National Uranium Resource Evaluation

McALLEN AND BROWNSVILLE QUADRANGLES TEXAS

Bendix Field Engineering Corporation
Grand Junction, Colorado

Issue Date
June 1982

BUREAU OF GEOLOGY
AND MINERAL TECHNOLOGY

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Nuclear Energy
Grand Junction Area Office, Colorado

metadc957797

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This report is a result of work performed by Bendix Field Engineering Corporation, Operating Contractor for the U.S. Department of Energy, as part of the National Uranium Resource Evaluation. NURE is a program of the U.S. Department of Energy's Grand Junction, Colorado, Office to acquire and compile geologic and other information with which to assess the magnitude and distribution of uranium resources and to determine areas favorable for the occurrence of uranium in the United States.

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NATIONAL URANIUM RESOURCE EVALUATION
McALLEN AND BROWNSVILLE QUADRANGLES
TEXAS

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(McAllen Quadrangle)

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(Brownsville Quadrangle)

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revised for "dot" track slide/revA
noted for processing May 1982
revised for processing
SPEL-1

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION AREA OFFICE
UNDER CONTRACT NO. DE-AC07-76GJ01664

This is the final version of the subject-quadrangle evaluation report to be placed on open file. This report has not been edited. In some instances, reductions in the size of favorable areas on Plate 1 are not reflected in the text.

CONTENTS

	<u>Page</u>
Abstract	1
Introduction	3
Purpose and scope	3
Acknowledgments	3
Procedures.	3
Geologic setting.	5
Structures	5
Stratigraphy	7
Uranium deposits	9
Environments favorable for uranium deposits.	10
Summary	10
Major-fault-controlled sandstone deposits	10
Areas A1 through A4.	10
Areas B1 and B2.	12
Areas C1 through C4.	12
Areas D1 through D5.	13
Channel-controlled sandstone deposits	14
Areas E1 through E3.	14
Areas F1 through F7.	14
Areas G1 and G2.	16
Domal structures.	17
Areas H1 and H2.	17
Areas I1 and I2.	17
Areas J1 and J2.	17
Areas K1 and K2.	19

CONTENTS (continued)

	<u>Page</u>
Strand plain-barrier bar deposits	19
Environments unfavorable for uranium deposits.	19
Summary	19
Carrizo-Wilcox Group.	19
Claiborne Group	20
Reklaw Formation	20
Queen City Formation	20
Weches Formation	20
Sparta Formation	20
Cook Mountain Formation.	20
Yegua Formation.	21
Caddell, Wellborn, and Manning Formations	21
Vicksburg Formation	21
Goliad Formation.	21
Uvalde Formation.	21
Quaternary deposits	22
Recommendations to improve evaluation.	22
Selected bibliography.	23
Appendix A. Table of uranium occurrences in the McAllen-Brownsville Quadrangles.	In pocket
Appendix B. Table of chemical analyses for the McAllen-Brownsville Quadrangles	In pocket
Appendix C. Uranium-occurrence reports.	In pocket
Appendix D. Table of electric well logs	In pocket
Appendix E. Table of gamma-ray well logs.	In pocket

ILLUSTRATIONS

		<u>Page</u>
Figure	1. Quadrangle location	4
	2. Structural setting.	6
	3. Stratigraphic column with lithologic descriptions (oversized)	In packet
Table	1. Area, thickness, volume, and depth from surface of favorable areas related to major fault-controlled sandstone deposits	11
	2. Area, thickness, and depth from surface of favorable areas related to channel-controlled sandstone deposits. . . .	15
	3. Area, thickness, volume, and depth from surface of favorable areas related to domal structures in sandstone. . .	18
Plate	1a. Areas favorable for uranium deposits	
	1b. Areas favorable for uranium deposits	
	1c. Areas favorable for uranium deposits in the Whitsett, Fleming-Oakville, and Goliad Formations	
	1d. Areas favorable for uranium deposits in the Catahoula-Frio Formations	
	2a. Uranium occurrences	
	2b. Uranium occurrences	
	3a. Interpretation of aerial radiometric data	
	3b. Interpretation of aerial radiometric data	
	4a. Interpretation of data from hydrogeochemical and stream-sediment reconnaissance	
	4b. Interpretation of data from hydrogeochemical and stream-sediment reconnaissance	
	5a. Location map of geochemical samples	
	5b. Location map of geochemical samples	
	6a. Drainage	
	6b. Drainage	

ILLUSTRATIONS (continued)

- Plate 7. Geologic map (available from the Bureau of Economic Geology,
 University of Texas at Austin)
8. Thickness of the Whitsett Formation (Feet)
9. Total sandstone thickness of the Whitsett Formation (Feet)
10. Total sandstone thickness of the lower half of the
 Catahoula-Frio Formation (Feet)
11. Total sandstone thickness of the upper half of the
 Catahoula-Frio Formation (Feet)
12. Total sandstone thickness of the lower third of the
 Fleming-Oakville Formation (Feet)
13. Total sandstone thickness of the middle third of the
 Fleming-Oakville Formation (Feet)
14. Total sandstone thickness of the upper third of the
 Fleming-Oakville Formation (Feet)
- 15a. Total sandstone thickness of the basal 500 ft of the Goliad
 Formation
- 15b. Total sandstone thickness of the basal 500 ft of Goliad
 Formation
16. Structure on top of the Whitsett Formation (Feet below sea level)
17. Structure on the base of the Catahoula-Frio Formation (Feet below
 sea level)
18. Structure on the base of the Fleming-Oakville Formation (Feet
 below sea level)
- 19a. Structure on the base of the Goliad Formation (Feet below sea
 level)
- 19b. Structure of the base of the Goliad Formation (Feet below sea
 level)
- 20a. Subsurface faults
- 20b. Subsurface faults
21. Cross section A-A'
22. Cross section A'-A''
23. Cross section A'''-A''''

ILLUSTRATIONS (continued)

- Plate 24. Cross section B-B'
25. Cross section B'-B''
26. Cross section B'''-B''''
27. Cross section C-C'
28. Cross section D-D'
29. Cross section D'-D''
30. Cross section E-E'
31. Cross section E'-E''
- 32a. Location of electric well logs
- 32b. Location of electric well logs
- 33a. Location of gamma-ray well logs
- 33b. Location of gamma-ray well logs
- 34a. Index to large-scale maps
- 34b. Index to large-scale maps
- 35a. Generalized land-status map
- 35b. Generalized land-status map
- 36a. Culture
- 36b. Culture
37. Composite map of supportive uranium favorability criteria

Plates in accompanying packet

ABSTRACT

The McAllen and Brownsville Quadrangles, Texas, were evaluated to a depth of 1500 m to identify geologic environments and delineate areas favorable for uranium deposits. The environments were selected according to criteria established for the National Uranium Resource Evaluation program. Surface studies included investigations of uranium occurrences described in the literature, of locations of aerial radiometric anomalies, of surface exposures, and of locations of anomalous hydrogeochemical and stream-sediment reconnaissance data and collation of information on uranium exploration. Subsurface evaluation of selected geologic units was accomplished by using electric and gamma-ray well logs to construct maps and cross sections. In the McAllen Quadrangle, an environment favorable for Texas roll-type sandstone uranium deposits is identified in 36 areas in the Goliad, Fleming-Oakville, Catahoula-Frio, and Whitsett Formations. All other units in both quadrangles are considered unfavorable.

INTRODUCTION

PURPOSE AND SCOPE

The McAllen and Brownsville Quadrangles, Texas (Fig. 1), were evaluated to a depth of 1500 m (5,000 ft) to identify geologic environments and delineate areas that exhibit characteristics favorable for the occurrence of uranium deposits. Favorable environments, as determined by surface and subsurface investigation, are those that could contain uranium deposits of at least 100 tons U_3O_8 at an average grade not less than 100 ppm U_3O_8 . Selection of a favorable environment is based on the similarity of its geologic characteristics to those (recognition criteria) of environments that contain known uranium deposits as described in Mickle and Mathews (eds., 1978). This study was conducted by Bendix Field Engineering Corporation (BFEC) for the National Uranium Resource Evaluation (NURE) program, managed by the Grand Junction Area Office of the U.S. Department of Energy (DOE).

The evaluation program began June 16, 1980, and ended May 31, 1981. Time spent in literature search, field work, evaluation of data, and preparation of the final report totaled approximately 2 man-years by the authors and other BFEC personnel of the Austin field office.

