1979

# Stratigraphic Interpretation of a Possible Paleostream Channel of the Ancient Nueces River, South Texas

Gerald Jacob Daub
*University of Rhode Island*

## Recommended Citation

Daub, Gerald Jacob, "Stratigraphic Interpretation of a Possible Paleostream Channel of the Ancient Nueces River, South Texas" (1979). *Open Access Master's Theses.* Paper 2071.
https://digitalcommons.uri.edu/theses/2071

# STRATIGRAPHIC INTERPRETATION OF A POSSIBLE PALEOSTREAM CHANNEL OF THE ANCIENT NUECES RIVER, SOUTH TEXAS

BY

GERALD JACOB DAUB

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN
GEOLOGY

UNIVERSITY OF RHODE ISLAND
1979

## ABSTRACT

The Nueces River in South Texas flows in a southeasterly direction toward the Texas Gulf Coast. In southeastern Lasalle County, the Nueces River makes an abrupt 90° turn and flows northeast for 56 miles. The Nueces River joins with the Frio and Atascosa Rivers to flow southeasterly, debouching in Corpus Christi Bay. It has been theorized that the Nueces River once flowed southeasterly crossing northeast Webb and central Duval Counties and then into Baffin Bay. The paleo-Nueces River is thought to have occupied the Las Animas and/or Parilla streams in Duval County. This study attempts to locate this ancient paleo-stream channel of the Nueces River.

A ground investigation including topographic maps, multispectral aerial photographs at various scales, along with Skylab photographs, and Landsat imagery, revealed no positive surficial expression of the paleo-system. A lineament study failed to depict any definitive structural control of the present course of the Nueces River. Termination of most electric well logs near the surface, resulted in a lack of data on Pleistocene or Holocene deposits to determine if a fluvial system did exist in the uppermost portion of the stratigraphic section. As a result, a lower stratigraphic sequence, upward from the

Catahoula (Miocene) through the Goliad (Pliocene) was examined with emphasis on the Catahoula and Oakville Formations. If stacked bar and channel sequences beneath the proposed former course of the Nueces River exist in these older sediments, they will lend credence to the theory that the course of the paleo-Nueces River crossed Duval County.

Electric log data including the construction of five cross sections provided no definitive evidence of the Las Animas and/or Parilla streams superposing a paleo-Nueces River. Construction of a sand dispersal system of the Oakville and Catahoula Formations included maximum sand, net sand, and percent sand lithofacies maps. These lithofacies maps depicted a sandy fluvial system, during Catahoula time (only) superposed by the Las Animas stream.

If the Nueces River ever followed the Las Animas and/or Parilla stream drainages, it did so during post Goliad (Pliocene) times but prior to the uplift of the Bordas escarpment. These sandy fluvial systems that have been delineated may be potential host rocks for uranium concentration.

# ACKNOWLEDGEMENTS

I would like to thank my committee members, Dr. John Fisher for helpful assistance with the lineation study and Dr. Tom A. Grigalunas for reviewing the study.

Special thanks and appreciation go to George W. Whitney, of the Anaconda Company for his devoted time and work in coordinating the thesis project through the Anaconda Company. Thanks are also expressed to Jim Alewine, Dick Owens and Stan McAlister of the Anaconda Company for their help while I was working on the project.

I also profited from discussions with W. E. Galloway, T. C. Gustavson, W. R. Kaiser, L. F. Brown, R. J. Finley, and R. Solis of the Texas Bureau of Economic Geology; J. M. Wilkerson of the Atlantic Richfield Company; J. Johnston and M. Barker of Exxon Company, U.S.A.; John C. Horne of the University of South Carolina; and Stanley Schumm and Frank Ethridge from Colorado State University.

Several organizations were of extreme benefit to me throughout the study, the first and foremost is the Anaconda Company, my employer during the summer of 1977, which made my field work possible. The Anaconda Company, as well as the University of Rhode Island Geology Department

funded various parts of the study. Other organizations which were of great help included the Atlantic Richfield Company, Exxon Company, U.S.A., the Texas Bureau of Economic Geology and the Texas Water Development Board.

Many people freely gave of their time to aid my work on this study. This group includes Ray Heimann, James Russell, Jim Thomas, Norm Fox, Steve Stancil and Mark Cable. Special thanks must go to Laura Hill for her devotation of time and work, helping me compile the electric log information in Austin, Texas. I would also like to express my thanks to Rick Kowalski, Kim Benjamin and John O'Brien for their help in various aspects of this study. I am indebted to Terri Gagliardi for her excellent typing and patience.

I wish to thank Earl Hagstrom and Nancy Friedrich for their moral support.

I should also like to express my gratitude to Joanna Varieur for her help and undying moral, spiritual and financial support throughout the duration of my study, none of which would have been possible without her.

Finally, I would like to dedicate this study and express my deepest gratitude to my mother and father, Ramona G. Daub and the late L. Harrison Daub, Jr. who both gave of their time, moral, spiritual, financial and parental support.

# PREFACE

This study is a result of personal interest in the Tertiary sediments of the Texas Gulf Coastal Plain. Some of these sediments contain commercial deposits of uranium in a modified roll-type environment. Most domestic uranium reserves are located in sandstone bodies of various origins. If a paleo-stream channel of an ancient Nueces River is delineated, it will result in an exploration target for uranium ore deposits along the south Texas Gulf Coastal Plain.

This thesis was written in manuscript style which conforms to an acceptable format for publication.

# TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

RESULTS (continued) Page

TABLE OF CONTENTS (continued)

DISCUSSION (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

## LIST OF APPENDICES

# INTRODUCTION

The Nueces River in South Texas (Fig. 1) flows in a southeasterly direction from the Edwards Plateau through Lasalle County, where in southeastern Lasalle County, the river makes an abrupt 90 degree turn and flows northeasterly for 56 miles, then joins the Frio and Atascosa Rivers to flow to Corpus Christi Bay.

Bailey (1926) notes that the principal river systems of the South Texas Gulf Coast region, except the Rio Grande, head in the Edwards Plateau, 190-250 miles from the coast. Except for the Nueces River, these consequent rivers flow in a southeastern direction toward the Gulf of Mexico. The Frio River, a tributary of the Nueces River, also flows in the same general pattern as the Nueces River, making a bend to the northeast but not as pronounced as the Nueces diversion.

## Background

The Bordas escarpment (Holocene) striking in a northeast-southwesterly direction controls stream drainage patterns including the present course of the Nueces River (Fig. 2). Those rivers west of the Bordas escarpment flow west-northwesterly to the Nueces River, whereas those to the east, including Parilla and Las Animas Creeks, flow south-southeasterly to the Gulf of Mexico. Deussen (1924) believes these river courses are a direct result of the Torrecillas uplift, which is the highest portion of the Reynosa Plain.

Figure 1. Location index map of South Texas.

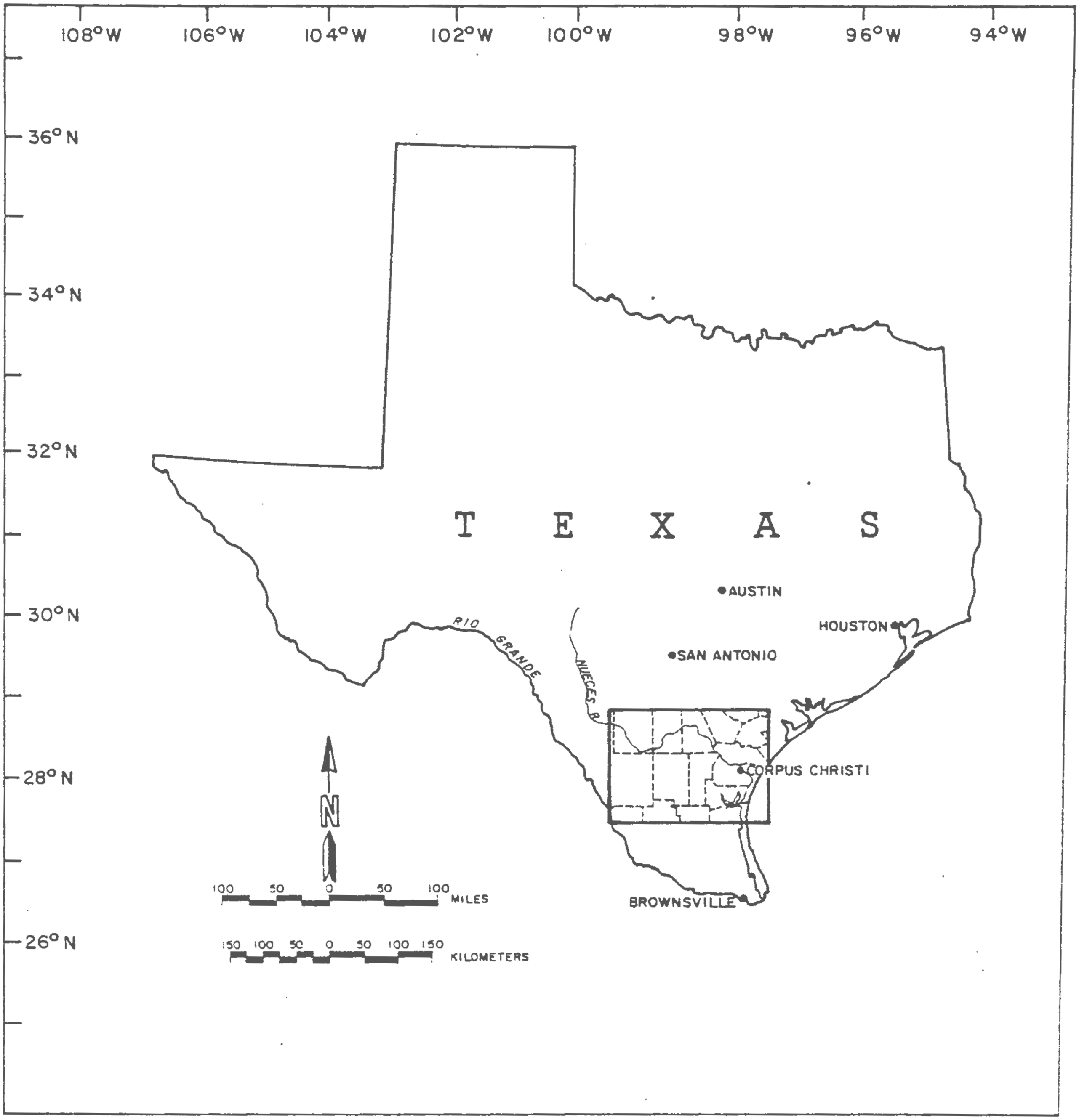
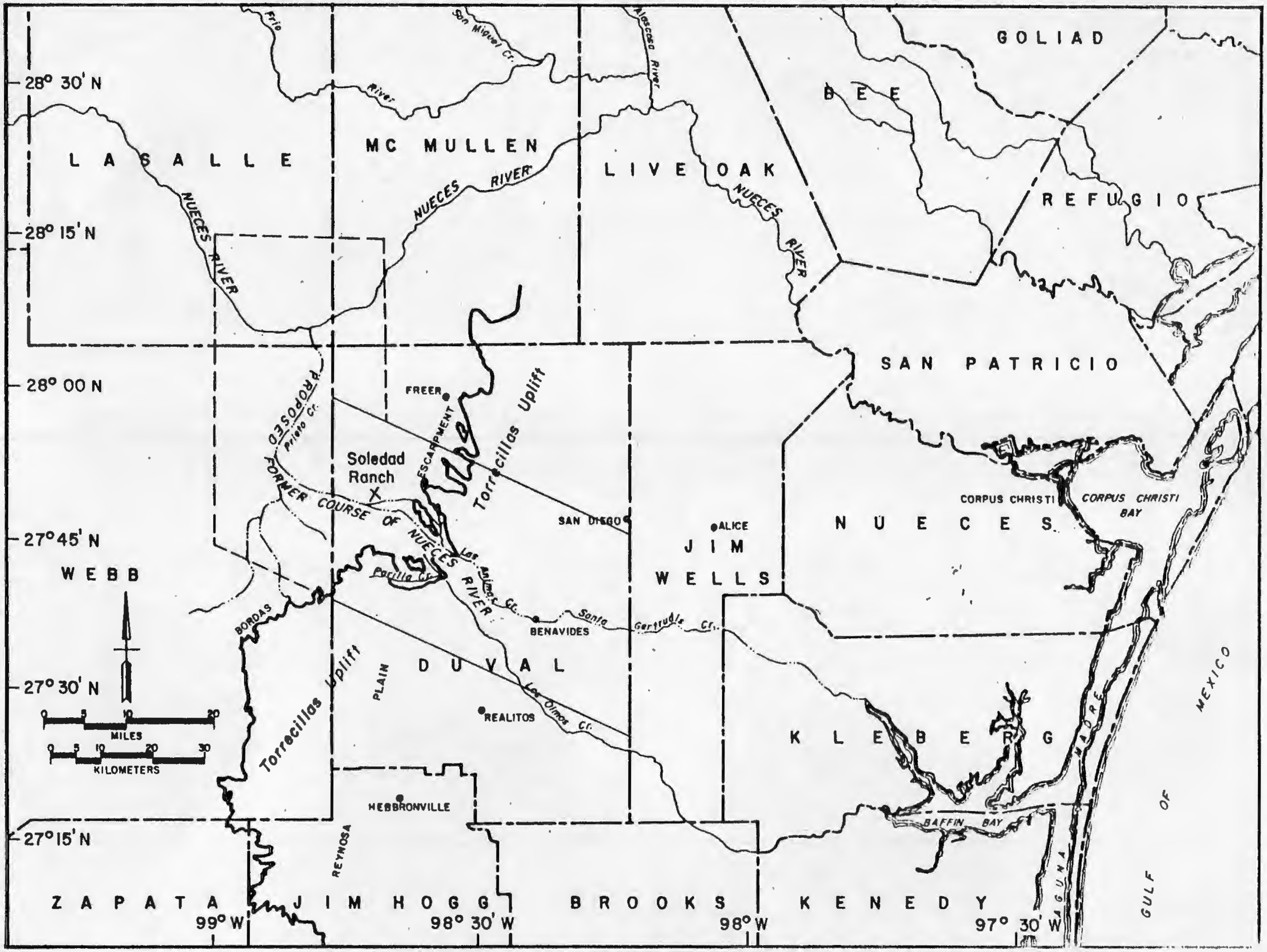

108°W
106°W
104°W
102°W
100°W
98°W
96°W
94°W
36°N
34°N
32°N
30°N
28°N
26°N
TEXAS
AUSTIN
HOUSTON
SAN ANTONIO
RIO GRANDE
NUECES R.
CORPUS CHRISTI
BROWNSVILLE
N
100 50 0 50 100 MILES
150 100 50 0 50 100 150 KILOMETERS

Figure 2. Map of South Texas showing present course and proposed former course of the Nueces River. The study area is outlined by the heavy dark line, the original study area also includes the region enclosed by the dashed line.

