conglomerate composed of novaculite, milky quartz and recrystallized limestone; channel filling.	33.00
2	CH1101	Very thick-bedded, reddish conglomerate of milky quartz, and recrystallized limestone; cobbles and large pebbles; large scale cross-bedding.	16.00
1	CH1100	Very thick-bedded, reddish, large cobble conglomerate; common boulders; fragments of novaculite and arenaceous, recrystallized mudstone.	<u>39.00</u>
		(Angular unconformity with schists)	
		Total Thickness	93.00
		Total Thickness of Section	494.00

POTRERO DE OBALLOS

16



POTRERO DE OBALLOS

SECTION 16

Northwestern corner of Potrero de
Oballos, approximately 3 Km. north
of Rancho Borregas.

CUPIDO FORMATION

UPPER MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
75		Very thick-to thick-bedded, gray, mollusc shell fragment wackestone; common caprinids.	30.10
74	CH1044	Very thick-bedded, caprinid boundstone.	18.20
73	CH1043 CH1042 CH1041	Thick-bedded, dark gray, foraminifera, shell fragment, miliolid wackestone; abundant <u>Orbitolina</u>.	11.00
72	CH1040	Medium-to thin-bedded, gray, mollusc shell fragment, miliolid wackestone.	34.00
71	CH1039	Medium-to thin-bedded, pelecypod shell fragment, algal fragment, intraclast grainstone; few <u>Choffatella</u>.	19.00
70	CH1038	Thick-bedded, dark gray, mollusc shell fragment, ostracod wackestone; few <u>Orbitolina</u>.	22.00

MIDDLE MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
69	CH1037	Medium-to thin-bedded, gray, intraclast, shell fragment, miliolid wackestone.	12.00
68		Collapse breccia.	9.00
67		Medium-to very thinly laminated, algal stromatolite.	6.00
66		Collapse breccia.	6.00

UNIT	SAMPLE	LITHOLOGY	METERS
65	CH1036	Very thick-bedded, gray, miliolid, foraminifera wackestone; few <u>Choffatella</u>.	2.00
64		Collapse breccia.	6.00
63		Thick-bedded, dark gray, intraclast, shell fragment grainstone.	3.00
62	CH1035	Collapse breccia.	13.00
LOWER MEMBER			
61	CH1034	Medium-to thin-bedded, gray, gastropod shell fragment, intraclast wackestone; slightly dolomitized.	17.00
60	CH1032	Thick-bedded, oolite, shell fragment grainstone.	2.00
59	CH1031	Thin-bedded, dark gray, intraclast, shell fragment grainstone; slightly dolomitized.	6.00
58	CH1030 CH1029 CH1028	Very thick-bedded, light gray, gastropod shell fragment, intraclast grainstone; abundant <u>Turritella</u>.	6.00
57		Collapse breccia.	2.00
56	CH1027	Thick-bedded, dark gray, shell fragment, miliolid wackestone; few tintinids (?).	16.00
55	CH1026	Thick-bedded, oolite, intraclast, shell fragment wackestone.	5.00
54	CH1024	Very thick-bedded, gray, mollusc shell fragment mudstone.	26.00
53	CH1023	Thick-bedded, coarse oolite, intraclast grainstone.	4.00
52	CH1022 CH1021	Thick-bedded, intraclast, shell fragment, oolite grainstone.	6.00

UNIT	SAMPLE	LITHOLOGY	METERS
51	CH1020	Thick-to medium-bedded, dark gray, miliolid, shell fragment muddy grainstone.	9.00
50	CH1019	Thick-to medium-bedded, greenish-gray, foraminifera, miliolid grainstone.	12.00
49	CH1018	Thick-bedded, foraminifera, miliolid, intraclast grainstone.	2.00
48	CH1017	Thick-to medium-bedded, gray, miliolid, shell fragment muddy grainstone.	22.00
47	CH1016	Thick-bedded, foraminifera, miliolid grainstone.	2.70
		Total Thickness	329.00

<u>LA MULA FORMATION</u>

UNIT	SAMPLE	LITHOLOGY	METERS
46	CH1015	Thin-to medium-bedded, gastropod shell fragment, miliolid, foraminifera mudstone and wackestone; few <u>Choffatella</u>.	41.90
45	CH1014	Medium-bedded, dark gray, gastropod shell fragment, algal fragment grainstone.	4.00
44		Medium-bedded, dark gray mudstone.	4.00
43		Collapse breccia.	2.60
42		Thin-bedded, slightly argillaceous mudstone.	7.00
41		Thick-to medium-bedded mudstone.	10.00
40	CH1013	Thick-bedded, gastropod shell fragment wackestone.	4.00
39	CH1012	Medium-to thin-bedded, gray, dolomitized mudstone.	52.00
38	CH1011	Thick-to medium-bedded dolomite.	4.00

UNIT	SAMPLE	LITHOLOGY	METERS
37		Medium-to thin-bedded, shell fragment, intraclast wackestone, interbedded with mudstone.	27.00
36	CH1010	Medium-to thin-bedded, dark gray, intraclast, gastropod shell fragment, slightly dolomitized grainstone.	4.00
35		Medium-to thick-bedded, slightly contorted mudstone.	13.00
34		Gray, fissile shale.	8.00
33		Collapse breccia.	3.00
32		Shale.	5.00
31		Very thin-bedded, contorted, gray, argillaceous mudstone.	4.00
30		Medium-to thin-bedded, greenish-gray, slightly contorted, argillaceous mudstone.	27.00
29	CH1009	Thin-bedded, reddish-gray dolomite.	3.50
28	CH1008	Thick-to thin-bedded, greenish-gray mudstone with few quartz grains.	32.00
27	CH1007 CH1006	Medium-to thick-bedded, gray, recrystallized, annelid fragment (?) mudstone, interbedded with nodular shale.	26.00
26	CH1005 CH1004	Medium-to thick-bedded, gray, shell fragment wackestone and mudstone with few quartz grains.	64.00
25	CH1003	Thick-to thin-bedded, reddish-gray, shell fragment mudstone, interbedded with gray, nodular shale.	47.00
24	CH1002	Thin-to medium-bedded, gray, quartz grains, foraminifera, ostracod fragment mudstone, interbedded with fissile, nodular shale; few <u>Choffatella</u>.	18.00

UNIT	SAMPLE	LITHOLOGY	METERS
23	CH1001	Thin-bedded, gray, intraclast, shell fragment, foraminifera, ostracod grainstone.	4.00
22		Thin- to medium-bedded, gray, shell fragment, intraclast mudstone, interbedded with gray, fissile shale.	9.00
21	CH1000	Medium-to thin-bedded, light gray, shell fragment, foraminifera grainstone; poor fracture porosity.	6.00
20	CH999	Medium-to thin-bedded, yellowish-weathering, argillaceous mudstone; interbedded with fissile shale.	15.00
19	CH998 CH997	Thin-bedded, slightly nodular, bluish-gray, foraminifera, mollusc shell fragment, intraclast wackestone, interbedded with nodular marl; abundant *Choffatella*.	41.00
18	CH996	Thick-bedded shale; interbedded with thin bedded, shell fragment, intraclast grainstone.	20.00
17	CH995 CH994 CH993	Thin-to medium-bedded, reddish weathering, very fine quartz grains, shell fragment, echinoderm fragment mudstone, interbedded with light green, fissile shale; few *Choffatella*.	46.00
16	CH992 CH991	Medium-bedded, dark gray, gastropod shell fragment, ostracod fragment, intraclast grainstone, interbedded with nodular shale; common *Choffatella*.	7.00
		Total Thickness	559.00

SACRAMENTO FORMATION

OBALLOS MEMBER

15	CH990	Thick-to medium-bedded, foraminifera, shell fragment wackestone, interbedded with nodular marls; common pelecypods and *Choffatella*.	47.00

UNIT	SAMPLE	LITHOLOGY	METERS
14	CH989 CH988	Medium-bedded, foraminifera, shell fragment mudstone, interbedded with nodular marls; common *Choffatella*.	54.00

AGUA CHIQUITA MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
13	CH987 CH986	Very thick-bedded, light gray, pellet, intraclast, shell fragment, algal fragment grainstone.	8.00
12		Thick-bedded, light gray, intraclast grainstone, interbedded with nodular marls.	11.00
11	CH985	Thick-bedded, gray, pellet, intraclast, algal fragment grainstone.	2.00
10	CH984 CH983	Very thick-bedded, light gray, pellet, intraclast, shell fragment wackestone; common *Monopleura* (?) and *Toucasia*	14.00
		Total Thickness	136.00

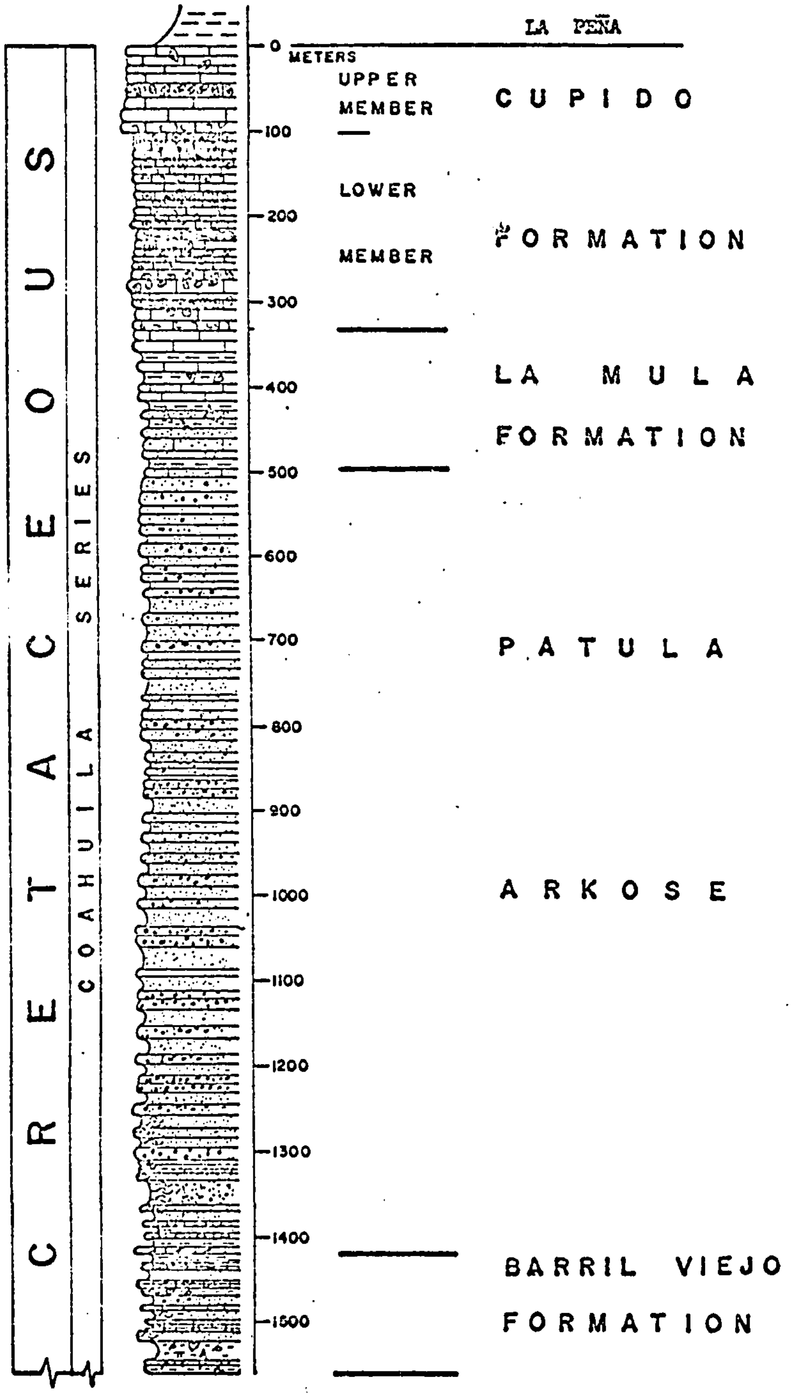
BARRIL VIEJO FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
9	CH982 CH981	Thick-to medium-bedded, gray, argillaceous, shell fragment, algal fragment mudstone, interbedded with nodular marl; few *Exogyra*.	37.00
8	CH980 CH980A CH979	Medium-to thin-bedded, yellowish-weathering, very arenaceous mudstone, interbedded with greenish-gray, nodular marl; common *Exogyra*, solitary corals and brachiopods.	93.00
6	CH976 to CH973	Medium-to thin-bedded, yellowish-weathering, mollusc shell fragment, foraminifera mudstone, interbedded with fissile shale; common *Exogyra*, oysters, pelecypods, gastropods and solitary corals.	47.00

UNIT	SAMPLE	LITHOLOGY	METERS
5		Thin-bedded, shell fragment mudstone, interbedded with fissile shale; most of the section is covered by alluvium.	174.00
		Total Thickness	351.00
MENCHACA FORMATION			
4	CH972 CH971	Medium-bedded, dark gray, mollusc shell fragment, echinoderm fragment wackestone, interbedded with dark gray, nodular marl; presence of numerous tintinids, *Tintinopsella carphatica*, *Lorenziella plicata*, *Remanella cadischiana*, *Calpionellopsis oblonga* and *Calpionellopsis simplex.*	52.00
3	CH970 CH969	Thick-to medium-bedded, black to dark gray, argillaceous, shell fragment mudstone, interbedded with nodular marl; common *Exogyra*, *Tintinopsella carphatica* and *Calpionella alpina*.	72.00
2	CH968	Medium-bedded, dark gray, argillaceous, slightly arenaceous mudstone, interbedded with nodular marl; common *Exogyra*, few *Calpionella alpina* and *Tintinopsella carpathica*.	29.00
1	CH967 CH966	Medium-bedded, dark gray, argillaceous, slightly arenaceous mudstone, interbedded with dark gray, nodular marl; *Calpionella alpina*, *Tintinopsella carpathica* and *Nannoconnus bronnimanni*.	27.00
		Total Thickness	180.00
		Total Thickness of Section	1555.00

POTRERO DE LA GAVIA

17



POTRERO DE LA GAVIA

SECTION 17

Central part of Potrero de La Gavia,
2 Km. south of Rancho La Muralla.
The section begins near a roadside
grave marker.

CUPIDO FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
119	CH195	Medium-to thick-bedded, miliolid, shell fragment mudstone; some chert nodules in the lower part.	22.50
118	CH194	Thick-bedded, shell fragment wackestone.	10.00
117		Covered interval.	3.00
116	CH193	Oyster fragment packstone.	1.50
115		Thick-bedded mudstone with chert nodules.	3.50
114	CH192	Very thick-to thick-bedded mudstone with scattered miliolids.	14.50
113	CH191	Thick-bedded, intraclast, shell fragment packstone.	3.50
112	CH190 CH189	Very thick-to thick-bedded mudstone.	38.00
111	CH188 CH186	Thick-bedded, shell fragment, oolite wackestone.	10.00
110	CH187 CH186	Thick-bedded, pellet, shell fragment wackestone.	15.50
109		Collapse breccia.	2.00
108		Thick-bedded, shell fragment mudstone.	3.00
107		Collapse breccia.	2.00
106		Thick-bedded mudstone.	2.50

UNIT	SAMPLE	LITHOLOGY	METERS
105	CH185	Thick-bedded, pellet, oolite grainstone.	6.50
104	CH184	Thick-to thin-bedded, shell fragment mudstone.	26.50
103	CH183	Very thick-to thick-bedded, pellet, oolite grainstone.	7.50
102	CH182	Very thick-to thick-bedded, slightly recrystallized mudstone.	14.00
101	CH181	Thick-bedded, oyster fragment packstone.	2.00
100	CH180	Thick-to medium-bedded, shell fragment, annelid tube mudstone.	13.00
99	CH179	Thick-bedded, pellet, shell fragment, oolite packstone to grainstone.	6.00
98	CH178	Medium-bedded, shell fragment mudstone.	5.00
97	CH177	Medium-bedded, algal stromatolite.	4.00
96	CH176	Thick-to medium-bedded dolomite.	5.00
95	CH175	Thick-bedded, shell fragment, oolite grainstone.	4.00
94	CH174	Very thick-to thick-bedded, shell fragment, intraclast wackestone.	8.00
93		Thin-bedded, nodular, argillaceous mudstone.	12.00
92	CH173	Medium-bedded, oolite, shell fragment packstone.	1.50
91		Thin-bedded, recrystallized mudstone.	3.00
90	CH172	Very thick-bedded, shell fragment packstone.	5.00
89	CH171	Medium-bedded, shell fragment, oolite grainstone.	1.00

UNIT	SAMPLE	LITHOLOGY	METERS
88	CH170	Very thick-bedded, shell fragment mudstone.	12.00
87	CH169	Thick-bedded, shell fragment, oolite grainstone with some lime intraclasts.	5.00
86		Medium-to thin-bedded, slightly nodular mudstone.	9.00
85	CH168	Very thick-bedded, shell fragment, intraclast packstone.	3.00
84	CH167 CH166	Thick-to thin-bedded, shell fragment wackestone.	11.00
83	CH165	Very thick-bedded, oolite grainstone.	5.00
82	CH164 CH163	Thick-to thin-bedded, shell fragment wackestone.	8.50
81	CH162	Thick-bedded mudstone, interbedded with shale.	14.50
80	CH161	Very thick-bedded dolomite.	6.50
		Total Thickness	330.00

LA MULA FORMATION

79		Medium-bedded mudstone, interbedded with shales.	3.50
78		Covered interval.	8.00
77	CH160 CH159	Thick-to medium-bedded, arenaceous mudstone, interbedded with shale.	17.00
76		Covered interval.	8.00
75	CH158 CH157	Medium-to thin-bedded, arenaceous mudstone, interbedded with shales; there are some pelecypods in the lower part.	44.00
74		Covered interval.	4.50

UNIT	SAMPLE	LITHOLOGY	METERS
73	CH156 CH155	Thin-bedded siltstone, interbedded with shales.	18.00
72	CH154 to CH151	Thick-to thin-bedded siltstone, interbedded with shales; common Turritella.	25.00
71	CH150	Thick-to thin-bedded, arenaceous mudstone, interbedded with shales.	19.00
		Total Thickness	147.00

PATULA ARKOSE

UNIT	SAMPLE	LITHOLOGY	METERS
70	CH149	Very thick-bedded, light, slightly granular, coarse subarkose; subrounded, mature and medium sorted grains.	25.20
69		Thick-bedded, light, cross-bedded, slightly conglomeratic (granules), coarse orthoquartzite and subarkose.	9.00
68	CH148	Very thick-to thick-bedded, light, coarse orthoquartzite to subarkose; rounded, medium sorted grains.	18.70
67		Thick-bedded, light, slightly conglomeratic (granules), coarse subarkose; angular and poorly sorted grains; interbedded with reddish, silty, fine sublitharenite.	21.10
66	CH147	Reddish, medium-bedded, silty, medium to fine subarkose with few coarse grains; interbedded with medium bedded, light, coarse arkose.	22.50
65	CH146	Very thick-bedded, conglomeratic (granules), coarse subarkose; subangular, poorly sorted grains; interbedded with reddish, slightly nodular, medium subarkose.	15.20
64		Thick-bedded, slightly nodular, reddish, medium subarkose with some coarse grains, interbedded with medium to thick bedded,	

UNIT	SAMPLE	LITHOLOGY	METERS
		reddish, slightly conglomeratic (granules, medium and large pebbles) subarkose.	22.40
63	CH144	Medium-to thick-bedded, conglomeratic (granules) subarkose, interbedded with reddish, nodular, medium subarkose.	42.00
62	CH143 CH142	Thick-to medium-bedded, reddish, nodular, coarse subarkose, interbedded with medium to thick bedded, light, very coarse subarkose.	53.80
61	CH141	Reddish, thick-bedded, coarse, slightly granular subarkose; interbedded with reddish, silty, medium subarkose with angular and poorly sorted grains.	29.00
60	CH140	Red, medium-bedded, few granules, coarse subarkose; angular and poorly sorted grains.	4.60
59	CH139 to CH135	Thick-to very thick-bedded, slightly conglomeratic (granules), coarse orthoquartzite; subrounded and medium sorted grains.	70.10
58	CH134	Light gray, thick-bedded, slightly conglomeratic (large pebbles), coarse subarkose, interbedded with arenaceous, reddish shale.	45.00
57	CH133	Medium-to thick-bedded, light, conglomeratic (small and medium pebbles) subarkose; subrounded and medium sorted grains.	21.60
56	CH132	Reddish, thick-bedded, slightly conglomeratic (granules), coarse subarkose, interbedded with nodular, arenaceous, reddish-brown, silty subarkose.	81.20
55	CH131	Bluish-white, fine orthoquartzite; medium sorted and subrounded grains; disseminated azurite and malachite.	4.40
54		Gray-bluish, thick bedded, slightly arenaceous, silty subarkose.	3.20

UNIT	SAMPLE	LITHOLOGY	METERS
53	CH130	Reddish, thick-bedded, slightly conglomeratic (medium and large pebbles), coarse subarkose; angular and poorly sorted grains, interbedded with arenaceous, red, nodular siltstone.	36.00
52	CH129	Very thick-bedded, white, conglomeratic (granules and large pebbles) subarkose.	29.60
51	CH128 CH127	Thick-bedded subarkose with subangular and poorly sorted grains, interbedded with medium bedded, subarkosic siltstone.	18.20
50	CH126	Reddish, nodular, sandy, subarkosic siltstone, interbedded with thick bedded, conglomeratic (granules and small pebbles) subarkose.	12.50
49	CH125 to CH122	Red, medium to thick-bedded, conglomeratic (granules and some large pebbles anc cobbles) subarkose, interbedded with arenaceous, reddish, nodular, subarkosic siltstone.	106.70
48	CH121 CH120	Reddish, medium to thick-bedded, slightly conglomeratic, coarse subarkose; subangular, medium sorted grains, interbedded with arenaceous subarkosic siltstone.	37.80
47	CH119	Reddish, thick-bedded, large pebbles, conglomeratic, coarse subarkose; interbedded with red, nodular siltstone.	11.20
46	CH118	Reddish, thick-bedded, conglomeratic (large pebbles and small cobbles), coarse subarkose.	7.00
45	CH117	Red, thick-bedded, slightly conglomeratic, coarse subarkose with angular, poorly sorted grains, interbedded with shaly, nodular, subarkosic siltstone, some large pebbles and small cobbles.	33.00

UNIT	SAMPLE	LITHOLOGY	METERS
44	CH116	Thick-bedded, reddish, conglomeratic (granules and small pebbles) subarkose with medium sorted, subangular grains, interbedded with nodular, reddish, shaly siltstone.	9.10
43		Reddish, thick-bedded, nodular, arenaceous, silty subarkose, interbedded with thick bedded, coarse subarkose; medium sorted, subangular grains.	13.70
42	CH115	Conglomeratic (granules and large pebbles) coarse subarkose with subangular and poorly sorted grains.	4.80
41	CH114 CH113	Reddish, thick-bedded, coarse subarkose with medium sorted, subangular grains, interbedded with nodular, reddish, shaly siltstone.	20.80
40	CH112	Red, medium-to thick-bedded, nodular, some coarse grains, fine subarkose.	12.00
39		Nodular, reddish, silty subarkose.	2.70
38	CH111	Medium-to thin-bedded, nodular, reddish subarkose with subrounded and well sorted grains.	25.60
37	CH110	Medium-bedded, white, slightly dolomitic, fine subarkose.	1.30
36		Nodular, arenaceous, subarkosic siltstone.	11.40
35	CH109	Thin-bedded, thinly laminated, reddish, silty, fine subarkose; medium rounded and well sorted grains, interbedded with nodular, subarkosic siltstone.	21.20
34	CH108	White, medium-bedded, fine orthoquartzite.	1.00
33		Reddish, medium-bedded, nodular, slightly granular, coarse arkose.	4.80

UNIT	SAMPLE	LITHOLOGY	METERS
32	CH107	Reddish, medium-to thin-bedded, medium subarkose with some coarse, subangular grains, interbedded with red, thin bedded, nodular, shaly, subarkosic siltstone.	17.60
		Total Thickness	927.00
BARRIL VIEJO FORMATION			
31		Thin-bedded, light gray, shell fragment wackestone, interbedded with thinly laminated, silty shale; one interval with abundant *Exogyra*.	14.60
30	CH106	Greenish, thin-bedded, arenaceous, recrystallized mudstone.	1.40
29	CH105 CH104	Light gray, thin-bedded, oolite, shell fragment, rock fragment grainstone, interbedded with thinly laminated, reddish siltstone.	4.00
28	CH103	Reddish, thin-bedded, coarse subarkose; angular and medium sorted grains, interbedded with laminar, slaty siltstone.	11.60
27	CH102	Very thin-to thin-bedded, light green, cross-bedded, fine orthoquartzite; well sorted and rounded grains.	6.40
26	CH101	Medium-to thin-bedded, light green, thinly laminated siltstone.	5.90
25		Thin-bedded, medium subarkose with rounded and medium sorted grains.	0.60
24	CH100	Medium-bedded, light greenish, subarkosic siltstone with few oxidized mud-balls, interbedded with light greenish, laminated, slaty shale.	5.10
23		Thin-bedded, slaty, nodular, calcareous shale, interbedded with medium bedded, calcareous siltstone; some large pebble size mud-balls.	2.80

UNIT	SAMPLE	LITHOLOGY	METERS
22		Medium-bedded, shell fragment wackestone.	0.60
21	CH99 CH98	Medium-bedded, intraclast, shell fragment wackestone, interbedded with nodular siltstone.	4.30
20	CH97	Thick-bedded, nodular, shell fragment wackestone; common pelecypods.	1.20
19	CH96	Thin-bedded mudstone, interbedded with nodular shale.	1.30
18	CH95	Thick-bedded, conglomeratic, coarse subarkose; angular and poorly sorted grains.	1.60
17		Thin-bedded mudstone, interbedded with nodular siltstone.	7.20
16	CH94	Very thinly laminated, stromatolitic dolomite with mud-cracks.	0.70
15		Medium-to thin-bedded mudstone, interbedded with thin bedded, calcareous siltstone.	4.90
14	CH93	Medium-bedded mudstone.	1.20
13		Thick-bedded, reddish, nodular siltstone.	4.80
12		Medium-bedded, nodular, arenaceous mudstone.	4.80
11		Thick-bedded, nodular, reddish siltstone.	1.40
10	CH92	Medium-bedded, nodular, argillaceous, intraclast, shell fragment mudstone.	8.90
9	CH91	Medium-bedded, light gray, arenaceous mudstone.	1.50
8		Thin-to very thin-bedded, slaty, argillaceous, very fine orthoquartzite.	6.80
7	CH90 CH89	Thick-to medium-bedded, light gray, intraclast, shell fragment grainstone.	1.00

UNIT	SAMPLE	LITHOLOGY	METERS
6	CH88 CH87 CH86	Thick-bedded, nodular, reddish, orthoquartzite siltstone.	1.00
5	CH203	Thin-bedded mudstone, interbedded with nodular marl; common _Exogyra_ and pelecypods.	24.60
4	CH202 CH201	Medium-bedded, nodular marls, interbedded with fissile shale; common pelecypods.	16.40
3		Nodular marl with abundant _Exogyra_.	0.80
2	CH200 CH199	Thin-bedded, calcareous, fine orthoquartzite, interbedded with nodular marls; abundant _Gryphea_ and _Exogyra_.	4.40
1	CH198 CH197 CH196	Medium-bedded, greenish, calcareous, fine orthoquartzite, interbedded with shales; common _Exogyra_.	5.20
		(Base of section not exposed)	
		Total Thickness	157.00
		Total Thickness of Section	1561.50

POTRERO DE MINAS VIEJAS

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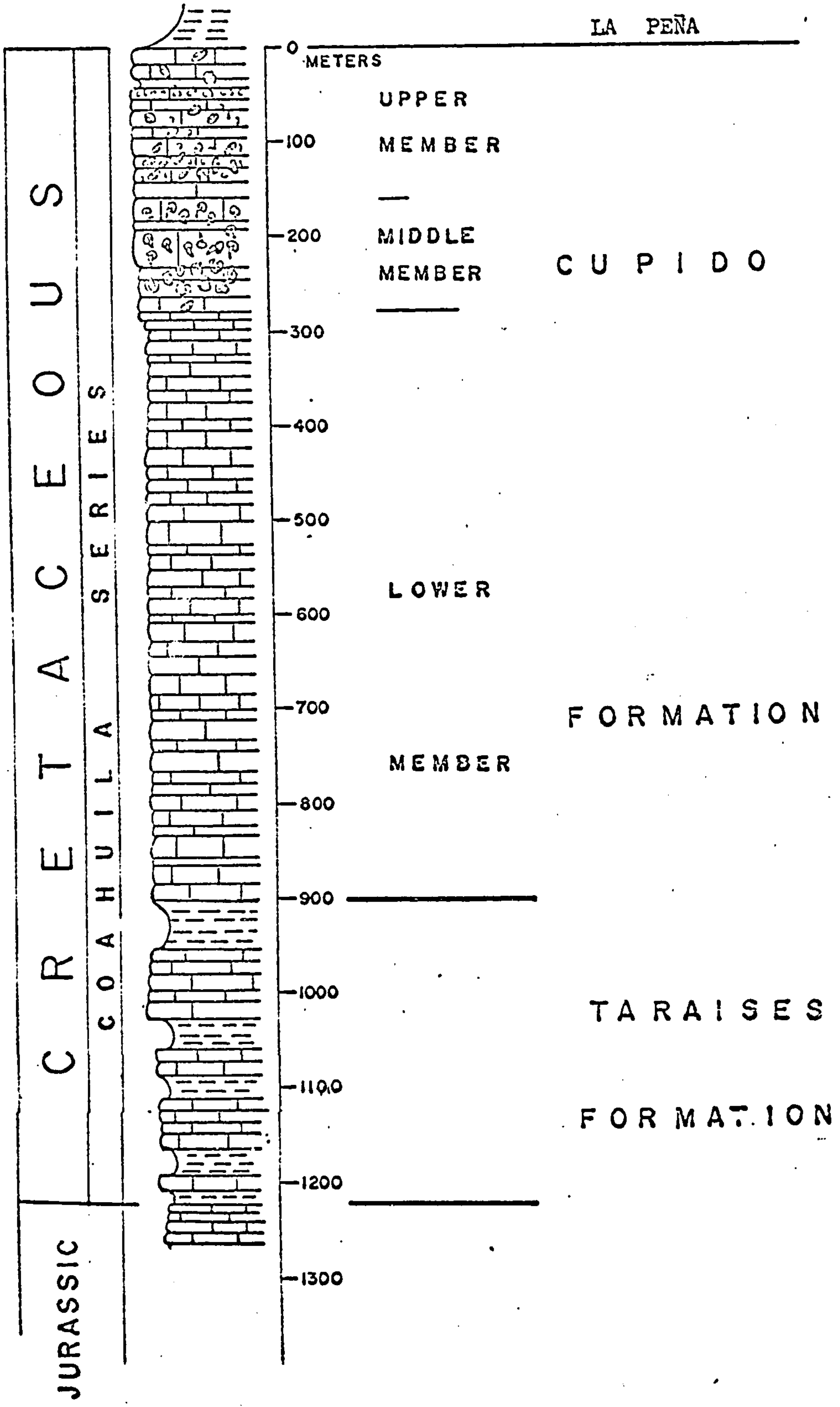


POTRERO DE MINAS VIEJAS

SECTION 19

Southern flank of Potrero de Minas Viejas,
approximately 5 Km. north of Villa
Hidalgo, N. L.

CUPIDO FORMATION

UPPER MEMBER

UNIT	SAMPLE	LITHOLOGY	METERS
28	CH1098 CH1097	Very thick-to thick-bedded, shell fragment, miliolid mudstone.	15.00
27	CH1096 to CH1094	Thick-bedded, shell fragment wackestone with <u>Toucasia</u>.	17.00
26	CH1093	Very thick-bedded, dark gray mudstone.	13.00
25	CH1092	Thick-bedded, dark gray, oyster fragment packstone.	4.00
24		Medium-bedded, arenaceous shale.	8.00
23	CH1090 to CH1086	Very thick-to thick-bedded, miliolid mudstone.	52.00
22	CH1085 CH1084	Thick-bedded, oyster fragment packstone.	8.00
21		Thick-bedded, shell fragment, miliolid mudstone to wackestone.	4.00
20		Medium-bedded, very thinly laminated, algal stromatolite.	2.00
19		Thick-to medium-bedded, miliolid, shell fragment, intraclast wackestone.	20.00
18	CH1083	Thick-bedded, intraclast, shell fragment packstone.	15.00

UNIT	SAMPLE	LITHOLOGY	METERS
17		Very thick-to thick-bedded, shell fragment wackestone with abundant caprinids and *Nerinea*.	35.00
16	CH1080 CH1079	Very thick-bedded, caprinid boundstone.	27.00
15	CH1075	Thick-bedded, oyster fragment, intraclast packstone.	6.00
14	CH1076	Very thick-to thick-bedded, caprinid and large *Toucasia* boundstone.	15.00
13		Thick-bedded, recrystallized, intraclast mudstone.	45.00
LOWER MEMBER			
12	CH1069 CH1068 CH1067	Very thick-to thick-bedded, echinoderm fragment mudstone; few calcified radiolarians and globular foraminifera.	104.00
11	CH1066	Thick-bedded, dark gray, slightly nodular mudstone.	29.00
10	CH1065	Thick-to medium-bedded, nodular, intraclast wackestone.	30.00
9	CH1064 CH1063 CH1062	Very thick-to thick-bedded, dark gray echinoid fragment mudstone; scattered globular foraminifera.	77.00
8	CH1061 CH1060	Very thick-to thick-bedded echinoid fragment mudstone; common *Globigerina* (?).	77.00
7	CH1059 CH1058	Very thick-to thick-bedded, dark gray, echinoderm fragment mudstone.	51.00
6	CH1057 CH1056	Very thick-to thick-bedded, echinoderm fragment mudstone.	68.00
5	CH1055	Thick-bedded, dark gray mudstone.	57.00

UNIT	SAMPLE	LITHOLOGY	METERS
4	CH1054 CH1053 CH1052	Very thick-to thick-bedded, dark gray, echinoderm fragment mudstone; few globular foraminifera.	124.00
		Total Thickness	903.00

TARAISES FORMATION

UNIT	SAMPLE	LITHOLOGY	METERS
3	CH1051 CH1050	Thick-to medium-bedded, dark gray mudstone, interbedded with nodular marls; common pyrite nodules ~~and~~ ammonite fragments of *Olcostephanus*. (?).	60.00
2	CH1049	Thick-to medium-bedded, dark gray, echinoderm fragment mudstone with some intervals of nodular marls.	95.00
1		Very thick-to thick-bedded mudstone, interbedded with nodular marls.	135.00
		Total Thickness	290.00
		Total Thickness of Section	1193.00

SIERRA DEL PINO

SECTION 14

Southern end of Sierra del Pino, approximately 12 Km. northwest of Ejido de Santa Elena.

CUPIDO FORMATION

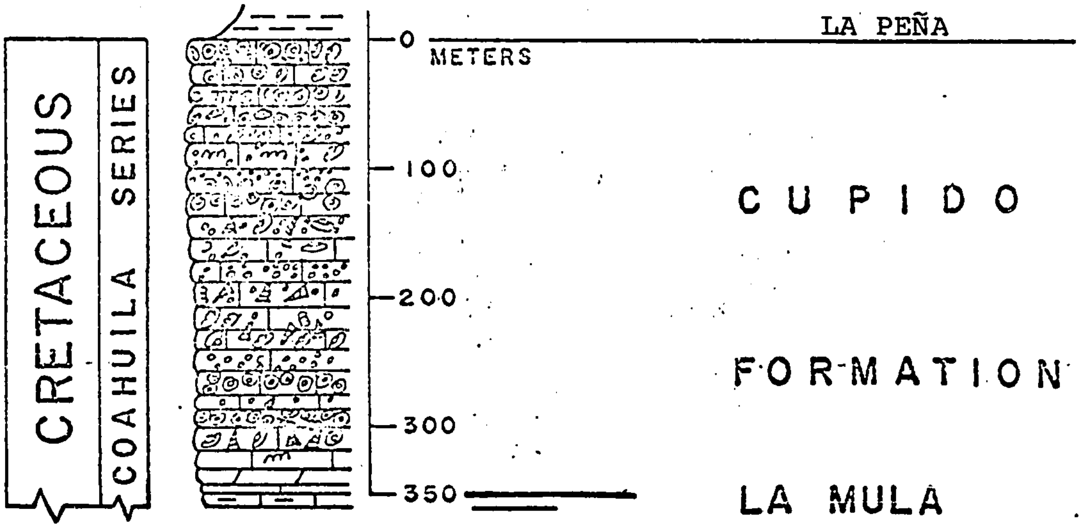
UNIT	SAMPLE	LITHOLOGY	METERS
5	CH1940	Thick-to medium-bedded, light gray, shell fragment, miliolid mudstone to wackestone.	26.50
4	CH1939 CH1938	Thick-bedded, gray, shell fragment mudstone.	10.50
		Total Thickness	37.00

LA VIRGEN FORMATION

3	CH1937	Massive beds of gypsum, interbedded with thin layers of mudstone and dolomites.	36.00
2	CH1936	Gypsum, interbedded with shales and mudstone.	4.50
1	CH1935	Medium-to thin-bedded mudstone, interbedded with gypsum.	27.50
		(Base of section not exposed)	
		Total Thickness	68.00
		Total Thickness of Section	105.50

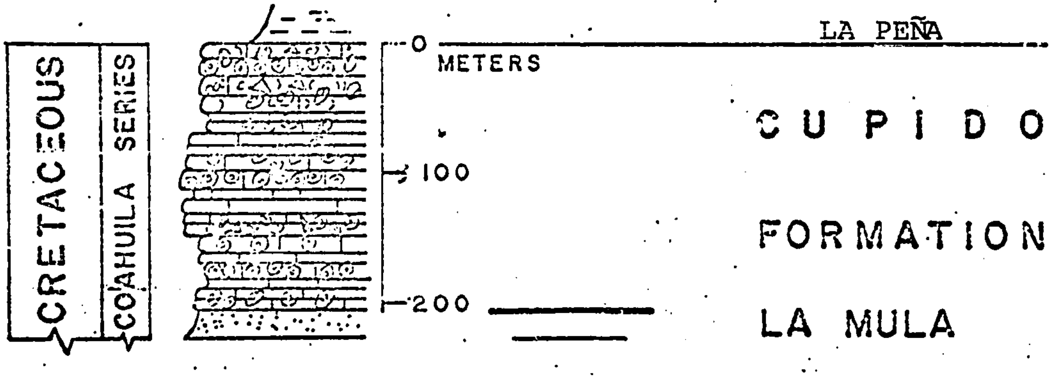
CAÑON DE LA ALAMEDA

12



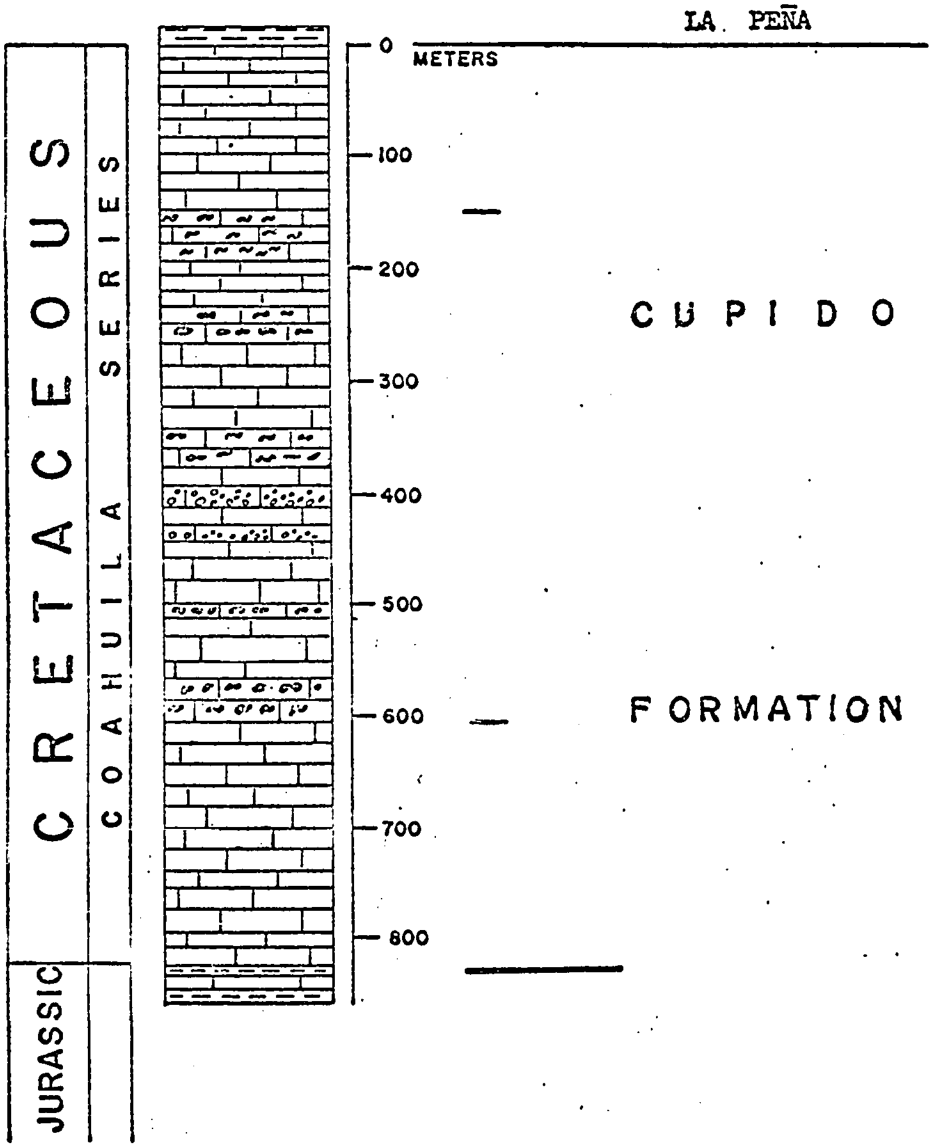
SIERRA DEL CEDRAL

22



CAÑON DE LA BOCA

37



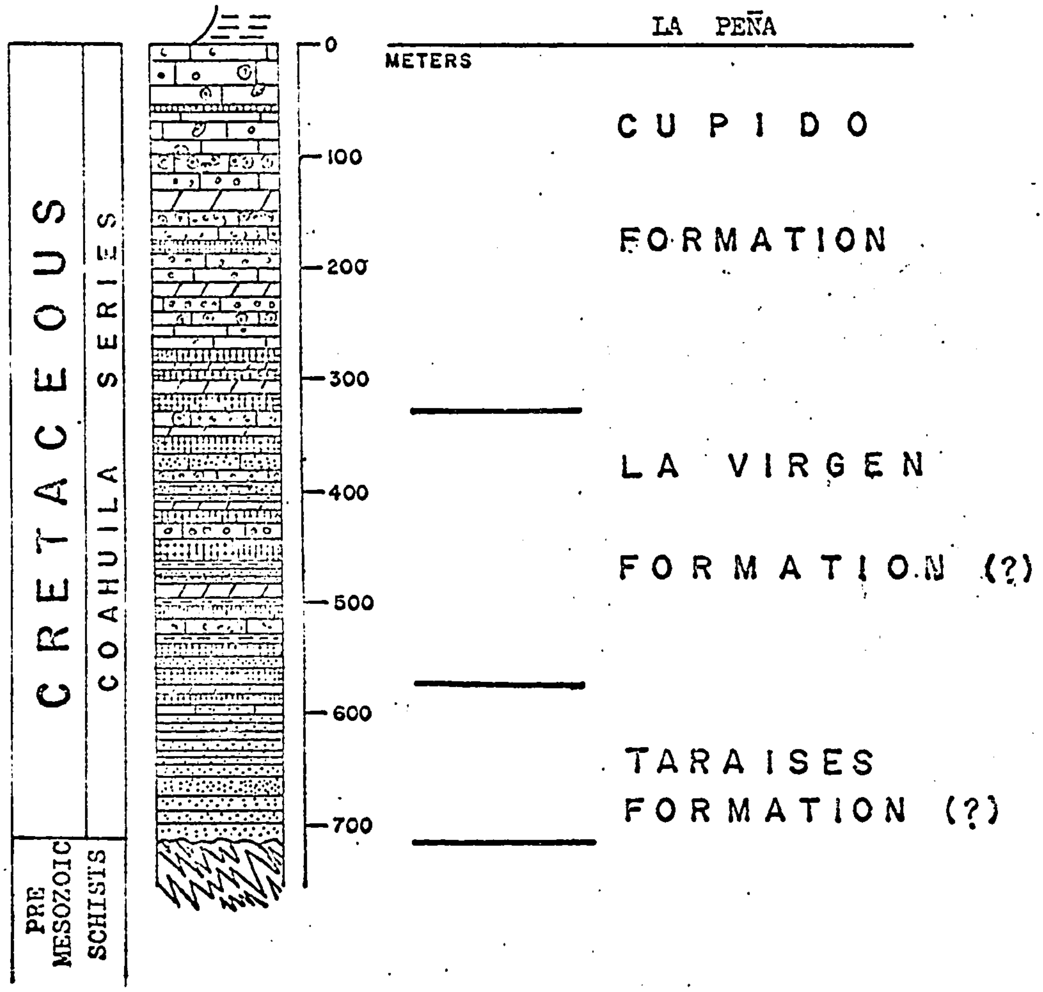
APPENDIX C

Lithologic columns of wells.

