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A GRAVIMETRIC SURVEY
OF
SOUTH-CENTRAL NEW MEXICO
AND
WEST TEXAS
VOLUME I

BY

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Presented to the Faculty of the Graduate School
of The University of Texas at El Paso
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE IN GEOLOGY

THE UNIVERSITY OF TEXAS AT EL PASO

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A GRAVIMETRIC SURVEY

OF

SOUTH-CENTRAL NEW MEXICO

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WEST TEXAS

APPROVED

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Dean of Graduate School

PREFACE

During the development and formulation of this thesis a large amount of data and support information was compiled. The thesis has therefore been separated into two volumes. The first volume contains the body of the thesis, bibliography and appendices 1 (Previous Geology) and 2 (Well Information). The second volume contains samples of field notes, base descriptions, the computer program (w/users guide) and computer printouts of the gravity measurements.

The original field notes and locations maps have been retained by the author.

ACKNOWLEDGMENTS

I wish to acknowledge and thank the people and institutions whose help and assistance have made this thesis possible.

I wish to thank Drs. David LeMone, Earl Lovejoy, Robert Schmidt and Ed White for their helpful suggestions and critical reading of the manuscript; Mr. Daniel Roberts and Ms. Linda Wright for the drafting of the cross sections and illustrations; Ms. Betty Barrie for the punching of the computer cards; and Ms. Glenda Bevel for her patience in typing the manuscript.

I also wish to thank Gulf Oil Corporation for a fellowship grant, The New Mexico Bureau of Mines for a grant, and Union Texas Petroleum for technical and financial assistance.

I also extend my appreciation to everyone at Union Texas Petroleum for their patience and assistance during the completion of this survey.

ABSTRACT

A gravimetric reconnaissance survey consisting of 1500 gravity measurements was made in South-Central New Mexico--West Texas. The results will assist the interpretations of subsurface geology in the area. Known geologic structures and previously unknown features are indicated by the gravity data.

The gravity data was calculated using a Fortran program on an IBM 360-50. The results of the calculations were compiled into a Bouguer gravity map and a series of profiles. Regional geologic cross-sections were constructed from outcrop and well information to aid in the interpretation of the gravity data. Good correlation exists between the gravity highs and outcrops and subsurface structures of pre-Cenozoic strata while gravity lows correlate with the Cenozoic basins. Relationships between the study area and the Rio Grande rift and Texas lineament are indicated from Bouguer gravity trends.

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CHAPTER I

INTRODUCTION

This report describes a reconnaissance gravity survey of nearly 1500 gravity observations in an area of approximately 6000 square miles in South Central New Mexico--West Texas between 31°30' and 32°30' north latitude, and 105°00' and 107°50' west longitude (Figure 1). The area surveyed is bounded on the south by the United States--Mexico border, on the west by New Mexico Highway 11, on the north by Interstate 10--U.S. Highway 70 and on the east by the Hueco Mountains. United States Geological Survey topographic maps of the study area include sixty-three 7½-minute and six 15-minute quadrangles (Figure 2).

In the area are the Franklin, East Potrillo, West Potrillo, Florida, Tres Hermanas, Hueco, and Organ Mountains. Bordering the study area are the Sierra de Juarez, the Sierra de las Uvas and the Robledo, Goodsight, Burro and Sacramento Mountains (Figures 1 & 2). The study area is accessible by dirt roads and trails with most of the paved highways on its perimeter.

Most of the gravity stations are in or adjacent to the southern end of the Rio Grande rift, along the Texas lineament and near the cities of El Paso, Texas; and Columbus, Deming, and Las Cruces, New Mexico.