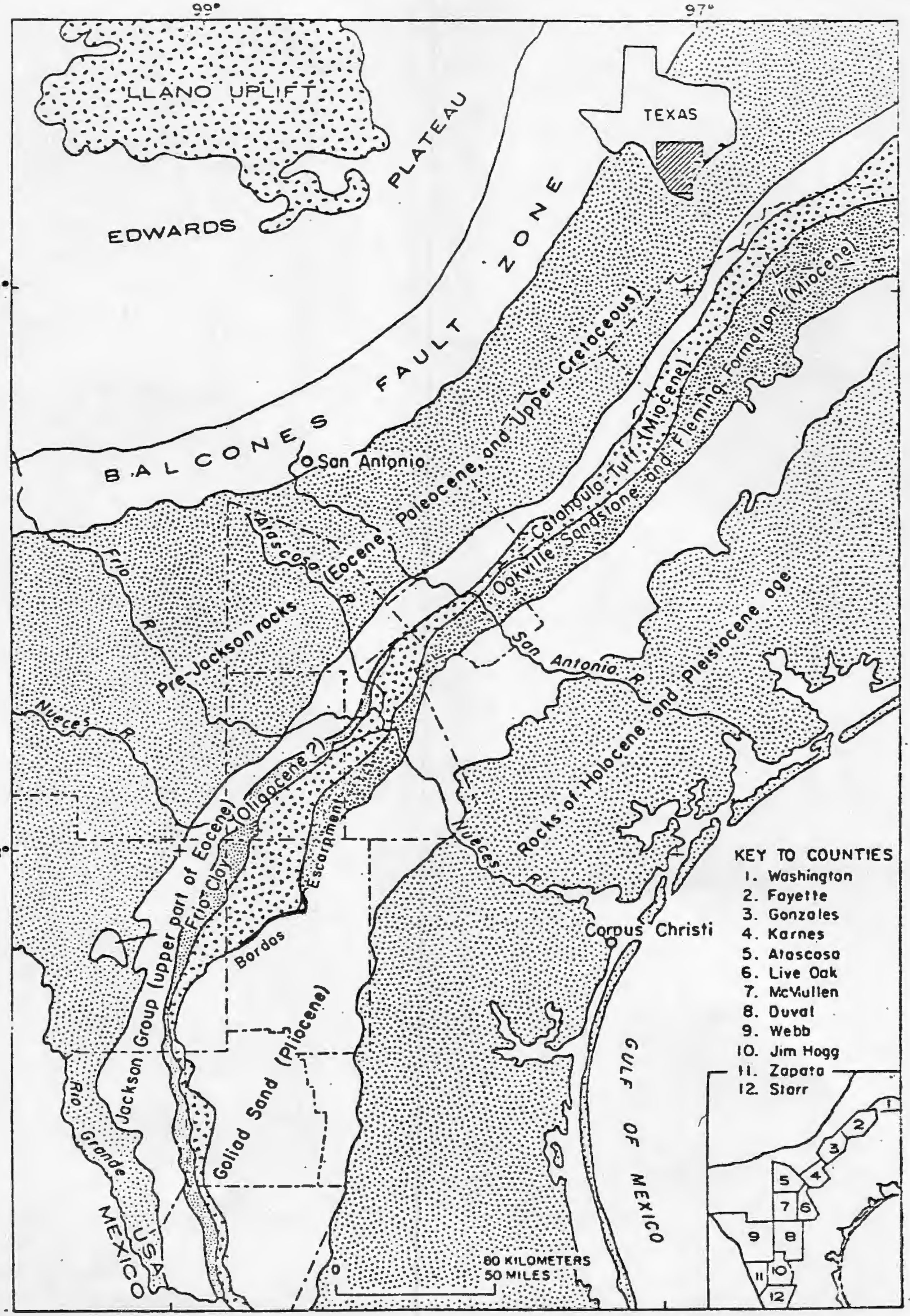

GOLIAD
BEE
REFUGIO
LIVE OAK
SAN PATRICIO
NUECES
CORPUS CHRISTI
CORPUS CHRISTI BAY
MC MULLEN
LASALLE
JIM WELLS
ALICE
SAN DIEGO
BENAVIDES
KLEBERG
DUVAL
FREER
REALITOS
HEBBRONVILLE
WEBB
ZAPATA
JIM HOGG
BROOKS
KENEDY
Frio River
San Miguel Cr.
Atascosa River
NUECES RIVER
Soledad Ranch
ESCARPMENT
Torrecillas Uplift
PROPOSED FORMER COURSE OF NUECES RIVER
Prieto Cr.
Parilla Cr.
Las Animas Cr.
Santa Gertrudis Cr.
Los Olmos Cr.
BORDAS
PLAIN
REYNOSA
BAFFIN BAY
LAGUNA MADRE
GULF OF MEXICO
28° 30' N
28° 15' N
28° 00 N
27° 45' N
27° 30' N
27° 15' N
99° W
98° 30' W
98° W
97° 30' W
0 5 10 20 MILES
0 5 10 20 30 KILOMETERS

The Nueces River is deflected behind the Torrecillas uplift which results in a northeasterly flow for approximately 56 miles. At Three Rivers, Texas, it joins with the Frio and Atascosa to flow in a southeasterly direction to the Gulf of Mexico at Corpus Christi Bay (Fig. 2). It has been noted by Bailey (1926) that the Torrecillas uplift may not have enough relief to divert the Nueces at its present rate of entrenchment.

Bailey (1926) mentions that the Nueces River has established its course as a result of the weakness of the Frio (Oligocene) clays in McMullen County, thus the Nueces River has become a subsequent stream (Fig. 3). Bailey (1926) also lists a number of supporting data for the former channel of the Nueces River which includes a broad valley-like depression, up to two miles wide, that is present in the northeast corner of Webb County. This valley contains Prieto Creek, an intermittent stream that could not have formed the existing valley. A reentrant is formed in the Bordas escarpment in western Duval County. This feature is a water gap, possibly the result of a much larger stream. Parilla Creek is found in the present reentrant and valley that could be a possible location for the ancient Nueces River (Fig. 2). The proposed termination of the ancient Nueces River is in Baffin Bay where there is no major drainage at present.

Bailey (1926) states three main hypotheses that could explain the existence of the channel. The first is

Figure 3. Geologic map of South Texas Coastal plain. Modified from Eargle, et al, (1975b).


99°
97°
30°
28°
LLANO UPLIFT
EDWARDS PLATEAU
BALCONES FAULT ZONE
TEXAS
San Antonio
(Eocene, Paleocene, and Upper Cretaceous)
Catahoula Tuff (Miocene)
Oakville Sandstone and Fleming Formation (Miocene)
Pre-Jackson rocks
Rocks of Holocene and Pleistocene age
Frio R
Atascosa R
San Antonio R
Nueces R
Frio Clay (Oligocene ?)
Jackson Group (upper part of Eocene)
Goliad Sand (Pliocene)
Bordas Escarpment
Corpus Christi
GULF OF MEXICO
Rio Grande
MEXICO
USA
0
80 KILOMETERS
50 MILES
KEY TO COUNTIES
1. Washington
2. Fayette
3. Gonzales
4. Karnes
5. Atascosa
6. Live Oak
7. McMullen
8. Duval
9. Webb
10. Jim Hogg
11. Zapata
12. Starr
1
2
3
4
5
6
7
8
9
10
11
12

that the Torrecillas uplift deflected the stream to the northeast. The second is that the Nueces River was captured by headward erosion of subsequent tributaries of the Atascosa River. The third is that a subsequent tributary existed before the river changed course and as a result of catastrophic floods, may have found a more favorable channel to the northeast.

Sayre (1937) believes that the valley containing Las Animas Creek appears wider and is in direct line with the wide valley south of the Soledad Ranch. The valley of Parilla Creek is separated from the above mentioned wide valley by a discontinuous ridge. Thus, the Las Animas is the probable location of the ancient Nueces River (Fig. 2).

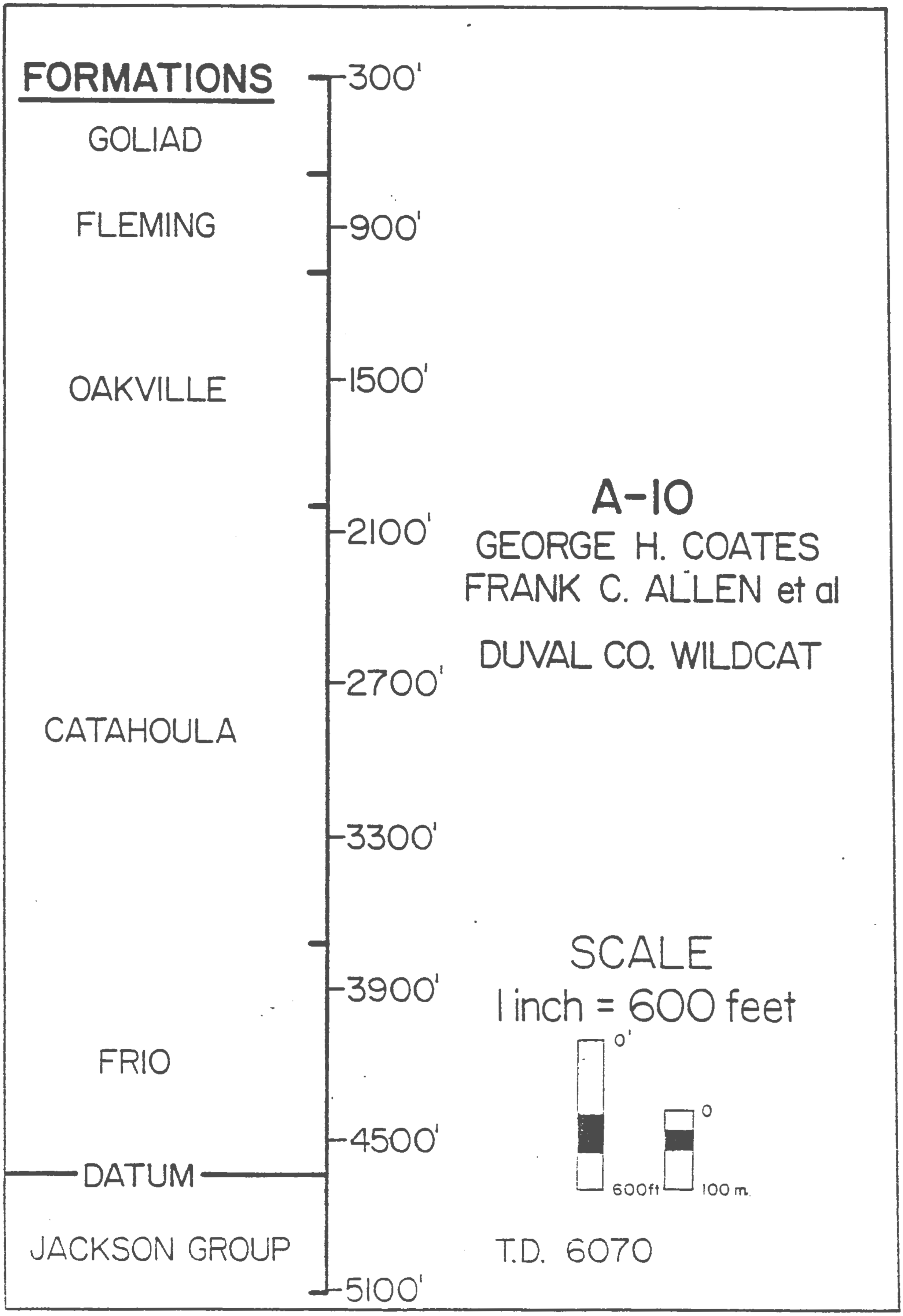
Duval County contains only ephemeral streams. Both Las Animas and Parilla Creeks are underfit streams, contained at present within very broad valleys. The Nueces River could have occupied one of these broad valleys prior to the activation of the Bordas escarpment.