Location of the wells is shown in Fig. 2 of the text, and the lithologic symbols in the Chart 3 of the Appendix B.

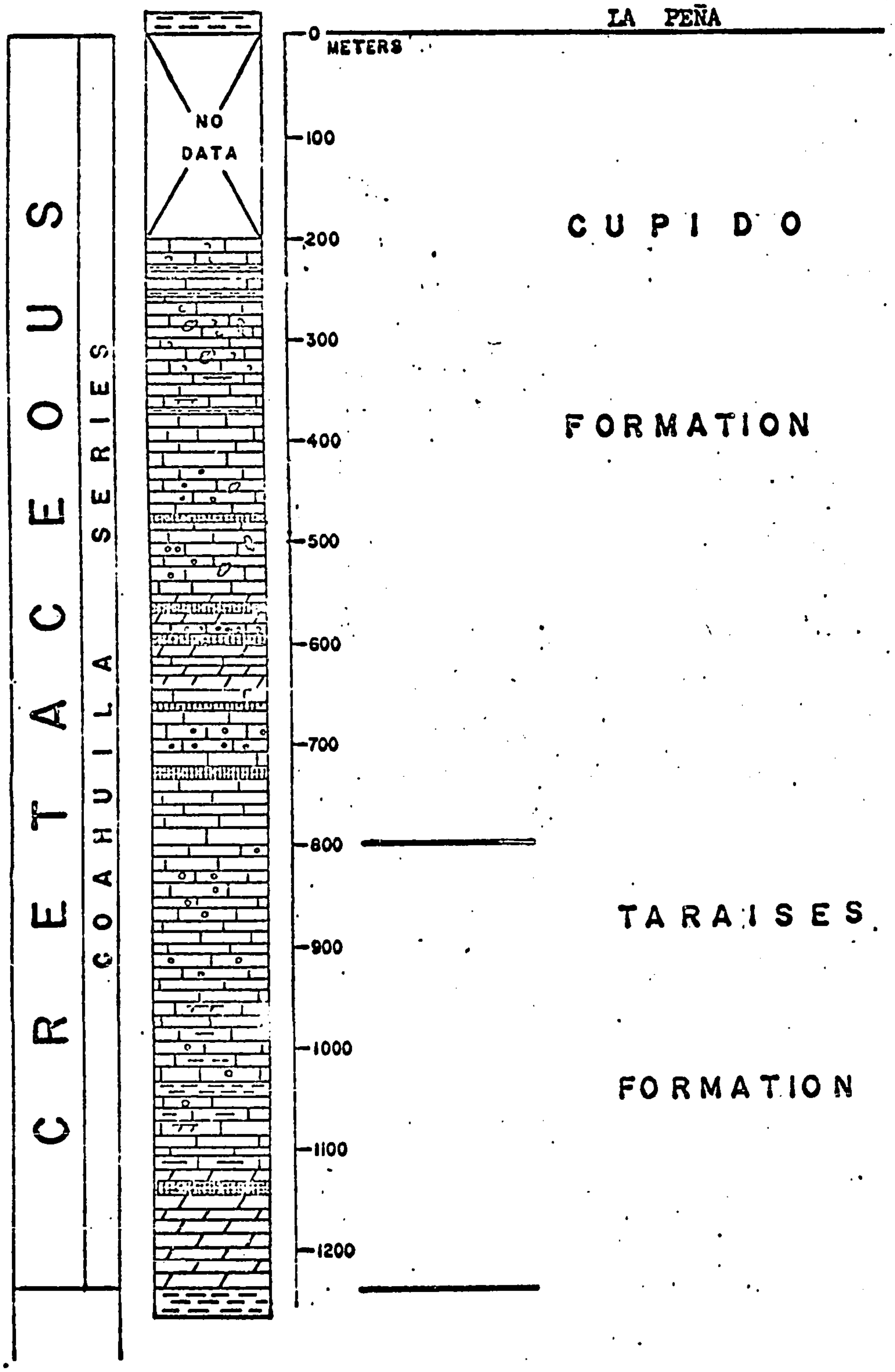
WELL PEYOTES 2-A

26



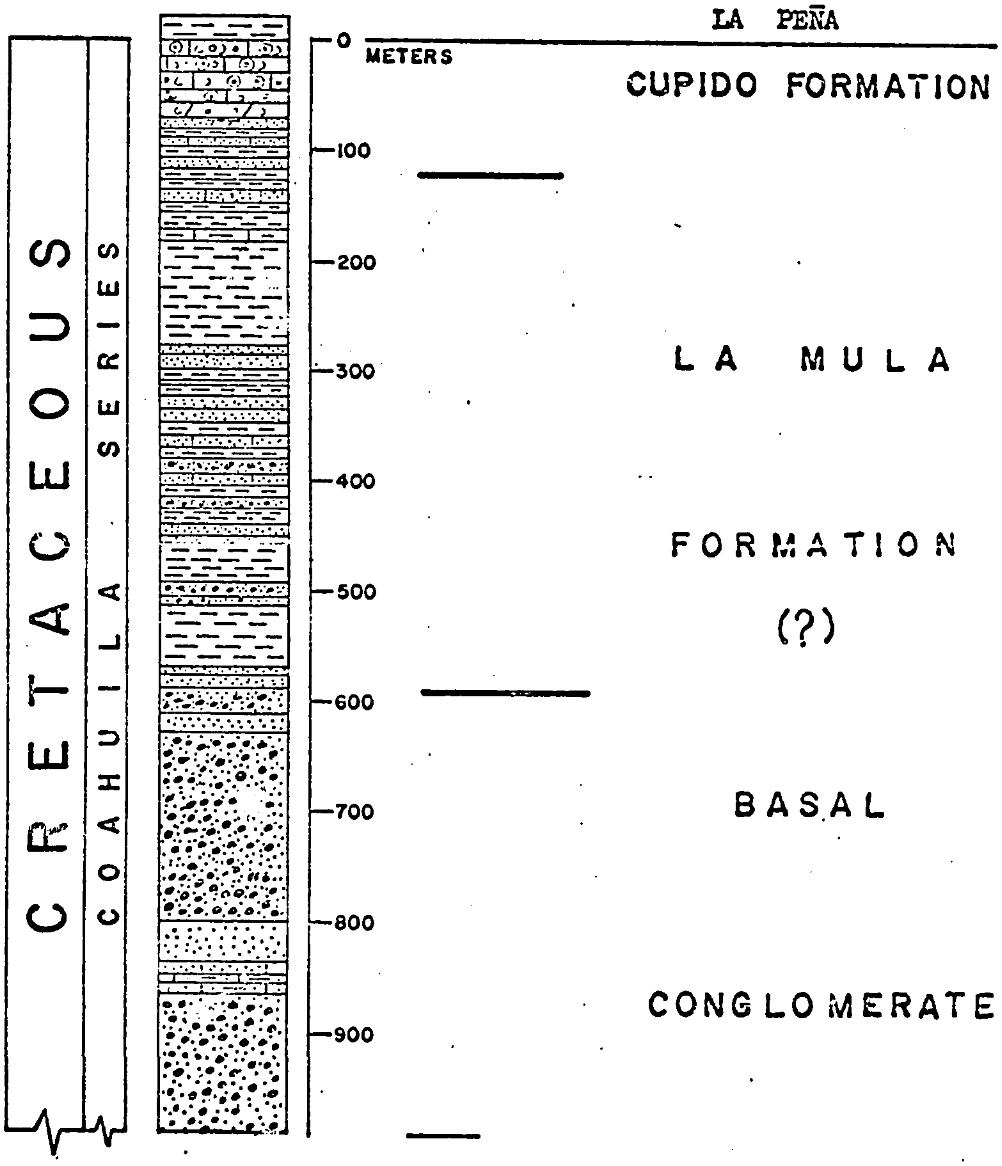
WELL ANHELO Nº 1

25



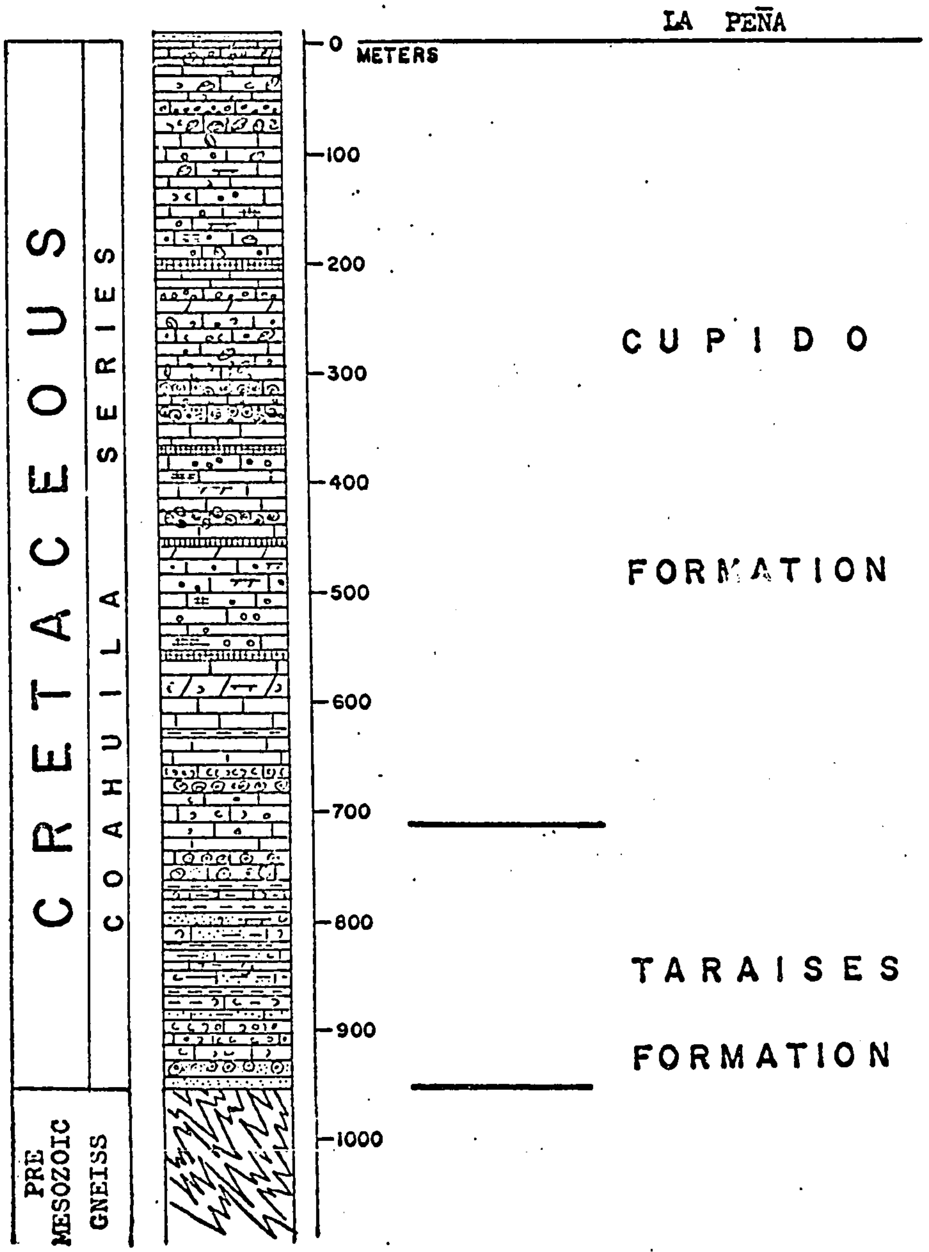
WELL CHUPADEROS Nº 1

27



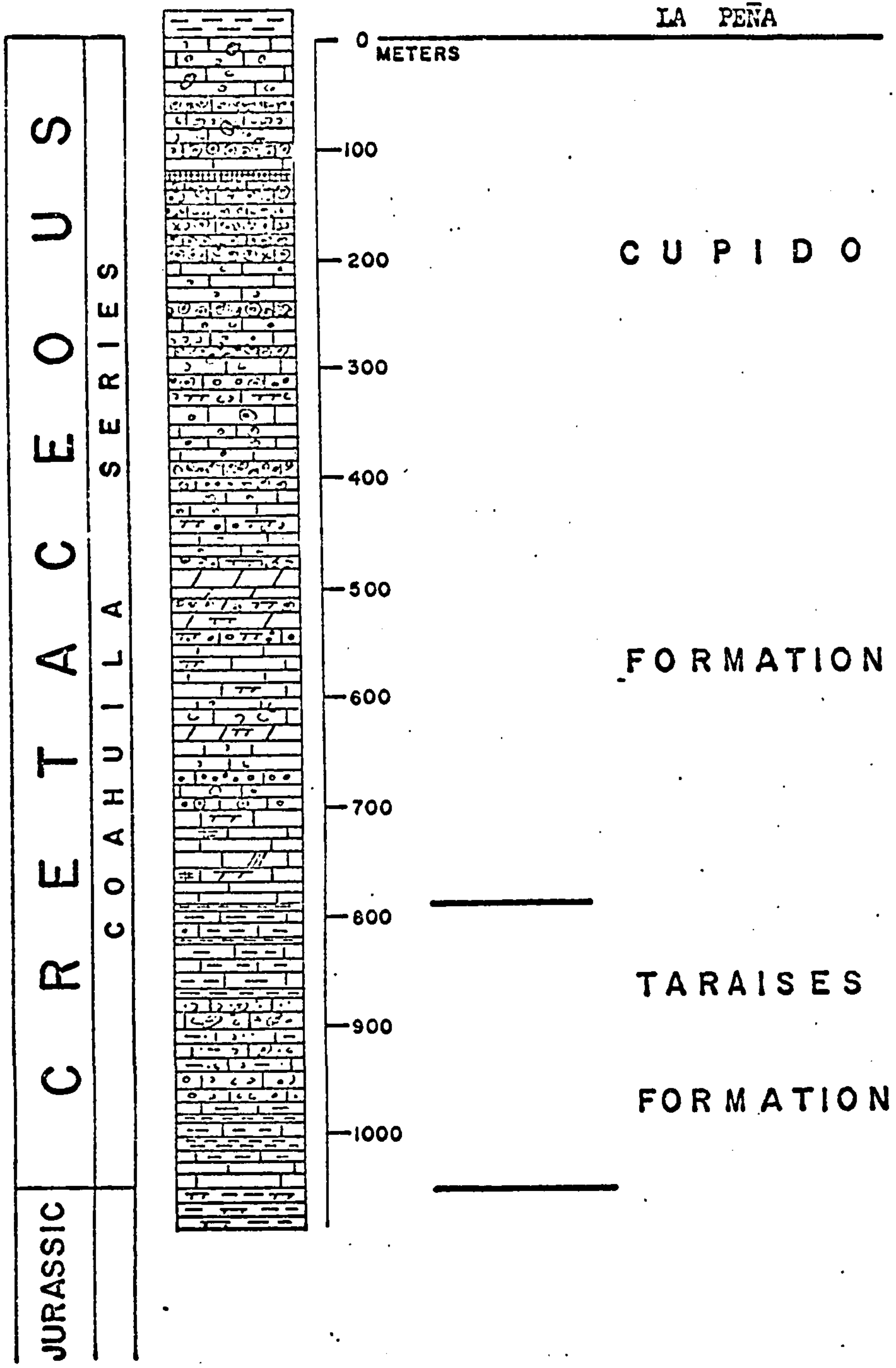
WELL LA PERLA Nº 1

28



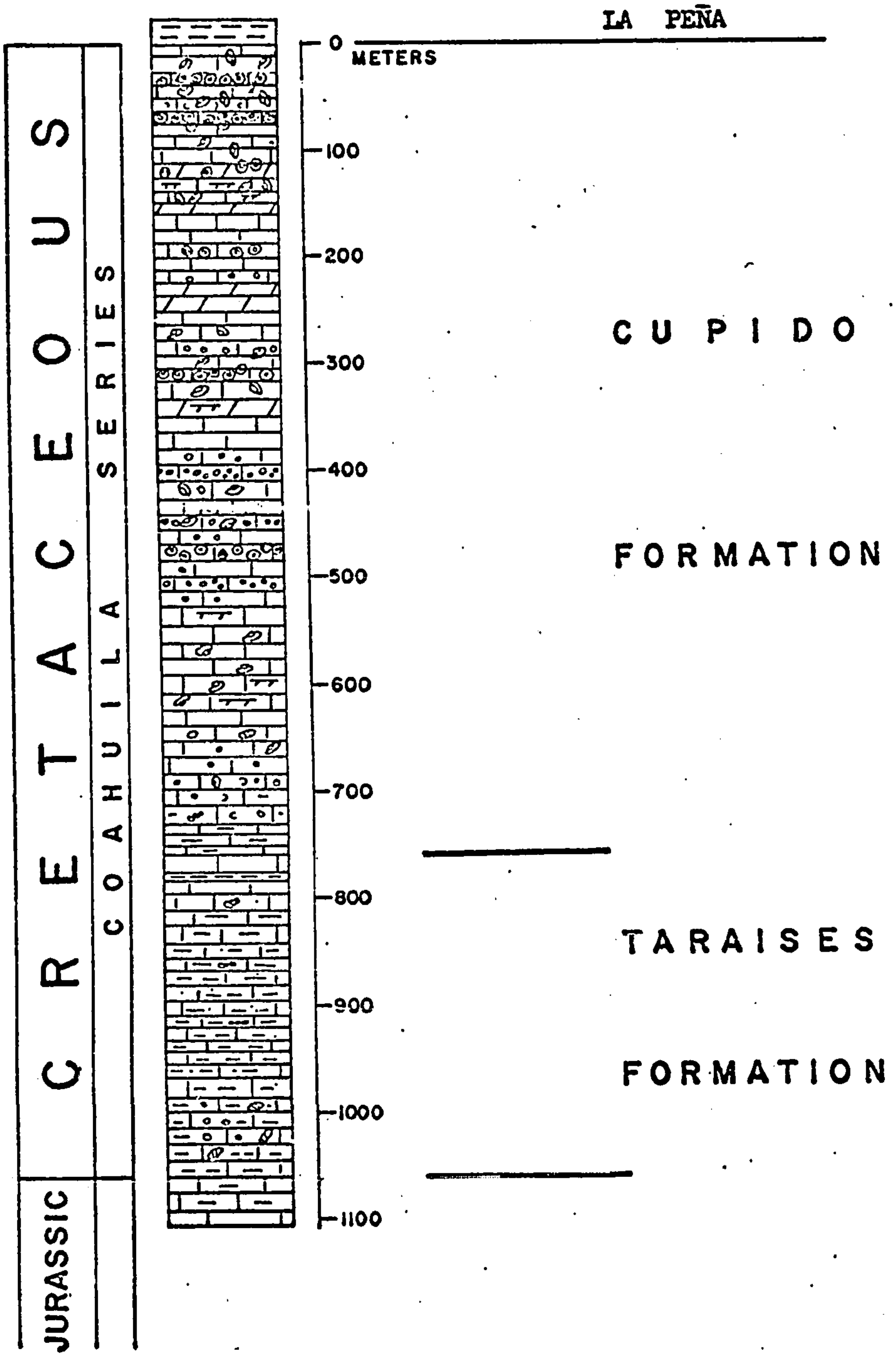
WELL GARZA Nº 1

29



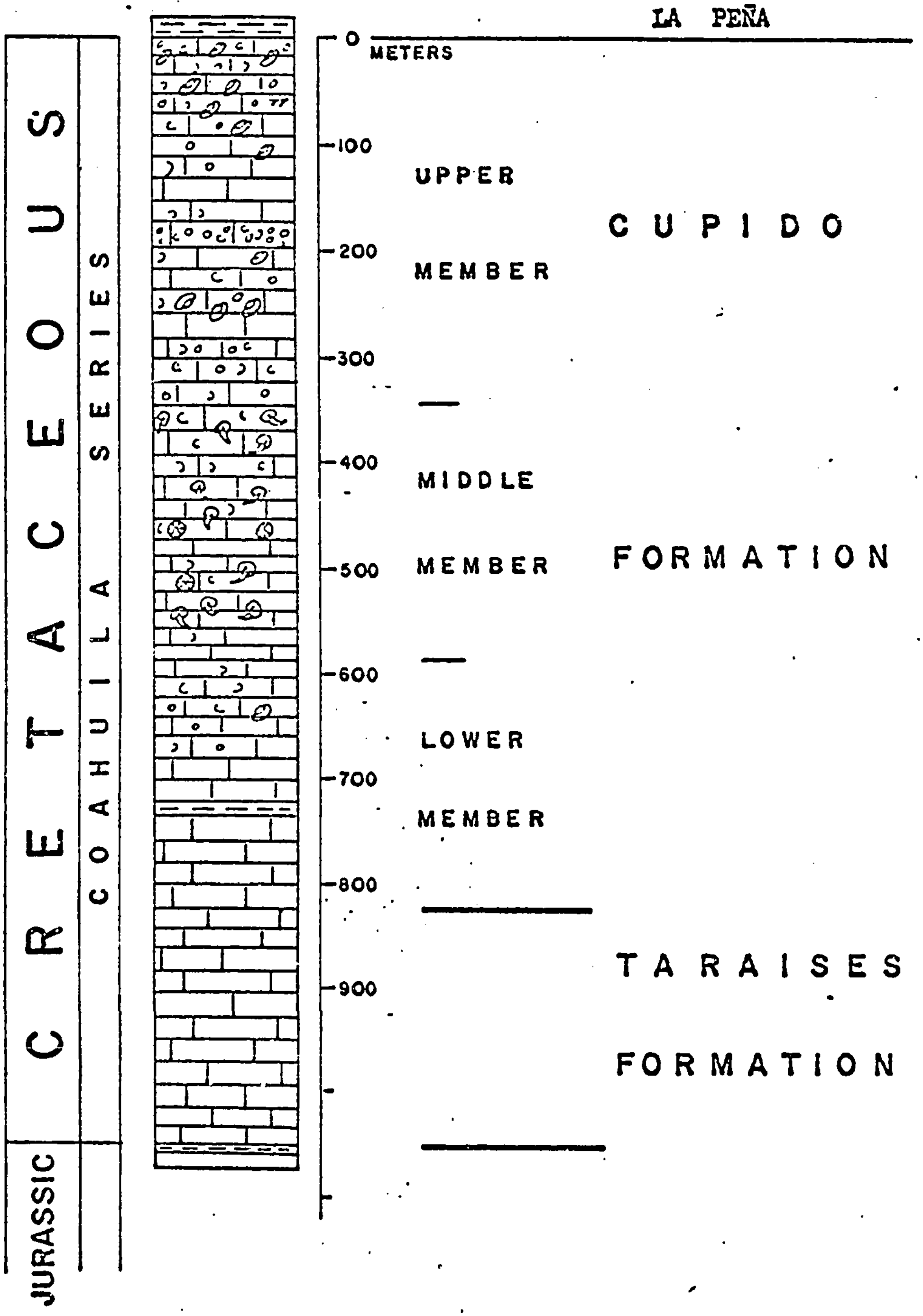
WELL REFORMA Nº 1

30



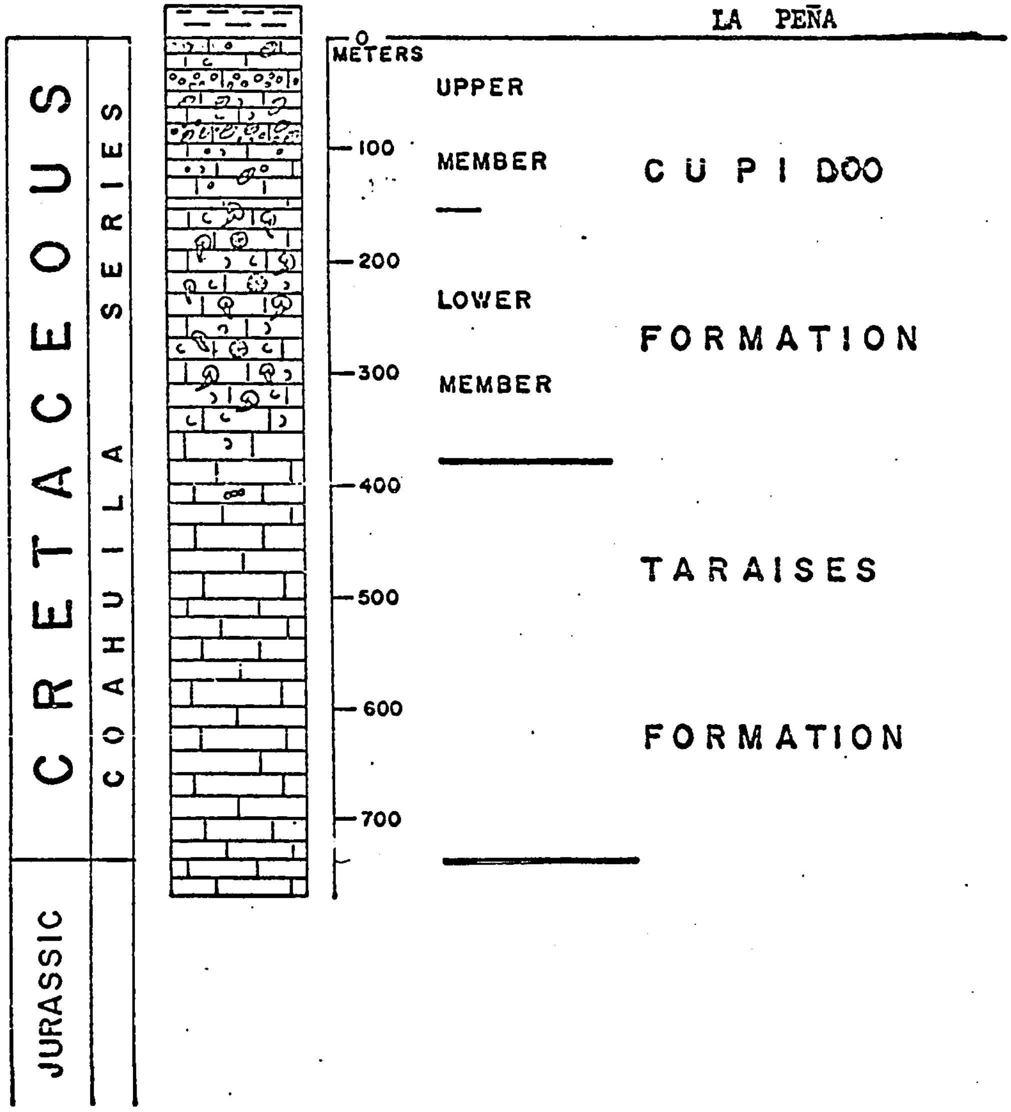
WELL CAMARON Nº 101

31



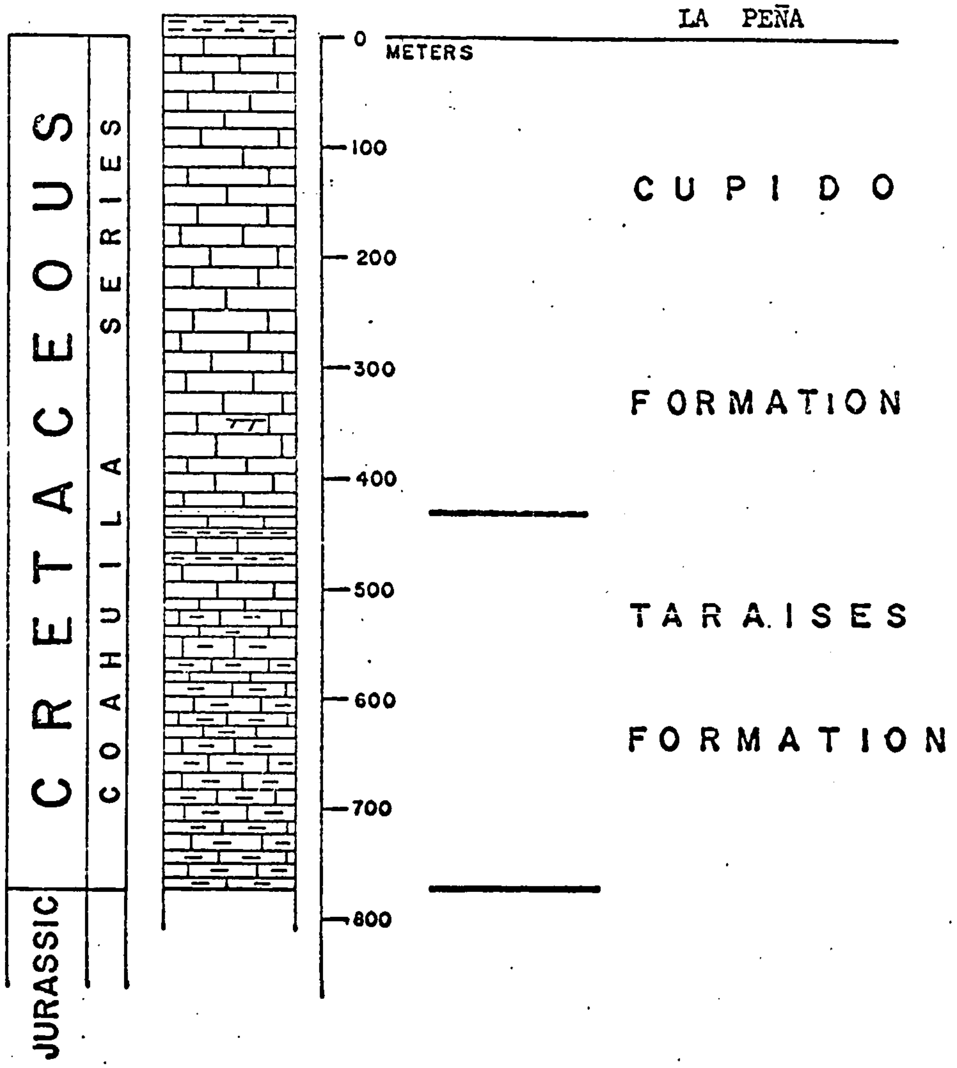
WELL ANAHUAC Nº 2

32



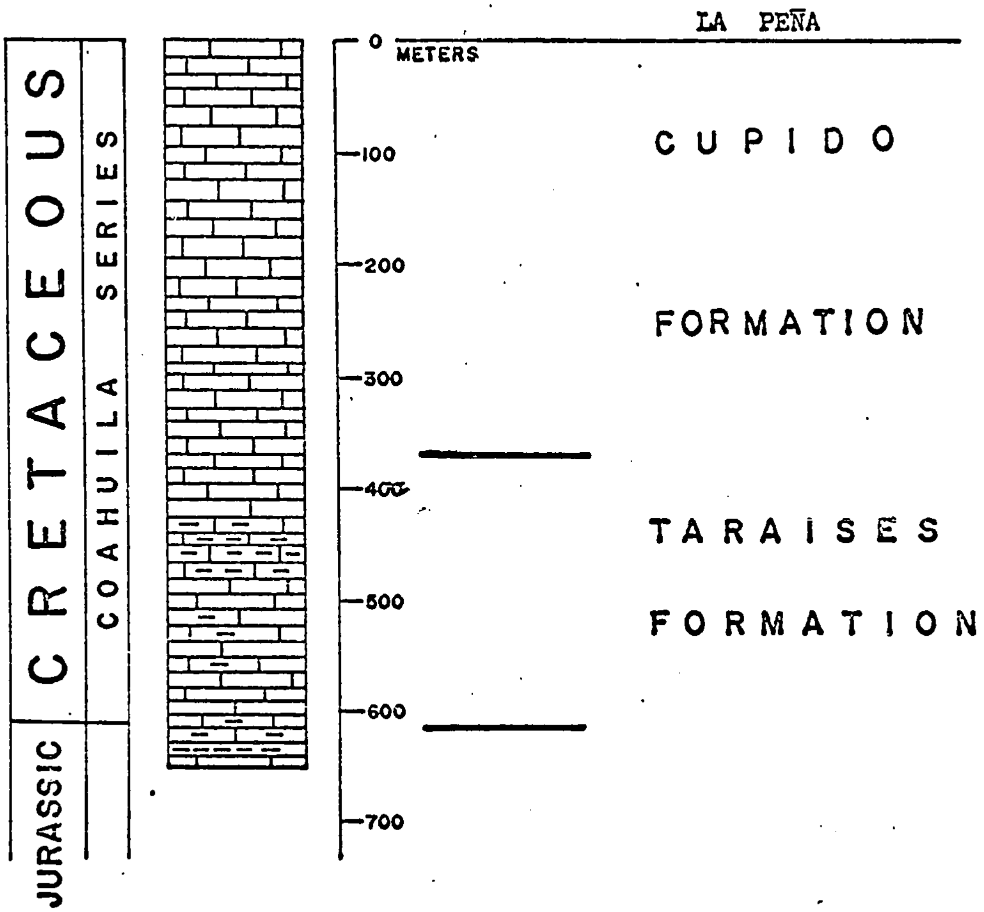
WELL SAN AMBROSIO Nº 1

33



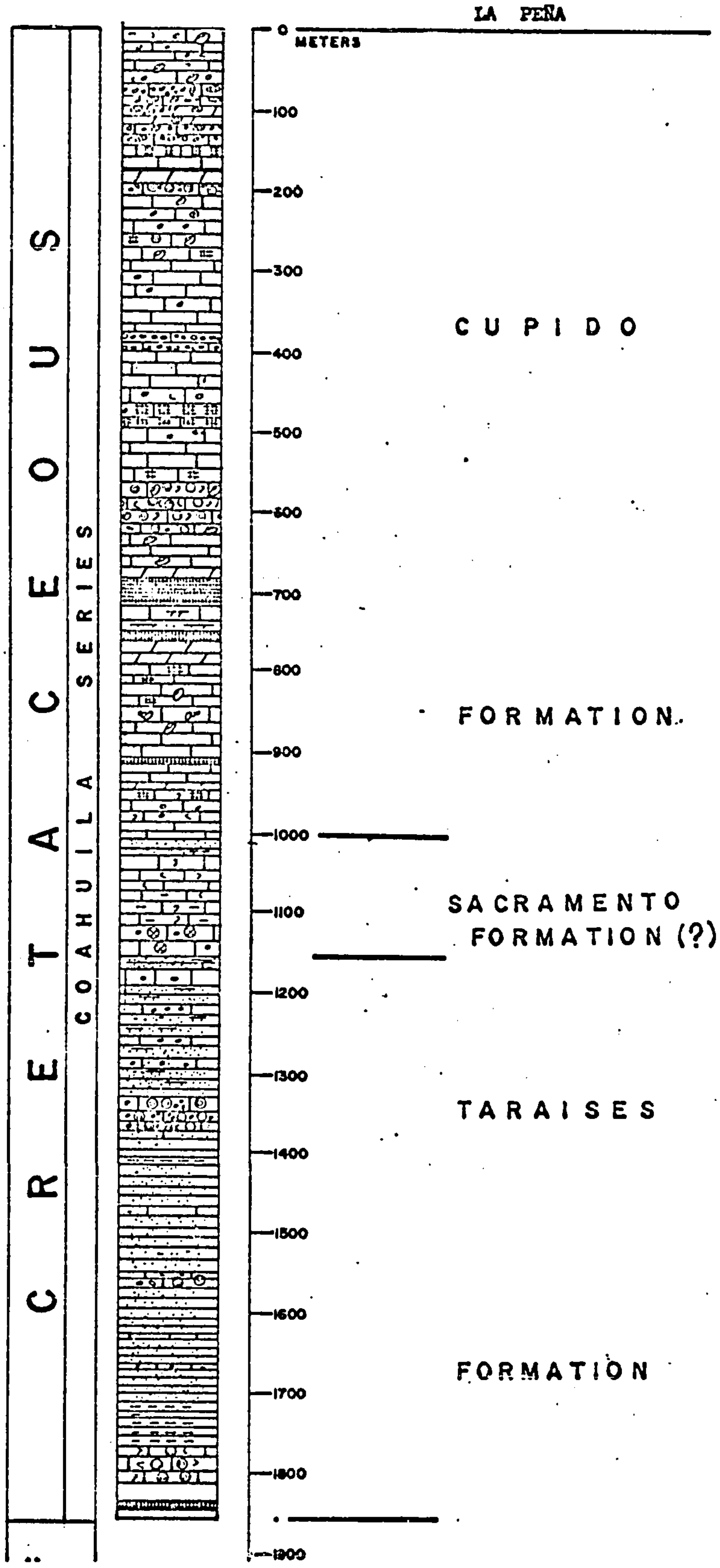
WELL LAJILLAS Nº 1

34



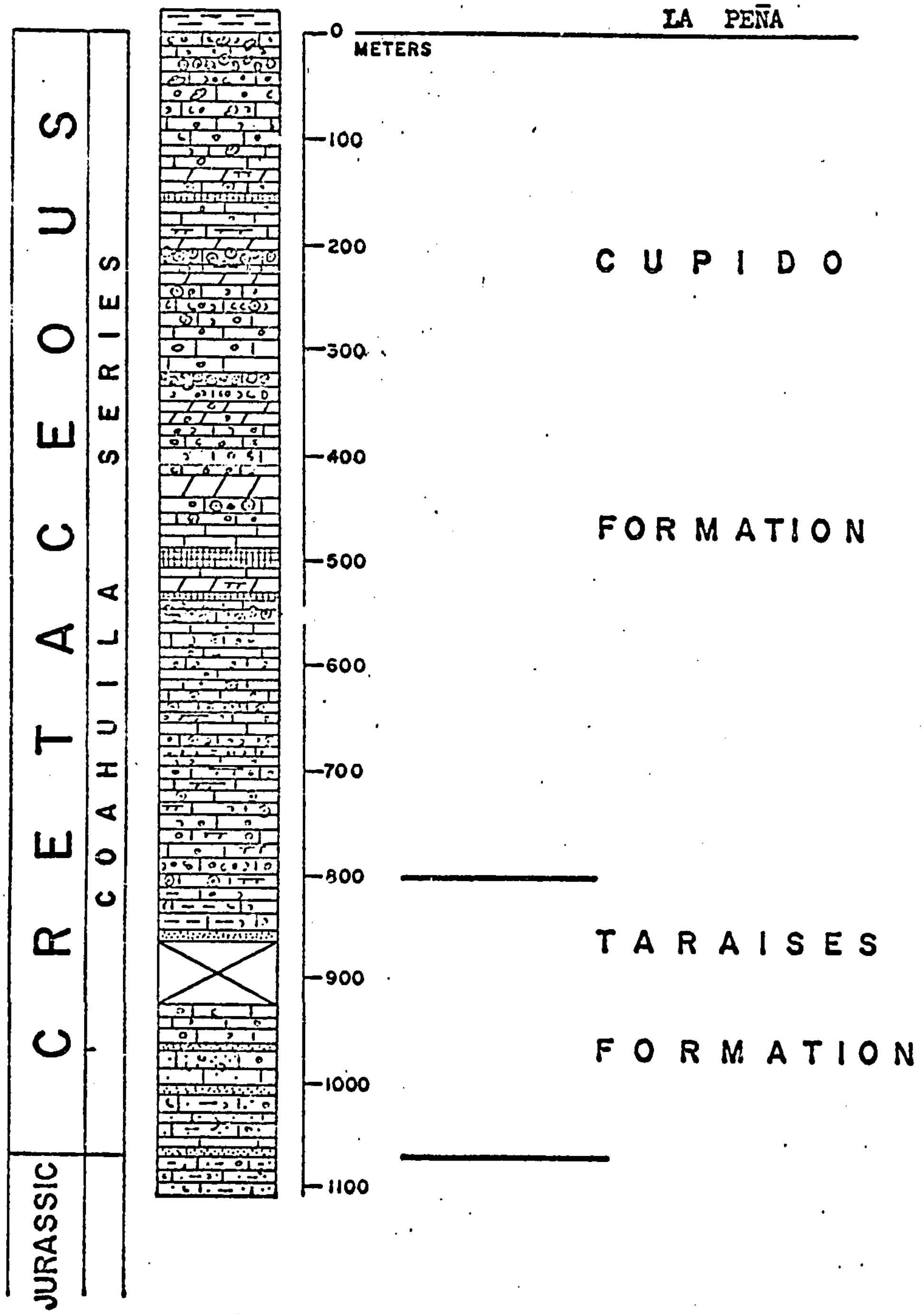
WELL EL GATO Nº 1

35



WELL DON MARTIN Nº 1

43



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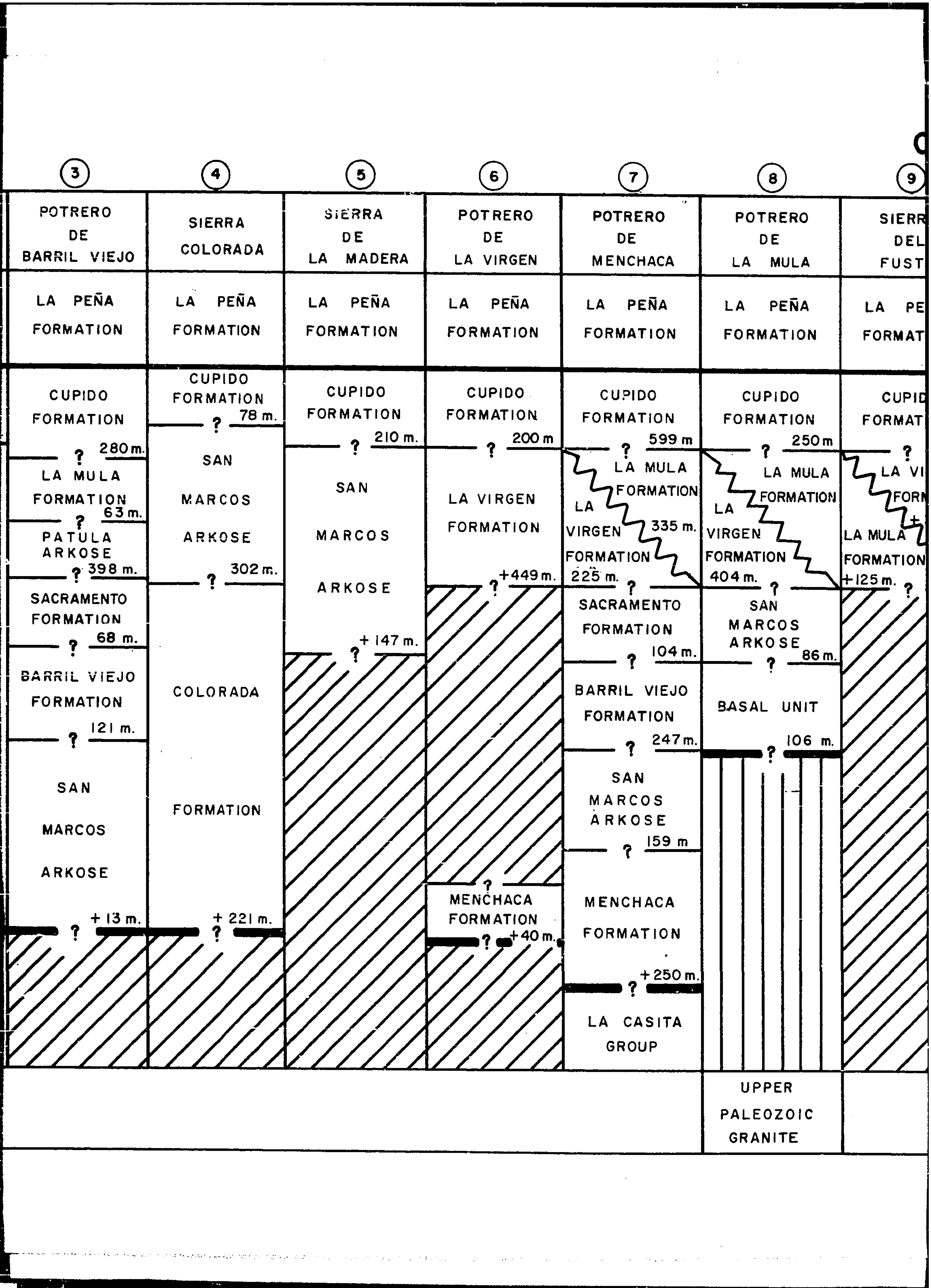
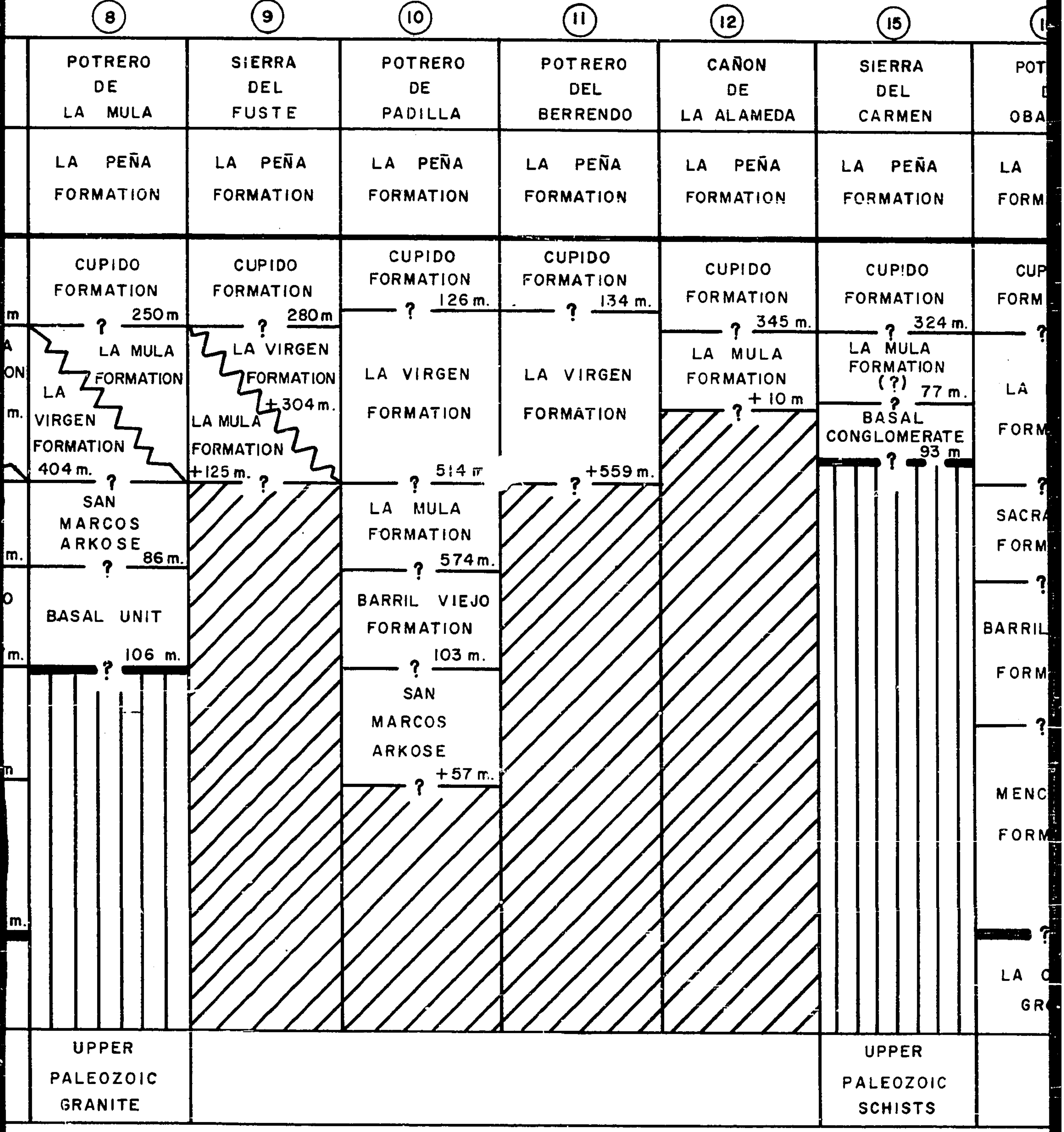
ERA	PERIOD	STAGE		SERIES	GROUP	② SIERRA DE SAN MARCOS	③ POTRERO DE BARRIL VIEJO
MESOZOIC	CRETACEOUS	APTIAN	GARGASIAN	COMANCHE	TRINITY	LA PEÑA FORMATION	LA PEÑA FORMATION
			BEDOULIAN	COAHUILA	NUEVO LEON	CUPIDO FORMATION ? 168 m.	CUPIDO FORMATION ? 280 m.
		NEOCOMIAN	BARREMIAN			SAN MARCOS ARKOSE	LA MULA FORMATION ? 63 m. PATULA ARKOSE ? 398 m.
			HAUTERIVIAN		DURANGO		SACRAMENTO FORMATION ? 68 m.
			VALANGINIAN				BARRIL VIEJO FORMATION ? 121 m.
			BERRIASIAN			? +744 m.	SAN MARCOS ARKOSE ? + 13 m.
	JURASSIC	TITHONIAN		SABINAS	LA CASITA	LA CASITA GROUP	▨
UNDERLYING ROCKS							


③
POTRERO DE BARRIL VIEJO
LA PEÑA FORMATION
CUPIDO FORMATION
? 280 m.
LA MULA FORMATION
? 63 m.
PATULA ARKOSE
? 398 m.
SACRAMENTO FORMATION
? 68 m.
BARRIL VIEJO FORMATION
? 121 m.
SAN MARCOS ARKOSE
? + 13 m.
④
SIERRA COLORADA
LA PEÑA FORMATION
CUPIDO FORMATION
? 78 m.
SAN MARCOS ARKOSE
? 302 m.
COLORADA FORMATION
? + 221 m.
⑤
SIERRA DE LA MADERA
LA PEÑA FORMATION
CUPIDO FORMATION
? 210 m.
SAN MARCOS ARKOSE
? + 147 m.
⑥
POTRERO DE LA VIRGEN
LA PEÑA FORMATION
CUPIDO FORMATION
? 200 m
LA VIRGEN FORMATION
? +449 m.
?
MENCHACA FORMATION
? +40 m.
⑦
POTRERO DE MENCHACA
LA PEÑA FORMATION
CUPIDO FORMATION
? 599 m
LA MULA FORMATION
335 m.
LA VIRGEN FORMATION
225 m. ?
SACRAMENTO FORMATION
? 104 m.
BARRIL VIEJO FORMATION
? 247 m.
SAN MARCOS ARKOSE
? 159 m
MENCHACA FORMATION
? + 250 m.
LA CASITA GROUP
⑧
POTRERO DE LA MULA
LA PEÑA FORMATION
