URANIUM RESOURCE EVALUATION
AMARILLO QUADRANGLE
TEXAS

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ABSTRACT

Uranium resources of the Amarillo Quadrangle, Texas, were evaluated, using criteria established for the National Uranium Evaluation (NURE) program, to a depth of 1500 m (5,000 ft) using available surface and subsurface information. No surface uranium occurrences were reported in the literature. Areas of anomalous radioactivity, interpreted from an aerial radiometric survey, and geochemical anomalies, interpreted from hydrogeochemical and stream-sediment reconnaissance, were investigated. No uranium occurrences were located during a detailed rock sampling program. Areas of uranium favorability in the subsurface were evaluated using driller's log descriptions and gamma-ray well logs. On the basis of subsurface data, five areas of uranium favorability were delineated within the quadrangle. Two areas in the Triassic Dockum Group are in sand-rich facies. Two areas are in thick arkosic alluvial fan and fluvial facies of Early Permian and Pennsylvanian age. Early Permian arkosic strata cover the greatest area. One favorable area along and northeast of the Amarillo Uplift is characterized by abundant gamma-ray log anomalies that are concentrated in Wolfcampian (Early Permian) and older strata. Geologic units considered unfavorable are all Pleistocene strata, all the Tertiary Ogallala Formation, most of the Triassic Dockum Group, all post-Wolfcampian Permian strata, and parts of Lower Permian, (Wolfcampian) and Pennsylvanian rock units. Recommendations for improving the reliability of this evaluation include drilling test holes for detailed subsurface information.

INTRODUCTION

PURPOSE

The Amarillo National Topographic Map Service Quadrangle, Texas (scale 1:250,000), was evaluated to identify and delineate areas and geologic units favorable for the occurrence of uranium deposits. All geologic units to a depth of 1500 m (5,000 ft) were evaluated by means of surface and subsurface investigations. Each geological unit was categorized as favorable, unfavorable, or not evaluated for uranium deposits, based on recognition criteria obtained from the study of significant uranium districts worldwide (Mickle and Mathews, 1978).

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SCOPE

Evaluation of the Amarillo Quadrangle was conducted by The University of Texas, Bureau of Economic Geology (BEG) under subcontract to Bendix Field Engineering Corporation (BFEC) for the National Uranium Resource Evaluation (NURE) program, managed by the Grand Junction Office of the U. S. Department of Energy (DOE). The evaluation program began March 31, 1978, and ended March 31, 1980. Time spent in literature search, field work, evaluation of data, and in preparation of the final report totaled approximately six man-years by the author and other BEG personnel.

PROCEDURES

An examination of both the surface and the subsurface geology was required for evaluating uranium potential in the Amarillo Quadrangle. Objectives of the surface geologic investigations were (1) to locate and determine the source of aerial radiometric anomalies (Geodata International, Inc., 1976), (2) to check areas with geochemical anomalies shown by results of the Hydrogeochemical and Stream-Sediment Reconnaissance (HSSR) Program (Oak Ridge Gaseous Diffusion Plant (ORGDP), 1979), and (3) to perform a general reconnaissance of the geologic environments exposed in surface outcrops. To carry out these objectives, samples of rock and soil were collected and submitted to BEG Mineral Studies Lab (MSL), Austin, Texas, for geochemical analysis. Detailed geologic descriptions of the areas sampled and general observations of the mineralogy, lithologies, and sedimentary structures seen in outcrop were recorded. A portable scintillometer, the geoMetrics Model GR-101A, was used to measure gross gamma counts of all sampled horizons and to determine the characteristic background radiation level for each geologic formation.

Rock and soil samples were analyzed according to techniques outlined by Ho and Dupre (1980) and Ho, Calvo, and Tweedy (1980). Total uranium in rock and acid-leachable uranium in soil samples were analyzed fluorometrically (Ho and Dupre, 1980). The remaining elements (Na, K, Mg, Ca, Al, Fe, Ti, Co, Cr, Cu, Mn, Ni, V, Zn, As, Cd, Mo, Pb, Sb, Se, Sn, Li, Be, Sr, Ba, Zr, Th, B, and P) were analyzed by inductively coupled plasma atomic emission spectrometry (Ho, Calvo, and Tweedy, 1980).

Evaluation of the subsurface geologic environments required examination of geophysical, lithologic, and water well driller's logs on file in Austin, Texas, at the Texas Department of Water Resources, and at The University of Texas BEG.

Subsurface maps of the Ogallala Formation were constructed using closely spaced water well driller's logs on file at the Texas Department of Water Resources, Austin, Texas. All subsurface maps of units below the Ogallala were constructed from gamma-ray, resistivity, and lithologic logs on file at the BEG and the Texas Department of Water Resources.

GEOLOGIC SETTING

The Amarillo 1° by 2° Quadrangle, an area of 20,420 km^2 (7,975 mi^2), is located in the Panhandle of Northwest Texas between lat 35°00'00"N. and 36°00'00"N., and long 100°00'00"W. and 102°00'00"W. (Fig. 1).

The physiography of the survey area is controlled by the surface geology and the Canadian River. The dissected terrain around the Canadian River is the Canadian Breaks. The area underlain by the cover sands and the Ogallala Formation forms the Great Plains physiographic province. In the southeastern part of the quadrangle, the area of Permian outcrop lies within the Osage Plains of the Central Lowlands Province.

Major structural elements in the survey area (Fig. 2) include the structurally positive Amarillo Uplift, which is flanked on the north by the Anadarko Basin and on the south by the Palo Duro Basin. Up to 3000 m (10,000 ft) of movement is associated with faults flanking the late Paleozoic Amarillo Uplift. Both the Anadarko and the Palo Duro Basins are filled exclusively with sedimentary rocks. Stratigraphic nomenclature and generalized lithologic descriptions are summarized in Figure 3.

Precambrian crystalline rocks occur in the subsurface above 1500 m (5,000 ft) along the crest and flanks of the Amarillo Uplift. A thin pre-Pennsylvanian section which includes Cambrian sandstone, Ordovician dolomite, and Mississippian limestone was deposited in the area, but erosion has stripped these deposits from the crest of the uplift. These rocks were deposited before the initiation of the Amarillo Uplift and basin development (Dutton and others, 1979), and only erosional remnants are preserved.

Mixed carbonate-clastic rocks compose the Pennsylvanian section, which records the initiation of uplift and basin formation. Tectonic activity strongly influenced sedimentation patterns (Dutton and others, 1979). Alluvial fan and fan delta granite wash and sandstone are interbedded with marine carbonates and dark shales.

The Permian carbonate-clastic-evaporite-red-bed sequence records the transition from maximum marine transgression in the Lower Permian to basin filling in the Upper Permian. Alternation of uplift and basin subsidence with facies progradation during the Lower Permian (Wolfcampian) resulted in the deposition of complexly interbedded carbonates, shale, and coarse clastics. Upper Permian evaporites and red beds were deposited in restricted back-shelf and sabkha environments.

Triassic Dockum Group strata occur in the western part of the survey area and include continental clastics and red beds deposited in a major lacustrine basin by rivers, deltas, and fan deltas (McGowen, Granata, and Seni, 1979).

The Tertiary Ogallala Formation was deposited on an erosional surface developed on Triassic and Permian strata. The Ogallala accumulated in a widespread wet alluvial fan system from debris shed off the Rocky Mountains (Seni, 1979). Pleistocene (Illinoian) eolian cover sands blanket the Ogallala to form the High Plains surface. The High Plains surface is dotted by playa depressions (Wisconsinan) formed by wind and stream erosion. The playa fill is predominantly clay and silt; coarser clastics accumulate around the periphery. Fluvial sand and gravel, eolian sand, and alluvium occur along the Canadian River and along major drainages.

ENVIRONMENTS FAVORABLE FOR URANIUM DEPOSITS

In total, five areas in the Amarillo Quadrangle are considered favorable for uranium deposits (Plate 1). The five areas are grouped into two genetically related regions (Areas A, B; Areas C, D, E), both of which occur in the subsurface and are considered favorable on the basis of indirect and direct evidence. Indirect evidence is the favorable recognition criteria for uranium occurrences--that is, favorable host rock, uranium source, and reductants (Areas A, B, C, D). Direct evidence is the presence of grouped gamma-log radioactivity anomalies (Area E). Airborne radiometric and geochemical surveys (water, rock, and soil samples) were unsuccessful in determining the favorable areas.

No surface uranium occurrences were located during the surface sampling program which included analysis of 1,120 rock and soil samples (Plates 2, 5, 8, 14, and 31).

Because uranium occurrences, favorable recognition criteria for the surface exposures of the formations, and significant radiometric and geochemical anomalies were lacking, conditions are not favorable for the occurrence of surficial uranium deposits.

DOCKUM GROUP (TRIASSIC)

Two areas of the Dockum Group (Areas A, B) are favorable in the subsurface for uranium occurrences of Subclass 244 because (1) uranium occurrences west and south of the Amarillo Quadrangle, (2) favorable sand-rich host-rock characteristics, (3) uranium source rocks--Pleistocene Pearlette ash and Triassic volcanic ash, and (4) organic debris in fluvial sequences act as uranium reductants.

Stratigraphy and Structure

The Dockum Group (Triassic) consists of mudstone, siltstone, sandstone, and conglomerate deposited in a lacustrine basin covering 150,000 km^2 (60,000 mi^2) in eastern New Mexico and western Texas (McGowen, Granata, and Seni, 1979). The Dockum is exposed in a small area of the Amarillo Quadrangle along the Canadian River and in upper Palo Duro Canyon. Numerous uranium occurrences have been reported in Triassic rocks west (Finch, 1975) and south (Amaral, 1979; Finch, 1975; McGowen, Granata, and Seni, 1979) of Amarillo Quadrangle. No surface uranium occurrences have previously been reported in the Amarillo Quadrangle and none were found during this investigation. Two oil field gamma-log anomalies were located (Plate 16, Appendices B and D) in Triassic strata.

In the Canadian River and Palo Duro Canyon areas, the Triassic Dockum Group rests unconformably on Permian strata and is overlain unconformably by the Tertiary Ogallala Formation. Erosion has removed Triassic deposits from the eastern twothirds of the quadrangle. The maximum thickness of the Dockum Group (Plate 17) is more than 200 m (600 ft) in the southwestern part of the quadrangle. As a result of post-Triassic erosion the Dockum Group thins toward the east and north and structure on the top of the group (Plate 19) indicates dip to the northeast. Structure on the base of the Dockum Group (Plate 18) illustrates general basinward thickening toward the west and south. Permian structural elements had little effect on Dockum sedimentation.

Lithology

The lithology of the Dockum Group in the Amarillo Quadrangle varies from reddish-brown and greenish-gray mudstones, to reddish-brown, light greenish-gray, and light brown sandstones and conglomerates. Coarse clastics are composed predominantly of quartz and sedimentary rock fragments (mudclasts, limestone clasts, caliche clasts, and chert). Organic material is present as carbonized logs at the base of channel sequences. Amaral (1979) has described carbonaceous material in fine-grained deposits in the lower reaches of the Palo Duro Canyon.

Depositional Environment

According to McGowen, Granata, and Seni (1979), the Dockum Group accumulated in a sedimentary lacustrine basin that was filled peripherally. Alluvial fan and fan-delta deposition were dominant in the Amarillo Quadrangle. Climate cycles affected lacustrine base level by producing changes in lake area and depth, resulting in deposition of multiple progradational sequences. Typical humid-cycle deposits are thin, progradational sequences consisting of basal lacustrine mudstones overlain by fluvial deltaic sandstone conglomerate. During arid-climate cycles, base level was lowered, and previously deposited sediments were eroded. Typical arid cycle sediments are red beds, thin lacustrine mudstones, fan deltas, and thick fluvial deposits. Subsurface percent sandstone trends (Plate 20) indicate a northeasterly sediment source, possibly the Amarillo Uplift - Wichita Mountains system or the Ouachita tectonic belt.