### Purpose

The original study area (Fig. 2) contained parts of Lasalle, McMullen, Webb and Duval counties, approximately 1,358 square miles. As field work progressed and electric log information was compiled, it became evident that there were not enough electric log data near the surface to define the various facies. A shallow subsurface study which included 235 electric logs from southeastern Lasalle, northeastern Webb, northwestern Duval and southwestern McMullen counties proved futile. A lack of significant data in most of the electric logs near the surface was the main reason to abandon further study of the aforementioned area. A number of cross sections were constructed across the present course of the Nueces River as well as Prieto creek, in order to determine if any fluvial channel sands were present. No fluvial channel systems were located in any of the cross sections. Termination of most electric well logs near the surface resulted in a lack of data on Recent or Quaternary deposits to determine if a fluvial system did exist in the uppermost portion of the stratigraphic section. As a result, a lower stratigraphic sequence, upward from the Catahoula (Miocene) through the Goliad (Pliocene) was studied in Duval County (Fig. 4), with emphasis on the Catahoula and Oakville Formations. If stacked bar and channel sequences beneath the proposed former course of the Nueces River exist in these older sediments, they will lend credence to the theory that the course of the paleo-Nueces River crossed Duval County.

Electric log information in Lasalle, McMullen and Webb counties represent late Eocene and early Oligocene sediments that include the Jackson group and Frio formations, respectively (Fig. 3). These sediments were deposited in a barrier island and deltaic environment which are not indicative of a continental fluvial system, such as the paleo-Nueces (Sellards, _et al_., 1932; Holcomb, 1964).

Figure 4. Complete stratigraphic section in eastern portion of study area (see Well A-10, Figure 11 and 12B).


FORMATIONS
GOLIAD
FLEMING
OAKVILLE
CATAHOULA
FRIO
DATUM
JACKSON GROUP
300'
900'
1500'
2100'
2700'
3300'
3900'
4500'
5100'
A-10
GEORGE H. COATES
FRANK C. ALLEN et al
DUVAL CO. WILDCAT
SCALE
1 inch = 600 feet
0'
600ft
0
100 m.
T.D. 6070

## METHODS OF STUDY

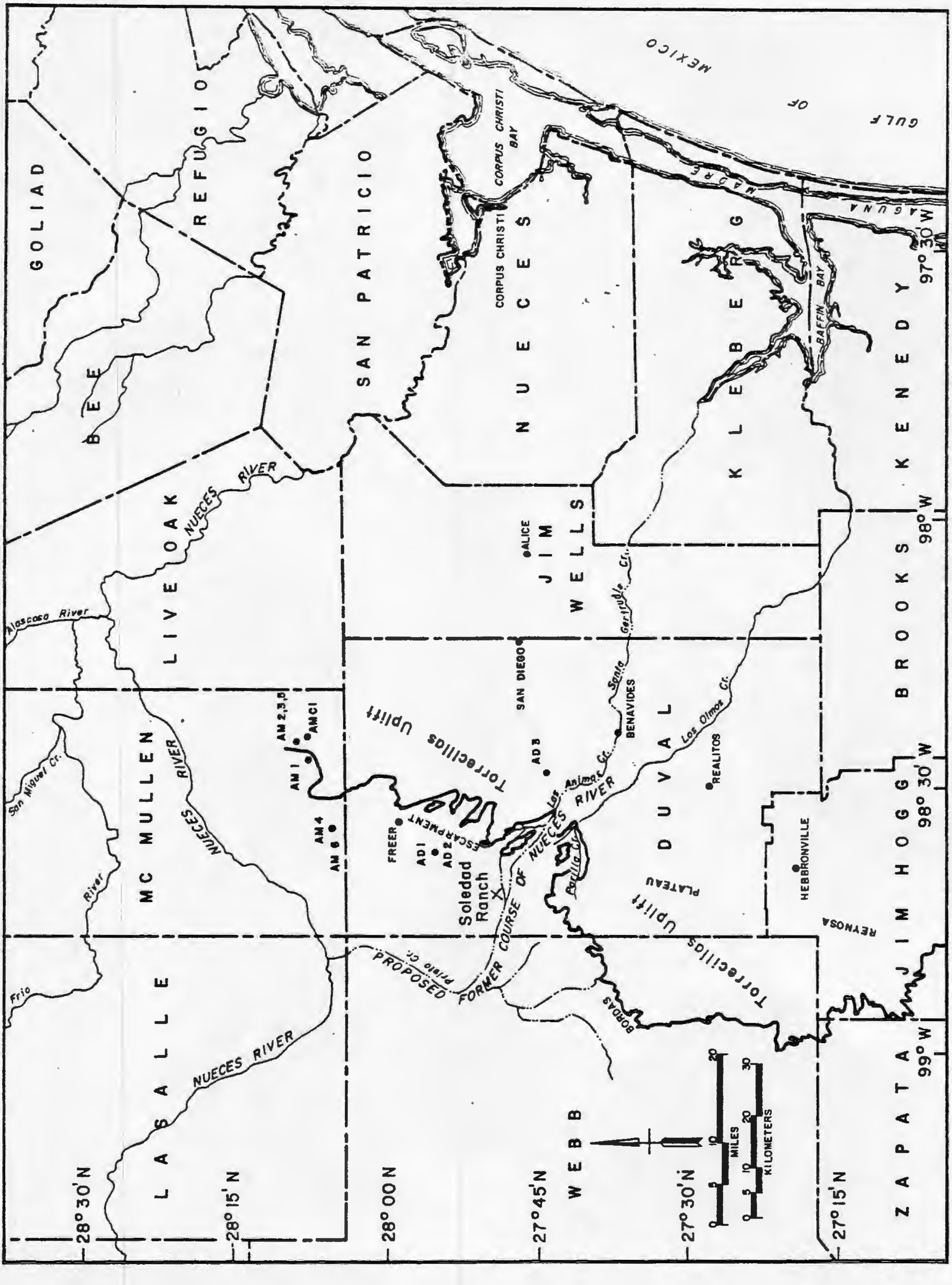
The field work was performed in South Texas during the summer of 1977 while in the employ of the Anaconda Company as a geologist on a uranium exploration program.

The field work consisted of outcrop work and verification of stream drainage patterns with topographic maps, aerial photographs, and Landsat imagery. Extensive electric log research and water well research was conducted at the Texas Water Development Board in Austin; The Texas Bureau of Economic Geology at the University of Texas, Austin, and the Atlantic Richfield Company's North American Producing Division located in Houston, Texas. Additional electric log data was compiled while in Corpus Christi, Texas.

### Outcrop Work

Outcrops in South Texas are very sparse and those that do exist are badly weathered and friable. Accessability to the various outcrops was a major problem, as most outcrops were on private, fenced land. Permission to even sample some outcrops was denied by certain land owners. Outcrop sampling consisted of retrieving a representative rock specimen of each particular outcrop in order to describe it megascopically at a later date. Due to the lack of any significant data from the various outcrops, this time consuming process of outcrop sampling was curtailed as the summer progressed. A total of nine outcrop locations had been sampled (Fig. 5).

Figure 5. Location of study area samples and outcrops (see Appendices 1 & 2).


GOLIAD
REFUGIO
BEE
SAN PATRICIO
NUECES
KLEBERG
KENEDY
LIVE OAK
JIM WELLS
BROOKS
MC MULLEN
DUVAL
JIM HOGG
LA SALLE
WEBB
ZAPATA
GULF OF MEXICO
CORPUS CHRISTI BAY
CORPUS CHRISTI
LAGUNA MADRE
BAFFIN BAY
NUECES RIVER
Atascosa River
San Miguel Cr.
Frio River
ALICE
SAN DIEGO
BENAVIDES
REALITOS
HEBBRONVILLE
FREER
Soledad Ranch
AM 1
AM 2,3,5
AMC1
AM 4
AM 6
AD 1
AD 2
AD 3
Torrecillos Uplift
ESCARPMENT
Los Animas Cr.
Santa Gertrudis Cr.
Los Olmos Cr.
Patilla Cr.
Prieto Cr.
PROPOSED FORMER COURSE OF NUECES RIVER
REYNOSA PLATEAU
BORDAS
28°30'N
28°15'N
28°00'N
27°45'N
27°30'N
27°15'N
99° W
98° 30' W
98° W
97° 30' W
MILES
0 5 10 20
KILOMETERS
0 5 10 20 30

The outcrops sampled consisted of the Oakville (Upper Miocene) sandstone and the Catahoula (Miocene) Formations. The Oakville sandstone, acting as a hard resistant cap rock, was found cropping out as mesas or outliers, where the Catahoula Formation was unconformably located directly under the Oakville sandstone. Oakville gravel and sand pits were sampled at various locations, in the study (Fig. 5) area as well as outside the study area in the surrounding counties. Within the study area, the Oakville was sampled at one location, AD-3, and the Catahoula was sampled at two locations, AD-1 and AD-2 (Fig. 5). The remaining six sampled locations were in McMullen County (Fig. 5) where the Oakville is better represented. These various outcrop samples were classified megascopically according to Folk (1974), (Appendix 2).

## Aerial Photographs

A number of aerial photographs of various scales were studied in order to determine if any surface expression of the paleo-stream channel existed. Photographs and scales included: black and white, 1:2,000; color, 1:40,000; black and white mosaics, 1:120,000; color infrared, 1:60,000 and 1:120,000. Drainage patterns were mapped on some of the photographs.

## Landsat Imagery

Landsat imagery at scales of 1:1,000,000 and 1:250,000 in band #7 (.8-1.1 micro meters) was used to accentuate the vegetation, water, and landforms. Landsat imagery was enlarged (scale; 1:250,000) and used to construct a mosaic to determine the presence of any topographic expression of the ancient paleo-stream channel. Skylab photographs (scales; 1:2,850,000 and 1:570,000) were also used to help determine if any surficial expression of the channel existed.

Landsat imagery at a scale of 1:500,000 in bands .6-.7 micro meters (red) was used to map lineaments to determine if any deep-seated structural control existed that might influence the present course of the Nueces River (Fig. 6, In Pocket = I.P.).

## Topographic Maps

Topographic maps were used to locate outcrops and depict the present as well as the possible ancient drainage patterns within the study area. Regional slope of the South Texas coastal plain was determined from topographic maps to be less than $1^{\circ}$ (8.9'/mile, 1.7m/km).

## Electric Logs

Electric log data from oil, gas, uranium and water wells were compiled from a number of various sources as previously stated, to try to obtain as much control as possible within the study area. A series of cross sections were constructed normal to the proposed course of the paleo-stream channel to try to determine if a channel of the ancient Nueces did exist, at depth, beneath the present course of the Las Animas and/or Parilla Creeks in Duval County. Four strike cross sections (A through D), (Fig. 7, I.P.), were constructed normal to the course of the Las Animas and Parilla Creeks. One dip section (E-E'), (Fig. 7, I.P.) was constructed along the course of the present Las Animas and Parilla Creeks drainage to try and depict any channel or valley fill facies sequences.

The cross sections were constructed to determine the lateral and vertical extent as well as continuity of the channel-sand facies throughout the study area in Duval County. The vertical persistence of channel sequences (through time) would be a good indicator for a valley-fill fluvial system that may be related to a paleo-Nueces.

### Sand Dispersal System

The main emphasis of this study is to create a map of the sand dispersal system and try to define the paleo-stream channel of the Nueces River by the interpretation of subsurface data. Net sand isopach maps of the Oakville and Catahoula Formations were constructed to determine those areas that contain an abundance of sand, fluvial channels, and/or valley fill. Maximum sand isopach maps were constructed to determine major channels. Sand percent maps were also constructed to obtain a more valid indication of any sand concentrations, because the South Texas coastal plain sediments thicken in a down dip, or Gulfward direction.

## Data Analysis

The cross sections were constructed from base maps of scale: 1"=2000'. The data were then plotted on graph paper to put it in acceptable form for the U.R.I. SYMAP computer program.

## Stratigraphic Correlation

Stratigraphic correlation of the entire section, from the Jackson group through the Goliad sand, was attempted with complete stratigraphic analysis of the Catahoula and Oakville Formations. The stratigraphic analysis was initiated from the eastern-most portion of the study area, on the Duval-Jim Wells County line, since the entire stratigraphic sequence is represented in well-log information. 403 electric logs were used in the construction of the cross sections and sand dispersal maps. The nature and distribution of sedimentary facies were determined by analysis of the shapes of the spontaneous potential (S.P.) and resistivity curves. Well control can be easily seen from the computer-generated base map (Fig. 8, I.P.).

Sand and shales were identified by their characteristic log response. In South Texas, the S.P. becomes suppressed near the surface in many instances. This may be due to a number of possibilities, the most likely being the abundance of fresh water in the upper part of the hole and/or the fact that the resistivity of the formation fluid is about equal to the resistivity of the mud, thus producing a rather featureless S.P. curve.