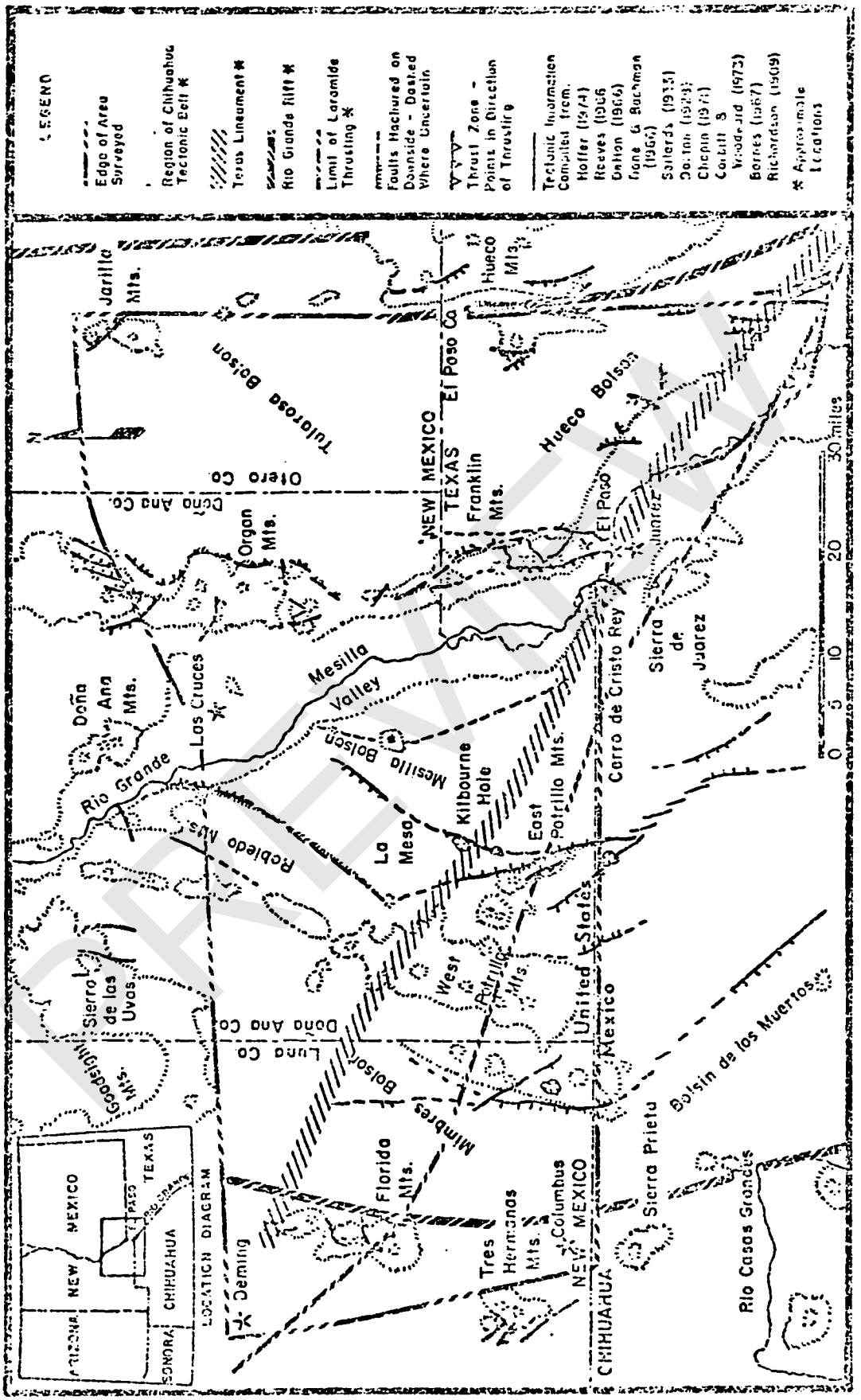

FIGURE 1
GENERALIZED LOCATION MAP OF STUDY AREA

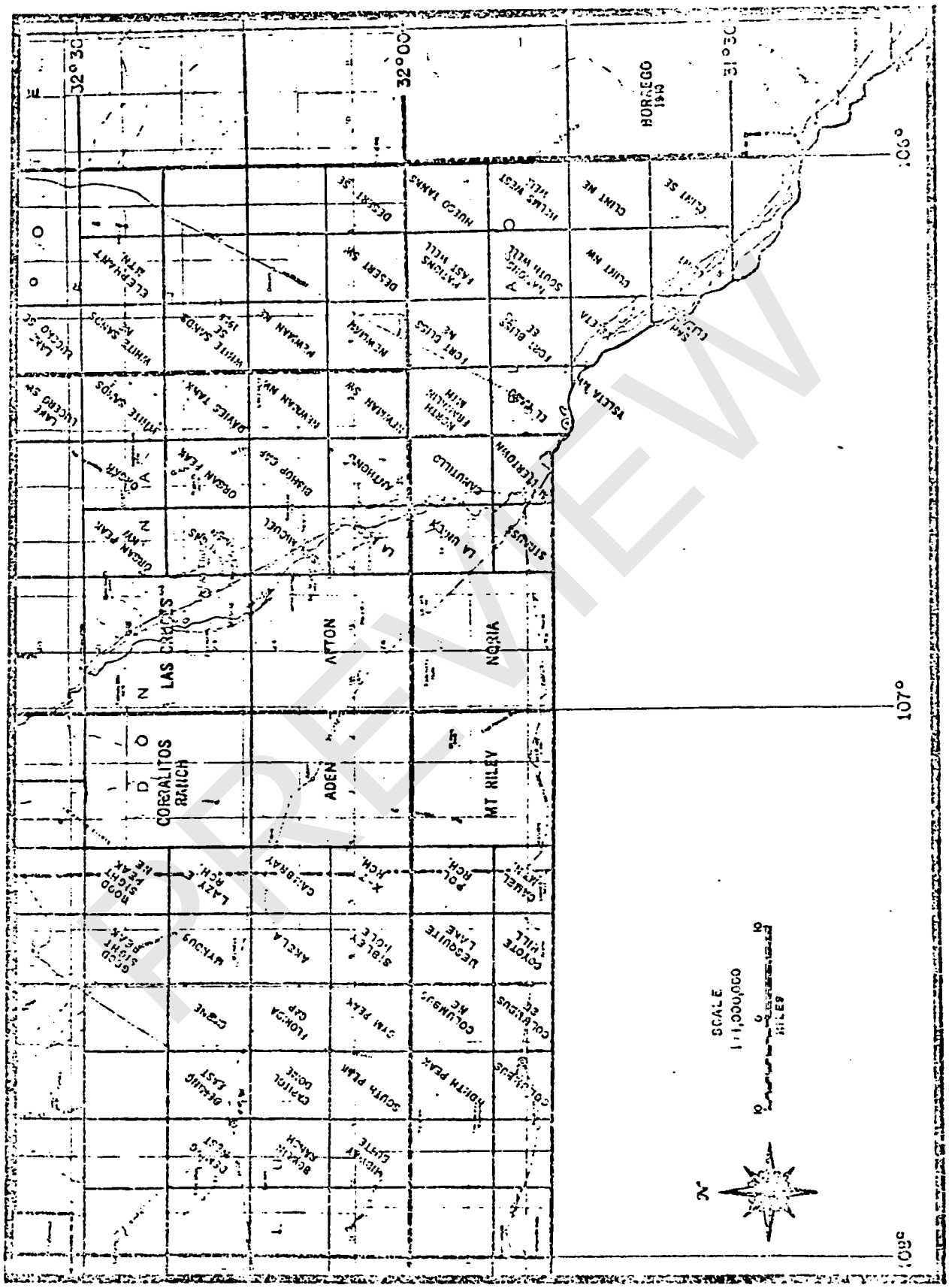

Figure 2 - TOPOGRAPHIC QUADRANGLE INDEX

PURPOSE AND METHOD OF INVESTIGATION

The primary task of the geophysical investigation was to obtain gravity readings (values) for the region. Gravity information for the region was lacking as is evidenced by the large uncontoured areas between Carlsbad and Deming, New Mexico on the Bouguer Gravity Map of the United States (Woollard and Joesting, 1964). The secondary task was to analyze the gravity expression of the area, locate the positions of known and speculated structures and relate them to regional trends. Gravity expressions of known features were compared with known geologic structures suggesting relationships between other gravity anomalies and geologic structures. Geologic features in the area include the Rio Grande rift (Bryan, 1938; Kelly, 1956; Chapin, 1971), the Aden and Potrillo basalt field (Hoffer, 1973; DeHon, 1965; Corbitt and Woodward, 1973) and the Texas lineament (Albriton and Smith,1957;Muehlburger,1965).

I also developed a computer program and associated coding and field forms which were implemented prior to beginning the field work. The program was designed to eliminate the simple, tedious manual calculations necessary for reduction of gravity data, and to establish a data file and format for advanced analysis. I also developed charts and nomographs necessary for compiling, recording and calculating the data (Chapter IV). A Worden gravimeter was used to obtain the field data.

PREVIOUS GEOLOGIC WORK IN THE AREA

Many varied and geographically separate geological studies have been conducted in this region since the early part of the century. These various studies have been included in Appendix I where they are separated into general categories and specified localities under which selected authors are mentioned.

PREVIOUS GEOPHYSICAL AND WELL STUDIES IN THE REGION

A great variety of geophysical and subsurface investigations has been conducted in widely separated areas in the region by many groups and companies, but a substantial portion remains in restricted files of the various companies.