Uranium Mineralization and Hydrology

No uranium occurrences or minerals were located in surface Dockum Group rock samples by this survey (Plate 21). Amaral (1979) noted 10 uranium occurrences in Triassic rocks in Palo Duro Canyon and Tule Canyon. He found the uranium associated with carbonized wood and plant debris in both fine- and coarse-grained host rocks; however, no uranium minerals were found.

Hydraulic information on Triassic ground water in Amarillo Quadrangle is scant (Fink, 1963; Rayner, 1965) because of the thin, truncated Triassic section. Rayner (1965) showed that around the exposed margin of the Dockum Basin, Triassic ground water is relatively fresh. Toward the basin center, concentrations of dissolved solids in ground water increase.

Favorable Areas

Areas A, B. The favorable sand-rich parts of the Dockum Group occur in the subsurface and are outlined by sandstone percentages greater than 40 % (Plate 20). In Areas A and B, Subclass 244 sandstone-type uranium deposits are expected. The favorable part of the Dockum (Areas A, B) covers approximately 1300 km^2 (500 mi^2). Thickness averages 60 m (180 ft), and the volume of favorable rock is about 80 km^3 (20 mi^3). Areas A and B are separated by the Canadian River valley.

The occurrence of uranium source and reductants is evidenced by uranium occurrences in Triassic strata west (Finch, 1975) and south of Amarillo Quadrangle

(Amaral, 1979; McGowen, Granata, and Seni, 1979; Finch, 1975). According to Amaral (1979), the uranium source is uncertain. He favors a source in Triassic volcanic ash. An alternative or additional source is Pleistocene Pearlette ashes.

Isopach, structure contour, and sandstone percentage maps (Plates 17, 18, 19, 20 and 23) were constructed using oil field gamma logs. A southwesterly and westerly trend in sand percentage locates the sites of maximum fluvial input and the areas with most favorable host-rock characteristics. The southwesterly transport direction indicates that the source area of these sandstones was the Amarillo Uplift - Wichita Mountain system (McGowen, Granata, and Seni, 1979).

Uranium reductants include the organic debris at the base of fluvial sequences and within fine-grained units (Amaral, 1979; McGowen, Granata, and Seni, 1979). The upward migration of Permian hydrocarbons toward discharge points along the Canadian River is a mechanism to bring additional uranium and uranium reductants into Triassic strata.

Although Dockum Group surface exposures did not indicate anomalous uranium concentrations (highest uranium values of rock samples from eight sample locations ranged from 2.0 to 14 ppm), favorable host rock, possible uranium source rock, and reductants were present in the subsurface. The Hydrogeochemical and Stream-Sediment Reconnaissance sampling program (ORGDP, 1979) indicated some anomalous uranium concentrations in Triassic ground water associated with B, Mg, Ca, Sr, Ba, Na, Li, SO_4, and Se.

Drainage, Generalized Land Status, and Culture

Areas B (north of the Canadian River) and C (south of the Canadian River) are both overlain by poorly drained cover sands, dissected Ogallala Formation, and

Dockum Group strata. The terrain in Area B is composed primarily of Ogallala bedrock and a small amount of Dockum strata in South Plum Creek. Cover sands overlie most of Area C. Dissection occurs near Palo Duro Canyon and Mulberry Creek. Playas are abundant in Area C but rare in Area B. All of Area B is under private ownership, Dumas being the largest city. The Pantex Ordnance Plant, a Federal installation, and Texas Technological College Research Farm, State of Texas withdrawal, occur in Area C. The remaining part of Area C is under private ownership. Claude is the largest town in Area C.

LOWER PERMIAN - UPPER PENNSYLVANIAN

Three areas of the Lower Permian - Pennsylvanian (Areas C, D, and E) are favorable in the subsurface for uranium occurrences of Classes 130, 210, and 240 because (1) host-rock characteristics are favorable, (2) favorable host rocks include first-cycle arkosic debris derived from and adjacent to uranium source rocks, (3) uranium source rocks include Precambrian granite and rhyolite, (4) uranium reductants oil, gas, and minor coal, and (5) occurrence of abundant gamma-ray log radioactivity anomalies indicate that the distribution of radioelements in the subsurface is widespread.

Lower Permian - Upper Pennsylvanian strata in Amarillo Quadrangle are known exclusively through subsurface data. Uplift, basin subsidence, and facies progradation formed a range of complexly interbedded environments capable of hosting broad classes of uranium deposits. Potential classes of uranium deposits include sandstone Class 240 in alluvial fans, Class 130 in marine black shales, and Class 210 in carbonaceous (coaly) strata.

In Amarillo Quadrangle, Lower Permian Wichita Group (Wolfcampian Series) and Upper Pennsylvanian Canyon and Cisco Group strata occur in the subsurface, and all data are derived from analysis of oil field gamma-ray logs and sample logs (Plates 22, 23, 24, and 25; Appendix C). Favorable Areas C and D are thick accumulations (greater than 60 m [200 ft]) of arkosic debris and coarse clastics deposited in alluvial fans and fan deltas flanking the north and south sides of the Amarillo Uplift. Area E outlines the area where eight or more gamma-ray log anomalies occur in Wolfcampian strata within a 7 1/2-minute quadrangle. In addition to favorable host rocks, these environments are adjacent to and are derived from uranium source rocks (uplifted, Precambrian rhyolite and granite). Uranium reductants include abundant oil, gas, hydrogen sulfide, and minor coal.

Favorable Areas

Areas C, D. Favorable Areas C and D are outlined by accumulations of greater than 60 m (200 ft) of arkosic granite wash and coarse clastics. These accumulations are alluvial-fan and fan-delta deposits composed of granite wash and feldspathic sandstone interbedded with varicolored and locally pyritic shale and marine carbonates. Thick accumulations of Permian granite wash occur both north and south of the Amarillo Uplift (Fig. 4). Favorable strata above 1500 m (5,000 ft) subsurface are concentrated in the southeastern corner of the Amarillo Quadrangle. These deposits resulted from tectonic activity -- faulting and uplift -- along the Amarillo Uplift from Late Pennsylvanian to Early Permian time. Because no unconformity separates Permian and Pennsylvanian rocks, favorable Areas C and D are discussed together.

Favorable Lower Permian strata covers a greater area and is much thicker than favorable Pennsylvanian strata. A comparison of favorable Area C in Plate 1 with the granite wash isopach map in Plate 27 shows that favorable Area C is composed primarily of Permian granite wash. Additional favorable Pennsylvanian granite wash (Plate 28) underlies favorable Permian rock. Structure of the top of the granite wash is shown in Plate 26. Depth to the top of granite wash ranges from 550 to 1500 m (1,700 to 5,000 ft) subsurface.

Favorable Permian environments cover approximately 7000 km^2 (2,700 mi^2), and range in thickness up to 700 m (2,200 ft). The average thickness is 300 m (1,000 ft). If the arkosic and feldspathic sandstone compose 25 percent of the granite wash interval, then the volume of favorable rock is approximately 525 km^3 (130 mi^3).

Favorable Pennsylvanian granite wash (part of Area C, Plate 1; Plate 28) and sandstone (Plate 29) occur in a limited area (approximately 750 km^2; 300 mi^2) above 1500 m (5,000 ft) subsurface. Thickness of favorable Pennsylvanian strata averages 100 to 150 m (300 to 450 ft). Approximately 25 km^3 (2 mi^3) of Pennsylvanian strata are favorable. The northwestern part of Area C is composed of Pennsylvanian granite wash that thins towards the north. Area D is favorable Pennsylvanian sandstone that was deposited in basinal facies north of arkosic granite wash. Maximum thickness of Pennsylvanian sandstone above 1500 m (5,000 ft) subsurface is approximately 60 m (200 ft).

In addition to favorable uranium host-rock conditions, favorable Permian and Pennsylvanian environments are composed of first-cycle arkosic clastics that were shed from a uranium source -- the Precambrian granite-rhyolite terrain. Tectonic activity associated with the Amarillo Uplift may have been accompanied by volcanism, another excellent uranium source. Uranium reductants include abundant oil, natural gas and hydrogen sulfide associated with the Panhandle Oil and Gas Field. Sample log descriptions in the granite wash interval indicate reducing conditions by the presence of pyrite, black shales, and minor coals and coaly material. Classes of uranium deposits include sandstone (Class 240), marine black shales (Class 130), and other carbonaceous deposits (Class 210).

Drainage, Generalized Land Status, and Culture

Areas C and D extend from the southeast corner to the northwest and northern parts of Amarillo Quadrangle. The physiography of Area C varies from the Osage Plains of the Central Lowlands in the east, and crossing the High Plains, to the Canadian River valley in the northwest. Drainage is typically well developed in the Osage Plains and along the Canadian River valley. Drainage of the High Plains is poorly integrated. Most of Area D lies north of the Canadian River and is composed predominantly of Ogallala bedrock dissected by tributaries of the Canadian River. Drainage is poorly developed in the northern one-third of Area E. All of Area E and most of Area C is under private ownership. Lake Meredith National Recreation Area covers about 25 km^2 (10 mi^2) in the northwestern corner of Area C and Lake McClellan National Grassland Park covers 15 km^2 (6 mi^2) in the southwestern part of Area C. Area C is elongated northwest-southeast along the trend of the Panhandle Oil and Gas Field. The main cities in Area C are Shamrock, Pampa, and Borger. No communities occur within Area D.

WOLFCAMPIAN (LOWER PERMIAN)

Favorable Area

Area E. Environments within Wolfcampian (Lower Permian) Area E are similar to favorable environments in Lower Permian and Pennsylvanian Areas C and D. Host rocks in Area E include granite wash, marine carbonates, and black shale. Favorable recognition criteria are similar to Areas C and D. Area E outlines the area where eight or more gamma-ray log anomalies occur in each 7 1/2-minute quadrangle. Because recognition criteria in Area E are similar to recognition criteria in Areas C and D, the classes of uranium deposits are similar. Classes of uranium deposits in Area E include sandstone Class 240 in alluvial fans, Class 130 in marine black shales, and Class 210 in carbonaceous (coaly) strata. Area E is the outline of the area in Amarillo Quadrangle having the highest frequency and greatest number of gamma-ray log anomalies. Gamma-log anomalies were defined by a log response that is twice the normal shale background (30 to 80 API units). Log response in the anomalous areas ranged from 100 to greater than 250 API units (6 to 21 μgm Ra eq/ton). Appendix D is a list of wells in Amarillo Quadrangle with gamma-log anomalies.

The exact significance of the gamma-log anomalies is uncertain. Natural sources of gamma radiation include radioactive elements of the thorium and uranium series and radioactive potassium isotope (K^{40}). Therefore gamma-log anomalies could represent K^{40}-rich arkoses and feldspathic sandstones, black shales, and radioactive decay products, as well as anomalous concentrations of uranium.

Figure 5 and Plate 30 illustrate the stratigraphic occurrence and areal distribution of gamma-log anomalies, respectively. The anomalies are concentrated in Wolfcampian (Permian) black shale, carbonate, and granite wash. The coincidence of anomalies along and on the northern side of the Amarillo Uplift suggests structural control and perhaps a relationship with oil and gas migration.

Drainage, Generalized Land Status, and Culture

The Canadian River and its tributaries cut across the northwest-southeast orientation of Area E. Small areas (approximately 100 km^2; 40 mi^2) at the northwestern and southeastern ends of Area E occur along the dissected margin of the High Plains. A corner of the Lake Meredith National Recreation Area occurs within Area E. Area E is elongated along the trend of the Panhandle Oil and Gas Field. Borger is the largest city in Area E.