ACKNOWLEDGMENTS

The authors are grateful to the many ranchers and land owners for the wealth of information they provided and for allowing samples to be taken on their land. Special thanks are extended to William E. Galloway of the University of Texas Bureau of Economic Geology (BEG) for the time and knowledge he shared with us.

PROCEDURES

In order to properly evaluate the uranium potential of the McAllen and Brownsville Quadrangles, an examination of the surface and subsurface geology was necessary. The surface geologic investigations involved literature research, examination of all uranium occurrences previously reported in Preliminary Reconnaissance Reports (PRR's) of the U.S. Atomic Energy Commission (AEC) (Pl. 2a and 2b; App. A and C), evaluation of aerial radiometric anomalies (Geodata International, 1975 and 1979) (Pl. 3a and 3b) and of data from the Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) program [Oak Ridge Gaseous Diffusion Plant (ORGDP), 1981] (Pl. 4a and 4b), and conversations with landowners regarding industry activity. Geologic environments exposed in surface outcrops were visited and sampled. Samples of rock and well water (Pl. 5a and 5b; App. B) were collected as followup work for HSSR and aerial surveys and were submitted for chemical analysis to BFEC laboratories in Grand Junction, Colorado. A Mt. Sopris Model SC-132 portable scintillometer was used in all surveys of outcrops, uranium occurrences, and aerial radiometric anomalies. When an anomalous area was found, readings were taken with a Scintrex GAD-6 portable gamma-ray spectrometer. A airborne survey of the western portion of the McAllen Quadrangle was also conducted with the GAD-6 in conjunction with an E & K Model 655P single-channel strip-chart recorder.

Figure1. Quadrangle location

The subsurface evaluation was accomplished by thorough examination of 572 electric well logs (Pl. 32a for McAllen, Pl. 32b for Brownsville; App. D) and 122 gamma-ray well logs (Pl. 34a for McAllen, Pl. 33b for Brownsville; App. E). These logs were obtained from Petroleum Information Corporation, the Texas Water Development Board, and the Geologic Information Library of Dallas, Texas. Correlation was aided by the use of published subsurface information and personal communications with William E. Galloway. Subsurface anomalies were located using the gamma-ray well logs, whereas the subsurface geologic environments and formational boundaries were evaluated using spontaneous potential (SP) and resistivity (RES) curves of the electric well logs. Information obtained from these data was used to construct five cross sections (Pl. 21 through 31), five structure maps (Pl. 16 through 18, 19a, and 19b), eight total-sandstone-thickness maps (Pl. 9 through 14, 15a, and 15b), and one isopach map (Pl. 8).

Maps illustrating the major subsurface fault zones in each quadrangle were prepared (Pl. 20a for McAllen and Pl. 20b for Brownsville) by using information supplied by Geomap, Inc. The aerial radiometric map for the McAllen Quadrangle (Pl. 3a) is from the report done by Geodata as previously cited. The plates showing drainage (Pl. 6a and 6b) and culture (Pl. 36a and 36b) were obtained from the U.S. Geological Survey (USGS), and the geologic map (Pl. 7, not included in this report) is a publication of the University of Texas BEG (1976). Generalized land status is shown on Plate 35a for the McAllen Quadrangle and Plate 35b for the Brownsville Quadrangle. The composite map of supportive data (Pl. 37) is a compilation of all information used for outlining areas of favorability in the McAllen Quadrangle. Favorable areas are shown on Plate 1a for the McAllen Quadrangle and Plate 1b for the Brownsville Quadrangle. Plates 1c and 1d, separations of the McAllen Quadrangle favorable areas (Pl. 1a), are presented for added clarity. A total of 53 plates accompany this report; 42 are quadrangle-sized maps, and 11 are stratigraphic cross sections.

GEOLOGIC SETTING

The McAllen and Brownsville Quadrangles are in South Texas between lat 25°45'00"N. and 27°00'00"N., and long 97°00'00"W. and 100°00'00"W. (Fig. 1). They encompass an area of 16,750 km² (6,450 mi²) bounded by lat 27°00'00"N. on the north, the Gulf of Mexico on the east, and the Rio Grande running diagonally from the northwest to the southeast along the southern portion of the quadrangles. This area is the southeast extension of the Texas Gulf Coastal Plain. Physiographic features include the Bordas Escarpment trending north and south along Starr County, plus a major delta system, domal features, barrier-bar islands, and modern eolian sand sheets. Topographic elevations vary from 750 ft in the northeast to sea level on the coast.

Structures

The quadrangles lie within the Rio Grande Embayment, a depositional basin that has existed since the Tertiary (Fig. 2). The basin is bounded by the San Marco Arch on the northeast and the Salado-Tamaulipas Arch to the southwest. Deposition of rocks of Eocene to recent age has prograded the land eastward into the Gulf of Mexico. However, this progradation has been interrupted

Figure 2. Structural setting

numerous times by marine transgressions and regressions resulting in many minor unconformities. The regional dip of these sediments is approximately 1° southeast toward the Gulf. Faulting and doming significantly alter regional dip.

Sediments of the embayment have been affected by structural features active since Jurassic time (Corpus Christi Geological Society, 1975). Data indicate numerous subsurface fault zones (Pl. 20a and 20b) trending northeast, but few faults extend to the surface. Many of the faults are syndepositional, and some show evidence of more than one growth period (Bornhauser, 1979). Normal movement along the faults has resulted in abrupt thickening of sediments on the downthrown side. Other faults, associated with the emplacement of domal features, are present at the surface and in the subsurface. Many oil- and gas-producing fields in the quadrangle are fault controlled, as are most of the anomalies believed by the authors to be associated with uranium (Pl. 37).

Stratigraphy

The undifferentiated Carrizo-Wilcox Group (Hargis, 1962) is present only in the subsurface of the quadrangles and is Eocene in age (Fig. 3). This is the oldest stratigraphic unit above the 1500-m study limit. The lower portion consists mainly of prodeltaic or strand-plain muds. The upper portion consists of numerous sandstones and occasional mudstones of the Zapata Delta Complex (Edwards, 1981). These deltaic sandstones in the upper portion thin and become marine in the southern portion of Zapata County and into Starr County. Correlation of these sandstones to the massive sandstones of the Carrizo Formation to the north and west is exceedingly difficult and will not be attempted in this report.

The Carrizo-Wilcox Group is overlain by the Claiborne Group, also Eocene in age. The Reklaw Formation, the oldest unit of the Claiborne Group, is composed of calcareous, gypsiferous claystones and sandy claystones representative of a prodeltaic environment. This unit gradually coarsens upward into the Queen City Formation, which in the lower section is composed of strand-plain, lagoonal, and prodeltaic mudstones and lignites, and in the upper section is composed of deltaic and barrier-bar sandstones. The Queen City Formation coarsens upward into highly destructive, wave-dominated deltas and grades into marine mudstones to the east. The Weches Formation overlies the Queen City Formation and is a distinct prodeltaic claystone facies that grades upward into the deltaic sandstones of the Sparta Formation. The Sparta Formation in turn grades upward into the basal claystones of the Cook Mountain Formation, which gives the Sparta Formation a characteristic bell-shaped curve on electric well logs. The Cook Mountain Formation is a marine, nearshore sequence of claystones and highly glauconitic sandstones. There is a higher percentage of sandstone in this unit due to the influence of the ancestral Rio Grande. The Cook Mountain coarsens upward into the sandy sediments of the Yegua Formation, the youngest formation of the Claiborne Group. The Yegua Formation consists of nonmarine sandstones mixed with occasional lignites and claystones and becomes marine downdip. Some bentonitic and calcareous glauconitic sandstones are also present. The authors were able to separate the above formations of the Claiborne Group in the subsurface and continue to the surface. The stratigraphic chart (Fig. 3)

shows this delineation, but does not combine the Sparta and Cook Mountain Formations into the Laredo Formation at the surface as is shown on the geologic map.

The Jackson Group, also of Eocene age, conformably overlies the Yegua Formation. It is composed of interbedded sandstones, mudstones, and lignites deposited in the upper portion of a major progradational cycle that includes the underlying Yegua Formation (White and Galloway, 1977). At the base of the Jackson Group is the Caddell Formation, a sequence of marine sandstones that is overlain by a sequence of strand plain-barrier bar sandstones of the Wellborn Formation (referred to in much of the oil-field literature as the Hockley Sands). Overlying the Wellborn Formation are the lagoonal mudstones and lignites of the Manning Formation which are in turn overlain by the sandstone of the Whitsett Formation (Fisher and others, 1970).