Gravity studies have been conducted along the Rio Grande depression by Sanford (1968) and Decker (1975), in the Hueco--Tularosa Bolson by Mattick (1967) and Zohdy (1969), in northern Chihuahua by Petroleos Mexicanos (Reeves, 1969), along Interstate 10 by Swift (1973) and on the Mesilla Bolson by Gulf Oil (Davies, 1975). Regional bases (absolute gravity-first order stations) were established by the United States Air Force and the Defense Mapping Agency (Salvermosher, 1974; Hauer, 1974; Woollard, 1964).

Seismic studies and investigations have been conducted by Amoco, Mobil, Texaco and the United States Geological Survey in the Hueco Bolson (Mattick, 1967); by the New Mexico Bureau of Mines and Mineral Resources in the Rio Grande Valley (Sanford, 1972); by Geophysical

Services Incorporated (Keaton, 1974), Gulf, Mobil and Texaco in Dona Ana County, New Mexico; and by Petroleos Mexicanos in the Bolson de los Muertos.

Resistivity studies have been conducted in the Mesilla Bolson by the United states Geological Survey (White, 1973) and in the Hueco--Tularosa Bolson by Zohdy (1969); and heat flow studies have been conducted by The University of Texas at Dallas, The University of Wyoming (Smithson and Decker, 1972; Decker and Smithson, 1975) and the New Mexico Institute of Mining and Technology (Reiter and others, 1975).

Subsurface information from water wells and wildcat wells has been reviewed by Cooley (1958), Kottlowski (1973), Wengerd (1969), King (1971), Knowles (1958), Winchester (1949) and Cliett (1969). The well information used in this thesis was collected from numerous sources. A number of wells have been listed in Appendix II.

CHAPTER II

GEOGRAPHY

The study area is in an arid transitional region between the northwestern Mexican Highland and the eastern Basin and Range Province, northeast of the Sierra Madre Occidental (Hawley, 1969). The area contains mountain ranges with sequences of sedimentary, metamorphic and igneous rocks, ranging in age from Precambrian through Cenozoic; extensive Cenozoic volcanic fields; a major river system and large basins.

Habitation and History

The region has been inhabited since very early times. Evidence of the early inhabitants may be found in the Franklin and Florida Mountains (Gerald, 1973; Darton, 1933) and the Rio Grande Valley (Hawley, 1970). Darton (1933) gives an excellent summary of the region's historical development and geology in the Guidebook of the Western United States.

The main population centers of the region are El Paso, Texas and Las Cruces, Deming and Columbus, New Mexico. The land in the interior of the study area, which contains a few ranches, is used for cattle ranching. The areas around Deming and Columbus, and between Las Cruces

and El Paso along the Rio Grande are extensively cultivated. Most of the farming is done by irrigation, with water from either wells or the Rio Grande. The main agricultural products are cotton, vegetables, and cattle.

Mineral Economics

Mining in the area has centered around the Florida and Organ Mountains (Dunham, 1935; Griswold, 1974). There are prospect pits in the Potrillo Mountains (Dunham, 1935; Bowers, 1960), and abandoned tin mines in the Franklin Mountains (Richardson, 1909). Current mining consists of quarrying rock and cinders for construction.

Wildcat petroleum wells drilled in the area are an excellent source for subsurface control in the basins (Plate A) (King and others, 1971; Kottlowski, 1965, 1970; Cooley, 1958). No economic hydrocarbon accumulations have been found in the region. Hydrologic studies using oil well and water-well information compiled by Knowles and Kennedy (1958) and King (1971, 1973) indicate the possibility of geothermal sources in the region.

Climate

The region is in the Chihuahuan Desert. Summer daytime temperatures often exceed 100°F. Winter temperatures may drop into the mid-20's. Average annual temperature for most of the area is 63°F.; average summer temperature is 78°F.; average winter temperature is 57°F.

The average relative humidity is about 38 per cent. Evaporation may exceed 100 inches per year. The average precipitation of 8 to 9 inches per year is chiefly in the form of scattered thunderstorms occurring between mid-summer and early fall (Knowles and Kennedy, 1958).

Winds are predominantly from the southwest. Windstorms are most common in the spring and often have velocities exceeding 40 mph. High winds also occur with thunderstorms.

Flora--Fauna

The Chihuahua biotic zone extends across most of the region (Schmidt, 1973; Leopold, 1950, 1970). The flora, such as yucca, mesquite and cactus and fauna, such as rattlesnake, coyotes, and antelope found in the region are typical of the desert southwest. Flora and fauna along the field trip routes have been described by Ammon (1958) and Johnson (1967). Phreatophytic and xerophytic plants are often used to indicate the presence or absence of ground water. Plants may also indicate changes in types of outcrops, shallow bedrock, soil conditions, and other related geologic features.