ENVIRONMENTS UNFAVORABLE FOR URANIUM DEPOSITS

Many formations within the Amarillo Quadrangle are considered unfavorable for uranium deposits. Unfavorable environments are (1) all Pleistocene and younger deposits, (2) the Ogallala Formation, (3) all post-Wolfcampian Permian formations, and (4) parts of Lower Permian - Upper Pennsylvanian units outside the area of favorability.

Radiometric and geochemical data indicate no significant radiometric or geochemical anomalies that would indicate surface or shallow subsurface uranium occurrences in the Amarillo Quadrangle.

PLEISTOCENE AND YOUNGER DEPOSITS

Pleistocene cover sands, alluvium, and fluvial deposits were judged to be environments unfavorable for uranium deposits because of limited thickness and areal extent and low uranium values from rock and stream-sediment samples. These surficial deposits are characterized by high transmissivities and oxidizing conditions. Any contained uranium (exclusive of uranium associated with resistate minerals) would be mobilized and redistributed downdip by infiltrating meteoric waters.

Although a number of airborne radiometric anomalies are associated with Pleistocene playa deposits, they were also considered unfavorable for uranium occurrences because of the limited thickness and extent. The airborne radiometric anomalies are caused by the contrast in background radiation between the cover sands (10 to 20 counts per second) and the higher (30 to 40 counts per second) clay-rich playa sediments.

Samples of Pleistocene ash deposits (MHA-732 and MHA-733) in the southwestern part of the quadrangle had low uranium values. These ash units were also considered unfavorable for uranium deposits because of limited thickness and extent, low uranium values, and high transmissivities.

OGALLALA FORMATION

The Ogallala Formation was judged to be unfavorable for uranium deposits because of the following combination of characteristics: open basin hydraulic conditions (Taylor, 1979) which would allow oxidizing ground water to flush highly transmissive, porous sands and gravels; lack of reductants; low uranium values in Ogallala rock samples; and presence of pedogenic caliche (after Reeves, 1970) (versus nonpedogenic caliche, after Carlisle and others, 1978).

To understand better factors controlling uranium distribution in the Ogallala Formation, subsurface maps were prepared. These maps include Ogallala isopach (Plate 11), structure base of Ogallala (Plate 12), and net sand and gravel (Plate 15). Strike and dip cross sections were also prepared (Plates 9 and 10).

A widespread grid of Ogallala outcrops was sampled (Pl. 13, Appendix A). Anomalous uranium values (maximum 36 ppm in sample MHA-982) occur in opalized sandstone, gravel, and caliche. Similar occurrences were noted in the Plainview

Quadrangle (Amaral, 1979) and the Lubbock Quadrangle (McGowen and others, in press). A study of sedimentary uraniferous silicates (Zielinski, 1979) indicates this type of uranium occurrence would have very low economic potential. Uranium is concentrated with silica by adsorption of uranium ions on silica gel. At best, the concentration of uranium in the silicate is 400 to 1,000 times higher than the concentration of uranium in ground water.

If, given the maximum concentration of uranium in Ogallala ground water in the Amarillo Quadrangle (maximum 40 ppb, 85th percentile, 7.5 ppb, Hydrogeochemical and Stream-Sediment Reconnaissance, ORGDP, 1979), and given the maximum 1,000 times concentration increase, then the maximum range expected for uranium content in these silicates would be from 7.5 to 40 ppm. This agrees well with the maximum values observed in the Amarillo Quadrangle. The low grade and the difficulty of separating silica and uranium indicate this type uranium occurrence has a very low resource potential. Except for such submarginal uranium associated with silicified zones, the uranium content of Ogallala caliche and rock samples is very low.

The pedogenic caliche in the Ogallala Formation has little in common with the highly uraniferous caliche at Yeelirrie, Western Australia (Carlisle and others, 1978). Differences in ground-water flow patterns and open basin hydrologic conditions make the Ogallala caliche an environment unfavorable for uranium occurences. A network of soil samples overlying Ogallala caliche failed to reveal anomalous uranium concentration (Plate 17).

OTHER PERMIAN FORMATIONS

Permian strata above the Wolfcampian consist of interbedded carbonates, evaporites, and red beds. Geochemical analysis of 605 rock samples from a grid network over the Quartermaster and Blaine Formations revealed no significant uranium occurrences (Pls. 5 and 31). Rocks were generally oxidized, except for thin (2 to 10 cm; 1 to 5 inches thick) reduced zones below many gypsum and sandstone beds. Rock samples from four Permian outcrops within a widespread airborne radiometric (Pl. 3) and ground-water anomaly (Pl. 4, Area I) had a range of uranium values from 1.2 to 9.0 ppm.

Although uranium values in ground water from Permian formations are high in local areas (Pl. 4), the association of uranium with high dissolved solids (moderate uranium-to-conductivity ratio) and with an evaporative suite of trace elements suggest that the areas are not favorable for uranium deposits.

Analysis of gamma-log anomalies provides some understanding of the distribution of radioelements in the subsurface. The gamma log is the standard tool for subsurface correlations in the Amarillo Quadrangle. The gamma log effectively differentiates lithologies on the basis of small changes in the amount of natural radioactivity present in various lithologies (Schlumberger, 1972). A gamma log radioactivity anomaly is defined as a log response twice (2X) normal shale baseline.

In strata younger than the Wolfcampian, gamma-log radioactivity anomalies are sparse. Only 12 percent of all gamma-log anomalies occur in post-Wolfcampian strata (Fig. 5). Four percent of all gamma-ray log anomalies occur in Leonardian strata that contain minor uraniferous asphaltite associated with the Panhandle Oil and Gas Field and structural highs in the Amarillo Quadrangle (Fig. 6).

According to Pierce and others (1964), the migration of uranium-bearing oil and gas is related to the occurrence of uraniferous asphaltite in the Amarillo Quadrangle. They described a Leonardian red-bed and caprock sequence with 10 to 20 ppm uranium distributed throughout an 85 m (230 ft) section in Moore County at a depth of 700 m (2,200 ft). Uranium is concentrated up to 1 percent in asphaltite nodules. The asphaltite is estimated to average 0.5 percent by weight of the rock. The mean uranium content of mineralized drill samples is calculated to be about 50 ppm (Pierce and others, 1964). On a regional scale, the relative abundance and distribution of uraniferous asphaltite is unknown (Handford and Granata, 1979). Both Pierce and others (1964) and Handford and Granata (1979) suggest that asphaltite is an epigenetic product derived from petroleum. Paragenetic relationships indicate that the uranium was introduced by aqueous solutions after the asphaltite (Pierce and others, 1964).

Post-Leonardian Permian formations, including the Tubb, Blaine, Seven Rivers, Whitehorse, and Quartermaster, are unfavorable for uranium deposits because unfavorable lithologic, hydraulic, geochemical, and radiometric properties failed to meet recognition criteria for areas suitable for uranium occurrences.

UPPER PENNSYLVANIAN - LOWER PERMIAN

Upper Pennsylvanian and Lower Permian (Wolfcampian and Leonardian) rock units less than 1500 m (5,000 ft) subsurface and outside the area considered favorable are considered unfavorable because uranium host rocks, such as granite wash and sandstone, become thin and pinch out, limestone deposition becomes predominant, and transmissibility probably decreases (Pls. 23, 24, 25, 26, 27, 28 and 29).

INTERPRETATION OF RADIOMETRIC AND HYDROGEOCHEMICAL DATA

Airborne radiometric and hydrogeochemical data were unsuccessful in defining favorable areas. The lack of significant radiometric or geochemical anomalies contributed to the determination of unfavorable environments at the surface.

Radiometric Data

During 1976, an aerial radiometric and total magnetic field survey was flown over the Amarillo NTMS Quadrangle by Geodata International, Incorporated (1976). The survey was flown in an east-west direction along lines 4.8 km (3.0 mi) apart and at a mean terrain clearance of 122 m (400 ft). North-south tielines were flown at 20.8 km (13 mi) intervals at the same terrain clearance. Aircraft speed averaged 225 kmph (140 mph).

Corrected data were statistically analyzed by Geodata using their in-house data processing techniques. The statistically reduced data were interpreted by the Bureau of Economic Geology following the procedure of Saunders and Potts (1978).

Radiometric instrumentation consisted of a 256-channel spectrometer and 54,415 cm^3 (3,320 $inch^3$) of crystal [Na(Tl)] volume. A single 29 cm by 10 cm (6802 cm^3) (11 1/2 inch by 4 inch [415 cubic inches]) sodium iodide crystal was designed to monitor radiation coming from the upper 2π solid angle. Energy ranges used to detect potassium (^{40}K), uranium (^{214}Bi), and thorium (^{208}Tl) were 1.053 to 1.322; 1.322 to 1.638; and 2.410 to 2.796 MeV, respectively.

All data used in this report were corrected for instrument live time, background radiation, atmospheric ^{214}Bi, and to a constant terrain clearance of 122 m.

Three parameters were used to delineate favorable areas for uranium mineralization: high counts per second in the uranium window (^{214}Bi); high counts per second in the uranium/thorium window ($^{214}Bi/^{208}Tl$); and high counts per second in the uranium/potassium window ($^{214}Bi/^{40}K$). Airborne radiometric anomalies are outlined on Plate 3.

Anomalies 1, 2, and 3 in the cover sand are related to local clayey playa deposits that have a background radiation higher than that of the cover sand. Anomaly 4 may be associated with the Pantex Ordnance Plant. Anomalies 5 and 6 at Panhandle and Amarillo, respectively, were not located and are related to cultural features.

Anomalies 7 and 8 in the Ogallala Formation are related to sporadic, low-grade opalized zones in caliche and sand and gravel layers. Maximum uranium concentration from anomalous rock samples was 36 ppm (MHA-982).

Anomalies 9, 10, and 11 in Permian rocks were not located. Rock samples from the area of the anomalies showed little or no uranium enrichment. The radiometric anomalies in Permian rocks may be related to rapid elevation changes, large outcrop exposures or uranium-enriched oil field brines associated with the Panhandle Oil and Gas Field.

Geochemical Data

Two areas in the Amarillo Quadrangle with elevated uranium values were identified by analysis of Hydrogeochemical and Stream-Sediment Reconnaissance data (Pl. 4). Although the uranium values in the ground water in Areas I and II are elevated, these areas are not considered favorable for the occurrence of uranium. Anomalously high uranium in ground water is associated with high dissolved solids and with the location of the Panhandle Oil and Gas Field and suggests that the anomalous uranium concentrations are due to the reducing nature of oil field brines and may represent natural migration of oil field brines or production of oil and gas. The sediment data indicate that uranium is associated with heavy minerals such as zircons.

An evaluation of Hydrogeochemical and Stream-Sediment Reconnaissance (HSSR) data for the Amarillo Quadrangle (Texas) (Oak Ridge Gaseous Diffusion Plant

[ORGDP], 1979) was performed by the BFEC Data Integration Group (G. J. Indelicato, personal communication). Stream sediments and ground-water data were used in the interpretation. Frequency distribution and cumulative probability curves were plotted and analyzed. Multivariant statistical techniques utilized included principal component analysis and step-wise multiple regression of uranium against all other variables. Techniques for interpreting Hydrogeochemical and Stream-Sediment Reconnaissance data are discussed by Garrett and Nichol (1969).