The Vicksburg Group is a marine depositional wedge consisting of gray, slightly calcareous claystones and sandstones. It overlies and separates the downdip portion of the Jackson Group from the Catahoula-Frio Formation. Correlation of this unit could not be extended west of the Vicksburg Fault Zone, and it is presumed that the faulting contributed greatly to the deposition of the Vicksburg Group eastward.

Overlying the Jackson Group on the surface and Vicksburg Group in the subsurface is the undifferentiated Catahoula and Frio Formations of Oligocene-Miocene age. These formations consist of mudstone, claystone, sandstone, tuff, and tuffaceous clay, deposited in fluvial and interfluvial environments. Due to the high degree of diagenetic alteration of these sediments, it becomes increasingly difficult to distinguish between the Catahoula and Frio Formations on the surface and in subsurface correlations. For this reason, the Catahoula-Frio Formation will not be separated in this report and will be discussed as an entire unit.

The Fleming and Oakville Formations, Miocene in age, overlie the Catahoula-Frio Formation in the subsurface. Both units do not extend to the surface and are overlain by the Goliad Formation and eolian deposits. Both formations consist of calc lithic fluvial sandstone and gravel interfingering with interfluvial clay and mud. The Oakville Formation is generally distinguished from the Fleming Formation because of its higher percentage of sandstone. However, in the study area, both formations contain a high percentage of sandstone, and it becomes difficult to distinguish between the two units. For this reason the Fleming-Oakville Formation is discussed as one unit.

The Goliad Formation unconformably overlies the Catahoula-Frio Formation on the surface and the Fleming-Oakville Formation in the subsurface. It consists of sandstones interbedded with conglomerates and claystone, and extensive and distinctive deposits of caliche (Mason, 1963). It is thought that the Goliad Formation, Pliocene in age, was deposited under arid climatic conditions by streams originating in the West Texas, New Mexico, and, possibly, the Rocky Mountain region (Eargle and others, 1975). However, it has been suggested (Galloway, pers. comm.) that the depositional environment of the Goliad Formation during the Pliocene was similar to that during deposition of Quaternary sand sheets of the northern and western portions of the McAllen and Brownsville Quadrangles.

The Uvalde Formation, of late Pliocene or early Pleistocene age, occurs in the western portion of the quadrangles. It consists of isolated deposits of sandstone, conglomerate, and caliche that are similar in lithology to the Goliad Formation (Lonsdale and Day, 1937).

Overlying the Goliad and Uvalde Formations are the Lissie and Beaumont Formations and river-terrace deposits. These units are fluvial sediments of continental origin that were deposited during Pleistocene time. They consist of interbedded sandstone, siltstone, claystone, and marl and minor amounts of conglomerate. Facies changes are sharp both laterally and vertically (Mason, 1963).

Deposits of recent age include alluvium in and along present rivers, windblown deposits that cover large areas of the quadrangles (especially in the north and east), and barrier-island complexes along the coast. The eolian sands were deposited by easterly winds that carried sand westward from the beaches in the eastern portion of the study area (Wood and others, 1963). Most of the eolian deposits are stabilized, but active sand dunes are present in portions of the quadrangles (Barnes, 1976). The barrier-island deposits are mostly sand, silt, clay, and locally abundant shell fragments. There is also a considerable amount of alluvium in the southeast that consists of clay, silt, sand, gravel, and organic matter deposited primarily in the Rio Grande Delta System.

Uranium Deposits

The tuffaceous Catahoula-Frio Formation is considered the dominant source of uranium for deposits occurring in the South Texas Coastal Plain. Uranium has been shown to have been leached from the tuffs shortly after they were deposited (Duex, 1971). Such uranium was carried by oxidizing meteoric ground waters into reducing environments in the Catahoula-Frio Formation and the underlying Whitsett Formation. Galloway (Galloway and Kaiser, 1979) believed that by normal hydrologic processes these uranium-rich waters could also flow into younger formations, such as the Fleming-Oakville Formation. These ground waters could also have flowed upward along fault zones into younger aquifers.

Reductants, necessary for uranium precipitation, occur in all formations in the form of lignites and carbonaceous trash. Anaerobic bacteria are another possible source of reductants in the form of H_2S . H_2S from underlying petroleum and natural gas accumulations may also enter the system along fault zones and permeable formations (Eargle and Weeks, 1961).

However, it should be noted that large aquitards prevent uranium-rich ground waters from migrating into otherwise favorable formations. For example, in the McAllen and Brownsville Quadrangles, all uranium-related anomalies in the Whitsett Formation lie updip of the Vicksburg Group, where the Catahoula-Frio Formation lies directly on top of the Whitsett Formation. The Vicksburg Group, composed predominantly of clay and discontinuous sands, appears to be an effective aquitard. This stratigraphic relationship has prevented Catahoula-Frio ground waters from entering the uppermost sands of the Whitsett Formation that are below the updip limit of the Vicksburg Group (Pl. 16).

ENVIRONMENTS FAVORABLE FOR URANIUM DEPOSITS

SUMMARY

In the McAllen and Brownsville Quadrangles, 36 areas contain an environment favorable for epigenetic Texas roll-type deposits of Subclass 242 (Austin and D'Andrea, 1978). All these areas are in the McAllen Quadrangle (Pl. 1a). These areas are discussed in four groups: major-fault-controlled sandstone deposits, channel-controlled sandstone deposits, domal structures, and strand plain-barrier bar sandstone deposits. These groups were selected on the basis of structural and sedimentary depositional environments that are known to have acted as major controls for uranium deposition in South Texas.

Fifteen areas are associated with major-fault-controlled sandstone deposits. Areas A1, A2, A3, and A4 are in the upper half of the Catahoula-Frio Formation. Areas B1 and B2 are in the Whitsett Formation. Areas C1, C2, C3, and C4 are in the Fleming-Oakville Formation. Areas D1, D2, D3, D4, and D5 are in the Goliad Formation.

Twelve areas are associated with channel-controlled sandstone deposits. Areas E1, E2, and E3 are in the upper half of the Catahoula-Frio Formation. Areas F1, F2, F3, F4, F5, F6, and F7 are in the lower half of the Catahoula-Frio Formation. Areas G1 and G2 are in the Whitsett Formation.

Eight areas are associated with domal structures. Areas H1 and H2 are in the Fleming-Oakville Formation. Areas I1 and I2 are in the upper half of the Catahoula-Frio Formation. Areas J1 and J2 are in the Goliad Formation. Areas K1 and K2 are in the lower half of the Catahoula-Frio Formation.

One area is associated with strand plain-barrier bar sandstone deposits. Area L is in the Whitsett Formation.

MAJOR-FAULT-CONTROLLED SANDSTONE DEPOSITS

Major fault trends in fluvial sandstone facies are favorable for Texas roll-type uranium deposits in the upper half of the Catahoula-Frio Formation (Areas A1 through A4), the Whitsett Formation (Areas B1 and B2), the Fleming-Oakville Formation (Areas C1 through C4), and the Goliad Formation (Areas D1 through D5). The dimensions of the favorable area are shown in Table 1. Land in this group of favorable areas is used generally for ranching and oil and gas production. Some farming is done in Area D5.

Areas A1 through A4

Areas A1 through A4 (Pl. 1a) are along major fault trends in the upper half of the Catahoula-Frio Formation. They contain fluvial-channel-system facies favorable for Texas roll-type uranium deposits. These sandstones are tuffaceous and contain various lithic fragments interlaminated with claystones (Barnes, 1975). Only major faults are shown on the subsurface fault map (Pl. 20a), although most have numerous small faults associated with them. These fault zones can act as aquitards and divert ground water to formations higher

Table 1. Area, thickness, volume, and depth from surface of favorable areas related to major fault controlled sandstone deposits.