Abundant well-log information between the four strike cross sections was used to maintain continuity and for additional data for the sand maps. The dip cross section was used to determine the lateral and vertical stratigraphic relationships between the strike sections as one proceeds up dip to the west and northwest.

## RESULTS

### Outcrop Data

The outcrops studied (Fig. 5) are listed in Appendix 1. At each outcrop, a sample was taken and later megascopically described according to Folk's (1974) classification (Appendix 2). The Catahoula Formation was sampled at two locations, AD-1, and a core specimen from McMullen County, AMC-1. The Oakville Formation was examined at seven locations including AD-3 which had three separate examples. The Oakville Formation outcrops that were studied showed both rooted and burrowed sections. The following areas: AM-2, AM-3, AM-4, AM-5, and AM-6 showed scoured basal sands with a pebbly channel-lag deposit, along with a gradational fining-upward sequence. Large scale trough cross stratification was present at AM-2 to AM-6. Abundant large-scale plane lamination was present at AD-3 along with trough cross stratification.

### Aerial Photographs

An aerial photograph study of the study area included various types of photographs at varying scales to try to depict any evidence of a former channel that may have existed. Black and white aerial photographs scale: 1:2,000, along with black and white mosaics scale: 1:120,000, were examined. No positive surficial expression of the paleo-stream channel was evident from either of these studies.

Color aerial photographs scale: 1:40,000, were also inspected for the expression of a paleo-stream channel from the diversion of the Nueces River in southeastern Lasalle County through Duval County. No positive surficial evidence of the paleo-stream channel exists. Color infrared positive transparencies at scales of 1:60,000 and 1:120,000 were examined through a zoom enlarger on a light table to delineate any possible existence of a paleo-stream channel throughout the study area. This color infrared study produced no surface evidence of any paleo-stream channels.

### Landsat Imagery

Landsat imagery in band #7, (.8-1.1mm) accentuating vegetation, water, and landforms was studied to depict surficial evidence of the paleo-stream channel. The Landsat imagery scales included 1:1,000,000 (Fig. 9) and 1:250,000. A mosaic was constructed from the 1:250,000 scale Landsat imagery which was enlarged from the 1:1,000,000 scale Landsat imagery to delineate surficial expression of a paleo-stream channel. Careful inspection with magnification revealed no positive evidence of the proposed former course of the Nueces River.

### Skylab Photographs

Slylab photographs (scales; 1:2,850,000 and approximately 1:570,000) (Fig. 10) were also used to help determine any surface expression of the paleo-stream channel.

Figure 9. Landsat imagery band #7 of South Texas showing; 1. Corpus Christi Bay, 2. Baffin Bay, and 3. northeast course of the Nueces River. Scale: 1:1,000,000. (Compare image with Figure 2). (Scenes 8275416052500 and 8271916123500, N 28°/W 99°, N 28°/W 98°, January 10, 1977, February 14, 1977).

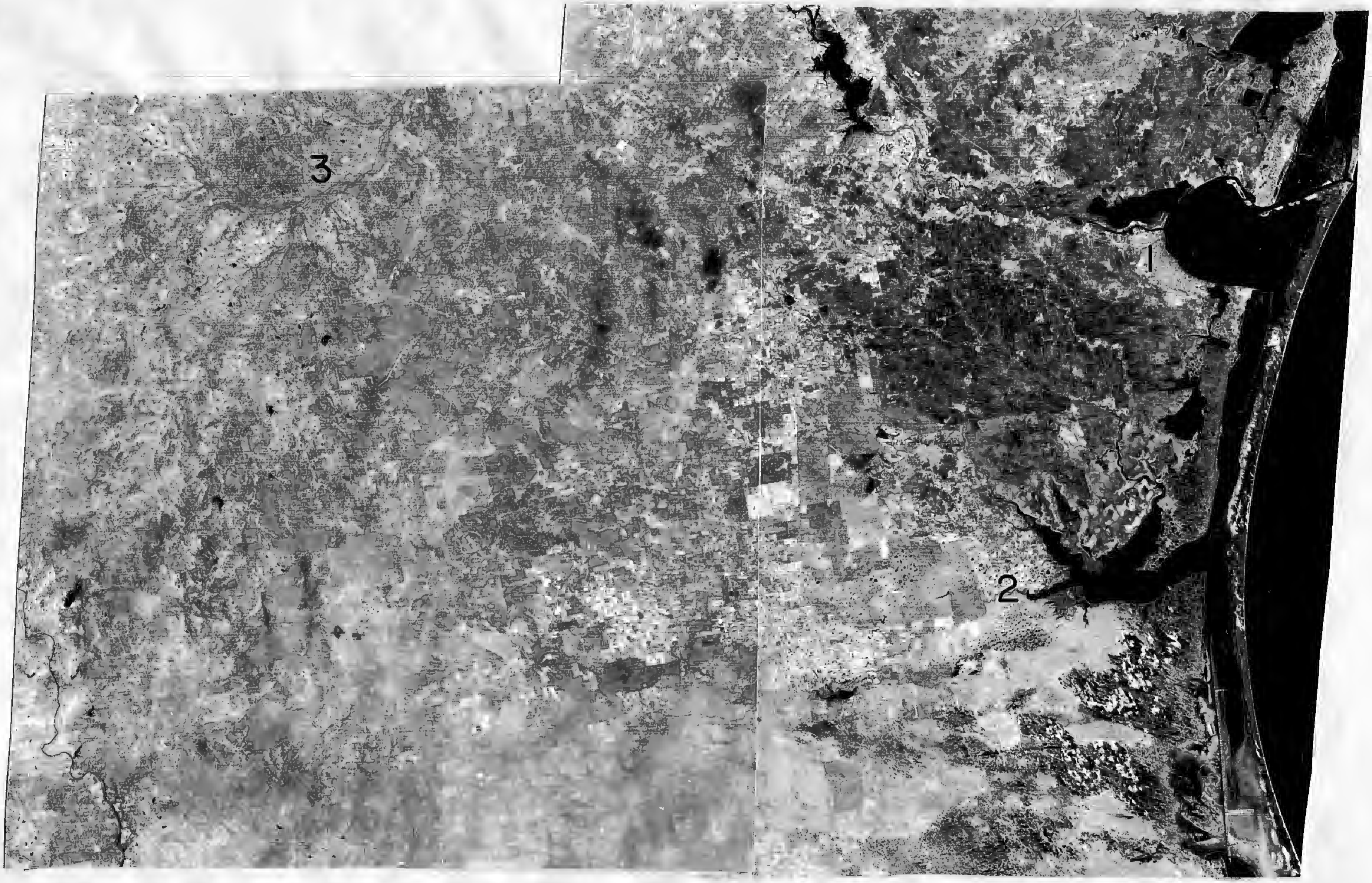

3
1
2

Figure 10. Low angle oblique Skylab photograph depicting; 1. Corpus Christi Bay, 2. Baffin Bay and 3. the present course of the Nueces River. Scale is variable, approximately 1:570,000, the distance across the bottom of photograph is 82.5 miles, 132.8 km (compare photograph with Figures 2 and 9) (scene G40A05301500, November 29, 1973).


3
1
2

After careful inspection and magnification, no positive surficial expression of the paleo-stream channel was evident from the Skylab photographs.

As a result of examining all of the aforementioned aerial photographs, Landsat imagery, and Skylab photographs, there was no definitive surficial evidence of the Las Animas and/or Parilla Creeks superposing a paleo-stream channel.

### Lineaments

Lineaments as defined by O'Leary, *et al.*, (1976) were mapped from Landsat (bands .6-.7mm) imagery at a scale of 1:500,000 (Fig. 6, I.P.) to determine if the present course of the Nueces River could possibly be controlled by any deep-seated structural feature. These lineaments are manifestations of the extensive network of growth faults and associated fractures that developed throughout the Tertiary Period (Kreitler, 1976). Two dominant trends, a northeast-southwest, and northwest-southeast trend developed as lineaments were mapped in and around the study area (Fig. 6, I.P.). The average northeast-southwest lineament direction was 051° while the average northwest-southeast lineament direction was 317°.

One plausible explanation for the lineaments could be faulting within the South Texas Gulf coastal plain sediments, also observed by Kreitler, (1976). These faults, possibly growth faults, were most likely contemporaneous with deposition of the Tertiary coastal plain sediments. The downthrown side of the fault receives the most sediment and is thus thicker. Subsidence occurs as a result of differential vertical motion of the fault blocks (Kreitler, 1976) or the very real possibility of consolidation of subsurface sediments.

Most of these faults are referred to as down-to-the-coast faults and exhibit a thicker section on the seaward side. These growth faults are associated with a rapid increase in the total sediment thickness on the downthrown side (Carver, 1968).

The growth faults were formed by salt tectonism, deltaic sedimentation (prodelta slope failure) and/or mass movement (Kreitler, 1976). The upward extension of these faults through the unconsolidated Tertiary sediments may result in a fault scarp (Kreitler, 1976) at the surface. The Bordas escarpment (Fig. 2) may be fault controlled and actually may be a lineament (Fig. 6, I.P.).

The present course of the Nueces River (Fig. 6, I.P.) could be fault controlled and thus appear as one of the lineaments mapped just southeast of the northeasterly course of the Nueces River in Lasalle County. There is no definitive evidence to prove or disprove that these lineations are actually faults that have affected the Nueces River drainage, although three northeasterly lineaments are parallel and in close proximity to the northeasterly flow of the Nueces River.

The proposed former courses of the Nueces River (Fig. 6, I.P.) do not superpose any lineaments. Thus, it is highly unlikely that either the Las Animas or Parilla Creeks are fault-controlled streams.

Surface morphology as well as the dendritic stream drainage pattern was determined from topographic maps (scale; 1:24,000 and 1:250,000). Topographic maps were used to locate outcrops and sample areas. The drainage of the ephemeral Las Animas and Parilla Creeks was examined on topographic maps to determine if any section of their drainage breached the Bordas escarpment at or near the reentrant (Fig. 2) mentioned by Bailey (1926). Neither the Las Animas nor Parilla Creeks drainage system could be traced beyond the Bordas escarpment reentrants to connect with Prieto Creek in northeastern Webb County (Fig. 2). The Bordas escarpment controls all stream drainage patterns within the study area.

## CROSS SECTIONS

A series of four (A-D) strike cross sections and one dip (E) cross section were constructed to try to determine if any evidence of a major channel existed beneath the Las Animas and/or Parilla Creeks (Fig. 7, I.P.). The Catahoula and Oakville Formations were studied in detail, to see if there was any stacking of sand bodies which could be attributed to a major fluvial system which may be located beneath the present course of the Las Animas and/or Parilla Creeks.

Individual sand bodies within the Oakville and Catahoula Formations were mapped to determine the following: fining upward sequences; coarsening upward sequences; channel fill; valley fill; channel axes; stacked/multi-storied channel sands; lateral continuity; vertical continuity; and the overall increase or decrease in sand content within each Formation.

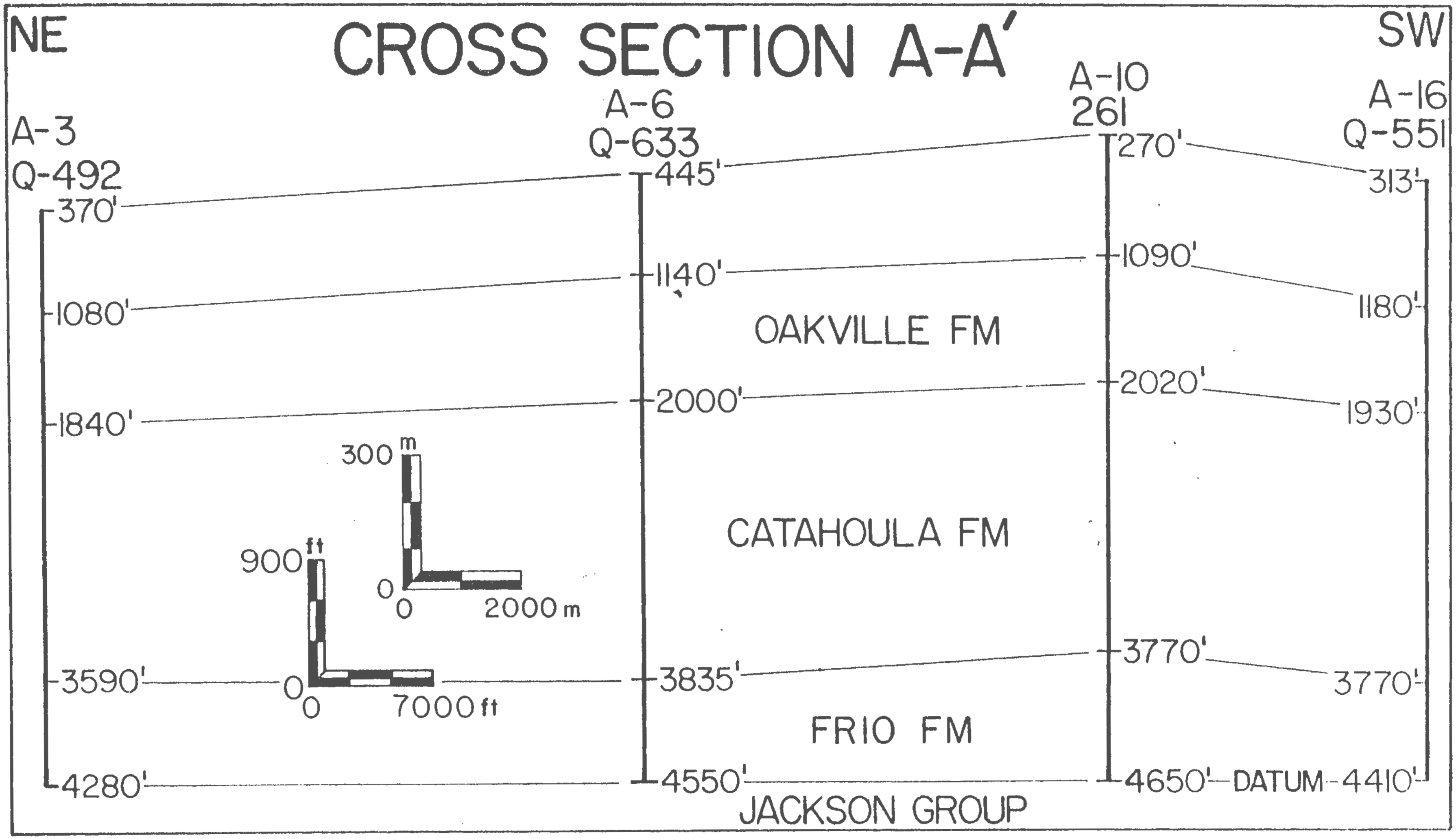
### Cross Section A-A'

Catahoula Formation (Fig. 12A, B,C, I.P., see explanation I.P.)