CUPIDO FORMATION
? 250 m
LA MULA FORMATION
LA VIRGEN FORMATION
404 m. ?
SAN MARCOS ARKOSE
? 86 m.
BASAL UNIT
? 106 m.
UPPER PALEOZOIC GRANITE
⑨
SIERR
DEL
FUST
LA PE
FORMAT
CUPID
FORMAT
?
LA VI
FORM
+
LA MULA FORMATION
+125 m. ?
C

CORRELATION CHART OF



PL

CHART OF THE COAHUILA SERI

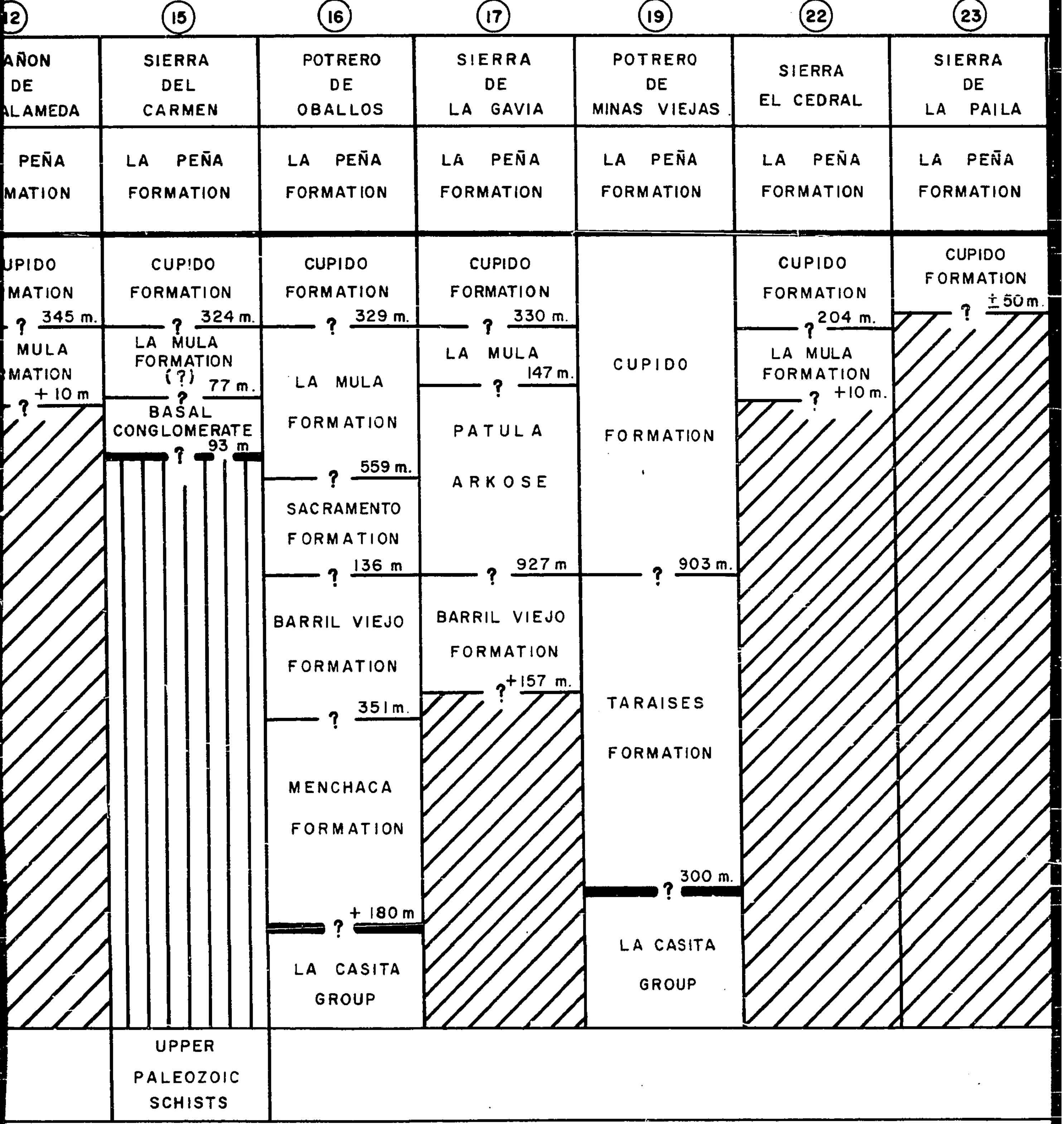
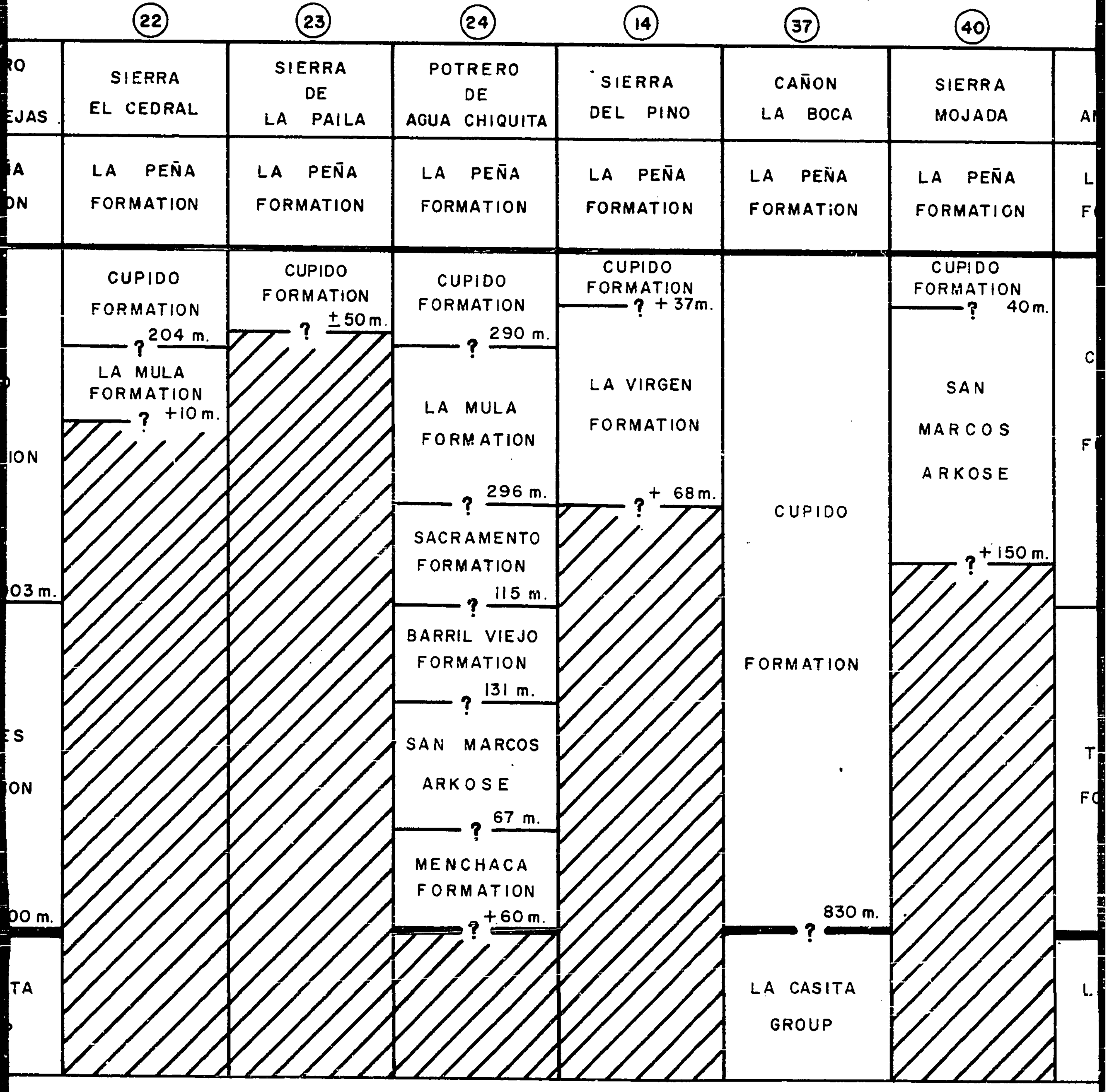
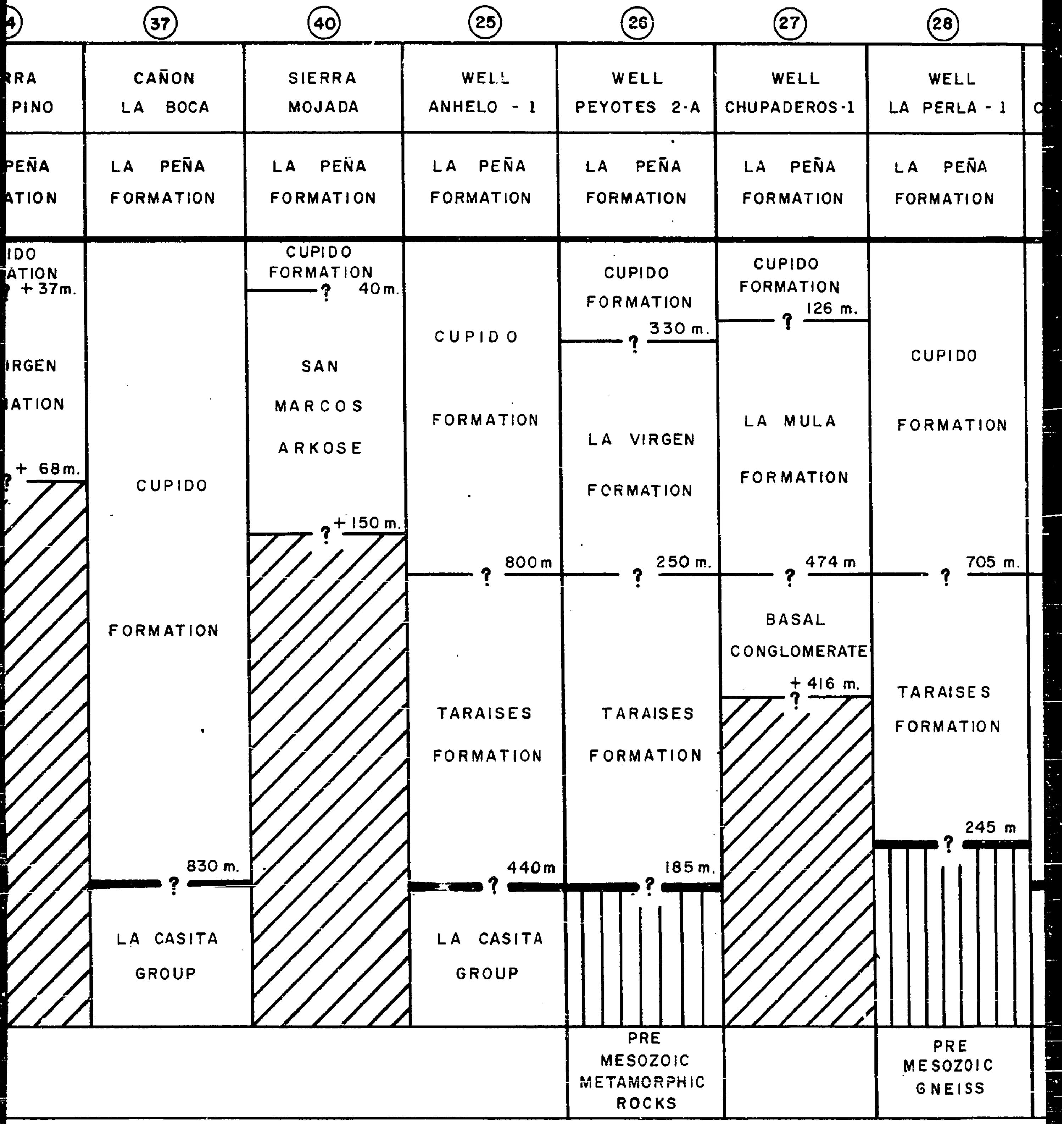


PLATE 16

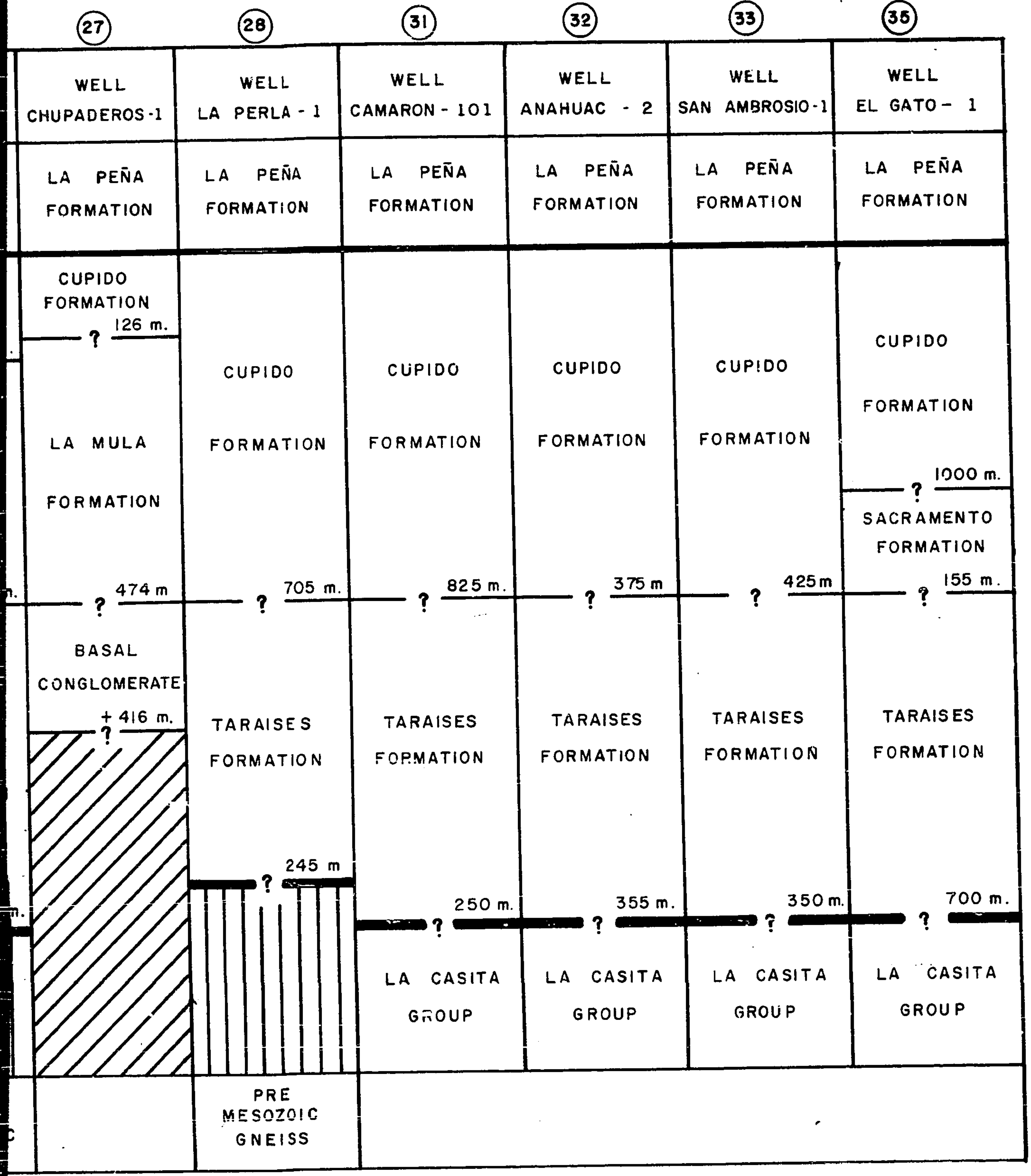
UILA SERIES



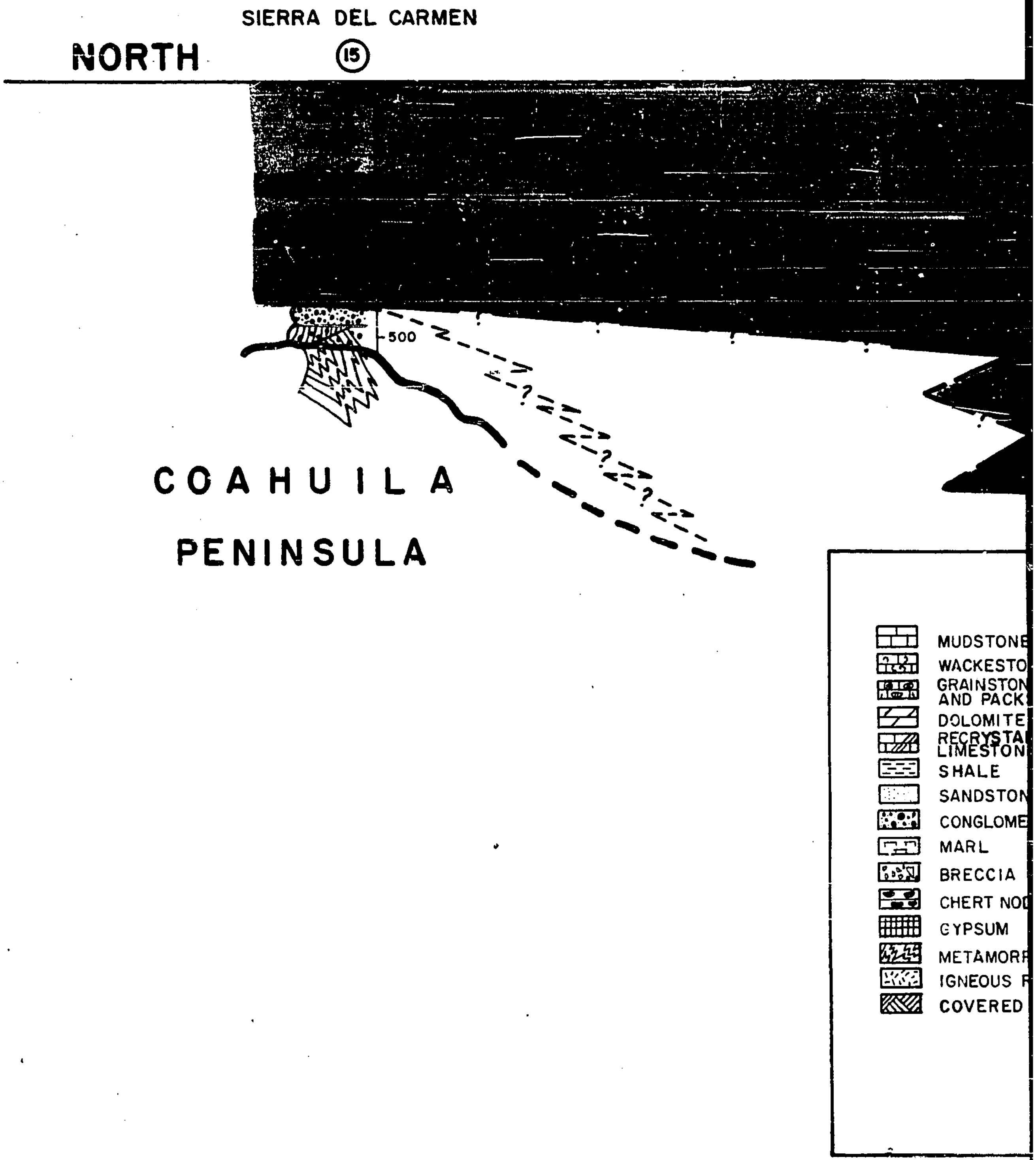
22
23
24
14
37
40
SIERRA EL CEDRAL
SIERRA DE LA PAILA
POTRERO DE AGUA CHIQUITA
SIERRA DEL PINO
CAÑON LA BOCA
SIERRA MOJADA
LA PEÑA FORMATION
CUPIDO FORMATION
? 204 m.
LA MULA FORMATION
? +10 m.
? ±50 m.
? 290 m.
LA MULA FORMATION
? 296 m.
SACRAMENTO FORMATION
? 115 m.
BARRIL VIEJO FORMATION
? 131 m.
SAN MARCOS ARKOSE
? 67 m.
MENCHACA FORMATION
? +60 m.
? +37m.
LA VIRGEN FORMATION
? +68m.
CUPIDO FORMATION
? 830 m.
LA CASITA GROUP
? 40 m.
SAN MARCOS ARKOSE
? +150 m.



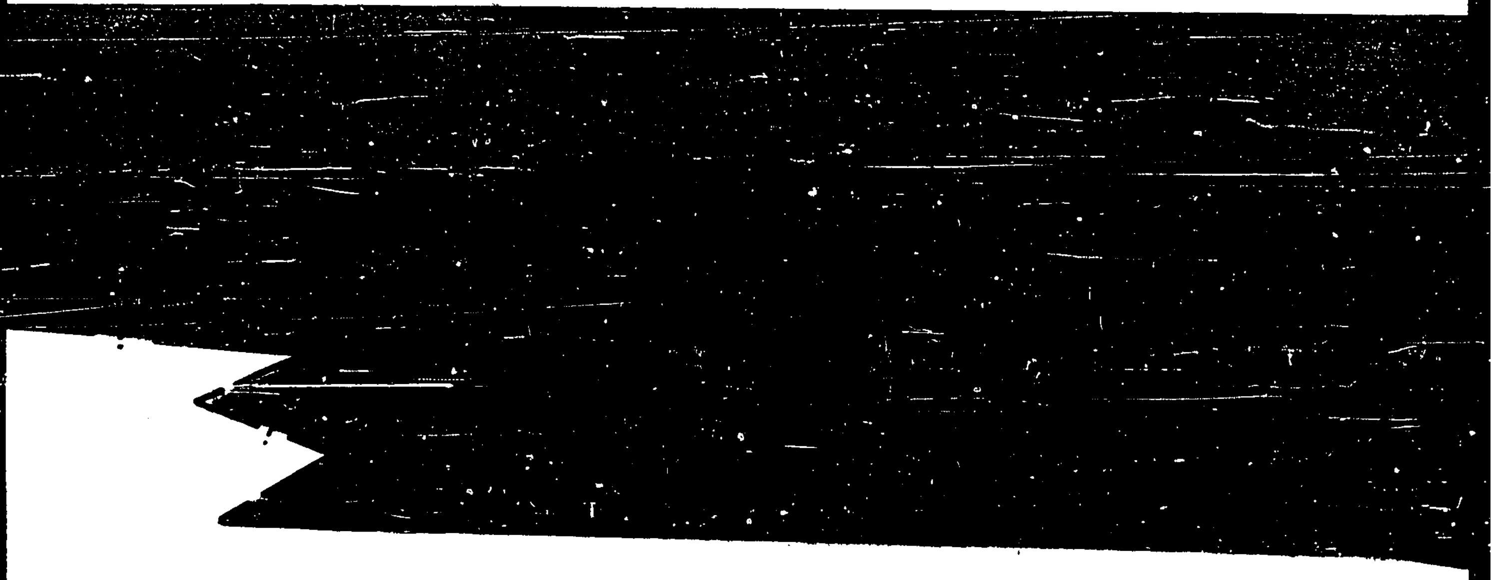
4
RRA
PINO
PEÑA
ATION
IDO
ATION
? + 37m.
IRGEN
IATION
? + 68m.
37
CAÑON
LA BOCA
LA PEÑA
FORMATION
CUPIDO
FORMATION
830 m.
?
LA CASITA
GROUP
40
SIERRA
MOJADA
LA PEÑA
FORMATION
CUPIDO
FORMATION
? 40m.
SAN
MARCOS
ARKOSE
? + 150 m.
25
WELL
ANHELO - 1
LA PEÑA
FORMATION
CUPIDO
FORMATION
? 800m
TARAISES
FORMATION
440m
?
LA CASITA
GROUP
26
WELL
PEYOTES 2-A
LA PEÑA
FORMATION
CUPIDO
FORMATION
? 330 m.
LA VIRGEN
FORMATION
? 250 m.
TARAISES
FORMATION
185 m.
?
PRE
MESOZOIC
METAMORPHIC
ROCKS
27
WELL
CHUPADEROS-1
LA PEÑA
FORMATION
CUPIDO
FORMATION
? 126 m.
LA MULA
FORMATION
? 474 m
BASAL
CONGLOMERATE
+ 416 m.
?
28
WELL
LA PERLA - 1
LA PEÑA
FORMATION
CUPIDO
FORMATION
? 705 m.
TARAISES
FORMATION
245 m
?
PRE
MESOZOIC
GNEISS
C



SANTIAGO CHARLESTON


SIERRA DEL CARMEN
NORTH
⑮
500
?
?
?
COAHUILA
PENINSULA
MUDSTONE
WACKESTO
GRAINSTON
AND PACK
DOLOMITE
RECRYSTAL
LIMESTON
SHALE
SANDSTON
CONGLOME
MARL
BRECCIA
CHERT NOD
GYPSUM
METAMORF
IGNEOUS R
COVERED

SIERRA EL CEDRAL
㉒



EXPLANATION

- MUDSTONE
- WACKESTONE
- GRAINSTONE AND PACKSTONE
- DOLOMITE
- RECRYSTALLIZED LIMESTONE
- SHALE
- SANDSTONE
- CONGLOMERATE
- MARL
- BRECCIA
- CHERT NODULES
- GYPSUM
- METAMORPHIC ROCK
- IGNEOUS ROCK
- COVERED

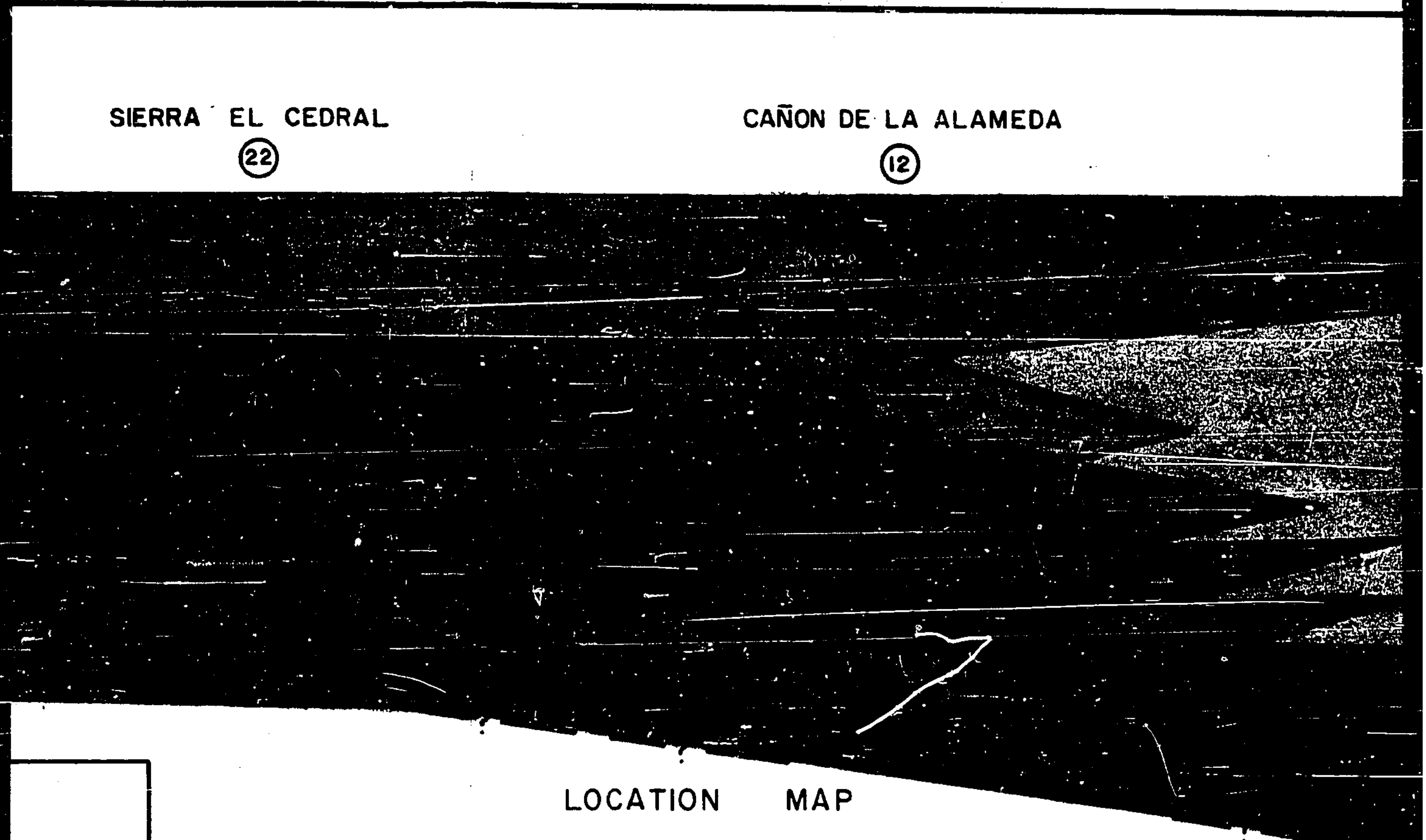
- OOLITE
- PELLET
- INTRACLAST
- SHELL FRAGMENT
- MILIOLID
- ORBITOLINA
- PLANKTONIC FORAMINIFERA
- BENTHONIC FORAMINIFERA
- PELECYPOD
- GASTROPOD
- EXOGYRA
- RUDISTID FRAGMENT