Favorable Area	Formation	Area (km ²)	Average Thickness (m)	Volume (km ³)	Depth from surface (m)
A1	Upper half Catahoula-Frio	313.14	42.67	13.36	60 to 1066
A2	Upper half Catahoula-Frio	775.37	76.20	59.08	289 to 1310
A3	Upper half Catahoula-Frio	14.95	103.63	1.55	198 to 609
A4	Upper half Catahoula-Frio	29.05	94.49	2.74	457 to 929
B1	Whitsett	49.56	45.72	2.27	304 to 640
B2	Whitsett	208.90	30.48	6.37	Near surface to 475
C1	Fleming-Oakville	859.10	219.46	188.54	106 to 807
C2	Fleming-Oakville	481.45	178.30	85.84	51 to 929
C3	Fleming-Oakville	528.87	565.40	299.02	822 to 1524
C4	Fleming-Oakville	52.97	205.74	10.90	131 to 640
D1	Goliad	496.83	60.96	30.29	Near surface to 184
D2	Goliad	363.12	67.05	24.35	Near surface to 405
D3	Goliad	169.17	205.74	34.81	30 to 304
D4	Goliad	45.71	91.44	4.18	Near surface to 822
D5	Goliad	22.64	82.30	1.86	60 to 518

up in the section. They can also be an avenue along which reductants from deep oil and gas accumulations can rise into younger formations and aid in the precipitation of the uranium.

Areas A1 and A2 lie along the Vicksburg Fault Zone. Updip from both areas are numerous anomalies in outcrop, water wells, and gamma-ray well logs (Pl. 37). These anomalies, as well as high uranium concentrations in intraformational tuffs, indicate an adequate uranium source area. The sandstones around the fault zone are good uranium host rocks and have abundant reductants. Area A2 has four anomalous gamma-ray well logs (no. 67, 68, 71, and 73; Pl. 33a; App. E) that lie along the margin of the fluvial-channel complex (Pl. 11). Area A1 has one anomalous gamma-ray well log (no. 58; Pl. 33a; App. E).

Areas A3 and A4 are southern extensions of major-fault-controlled favorable areas from the Laredo Quadrangle (Cherepon and Stauber, 1981). Both lie along a fluvial-channel axis.

Areas B1 and B2

Areas B1 and B2 (Pl. 1a) contain an environment favorable for Texas roll-type uranium deposits in the Whitsett Formation. Both areas are situated on faults and along fluvial sandstone trends (Pl. 9). A source of the uranium could be either the overlying Catahoula-Frio Formation or tuffs within the Whitsett Formation itself. The electric well-log patterns show enough sandstone at the top of the Whitsett Formation and base of the Catahoula-Frio Formation to allow ground-water mixing between the two units. The faults in these areas could have acted as conduits for reductants from deeper hydrocarbon deposits, as well as acting as aquitards.

Sandstones in these areas are commonly fine to coarse grained, quartzitic, friable, laminated to cross-bedded, and fossiliferous and have some tuffs (Barnes, 1975). These sandstones contain abundant carbonaceous matter and lignite.

Areas B1 and B2 have anomalous gamma-ray logs (no. 5 and 7; Pl. 33a; App. E). Area B2 also has anomalous HSSR well-water samples (ORGDP, 1980) updip in an older portion of the Jackson Group along a fluvial trend that persists into the Whitsett sandstones (Pl. 9).

Areas C1 through C4

Areas C1 through C4 (Pl. 1a) have environments favorable for Texas roll-type uranium deposits along major fault trends associated with fluvial-channel sandstones of the Fleming-Oakville Formation. These tuffaceous sandstones are mostly medium grained, calcite cemented, and, in some places, thick bedded; they contain some carbonaceous material. The mechanisms for mineralization are similar to those of all other fault-related areas.

Areas C1 and C2 lie along the Vicksburg Fault Zone. Updip from both areas are numerous anomalies in the Catahoula-Frio Formation (Pl. 37). It appears that the Catahoula-Frio sands form a continuous aquifer with the sands

of the overlying Fleming-Oakville Formation. This allows uranium-rich Catahoula-Frio waters to flow into the Fleming-Oakville Formation. Catahoula-Frio waters may also enter the Fleming-Oakville Formation along fault zones, or tuffs within the Fleming-Oakville Formation could be an additional source for uranium within the unit. Deep oil and gas accumulations could provide reductants to the system along the deeper seated fault zones. As mentioned earlier, anaerobic bacteria could have also produced intraformational H_2S to aid in the precipitation of uranium.

The southern two-thirds of Area C1 contains an anomalous structure from which numerous anomalous well-water samples (Pl. 37) were collected by James Olsen (DOE, pers. comm., 1981). These samples are from the Goliad Formation. Olsen believed these well-water anomalies in the Goliad may represent mineralized halos from a deeper unit, which in this area is the Fleming-Oakville Formation. The Goliad and upper Fleming-Oakville Formation are part of the Evangeline Aquifer (ORGDP, 1980).

Area C3 encompasses two fluvial-channel systems of the Fleming-Oakville Formation (Pl. 12, 13, and 14) intersecting with numerous faults (Pl. 20a). Gas deposits that provide reductants are associated with these faults, and the complex fault system provides conduits and aquitards to control the flow of uranium-rich ground waters.

Area C4 is a southward extension of a favorable area in the Laredo Quadrangle (Cherepon and Stauber, 1981). It is an area where a fluvial system in the Fleming-Oakville Formation is intersected by a major fault zone.

Areas D1 through D5

Areas D1 through D5 (Pl. 1a) each have an environment favorable for Texas roll-type uranium deposits in major fault zones associated with fluvial-channel sandstones of the Goliad Formation. The sandstones are medium to very coarse grained, partly cross-bedded, and quartzose and have some chert, conglomerate, and marl. Mineralization mechanisms are similar to those of all other related areas. The source for uranium appears to be older formations entirely.

Area D1 lies along the Vicksburg Fault Zone. HSSR data (ORGDP, 1980) include numerous water-well anomalies (Pl. 4a and 37).

Area D2 is also along the Vicksburg Fault Zone. It continues along a fluvial trend toward the northwest (Pl. 15a). Water wells having anomalous uranium concentration are found along this trend (Pl. 4a and 5a). A graben structure, associated with deeper faults, is evident in much of the area (Pl. 20a) over which Olsen collected anomalous well-water samples (Pl. 37). Core from the South Texas Oakville-Goliad Drilling Project (DOE, 1981) has zones of primary oxidation within this portion of the normally reduced lower Goliad Formation.

Area D3 lies along a fluvial-channel axis (Pl. 15a) that crosses numerous and complex faults in eastern Brooks County. One anomalous gamma-ray well log is from the area (no. 90; Pl. 32a; App. E).

Area D5 is a fluvial-channel trend through an area where numerous faults intersect (Pl. 15a). Nearby gas fields could provide reductants. An anomalous gamma-ray well log is also from the area (no. 110; Pl. 33a; App. F).

CHANNEL-CONTROLLED SANDSTONE DEPOSITS

Margins of fluvial channels are favorable for Texas roll-type uranium deposits in the upper half of the Catahoula-Frio Formation (Areas E1 through E3), the lower half of the Catahoula-Frio Formation (Areas F1 through F7), and the Whitsett Formation (Areas G1 and G2). The dimensions of the favorable areas are shown on Table 2. Land in these areas is used for ranching and oil and gas production.

Areas E1 through E3

Areas E1 through E3 (Pl. 1a) contain an environment favorable for Texas roll-type uranium deposits in margins of fluvial-channel facies of the upper half of the Catahoula-Frio Formation. These areas lie along the fluvial axis defined by sand "thicks" and "thins" on Plate 11. The sandstones are tuffaceous, contain various colored grains, and are in part interlaminated with claystone. The source for uranium is the tuffaceous material within the formation. Reductants could be provided by carbonaceous matter, anaerobic bacteria within the formation, or hydrocarbons escaping through faults near oil and gas fields.

Area E1 contains numerous well-water and surface anomalies (Olsen, pers. comm.) (Pl. 37), uranium occurrence 1 (Pl. 2a; App. A and C), and aerial radiometric anomalies (Geodata International, 1975 and 1979) in the area slightly updip (Pl. 3a). Nine anomalous gamma-ray well logs were also observed (no. 44 through 46, 50 through 53, and 55 and 56; Pl. 33a; App. E). Two channel axes that trend through the area (Pl. 11) end at a fault. The western edge of this favorable area is about midway through the outcrop area. The uranium occurrences are oxidized, which suggests that more mineralization may have occurred downdip in the section.

Area E2 has two small fluvial-channel systems (Pl. 11). There are an anomalous gamma-ray well log (no. 12; Pl. 34a; App. E) and numerous HSSR well-water anomalies (ORGDP, 1980) (Pl. 41) in the area and updip from it.