The Catahoula Formation (Fig. 11) in A-A' (Fig. 12A, B,C, I.P.) seems to have abundant individualized sand bodies as seen in Wells A2, A6, A10 and A14. Occasional fining upward sequences are represented in Well A4 (Fig. 12A, I.P.) from 2800'-2500'. Coarsening upward sequences seem to be more abundant, as in A6 (Fig. 12B, I.P.) at 3800'.

Figure 11. Strike cross section A-A' depicting overall thickness of Catahoula and Oakville Formations in the eastern portion of the study area. "A" numbers refer to Wells located within A-A' cross section. "Q" numbers refer to Texas Water Development Board classification scheme. All depths in feet.

# CROSS SECTION A-A′



Well A15 (Fig. 12C, I.P.) contains numerous sand sequences that indicates the probability of a channel axis at this location. Well A4 (Fig. 12A, I.P.) contains a series of four stacked, fining upward lenticular sand bodies ranging from 15 to 40 feet in thickness between 2800'-2500'. Lateral and vertical continuity of the Catahoula sand bodies within the A-A' cross section is not well developed. The Catahoula Formation contains more shale and clay than the overlying Oakville Formation.

### Oakville Formation (Fig. 12A, B,C, I.P.)

The Oakville Formation (Fig. 11) in A-A' (Fig. 12A, B,C, I.P.) contains abundant fining upward sequences at the following locations: Well A4, 1200'; A5 1525'; A6, 1500'-1400'; A9, 1550'-1500'; A12, 1800'; A16, 1900'; some of which are up to 50 feet thick as in A6 at 1450'. An excellent example of a fining upward unit is present at the base of the Oakville Formation (A15, A16, Fig. 12C, I.P.). Large individual sand bodies indicative of a channel and/or valley fill sequences are common in A4 (Fig. 12A, I.P.) from 1900'-1200'. A8 (Fig. 12B, I.P.) contains a channel fill sand sequence 100 feet thick. A3 (Fig. 12A, I.P.) contains a valley-fill sequence up to 140 feet thick. A major channel axis, 200 feet thick is present between A6 and A7 (Fig. 12B, I.P.) from 1540'-1340'. A channel axis, with thinner (10-50 feet) stacked sands is present in A11 (Fig. 12B, I.P.) from 2060'-1350'. A15 (Fig. 12C, I.P.)

contains a thick channel axis with abundant sand from 1990'-1470'. A4 (Fig. 12A, I.P.) contains a series of stacked channel sands 20-70 feet thick from 1485'-1150'. Multi-storied channel sands exist in Wells A6 (Fig. 12B, I.P.) from 1540'-1340' and A7 (Fig. 12B, I.P.) from 1460'-1280'. Four multi-storied fining upward sequences 20-40 feet thick are present in A12 (Fig. 12C, I.P.) from 2020'-1780'. These fining upward stacked fluvial sequences can be traced through Well A15 (Fig. 12C, I.P.). The lateral and vertical continuity of the Oakville sand units is good throughout the A-A' cross section.

### Cross Section B-B'

Catahoula Formation (Fig. 13A, B,C, I.P.)

Individual sand bodies with little continuity are still abundant as in B18 (Fig. 13B, I.P.) from 2700'-2520'. Excellent examples of fining upward sequences are well represented in B18 (Fig. 13B, I.P.) between 2700' and 2520'. There are more coarsening upward sequences as seen in B2 and B3 (Fig. 13A, I.P.) from 2650'-2400', however, not as much sand is present. A major channel axis, 120 feet thick with four well developed channel sands is present at the base (3350'-2990') of the Catahoula Formation in B17 (Fig. 13B, I.P.). The Catahoula Formation in B-B' (Fig. 13A, B,C, I.P.) is much the same as that of A-A' with the exception of a somewhat better lateral persistence of the sand bodies especially between B21-B25 (Fig. 13C, I.P.)

Oakville Formation (Fig. 13A, B,C, I.P.)

There are not as many fining upward sequences present. A major channel fill axis 100 feet thick exists in B9 (Fig. 13A, I.P.) at the base of the Oakville Formation (1670'-1570'). A 180 foot thick valley-fill sand deposit is also present at the top of the Oakville Formation (1270'-1090'). B19 (Fig. 13B, I.P.) contains a major channel fill sand axis 150 feet thick from 1650'-1500', as well as a series of multi-storied channel fill sand bodies from 1425'-1100'. Well B24 (Fig. 13C) contains a channel fill sand axis defined by the multi-storied channel sands of varying thickness from 1560'-1150'. The sand bodies of the Oakville Formation in B-B' (Fig. 13A, B,C, I.P.) display good lateral continuity. Wells B15-B17 (Fig. 13B) contain three laterally continuous sand units up to 100 feet thick from 1680'-1160' including a good basal Oakville sand body. Sand bodies in Wells B21-B25 (Fig. 13C) display good lateral continuity. Wells B1 to B6 (Fig. 13A) contain three stacked sand units representing good vertical persistence of a fluvial system. The sand content of B-B' is not as high as in A-A'.

## Cross Section C-C'

Catahoula Formation (Fig. 14A, B,C, I.P.)

There are occasional coarsening upward sequences present at the following locations: C6 (Fig. 14A, I.P.) 1200'-1150'; C7 (Fig. 14A, I.P.) 1340'-1310'; C12 (Fig. 14B, I.P.) 830'-780'; and C15 (Fig. 14C, I.P.)

1650'-1600'. A 120 foot thick channel fill sand axis is present in C8 (Fig. 14A, I.P.) from 940'-820'. Well C21 (Fig. 14C, I.P.) contains a channel fill sand body 90 feet thick from 1410'-1320'. Seven multistoried sand bodies exist in C11 (Fig. 14B, I.P.) from 1500'-700' representing good vertical persistence of channel facies. The lateral persistence of the sand bodies is better than those of A-A' and B-B'. The Catahoula Formation represented in C-C' contains much less sand than that found in A-A' or B-B'.

Oakville Formation (Fig. 14A, B,C, I.P.)

At the top of the Oakville Formation in Well C7 (Fig. 14A, I.P.) a 100 foot channel fill sand body is present. A basal sand unit 50 feet thick is present in Well C14 (Fig. 14A, I.P.) from 610'-560'. The Oakville Formation in C-C' contains much less sand with much more shale and fine-grained material present.

### Cross Section D-D'

Catahoula Formation (Fig. 15A, B,C, I.P.)

A fining upward sequence is well represented in D10 (Fig. 15A, I.P.) from 800'-770'. An excellent example of a coarsening upward unit is represented in D23 (Fig. 15C, I.P.) from 550'-470'. A major channel fill sand 85 feet thick exists in D2 and D3 (Fig. 15A, I.P.) from 665'-580'. D9 (Fig. 15A, I.P.) also contains a major channel fill sand 130 feet thick from 730'-600'. A major channel axis 75 feet thick that coarsens upward is found in Well D21 (Fig. 15B, I.P.) from 485'-410'. Wells D14 and D15 (Fig. 15B, I.P.) contain a series of four stacked fining upward sand bodies from 910'-540'. Multi-storied channel fill sands with good lateral continuity and varying overall thicknesses are abundant in the following Wells: D17 (Fig. 15B, I.P.) 1100'-600'; D18 (Fig. 15B, I.P.) 1180'-800'; D20 (Fig. 15B, I.P.) 1150'-730'. The Catahoula Formation (Fig. 16) from D14 to D21 (Fig. 15B, I.P.) contains much more sand than the other areas of the D-D' cross section.

### Oakville Formation (Fig. 15A, B,C, I.P.)

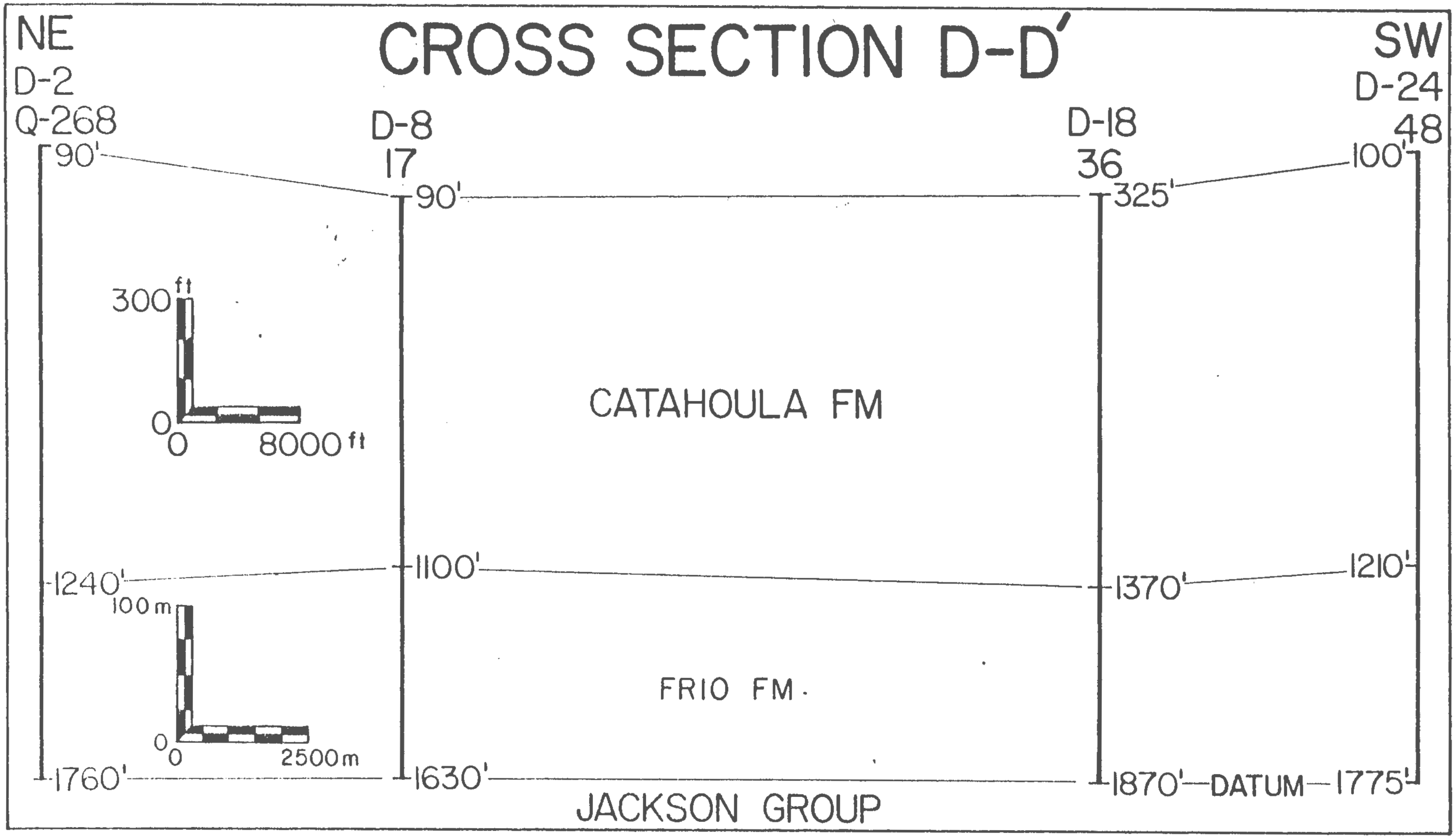
The Oakville Formation is not present in D-D' (Fig. 16) (Fig. 15A, B,C, I.P.) as the up dip limit of the Oakville Formation is reached and found in outcrop at the surface.