- AMMONITE
- TOUCASIA
- CAPRINID
- MONOPLEURID
- RADIOLITID
- SERPULID
- ECHINOID
- BRACHIOPOD
- OYSTER
- OSTRACOD
- ALGAL FRAGMENT
- CORAL

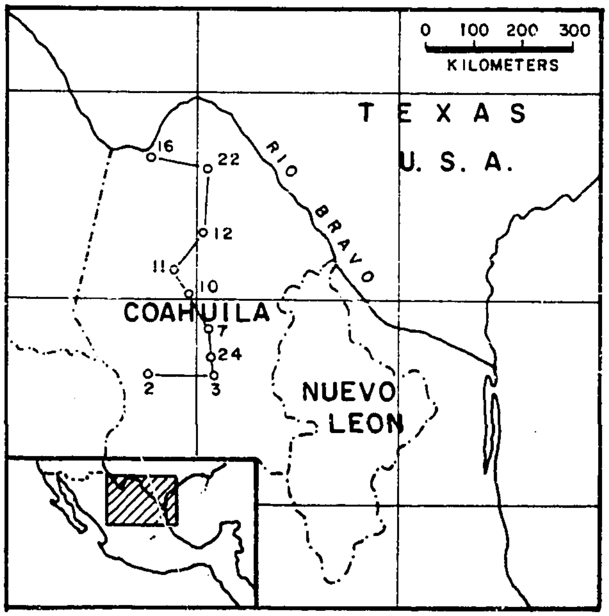
STRUCTURES

- NODULAR
- LAMINATION
- BURROWS
- STYLOLITIC LINE

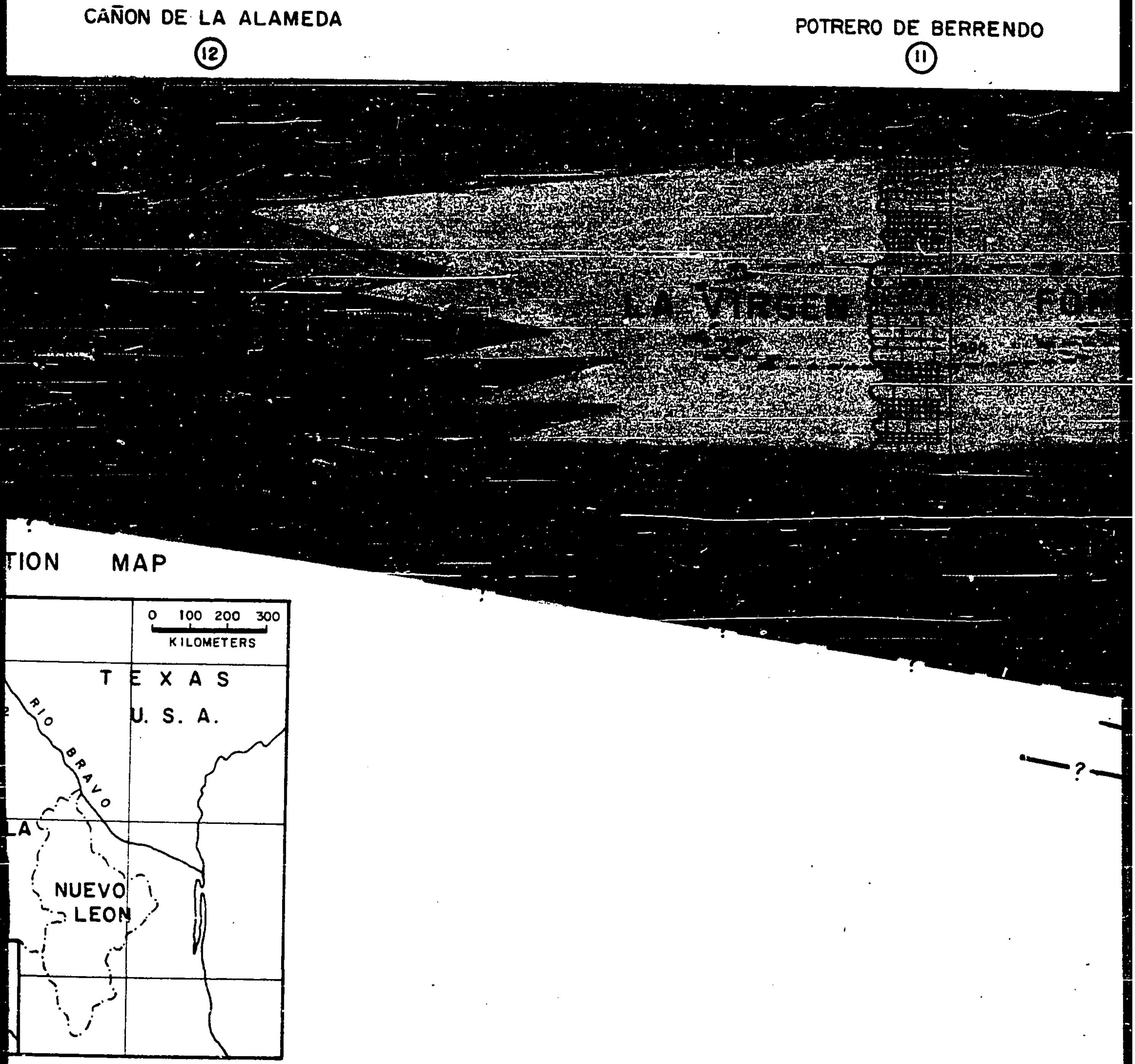
- CROSS-BEDDING
- MUD-CRACKS
- BORINGS

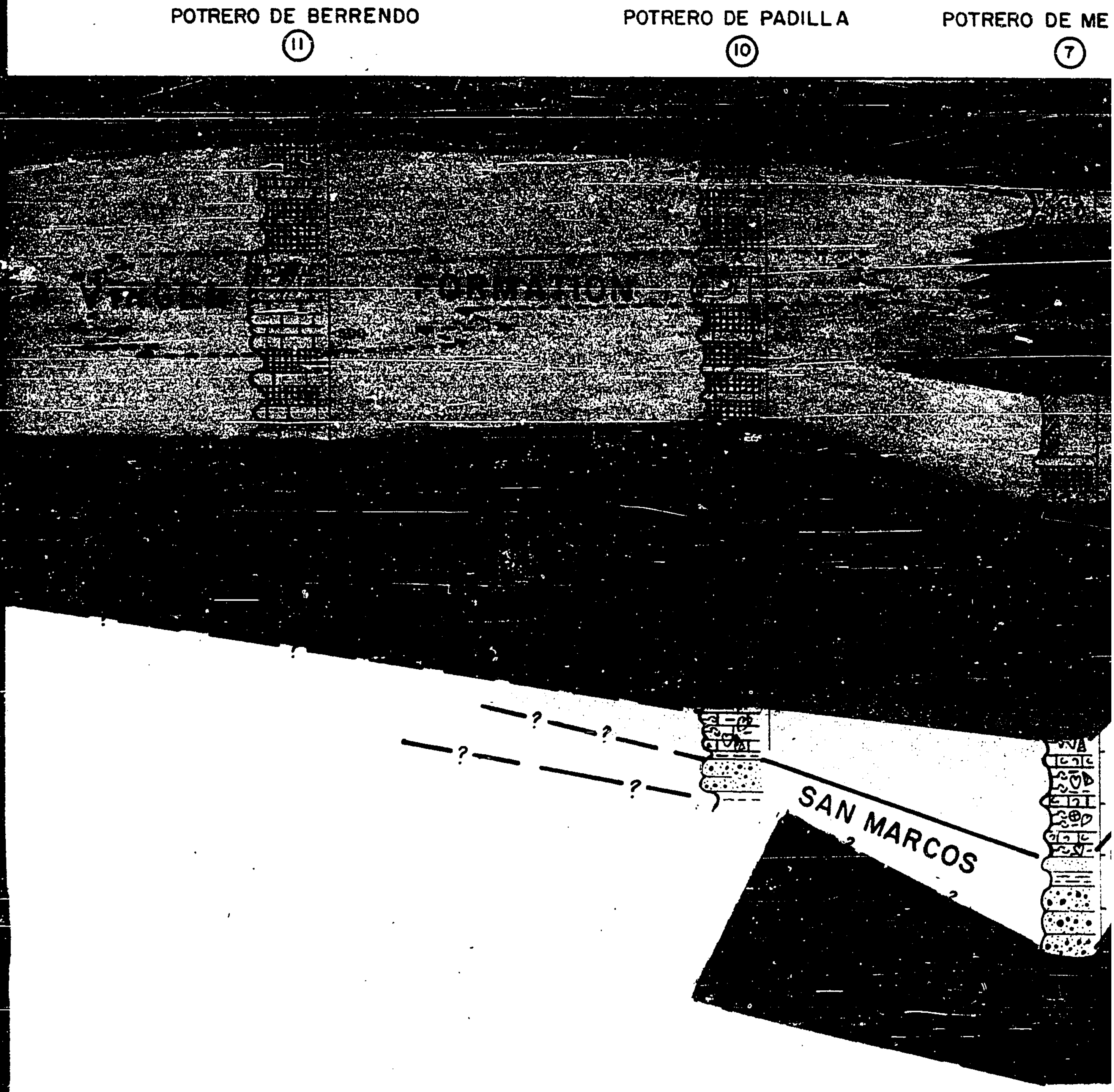


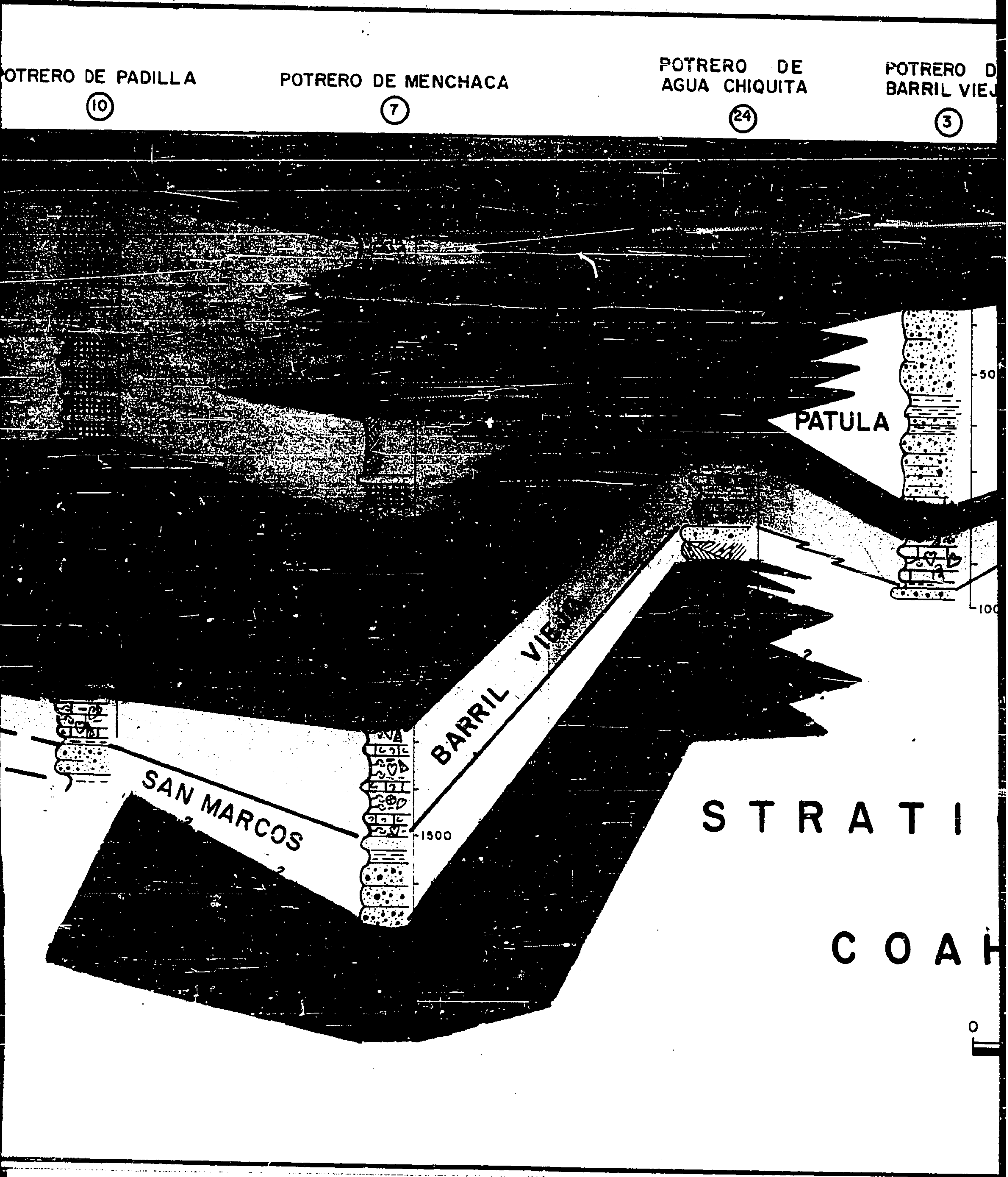
LOCATION MAP



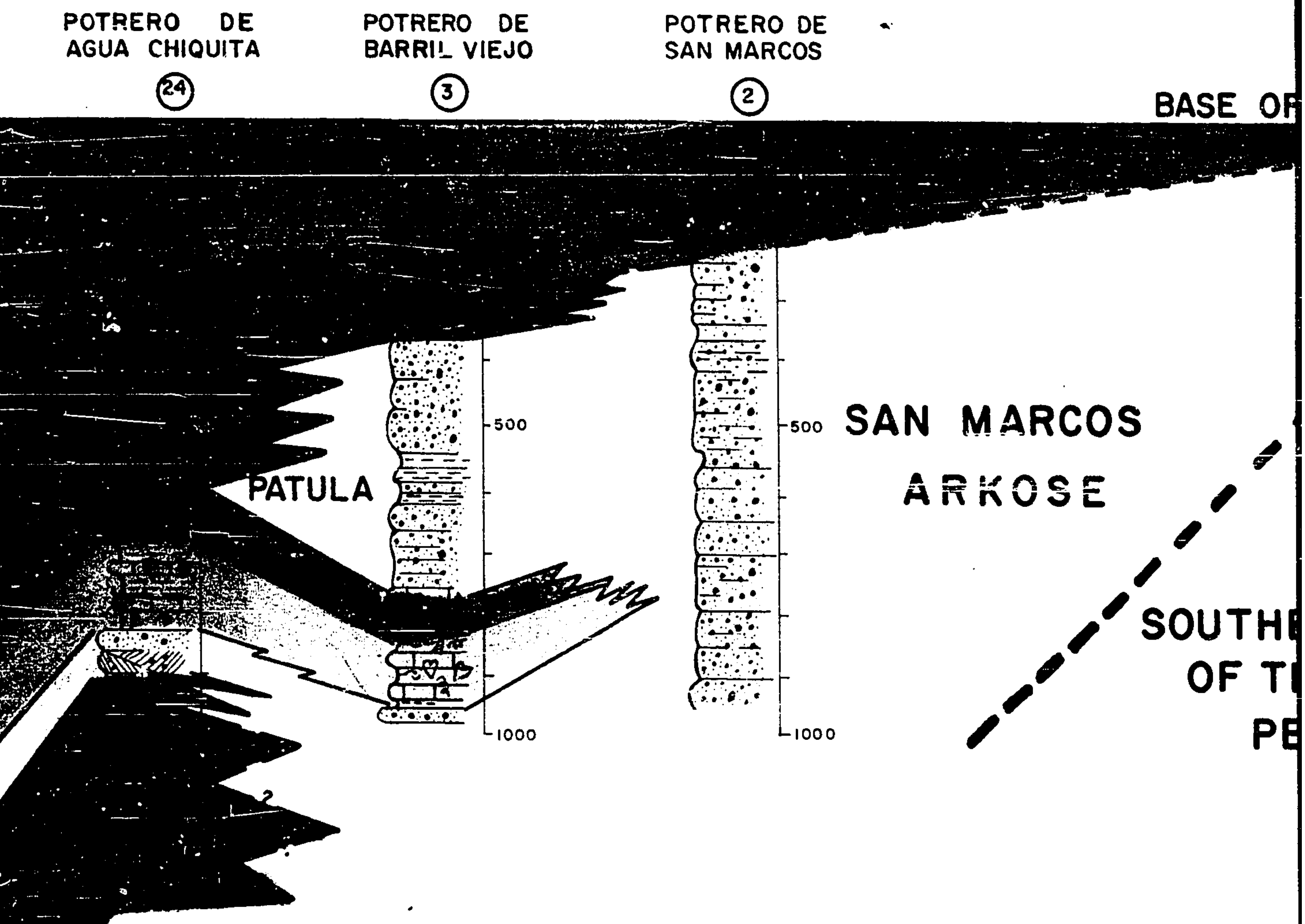
DDING
CKS


CAÑON DE LA ALAMEDA
12
POTRERO DE BERRENDO
11
LA VIRGEN
FOR
?
TION MAP
0 100 200 300
KILOMETERS
TEXAS
U. S. A.
RIO BRAVO
LA
NUEVO LEON


POTRERO DE BERRENDO
⑪
POTRERO DE PADILLA
⑩
POTRERO DE ME
⑦
FORMATION
?
?
?
?
SAN MARCOS

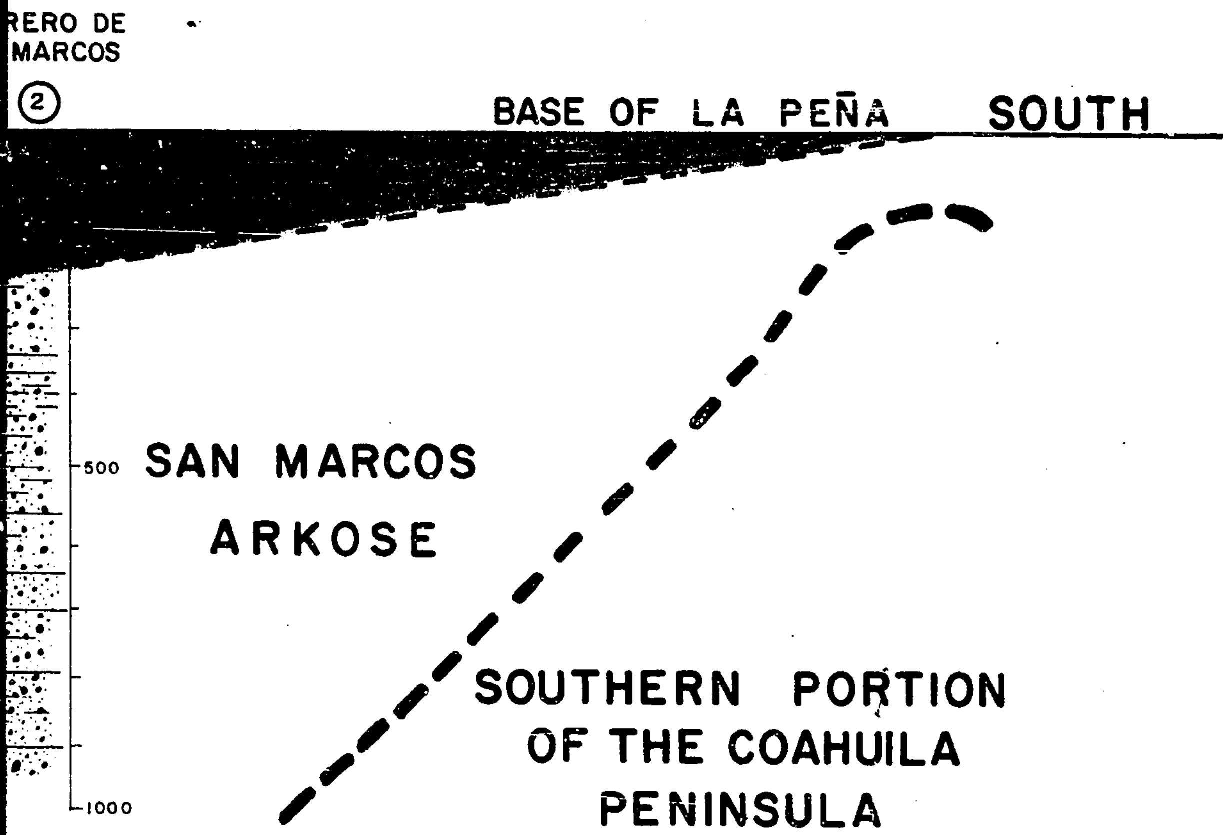


POTRERO DE PADILLA
10
POTRERO DE MENCHACA
7
POTRERO DE AGUA CHIQUITA
24
POTRERO D
BARRIL VIEJ
3
PATULA
50
100
BARRIL VIEJO
SAN MARCOS
1500
2
2
2
STRATI
COAH
0



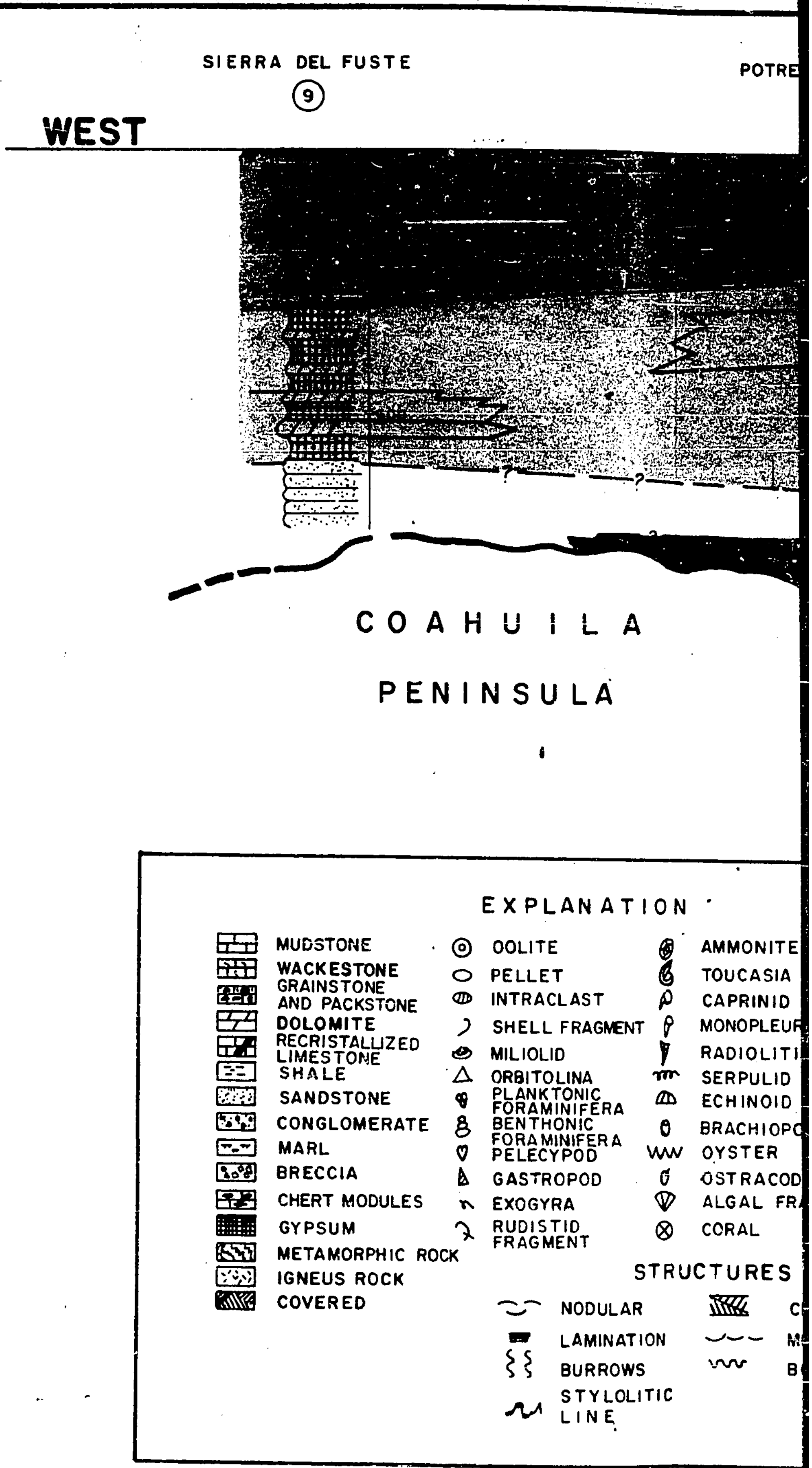
STRATIGRAPHIC SEC
OF THE
COAHUILA SERIE

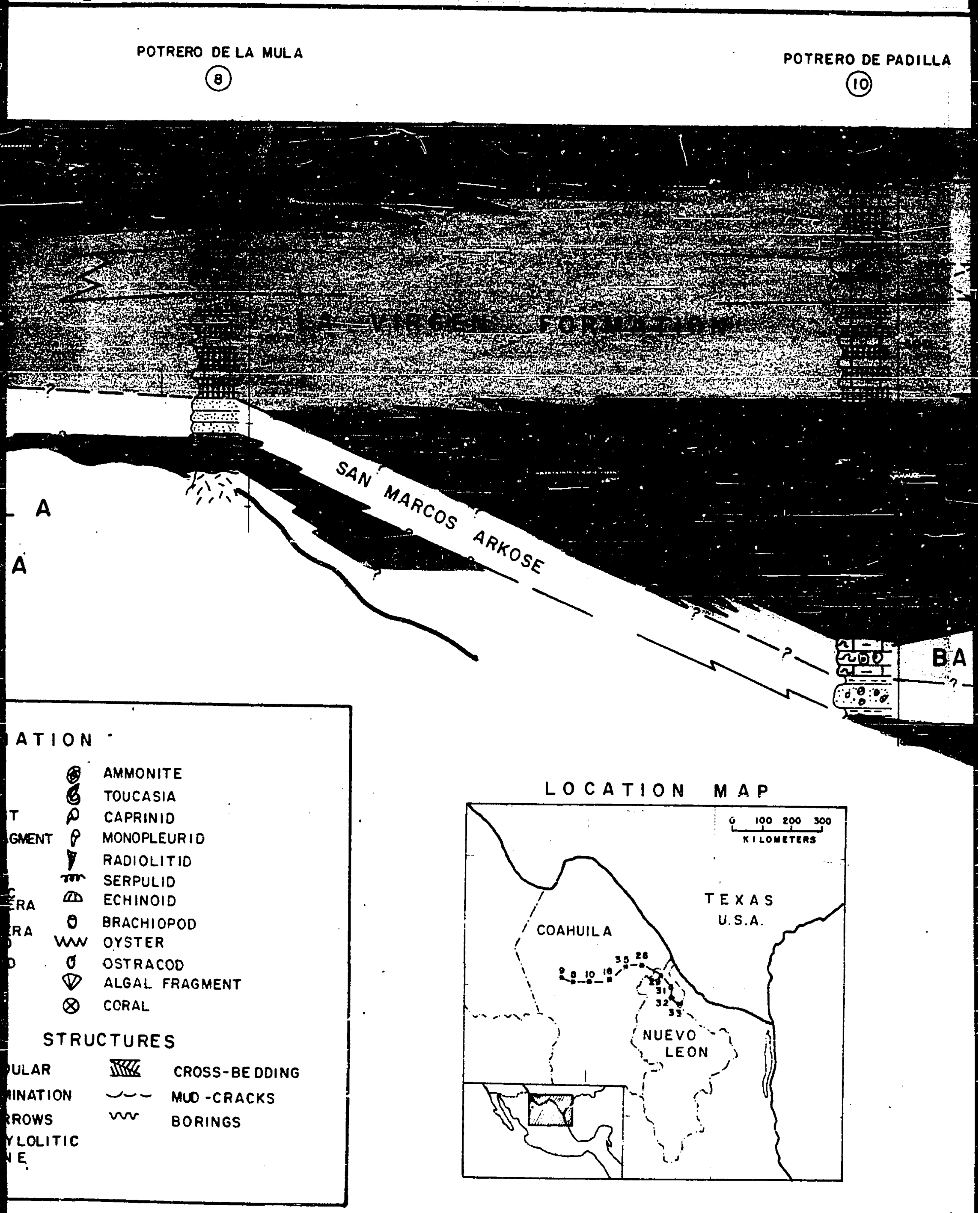
PLATE 17

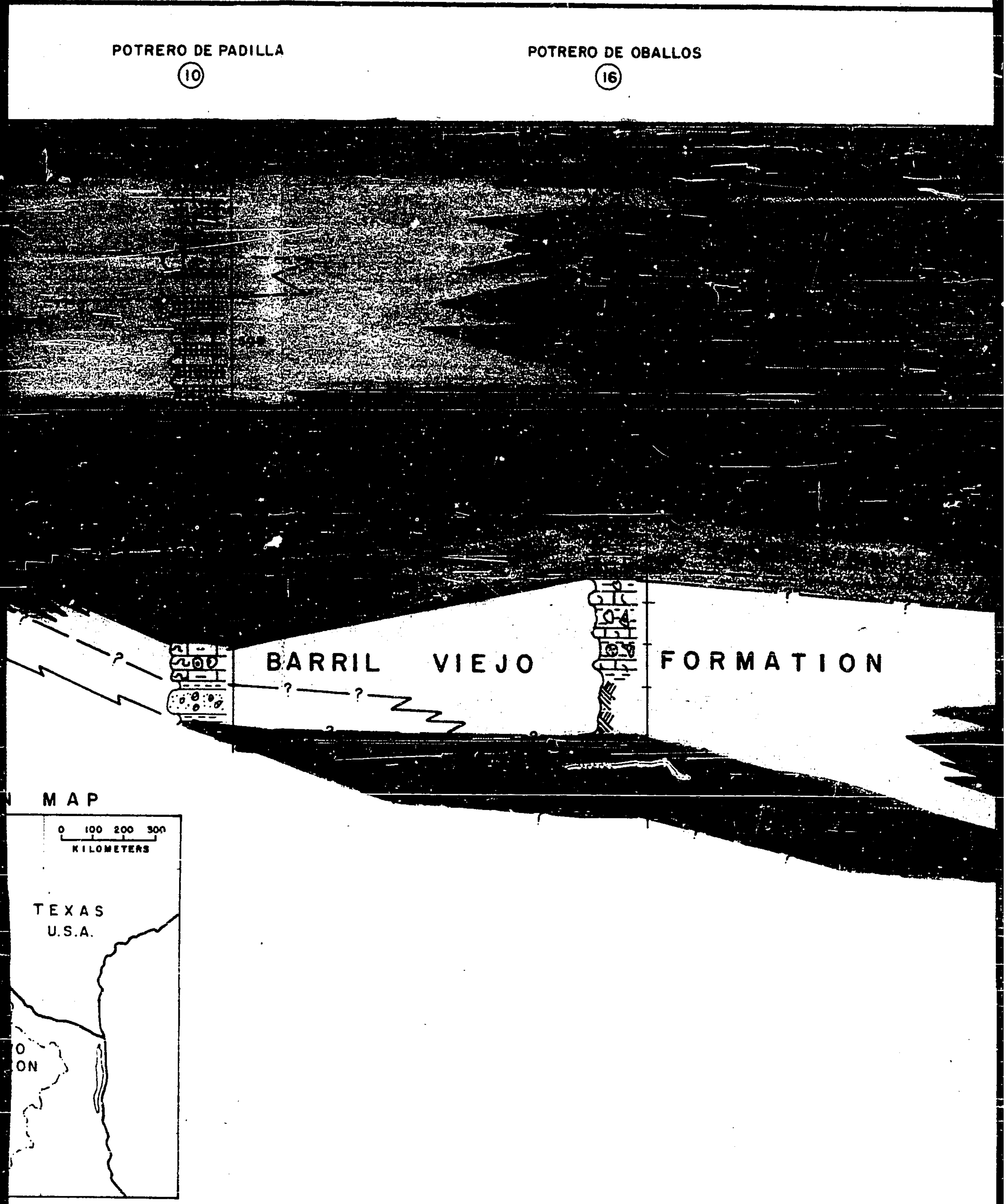


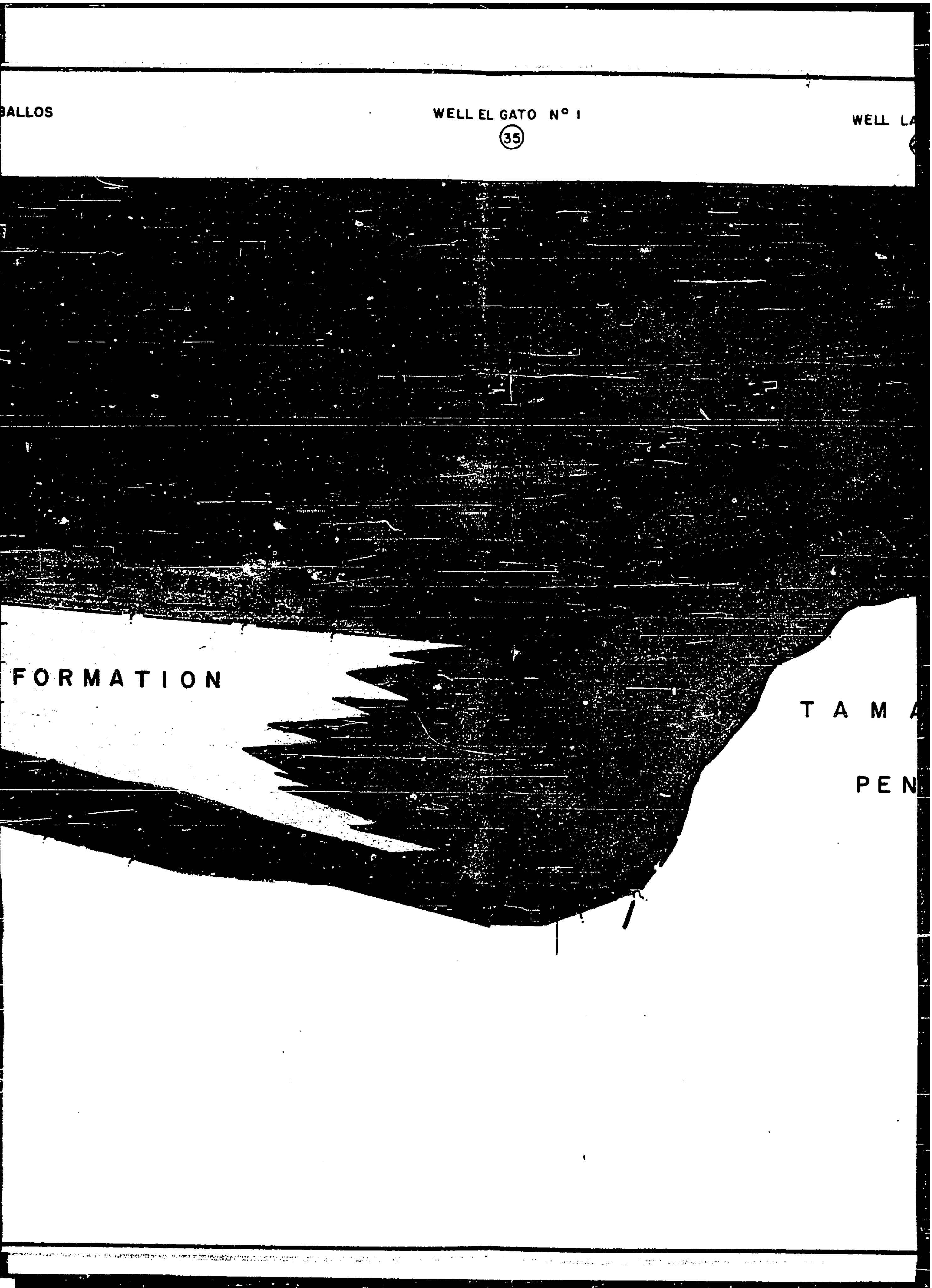
PHIC SECTION
THE
A SERIES

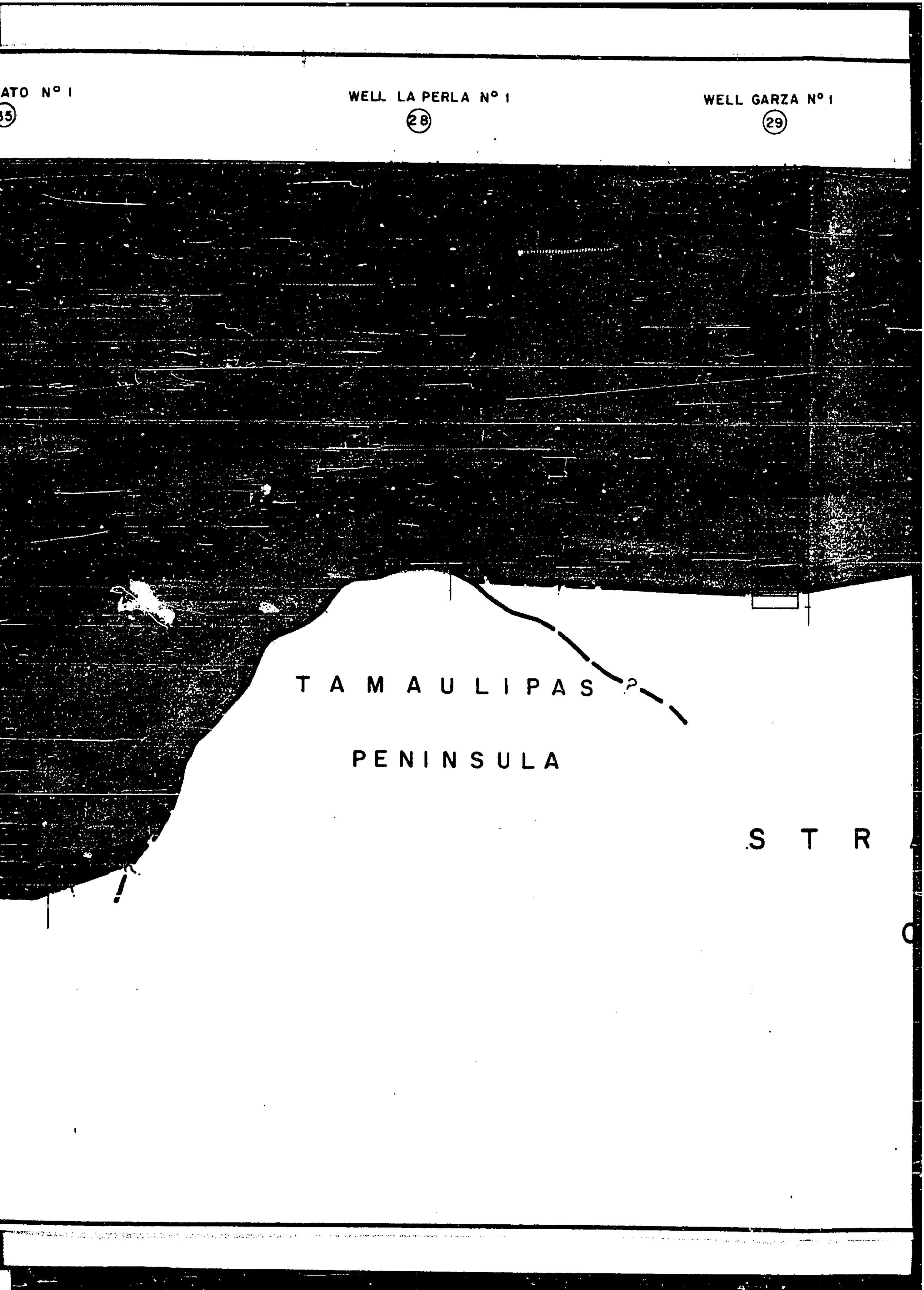
PLATE 17

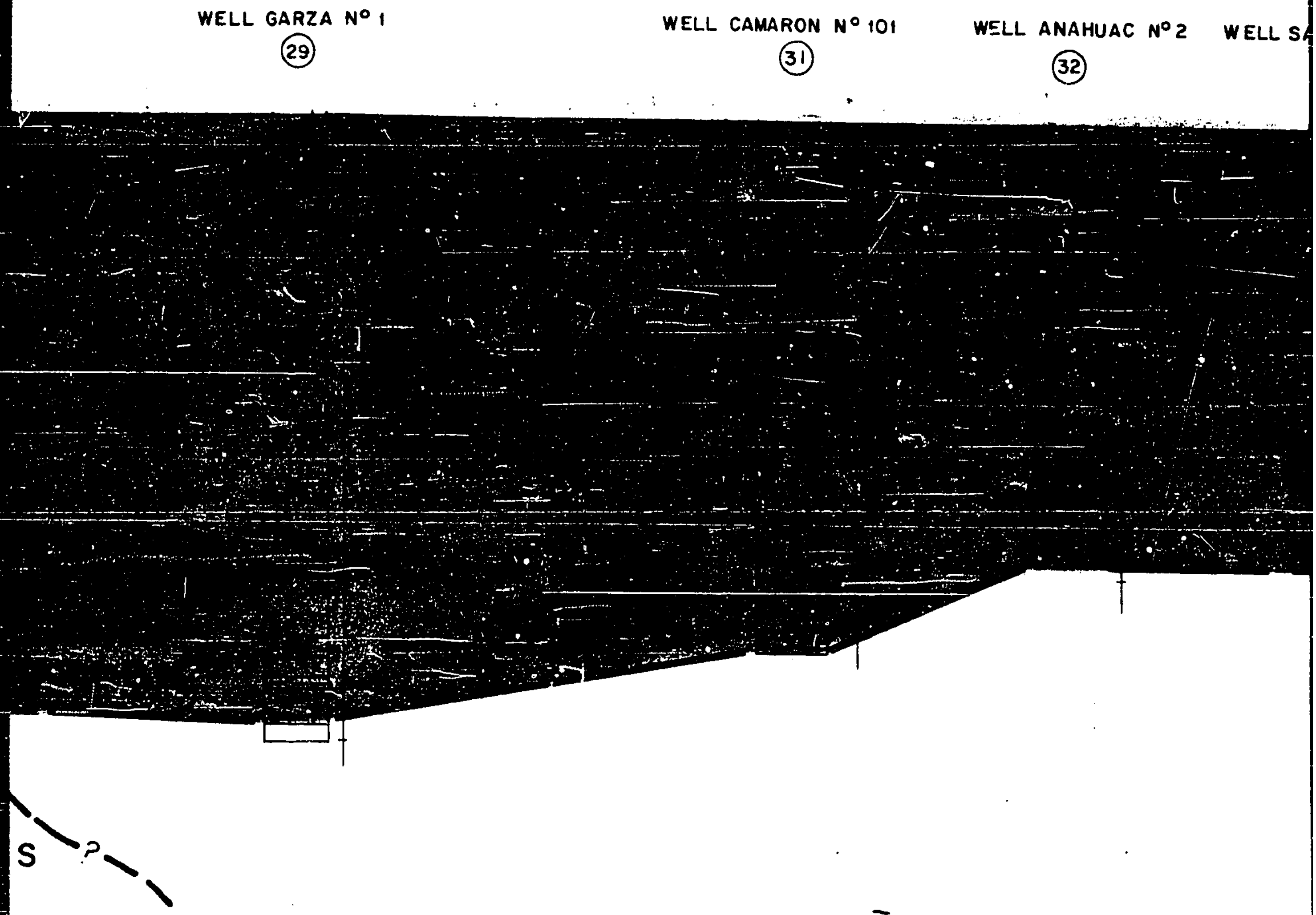

SIERRA DEL FUSTE
9
POTRE
WEST
?
?
COAHUILA
PENINSULA
EXPLANATION
MUDSTONE
WACKESTONE
GRAINSTONE AND PACKSTONE
DOLOMITE
RECRISTALLIZED LIMESTONE
SHALE
SANDSTONE
CONGLOMERATE
MARL
BRECCIA
CHERT MODULES
GYPSUM
METAMORPHIC ROCK
IGNEUS ROCK
COVERED
OOLITE
PELLET
INTRACLAST
SHELL FRAGMENT
MILIOLID
ORBITOLINA
PLANKTONIC FORAMINIFERA
BENTHONIC FORAMINIFERA
PELECYPOD
GASTROPOD
EXOGYRA
RUDISTID FRAGMENT
AMMONITE
TOUCASIA
CAPRINID
MONOPLEUR
RADIOLITI
SERPULID
ECHINOID
BRACHIOPO
OYSTER
OSTRACOD
ALGAL FR
CORAL
STRUCTURES
NODULAR
LAMINATION
BURROWS
STYLOLITIC LINE
C
M
B


POTRERO DE LA MULA
8
POTRERO DE PADILLA
10
LA VIRGEN FORMATION
SAN MARCOS ARKOSE
L A
A
BA
ATION
AMMONITE
TOUCASIA
CAPRINID
MONOPLEURID
RADIOLITID
SERPULID
ECHINOID
BRACHIOPOD
OYSTER
OSTRACOD
ALGAL FRAGMENT
CORAL
STRUCTURES
CROSS-BEDDING
MUD-CRACKS
BORINGS
LOCATION MAP
0 100 200 300
KILOMETERS
TEXAS
U.S.A.
COAHUILA
NUEVO LEON
9 8 10 16 35 28 29 31 32 33

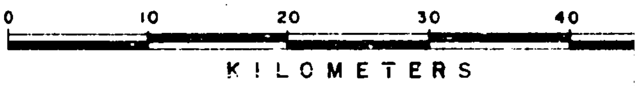

POTRERO DE PADILLA
10
POTRERO DE OBALLOS
16
BARRIL VIEJO FORMATION
?
MAP
0 100 200 300
KILOMETERS
TEXAS
U.S.A.