Area E3 is a southward extension of a favorable area in the Laredo Quadrangle (Cherepon and Stauber, 1981). The southern extent of this channel system is shown on Plate 11.

Areas F1 through F7

Areas F1 through F7 (Pl. 1a) each contain an environment favorable for Texas roll-type uranium deposits in fluvial-channel facies of the lower half of the Catahoula-Frio Formation. In the quadrangles to the north, the Catahoula Formation is a tuffaceous sandstone, whereas the Frio is a nontuffaceous claystone. In the McAllen Quadrangle, the characteristics of the Catahoula and Frio Formations change in that they both are sandy and

Table 2. Area, thickness, volume, and depth from surface of favorable areas related to channel controlled sandstone deposits.

Favorable Area	Formation	Area (km ²)	Average Thickness (m)	Volume (km ³)	Depth from surface (m)
E1	Upper half Catahoula-Frio	275.54	45.72	12.60	Near surface to 533
E2	Upper half Catahoula-Frio	160.20	54.86	8.79	Near surface to 335
E3	Upper half Catahoula-Frio	23.50	60.96	1.43	Near surface to 573
F1	Lower half Catahoula-Frio	123.89	67.05	8.31	Near surface to 941
F2	Lower half Catahoula-Frio	92.28	60.96	5.63	368 to 762
F3	Lower half Catahoula-Frio	188.82	60.96	11.51	Near surface to 1127
F4	Lower half Catahoula-Frio	79.03	76.20	6.02	448 to 1167
F5	Lower half Catahoula-Frio	49.99	60.96	3.05	335 to 1237
F6	Lower half Catahoula-Frio	104.66	97.54	10.21	816 to 1560
F7	Lower half Catahoula-Frio	21.36	83.82	1.79	487 to 1280
G1	Whitsett	63.23	45.72	2.89	Near surface to 381
G2	Whitsett	18.37	42.67	0.78	Near surface to 356

appear to contain the tuffs that are the major source of uranium for the South Texas uranium belt. This part of the unit is also bounded by potential source rocks above and below. The underlying Whitsett and the overlying upper half of the Catahoula-Frio Formation both contain uranium-enriched tuffaceous sediments. Well-defined channel patterns are present in the lower half of these formations (Pl. 10). Reductants could be provided by carbonaceous trash, anaerobic bacteria, or hydrocarbons from underlying oil and gas deposits that could move upward along faults.

A gamma-ray well log (no. 7; Pl. 33a; App. E) from Area F1 contains an anomalous interval in the lower half of the Catahoula-Frio sands. This well also has an anomalous interval in the sands of the underlying uppermost Whitsett Formation. If the uranium were leached from the Catahoula-Frio Formation down into the Whitsett Formation, it is reasonable to assume that the uranium-rich fluids could also have gone farther downdip in the Catahoula-Frio Formation. In flowing downdip, these fluids are following a normal ground-water gradient. The area follows a channel margin downdip to the boundary of a fault-controlled area on the east and up to outcrop on the west, where it is bounded by a fault.

Area F3 contains five anomalous gamma-ray well logs (no. 22, 25, 28, 33, and 43; Pl. 33a; App. E), one possible up-to-the-coast fault at the surface (Pl. 7), and one subsurface fault (Pl. 20a). There are two slightly anomalous gamma-ray well logs (no. 66 and 67; Pl. 33a; App. E) downdip from this area, which may indicate a remote seepage zone in front of a mineralized zone near a fault.

Area F4 is similar to Area F2 in that it has two faults extending through it. However, Area F4 follows both sides of a fluvial axis downdip to the Vicksburg Fault Zone.

Area F5 also follows the margin of a fluvial system; it is downdip from numerous anomalies in both older and younger units (Pl. 37).

Area F6 contains three wells in the Sun Field (Copper, 1955). Drill cores having anomalous radioactivity have been taken in quartz sandstone in these wells, which lie updip from the Vicksburg Fault, and show evidence for uranium occurrences 3, 4, and 5 (Pl. 2a; App. A).

Area F7 is the southward continuation of a favorable area in the Laredo Quadrangle (Cherepon and Stauber, 1981). This portion of the Catahoula-Frio Formation is mapped as the Frio Formation in that quadrangle.

Areas G1 and G2

Areas G1 and G2 (Pl. 1a) each contain an environment favorable for Texas roll-type uranium deposits in fluvial-channel facies of the Whitsett Formation. These sandstones are fine- to coarse-grained, quartzitic, laminated to cross-bedded, and fossiliferous and have volcanic ash and carbonaceous matter in places. Good sources for the uranium are the overlying Catahoula-Frio Formation and the Whitsett Formation itself. Carbonaceous matter is the probable reductant in this formation.

Areas G1 and G2 are associated with sands marginal to a major fluvial axis extending into a lagoonal environment (Pl. 9). Area G1 has faults on both the eastern and western margins.

DOMAL STRUCTURES

Domal structures are favorable for Texas roll-type uranium deposits in the sandstones of the Fleming-Oakville Formation (Areas H1 and H2), the upper half of the Catahoula-Frio Formation (Area I1 and I2), the Goliad Formation (Areas J1 and J2), and the lower half of the Catahoula-Frio Formation (Areas K1 and K2).

Areas H1, I1, J1, and K1 are over the Alta Mesa Dome. Areas H2, I2, J2, and K2 are over the Alta Mesa North Dome. Areas H2 and K2 are extensions of favorable areas in the Laredo Quadrangle (Cherepon and Stauber, 1981). The dimensions of the favorable areas are shown in Table 3. Land use in these areas is ranching and oil and gas production.

Areas H1 and H2

Areas H1 and H2 (Pl. 1a) each contain an environment favorable for Texas roll-type uranium deposits in fluvial sandstone of the Fleming-Oakville Formation. Domal structures have oil and gas accumulations that could provide reductants. Numerous faults that could act as conduits for reducing solutions are also associated with these features. These faults could also act as aquitards to slow ground-water flow and conduct it into overlying formations. Sources for uranium are intraformational tuffaceous material and the underlying Catahoula-Frio Formation.

Areas I1 and I2

Areas I1 and I2 (Pl. 1a) each contain an environment favorable for Texas roll-type uranium deposits in the fluvial-channel sandstones of the upper half of the Catahoula-Frio Formation. The mechanism for mineralization is similar to that for the previous domal areas. The Catahoula-Frio Formation is considered the uranium source for these areas. Area I2 has an anomalous gamma-ray well log (no. 79; Pl. 33a; App. E) associated with it.

Areas J1 and J2

Areas J1 and J2 (Pl. 1a) each contain an environment favorable for Texas roll-type uranium deposits in fluvial-channel sandstones of the Goliad Formation. The mineralization mechanism is similar to that of the previous four domal areas, except the source is probably from older units. Area J1 has a gamma-ray well log associated with it (no. 84; Pl. 33a; App. F).

Table 3. Area, thickness, volume, and depth from surface of favorable areas related to domal structures in sandstone.

Favorable Area	Formation	Area (km ²)	Average Thickness (m)	Volume (km ³)	Depth from surface (m)
H1	Fleming-Oakville	60.24	213.36	12.85	192 to 710
H2	Fleming-Oakville	8.97	228.60	2.05	158 to 726
I1	Upper half Catahoula-Frio	52.55	82.30	4.32	710 to 1097
I2	Upper half Catahoula-Frio	20.51	67.06	1.38	670 to 1133
J1	Goliad	60.24	70.10	4.22	60 to 265
J2	Goliad	8.97	60.96	0.55	60 to 176
K1	Lower half Catahoula-Frio	52.55	167.64	8.81	1097 to 1524
K2	Lower half Catahoula-Frio	10.68	91.44	0.98	1066 to 1524

Areas K1 and K2

Areas K1 and K2 (Pl. 1a) each contain an environment favorable for Texas roll-type uranium deposits in the fluvial-channel sandstones of the lower half of the Catahoula-Frio Formation. Mineralization mechanisms are similar to those of the other areas associated with domal structures. The overlying Catahoula-Frio Formation is considered to be the uranium source.