CHAPTER III

GEOLOGY

The geology of the South-Central New Mexico--West Texas region is structurally complex. The study area is located in a transition zone between the Colcrado plateau, the Basin and Range Province and the Great Plains. The regional geology includes the Chihuahuan tectonic belt (Deford, 1969; Kottlowski, 1970; Gries and Haenggi, 1970), the Laramide thrust belt (Cortitt and Woodward, 1973), the Texas lineament (Albritton and Smith, 1957; Muehlburger, 1965) and the Rio Grande rift (Bryan, 1938; Chapin, 1970). Major areas of surface stratigraphic and structural control are the Franklin, Robledo, Florida, Tres Hermanas, Potrillo and Organ Mountains. The major subsurface control locations (wells) are listed in Table 1. Sample logs and outcrops of igneous and sedimentary rocks represent geologic periods from Precambrian through the Cenozoic (Plate C). The present geologic features may have been controlled by Paleozoic or Precambrian structural trends (Ramberg and Smithson, 1975) and probably were affected by continental movement, triple junctions and hot spots (Suppe and others, 1975; Burke and Dewey, 1973; Burchfiel and Davis, 1975). Lack of adequate subsurface controls, the cover of extrusive igneous rocks and the complications associated with intrusive

igneous rocks hinders correlation and makes accurate interpretations difficult.

The regional stratigraphy consists of a sequence beginning with the Precambrian Red Bluff granite (Nelson, 1940; Le Mone, 1968). The Precambrian rock is overlain by Cambrian through Permian strata, which may be divided into Early Paleozoic shallow shelf seas carbonate-rock sequences and the Late Paleozoic shelf reef-basinal sequences. A late Silurian--Middle Devonian erosional surface overlain by black silty Devonian shale separates the Early and Late Paleozoic sequences (Kottlowski, 1970). The upper Paleozoic rocks are also separated from overlying Cretaceous rock by one erosional surface; Triassic and Jurassic beds have not been identified in the region. The Cretaceous sequence contains strata of thinly bedded limestones and shales in the lower section to massive limestones and reef structures in the upper section (Zeller, 1953; Cserna, 1970). The Cenozoic section is unconformable on strata from Precambrian to Cretaceous. Cenozoic sediments are interbedded with and to a large extent derived from volcanic sequences. The Cenozoic section goes from basal redbed and volcanic sequences to the uppermost bolson and recent valley fill sediments (Kottlowski, 1973; Strain, 1969). Stratigraphic sections from various localities in the region are represented in Plates C, D, E, and F.

The Hueco Mountains, which border the east edge of the study area (Figure 1), contain rocks ranging in age from Precambrian to Permian. The west central portion of the range consists of large Tertiary intrusive outcrops surrounded by upper Paleozoic strata (Richardson, 1909; King, 1945).

The Hueco Bolson which lies west of the Hueco Mountains consists of Cenozoic fill which thickens from nil on the flanks of the Hueco Mountains to several thousand feet of the western edge of the bolson (Mattick, 1967). The central bolson fill overlies upper Paleozoic strata (Zohdy, 1969; Cliett, 1970). In the south-central portion of the bolson, fill overlies Cretaceous strata (Plate C; Chambers 1-Surratt and Mobil 1-Dorough well logs). Tops from the Chambers 1-Surratt well indicate about 5000 feet of stratigraphic separation with reverse faulting (or thrust faulting) in Cretaceous strata. The faulting is probably part of the Laramide thrusting of the Chihuahuan tectonic belt described by Campuzano (1972) and Wacker (1972) in the Sierra de Juarez, 25 miles west of the wells.

The Franklin Mountains form the western boundary of the Hueco Bolson. The range consists of several thousand feet of Paleozoic limestones and dolomites, Ordovician to Permian in age (Le Mone, 1968). In the center of the range 4500 feet of Precambrian granite and younger metamorphic and igneous rocks are exposed (Harbour, 1960; Richardson, 1909). The range is bounded on the east and west sides by north trending faults (Richardson, 1909; Darton, 1928; Mattick, 1967; Harbour, 1972; Lovejoy, 1973). Vertical displacement and stratigraphic separation along the eastern boundary fault is not known, due to lack of subsurface control, but estimates from geophysical and well data indicate in excess of 10,000 feet for stratigraphic separation (Mattick, 1967). Lovejoy (1973,1975) estimates 10,000 feet of stratigraphic separation along the western boundary fault. The abrupt termination of Paleozoic