## Cross Section E-E'

### Catahoula Formation (Fig. 17, Fig. 18A, B,C,D,E, I.P.)

Abundant individual sand bodies are present in the following Wells: E6 at 3500', 2700' and 2260'; E5 at 3750', 2850' and 2400'; and E4 at 3000' (Fig. 18A, I.P.). Occasional fining upward sequences occur from E22 to E17 (E20, 1850', E18, 2250', E17, 2500') (Fig. 18C, I.P.). A good example of a channel fill sand body 70 feet thick is present in E23 (Fig. 18D, I.P.) from 1040'-970'. Multi-storied sand units, both coarsening upward (E25, Fig. 18D, I.P., 900' and 700', E24, Fig. 18D, I.P., 900') and fining upward (E25, Fig. 18D, I.P., 1150', E24, Fig. 18D,

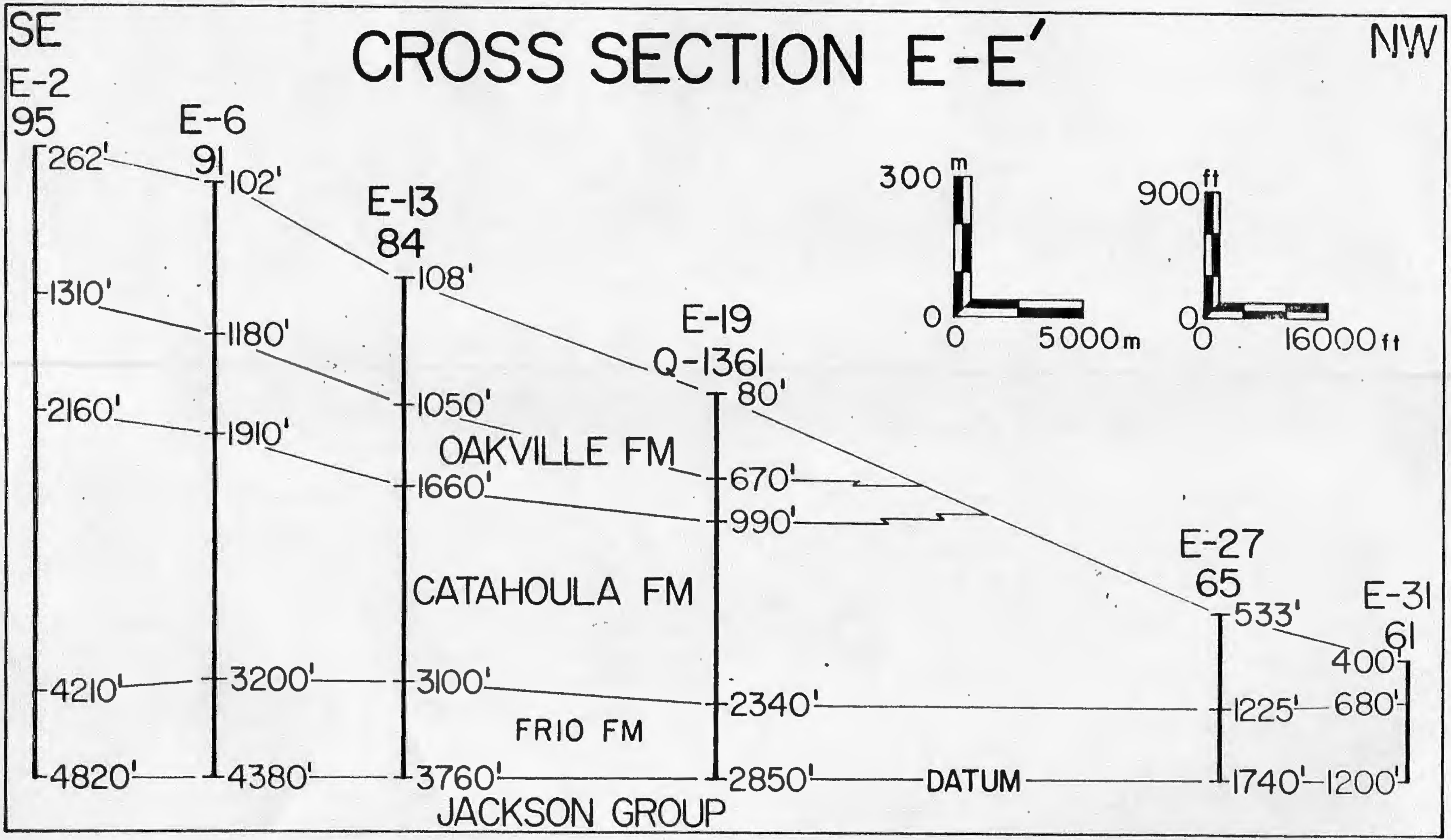
Figure 16. Strike cross section D-D' showing thickness of Catahoula Formation and the absence of the Oakville Formation in the western portion of the study area. "D" numbers refer to Wells located within D-D' cross section. "Q" numbers refer to Texas Water Development Board classification scheme.



# CROSS SECTION D-D′

Figure 17. Dip Cross Section E-E' showing relationship of the Catahoula Formation and the Oakville Formation in an up dip direction from southeast to northwest. "E" numbers refer to Wells located within E-E' cross section. "Q" numbers refer to Texas Water Development Board classification scheme.

# CROSS SECTION E-E′



I.P., 550') sequences are evident. The basal sand in E9-E2 (E2, 4210'-4160') (Fig. 18A, I.P.) shows good longitudinal persistence. The Catahoula Formation in dip section E-E' (Fig. 17) (Fig. 18A, B,C,D,E, I.P.) undergoes a gradational change from west to east in that the overall sand content increases. A large increase in sand content is evident from Wells E31-E29 (Fig. 18E, I.P.) that indicates the following: the possibility of a lithologic change in source material; an increase in the overall competency of the fluvial system to carry larger-sized material; and/or a possible directional change of the course of the fluvial system that resulted in the deposition of fine-grained overbank material from E31-E29.

## Oakville Formation (Fig. 18A, B,C,D,E, I.P.)

A major channel fill sand (70 feet thick) is present in E6 (Fig. 18A, I.P.). Abundant multi-storied sand bodies are present with occasional fining upward sequences occurring in the Oakville Formation of E-E' (Fig. 17), (Fig. 18A, B,C,D,E, I.P.) especially from E5-E3 (Fig. 18A, I.P.) (E5, 2000'-1300'; E4, 2000'-1350', and E3, 2000'-1400') a possible fluvial axis. Abundant multi-storied channel sands are present in Wells E12-E9 (Fig. 18A, B, I.P.) from 1680'-1100'. Well E12 (Fig. 18B, I.P.) contains the fluvial axis for this system. The sand content of the Oakville Formation increases rapidly from E15-E12 (Fig. 18B, I.P.). Very little sand is present from E23-E17 (Fig. 18C, D, I.P.). This lack of sand may be due to depositional conditions similar to those of the Catahoula Formation previously stated. The Oakville Formation is not represented in the subsurface west of Well E24 (Fig. 18D, I.P.).

## Cross Section Summary

### Catahoula Formation

The Catahoula Formation contains an abundance of individual sand bodies with limited lateral and vertical extent. Occasional fining upward sequences are present, however, coarsening upward sequences seem to be dominant. Multi-storied channel fill sands are not abundant within the A,B, and C cross sections. Cross sections D and E contain multi-storied channel fill sands with good lateral continuity. The lateral and vertical continuity of the sand bodies is not well developed in cross section A,B, or C except for B-B' (B21 to B25, Fig. 15C). The overall sand content of the Catahoula Formation increases in a downstream or easterly direction (from D to A, E to E').

### Oakville Formation

The Oakville Formation contains numerous fining upward sequences. Coarsening upward sequences are sparse. Channel fill as well as valley-fill systems are abundant. Stacked sand sequences are numerous within the A,B, and E cross sections. The lateral continuity of the sand bodies is well developed in the A and B cross sections. A pronounced increase in sand content is evident from E15 to E12 (Fig. 18B). Very little sand is present from E23 to E17 (Fig. 18C, 18D).

There are more fining upward deposits in the Oakville Formation as compared to the individualized sand bodies of the Catahoula Formation. The Oakville Formation also contains the larger channel fill sands (up to 200' thick) in addition to the most multi-storied channel fill sands. The Oakville Formation contains more continuous sand sequences both vertically and laterally. The Oakville Formation seems to have less sand in the western part of the study area as compared to the Catahoula Formation in the same region. In both formations, the sand content increases downstream.

The course of the Las Animas and Parilla Creeks intersects the strike and dip cross sections A-E at various locations (Fig. 7, I.P.). The course of the Las Animas Creek intersects the cross sections between the following Wells: D6-D8, (Fig. 15A, I.P.); C9-C13, (Fig. 14B, I.P.); B14-B17, (Fig. 13B, I.P.); A9-A12, (Fig. 12B, 12C, I.P.); E15-E11, (Fig. 18B, I.P.). The course of Parilla Creek intersects the cross sections between the following Wells: D17-D20, (Fig. 15B, I.P.); C13-C15,(Fig. 14B, 14C, I.P.); B22-B25, (Fig. 13C, I.P.); E23-E21,(Fig. 18D, 18C, I.P.). If the ancient Nueces River ever followed the present course of the Las Animas and/or Parilla Creeks, some evidence of this fluvial system would exist at depth, beneath their courses. As seen in the aforementioned cross sections and cross section location map, no multi-storied channel sands or channel axes are present within the Catahoula Formation as well as the overlying Oakville Formation. The Las Animas and/or Parilla Creeks do not superpose the stacked channel sands or channel axes of the Oakville and Catahoula Formation.

No channel sands of any type were depicted in the Lagarto Formation which overlies the Oakville Formation, thus reinforcing the idea that the ancient Nueces River did not follow the course of either the Las Animas or Parilla Creeks.

If uranium mineralization has occurred within either of the Oakville or Catahoula Formations, it would most likely be concentrated in and around the border or edges of these ancient channel axes.

## SAND DISPERSAL SYSTEM

Three types of lithofacies maps were constructed for the Catahoula and Oakville Formations. For each formation, the maps represent: 1) the net, or total thickness of sandstone; 2) the maximum, or thickest single sand body present and 3) the percentage of sand present. These maps were constructed from sandstone data obtained from 323 electric logs for the Catahoula Formation (Fig. 8, I.P.) and 221 electric logs for the Oakville Formation (Fig. 8, I.P.).

These lithofacies maps were constructed, using the U.R.I. SYMAP program. Data from the electric logs were compiled and reduced to acceptable programmable form for U.R.I. SYMAP. The courses of the Las Animas (most northerly) and Parilla streams were plotted on all of the maps to see if their courses superposed any thick sand sequences.

### Catahoula Net Sand

The net sand of the Catahoula Formation (Fig. 19, I.P., see explanation I.P.) was mapped to determine thick sand sequences within the study area. If the highest sand concentrations are traced in a southeasterly direction, (outlined) from (2.2, 1.0) to (5.2, 6.4) to (9.0, 12.0), a thicker sand concentration can be seen which is superposed by the Las Animas stream. This sand concentration represents deposition of a fluvial system that was active during Catahoula time. This fluvial system is joined by another smaller system (outlined) at (5.1, 4.3) (Fig. 19, I.P.). This secondary sand concentration begins at (5.2, 0.5) (Fig. 19, I.P.) and heads slightly northeast before connecting with the aforementioned primary sand concentration along the Las Animas stream at (5.1, 4.3) (Fig. 19, I.P.).

There are no thick net sand concentrations associated with Parilla stream (Fig. 19, I.P.). No positive correlation of net sand concentrations with Parilla Creek exists.

### Catahoula Maximum Sand

The maximum sand of the Catahoula Formation (Fig. 20, I.P.) also depicts a similar fluvial system (outlined) as represented in the net sand map (Fig. 20, I.P.). The secondary sand concentrations seen in the net sand maps do not show up as well in the maximum sand map (Fig. 20, I.P.). This is probably due to the fact that this secondary fluvial system was smaller in overall size thus resulting in a smaller channel size and thinner sand bodies. Maximum sand concentrations depict the course of a fluvial system (outlined) in the same location (2.1, 0.7) to (5.3, 6.4) to (9.0, 12.1) as that of the net sand map (Fig. 19, I.P.), thus reinforcing the theory of a sandy fluvial system existing at this location through Catahoula time.

The position of Parilla stream seems to be in an interfluve region. There are no maximum sand concentrations associated with Parilla stream (Fig. 20, I.P.).

Catahoula Percent Sand

The percent sand map of the Catahoula Formation (Fig. 21, I.P.) depicts a somewhat less continuous sand concentration (outlined) than both the maximum and net sand maps. As can be seen (Fig. 21, I.P.), the sand concentrations are aligned with the fluvial system of the maximum and net sand maps (2.1, 1.4) to (5.2, 6.4) to (9.0, 11.8), however, these thick sandy sequences are not continuous. The sand concentrations seem to be less continuous in the east and southeastern portion of the study area. This represents a general decrease in the sand content within the Catahoula Formation to the southeast. This could be due to the competency of the stream where the overall competency of the fluvial system decreased in a southeasterly direction as a result of a change in gradient. This may have resulted in the deposition of more fine-grained material. An alternate and more probable explanation is: since the Catahoula Formation increases in thickness downstream, the percent sand map does not represent the concentration of sand as accurately as the net sand and maximum sand maps. The secondary sand concentrations (outlined) in the western portion of the study area, (5.3, 0.5) to (5.1, 4.5) (Fig. 21, I.P.) which represents a probable tributary, however, do show up well.