STRAND PLAIN-BARRIER BAR DEPOSITS

Area L (Pl. 1a) contains an environment favorable for Texas roll-type uranium deposits of Subclass 242 in the strand plain-barrier bar facies of the Whitsett Formation (Pl. 9). The area is delineated by the updip limit of the Vicksburg Group on the east and the barrier-bar facies on the west. A source for the uranium could be intraformational tuffaceous material, but more likely is the overlying Catahoula-Frio Formation, which contains numerous anomalies that are nearby (Pl. 37). Reductants are in the form of carbonaceous matter and lignites associated with this depositional environment. A reasonable model for mineralization would involve uranium-rich ground waters from above flowing into sands of a barrier-bar facies below. Carbonaceous matter along the lagoonal to barrier facies change could reduce the uranium-bearing water and precipitate uranium. Four anomalous gamma-ray logs are present in the area (no. 22, 24, 33, and 34; Pl. 33a; App. E).

Area L covers an area of 65.79 km^2 , has a thickness of 30.48 m, and has a volume of 2.01 km^3 . It is from 384 to 518 m below the surface. The land is used for ranching and oil and gas production.

ENVIRONMENTS UNFAVORABLE FOR URANIUM DEPOSITS

SUMMARY

The Carrizo-Wilcox, Claiborne, and Jackson Groups [except for the Whitsett favorable area (Pl. 1a) in the McAllen Quadrangle] are considered unfavorable for the formation of uranium deposits. The Vicksburg, Goliad [except for the Goliad favorable areas (Pl. 1a) in the McAllen Quadrangle], and Uvalde Formations are also considered unfavorable for the formation of uranium deposits, as are the formations of Quaternary age. These units do not sufficiently meet the uranium-favorability recognition criteria established by Mickle and Mathews (eds., 1978).

CARRIZO-WILCOX GROUP

The Carrizo-Wilcox Group is considered unfavorable for the formation of uranium deposits because no evidence of uranium enrichment was found. The favorable sandstone facies in this unit are effectively isolated from uranium-bearing solutions by impervious units in the overlying formations.

CLAIBORNE GROUP

The Claiborne Group, consisting of the Reklaw, Queen City, Weches, Sparta, Cook Mountain, and Yegua Formations, is considered unfavorable for the formation of uranium deposits. The criteria used in this determination are discussed below on a formation-by-formation basis.

Reklaw Formation

The Reklaw Formation is predominantly a claystone, contains no uranium source or host lithologies, and has extremely low permeability. It is therefore considered unfavorable for the formation of uranium deposits.

Queen City Formation

The Queen City Formation contains sandstone facies capable of acting as hosts for uranium deposits. However, these sandstones are effectively isolated from uranium-bearing solutions by the overlying formations, and no evidence of uranium enrichment was found. The formation is therefore considered unfavorable for the formation of uranium deposits.

Weches Formation

The Weches Formation is predominantly a claystone, contains no uranium source or host lithologies, and has extremely low permeability. It is therefore considered unfavorable for the formation of uranium deposits.

Sparta Formation

The Sparta Formation contains sandstone facies capable of acting as hosts for uranium deposition. However, these sandstones are effectively isolated from any uranium-bearing solutions by the overlying formations, and no evidence of uranium enrichment was found. The formation is therefore considered unfavorable for the formation of uranium deposits.

Cook Mountain Formation

The Cook Mountain Formation contains sandstone facies capable of acting as hosts for uranium deposition. However, these sandstones are effectively isolated from any uranium-bearing solutions by the overlying formations. Uranium occurrence 7 is on a sandstone ridge north of Zapata, Texas (Pl. 2a; App. A). This occurrence is thought to be associated with phosphates in glauconitic sandstone. No other evidence for uranium enrichment was found. The formation is therefore considered unfavorable for the formation of uranium deposits.

Yegua Formation

The Yegua Formation contains sandstone facies capable of acting as hosts for uranium deposition. However, these sandstones are effectively isolated from any uranium-bearing solutions by the overlying formations, and no evidence of uranium enrichment was found. This unit is therefore considered unfavorable for the formation of uranium deposits.

CADDELL, WELLBORN, AND MANNING FORMATIONS

The Caddell, Wellborn, and Manning Formations of the Jackson Group have some uranium-related anomalies in well-water samples (ORGDP, 1980) in the McAllen Quadrangle. However, no deposits of economic grade have been found. Lagoonal mudstones and lignites of the Manning Formation act as an aquitard and prevent the sandstones of the Caddell and Wellborn Formations from receiving any uranium-rich solutions from the surface. The uranium concentrations in the lignites are minimal and not considered important. These formations are therefore considered unfavorable for the formation of uranium deposits.

VICKSBURG FORMATION

The Vicksburg Formation does not contain favorable uranium host- or source-rock lithologies. There are a few lenses of fine-grained sandstone, but they are surrounded and isolated by claystones. This unit is therefore considered unfavorable for the formation of uranium deposits.

GOLIAD FORMATION

The Goliad Formation in the Brownsville Quadrangle contains as much as 85% sandstone that was deposited as eolian sand sheets. Similar sand sheets are currently being deposited on the surface of the quadrangles. Organic reductants are minimal. Investigations of the Goliad Formation indicate there are two productive fresh-water aquifers (Evangeline and Chicot) in the unit that discharge along a salt-water interface near the coast (Baker, 1978).

Any concentrations of uranium in this portion of the Goliad Formation would be along reduced zones in the aquifers. These reduced zones may be caused by variations along the fresh- to salt-water boundaries (Galloway and others, 1979), or by hydrogen sulfide-bearing solutions that have migrated up fault zones into the fresh-water aquifers. Uranium deposits associated with these reduced zones would be remobilized by the oxygenated waters flowing through the aquifers. Therefore, it appears that any uranium deposits found would be small and not favorable for production.

UVALDE FORMATION

The conglomerates of this formation are considered unfavorable for the formation of uranium deposits. There are no uranium source lithologies, reductants, or supportive evidence to show this unit to be favorable.

QUATERNARY DEPOSITS

This unit consists of the Lissie and Beaumont Formations, fluviatile terrace deposits, eolian deposits, barrier-island deposits, and alluvium. Some anomalous waters (ORGDP, 1980) occur in these deposits but are considered to be contaminated by oil-field brines and phosphatic fertilizer, used extensively along the Rio Grande. These units are highly oxidized and leached and have no characteristics suggesting uranium favorability.

RECOMMENDATIONS TO IMPROVE EVALUATION

No formations were left unevaluated in the McAllen and Brownsville Quadrangles. Improvements in the evaluations could possibly be made by collecting more gamma-ray well logs, logging of the upper portion of the Goliad Formation, field checking inaccessible areas, and more data on the geology in adjacent Mexico.

A greater number of gamma-ray well logs in the western portion of the quadrangles may show the formations older than the Jackson Group to have favorable environments that have been overlooked due to sparsity of data. Whereas the outcrops of these formations were field checked extensively, there is a much greater volume in the subsurface that could be better evaluated if more data were available.

Logging of additional wells by portable gamma-ray logging units would allow the entire Goliad Formation to be better evaluated. Many electrical well logs did not include the upper portion of the Goliad Formation, so only the lower 500 ft were mapped for the quadrangle.

A greater effort needs to be made to gain access to certain ranches. There were numerous surface and well-water anomalies that could not be field checked. If permission were granted to do closer spaced sampling on these ranches, then knowledge of uranium favorability in the quadrangle would increase greatly.

There is also a need to collect more data on the geology of adjacent Mexican land. There is at least one uranium deposit that is not far south of the border. This is the La Coma deposit. More occurrences may exist in Mexico and could show a trend that may extend into the McAllen and Brownsville Quadrangles.