Area I, near Lake Meredith, is identified primarily by anomalous uranium concentrations in ground water (from 10 to greater than 50 ppb). The ground water was produced from Permian Quartermaster Formation, Cloud Chief Gypsum, Whitehorse Sandstone, and Triassic Dockum Group. The variables associated with uranium are B, Mg, Ca, Sr, Ba, Na, Li, SO_4, and Se. Most of these variables are associated geochemically with evaporite sequences, such as the Cloud Chief Gypsum. Uranium-to-conductivity ratios are moderate and suggest that the elevated uranium values are due to the high dissolved solids content.

The Panhandle Oil and Gas Field underlies most of Area I. In the Amarillo Quadrangle, minor uraniferous asphaltite nodules occur 700 m (2,000 ft) subsurface in structurally high Red Caves (Permian) strata that cap the Panhandle Oil and Gas Field.

Area II in Donley and Collingsworth Counties is identified by ground-water and sediment data.

Principal component analyses of the data yields the following geochemical associations. In sediments, the first principal component is due to two heavy mineral associations (a) a spinel series (V, Fe, Sc, Cr, Zn) and (b) a resistate rare earth element mineral series (Y, Ce). The second principal component is due to uranium with a heavy mineral suite (Ti, Nb, Zr). Ground-water data shows similarities with Area I. Uranium in Area II is associated with Mg, Ca, Na, Li, Sr, B, and SO_4. Most of these variables are associated with evaporative sequences.

UNEVALUATED ENVIRONMENTS

The uranium potential of pre-Pennsylvanian strata, including Precambrian crystalline basement, Cambrian sandstone, Ordovician dolomite, and Mississippian limestone, was not studied. The inability to determine uranium potential stemmed from a lack of data, in this case well control. In the Amarillo Quadrangle, the pre-Pennsylvanian section is thin and occurs below the main oil- and gas-producing horizons, and hence is largely undrilled. In addition, only a limited volume of pre-Pennsylvanian strata lies above 1500 m (5,000 ft) subsurface.

RECOMMENDATIONS TO IMPROVE EVALUATIONS

The uranium evaluation of the Amarillo Quadrangle can be improved by addition of detailed subsurface information regarding the uranium potential of Permian and Pennsylvanian arkoses, uraniferous asphaltite, and gamma-log anomalies. A test hole drilling program designed to intercept as many favorable environments as possible is recommended. Test hole drilling is recommended in areas where the uranium favorability of different stratigraphic units overlap at various structural positions.

A drill site 13 km (8 mi) southeast of Panhandle, Texas, will encounter 160+ m (500+ ft) of favorable Tertiary Ogallala strata, 80+ m (250+ ft) of favorable Permian granite wash, and 65+ m (200+ ft) of favorable Pennsylvanian sandstone. A test hole near the crest of the Amarillo Uplift, 10 km (6 mi) north of Pampa, would encounter 100+ m (300+ ft) of favorable Triassic strata, 80+ m (250+ ft) of favorable Permian granite wash, and 8 or more gamma log anomalies (greater than 2 times shale background) in the Paleozoic section. The thickest section of favorable Permian granite wash would be encountered along the Gray-Wheeler county lines 13 km (8 mi) north of Shamrock. Approximately 650 m (2,000 ft) of Permian granite wash occur within 1500 m (5,000 ft) subsurface.

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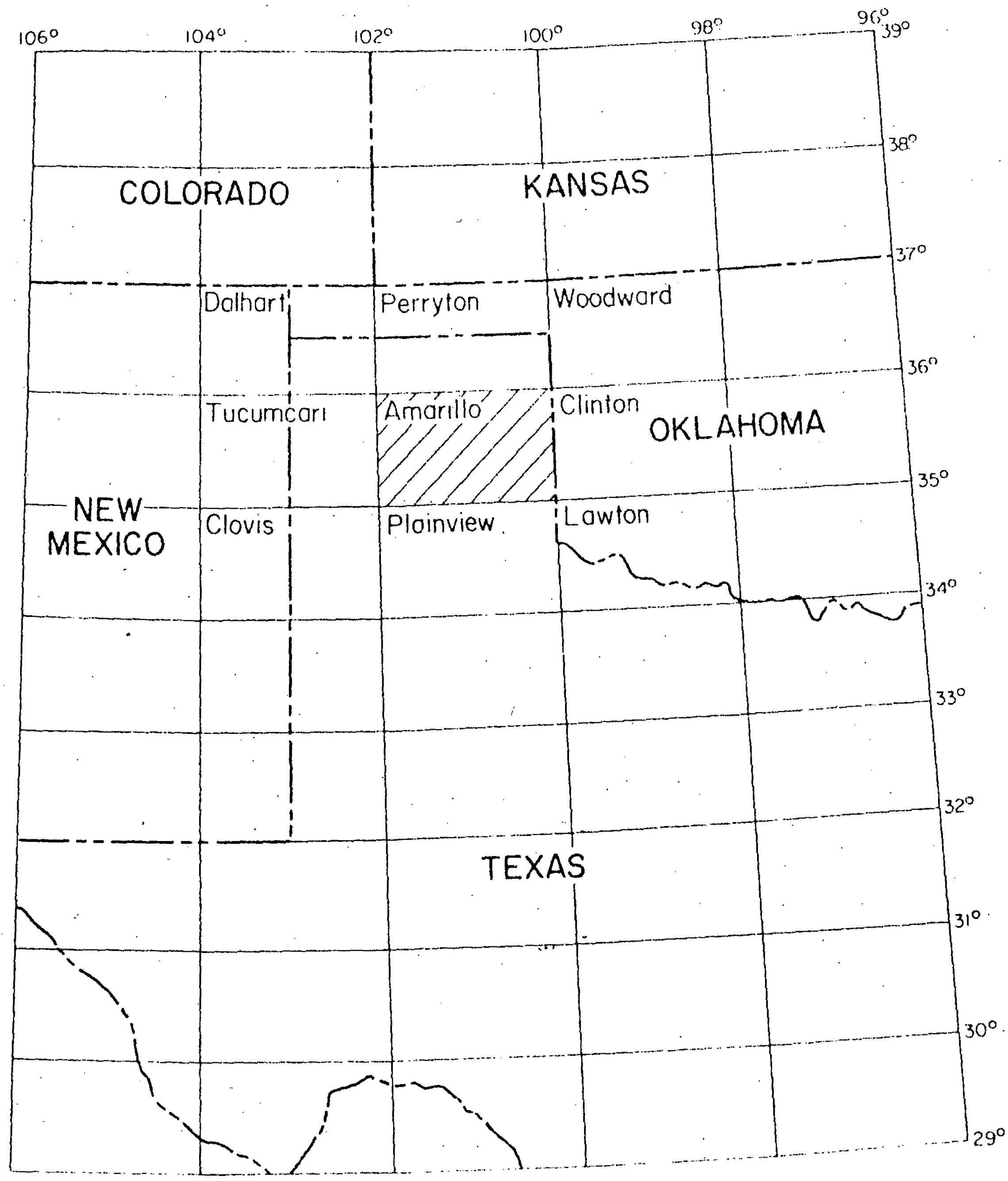
FIGURE CAPTIONS