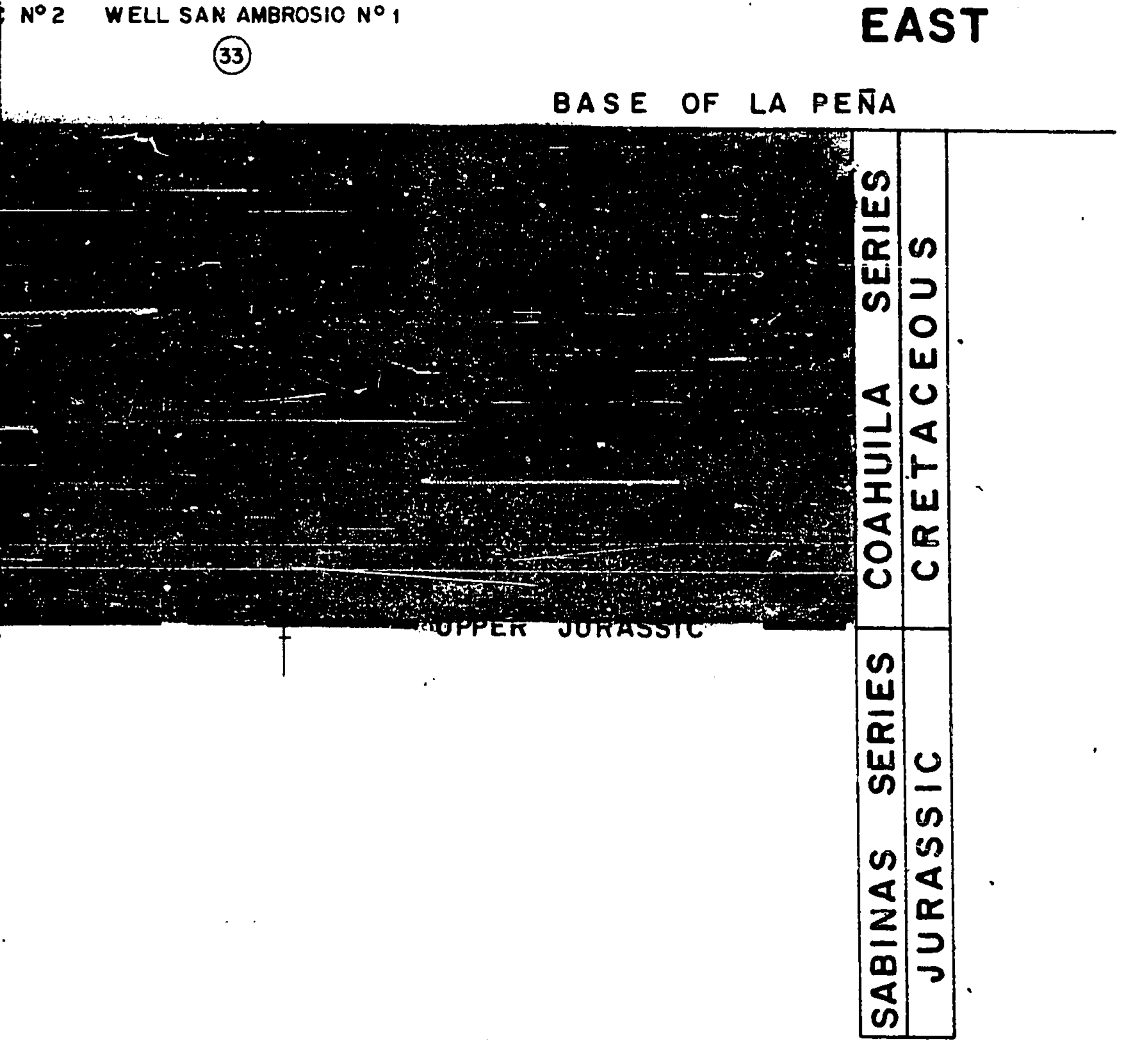

BALLOS
WELL EL GATO Nº I
35
WELL LA
FORMATION
TAMA
PEN


ATO Nº 1
35
WELL LA PERLA Nº 1
28
WELL GARZA Nº 1
29
TAMAULIPAS
?
PENINSULA
S T R



STRATIGRAPHIC
OF THE
COAHUILA S
PLATE 18



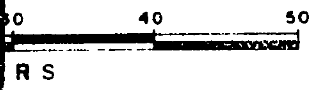


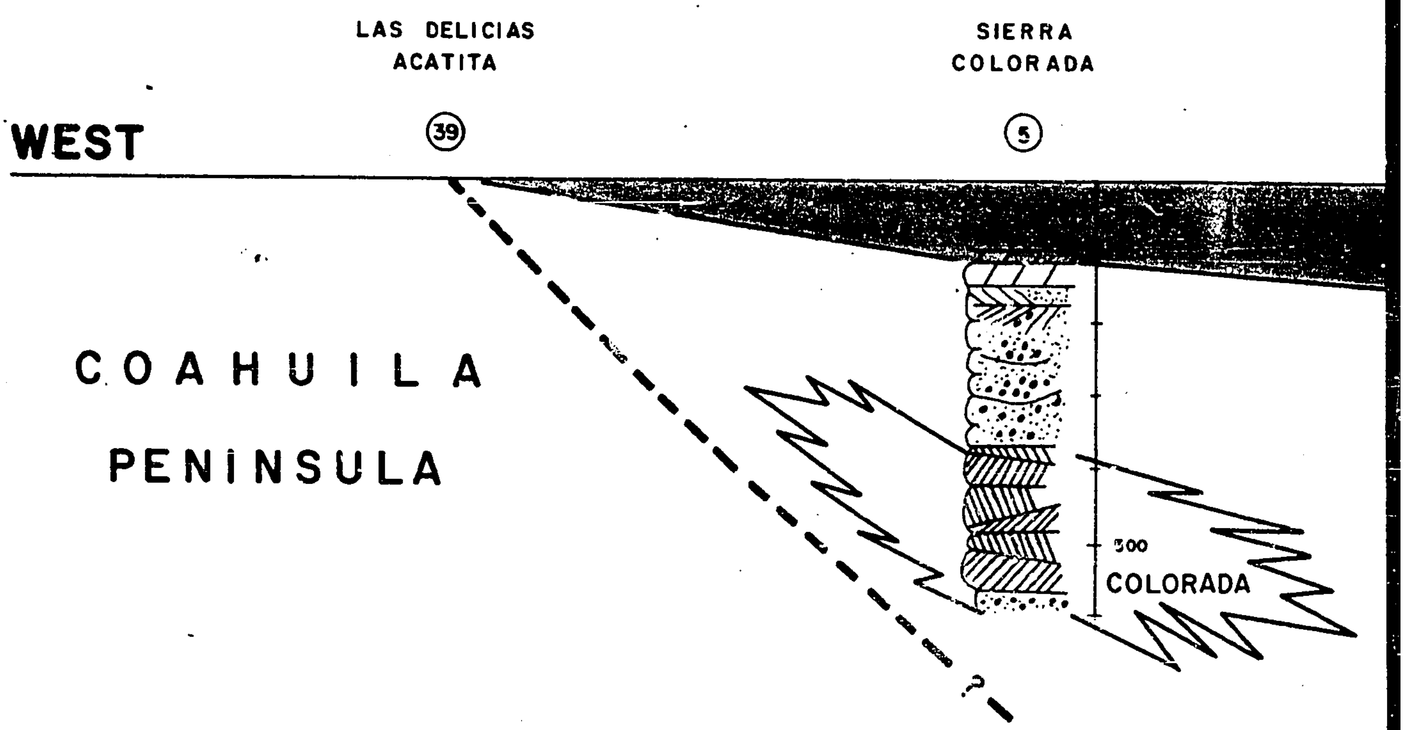
IC SECTION

THE

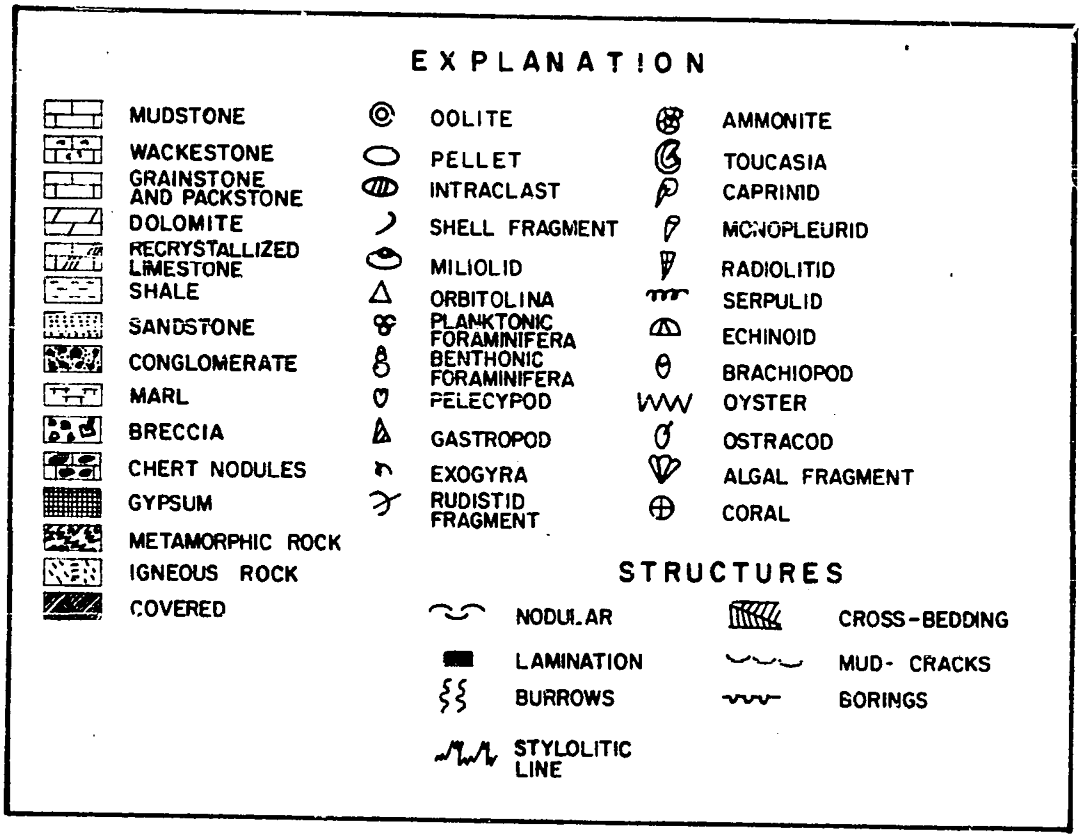
SERIES

E 18

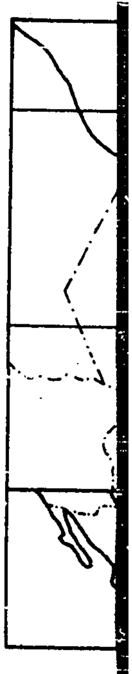


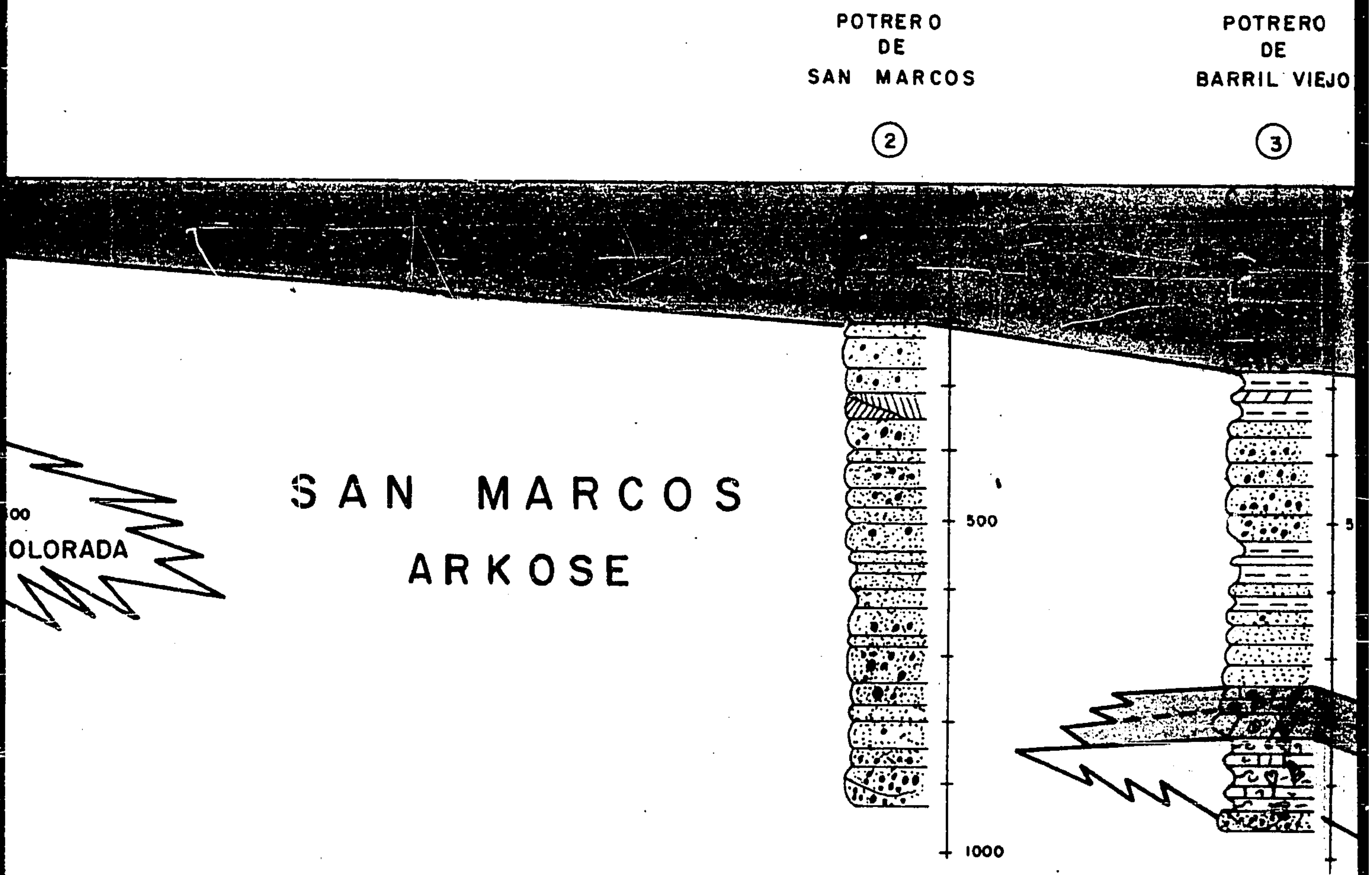


LAS DELICIAS
ACATITA
SIERRA
COLORADA
WEST
39
5
COAHUILA
PENINSULA
500
COLORADA
?

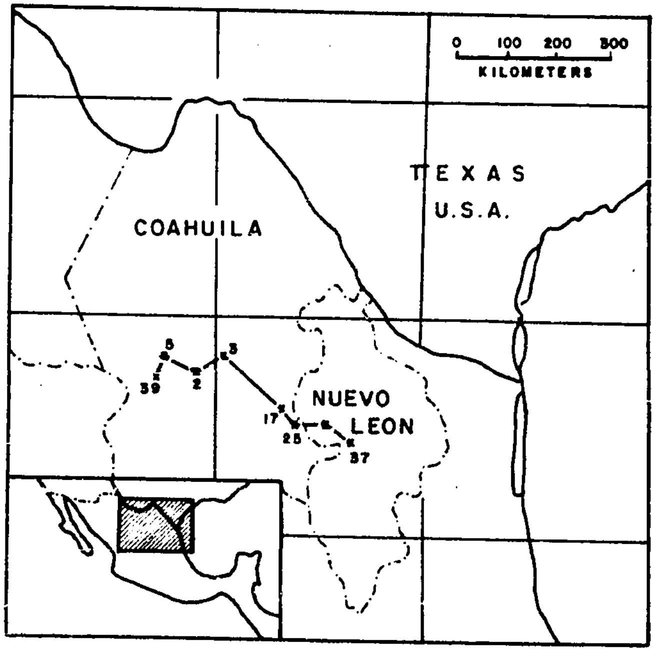


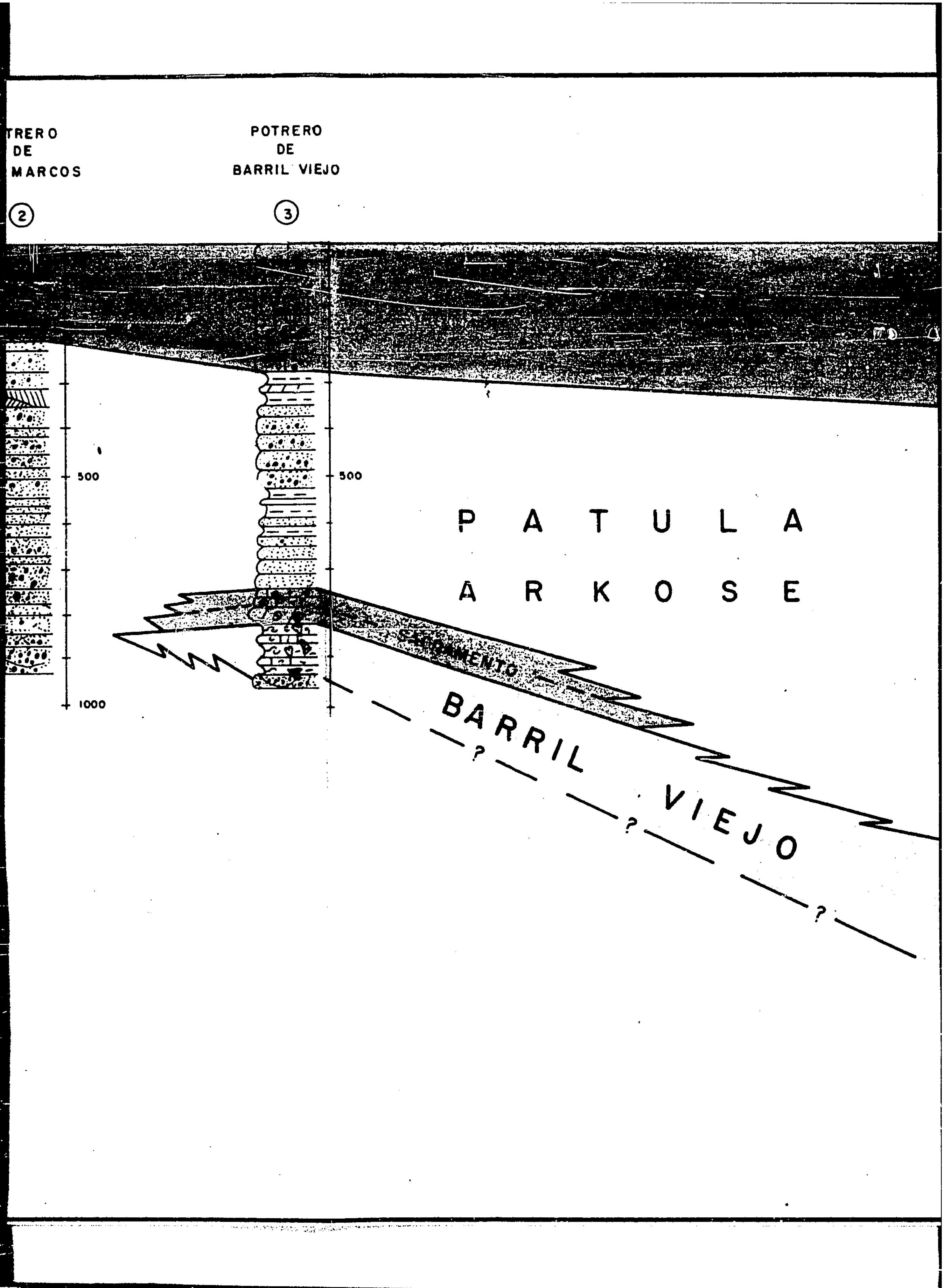
EXPLANATION
MUDSTONE
WACKESTONE
GRAINSTONE AND PACKSTONE
DOLOMITE
RECRYSTALLIZED LIMESTONE
SHALE
SANDSTONE
CONGLOMERATE
MARL
BRECCIA
CHERT NODULES
GYPSUM
METAMORPHIC ROCK
IGNEOUS ROCK
COVERED
OOLITE
PELLET
INTRACLAST
SHELL FRAGMENT
MILIOLID
ORBITOLINA
PLANKTONIC FORAMINIFERA
BENTHONIC FORAMINIFERA
PELECYPOD
GASTROPOD
EXOGYRA
RUDISTID FRAGMENT
AMMONITE
TOUCASIA
CAPRINID
MONOPLEURID
RADIOLITID
SERPULID
ECHINOID
BRACHIOPOD
OYSTER
OSTRACOD
ALGAL FRAGMENT
CORAL
STRUCTURES
NODULAR
LAMINATION
BURROWS
STYLOLITIC LINE
CROSS-BEDDING
MUD-CRACKS
BORINGS

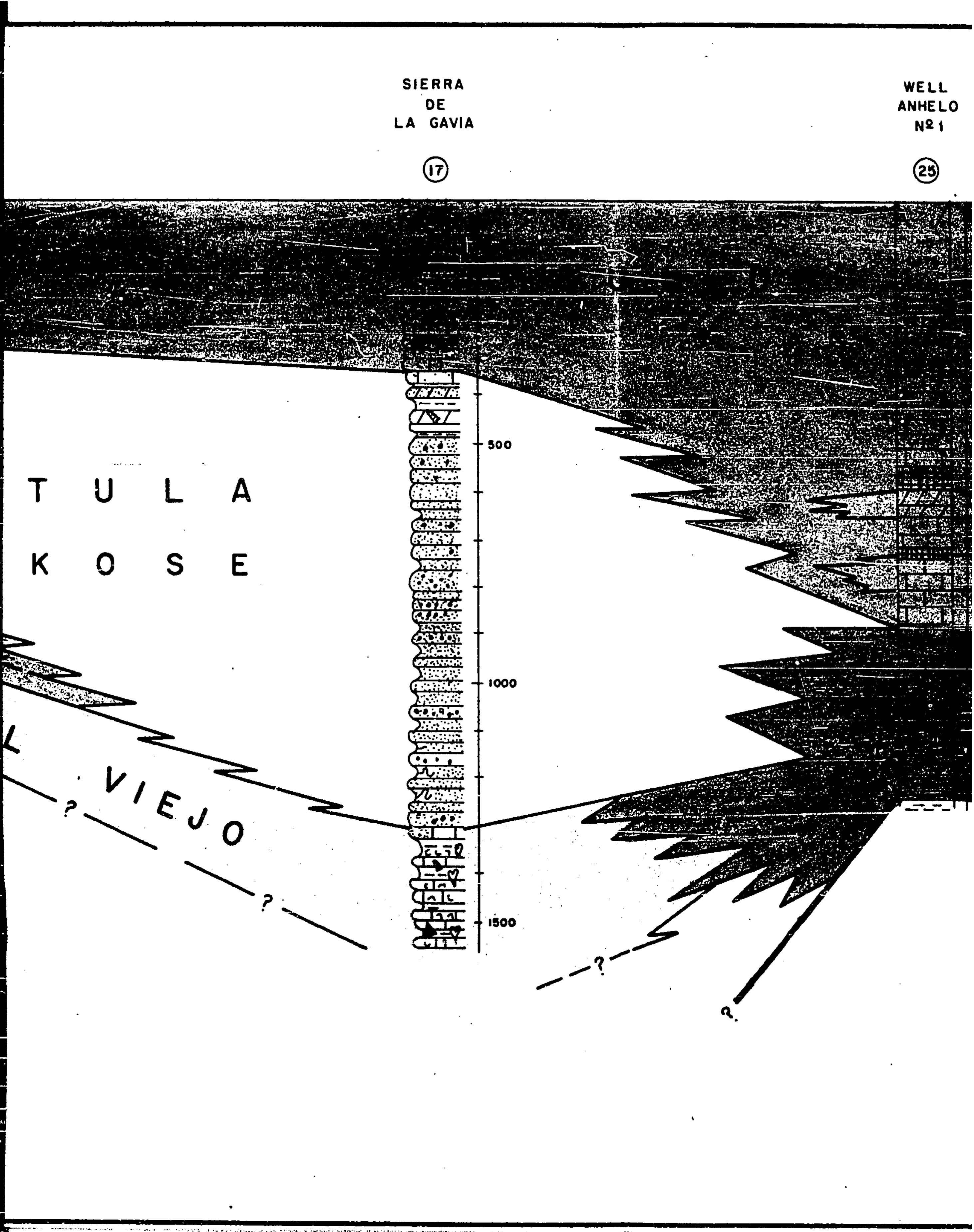


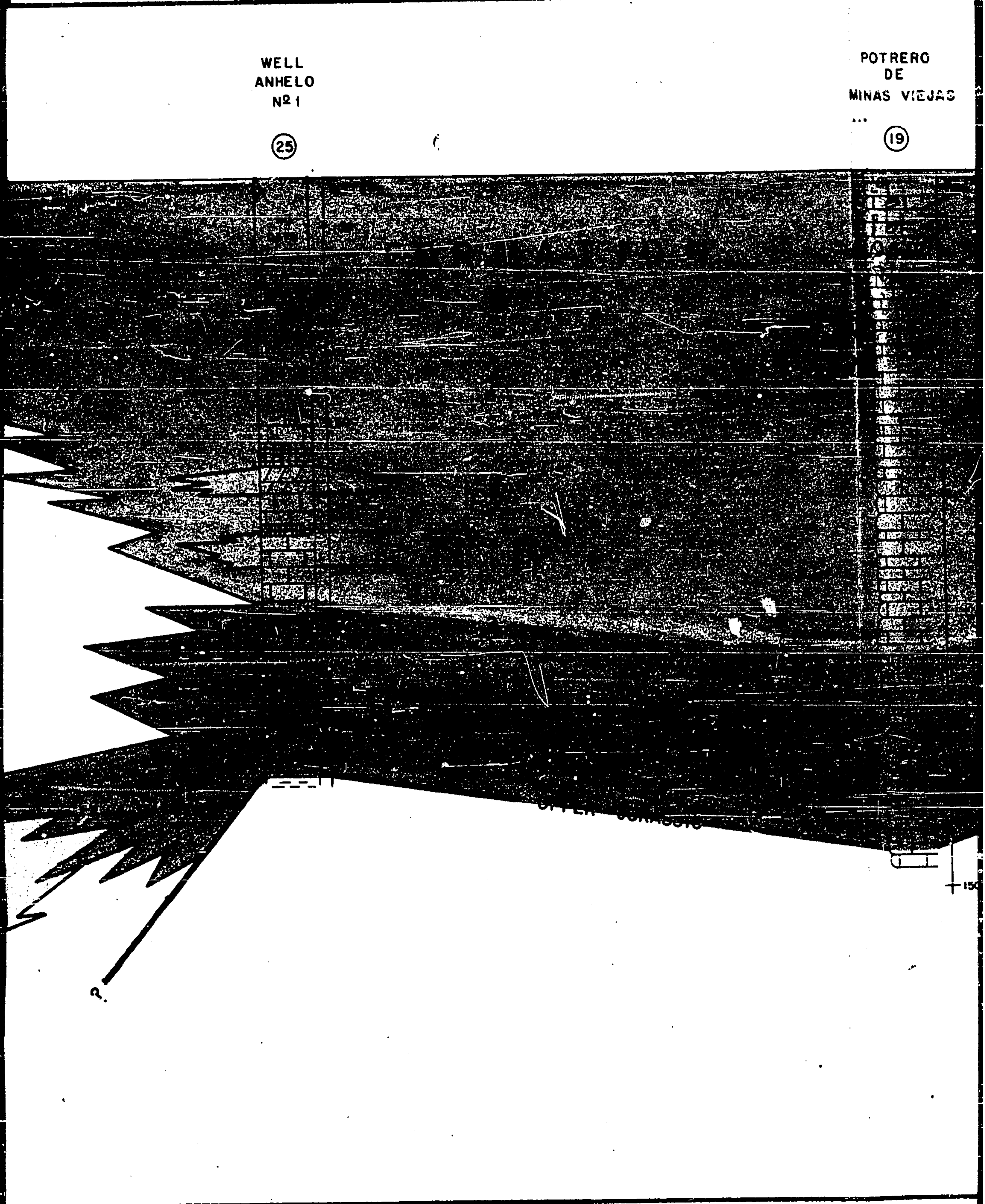


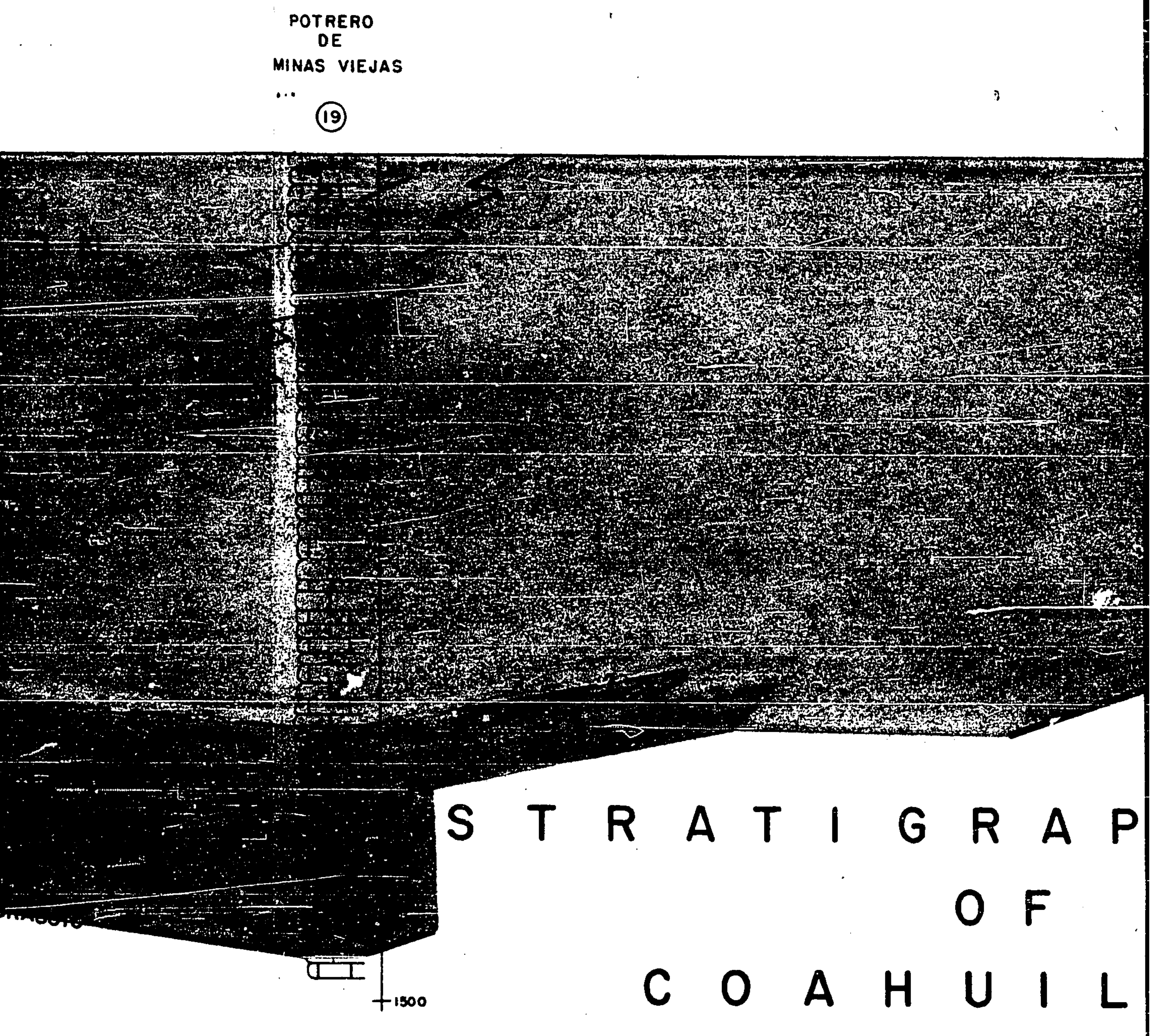
LOCATION MAP




TRERO
DE
MARCOS
②
POTRERO
DE
BARRIL VIEJO
③
500
1000
500
PATULA
ARKOSE
SACRAMENTO
BARRIL VIEJO
?
?
?


SIERRA
DE
LA GAVIA
17
WELL
ANHELO
Nº 1
25
TULA
KOSE
L
VIEJO
500
1000
1500
?
?
?
?


WELL
ANHELO
Nº 1
25
POTRERO
DE
MINAS VIEJAS
19
UPPER JURASSIC
150
a.