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ERA	SYSTEM	SERIES	GROUP	FORMATION	LITHOLOGY	DESCRIPTION
CENOZOIC	QUATERNARY	RECENT		Alluvium		Clay, silt, sand, gravel, and organic matter
				Barrier island deposits†		Beach ridge, sand dunes, and tidal deposits
				Windblown deposits		Sand dunes and sand sheets
		PLEISTOCENE		Fluvatile river deposits†		Sand, silt, clay, and gravel; iron oxide and caliche in weathered zones
				Beaumont‡		
				Lissie		
		?		Uvalde Gravel†		Well-rounded chert pebbles and cobbles
	TERTIARY	PLIOCENE		Goliad*		Calcitic, medium- to very coarse-grained sandstone and conglomerate; marl, limestone, clay, and caliche
		MIOCENE	FLEMING	Fleming-Oakville*		Subsurface only; calcitic mudstone, thick-bedded medium-grained sanstone, and intermittent volcanic ash; caliche in weathered zones
		OLIGOCENE	CATAHOULA	Catahoula-Frio*†		Varicolored, massively bedded tuff and tuffaceous mudstone, sandstone, clayey sandstone, and clay; loosely cemented, coarse volcanic conglomerate; caliche in weathered zones
			VICKSBURG †			Subsurface only; greenish-gray clay and sandstone, volcanic rock fragments
		EOCENE	JACKSON	Whitsett*†		Fine- to coarse-grained, fossiliferous, laminated, and crossbedded sandstone; sandy, calcitic clay with abundant fossil wood; some volcanic ash beds
				Manning†		
				Wellborn†		
				Caddell†		
			CLAIBORNE	Yegua†		Lignitic, bentonitic, silty, brown clay and fine-grained, calcareous, glauconitic sandstone with some fossil wood
				Cook Mountain†		Thin-bedded, fine-grained sandstone overlain by clay and sandstone
				Sparta†		
				Wechest†		Subsurface only; clay, fine-grained sandstone, and coal, interfingering to the northeast with fine-grained sandstone and shale overlain by clay
				Queen City†		
				Reklaw†		Subsurface only; calcareous, gypsiferous clay and sandy clay; thin- to thick-bedded coarse-grained sandstone; lignite
		CARRIZO-WILCOX†			Subsurface only; thin-bedded, fine-grained, carbonaceous sandstone; sandy shale; lignite	

*Favorable for uranium deposition
†Unit does not occur in Brownsville Quadrangle
‡Unit does not occur in McAllen Quadrangle

Figure 3. Stratigraphic column with lithologic descriptions.

MC ALLEN, TEXAS

EXPLANATION

- Area favorable for uranium in the Whitsett Formation
- Area favorable for uranium in the Fleming-Oakville Formations
- Area favorable for uranium in the Gollad Formation
- Area favorable for uranium in the upper half of the Catahoula-Frio Formation
- Area favorable for uranium in the lower half of the Catahoula-Frio Formation

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 1a. AREAS FAVORABLE FOR URANIUM DEPOSITS

BROWNSVILLE, TEXAS

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 1b. AREAS FAVORABLE FOR URANIUM DEPOSITS

MC ALLEN, TEXAS

EXPLANATION

- Area favorable for uranium in the Whitsett Formation
- Area favorable for uranium in the Fleming-Oakville Formation
- Area favorable for uranium in the Goliad Formation

Plate 1c. AREAS FAVORABLE FOR URANIUM DEPOSITS IN THE WHITSETT, FLEMING-OAKVILLE, AND GOLIAD FORMATIONS

MC ALLEN, TEXAS

EXPLANATION

- Area favorable for uranium in the upper half of the Catahoula-Frio Formation
- Area favorable for uranium in the lower half of the Catahoula-Frio Formation

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 1d. AREAS FAVORABLE FOR URANIUM DEPOSITS IN THE CATAHOULA-FRIO FORMATIONS

MC ALLEN, TEXAS

	URANIUM OCCURRENCES			
	CLASSIFICATION			
	Sedimentary	Plutonic	Volcanic	Other
Minor prospect or mineral occurrence	□	△	◇	⊛
Prospect or mine, production unknown	◻	▲	◼	⊛
Significant prospect or mine reporting minor production	◻	▲	◼	⊛
Mine having production over 200,000 pounds U ₃ O ₈	◻	▲	◼	⊛
Not visited	□Y	△Y	◇Y	⊛Y
Not found	□X	△X	◇X	⊛X
Mining District	-----			

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 2a. URANIUM OCCURRENCES

BROWNSVILLE, TEXAS

Plate 2b. URANIUM OCCURRENCES

MC ALLEN, TEXAS

EXPLANATION

- Area of Bi-Bi/Ti anomaly overlap
- Area of Bi or Bi/Ti anomaly

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 3a. INTERPRETATION OF AERIAL RADIOMETRIC DATA

BROWNSVILLE, TEXAS

Plate 3b. INTERPRETATION OF AERIAL RADIOMETRIC DATA

MC ALLEN, TEXAS

EXPLANATION

- Uranium ≥ 33.56 ppb in ground water
- Uranium ≥ 18.52 ppb but < 33.56 ppb in ground water
- Outline of geochemical anomaly
- - - Uranium > 20 ppb in ground water, area from Brownsville Quadrangle HSSR data from ORGDP, 1980, 1981

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 4a. INTERPRETATION OF DATA FROM HYDROGEOCHEMICAL AND STREAM-SEDIMENT RECONNAISSANCE

BROWNSVILLE, TEXAS

EXPLANATION

- HSSR ground-water sample
- HSSR stream-sediment sample
- Computer generated anomalous area
- Uranium > 20 ppb in ground water
- ||| Molybdenum > 50 ppb in ground water
- /// Arsenic > 10 ppb in ground water
- HSSR data from ORDGP, 1980

Plate 4b. INTERPRETATION OF DATA FROM HYDROGEOCHEMICAL AND STREAM-SEDIMENT RECONNAISSANCE

MC ALLEN, TEXAS

EXPLANATION

- Rock samples
- Well-water samples

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 5a. LOCATION MAP OF GEOCHEMICAL SAMPLES

BROWNSVILLE, TEXAS

EXPLANATION

○ Well water samples

Plate 5b. LOCATION MAP OF GEOCHEMICAL SAMPLES

MC ALLEN, TEXAS

Latitude: 27° 10' 00", 25° 10' 00", 23° 10' 00", 21° 10' 00", 19° 10' 00", 17° 10' 00", 15° 10' 00", 13° 10' 00", 11° 10' 00", 9° 10' 00", 7° 10' 00", 5° 10' 00", 3° 10' 00", 1° 10' 00", 0° 10' 00", 1° 10' 00", 3° 10' 00", 5° 10' 00", 7° 10' 00", 9° 10' 00", 11° 10' 00", 13° 10' 00", 15° 10' 00", 17° 10' 00", 19° 10' 00", 21° 10' 00", 23° 10' 00", 25° 10' 00", 27° 10' 00"

Longitude: 100° 00' 00", 99° 00' 00", 98° 00' 00", 97° 00' 00", 96° 00' 00", 95° 00' 00", 94° 00' 00", 93° 00' 00", 92° 00' 00", 91° 00' 00", 90° 00' 00", 89° 00' 00", 88° 00' 00", 87° 00' 00", 86° 00' 00", 85° 00' 00", 84° 00' 00", 83° 00' 00", 82° 00' 00", 81° 00' 00", 80° 00' 00", 79° 00' 00", 78° 00' 00", 77° 00' 00", 76° 00' 00", 75° 00' 00", 74° 00' 00", 73° 00' 00", 72° 00' 00", 71° 00' 00", 70° 00' 00", 69° 00' 00", 68° 00' 00", 67° 00' 00", 66° 00' 00", 65° 00' 00", 64° 00' 00", 63° 00' 00", 62° 00' 00", 61° 00' 00", 60° 00' 00", 59° 00' 00", 58° 00' 00", 57° 00' 00", 56° 00' 00", 55° 00' 00", 54° 00' 00", 53° 00' 00", 52° 00' 00", 51° 00' 00", 50° 00' 00", 49° 00' 00", 48° 00' 00", 47° 00' 00", 46° 00' 00", 45° 00' 00", 44° 00' 00", 43° 00' 00", 42° 00' 00", 41° 00' 00", 40° 00' 00", 39° 00' 00", 38° 00' 00", 37° 00' 00", 36° 00' 00", 35° 00' 00", 34° 00' 00", 33° 00' 00", 32° 00' 00", 31° 00' 00", 30° 00' 00", 29° 00' 00", 28° 00' 00", 27° 00' 00", 26° 00' 00", 25° 00' 00", 24° 00' 00", 23° 00' 00", 22° 00' 00", 21° 00' 00", 20° 00' 00", 19° 00' 00", 18° 00' 00", 17° 00' 00", 16° 00' 00", 15° 00' 00", 14° 00' 00", 13° 00' 00", 12° 00' 00", 11° 00' 00", 10° 00' 00", 9° 00' 00", 8° 00' 00", 7° 00' 00", 6° 00' 00", 5° 00' 00", 4° 00' 00", 3° 00' 00", 2° 00' 00", 1° 00' 00", 0° 00' 00", 1° 00' 00", 2° 00' 00", 3° 00' 00", 4° 00' 00", 5° 00' 00", 6° 00' 00", 7° 00' 00", 8° 00' 00", 9° 00' 00", 10° 00' 00", 11° 00' 00", 12° 00' 00", 13° 00' 00", 14° 00' 00", 15° 00' 00", 16° 00' 00", 17° 00' 00", 18° 00' 00", 19° 00' 00", 20° 00' 00", 21° 00' 00", 22° 00' 00", 23° 00' 00", 24° 00' 00", 25° 00' 00", 26° 00' 00", 27° 00' 00", 28° 00' 00", 29° 00' 00", 30° 00' 00", 31° 00' 00", 32° 00' 00", 33° 00' 00", 34° 00' 00", 35° 00' 00", 36° 00' 00", 37° 00' 00", 38° 00' 00", 39° 00' 00", 40° 00' 00", 41° 00' 00", 42° 00' 00", 43° 00' 00", 44° 00' 00", 45° 00' 00", 46° 00' 00", 47° 00' 00", 48° 00' 00", 49° 00' 00", 50° 00' 00", 51° 00' 00", 52° 00' 00", 53° 00' 00", 54° 00' 00", 55° 00' 00", 56° 00' 00", 57° 00' 00", 58° 00' 00", 59° 00' 00", 60° 00' 00", 61° 00' 00", 62° 00' 00", 63° 00' 00", 64° 00' 00", 65° 00' 00", 66° 00' 00", 67° 00' 00", 68° 00' 00", 69° 00' 00", 70° 00' 00", 71° 00' 00", 72° 00' 00", 73° 00' 00", 74° 00' 00", 75° 00' 00", 76° 00' 00", 77° 00' 00", 78° 00' 00", 79° 00' 00", 80° 00' 00", 81° 00' 00", 82° 00' 00", 83° 00' 00", 84° 00' 00", 85° 00' 00", 86° 00' 00", 87° 00' 00", 88° 00' 00", 89° 00' 00", 90° 00' 00", 91° 00' 00", 92° 00' 00", 93° 00' 00", 94° 00' 00", 95° 00' 00", 96° 00' 00", 97° 00' 00", 98° 00' 00", 99° 00' 00", 100° 00' 00"