106°
104°
102°
100°
98°
96°
39°
38°
37°
36°
35°
34°
33°
32°
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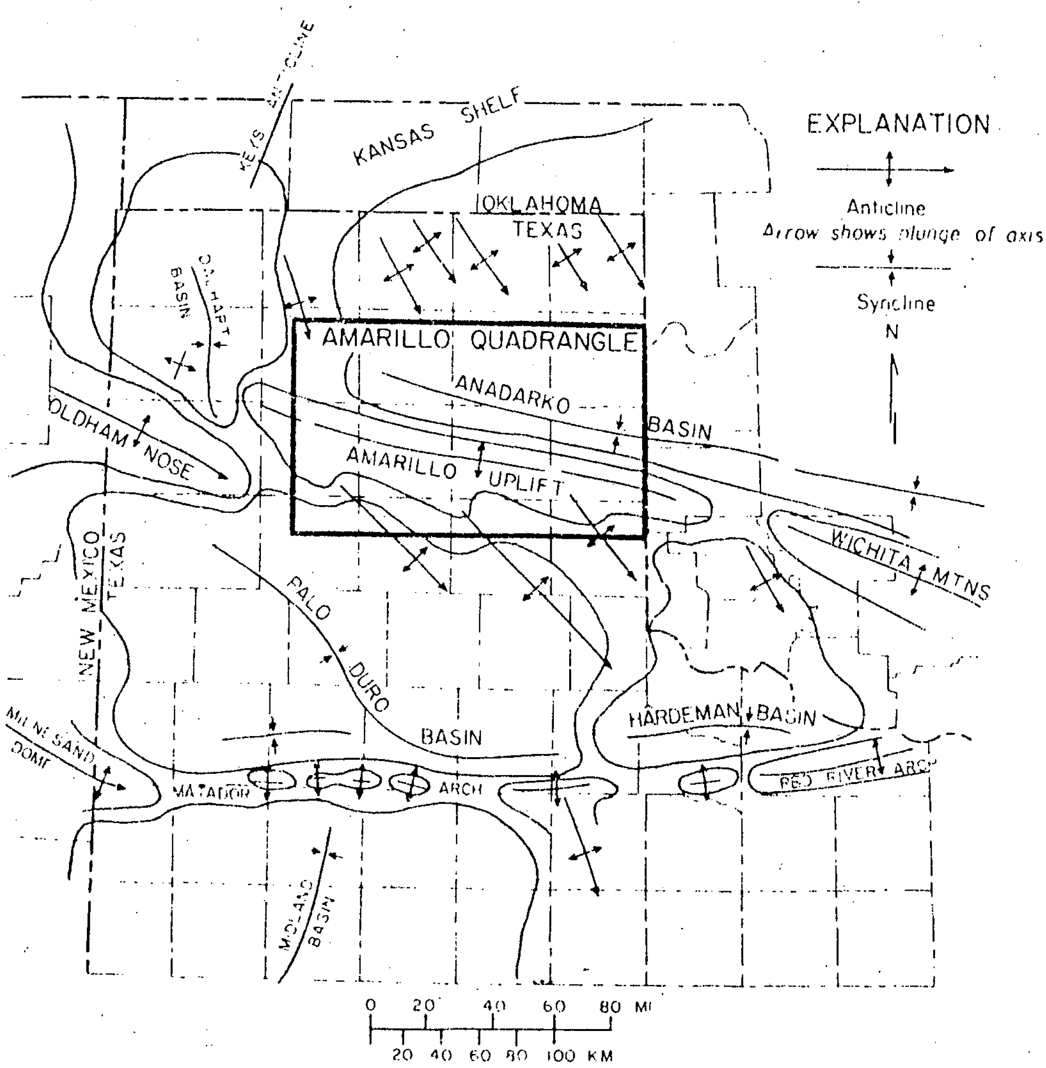
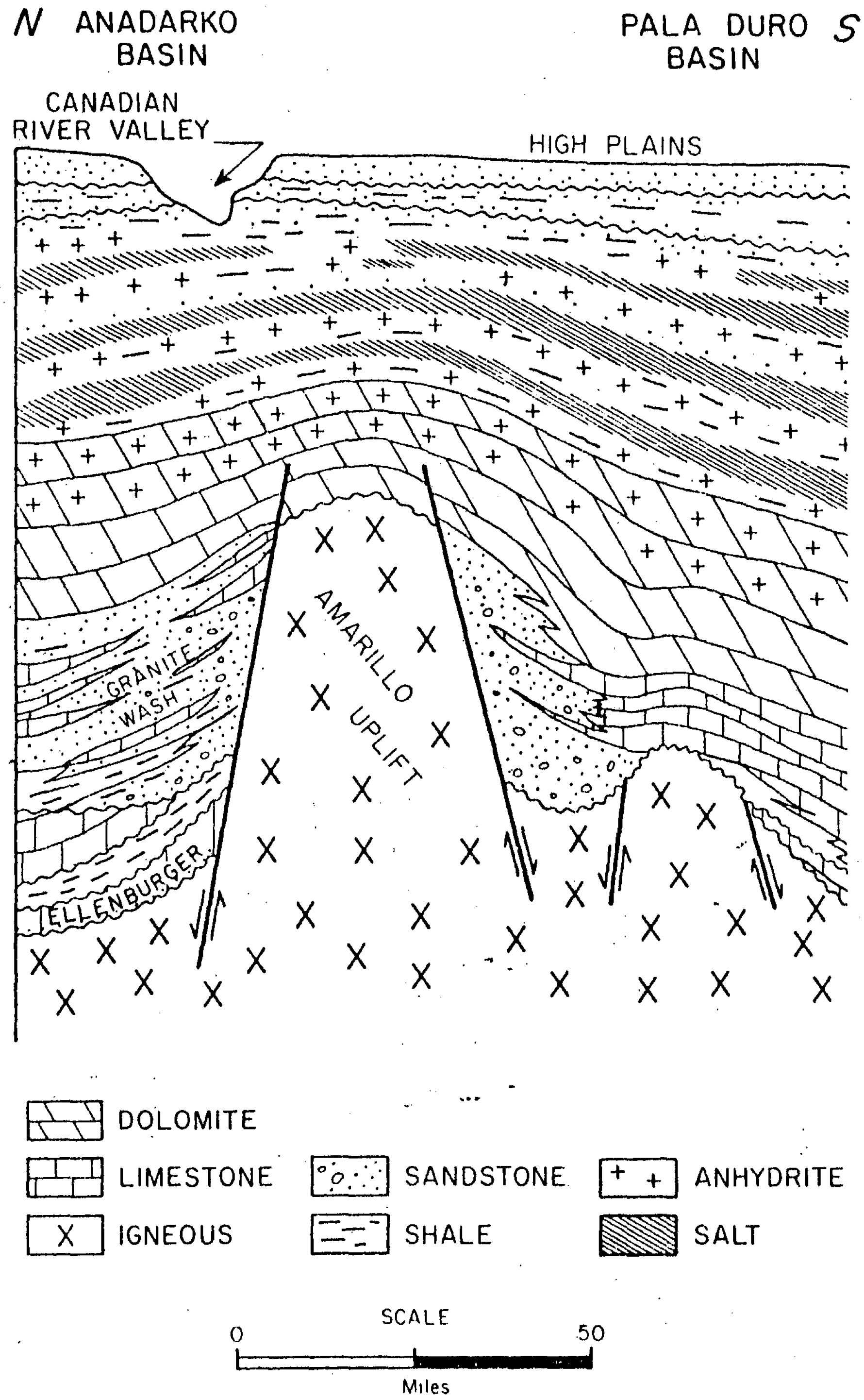
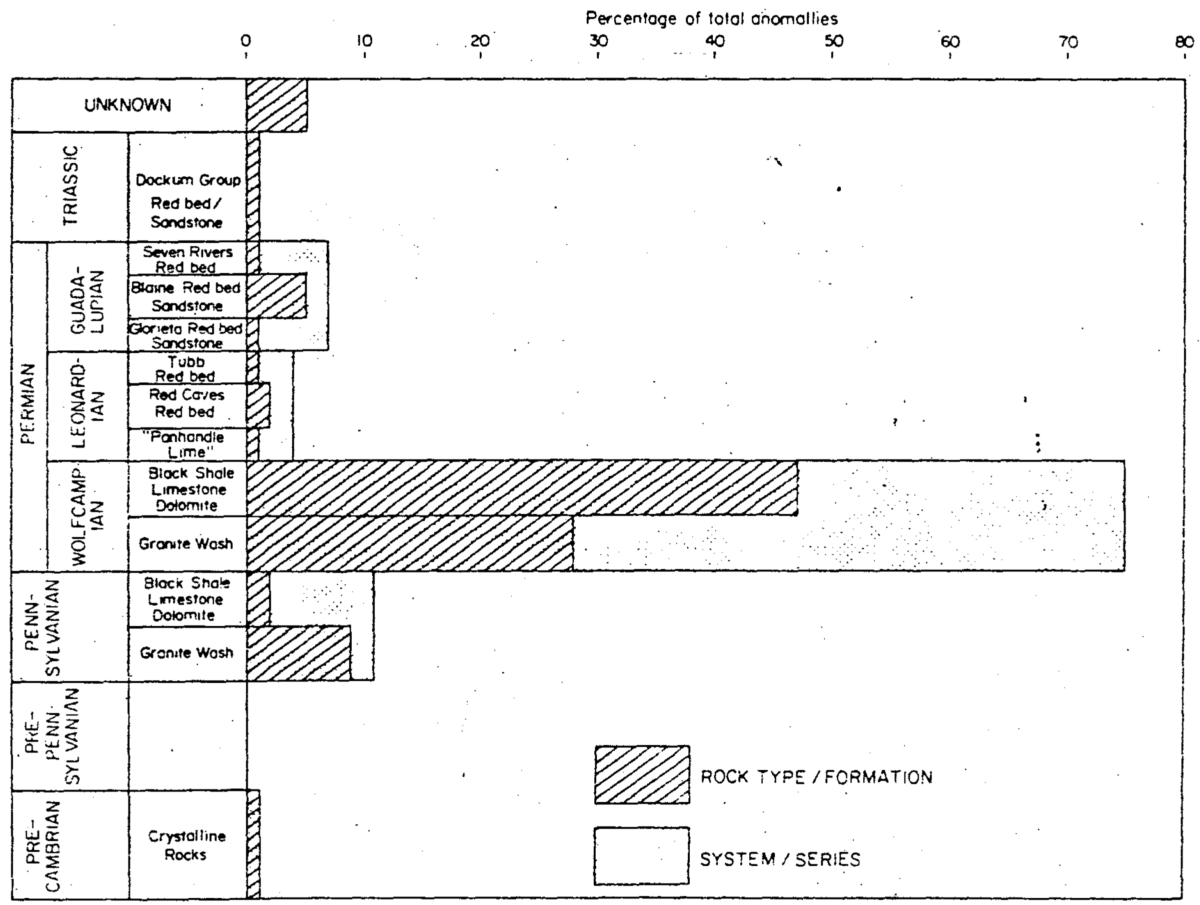
29°
COLORADO
KANSAS
Dalhart
Perryton
Woodward
Tucumcari
Amarillo
Clinton
OKLAHOMA
NEW MEXICO
Clovis
Plainview
Lawton
TEXAS

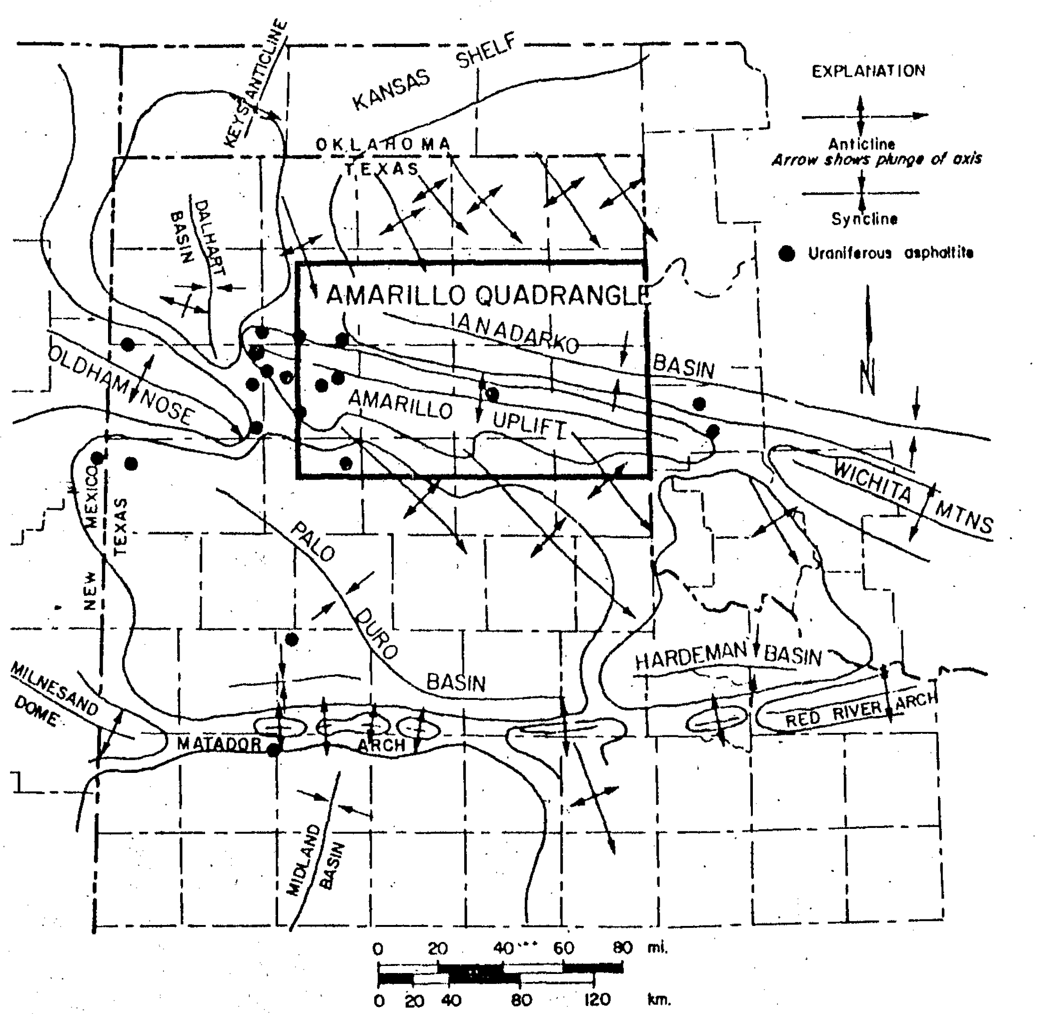

EXPLANATION
Anticline
Arrow shows plunge of axis
Syncline
N
KANSAS SHELF
OKLAHOMA
TEXAS
AMARILLO QUADRANGLE
ANADARKO
BASIN
AMARILLO
UPLIFT
OLDHAM NOSE
WICHITA MTNS
NEW MEXICO
TEXAS
PALO DURO
BASIN
HARDEMAN BASIN
MATADOR
ARCH
RED RIVER ARCH
0 20 40 60 80 MI
20 40 60 80 100 KM

SYSTEM	SERIES	GROUP	FORMATION includes informal names	LITHOLOGY	DESCRIPTION
QUATERNARY	HOLOCENE				Alluvium-floodplain and terrace deposits Wind-blown sand and silt
QUATERNARY	PLEISTOCENE				Fluvatile terrace deposits–gravel, sand and silt Playa deposits–clay and silt; weathers light gray Wind-blown cover sand, calcareous, pink to grayish-red, reddish brown, olive gray
TERTIARY	PLIOCENE		OGALLALA		Sand, silt, clay, gravel, and caliche, locally cemented by calcite and silica, various shades of gray brown and red Gravel, not everywhere present, concentrated at base, composed of pebbles and cobbles of quartz, quartz and chert, minor igneous and metamorphic rocks. Caliche, not everywhere present, concentrated at top, forms caprock
TRIASSIC		DOCKUM			Conglomerate, sandstone, siltstone and shale; locally micaceous, with minor siliceous and lignitic woody debris. Various shades of gray, greenish gray, brown, red, reddish brown, yellow, and purple
PERMIAN	OCHOAN		QUARTERMASTER		Red clay, shale, siltstone, sandstone, granite wash, gypsum, anhydrite, salt, limestone, and dolomite
PERMIAN	GUADALUPIAN	WHITEHORSE	CLOUD CHIEF GYPSUM WHITEHORSE SANDSTONE ALIBATES DOLOMITE SEVEN RIVERS QUEEN/GRAYBURG		
PERMIAN	GUADALUPIAN	PEASE RIVER	BLAINE/ (SAN ANDRES) GLORIETA		
PERMIAN	LEONARDIAN	CLEAR FORK	TUBB RED CAVE		
PERMIAN	WOLFCAMPIAN	WICHITA	PANHANDLE LIME		
PENNSYLVANIAN	UPPER LOWER				Coarse orkosic sandstone conglomerate (granite wash) interbedded with dark shales, limestone, and dolomite
MISSISSIPPIAN					Limestone and dolomite
ORDOVICIAN			ELLENBURGER		Dolomite
CAMBRIAN			HICKORY		Arkosic and glauconitic sandstones
PRE-CAMBRIAN					Granite, gneiss, rhyolite