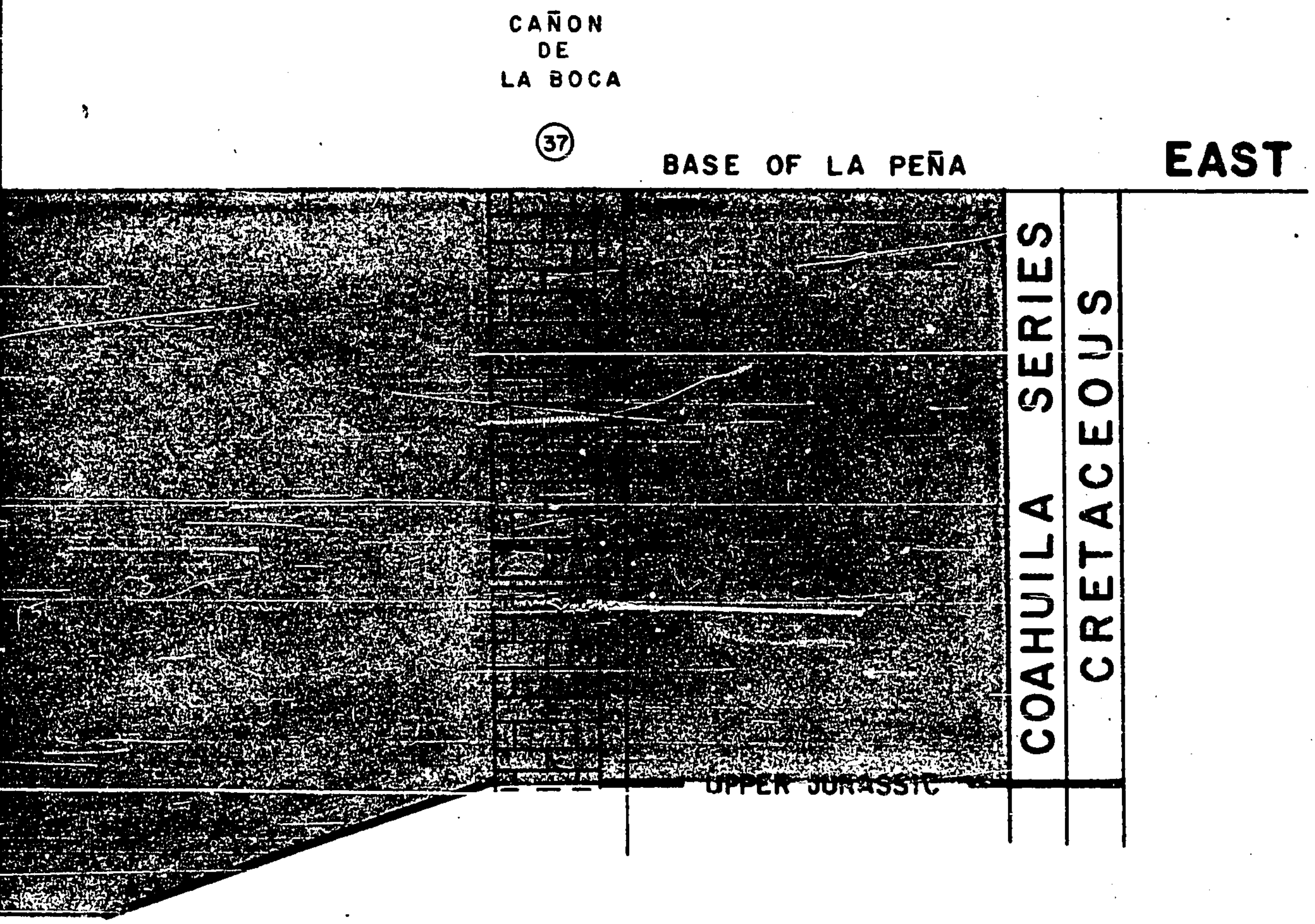


STRATIGRAP
OF
COAHUIL

PL

0 10 20

KILO



RAPHIC SECTION

OF THE

UILA SERIES

PLATE 19

POTRERO DE AGUA CHIQUI

PLATE 20

SERIES

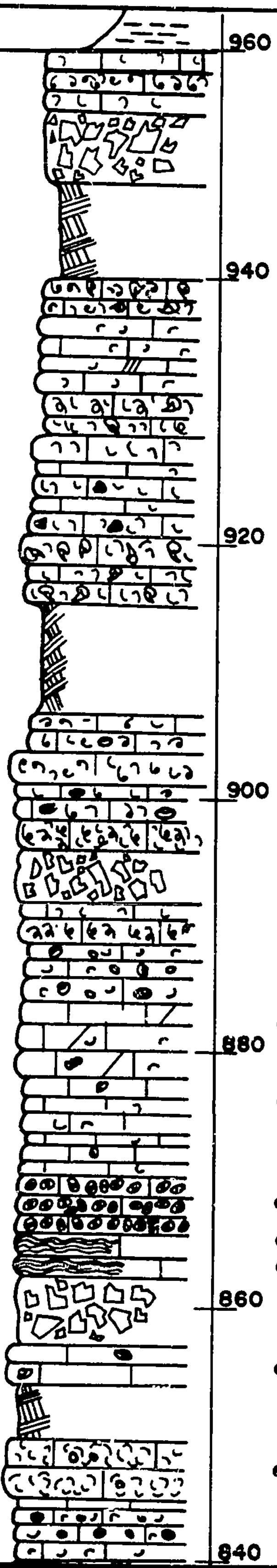
FORMATION

COLUMN

DESCRIPTION

LA PEÑA

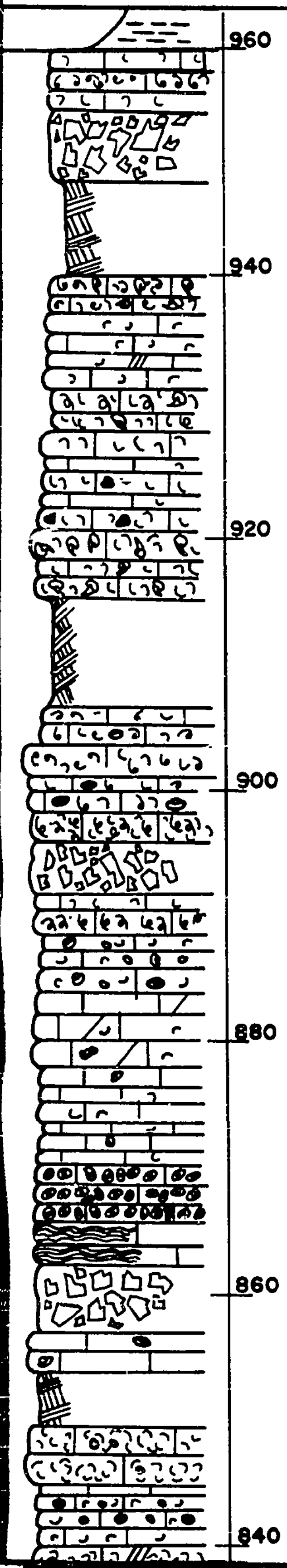
MATION



	89	THICK BEDDED, MOLLUSC SHELL FRAGMENT WA
	88	COLLAPSE BRECCIA.
	87	COVERED INTERVAL.
69CH262	86	THICK BEDDED, RUDISTID SHELL FRAGMENT W ABUNDANT CAPRINIDS.
69CH263	85	THICK TO MEDIUM BEDDED, MOLLUSC SHELL F ALGAL FRAGMENT WACKESTONE.
69CH264 69CH266 69CH265	84	VERY THICK TO THICK BEDDED, GRAY, MOLLUS FRAGMENT, ALGAL FRAGMENT WACKESTONE; COM CAPRINIDS.
	83	COVERED INTERVAL.
69CH260 69CH259	82	THICK TO MEDIUM BEDDED, PELECYPOD SHELL MILIOLID WACKESTONE WITH ABUNDANT TOUCA SOME INTERGRANULAR POROSITY.
	81	COLLAPSE BRECCIA.
69CH258 69CH257	80	THICK BEDDED, MOLLUSC SHELL FRAGMENT, PE MILIOLID WACKESTONE; COMMON TOUCASIA.
69CH256	79	THICK BEDDED, SHELL FRAGMENT, FORAMINIFE DOLOMITIZED MUDSTONE.
69CH255	78	MEDIUM BEDDED, SHELL FRAGMENT MUDSTONE.
69CH254	77	FORAMINIFERA, ALGAL FRAGMENT, INTRACLAST
69CH253 69CH252	76	ALGAL STROMATOLITE.
	75	COLLAPSE BRECCIA.
69CH251	74	MEDIUM BEDDED, MILIOLID MUDSTONE.
	73	COVERED INTERVAL.
69CH250	72	THICK TO MEDIUM BEDDED, INTRACLAST, SHELL PELLET, DOLOMITIZED WACKESTONE; THIN BED MUDSTONE AT THE BASE.

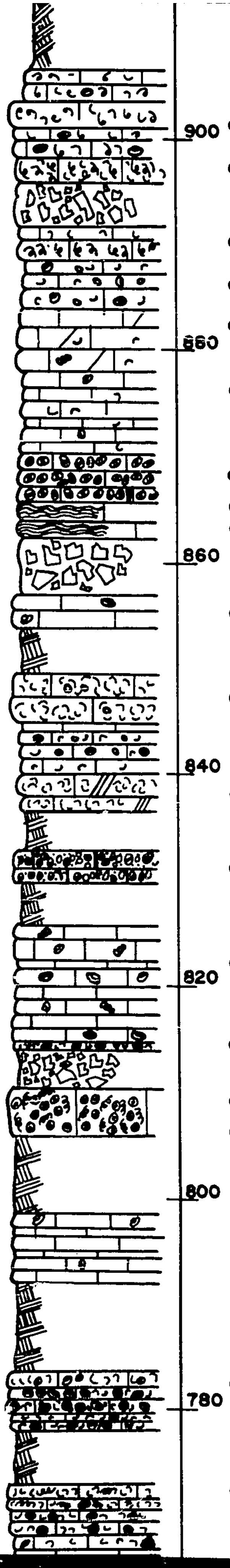
RERO DE AGUA CHIQUITA

PLATE 20

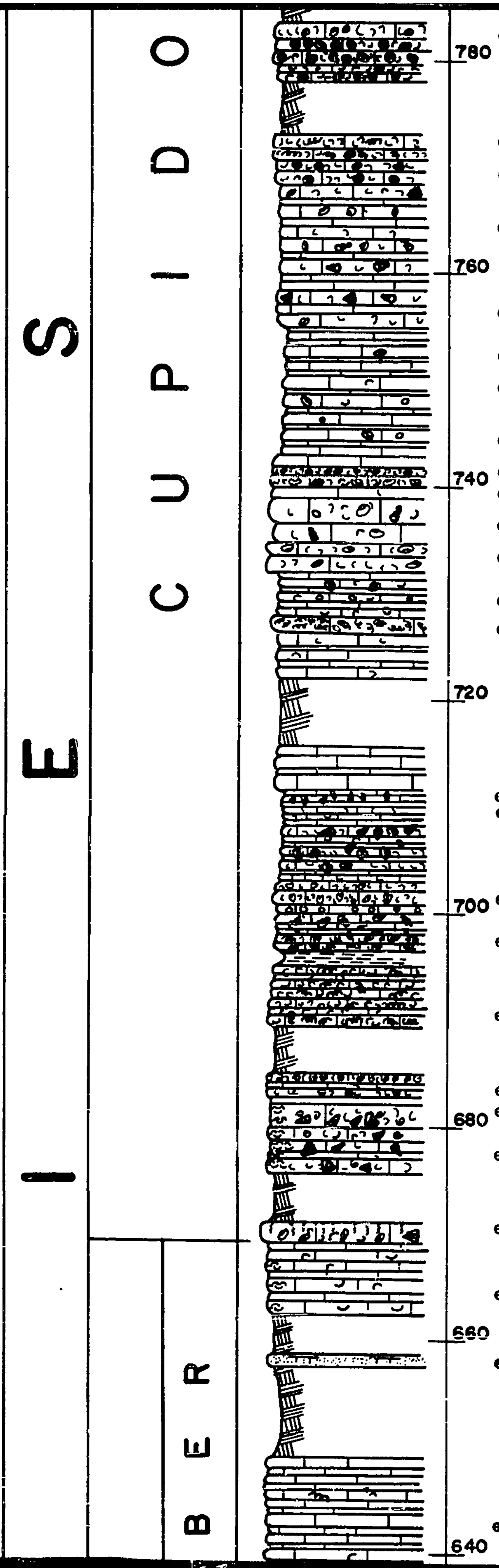


COLUMN		DESCRIPTION
	89	THICK BEDDED, MOLLUSC SHELL FRAGMENT WACKESTONE.
	88	COLLAPSE BRECCIA.
	87	COVERED INTERVAL.
69CH262	86	THICK BEDDED, RUDISTID SHELL FRAGMENT WACKESTONE; ABUNDANT *CAPRINIDS*.
69CH263	85	THICK TO MEDIUM BEDDED, MOLLUSC SHELL FRAGMENT, ALGAL FRAGMENT WACKESTONE.
69CH264 69CH266 69CH265	84	VERY THICK TO THICK BEDDED, GRAY, MOLLUSC SHELL FRAGMENT, ALGAL FRAGMENT WACKESTONE; COMMON *CAPRINIDS*.
	83	COVERED INTERVAL.
69CH260 69CH259	82	THICK TO MEDIUM BEDDED, PELECYPOD SHELL FRAGMENT, MILIOLID WACKESTONE WITH ABUNDANT *TOUCASIA*; SOME INTERGRANULAR POROSITY.
	81	COLLAPSE BRECCIA.
69CH258 69CH257	80	THICK BEDDED, MOLLUSC SHELL FRAGMENT, PELLET, MILIOLID WACKESTONE; COMMON *TOUCASIA*.
69CH256	79	THICK BEDDED, SHELL FRAGMENT, FORAMINIFERA, DOLOMITIZED MUDSTONE.
69CH255	78	MEDIUM BEDDED, SHELL FRAGMENT MUDSTONE.
69CH254	77	FORAMINIFERA, ALGAL FRAGMENT, INTRACLAST PACKSTONE.
69CH253 69CH252	76	ALGAL STROMATOLITE.
	75	COLLAPSE BRECCIA.
69CH251	74	MEDIUM BEDDED, MILIOLID MUDSTONE.
	73	COVERED INTERVAL.
69CH250	72	THICK TO MEDIUM BEDDED, INTRACLAST, SHELL FRAGMENT, PELLET, DOLOMITIZED WACKESTONE; THIN BEDDED MUDSTONE AT THE BASE.

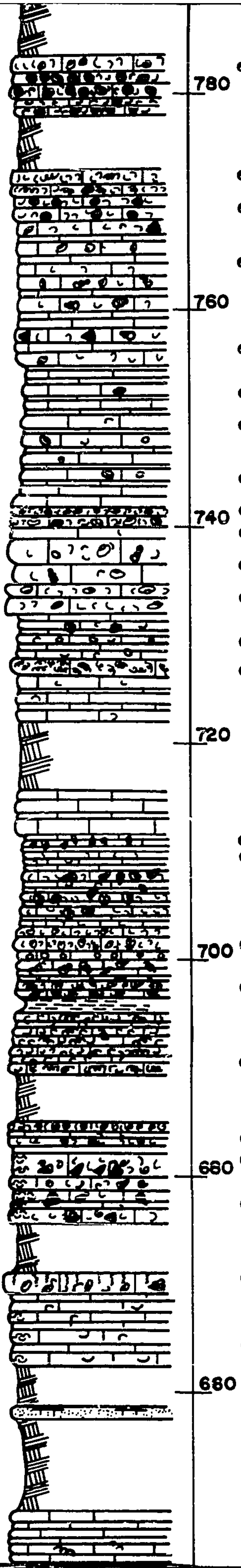
DO FORMATION



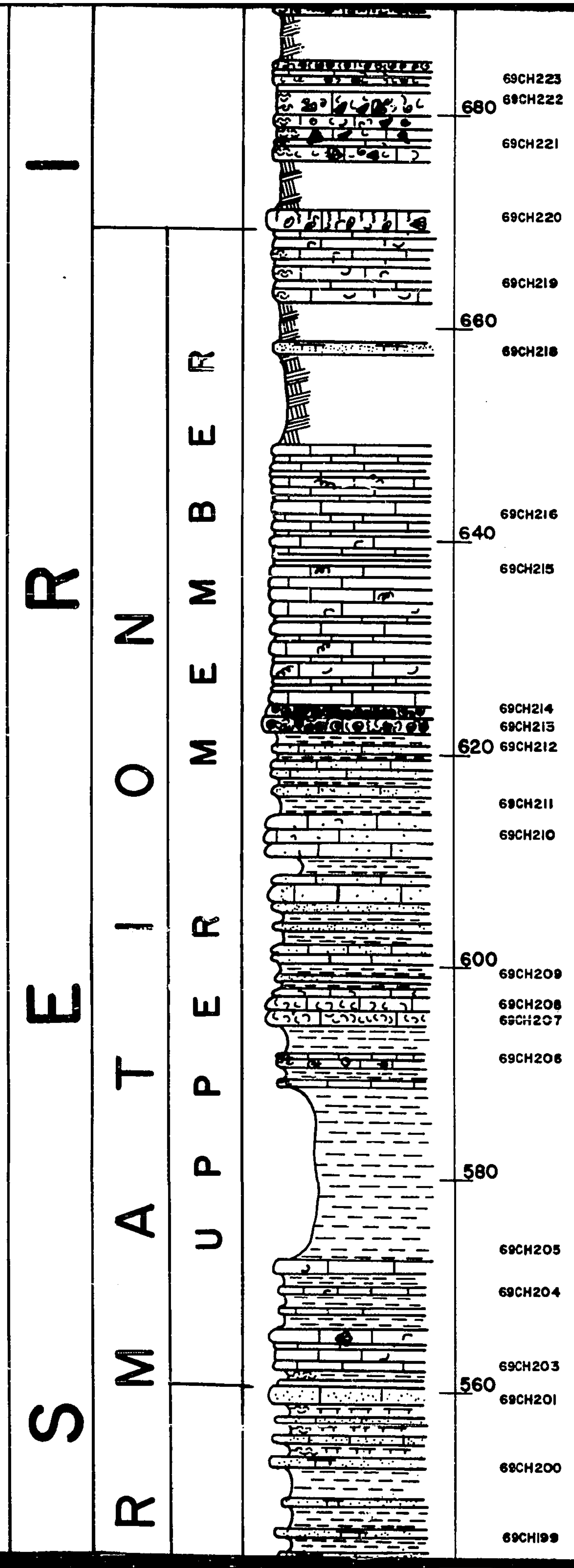
	83	COVERED INTERVAL.
69CH260 69CH259	82	THICK TO MEDIUM BEDDED,PELECYPOD SHELL FRAGMENT, MILIOLID WACKESTONE WITH ABUNDANT *TOUCASIA*; SOME INTERGRANULAR POROSITY.
	81	COLLAPSE BRECCIA.
69CH258 69CH257	80	THICK BEDDED,MOLLUSC SHELL FRAGMENT,PELLET, MILIOLID WACKESTONE; COMMON *TOUCASIA*.
69CH256	79	THICK BEDDED,SHELL FRAGMENT,FORAMINIFERA, DOLOMITIZED MUDSTONE.
69CH255	78	MEDIUM BEDDED,SHELL FRAGMENT MUDSTONE.
69CH254	77	FORAMINIFERA,ALGAL FRAGMENT,INTRACLAST PACKSTONE.
69CH253 69CH252	76	ALGAL STROMATOLITE.
	75	COLLAPSE BRECCIA.
69CH251	74	MEDIUM BEDDED,MILIOLID MUDSTONE.
	73	COVERED INTERVAL.
69CH250 69CH249	72	THICK TO MEDIUM BEDDED,INTRACLAST,SHELL FRAGMENT, PELLET,DOLOMITIZED WACKESTONE; THIN BEDDED MUDSTONE AT THE BASE.
	71	COVERED INTERVAL.
69CH248	70	PELLET,INTRACLAST,ARENACEOUS PACKSTONE.
	69	COVERED INTERVAL.
69CH247	68	THICK TO MEDIUM BEDDED,FORAMINIFERA,MILIOLID WACKESTONE.
69CH246	67	SHELL FRAGMENT,INTRACLAST GRAINSTONE.
	66	COLLAPSE BRECCIA.
69CH245 69CH244	65	SERPULID TUBE, OOLITE GRAINSTONE.
	64	COVERED INTERVAL.
69CH243	63	MEDIUM BEDDED,MILIOLID MUDSTONE.
	62	COVERED INTERVAL.
69CH242	61	OOLITE,SHELL FRAGMENT,MILIOLID PACKSTONE.
	60	COVERED INTERVAL.
69CH241 69CH240	59	INTRACLAST,ALGAL FRAGMENT,ANNELID TUBE GRAINSTONE
		MEDIUM TO THIN BEDDED,MOLLUSC SHELL FRAGMENT,



69CH242	61	OOLITE, SHELL FRAGMENT, MILIOLID PACKSTON
	60	COVERED INTERVAL.
69CH241 69CH240	59	INTRACLAST, ALGAL FRAGMENT, ANNELID TUBE
69CH239	58	MEDIUM TO THIN BEDDED, MOLLUSC SHELL FRA ALGAL FRAGMENT, FORAMINIFERA WACKESTONE; ECHINODERM SPICULES AND TEXTULARID FORA
69CH238 69CH237 69CH236 69CH235	57	THIN TO VERY THIN BEDDED, DARK GRAY, MILI PELLET, SHELL FRAGMENT MUDSTONE.
69CH234	56	SHELL FRAGMENT, MILIOLID PACKSTONE.
69CH233 69CH232	55	THICK BEDDED, MOLLUSC SHELL FRAGMENT, FOR WACKESTONE.
69CH231 69CH230	54	THICK TO MEDIUM BEDDED, SHELL FRAGMENT, M PELLET WACKESTONE.
69CH229	53	MEDIUM BEDDED MUDSTONE.
	52	COVERED INTERVAL.
	51	MEDIUM TO THIN BEDDED MUDSTONE.
69CH228 69CH227	50	MEDIUM TO THIN BEDDED, SHELL FRAGMENT, MI WACKESTONE; COMMON *TURRITELA*.
69CH226	49	SHELL FRAGMENT, ECHINODERM, PELLET GRAINS
69CH225	48	FORAMINIFERA, ANNELID TUBE PACKSTONE.
69CH224	47	MEDIUM BEDDED, GRAY, SHELL FRAGMENT, ANNEL GRAINSTONE.
	46	COVERED INTERVAL.
69CH223 69CH222 69CH221	45	MEDIUM BEDDED, GRAY, MOLLUSC SHELL FRAGME FRAGMENT WACKESTONE; COMMON *GRYPHEA* AND
	44	COVERED INTERVAL.
69CH220	43	ALGAL AND MOLLUSC FRAGMENT WACKESTONE.
69CH219	42	MEDIUM BEDDED, DARK GRAY, NODULAR, SHELL F MUDSTONE.
	41	COVERED INTERVAL.
69CH218	40	MEDIUM BEDDED, SILTY MUDSTONE.
	39	COVERED INTERVAL.
69CH216		MEDIUM TO THIN BEDDED, LIGHT GRAY, SHELL



	62	COVERED INTERVAL.
69CH242	61	OOLITE,SHELL FRAGMENT,MILIOLID PACKSTONE.
	60	COVERED INTERVAL.
69CH241 69CH240	59	INTRACLAST,ALGAL FRAGMENT,ANNELID TUBE GRAINSTONE
69CH239 69CH238	58	MEDIUM TO THIN BEDDED,MOLLUSC SHELL FRAGMENT, ALGAL FRAGMENT,FORAMINIFERA WACKESTONE; FEW ECHINODERM SPICULES AND TEXTULARID FORAMINIFERA.
69CH237 69CH236 69CH235	57	THIN TO VERY THIN BEDDED,DARK GRAY,MILIOLID, PELLET,SHELL FRAGMENT MUDSTONE.
69CH234	56	SHELL FRAGMENT,MILIOLID PACKSTONE.
69CH233 69CH232	55	THICK BEDDED,MOLLUSC SHELL FRAGMENT,FORAMINIFERA WACKESTONE.
69CH231 69CH230	54	THICK TO MEDIUM BEDDED,SHELL FRAGMENT,MILIOLID, PELLET WACKESTONE.
69CH229	53	MEDIUM BEDDED MUDSTONE.
	52	COVERED INTERVAL.
	51	MEDIUM TO THIN BEDDED MUDSTONE.
69CH228 69CH227	50	MEDIUM TO THIN BEDDED,SHELL FRAGMENT,MILIOLID WACKESTONE; COMMON TURRITELA.
69CH226	49	SHELL FRAGMENT,ECHINODERM,PELLET GRAINSTONE.
69CH225	48	FORAMINIFERA,ANNELID TUBE PACKSTONE.
69CH224	47	MEDIUM BEDDED,GRAY,SHELL FRAGMENT,ANNELID TUBE GRAINSTONE.
	46	COVERED INTERVAL.
69CH223 69CH222 69CH221	45	MEDIUM BEDDED,GRAY,MOLLUSC SHELL FRAGMENT,ALGAL FRAGMENT WACKESTONE; COMMON GRYPHEA AND TURRITELA
	44	COVERED INTERVAL.
69CH220	43	ALGAL AND MOLLUSC FRAGMENT WACKESTONE.
69CH219	42	MEDIUM BEDDED,DARK GRAY,NODULAR,SHELL FRAGMENT MUDSTONE.
	41	COVERED INTERVAL.
69CH218	40	MEDIUM BEDDED,SILTY MUDSTONE.
	39	COVERED INTERVAL.



46 COVERED INTERVAL.

45 MEDIUM BEDDED, GRAY, MOLLUSC SHELL FRAG
FRAGMENT WACKESTONE; COMMON <u>GRYPHEA</u> AN

44 COVERED INTERVAL.

43 ALGAL AND MOLLUSC FRAGMENT WACKESTONE.

42 MEDIUM BEDDED, DARK GRAY, NODULAR, SHELL
MUDSTONE.

41 COVERED INTERVAL.

40 MEDIUM BEDDED, SILTY MUDSTONE.

39 COVERED INTERVAL.

38 MEDIUM TO THIN BEDDED, LIGHT GRAY, SHEL
ANNELID TUBE MUDSTONE.

37 SHELL FRAGMENT, OOLITE GRAINSTONE.

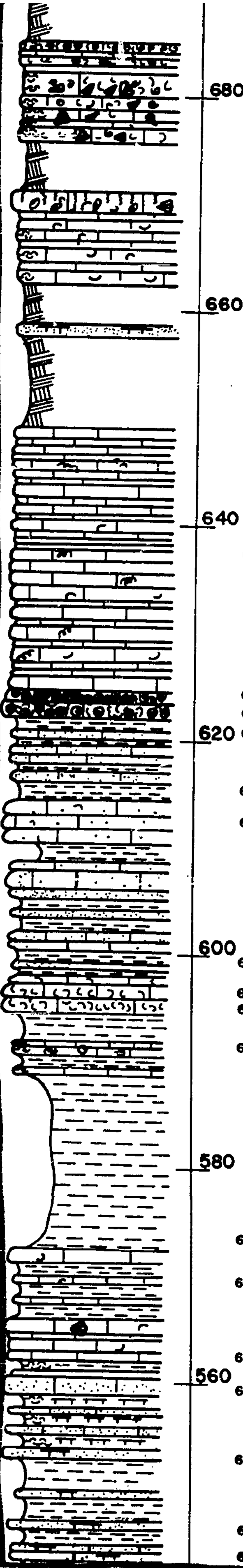
36 MEDIUM TO THIN BEDDED, GRAY, SLIGHTLY A
MUDSTONE, INTERBEDDED WITH SHALE.

35 MOLLUSC SHELL FRAGMENT WACKESTONE.

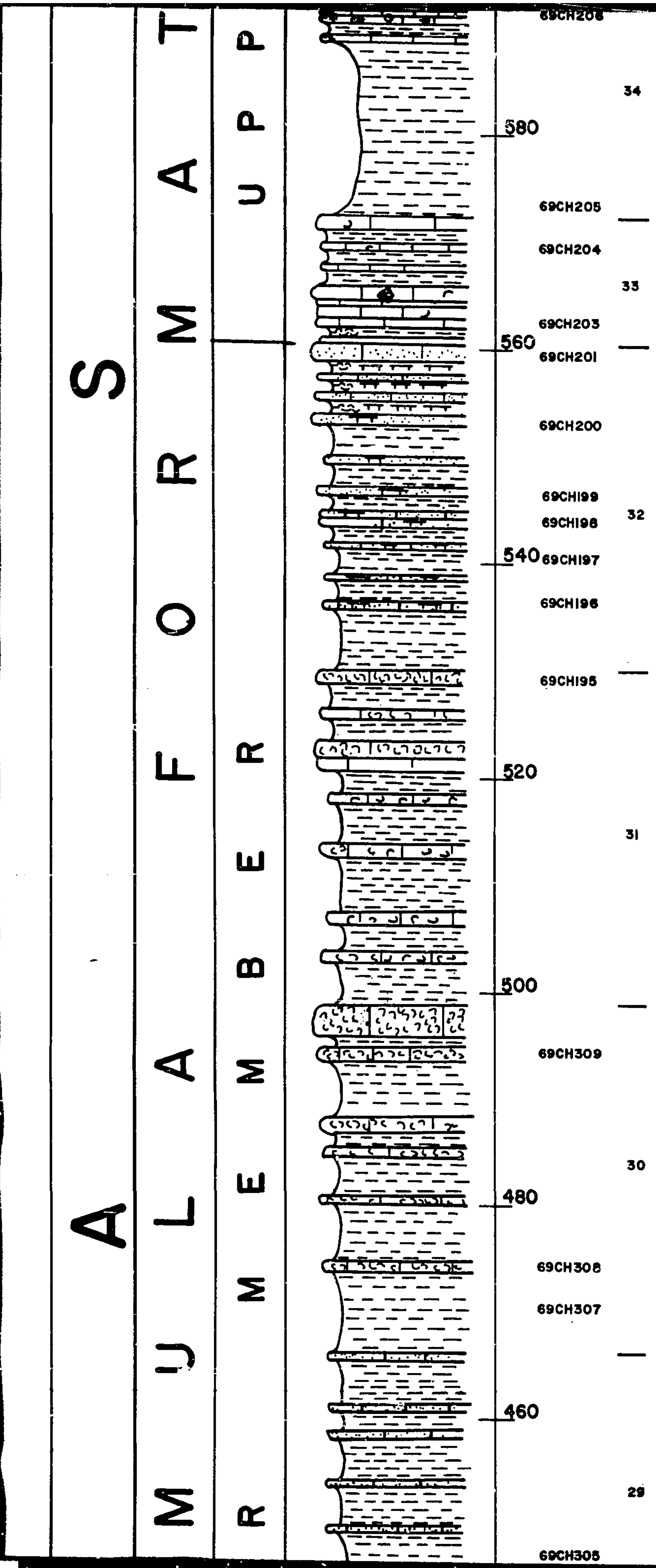
34 THIN BEDDED, DARK GRAY, SLIGHTLY NODULA
FRAGMENT, OSTRACOD MUDSTONE, INTERBEDD
SHALE.

33 MEDIUM TO THIN BEDDED, DARK GRAY, ARENA
ALGAL FRAGMENT, SHELL FRAGMENT MUDST
INTERBEDDED WITH YELLOWISH SHALE.

MEDIUM TO THIN BEDDED, YELLOWISH WEATH
32 SLIGHTLY ARENACEOUS MUDSTONE, INTERBE



	46	COVERED INTERVAL.
69CH223 69CH222 69CH221	45	MEDIUM BEDDED, GRAY, MOLLUSC SHELL FRAGMENT, ALGAL FRAGMENT WACKESTONE; COMMON GRYPHEA AND TURRITELA
	44	COVERED INTERVAL.
69CH220	43	ALGAL AND MOLLUSC FRAGMENT WACKESTONE.
69CH219	42	MEDIUM BEDDED, DARK GRAY, NODULAR, SHELL FRAGMENT MUDSTONE.
	41	COVERED INTERVAL.
69CH218	40	MEDIUM BEDDED, SILTY MUDSTONE.
	39	COVERED INTERVAL.
69CH216 69CH215	38	MEDIUM TO THIN BEDDED, LIGHT GRAY, SHELL FRAGMENT, ANNELID TUBE MUDSTONE.
69CH214 69CH213	37	SHELL FRAGMENT, OOLITE GRAINSTONE.
69CH212 69CH211 69CH210 69CH209	36	MEDIUM TO THIN BEDDED, GRAY, SLIGHTLY ARENACEOUS MUDSTONE, INTERBEDDED WITH SHALE.
69CH208 69CH207	35	MOLLUSC SHELL FRAGMENT WACKESTONE.
69CH206 69CH205	34	THIN BEDDED, DARK GRAY, SLIGHTLY NODULAR, ECHINODERM FRAGMENT, OSTRACOD MUDSTONE, INTERBEDDED WITH SHALE.
69CH204 69CH203	33	MEDIUM TO THIN BEDDED, DARK GRAY, ARENACEOUS, ALGAL FRAGMENT, SHELL FRAGMENT MUDSTONE, INTERBEDDED WITH YELLOWISH SHALE.
69CH201 69CH200 69CH199 69CH198	32	MEDIUM TO THIN BEDDED, YELLOWISH WEATHERING, SLIGHTLY ARENACEOUS MUDSTONE, INTERBEDDED



THIN BEDDED, DARK GRAY, SLIGHTLY NODULAR, EC

FRAGMENT, OSTRACOD MUDSTONE, INTERBEDDED W

SHALE.

MEDIUM TO THIN BEDDED, DARK GRAY, ARENACEOU

ALGAL FRAGMENT, SHELL FRAGMENT MUDSTONE,

INTERBEDDED WITH YELLOWISH SHALE.

MEDIUM TO THIN BEDDED, YELLOWISH WEATHERIN

SLIGHTLY ARENACEOUS MUDSTONE, INTERBEDDED

WITH NODULAR SHALE.

MEDIUM TO THIN BEDDED, LIGHT GRAY, SHELL

FRAGMENT WACKESTONE, INTERBEDDED WITH SHA

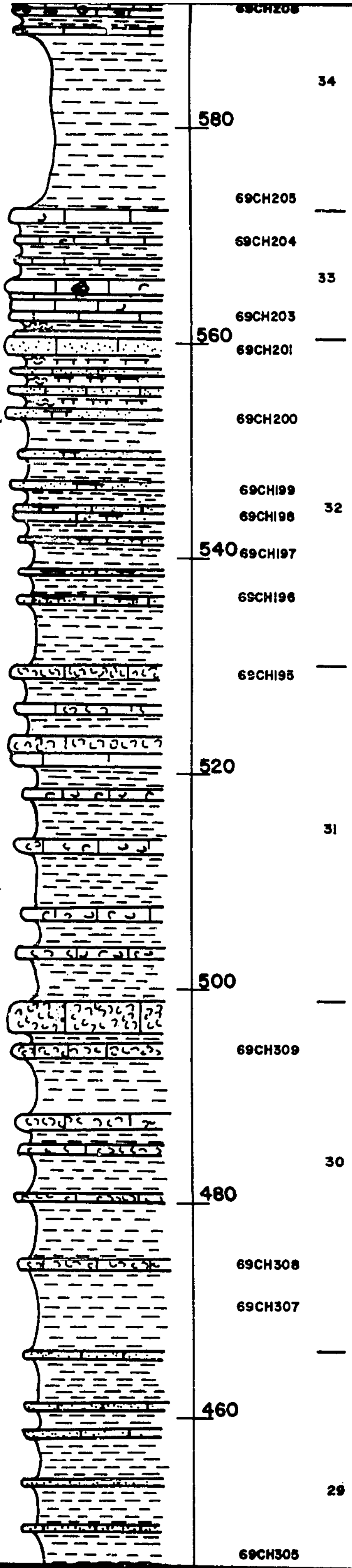
MEDIUM TO THIN BEDDED, GREENISH GRAY, ARENAC

SHELL FRAGMENT, OSTRACOD WACKESTONE,

INTERBEDDED WITH SHALE.

THIN BEDDED, YELLOWISH WEATHERING, SILTY

MUDSTONE, INTERBEDDED WITH SHALE.



34 THIN BEDDED, DARK GRAY, SLIGHTLY NODULAR, ECHINODERM FRAGMENT, OSTRACOD MUDSTONE, INTERBEDDED WITH SHALE.

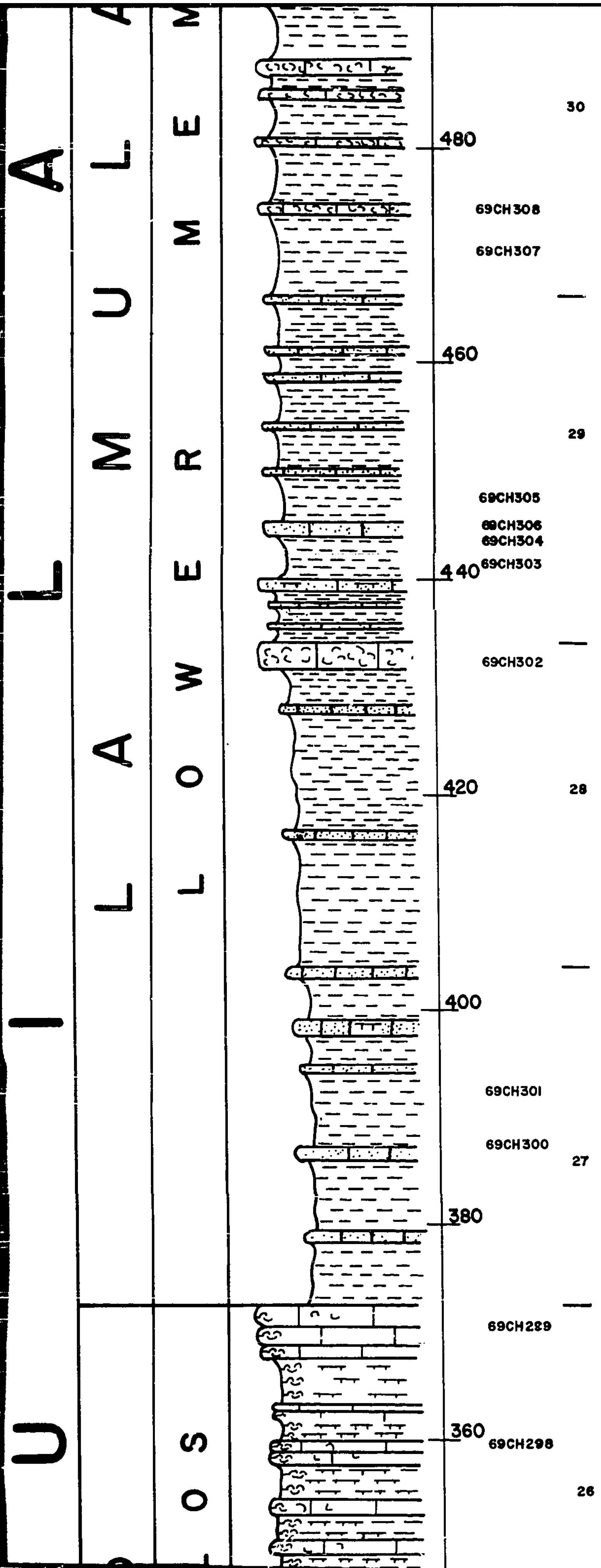
33 MEDIUM TO THIN BEDDED, DARK GRAY, ARENACEOUS, ALGAL FRAGMENT, SHELL FRAGMENT MUDSTONE, INTERBEDDED WITH YELLOWISH SHALE.

32 MEDIUM TO THIN BEDDED, YELLOWISH WEATHERING, SLIGHTLY ARENACEOUS MUDSTONE, INTERBEDDED WITH NODULAR SHALE.

31 MEDIUM TO THIN BEDDED, LIGHT GRAY, SHELL FRAGMENT WACKESTONE, INTERBEDDED WITH SHALE.

30 MEDIUM TO THIN BEDDED, GREENISH GRAY, ARENACEOUS SHELL FRAGMENT, OSTRACOD WACKESTONE, INTERBEDDED WITH SHALE.

29 THIN BEDDED, YELLOWISH WEATHERING, SILTY MUDSTONE, INTERBEDDED WITH SHALE.



30 MEDIUM TO THIN BEDDED, GREENISH GRAY, ARENACEOUS SHELL FRAGMENT, OSTRACOD WACKESTONE, INTERBEDDED WITH SHALE.

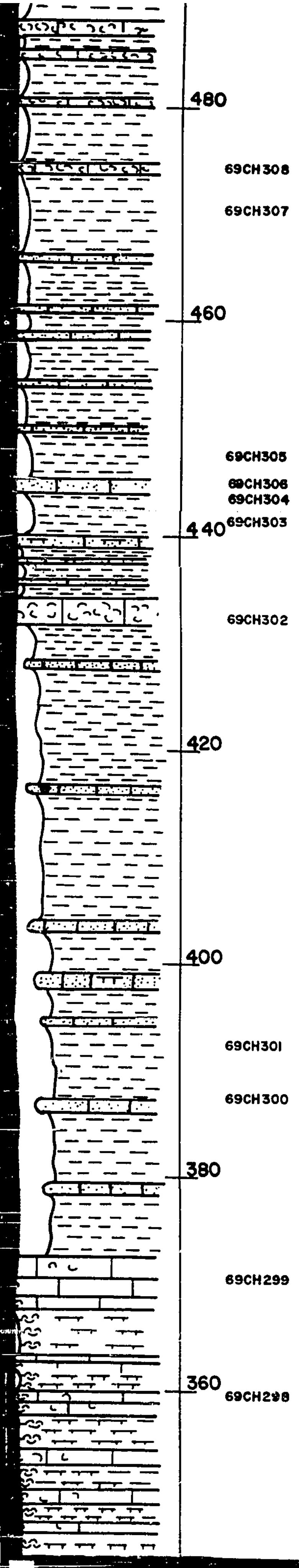
29 THIN BEDDED, YELLOWISH WEATHERING, SILTY MUDSTONE, INTERBEDDED WITH SHALE.

28 MEDIUM TO THIN BEDDED, LIGHT GRAY, MOLLUSC AND ECHINODERM SHELL FRAGMENT, OSTRACOD, ARENACEOUS WACKESTONE, INTERBEDDED WITH SHALE.

27 MEDIUM TO THIN BEDDEB, YELLOWISH, ARENACEOUS MUDSTONE, INTERBEDDED WITH GREENISH SHALE.

26 MEDIUM TO THIN BEDDED, SLIGHTLY NODULAR, MOLLUSC SHELL FRAGMENT MUDSTONE, INTERBEDDED WIT

MARLS; COMMON CALPIONELLIDS.