BASE MAP CONTROL FROM USGS

Plate 6a. DRAINAGE

BROWNSVILLE, TEXAS

Plate 6b. DRAINAGE

MC ALLEN, TEXAS

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS
CONTOUR INTERVAL IS 100 FT

Plate 8. THICKNESS OF THE WHITSETT FORMATION (FEET)

MC ALLEN, TEXAS

Plate 9. TOTAL SANDSTONE THICKNESS OF THE WHITSETT FORMATION (FEET)

MC ALLEN, TEXAS

Plate 10. TOTAL SANDSTONE THICKNESS OF THE LOWER HALF OF THE CATAHOULA-FRIO FORMATION (FEET)

MC ALLEN, TEXAS

Plate 11. TOTAL SANDSTONE THICKNESS OF THE UPPER HALF OF THE CATAHOULA-FRIO FORMATION (FEET)

MC ALLEN, TEXAS

Plate 12. TOTAL SANDSTONE THICKNESS OF THE LOWER THIRD OF THE FLEMING-OAKVILLE FORMATION (FEET)

MC ALLEN, TEXAS

Plate 13. TOTAL SANDSTONE THICKNESS OF THE MIDDLE THIRD OF THE FLEMING-OAKVILLE FORMATION (FEET)

MC ALLEN, TEXAS

Plate 14. TOTAL SANDSTONE THICKNESS OF THE UPPER THIRD OF THE FLEMING-OAKVILLE FORMATION (FEET)

MC ALLEN, TEXAS

Plate 15a. TOTAL SANDSTONE THICKNESS OF THE BASAL 500 FEET OF THE GOLIAD FORMATION

BROWNSVILLE, TEXAS

Plate 15b. TOTAL SANDSTONE THICKNESS OF THE BASAL 500 FT OF THE GOLIAD FORMATION

MC ALLEN, TEXAS

Plate 16. STRUCTURE ON TOP OF THE WHITSETT FORMATION (FEET BELOW SEA LEVEL)

MC ALLEN, TEXAS

Plate 17. STRUCTURE ON THE BASE OF THE CATAHOULA-FRIO FORMATION (FEET BELOW SEA LEVEL)

MC ALLEN, TEXAS

Plate 18. STRUCTURE ON THE BASE OF THE FLEMING-OAKVILLE FORMATION (FEET BELOW SEA LEVEL)

MC ALLEN, TEXAS

Plate 19a. STRUCTURE ON THE BASE OF THE GOLIAD FORMATION (FEET BELOW SEA LEVEL)

BROWNSVILLE, TEXAS

Plate 19b. STRUCTURE ON THE BASE OF THE GOLIAD FORMATION (FEET BELOW SEA LEVEL)

EXPLANATION

- Fault
- - - Datum change
- SOURCE OF DATA: GEOMAP COMPANY

Plate 20a. SUBSURFACE FAULTS

BROWNSVILLE, TEXAS

Plate 20b. SUBSURFACE FAULTS

Mc Allen, Texas

Plate 21. CROSS SECTION A-A'

See Plate 34a for location of cross section.

MAY 1981
Plate 21.

Plate 22. CROSS SECTION A'-A''

See Plate 34a for location of cross section.

Plate 23. CROSS SECTION A''-A'''

See Plate 34b for location of cross section

Plate 24. CROSS SECTION B-B'

See Plate 34a for location of cross section

Plate 25. CROSS SECTION B'-B''

See Plate 34a for location of cross section.

Plate 26. CROSS SECTION B''-B'''

See Plate 34b for location of cross section

Plate 27. CROSS SECTION C-C'

See Plate 34a for location of cross section.

Mc Allen, Texas

Plate 28. CROSS SECTION D-D'

See Plate 34a for location of cross section.

MAY 1981
Plate 28.

Plate 29. CROSS SECTION D'-D''

See Plate 34a for location of cross section.

Brownsville, Texas

Plate 30. CROSS SECTION E-E'

See Plate 34b for location of cross section

MAY 1981
Plate 30.

Plate 31. CROSS SECTION E'-E''

See Plate 34b for location of cross section

MC ALLEN, TEXAS

BROWNSVILLE, TEXAS

Plate 32b. LOCATION OF ELECTRIC WELL LOGS

MC ALLEN, TEXAS

EXPLANATION

- Wells with anomalies
- Wells without anomalies

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 33a. LOCATION OF GAMMA-RAY WELL LOGS

BROWNSVILLE, TEXAS

EXPLANATION

- Wells without anomalous intervals
(See Appendix E)
- (No anomalous intervals > 3 times background
were found)

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 33b. LOCATION OF GAMMA-RAY WELL LOGS

MC ALLEN, TEXAS

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 34a. INDEX TO LARGE-SCALE MAPS

BROWNSVILLE, TEXAS

Plate 34b. INDEX TO LARGE-SCALE MAPS

MC ALLEN, TEXAS

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

INDEX

- J. National Wildlife Reserve and Refuge**
 - J-1 Santa Ana National Wildlife Refuge
- G. Government Installations**
 - G-1 Moore Air Force Base

Plate 35a. GENERALIZED LAND STATUS MAP

BROWNSVILLE, TEXAS

INDEX

- A. Areas Managed by Natural Park Service
 - A-1 Padre Island National Seashore
- J. National Wildlife Reserves and Refuges
 - J-1 Laguna Atascosa Wildlife Refuge

Plate 35b. GENERALIZED LAND STATUS MAP

MC ALLEN, TEXAS

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

Plate 36a. CULTURE

BASE MAP CONTROL FROM USGS

BROWNSVILLE, TEXAS

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 36b. CULTURE

MC ALLEN, TEXAS

EXPLANATION

- Uranium occurrences
- Olsen's surface anomalies
- Olsen's well-water anomalies
- ARRS Bi/Bi/Ti overlap (Geodata International, 1975 and 1979)
- ARRS Bi or Bi/Ti non-overlap (Geodata International, 1975 and 1979)
- ⊙ HSSR anomalous areas (well water) (ORGDP, 1981)
- ◇ HSSR follow-up anomalous well-water samples (ORGDP, 1981)
- ★ Anomalous gamma-ray well logs

URANIUM RESOURCE EVALUATION
ISSUED BY THE U.S. DEPARTMENT OF ENERGY

BASE MAP CONTROL FROM USGS

Plate 37. COMPOSITE MAP OF SUPPORTIVE URANIUM FAVORABILITY CRITERIA