N ANADARKO BASIN
PALA DURO S BASIN
CANADIAN RIVER VALLEY
HIGH PLAINS
GRANITE WASH
AMARILLO UPLIFT
ELLENBURGER
DOLOMITE
LIMESTONE
SANDSTONE
ANHYDRITE
IGNEOUS
SHALE
SALT
SCALE
0
50
Miles



Percentage of total anomalies
0
10
20
30
40
50
60
70
80
UNKNOWN
TRIASSIC
Dockum Group
Red bed / Sandstone
PERMIAN
GUADA-LUPIAN
Seven Rivers Red bed
Blaine Red bed Sandstone
Glorieta Red bed Sandstone
LEONARD-IAN
Tubb Red bed
Red Caves Red bed
"Panhandle Lime"
WOLFCAMP-IAN
Black Shale Limestone Dolomite
Granite Wash
PENN-SYLVANIAN
Black Shale Limestone Dolomite
Granite Wash
PRE-PENN-SYLVANIAN
PRE-CAMBRIAN
Crystalline Rocks
ROCK TYPE / FORMATION
SYSTEM / SERIES



EXPLANATION
Anticline
Arrow shows plunge of axis
Syncline
Uraniferous asphaltite
KANSAS SHELF
KEYS ANTICLINE
OKLAHOMA
TEXAS
DALHART BASIN
AMARILLO QUADRANGLE
ANADARKO BASIN
AMARILLO UPLIFT
OLDHAM NOSE
WICHITA MTNS
NEW MEXICO
TEXAS
PALO DURO BASIN
HARDEMAN BASIN
RED RIVER ARCH
MILNESAND DOME
MATADOR ARCH
MIDLAND BASIN
N
0 20 40 60 80 mi.
0 20 40 80 120 km.

APPENDIX B

TRIASSIC WELL DATA

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Carson	Q-1	Shamrock	4 Wigham		3404
Carson	Q-4	Cabot Carbon	1 Riggins		3323
Carson	Q-25	Cities	4 Empire Grant		3409
Carson	Q-52	Cities	H-S Burnett		3320
Carson	Q-68	Pure Oil	1 Read		3517
Carson	Q-69	Tx. Gulf	1 Bobbitt		3502
Carson	Q-73	Tx. Gulf	1 Biggs Horn		3348
Moore	-12	Sinclair	2 McDowell		3472
Moore	-21	Pioneer	1 Thompson		3751
Moore	-36	Rowland	1-A Terry		3618
Moore	-53	Texas Gas Prod Co	1 Brown		-
Moore	Q-7	Graham & Michalis	1 Mather		3646
Moore	Q-8	M. Shaffer	1 Sally		3387
Moore	Q-10	Union O., Calif.	1-384 Wooster		3815
Moore	Q-14	Col. Int. Gas.	B-13 Thompson		3549
Moore	Q-15	Texaco	1' Meek		3705
Moore	Q-16	Kerr-McGee	1 Lane		3501
Moore	Q-22	Shamrock	1 Burnett et al.		3557
Moore	Q-23	Sinclair	3 Masterson		3600 (est.)
Moore	Q-26	Col. Int. Gas.	M-5 Masterson		3289
Moore	Q-28	Col. Int. Gas.	1-R Seay		3204
Moore	Q-32	Texaco	1 Swinehart et. al.		3689
Moore	Q-33	Shamrock	2-LPG		3549
Moore	Q-35	Shamrock	1-Roberts		3640
Moore	Q-36	Texaco	1-Johnson		3781
Moore	Q-40	Col. Int. Gas.	3-R Sneed		3466
Moore	Q-41	Yucca Pet.	A-1 Thompson		3494
Moore	Q-42	Shamrock	1 Harrison		3572
Moore	Q-43	Col. Int. Gas.	2-R Thompson		3510
Moore	Q-44	Col. Int. Gas.	3-R Thompson		3472
Moore	Q-47	G. Whittington	ISWD Wright		3770 (est.)
Moore	Q-53	Col. Int. Gas	31-R Masterson		3554
Moore	Q-56	Phillips Pet.	2 Ellis		3784

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Moore	Q-57	Phillips Pet.	1 Idell		3657
Moore	Q-60	Phillips Pet.	7 Zell		3261
Moore	Q-63	Phillips Pet.	2 Drury		3770
Moore	Q-70	Shamrock	1-2 Coffee		3475
Moore	Q-74	Barnett O.	33-15 Bivins		3712
Moore	Q-76	R. Bauman	1 Johnson		3687 (est.)
Potter	-14	H.O.R.	1 Emeny		3258
Potter	-16	Nabob Prod.	1 Fuqua		3150 (est.)
Potter	-20	Bivins	2 Pedrosa		3191
Potter	Q-2	Col. Int. Gas	A-25 Masterson		3369
Potter	Q-5	Texaco	1 SWD Amarillo Plant		3638
Potter	Q-9	Col. Int. Gas	A-2 Bivins		3689
Potter	Q-14	Col. Int. Gas	B-90 Masterson		3404
Potter	Q-15	Amarillo Oil	1 Wilkins		3388
Potter	Q-17	J. Brown	1 Mill		3473
Potter	Q-33	Sinclair	5 Bivins		3648
Potter	Q-34	Sinclair	2 Bivins		3520
Potter	Q-36	Sinclair	16 Bivins		3593
Potter	Q-37	Sinclair	7 Bivins		3697
Potter	Q-42	Texaco	1 Bivins		3596
Potter	Q-43	Col. Int. Gas	3R Crawford		3439
Potter	Q-47	Col. Int. Gas	2R Crawford		3684
Potter	Q-54	Shell	2-60 Bivins		3326
Potter	Q-56	Shell	1-60 Bivins		3233
Potter	Q-59	Col. Int. Gas	23R Masterson		3663
Potter	Q-66	Col. Int. Gas	30-R Bivins		3565
Potter	Q-69	Col. Int. Gas	2R Coughlan		3592
Potter	Q-76	Col. Int. Gas	1R Gage		3484
Potter	Q-85	HOR	1 Gouldy		3887
Potter	Q-88	Asarco	WDW 1-29 Amarillo Field		3547
Randall	-9	Texaco	1 Stomm		3640
Randall	-11	Furr	1 Beckman		3788
Randall	-12	Amarillo O.	1 Hicks		3744
Randall	-16	Texaco	1 Leseberg		3638
Randall	Q-1	Burdell	1 Winters		3585

APPENDIX B (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Randall	Q-2	Frankfort O.	B-1 Stinnett		3703
Randall	Q-4	Canyon	1 Barker		3519
Randall	Q-5	Frankfort O.	1 Grogan		3662

Q = Texas Department of Water Resources
number = Bureau of Economic Geology

APPENDIX C

PALEOZOIC WELL DATA

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Armstrong	1	Standard Oil	#1-A Palm	6140	3496
Armstrong	2	Texas Crude	#1-142 Riley	5049	3521
Armstrong	3	Pelican Product	#1 Burnett	6969	3514
Armstrong	4	Sunray Mid Conti	#1 Cope	5083	3433
Armstrong	5	Texam-Creen & Mi	#1 Bagwell	5007	3416
Armstrong	6	Nebo Oil	#1 Thom Buobee	4705	3352
Armstrong	7	Cities Service	#1 Swift	3620	3032
Armstrong	8	Placid Oil	#1 Matheson	4674	3194
Armstrong	9	Texaco	#1 Tray Vance	4705	3312
Armstrong	10	Stanolind	#1 A. Corbin	6120	3376
Armstrong	11	Ketal Oil	#1 F. B. Massie-Mo	5551	3286
Armstrong	12	Geochemical Surv	#1 Cobb	6722	3417
Carson	1	Headington	#1-A Sanford	3185	3170
Carson	2	Mesa Petroleum	#1-101 Burnett	3366	3331
Carson	3	?	?	?	?
Carson	4	Natural Gas Pipe	#9-R-T Burnett	2953	3090
Carson	5	Phillips	#42 Jordan	3035	3041
Carson	6	Mobil Oil	#1-165 Mobil Tee	6500	3064
Carson	7	Skelly	#262-Schafer	3280	3222
Carson	8	Skelly	#1 Skelly-Schafe	5990	3248
Carson	9	Sibo Oil	#8 Barnard	3268	3303
Carson	10	Cities Service	#1 O'Neal	3287	3229
Carson	11	Texaco	#10 White Deer	3156	3238
Carson	12	Shamrock	#1-33 Burnett	2040	3319
Carson	13	Jay Dee	#2-17 Burnett	3200	3287
Carson	14	B. A. Smith	#1 Tharp	3871	3503
Carson	15	Bridger Petroleu	#1 Leven	3468	3500
Carson	16	E. H. Rice	#1 Chapman	4535	3566
Carson	17	Continental	#1 Bitting	4181	3574
Carson	18	C. C. Whitten Burg	#1 Morris	9311	3499
Carson	19	Phillips	#1-A O'Neal	4120	3490
Carson	20	Texas Gulf	#1 Bobbitt	4765	3501
Carson	21	Consolidated Gas	#2 Wigham	5629	3434

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Carson	22	Consolidated ETA	#1 Biggs A	3265	3465
Carson	23	Amarillo Nat. Gas	#5 Boone	3165	3350
Carson	24	Consolidated ETA	#1 Nickelson	3010	3351
Carson	25	Consolidated Gas	#1 Harnley	1220	3020
Carson	26	Consolidated ETA	#1 Crawford	3625	3346
Carson	27	L. B. Nlwman	#4 Meaker	3233	3370
Carson	28	Consolidated Gas	#1 Everly	1170	?
Carson	29	Texas Gulf	#1 J. B. Horn	4309	3348
Carson	30	Consolidated ETA	#1 Mlaker	2792	3366
Carson	31	Consolidated ETA	#1 Urbanczyk	2123	?
Carson	32	Consolidated ETA	#1 Gladys Armstr	3183	?
Carson	33	Roy King	#1 Peacock	7503	3462
Carson	34	Pure	#1 Read	6997	3514
Carson	35	Texas Gulf	#1 Calliham	7615	3461
Carson	36	Phillips	#1 Ardis	6257	3417
Carson	37	J. M. Huber	#1 Mlwton	3575	3357
Carson	38	Shenandoah	#1 Kotara	3914	3365
Carson	39	Paradox Petroliu	#1 Friemel	4610	3367
Carson	40	Phillips	#1 Smith U	4985	3571
Carson	41	Consolidated ETA	#1 Biggs	1318	?
Carson	42	Cities Service Oil	#9 Whittenmore	3452	3404
Collingsworth	1	Panoka Drlg	#4-P H. B. Franks	2320	?
Collingsworth	2	Mayfield Drlg. Co.	#1 Franks	2046	2447
Collingsworth	3	Steeple Oil	#1 Bryan	2145	2264
Collingsworth	4	E. C. & R. C. Sidwel	#1 Knoll	2016	2227
Collingsworth	5	E. C. & R. C. Sidwel	#2 Betenbrough	2040	2242
Collingsworth	6	Texas Pacific	#7 Oscar Laycock	2180	2213
Collingsworth	7	Eldorado Oil	#5 Laycock	2200	2212
Collingsworth	8	Hi-Plains Prod.	#1 Williams	2200	2147
Collingsworth	9	Hi-Plains Prod.	#2 Williams	2160	2181
Collingsworth	10	Texas Co.	#1 A. M. Atkinson	1950	2072
Collingsworth	11	King Resources	#1 Geraldine Bur	2250	2224
Collingsworth	12	A. M. Park&Hammer	#1 Tindall	7396	2100
Collingsworth	13	Elza Adams	#1 Boyd	4456	2077
Collingsworth	14	Gulf Oil	#1 Boyd	4436	2114

APPENDIX C (cont.)