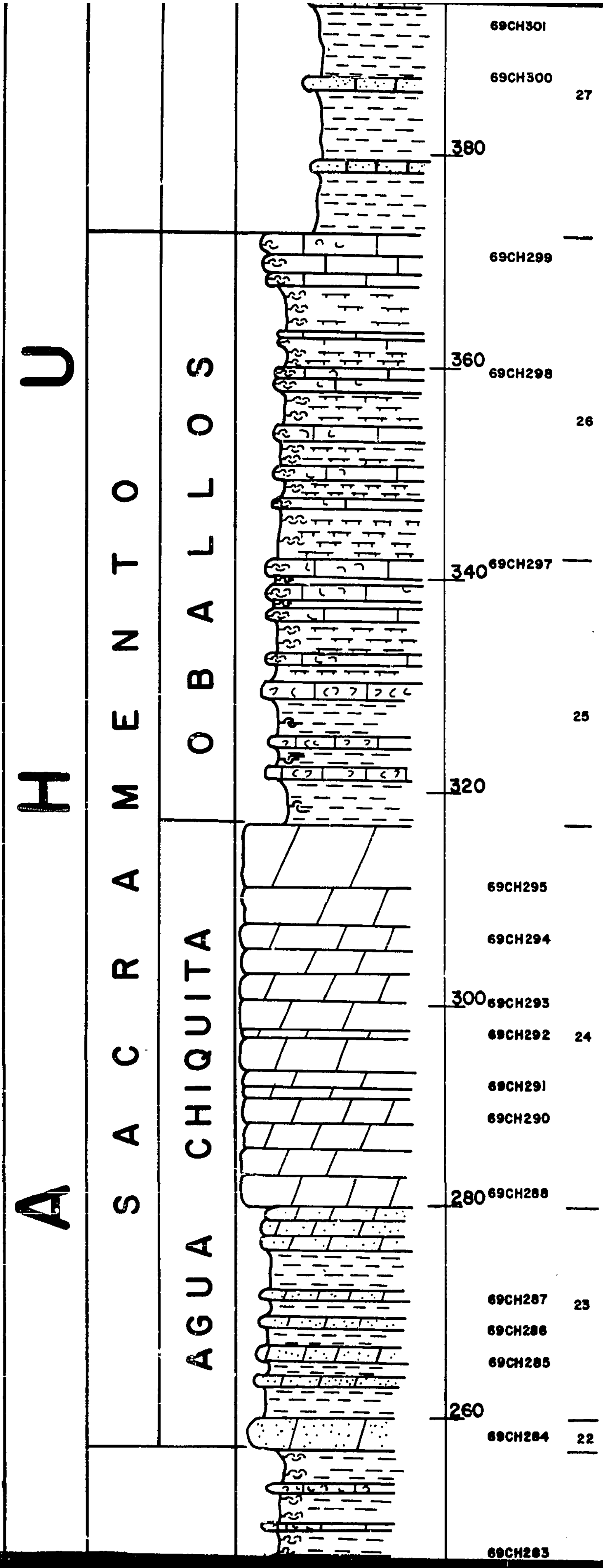
30 MEDIUM TO THIN BEDDED, GREENISH GRAY, ARENACEOUS SHELL FRAGMENT, OSTRACOD WACKESTONE, INTERBEDDED WITH SHALE.

29 THIN BEDDED, YELLOWISH WEATHERING, SILTY MUDSTONE, INTERBEDDED WITH SHALE.

28 MEDIUM TO THIN BEDDED, LIGHT GRAY, MOLLUSC AND ECHINODERM SHELL FRAGMENT, OSTRACOD, ARENACEOUS WACKESTONE, INTERBEDDED WITH SHALE.

27 MEDIUM TO THIN BEDDEB, YELLOWISH, ARENACEOUS MUDSTONE, INTERBEDDED WITH GREENISH SHALE.

26 MEDIUM TO THIN BEDDED, SLIGHTLY NODULAR, MOLLUSC SHELL FRAGMENT MUDSTONE, INTERBEDDED WITH MARLS; COMMON CALPIONELLIDS.



MEDIUM TO THIN BEDDEB, YELLOWISH, ARENACE

MUDSTONE, INTERBEDDED WITH GREENISH SH

MEDIUM TO THIN BEDDED, SLIGHTLY NODULAR,

MOLLUSC SHELL FRAGMENT MUDSTONE, INTERB

MARLS; COMMON CALPIONELLIDS.

MEDIUM TO THIN BEDDED, DARK GRAY, SLIGHT

DOLOMITIZED, SHELL FRAGMENT MUDSTONE,

INTERBEDDED WITH NODULAR MARL.

VERY THICK TO THICK BEDDED, DARK GRAY, V

COARSE GRAIN DOLOMITE; COMMON SECONDARY

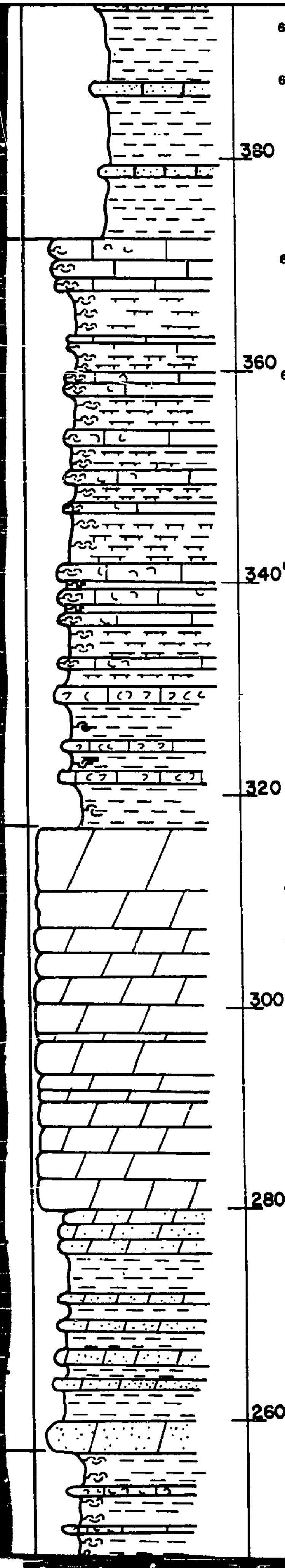
QUARTZ. SOME INTERCRYSTALLINE POROSITY.

MEDIUM TO THIN BEDDED, ARENACEOUS DOLOMI

INTERBEDDED WITH SHALE.

THICK BEDDED, ARENACEOUS DOLOMITE.

MEDIUM TO THIN BEDDED, DARK GRAY, SHELL



69CH301 69CH300	27	MEDIUM TO THIN BEDDEB, YELLOWISH, ARENACEOUS MUDSTONE, INTERBEDDED WITH GREENISH SHALE.
69CH299 69CH298	26	MEDIUM TO THIN BEDDED, SLIGHTLY NODULAR, MOLLUSC SHELL FRAGMENT MUDSTONE, INTERBEDDED WITH MARLS; COMMON <u>CALPIONELLIDS</u>.
69CH297	25	MEDIUM TO THIN BEDDED, DARK GRAY, SLIGHTLY NODULAR, DOLOMITIZED, SHELL FRAGMENT MUDSTONE, INTERBEDDED WITH NODULAR MARL.
69CH295 69CH294 69CH293 69CH292 69CH291 69CH290 69CH288	24	VERY THICK TO THICK BEDDED, DARK GRAY, VERY COARSE GRAIN DOLOMITE; COMMON SECONDARY QUARTZ. SOME INTERCRYSTALLINE POROSITY.
69CH287 69CH286 69CH285	23	MEDIUM TO THIN BEDDED, ARENACEOUS DOLOMITE, INTERBEDDED WITH SHALE.
69CH284	22	THICK BEDDED, ARENACEOUS DOLOMITE.
69CH283		MEDIUM TO THIN BEDDED, DARK GRAY, SHELL FRAGMENT

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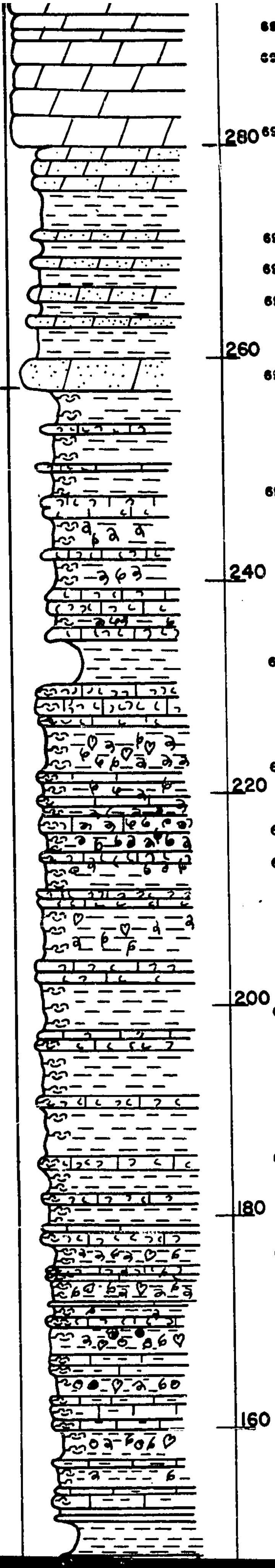
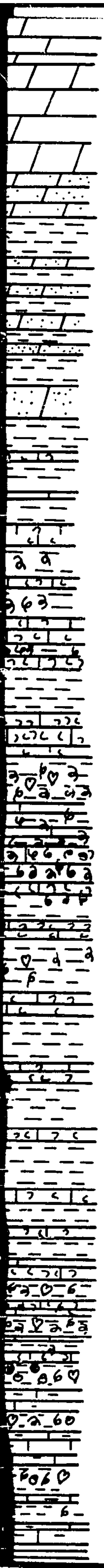
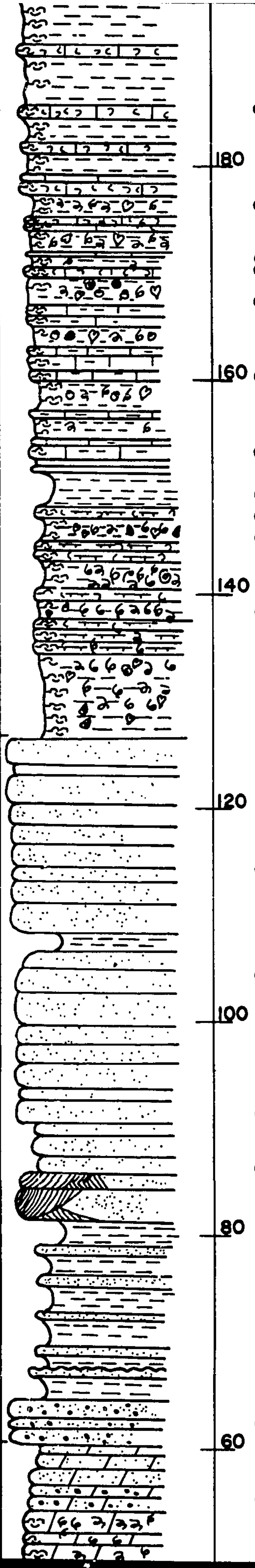


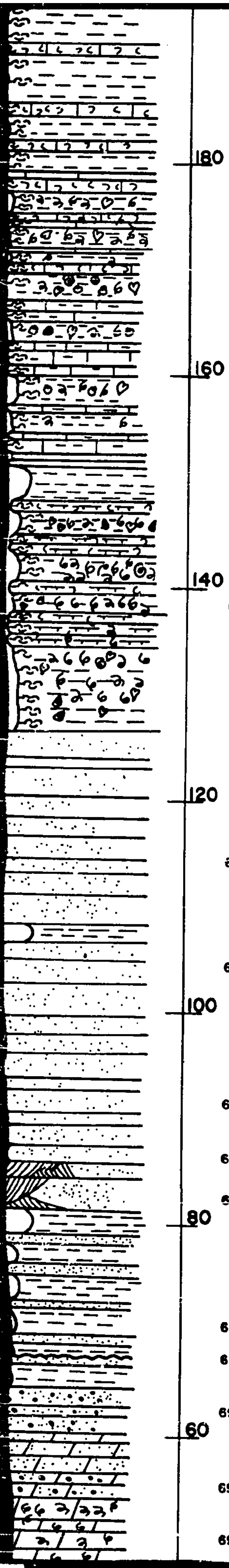
69CH291 69CH290		QUARTZ. SOME INTERCRYSTALLINE POROSIT
69CH288		
69CH287 69CH286 69CH285	23	MEDIUM TO THIN BEDDED, ARENACEOUS DOLO INTERBEDDED WITH SHALE.
69CH284	22	THICK BEDDED, ARENACEOUS DOLOMITE.
69CH283	21	MEDIUM TO THIN BEDDED, DARK GRAY, SHEL WACKESTONE, INTERBEDDED WITH NODULAR EXOGYRA.
69CH282	20	GREENISH GRAY SHALE.
69CH281 69CH280 69CH279	19	THIN BEDDED, NODULAR, SHELL FRAGMENT, F OSTRACOD MUDSTONE TO WACKESTONE, INT WITH NODULAR MARL; COMMON EXOGYRA AN ORDOÑESI.
69CH278 69CH277	18	THIN BEDDED, GRAY, SLIGHTLY NODULAR, MO SHELL FRAGMENT WACKESTONE, INTERBEDD NODULAR MARL.
69CH276 69CH275 69CH274 69CH273 69CH272 69CH271	17	MEDIUM TO THIN BEDDED, NODULAR, MOLLUSC FRAGMENT MUDSTONE, INTERBEDDED WITH N MARL; ABUNDANT EXOGYRA AND TEREBRATU FRAGMENT RESEMBLES OLCOSTEPHANUS SP.
69CH270	16	SHALE



	69CH291		QUARTZ. SOME INTERCRYSTALLINE POROSITY.
	69CH290		
280	69CH288		
	69CH287	23	MEDIUM TO THIN BEDDED,ARENACEOUS DOLOMITE, INTERBEDDED WITH SHALE.
	69CH286		
	69CH285		
260			
	69CH284	22	THICK BEDDED,ARENACEOUS DOLOMITE.
	69CH283	21	MEDIUM TO THIN BEDDED,DARK GRAY,SHELL FRAGMENT WACKESTONE, INTERBEDDED WITH NODULAR MARL; COMMON *EXOGYRA*.
240			
	69CH282	20	GREENISH GRAY SHALE.
	69CH281		THIN BEDDED,NODULAR,SHELL FRAGMENT,FORAMINIFERA, OSTRACOD MUDSTONE TO WACKESTONE, INTERBEDDED WITH NODULAR MARL; COMMON *EXOGYRA* AND *PROHINNITES ORDOÑESI*.
220			
	69CH280	19	
	69CH279		
200	69CH278		
		18	THIN BEDDED,GRAY,SLIGHTLY NODULAR,MOLLUSC SHELL SHELL FRAGMENT WACKESTONE, INTERBEDDED WITH NODULAR MARL.
	69CH277		
180			
	69CH276		
	69CH275		
	69CH274		MEDIUM TO THIN BEDDED,NODULAR,MOLLUSC SHELL FRAGMENT MUDSTONE, INTERBEDDED WITH NODULAR MARL; ABUNDANT *EXOGYRA* AND *TEREBRATULA*. AN AMMONITE FRAGMENT RESEMBLES *OLCOSTEPHANUS* SP. (?)
	69CH273	17	
160	69CH272		
	69CH271		

BARRIL	69CH277	18	SHELL FRAGMENT WACKESTONE, INTERBEDDED NODULAR MARL.
	69CH276 69CH275 69CH274 69CH273 69CH272 69CH271	17	MEDIUM TO THIN BEDDED,NODULAR,MOLLUSC SH FRAGMENT MUDSTONE, INTERBEDDED WITH NODU MARL; ABUNDANT *EXOGYRA* AND *TEREBRATULA*. FRAGMENT RESEMBLES *OLCOSTEPHANUS* SP. (?)
	69CH270	16	SHALE
	69CH269 69CH268 69CH267	15	MEDIUM BEDDED,DARK GRAY,PELECYPOD SHELL NODULAR MUDSTONE, INTERBEDDED WITH NODUL COMMON *GRYPHEA*, *EXOGYRA* AND *TEREBRATULA*
SAN MARCOS	69CH167	14	THICK TO MEDIUM BEDDED,GRAY,FINE ORTHOQ WITH SUB-ANGULAR,WELL SORTED GRAINS.
	69CH166	13	THICK BEDDED,COARSE TO VERY COARSE ORTH WITH SUB-ANGULAR,POORLY SORTED GRAINS.
	69CH165 69CH164 39CH163	12	THICK BEDDED,FINE TO MEDIUM SUBARKOSE W SUB-ANGULAR,WELL SORTED GRAINS; LARGE S PLANAR AND FESTOON CROSS-BEDDING.
	69CH162 69CH161	11	MEDIUM TO THIN BEDDED,FINE OTHOQUARTZIT SUB-ANGULAR,WELL SORTED GRAINS, INTERBE WITH GREENISH SHALE; ASYMMETRIC RIPPLE
	69CH160	10	CONGLOMERATIC(GRANULES) COARSE SUBARKOS
A	69CH159	9	THICK TO MEDIUM BEDDED, VERY ARENACEOUS DOLOMITE.
	69CH158	8	DARK GRAY,SLIGHTLY NODULAR,PELECYPOD SH





18

SHELL FRAGMENT WACKESTONE, INTERBEDDED WITH NODULAR MARL.

69CH277

69CH276

69CH275
69CH274

MEDIUM TO THIN BEDDED, NODULAR, MOLLUSC SHELL FRAGMENT MUDSTONE, INTERBEDDED WITH NODULAR MARL; ABUNDANT EXOGYRA AND TEREBRATULA. AN AMMONITE FRAGMENT RESEMBLES OLCOSTEPHANUS SP. (?)

69CH273

17

69CH272

69CH271

69CH270

16

SHALE

69CH269
69CH268

MEDIUM BEDDED, DARK GRAY, PELECYPOD SHELL FRAGMENT, NODULAR MUDSTONE, INTERBEDDED WITH NODULAR MARL. COMMON GRYPHEA, EXOGYRA AND TEREBRATULA

69CH267

15

THICK TO MEDIUM BEDDED, GRAY, FINE ORTHOQUARTZITE WITH SUB-ANGULAR, WELL SORTED GRAINS.

14

69CH167

69CH166

THICK BEDDED, COARSE TO VERY COARSE ORTHOQUARTZITE WITH SUB-ANGULAR, POORLY SORTED GRAINS.

13

69CH165

THICK BEDDED, FINE TO MEDIUM SUBARKOSE WITH SUB-ANGULAR, WELL SORTED GRAINS; LARGE SCALE PLANAR AND FESTOON CROSS-BEDDING.

69CH164

12

69CH163

MEDIUM TO THIN BEDDED, FINE OTHOQUARTZITE WITH SUB-ANGULAR, WELL SORTED GRAINS, INTERBEDDED WITH GREENISH SHALE; ASYMMETRIC RIPPLE MARKS BELOW

11

69CH162

69CH161

69CH160

10

CONGLOMERATIC(GRANULES) COARSE SUBARKOSE.

THICK TO MEDIUM BEDDED, VERY ARENACEOUS DOLOMITE.

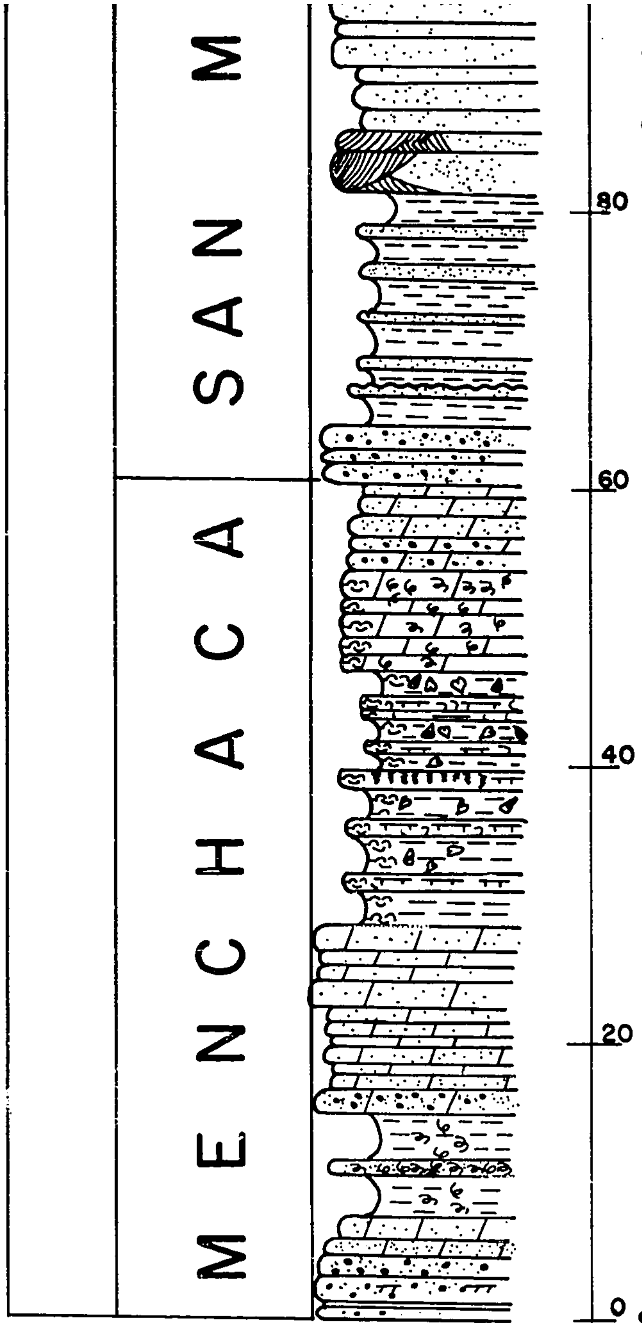
9

69CH159

DARK GRAY, SLIGHTLY NODULAR, PELECYPOD SHELL FRAGMENT DOLOMITE; COMMON EXOGYRA

69CH158

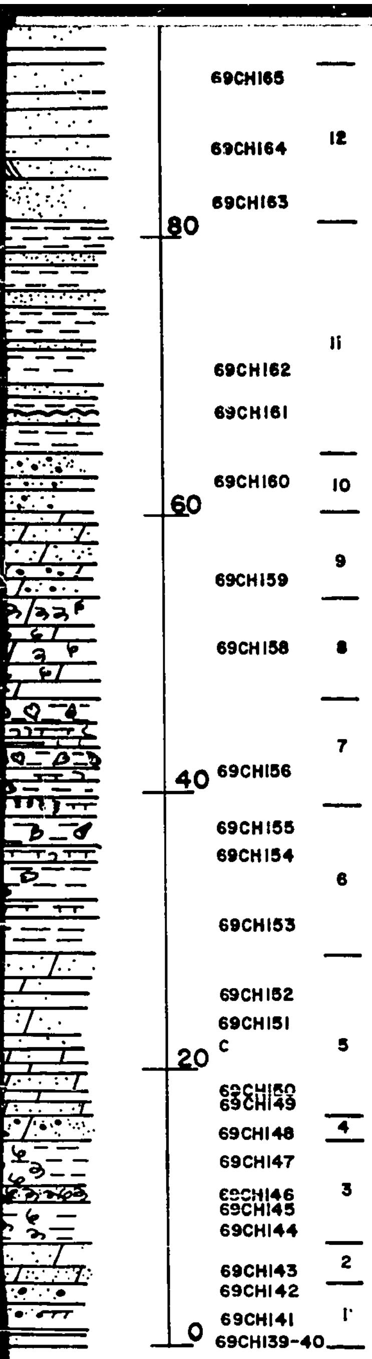
8



69CH165 69CH164 69CH163	12	THICK BEDDED,FINE TO MEDIUM SUBARKOSE SUB-ANGULAR,WELL SORTED GRAINS; LARGE PLANAR AND FESTOON CROSS-BEDDING.
69CH162 69CH161	11	MEDIUM TO THIN BEDDED,FINE OTHOQUARTZIT SUB-ANGULAR,WELL SORTED GRAINS, INTERBE WITH GREENISH SHALE; ASYMMETRIC RIPPLE
69CH160	10	CONGLOMERATIC(GRANULES) COARSE SUBARKOS
69CH159	9	THICK TO MEDIUM BEDDED, VERY ARENACEOUS DOLOMITE.
69CH158	8	DARK GRAY,SLIGHTLY NODULAR,PELECYPOD SH FRAGMENT DOLOMITE; COMMON EXOGYRA .
69CH156	7	DARK GRAY,NODULAR,SHELL FRAGMENT MUDSTO INTERBEDDED WITH MARL; PELECYPODS AND
69CH155 69CH154 69CH153	6	MEDIUM BEDDED,NODULAR, ARENACEOUS,SHELL BRYOZOA FRAGMENTS MARL, INTERBEDDED WI NODULAR SHALE; COMMON PELECYPODS.
69CH152 69CH151 C 69CH150 69CH149	5	MEDIUM BEDDED,DARK GRAY,VERY ARENACEOU FINE DOLOMITE.
69CH148	4	SILTY DOLOMITE.
69CH147 69CH146 69CH145 69CH144	3	ARENACEOUS DOLOMITE, INTERBEDDED WITH COMMON EXOGYRA .
69CH143	2	DARK GRAY,ARENACEOUS DOLOMITE.
69CH142 69CH141 69CH139-40	1	THICK BEDDED,DOLOMITIZED,COARSE SUBARK

LITHOLOGIC SYMBOLS

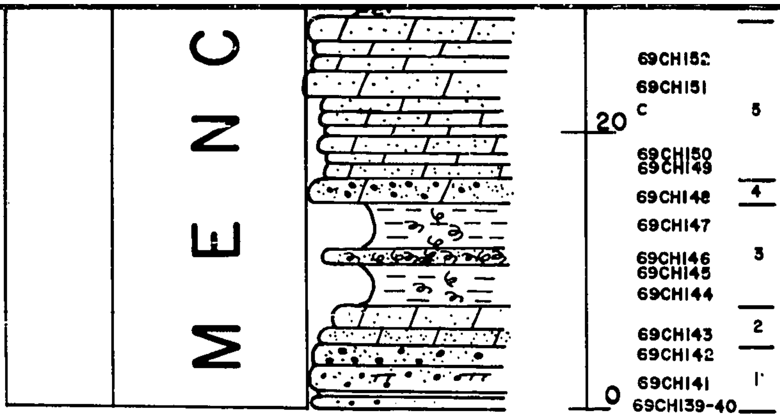
▦	MUDSTONE	◎	OOLITE	⊛	AMMONITE
▦	WACKESTONE	⬭	PELLET	⊚	TOUCASIA
▦	GRAINSTONE AND PACKSTONE	⊘	INTRACLAST	⚲	CAPRINID
▨	DOLOMITE	◡	SHELL FRAGMENT	▽	MONOPLEURID
▨	RECRYSTILLIZED LIMESTONE	⌓	MILIOLID	▽	RADIOLITID



12	THICK BEDDED, FINE TO MEDIUM SUBARKOSE WITH SUB-ANGULAR, WELL SORTED GRAINS; LARGE SCALE PLANAR AND FESTOON CROSS-BEDDING.
11	MEDIUM TO THIN BEDDED, FINE OTHOQUARTZITE WITH SUB-ANGULAR, WELL SORTED GRAINS, INTERBEDDED WITH GREENISH SHALE; ASYMMETRIC RIPPLE MARKS BELOW
10	CONGLOMERATIC(GRANULES) COARSE SUBARKOSE.
9	THICK TO MEDIUM BEDDED, VERY ARENACEOUS DOLOMITE.
8	DARK GRAY, SLIGHTLY NODULAR, PELECYPOD SHELL FRAGMENT DOLOMITE; COMMON EXOGYRA .
7	DARK GRAY, NODULAR, SHELL FRAGMENT MUDSTONE, INTERBEDDED WITH MARL; PELECYPODS AND GASTROPODS
6	MEDIUM BEDDED, NODULAR, ARENACEOUS, SHELL AND BRYOZOA FRAGMENTS MARL, INTERBEDDED WITH NODULAR SHALE; COMMON PELECYPODS.
5	MEDIUM BEDDED, DARK GRAY, VERY ARENACEOUS, FINE DOLOMITE.
4	SILTY DOLOMITE.
3	ARENACEOUS DOLOMITE, INTERBEDDED WITH SHALE; COMMON EXOGYRA .
2	DARK GRAY, ARENACEOUS DOLOMITE.
1	THICK BEDDED, DOLOMITIZED, COARSE SUBARKOSE.

LITHOLOGIC SYMBOLS

◎	OOLITE
⬭	PELLET
⦶	INTRACLAST
︶	SHELL FRAGMENT
	AMMONITE
	TOUCASIA
	CAPRINID
	MONOPLEURID
	RADIOLITID



MEDIUM BEDDED, DARK GRAY, VERY ARENACEOUS
FINE DOLOMITE.

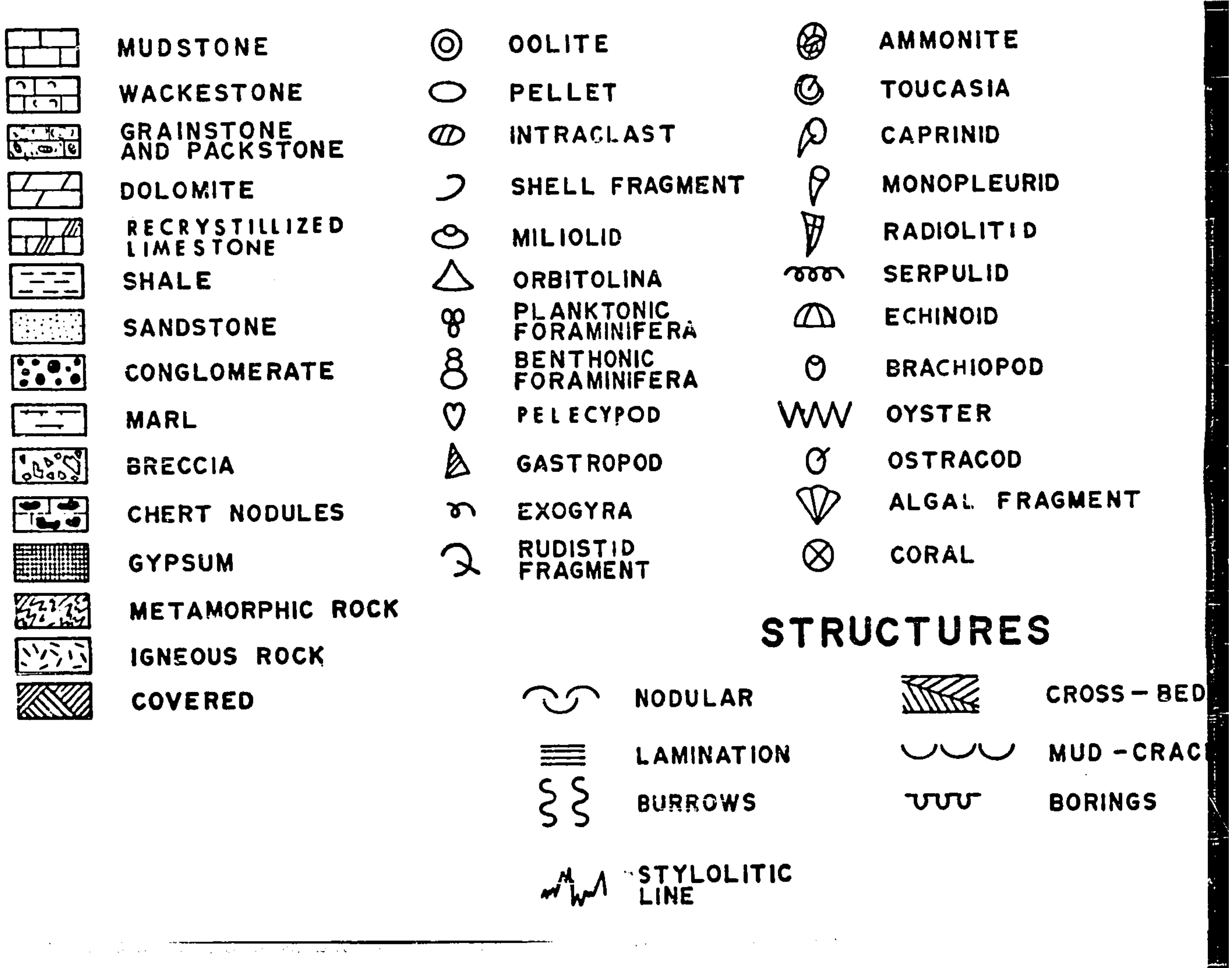
SILTY DOLOMITE.

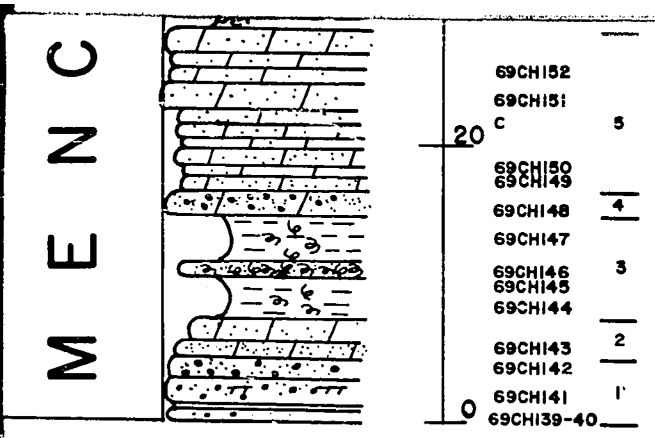
ARENACEOUS DOLOMITE, INTERBEDDED WITH S
COMMON *EXOGYRA* .

DARK GRAY, ARENACEOUS DOLOMITE.

THICK BEDDED, DOLOMITIZED, COARSE SUBARKO

LITHOLOGIC SYMBOLS





MEDIUM BEDDED, DARK GRAY, VERY ARENACEOUS, FINE DOLOMITE.

SILTY DOLOMITE.

ARENACEOUS DOLOMITE, INTERBEDDED WITH SHALE; COMMON EXOGYRA .

DARK GRAY, ARENACEOUS DOLOMITE.

THICK BEDDED, DOLOMITIZED, COARSE SUBARKOSE.

LITHOLOGIC SYMBOLS

MUDSTONE
WACKESTONE
GRAINSTONE AND PACKSTONE
DOLOMITE
RECRYSTILLIZED LIMESTONE
SHALE
SANDSTONE
CONGLOMERATE
MARL
BRECCIA
CHERT NODULES
GYPSUM
METAMORPHIC ROCK
IGNEOUS ROCK
COVERED

OOLITE
PELLET
INTRACLAST
SHELL FRAGMENT
MILIOLID
ORBITOLINA
PLANKTONIC FORAMINIFERA
BENTHONIC FORAMINIFERA
PELECYPOD
GASTROPOD
EXOGYRA
RUDISTID FRAGMENT

AMMONITE
TOUCASIA
CAPRINID
MONOPLEURID
RADIOLITID
SERPULID
ECHINOID
BRACHIOPOD
OYSTER
OSTRACOD
ALGAL FRAGMENT
CORAL

STRUCTURES

NODULAR
LAMINATION
BURROWS
STYLOLITIC LINE

CROSS-BEDDING
MUD-CRACKS
BORINGS

POTRERO DE LA MULA

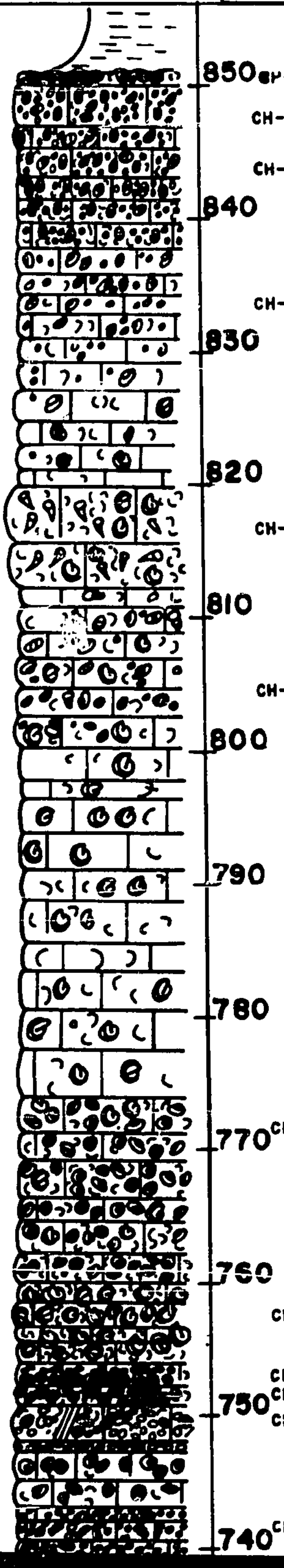
PLATE 21

SERIES | FORMATION | COLUMN | DESCRIPTION

LA PEÑA

RMATION

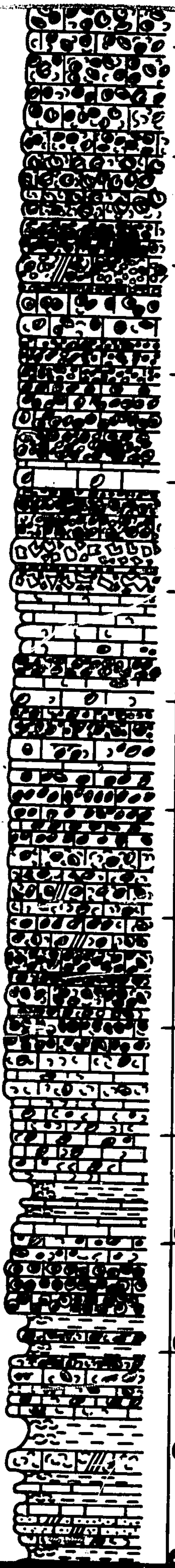
S



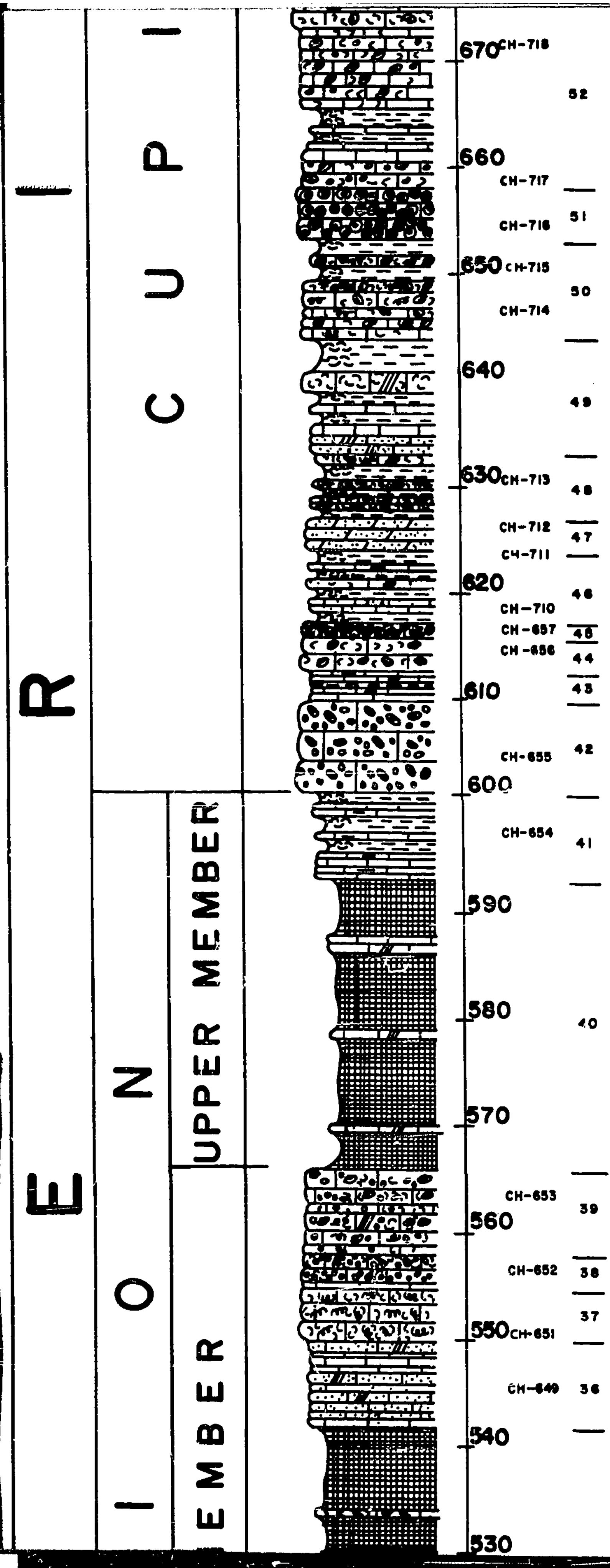
SP-744	80	SHELL FRAGMENT, OOLITE GRAINSTONE.
CH-743	79	OOLITE, SHELL FRAGMENT, PELLET GRAINSTONE.
CH-742	78	INTRACLAST, PELLET GRAINSTONE.
	77	SHELL FRAGMENT, PELLET, INTRACLAST PACKSTONE.
CH-741	76	MILIOLID, PELLET, SHELL FRAGMENT PACKSTONE
	75	VERY THICK BEDDED, MILIOLID, SHELL FRAGMENT MUDSTONE; FEW *TOUCASIA*.
CH-740	74	VERY THICK BEDDED, LIGHT GRAY, SHELL FRAGMENT WACKESTONE; ABUNDANT *TOUCASIA* AND *MONOPLEURA*
CH-739	73	VERY THICK BEDDED, INTRACLAST, PELLET, SHELL FRAGMENT PACKSTONE. COMMON *TOUCASIA* AND *CHOFFATELLA*
	72	VERY THICK BEDDED, SHELL FRAGMENT WACKESTONE; COMMON *TOUCASIA*.
CH-738	71	VERY THICK BEDDED, OOLITE, SHELL FRAGMENT, MILIOLID GRAINSTONE; FEW *TOUCASIA*.
	70	MILIOLID, OOLITE GRAINSTONE.
CH-737	69	VERY THICK BEDDED, LIGHT GRAY, SHELL FRAGMENT WACKESTONE; ABUNDANT *TOUCASIA*.
CH-736 CH-735 CH-734	68	VERY THICK BEDDED, PELLET, OOLITE, SHELL FRAGMENT GRAINSTONE.
	67	OOLITE, MILIOLID WACKESTONE.
CH-733	66	FORAMINIFERA, MILIOLID, PELLET GRAINSTONE.