There is no positive correlation of the percent sand of the Catahoula Formation (Fig. 21, I.P.) and Parilla stream. The course of Parilla Creek does not superpose any sand buildups.

### Oakville Net Sand

The net sand of the Oakville Formation (Fig. 22, I.P.) was mapped to locate any significant sand concentrations within the Oakville Formation. The net sand content of the Oakville Formation gradually increases in an easterly direction as can be seen on the Oakville net sand map (Fig. 22, I.P.). There are no sand concentrations with the Oakville Formation associated with the present drainage of the Las Animas and/or Parilla streams (Fig. 22, I.P.). The course of the Las Animas and/or Parilla Creek do not superpose any thick sand sequences. Sand concentrations do occur at the following locations: (4.9, 12.0), (6.9, 12.4), (9.8, 11.8) (Fig. 22, I.P.). This sand buildup is most likely due to the gradual thickening of the Oakville Formation in a Gulfward direction. Down to the coast (normal) faulting is a possible explanation for the thickening of the Oakville section, as well as the increase in sand content in an easterly direction. Down to the coast faults are known to parallel the strike of the gulf coast sediments. The increase in sand content in an easterly direction could be explained by a series of en echelon growth faults that parallel the strike of the sediments. An alternate explanation for the

Oakville net sand pattern is that the Oakville fluvial system was fault controlled. After traversing one of the down-to-the-coast faults, the fluvial system was deflected along strike and followed the course of the fault. Another possibility which exists but is not as likely, is that the Oakville net sand pattern represents a barrier island (beach) deposit or lacustrine deposit. During Oakville time, the shoreline may have been located farther inland. No paleontological evidence was available to confirm or deny this hypothesis.

### Oakville Maximum Sand

The maximum sand content of the Oakville Formation (Fig. 23, I.P.) seems to represent a similar pattern as the Oakville net sand map, (Fig. 22, I.P.) in that the thickest sand bodies are present in the eastern portion of the study area. Some thick sand bodies are present in the western portion of the study area (2.8, 4.2), (5.5, 3.4), (7.1, 2.5), (4.2, 5.9) (Fig. 22, I.P.), but are not as large or distinct as the same areas in the Oakville maximum sand (Fig. 23, I.P.).

There seems to be no positive correlation with the maximum sand content of the Oakville Formation and the drainage of either the Las Animas or Parilla streams (Fig. 23, I.P.). The Las Animas and/or Parilla Creeks do not superpose any sand concentrations in the Oakville Maximum Sand map.

### Oakville Percent Sand

The percent sand map of the Oakville Formation (Fig. 24, I.P.) represents a similar sand distribution pattern as that depicted in the maximum sand (Fig. 23, I.P.) and net sand (Fig. 22, I.P.) maps. The percent sand of the Oakville Formation increases in an easterly direction. Large sand concentrations occur at (2.8, 4.8), (5.5, 3.5), (6.9, 3.5) and (4.0, 9.0).

The Las Animas and/or Parilla Creeks do not superpose any sand concentrations. No positive correlation of the percent sand of the Oakville Formation and the Las Animas and/or Parilla streams drainage is evident (Fig. 24, I.P.).

### Sand Dispersal Summary

After constructing the Oakville net sand, maximum sand, and percent sand maps, it can clearly be seen that there is no definitive correlation of any sand concentrations with either of the proposed former courses of the Nueces River. The only positive correlation occurs with the Las Animas stream, during deposition of the Catahoula Formation (Figs. 19, 20, 21, I.P.). No other positive correlation can be made. No correlation could be made during Oakville deposition, thus implying the absence of vertical stacking of the fluvial system through Oakville time.

Upon careful study of the electric logs, the overlying Lagarto and Goliad Formations clearly show there is no vertical persistence of any of the fluvial sequences defined, including that present during Catahoula time.

# DISCUSSION

## Photographs, Landsat Imagery, and Topographic Maps

The aerial photograph, Landsat, Skylab, and topographic map studies that were conducted at various scales helped to determine the extent of the present drainage of both the Las Animas and Parilla streams. No positive surficial expression of a paleo-stream channel was discerned on any of the aforementioned photographs, maps, or Landsat imagery. Despite Sayre (1937) and Bailey's (1926) geomorphologic evidence of a former course of the Nueces River in northeastern Webb and central Duval Counties, it is apparent from these studies that no surface expression of a paleo-channel is evident. Stream drainage within the study area is totally controlled by the Torrecillas uplift. No stream drainage, present or past, can be traced from the Baffin Bay area northwest through Duval and Webb Counties to conjoin with the present course of the Nueces River.

## Lineaments

Lineaments that were mapped (Fig. 6, I.P.) could not be positively related to the subsequent course of the Nueces River. However, the prominent northeast-southwesterly trend of these lineaments could possibly be surface expressions of faults that have affected the present course of the Nueces River some time since the Pliocene. The

Las Animas and/or Parilla streams do not superpose any lineaments, implying the lack of fault control.

## Oakville and Catahoula Formations

The subsurface type section of the Oakville and Catahoula Formations were determined from electric log information according to Eargle et al., (1975a) and Galloway (1977a, 1977b). Outcrops of the Oakville Formation contain about 40 percent sand, 30 percent sandy or bentonitic clay, 20 percent marl and 10 percent gravel and Cretaceous fossils (Sellards et al., 1932). The majority of the Oakville sands are light-medium gray, medium grained, cross bedded, friable, and cemented with calcium carbonate.

The Catahoula Formation in South Texas contains 82 percent tuffaceous clay, 9 percent sandstone, 3 percent vitric tuff, 5 percent bentonitic clay and 1 percent conglomerate (McBride et al., 1968). The Catahoula sandstones are medium-coarse grained, gray to light brown, cross bedded, and cemented with opal.

## Depositional Environment

The samples and outcrops studied, provided data concerning the environment under which the Catahoula and Oakville Formations were deposited. The Oakville and up dip portion of the Catahoula Formation were described as a terrigenous fluvial system by Deussen (1924), Bailey (1926), Sellards et al., (1932), Sayre (1937), Thomas (1960), Lindemann (1963), Klohn and Pickens (1970), Galloway (1977a) and Daub and Boothroyd (1978). Most sampled locations and outcrops studied were indicative of fluvial channel deposits with coarse basal sand deposits. A majority of these channel deposits contained trough cross stratification as well as a fining upward sequence indicating the possibility of point bar deposition. A complete classic fining up, point bar sequence described by Allen (1964), Selley (1970), McGowen and Garner (1975), Walker (1976) and Cant and Walker (1976) is not completely represented in the South Texas outcrops. The channel sands of AM-2 to AM-6 were 25-30 feet in thickness and thinned to either side. Thus, this fining upward channel sand thickness (25-30 feet) is roughly equal to the maximum channel depth (Blatt *et al*., 1972) of the fluvial system present during Oakville time.

The possibility exists, that these sediments were deposited by a braided fluvial system similar to the ones described by Williams and Rust (1969), Smith (1971), Campbell (1976), and Maill (1977a, 1977b). The deposition of aggrading and coalescing braided streams would produce a sheet-like sand deposit. Costello and Walker (1972) as well as Campbell (1976) described braided systems that contained fining upward sequences. According to Walker (1976) very few ancient sandy systems have been positively identified as braided (or low sinuosity) rivers. In contrast to meandering streams, Walker (1976) also notes that the vertical accretion deposits of braided streams are less commonly deposited and only rarely preserved.

## Depositional Environment from Electric Log Data

Electric log characteristics of sandy sequences that are most commonly seen in the Oakville and Catahoula Formations are of two basic types. The first, being the channel fill (Pirson, 1977; Kreueger, 1968; Shelton, 1967) which is characterized by extreme variation in grain size between the center of the channel and the sides (Pirson, 1977). The center of the channel is made up of a coarse grained sediment which would be depicted as the massive channel sands seen in the Oakville Formation in Wells:

| Figure (In pocket) | Well Number | Depth (in feet) |
|---|---|---|
| 12A | A2 | 1400-1300 |
| 12B | A8 | 1500-1390 |
| 13A | B5 | Base of Oakville |
| 13A | B9 | 1670-1570 and 1260-1090 |
| Catahoula Formation | | |
| 13B | B17 | 1680-1580 |
| 14A | C8 | 940-820 |
| 15A | D2 | 670-580 |
| 15C | D22 | 570-470 |

The edges of the channels will show slender, finger like projections which are highly variable in length but dip toward the channel (Pirson, 1977), as in Wells:

Oakville Formation

| Figure (In pocket) | Well Number | Depth (in feet) |
|---|---|---|
| 12B | A9 | 1500-1400 |
| 13A | B4 | 1150-1100 |
| Catahoula Formation | | |
| 13B | B18 | 3200-3160 |
| 14B | C9 | 1210-1130 |
| 15A | D3 | 530-450 |
| 15C | D23 | 550-470 |

The fluvial point bar channels are represented in the electric logs by a horizontal layer at the base and a gradational fining of the sediments in an upward direction. This sequence is represented in the Catahoula Formation in Wells:

| Figure (In pocket) | Well Number | Depth (in feet) |
|---|---|---|
| 12A | A4 | 2800-2750 |
| 13B | B18 | 2700-2650 and<br>2560-2520 |
| 14C | C20 | 1730-1700 |
| 14C | C21 | 1660-1620 and<br>950-900 |
| 15A | D10 | 800-770 |
| 18C | E17 | 2600-2550 and<br>2500-2460 |
| 18C | E20 | 1860-1820 |
| **Oakville Formation** | | |
| 12B | A9 | 1940-1900 |
| 12C | A12 | 1830-1770 |
| 12C | A15 | 1990-1940 |
| 12C | A16 | 1940-1830 |
| 13A | B1 | 1120-1050 |
| 13A | B8 | 1210-1150 |
| 13B | B17 | 1260-1160 |
| 18A | E3 | 1430-1400 |

## Cross Sections

From the extensive cross section work, the course of the Las Animas and/or Parilla streams do not superpose a fluvial paleo-channel that maintains vertical persistence or channel stacking. However, major fluvial channel systems were located in a number of places during Catahoula time including:

| Figure (In pocket) | Well Number | Depth (in feet) |
|---|---|---|
| 13B | B17 | 3350-2080 |
| 14A | C8 | 940-820 |
| 14C | C21 | 1410-1320 |
| 15A | D2 | 670-585 |
| 15A | D3 | 530-450 |
| 15A | D9 | 730-600 |
| 15B | D21 | 480-400 |
| 18D | E23 | 1050-970 |
| Oakville Channel Systems | | |
| 12A | A3 | 1370-1230 |
| 12A | A4 | 1900-1150 |
| 12B | A6 | 1820-1340 |
| 12B | A7 | 1730-1280 |
| 12C | A15 | 1990-1470 |
| 13A | B9 | 1260-1090 |
| 13B | B15 | 1540-975 |
| 13B | B16 | 1670-1110 |
| 13B | B17 | 1680-1160 |
| 13B | B19 | 1650-1200 |
| 14A | C7 | 140-32 |
| 14B | C14 | 615-560 |
| 18A | E3 | 1980-1400 |
| 18A | E4 | 1980-1350 |
| 18A | E5 | 1990-1300 |
| 18A | E6 | 1870-1410 |
| 18B | E12 | 1670-1150 |

## Sand Dispersal System

The sand dispersal system that was studied provided information on fluvial channel systems in addition to channels of considerable magnitude. The only continuous fluvial system that was discerned on all three lithofacies maps occurred in the Catahoula Formation (Figs. 19, 20, & 21, I.P.) and is almost superposed by the course of the Las Animas stream, with an accompanying tributary (Figs. 19 & 21, I.P.). No continuation of this fluvial system existed in the Oakville sediments (Figs. 22, 23, & 24, I.P.) so vertical persistence of facies from Catahoula to Oakville time was lacking. This Catahoula fluvial system represents a depositional facies unique to Catahoula time. Further study is needed in a down dip direction through Jim Wells and Kleberg Counties for confirmation of this fluvial system debouching in or near the Baffin Bay area.

During deposition of the Catahoula Formation in early Miocene time, a continental fluvial system existed within the boundaries of the study area. The Las Animas River superposes the course of this fluvial system (Figs. 19, 20, & 21, I.P.). This consequent Catahoula fluvial system may be part of the ancestral Nueces River system which flowed across northeastern Webb County and central Duval County. This Catahoula fluvial system was operating prior to the uplift of the Reynosa plain which presently controls stream drainage in Duval County.

Oakville deposition (mid-Miocene) within the study area consisted of a continental fluvial system. This particular area is considered to be an interfluve, due to the lack of any definitive evidence of any fluvial channels superposed by the Las Animas and/or Parilla streams. The fluvial system which was operating during Catahoula time (ancestral Nueces?) may have shifted its course somewhat north or south of the study area during Oakville time. Galloway (1979) refers to this area as a playa floodplain facies during Oakville time. This floodplain facies was associated with a fluvial system which was located nearby and could possibly be associated with the ancestral Nueces River.