COUNTY	WELL NO.	COUNTY	WELL NAME	DEPTH	ELEVATION
Collingsworth	15	Monsanto Chemica	#1 Fain	2373	2035
Collingsworth	16	Gulf Oil	#1 Ward	4225	2166
Collingsworth	17	Lubbock Mach&Sup	#1 Alexander	4570	?
Collingsworth	18	Tatum-Bennett-De	#1 A. F. Wischkae	4815	?
Collingsworth	19	Superior Oil	#85-75 M. F. Brown	5710	2338
Collingsworth	20	Roden Oil	#1 Dwyer	4000	2273
Collingsworth	27	Herbert Oil	#1 Coleman-Hess	4643	?
Donley	1	R. E. Bryan	#1 Hermesmeyer	4286	3249
Donley	2	B. J. Dunigan	#1 Steed	3436	3250
Donley	3	Service Drlg	#1 Kathleen Crib	4850	2905
Donley	4	Lefors Petr.	#1 Trew	3698	2914
Donley	5	Ambassador Oil	#1 Frank Hommel	3025	2796
Donley	6	Jake L. Hamon	#1 Hommell	2882	2879
Donley	7	James Witherspoo	#1 McMurtry	2900	2908
Donley	8				
Donley	9	El Paso Nat. Gas	#3 Lewis	2736	2796
Donley	10	El Paso Nat. Gas	#1 Saunders	2690	2810
Donley	11	El Paso Nat. Gas	#1 Brown	2746	2811
Donley	12	El Paso Nat. Gas	#1-A Baptist Fou	2753	2842
Donley	13	El Paso Nat. Gas	#1 Baptist Found	2838	2818
Donley	14	El Paso Nat. Gas	#1 McMurtry	4151	2737
Donley	15	Roden Oil	#1 Sitter	3395	2443
Donley	16	Standolind	#1 W. J. Lewis	4092	2528
Donley	17	Texas Gulf	#1 Lewis	5360	2576
Donley	18	Magnolia Petr.	#1 W. J. Lewis	5050	2586
Donley	19	Texas Gulf & Sunra	#1 Lewis	4255	2768
Donley	20	Thomas Doswell	#1 C. T. McMurtry	5375	2703
Donley	21	Humble	#1 Coleman-Buffm	4798	2842
Donley	22	C. B. Cree	#1 Robertson	3716	2951
Donley	23	Humble	#1 T. L. Roach	5265	2960
Donley	24	Russell Maguire &	#1 Ritchie	6797	
Donley	28	Alan Drlg.	#1 Sharret Myers	6513	2621
Gray	1	E. B. Clark Drilling Co.	#1 D. J. Barnett	7620	3160
Gray	2	Alpar Resources	#1 Graham	8300	3184
Gray	3	Gulf	#1 Graham	4585	3160

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Gray	4	Phillips	#1 Campbell	10355	3106
Gray	5	Sidewell Oil & Gas	#1 Fatheree	5602	3141
Gray	6	Cabot Corp.	#1 Hobart-Fatheree	10008	3106
Gray	7	C.I.G. Expl. Inc.	#1 Hobart	9340	3094
Gray	8	Sinclair	#1 Spearman	9295	3060
Gray	9	Sinclair	#1 Spearman	9130	3060
Gray	10	Gulf	#1-A Cousins	8632	
Gray	11	Phillips	#1-C Jackson	10454	3034
Gray	12	Underwood	#1 Jackson	9013	3135
Gray	13	Underwood	#1 Beville	9924	3122
Gray	14	Apache Corp.	#1 Turcotte	11400	3107
Gray	15	Holly Uranium	#1 W. C. Heaston	11035	3093
Gray	16	Phillips	#1-A Eunice	12033	3084
Gray	17	Dean Cluck	#1 Harnly	8034	3062
Gray	18	Phillips	#1 Delp	9565	3077
Gray	19	Shamrock	#1 Byrum	13051	3040
Gray	20	Standard of Texas	#1 A. R. Bell	8089	3034
Gray	21	Standard of Texas	#1 Gordon Mathers	11891	3006
Gray	22				
Gray	23	Standard of Texas	#2-1 Mathers	8500	2943
Gray	24	Standard of Texas	#3-1 Mathers	12000	2852
Gray	25	Ferguson Oil Co.	#1 Cook	8000	2840
Gray	26	Tesoro Pet. Corp.	#1 Berry	12380	2993
Gray	27	Amarex Inc.	#1 R. B. Mathers	11900	2869
Gray	28	Sun Oil	#1 A. Kirkwood	11895	2878
Gray	29	Sun Oil	#1 M. H. Boston	12061	2893
Gray	30	Sun Oil	#1 Renner Gas Unit	10880	2894
Gray	31	Humble	#1 Freeman	11915	3056
Gray	32	Phillips	#1-B Troy	4094	3039
Gray	33	Noble Drilg. Co.	#1 Ray Jones	11700	3029
Gray	34	Don Earney	#2 Corbin	4110	3124
Gray	35	Cree Oil Co.	#1 Forsman	5206	3180
Gray	36	Gulf Oil	#1 Shackleton	8048	3225
Gray	37	Kewanee Oil Co.	#1 Washoma	7210	3271
Gray	38	Mobil	#10 Heitholt	3500	3272

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Gray	39	Tenneco	#81 Worley	4764	3037
Gray	40	A. E. Herrmann	#3 Worley-Combs	3112	2918
Gray	41	Collier Diamond	#1 M. White	11550	3088
Gray	42	Gulf	#1 C. M. McAfee	12541	2909
Gray	43	Pan American	#1 Frankline	4000	2707
Gray	44	Russell Maguire	#1 Frankline	7535	2831
Gray	45	Phillips	#1-D Franklin	13594	2840
Gray	46	C. I. G. Expl. Inc.	#1 Webb	13510	2769
Gray	47	Sun Oil	#1 Webb	13650	2838
Gray	48	Gulf	#1 L. E. Webb	11920	2719
Gray	49	Phillips	#5 Morse	2900	2719
Gray	50	C.R.A.	#30-A Parker	3500	2900
Gray	51	R. W. Adams & Sons	#1 Karen	2899	2936
Gray	52	Kimberlin & Miller	#2 Saunders	2500	2739
Gray	53	Pan American	#8 W. Benedict	3150	3077
Gray	54	Phillips	#3 Caly	3239	3254
Gray	55	Cities Service	#1-C Dauer	2994	3280
Gray	56	Cities Service	#19 Baggerman	3400	3259
Gray	57	Phillips	#2 Osborne	3169	3322
Gray	58	Dunigan	#1 Maddox	3015	3207
Gray	59	Pet. Exploration	#1 W. P. Orr	2200	
Gray	60	Southwestern Natural Gas	#1 McClellan	3225	2773
Gray	61	Panoma	#1 Johnson	4084	2931
Gray	62	H.D. & J.C. Egger	#1 Hommel	2900	2915
Gray	63	E. J. McCurdy	#1-26 Lewis	2893	2924
Gray	64	T. J. Wagner	#1 Yoes	2673	2933
Gray	65	D. D. Harrington	#1-A Johnson	2743	2946
Gray	66	Armour	#2 Hommel	2825	2976
Gray	67	Armour	#1 Hommel	2825	2951
Gray	68	Roy H. King	#1 Johnson	3050	2017
Gray	69	Phillips	#1 Johnson	2850	2956
Gray	70	Baker & Taylor	#5 Johnson	2484	2854
Gray	71	Baker & Taylor	#1-15 Johnson	2845	2953
Gray	72	Phillips	#1 Johnson	2985	2994
Gray	73	Phillips	#1 Wheat	2817	3101

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Gray	74	Quintin Little	#1 Kirby	3598	
Gray	75	J. D. Amend	#1 Knorpp	3210	3205
Gray	76	C. M. Smith	#1 Knorpp	3061	3246
Hemphill	1	Diamond Shamrock Corp.	#1 Shell Fee	11250	2470
Hemphill	9	Phillips Petroleum Co.	#1 Jones Q	8907	2500
Hemphill	10	Druer & McClintoc	#3 Humphreys	13402	2515.5
Hemphill	11	Pan American Petroleum Corp.	#1 L. B. Urschel	9497	2449
Hemphill	12	Mobil Oil Corp.	#13 Urschel	6850	2346
Hemphill	13	Diamond Shamrock Corp.	#1-98 Mae E. Yokley et. al. "D"	12006	2419
Hemphill	15	Diamond Shamrock Corp.	#1-189 Leslie Webb	13267	2659
Hemphill	16	Diamond Shamrock Corp.	#1 E.S.F. Brainard "M"	12688	2500
Hemphill	17	Diamond Shamrock Corp.	#1-55 Frank Schaller "C"	11496	2275
Hemphill	18	Amarex Drilling	#1 Conatser	17639	2265
Hemphill	19	Gulf Oil Corp.	#1 Humphreys "A"	7500	2422
Hemphill	20	Phillips Petroleum Co.	#1 McQuiddy "A"	13910	2433
Hemphill	21	Phillips Petroleum Co.	#1 Jones R.	8270	2429
Hemphill	22	Diamond Shamrock Corp.	#1 Stella McQuiddy "D"	15700	2312
Hemphill	23	El Paso Natural Gas Co.	#3 Gene Howe	17500	2212
Hemphill	24	Bill Allen	#1 Johnel	8480	2320
Hemphill	25	Alpar Resources, Inc.	#1 J. O. Wells Ranch	15300	2366
Hemphill	26	Sinclair	#1 Issaacs	13500	2374
Hemphill	27	Diamond Shamrock Corp.	#1-118 Wayne Cleveland "C"	18366	2501
Hemphill	28	Gasanadarko, Ltd.	#1-39 Flowers	7547	2585
Hemphill	29	Humble Oil & Refining Co.	#1 R. A. Flowers	11907	2840
Hemphill	30	Mobil Oil Co.	#1 Campbell	13729	2704
Hemphill	31	Sinclair O & G	#1 Risley	11478	2697
Hemphill	32	Alpar Resources, Inc.	#1 Flowers	13500	2604
Hemphill	33	Gulf Oil Co.	#1 Ramp	8900	2498
Hemphill	34	Apexco Inc.	#1-33 Flowers	16350	2359.6
Hemphill	35	Phillips Petroleum Co.	#1 Bowers "D"	20100	2458