IES

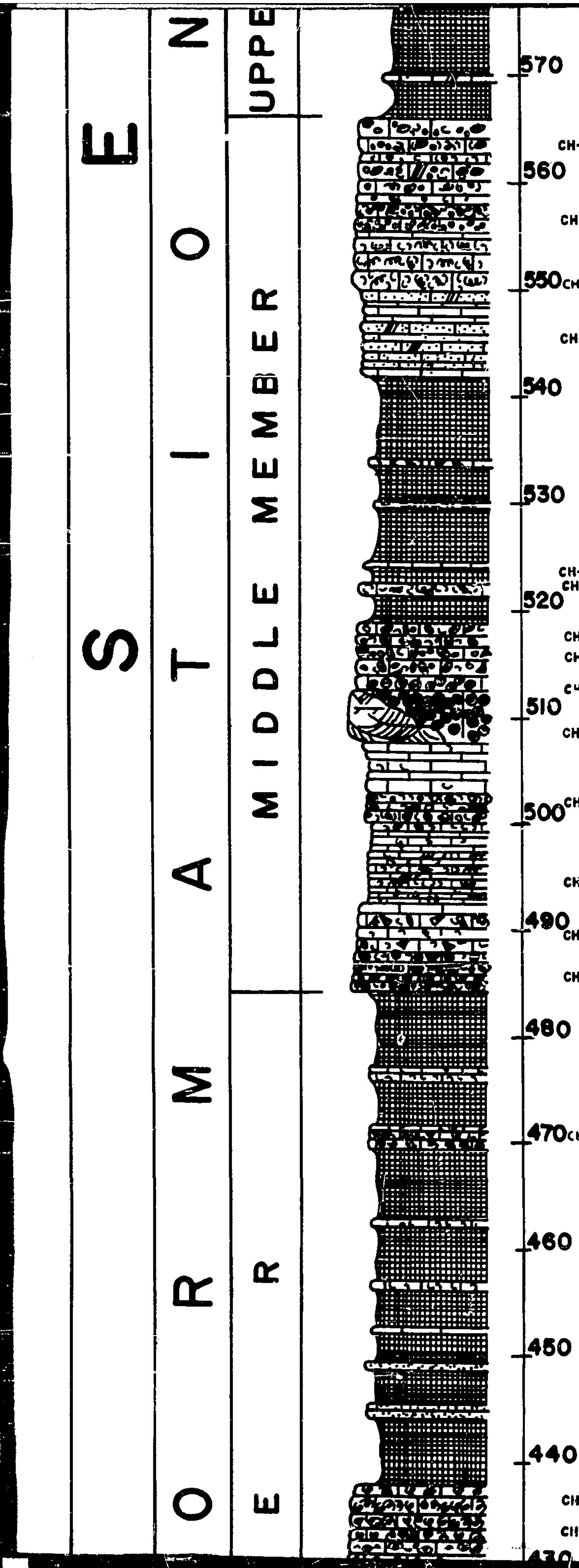
CUPIDO FORMA



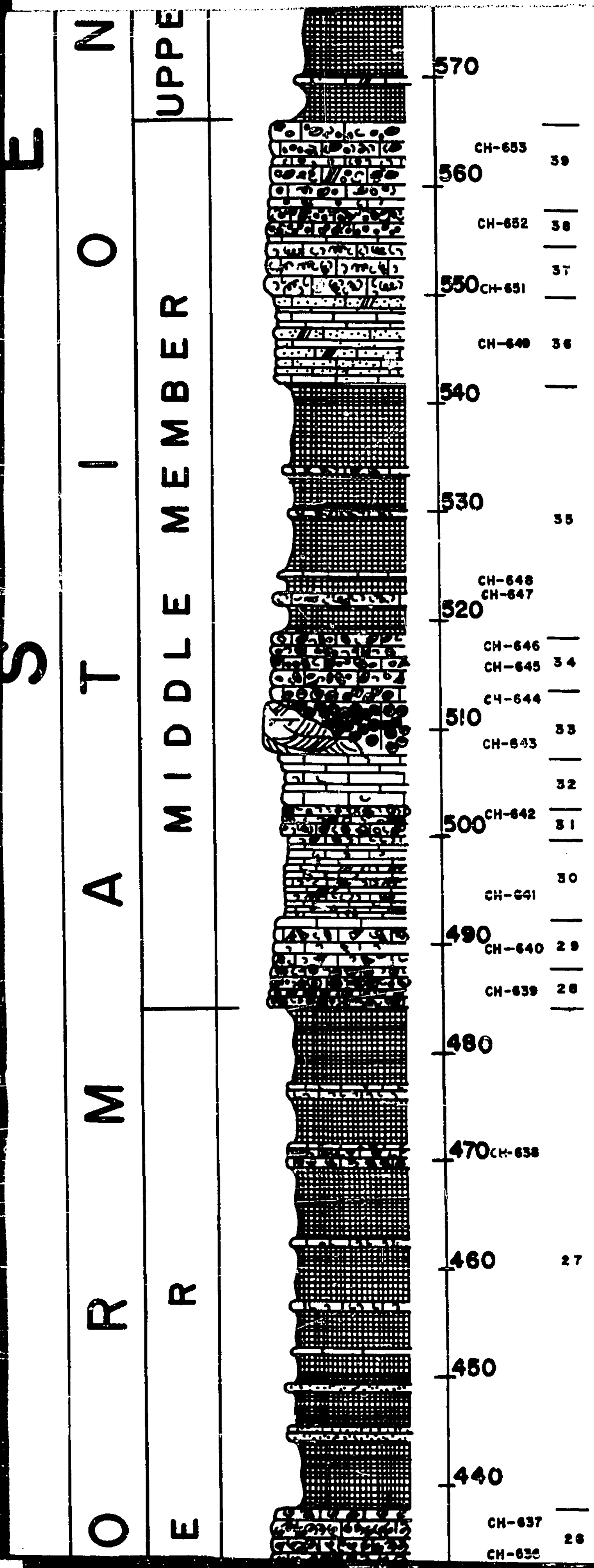
770	CH-738	71	VERY THICK BEDDED, OOLITE, SHELL FRAGMENT, MILIOLID GRAINSTONE; FEW TOUCASIA.
760		70	MILIOLID, OOLITE GRAINSTONE.
	CH-737	69	VERY THICK BEDDED, LIGHT GRAY, SHELL FRAGMENT WACKESTONE; ABUNDANT TOUCASIA.
750	CH-736 CH-735 CH-734	68	VERY THICK BEDDED, PELLET, OOLITE, SHELL FRAGMENT GRAINSTONE.
		67	OOLITE, MILIOLID WACKESTONE.
740	CH-733	66	FORAMINIFERA, MILIOLID, PELLET GRAINSTONE.
	CH-732	65	OOLITE, MILIOLID WACKESTONE.
	CH-731	64	RECRYSTALLIZED, PELLET, OOLITE GRAINSTONE.
730		63	VERY THICK BEDDED, MILIOLID MUDSTONE.
	CH-730 CH-729	62	PELLET, OOLITE, SHELL FRAGMENT GRAINSTONE.
720	CH-728	61	COLLAPSE BRECCIA.
	CH-727 CH-726	60	SHELL FRAGMENT, MILIOLID MUDSTONE.
		59	THICK BEDDED, INTRACLAST GRAINSTONE.
710		58	MILIOLID, SHELL FRAGMENT MUDSTONE.
	CH-725	57	PELLET, INTRACLAST GRAINSTONE.
	CH-724	56	INTRACLAST, MILIOLID, SHELL FRAGMENT WACKESTON
700	CH-722	55	VERY THICK BEDDED, RECRYSTALLIZED, SHELL FRAGMENT, MILIOLID GRAINSTONE.
690	CH-721	54	VERY THICK BEDDED, SHELL FRAGMENT, MILIOLID PACKSTONE.
680	CH-720 CH-719	53	VERY THICK BEDDED, SHELL FRAGMENT, MILIOLID, FORAMINIFERA GRAINSTONE.
670 660	CH-718	52	MEDIUM BEDDED, MILIOLID, SHELL FRAGMENT, PELLET WACKESTONE; NODULAR SHALE BELOW.
	CH-717 CH-716	51	THICK BEDDED, OOLITE GRAINSTONE.
650	CH-715 CH-714	50	MEDIUM BEDDED, DARK GRAY, MILIOLID, SERPULID TUBE WACKESTONE, INTERBEDDED WITH SHALE.
640		49	MEDIUM BEDDED, GRAY, RECRYSTALLIZED MUDSTONE, INTERBEDDED WITH NODULAR SHALE.
630	CH-713		SERPULID TUBE, SHELL FRAGMENT GRAINSTONE



52	CH-718	MEDIUM BEDDED, MILIOLID, SHELL FRAGMENT, PELLET WACKESTONE; NODULAR SHALE BELOW.
51	CH-717 CH-716	THICK BEDDED, OOLITE GRAINSTONE.
50	CH-715 CH-714	MEDIUM BEDDED, DARK GRAY, MILIOLID, SERPULID TUBE WACKESTONE, INTERBEDDED WITH SHALE.
49		MEDIUM BEDDED, GRAY, RECRYSTALLIZED MUDSTONE, INTERBEDDED WITH NODULAR SHALE.
48	CH-713	SERPULID TUBE, SHELL FRAGMENT GRAINSTONE, INTERBEDDED WITH NODULAR SHALE.
47	CH-712	ARENACEOUS DOLOMITE.
46	CH-711 CH-710	MILIOLID, SHELL FRAGMENT MUDSTONE, INTERBEDDED WITH NODULAR SHALE.
45	CH-657	OOLITE, SHELL FRAGMENT GRAINSTONE.
44	CH-656	SHELL FRAGMENT, MILIOLID WACKESTONE.
43		MUDSTONE, INTERBEDDED WITH NODULAR SHALE.
42	CH-655	THICK TO MEDIUM BEDDED, GRAY, PELLET, INTRACLAST WACKESTONE.
41	CH-654	THIN TO VERY THIN BEDDED, GRAY, SHELL FRAGMENT MUDSTONE, INTERBEDDED WITH NODULAR SHALE.
40		GYPSUM, INTERBEDDED WITH THIN LAYERS OF RECRYSTALLIZED MUDSTONE.
39	CH-653	SLIGHTLY RECRYSTALLIZED, SHELL FRAGMENT, PELLET, MILIOLID PACKSTONE; FEW *EXOGYRA*.
38	CH-652	SHELL FRAGMENT, PELLET GRAINSTONE; FEW *TURRITELA*
37	CH-651	SHELL FRAGMENT, SERPULID TUBE PACKSTONE.
36	CH-649	DOLOMITIZED, ARENACEOUS MUDSTONE.
		GYPSUM, INTERBEDDED WITH THIN BEDDED, SHELL



39	CH-653	SLIGHTLY RECRYSTALLIZED, SHELL FRAGMENT, PE MILIOLID PACKSTONE; FEW EXOGYRA.
38	CH-652	SHELL FRAGMENT, PELLET GRAINSTONE; FEW TU
37	CH-651	SHELL FRAGMENT, SERPULID TUBE PACKSTONE.
36	CH-649	DOLOMITIZED, ARENACEOUS MUDSTONE.
35	CH-648 CH-647	GYPSUM, INTERBEDDED WITH THIN BEDDED, SHELL FRAGMENT WACKESTONE; COMMON TURRITELA.
34	CH-646 CH-645	SHELL FRAGMENT, PELLET GRAINSTONE.
33	CH-644 CH-643	THICK BEDDED, SHELL FRAGMENT, OOLITE GRAINST EXTENSIVE DOLOMITIZATION; GOOD MOLDIC POROS
32		SHELL FRAGMENT MUDSTONE.
31	CH-642	PELLET, SHELL FRAGMENT GRAINSTONE.
30	CH-641	SERPULID TUBE, SHELL FRAGMENT WACKESTONE.
29	CH-640	SERPULID TUBE WACKESTONE WITH TURRITELA.
28	CH-639	PELLET, OOLITE GRAINSTONE.
27	CH-638	GYPSUM, INTERBEDDED WITH VERY THIN BEDDED, DA GRAY, SHELL FRAGMENT WACKESTONE; ABUNDANT EXOGYRA IN THE MIDDLE.
26	CH-637 CH-636	MEDIUM BEDDED, DARK GRAY, SHELL FRAGMENT PACK ABUNDANT EXOGYRA.



39 SLIGHTLY RECRYSTALLIZED, SHELL FRAGMENT, PELLET, MILIOLID PACKSTONE; FEW EXOGYRA.

38 SHELL FRAGMENT, PELLET GRAINSTONE; FEW TURRITELA

37 SHELL FRAGMENT, SERPULID TUBE PACKSTONE.

36 DOLOMITIZED, ARENACEOUS MUDSTONE.

35 GYPSUM, INTERBEDDED WITH THIN BEDDED, SHELL FRAGMENT WACKESTONE; COMMON TURRITELA.

34 SHELL FRAGMENT, PELLET GRAINSTONE.

33 THICK BEDDED, SHELL FRAGMENT, OOLITE GRAINSTONE; EXTENSIVE DOLOMITIZATION; GOOD MOLDIC POROSITY.

32 SHELL FRAGMENT MUDSTONE.

31 PELLET, SHELL FRAGMENT GRAINSTONE.

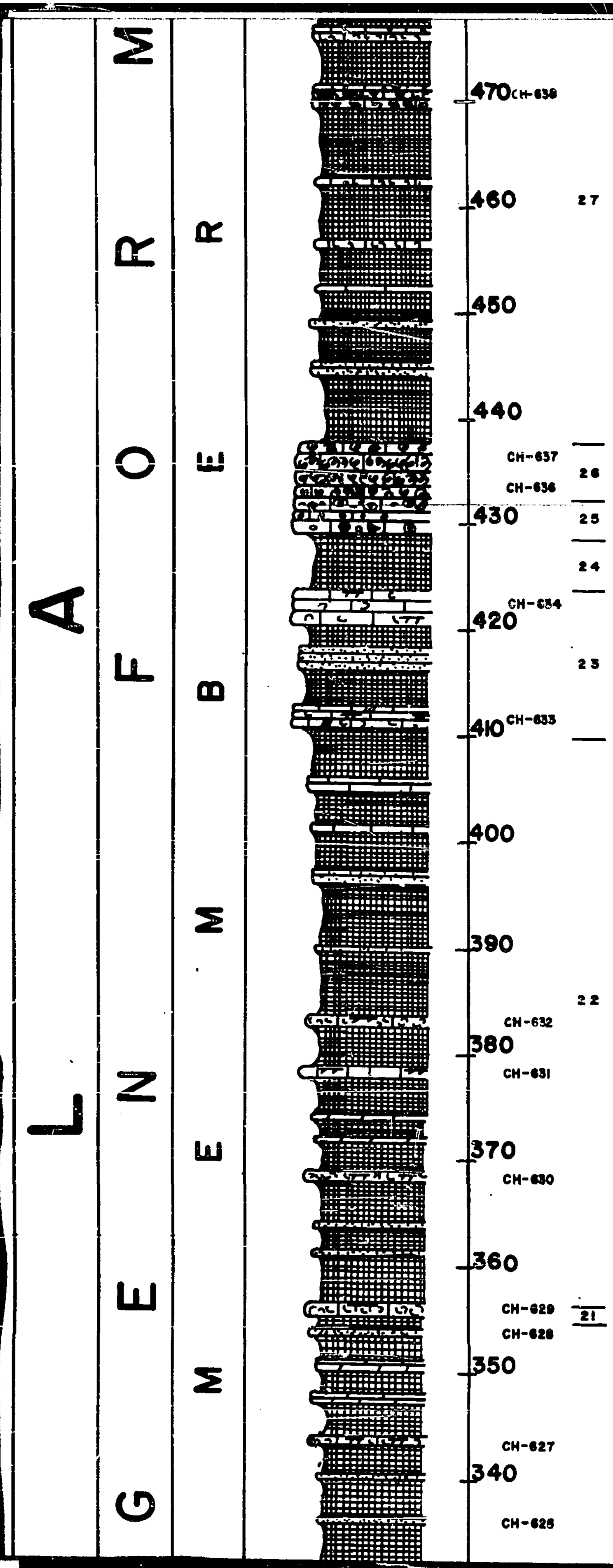
30 SERPULID TUBE, SHELL FRAGMENT WACKESTONE.

29 SERPULID TUBE WACKESTONE WITH TURRITELA.

28 PELLET, OOLITE GRAINSTONE.

27 GYPSUM, INTERBEDDED WITH VERY THIN BEDDED, DARK GRAY, SHELL FRAGMENT WACKESTONE; ABUNDANT EXOGYRA IN THE MIDDLE.

26 MEDIUM BEDDED, DARK GRAY, SHELL FRAGMENT PACKSTONE ABUNDANT EXOGYRA.



27 GYPSUM, INTERBEDDED WITH VERY THIN BEDDED, DARK GRAY, SHELL FRAGMENT WACKESTONE; ABUNDANT *EXOGYRA* IN THE MIDDLE.

26 MEDIUM BEDDED, DARK GRAY, SHELL FRAGMENT PACKSTONE; ABUNDANT *EXOGYRA*.

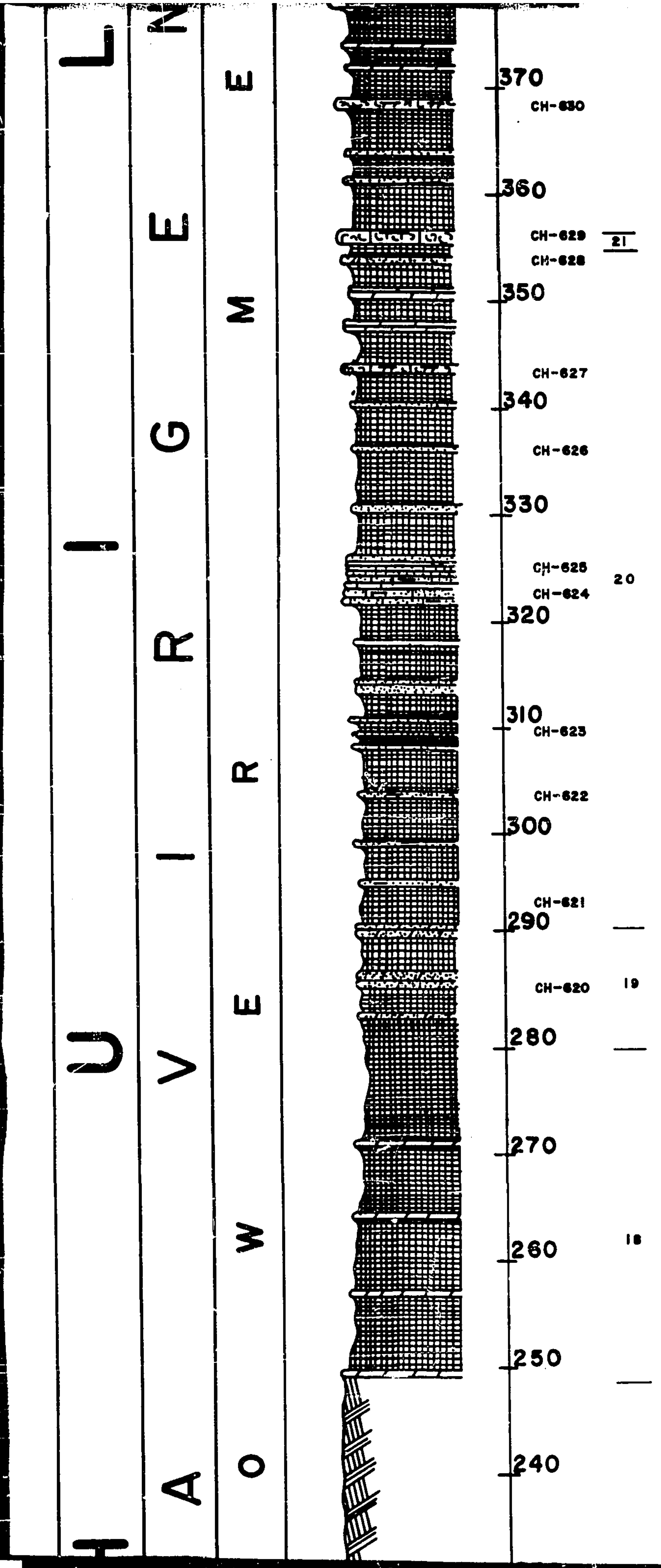
25 SHELL FRAGMENT, OOLITE WACKESTONE.

24 GYPSUM

23 GYPSUM, INTERBEDDED WITH MEDIUM TO THIN BEDDED DOLOMITIZED, ARENACEOUS MUDSTONE.

22 THICKLY LAMINATED GYPSUM, INTERBEDDED WITH OYSTER SHELL FRAGMENT WACKESTONE. AUTHIGENIC QUARTZ IN THE LOWER PART.

21 DOLOMITIZED, SHELL FRAGMENT MUDSTONE.

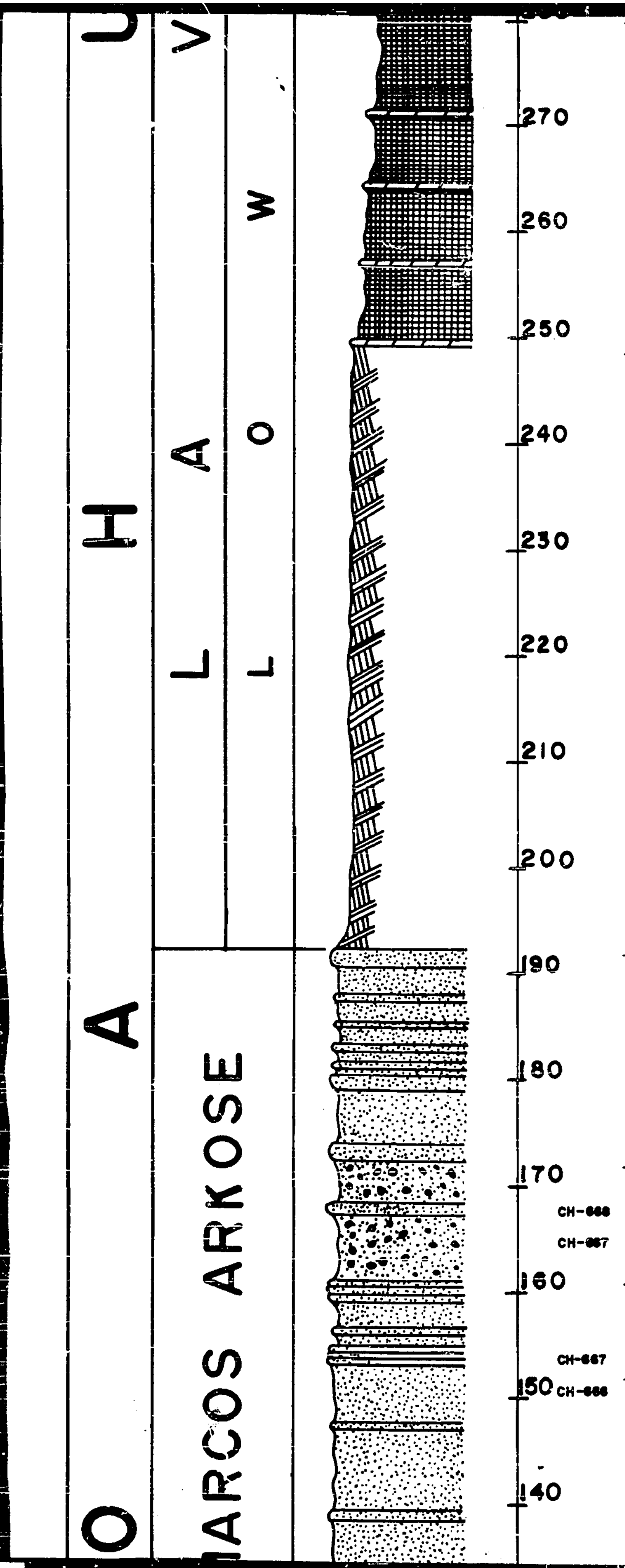


21 DOLOMITIZED, SHELL FRAGMENT MUDSTONE.

20 GYPSUM, INTERBEDDED WITH THINLY LAMINATED, ARENACEOUS DOLOMITE; GOOD INTERCRYSTALLINE AND VUGGY POROSITY; SOME AUTHIGENIC QUARTZ.

19 THICKLY LAMINATED GYPSUM, INTERBEDDED WITH YELLOWISH, SILTY DOLOMITE.

18 MASSIVE GYPSUM, INTERBEDDED WITH DOLOMITE.



18 MASSIVE GYPSUM, INTERBEDDED WITH DOLOMITE.

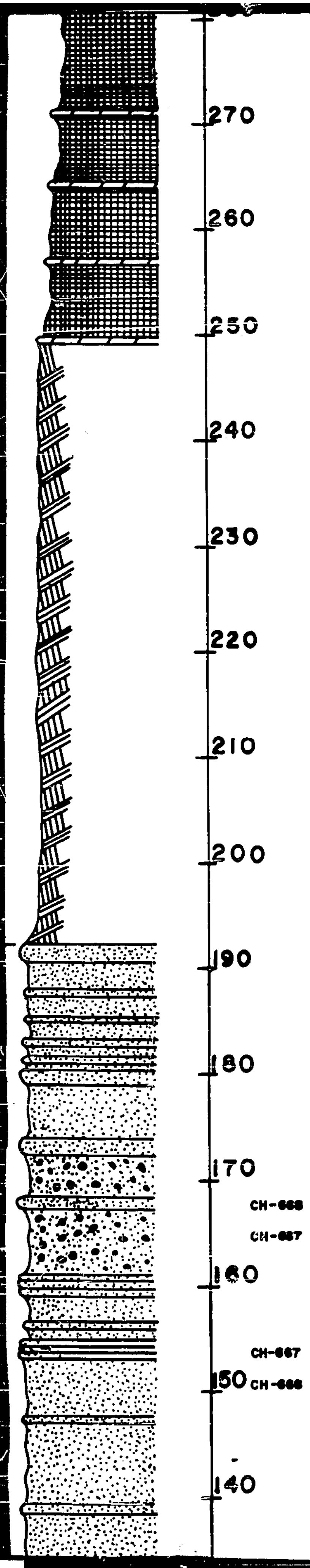
17 COVERED INTERVAL.

16 THIN TO VERY THIN BEDDED, REDDISH, FINE SUBARKOSE WITH SUBANGULAR POORLY SORTED GRAINS.

15 THICK BEDDED, REDDISH, SLIGHTLY CONGLOMERAT (GRANULES AND SMALL PEBBLES) COARSE SUBAR WITH SUBROUNDED, POORLY SORTED GRAINS.

14 THIN BEDDED, ARKOSIC SILSTONE.

13 THIN BEDDED, REDDISH, MEDIUM TO COARSE SUBA WITH SUBANGULAR, MEDIUM SORTED GRAINS, INTERBEDDED WITH REDDISH SILSTONE.



18 MASSIVE GYPSUM, INTERBEDDED WITH DOLOMITE.

17 COVERED INTERVAL.

16 THIN TO VERY THIN BEDDED, REDDISH, FINE SUBARKOSE WITH SUBANGULAR POORLY SORTED GRAINS.

15 THICK BEDDED, REDDISH, SLIGHTLY CONGLOMERATIC (GRANULES AND SMALL PEBBLES) COARSE SUBARKOSE. WITH SUBROUNDED, POORLY SORTED GRAINS.

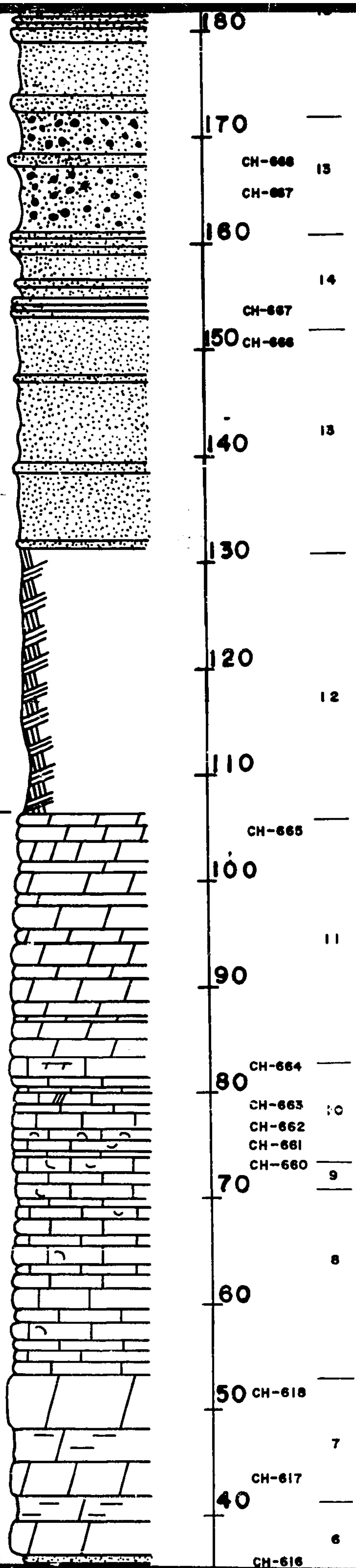
14 THIN BEDDED, ARKOSIC SILSTONE.

13 THIN BEDDED, REDDISH, MEDIUM TO COARSE SUBARKOSE WITH SUBANGULAR, MEDIUM SORTED GRAINS, INTERBEDDED WITH REDDISH SILSTONE.

UNIT C

SAN MARCOS ARKOSE

UPPER



SUBARKOSE WITH SUBANGULAR POORLY SORTED GRAINS.

13 THICK BEDDED, REDDISH, SLIGHTLY CONGLOMERATI
(GRANULES AND SMALL PEBBLES) COARSE SUBARK
WITH SUBROUNDED, POORLY SORTED GRAINS.

14 THIN BEDDED, ARKOSIC SILSTONE.

13 THIN BEDDED, REDDISH, MEDIUM TO COARSE SUBAR
WITH SUBANGULAR, MEDIUM SORTED GRAINS,
INTERBEDDED WITH REDDISH SILSTONE.

12 COVERED INTERVAL.

11 THICK TO MEDIUM BEDDED, COARSE DOLOMITE.

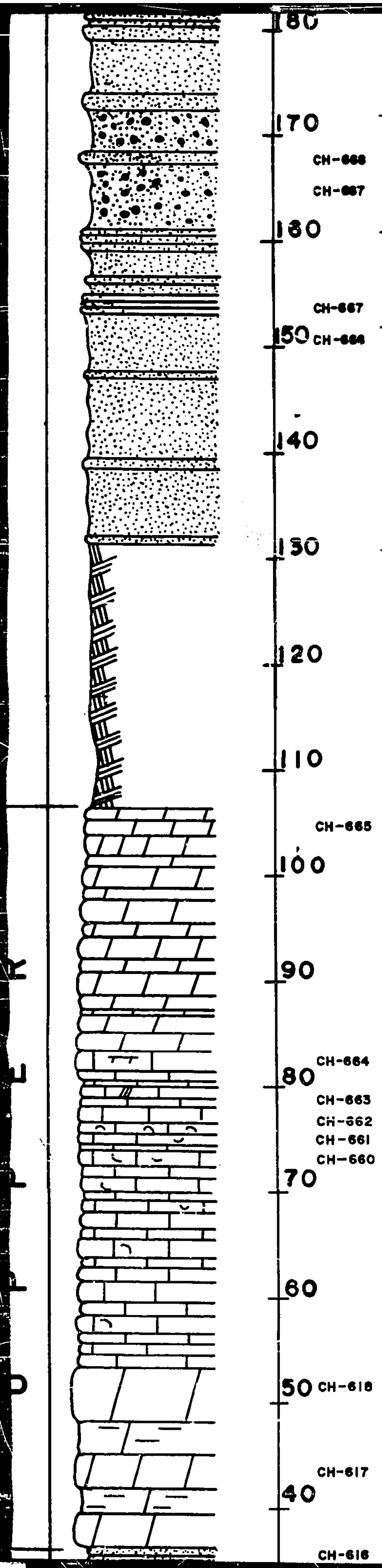
10 MEDIUM BEDDED, COARSE DOLOMITE.

9 DOLOMITIC, SHELL FRAGMENT (?) MUDSTONE.

8 MEDIUM BEDDED, COARSE DOLOMITE.

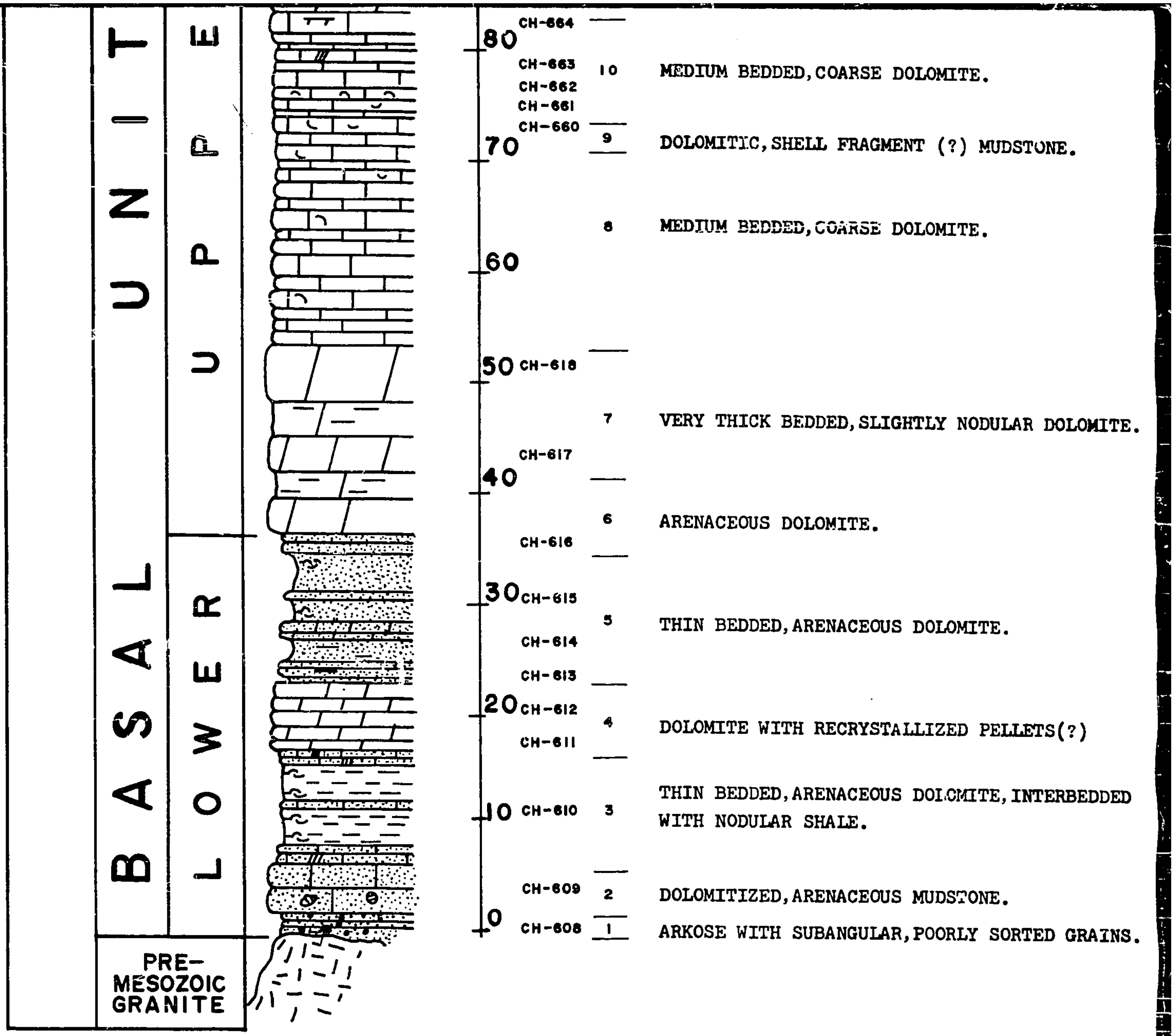
7 VERY THICK BEDDED, SLIGHTLY NODULAR DOLOMIT

6 ARENACEOUS DOLOMITE.



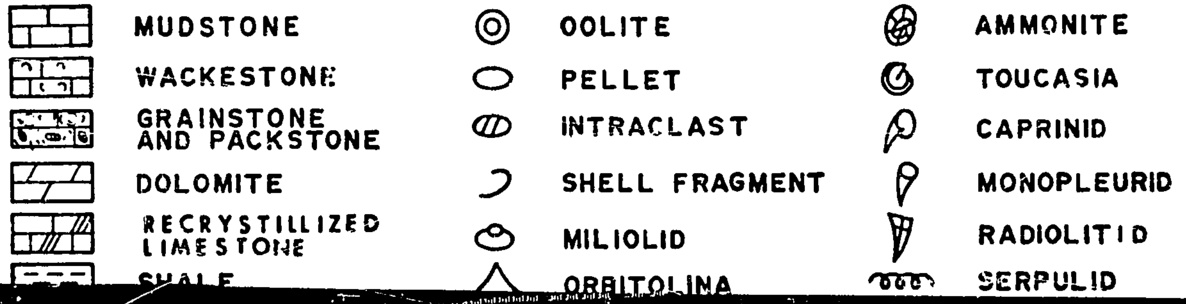
SUBARKOSE WITH SUBANGULAR POORLY SORTED GRAINS.

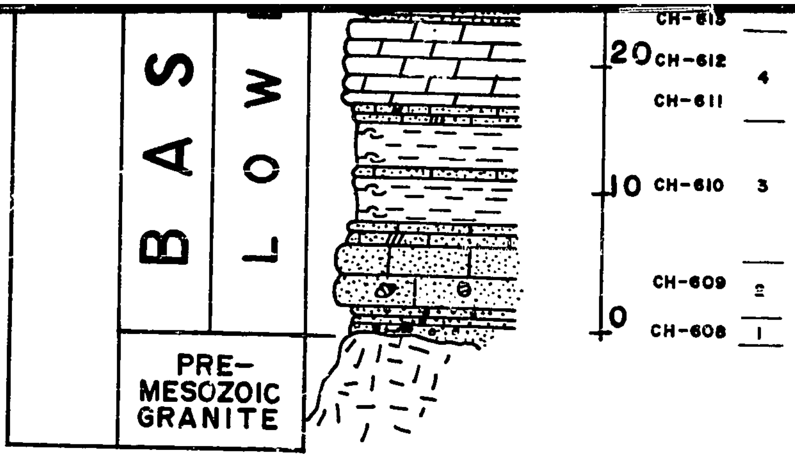
15	THICK BEDDED, REDDISH, SLIGHTLY CONGLOMERATIC (GRANULES AND SMALL PEBBLES) COARSE SUBARKOSE. WITH SUBROUNDED, POORLY SORTED GRAINS.
14	THIN BEDDED, ARKOSIC SILSTONE.
13	THIN BEDDED, REDDISH, MEDIUM TO COARSE SUBARKOSE WITH SUBANGULAR, MEDIUM SORTED GRAINS, INTERBEDDED WITH REDDISH SILSTONE.
12	COVERED INTERVAL.
11	THICK TO MEDIUM BEDDED, COARSE DOLOMITE.
10	MEDIUM BEDDED, COARSE DOLOMITE.
9	DOLOMITIC, SHELL FRAGMENT (?) MUDSTONE.
8	MEDIUM BEDDED, COARSE DOLOMITE.
7	VERY THICK BEDDED, SLIGHTLY NODULAR DOLOMITE.
6	ARENACEOUS DOLOMITE.



10	MEDIUM BEDDED, COARSE DOLOMITE.
9	DOLOMITIC, SHELL FRAGMENT (?) MUDSTONE.
8	MEDIUM BEDDED, COARSE DOLOMITE.
7	VERY THICK BEDDED, SLIGHTLY NODULAR DOLOMITE.
6	ARENACEOUS DOLOMITE.
5	THIN BEDDED, ARENACEOUS DOLOMITE.
4	DOLOMITE WITH RECRYSTALLIZED PELLETS(?)
3	THIN BEDDED, ARENACEOUS DOLOMITE, INTERBEDDED WITH NODULAR SHALE.
2	DOLOMITIZED, ARENACEOUS MUDSTONE.
1	ARKOSE WITH SUBANGULAR, POORLY SORTED GRAINS.

LITHOLOGIC SYMBOLS





DOLOMITE WITH RECRYSTALLIZED PELLETS(?)

THIN BEDDED, ARENACEOUS DOLOMITE, INTERBEDDED WITH NODULAR SHALE.

DOLOMITIZED, ARENACEOUS MUDSTONE.

ARKOSE WITH SUBANGULAR, POORLY SORTED GRAINS.

LITHOLOGIC SYMBOLS