The subsurface Fleming Formation (late Miocene) is indicative of a very fine grained fluvial system with no sandy channel sequences present within the study area. Thus, the sandy ancestral Nueces River probably existed either north or south of the study area. Another possible explanation could be that the fluvial Fleming Formation consisted of only very fine grained material, resulting in a very fine grained (low gradient) sheet-like deposit.

The overlying Goliad (Pliocene) Formation is represented within the study area by abundant sandy channel sequences. These sandy sequences are known to exist both north and south of the study area. These sandy channel sequences may be indicative of the former course of the ancestral Nueces River.

Activation of the Torrecillas uplift may have deflected the ancestral Nueces River in a northeasterly direction. Thus, the consequent Nueces River became a subsequent river system. If the Nueces River has maintained its present course since (Frio) Oligocene time, then the sediments found within the overlying (later) formations are related to some fluvial system other than the ancestral Nueces River.

## Uranium Concentration

These sandy fluvial systems which are represented in cross sections (A-E) and on lithofacies maps may be host rocks for uranium enrichment. It has been reported (Finch, 1967; Klohn and Pickens, 1970; Eargle *et al*., 1975b; Offield, 1976; Gabelman, 1977; Galloway 1977a, 1977b; and Daub and Boothroyd 1978) that uranium mineralization occurs in sandy fluvial systems, especially concentrated along the flanks of the principal belts of fluvial channel facies. The marginal areas of these fluvial systems that have been defined by cross sections and lithofacies maps become potential exploration targets for uranium.

Other factors, not considered in this study that enhance the exploration potential include the presence of significant interbedded or superajacent volcanic ash, paleoclimatic conditions favorable to recharge of aquifers, availability of reductants, and the preservation of interconnecting aquifers within the system (Galloway, 1977a).

The distribution of the uranium within a depositional system is controlled by various factors such as, average permeability, thickness, orientation, vertical interconnection and structural segmentation of permeable elements (Galloway, 1977a). With the consideration and integration of all of these various geologic factors, both regional and local, uranium exploration should become somewhat less fortuitous.

## CONCLUSIONS

1. Careful inspection of outcrop, aerial photograph, Landsat, Skylab, lineament, and topographic map data revealed no definitive evidence to substantiate a surficial paleo-stream channel of the Nueces River in northeastern Webb and central Duval Counties. No correlation of the Las Animas and/or Parilla streams with a paleo-Nueces channel was evident.

2. Close examination of all electric logs, cross sections, and lithofacies maps, revealed no correlative data to substantiate a paleo-stream channel existing beneath the Las Animas and/or Parilla streams through time. Stacking of fluvial sequences were not evident from Catahoula throughout Goliad time.

3. One definitive fluvial system was located, almost superposed by the Las Animas stream during Catahoula time. This solitary fluvial system lacked vertical persistence through Oakville, Lagarto and/or Goliad time.

4. If the Nueces River ever flowed through northeast Webb and central Duval Counties maintaining the course of the Las Animas and/or Parilla Creeks, it did so during post Goliad (Pliocene) time, prior to the activation and uplift of the Bordas escarpment which Deussen (1924) refers to as Pleistocene in age.

5. If uranium concentration has occurred within the Oakville and Catahoula sediments, it would most likely be associated with these various fluvial systems including, the fining upward, coarsening upward, channel fill, and valley-fill sequences. These fluvial systems that have been defined within the Oakville and Catahoula sediments thus become potential exploration targets for uranium.

# REFERENCES CITED

Allen, J.R.L., 1964, Studies in fluviatile sedimentation: six cyclothems from the Lower Old Red Sandstone, Anglo Welsh Basin: Sedimentology, V3, p. 163-198.

Bailey, T.L., 1926, The Gueydan, a new middle Tertiary Formation from the southwestern coastal plain of Texas: Texas Univ. Bur. Econ. Geology Bull. 2645, p. 7-35.

Barker, M., 1977, Personal communication.

Blatt, H., Middleton, G., and Murray, R., 1972, Origin of sedimentary rocks: New Jersey, Prentice-Hall, Inc., 634p.

Campbell, C.V., 1976, Reservoir geometry of a fluvial sheet sandstone: Am. Assoc. Petroleum Geologists Bull., V. 60, No. 7, p. 1009-1020.

Cant, D.J., and Walker, R.G., 1976, Development of a braided-fluvial facies model for the Devonian Battery Point Sandstone, Quebec: Canadian Jour. Earth Science, V. 13, p. 102-119.

Carver, R.E., 1968, Differential compaction as a cause of regional contemporaneous faults: Am. Assoc. Petroleum Geologists Bull., V. 52, No. 3, p. 414-419.

Daub, G.J., and Boothroyd, J.C., 1978, The stratigraphic interpretation of a possible paleo-stream channel of the ancient Nueces River, South Texas: Gulf Coast Assoc. Geol. Socs., Trans., V. 28, Pt. 1, p. 121.

Deussen, A., 1924, Geology of the coastal plain of Texas west of Brazos River: U.S. Geol. Survey Prof. Paper 126, 145p.

Eargle, D.H., Dickinson, K.A., and Davis, B.O., 1975a, Electric-log sections from uranium areas in the South Texas Coastal Plain: U.S. Geol. Survey Open-File Report, 75-122.

Eargle, D.H., Dickinson, K.A., and Davis, B.O., 1975b, South Texas uranium deposits: Am. Assoc. Petroleum Geologists Bull., V. 59, No. 5, p. 766-779.

Finch, W.I., 1967, Epigenetic uranium deposits in sandstone: U.S. Geol. Survey Prof. Paper 538, 121p.

FitzPatrick, E.A., 1971, Pedology: Edinburgh, Oliver and Boyd, 306p.

Folk, R.L., 1974, Petrology of sedimentary rocks: Austin, Hemphill Publishing Co., 182p.

Gabelman, J.W., 1977, Migration of uranium and thorium exploration significance: Am. Assoc. Petroleum Geologists, Studies in Geol., No. 3, p. 1-76.

Galloway, W.E., 1977a, Catahoula Formation of the Texas coastal plain: Depositional systems, composition, structural development, ground-water flow history, and uranium distribution: Texas Univ. Bur. Econ. Geology Rept. Inv. 87, 59p.

Galloway, W.E., 1977b, Personal communication.

Galloway, W.E., Finley, R.J., and Henry, C.D., 1979, South Texas uranium province-geologic perspective: Texas Univ. Bur. Econ. Geology Guidebook 18, 81p.

Holcomb, C.W., 1964, Frio Formation of southern Texas: Gulf Coast Assoc. Geol. Socs., Trans., V. 14, p. 23-33.

Jackson, R.G., 1976, Largescale ripples of the Lower Wabash River: Sedimentology, V. 23, No. 5, p. 593-621.

Klohn, M.L. and Pickens, W.R., 1970, Geology of the Felder Uranium Deposit Live Oak County, Texas: Corpus Christi, Humble Oil and Refining Co., 24p.

Kreitler, C.W., 1976, Lineations and faults in the Texas coastal zone: Texas Univ. Bur. Econ. Geology Rept. Inv. 85, 32p.

Kreuger, W.C. Jr., 1968, Depositional environment of sandstone as interpreted from electrical measurements, an introduction: Gulf Coast Assoc. Geol. Socs., Trans., V. 18, p. 226-241.

Lindemann, W.L., 1963, Catahoula Formation, Duval County, Texas: University of Texas (Austin), Masters Thesis, 191p.

McBride, E.F., Lindemann, W.L., and Freeman, P.S., 1968, Lithology and petrology of the Gueydan (Catahoula) Formation in South Texas: Texas University Bur. Econ. Geology Rept. Inv. 63, 122p.

McGowen, J.H. and Garner, L.E., 1975, Physiographic features and stratification types of coarse-grained point bars: Modern and Ancient Examples: Texas Univ. Bur. Econ. Geology Circ. 75-9, 27p.

Miall, A.D., 1977a, Fluvial sedimentology: Calgary, Canadian Society of Petroleum Geologists, Pt. 2, 37p.

Miall, A.D., 1977b, A review of the braided-river depositional environment: Earth Science Reviews, V. 13, p. 1-62.

Offield, T.W., 1976, Remote sensing in uranium exploration: Vienna, International Atomic Energy Agency, p. 731-744.

O'Leary, D.W., Friedman, J.D., and Pohn, H.A., 1976, Lineament, linear, lineation: Some proposed new standards for old terms: Geol. Soc. America Bull., V. 87, p. 1463-1468.

Pirson, S.J., 1970, Geologic well log analysis: Houston, Gulf Publishing Co., 377p.

Sayre, A.N., 1937, Geology and ground-water resources of Duval County, Texas: U.S. Geol. Survey Water Supply paper 776, 116p.

Sellards, E.H., Adkins, W.S., and Plummer, F.B., 1932, The geology of Texas: Texas Univ. Bur. Econ. Geology Bull. 3232, V. 1, 1007p.

Selley, R.C., 1970, Ancient sedimentary environments: Ithaca, Cornell Univ. Press, 237p.

Shelton, J.W., 1967, Stratigraphic models and general criteria for recognition of alluvial, barrier bar and turbidity-current sand deposits: Am. Assoc. Petroleum Geologists Bull., V. 51, No. 12, p. 2441-2461.

Smith, N.D., 1971, Transverse bars and braiding in the lower Platte River, Nebraska: U.S. Geol. Survey Bull., V. 82, p. 3407-3420.

Thomas, G.L., 1960, Petrography of the Catahoula Formation in Texas: University of Texas (Austin), Masters Thesis, 87p.

Walker, R.G., 1976, Facies models 3, sandy fluvial systems, Geoscience Canada, V. 3, p. 101-109.

Williams, P.F., and Rust, B.R., 1969, The sedimentology of a braided river: Jour. Sed. Petrology, V. 39, No. 2, p. 649-679.

## Appendix I

## South Texas Outcrop Samples

A = ARCO - Anaconda

C = Core Sample

D = Duval County

M = McMullen County

| | |
|---|---|
| AD-1 | Catahoula Formation, Soledad Volcanic conglomerate. U.S. Highway 59, 5 miles south of Freer, Texas. |
| AD-2 | Catahoula Formation, Soledad Volcanic conglomerate. U.S. Highway 59, 5 miles south of Freer, Texas. |
| AD-3 | Oakville Formation, Abandon Carillio gravel pit. Dougherty ranch south of Freer, Texas. |
| AM-1 | Oakville Formation. Sandstone quarry off of County Route 624 in McMullen County. |
| AM-2 | Oakville Formation. Mesa top near Rhode Ranch. County Route 624 in McMullen County. |
| AM-3 | Oakville Formation. Mesa top near Rhode Ranch. County Route 624 in McMullen County. |
| AM-4 | Oakville Formation. Loma Alta mesa top. Off Seven-Sisters Road, McMullen County. |
| AM-5 | Oakville Formation. Mesa top near Rhode Ranch. County Route 624 in McMullen County. |
| AM-6 | Oakville Formation. Loma Alta mesa top. Off Seven-Sisters Road, McMullen County. |
| AMC-1 | Catahoula Formation. Core hole from Rhode Ranch. County Route 624 in McMullen County. |

## Appendix 2

## Classification of Outcrop Samples

| | |
|---|---|
| AD-1 | Muddy, pebbly coarse sandstone: calcareous submature volcanic sedarenite. |
| AD-2 | Volcanic-arenite boulder. |
| AD-3A | Massive fine sandstone: siliceous mature lithic bearing subarkose. (dark black staining, very hard, very well cemented) |
| AD-3B | Laminated fine sandstone: siliceous mature feldspathic sublitharenite. |
| AD-3C | Laminated, etched fine sandstone: siliceous mature feldspathic sublitharenite. |
| AM-1 | Rooted, pebbly, medium sandstone: calcareous submature lithic bearing subarkose. |
| AM-2 | Muddy disturbed, (chemically, rooted, burrowed) pebbly medium sandstone: sub-rounded bimodal moderate calcareous submature chert-bearing litharenite. |
| AM-3 | Pebbly muddy coarse sandstone: calcareous submature volcanic bearing sub-sedarenite. |
| AM-4 | Sandy "rip up clast" conglomerate: siliceous submature volcanic bearing sub-sedarenite. |
| AM-5 | Silty fine sandstone: calcareous mature lithic bearing quartz-arenite. |
| AM-6 | Medium sandstone: siliceous mature lithic arkose. |
| AMC-1 | Medium-fine sandstone: calcareous mature sedarenite. |

## Lithofacies Map Explanation

For Figures: 19,20,21,22,23,24 located in the pocket.

### Sand Dispersal System

Figure 19. Catahoula Net Sand
range 0.0-393.0 ft.

Figure 20. Catahoula maximum sand
range 0.0-110 ft.

Figure 21. Catahoula percent sand
range 0.0-51 ft.

Figure 22. Oakville net sand
range 5.0-439 ft.

Figure 23. Oakville maximum sand
range 5.0-105 ft.

Figure 24. Oakville percent sand
range 0.0-64 ft.

All values are in feet.

Location of areas described in text refer to grid pattern around perimeter of maps. Vertical coordinate is described first followed by the horizontal coordinate (V, H).