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Hemphill	36	Sun Oil Co.	#1 N. C. Pyfatt	13100	2530
Hemphill	37	Anadarko Production Co.	#1 Flowers "A"	20006	2488.2 A
Hemphill	38	Shell Oil Co.	#1-21 Fred Hobart	15850	2579
Hemphill	39	El Paso Natural Gas Co.	#1-20 Hobart	16100	2590
Hemphill	40	Shell Oil Co.	#1-51 Young	13343	2634
Hemphill	41	Humble Oil & Refining Co.	#1 Miami Cattle Co.	13650	2782
Hemphill	42	Humble Oil & Refining Co.	#1 Cecil Gill	13520	2798
Hemphill	43	Continental Oil Co.	#1 E. R. Miller	18253	2895
Hemphill	44	Basin Petroleum Corp.	#1 Hemphill	11800	2684
Hemphill	45	Brooks Hall Oil Co.	#1 Riley	11460	2535.3
Hemphill	46	Gulf Oil Corp.	#1 Melvin-Helton	20031	2552
Hemphill	47	Sunray	#1 McQuiddy	8200	2440
Hemphill	48	Humble	#1 Earp	12932	2760
Hutchinson	9	Great Plains Const.	#6 Brainard	8400	2864
Hutchinson	10	Gulf	#1 Brainard	8600	2798
Hutchinson	11	H. C. Federer	#1 Clark	8226	2983
Hutchinson	12	Kerr-McGee	#1 Coble	9005	3009
Hutchinson	13	Brooks Hall Oil	#1 Patterson	8850	3193
Hutchinson	14	Blair Oil	#1 Jarvis Unit	6193	3212
Hutchinson	15	Blair Oil	#1 Jenkins	7878	3211
Hutchinson	16	Anadarko Production	#B-1 Kirk	8195	3201
Hutchinson	17	Shenandoah	#1-87 Dearman	7700	3232
Hutchinson	18	H. A. Chapman, et. al.	#L General American	8480	
Hutchinson	19	Roy H. King	#1 C. E. Lieb	7054	3265
Hutchinson	20	Shamrock	#1 McCloy	6825	3300
Hutchinson	21	J. M. Huber	#5 Harrison	3322	
Hutchinson	22	Continental	#A-1 C.C.W. Henburg	3299	3360.5
Hutchinson	23	Mapco	#1 Walters	7210	3343.6
Hutchinson	24	Gulf-Phillips	#1 Amarillo Nat'l Bank	8284	3284
Hutchinson	25	Gulf	#1 B. Wisdom	6916	3115
Hutchinson	26	Catharine C. Wittenburg	#1 Turkey Track	3169	3113
Hutchinson	27	V. A. Brill	#1 Haley	7310	2846
Hutchinson	28	Claro Inc.	#1 M.A.T. Petroleum	3153	2882
Hutchinson	29	Claro Inc.	#1-A M.A.T. Petroleum	9715	2817

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Hutchinson	30	Claro Inc.	#1-B M.A.T. Petroleum	9560	2913
Hutchinson	31	Page Petroleum	#1 Brainard	8355	2706
Hutchinson	32	Gulf	#1 Duncan	8250	2732
Huchinsonn	33	Horizon Oil & Gas	#1-42 Harvey-W	7150	2711
Hutchinson	34	Horizon Oil & Gas	#Q-1 Harvey	7200	2765
Hutchinson	35	Horizon Oil & Gas	#0-1 Harvey	8210	2912
Hutchinson	36	Standard Oil	#1 Mary R. Allen et. al.	5008	2934
Hutchinson	37	Texas Crude Oil	#1 John O. Pitts	3085	2829
Hutchinson	38	Brannan & Clower	#27 Whittenburg	2924	2902
Hutchinson	39	Phillips	#5 Erle	4000	3048
Hutchinson	40	Bill Allen	#1 Smith-Thompson	6600	3127
Hutchinson	41	A. E. Herrmann	#15 Hardin	3100	3161
Hutchinson	42	J. M. Huber	A-60A State	2079	2932
Hutchinson	43	Texas Oil & Gas	#1 Bivins	5454	3110
Hutchinson	44	Phillips	#2 Plains Plant	4977	2803
Hutchinson	45	A. E. Hermann Corp.	#5 Scott	3004	2956
Hutchinson	46	Huber	#43 Weatherly	6280	3077
Hutchinson	47	A. E. Hermann	#14 Kinsland	3094	3040
Hutchinson	48	Cities Service	#F-8 Cockrell	6075	3076
Hutchinson	49	Allen & Parker	#1 Terry	6810	2906
Hutchinson	50	Allen & Parker	#1 W. D. Price	6440	3043
Hutchinson	51	Phillips	#F-1 Price	8073	2968
Hutchinson	52	Service Drilling & Western Oil	#1 W. D. Price	6610	3016
Hutchinson	53	Roy H. King	#1 T. J. Price	4950	2948
Hutchinson	54	Allen & Parker	#1 Kay	6600	
Hutchinson	55	Amarex	#2 T. J. Price	3320	3011
Hutchinson	56	Federal Petroleum	#1 Price	7010	2964
Hutchinson	57	Kay Kimbell	#1 Johnson	5112	2997
Hutchinson	58	Texaco	#3-33 Cooper Unit	3238	3119
Hutchinson	59	Phillips	#B-3 Cooper	3338	3175
Lipscomb	42	Falcon Seaboard Drilling Co.	#1 Harry L. King	6825	2564
Lipscomb	53	Shamrock Oil & Gas Corp.	#1 George E. Beal et. al.	10960	2761

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Lipscomb	54	Phillips	#1 Rachel "A"	13750	2801
Lipscomb	55	Shamrock Oil & Gas Corp.	#1 Albert McGarraugh	11250	2774
Lipscomb	56	El Paso Natural Gas Products Co.	#3 Kelln	7370	2719
Moore	5	R. P. Fuller	#5 Morton	3310	3390
Moore	6	Phillips	#2 Wilson	6702	?
Moore	7	Kerr-McGee	#1 M. C. L. Morton	3490	3418
Moore	8	Continental Oil	#1 B. L. Amis	3370	3406
Moore	9	Socony-Mobil Oil	#1 Nunley & Mc C	6987	3407
Moore	10	Socony-Mobil Oil	#100-A E. C. Brita	3620	3442
Moore	11	Mobil Oil	#18 Brittian	3480	3450
Moore	12	Sinclair Oil	#2 Mc Donell Gas	3245	3472
Moore	13	Diamond Shamrock	#1 Robertson Sto	2143	3548
Moore	14	Diamond Shamrock	#2 Garland-Mc Ke	5763	3514
Moore	15	Phillips Pet.	#1-A Chamberlin	3610	3573
Moore	24	Shamrock Oil	#2 C. J. Fowlston	2400	3551
Moore	25	Skelly	#16 M. B. Armstron	5606	3266
Moore	26	Shamrock Oil	#2 A. A. Stewart	2250	3355
Moore	27	G. D. Anderson	#2 Haile	3550	3344
Moore	28	Natural Gas Pipe	#1-1 W. F. Bennett	6500	3193
Moore	29	Gabe D. Anderson	#1-24 Bennett	3600	3294
Moore	30	Shamrock	?#2 Taylor	6705	3326
Moore	31	Socony Mobil Oil	#6-M Sneed Coon	3498	3349
Moore	32	Magnolia Pet.	#1 Elizabeth Pod	5762	3332
Moore	33	Socony Mobil Oil	#6-M R.S. Coon	3500	3445
Moore	34	Natural Gas Pipe	#33-M R.S. Coon	5900	3358
Moore	35	Natural Gas Pipe	#R-22-M R.S. Coon	3170	?
Moore	36	A. H. Rowland	#1-A Terry	2960	3615
Moore	40	Four Way Opratin	#1-60 Thompson	2400	3566
Moore	41	Kerr-Mc Gee Oil	#1-31-A Sneed	3510	3288
Moore	42	South Western Na	#2 Sneed	3500	3423
Moore	43	Grady L. Fox	#1 Sneed	3496	3000
Moore	44	Natural Gas Pipe	#202 J. T. Sneed	2108	3145
Moore	45	South Western Na	#1 Shelton	4880	3097
Moore	46	Colorado Interst	#36-A Masterson	3840	3295
Moore	47	Anadarko Product	#1-C Masterson	2010	3450

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Moore	48	Anadarko Product	#1-E Sneed	1985	3417
Moore	49	Sinclair	#2 R. B. Masterson	3540	3545
Moore	50	Sinclair Oil	#1 Masterson	3510	3604
Moore	51	Sinclair	#1 Masterson	3510	3610
Potter	6	Sinclair	#5 Bivins	3648	3648
Potter	7	Colorado Interst	#33-R Masterson	2225	3674
Potter	8	Colorado Interst	#34-R Masterson	1954	3472
Potter	9	Sinclair	#11 Bivins	2838	3119
Potter	10	Sinclair	#17 Bivins	2003	?
Potter	11	Barnett Oil	#68-47-1 Masters	1945	3286
Potter	12	Grvenerwald	#2-1X Masterson	7964	3324
Potter	13	Sinclair	#4 Masterson	6504	3150
Potter	17	Bivins	#1 Strip	3513	3128
Potter	18	Amarillo Oil	#1 Frank Givens	3550	3246
Potter	19	Shell	#1-207 Bivins	6379	3245
Potter	20	Bivins	#2 Pedrosa	3484	3180
Potter	21	Eason	#1-3 Bivins	3689	3277
Potter	22	Lee Bivins	#1 Pedrosa	4510	3184
Potter	23	Bivins	#3 Pedrosa	2667	3119
Potter	24	Eason	#1-60 Bivins	3404	3341
Potter	25	Bivins	#1-LX-Shell	4184	3302
Potter	26	E. H. Rice	#1 Williams	6012	3540
Potter	27	C. C. Whittenburg	#1 Masterson	12581	3556
Potter	28	James Brown Asso	#1 T. V. Hill	4000	3466
Potter	29	Amarillo & Socony	#1 J. E. Wilkens	3799	3376
Potter	30	Grady Fox	#1 Abbott	3680	3317
Potter	31	U. S. Bureau of Mi	#6-A Bush	3825	3347
Potter	32	U. S. Bureau of Mi	#15-A Bivins	3783	3519
Potter	33	Sinclair-Prairie	#1 Bush	6155	3428
Potter	38	Amarillo	#1 Lundegreen	3299	3536
Potter	39	Texaco	#1 Bivins	5255	3584
Potter	40	Canadian River	#1 City Amarillo	5018	3551
Potter	41	Asarco	#1-29 WDW	4090	3535
Potter	42	Iowa Beef Proces	#1 Iowa Beef	4875	3535
Randall	1	Frankfort Oil	#1 H. L. Erwin	7792	3570
Randall	2	Burdell Oil	#1 Winters	5038	3576

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Randall	3	Woolsey-Devore	#1 Oxnard	5680	?
Randall	4	Burdell	#1-A Winters	5030	?
Randall	5	Frankfort Oil	#1 Rex White	7264	3538
Randall	6	T. W. Carter	#1 Currie	6110	?
Randall	7	Big Bear Oil	#1 Currie	6142	?
Randall	8	Pan Eastern Expl	#1 Powers	8141	3624
Randall	9	Texaco	#1 Ralph Stomm	8202	3629
Randall	15	Arkla Exploratio	#1-83 Kuhlman	8272	3628
Randall	19	Frankfort Oil	#1 Grogan	8436	3649
Roberts	2	Cotton Petroleum Corp.	Ruth Wilson #1	8850	2701
Roberts	4	Diamond Shamrock Corp.	Caroline P. Killebrew et al. "D" #1-220	6050	2519
Roberts	6	Gulf	Fanny Scott #1	9500	2496
Roberts	10	The Shamrock O&G Corp.	Warren B. Parsell et al. "B" #2	10205	2575
Roberts	11	Shamrock (Sun)	#1 J. B. Waterfield	12110	2519
Roberts	12	Diamond Shamrock Corp.	James Bruce Water-field "F" #1-113	12202	2630
Roberts	13	Humble	Flowers #1	11140	2850
Roberts	14	Amarillo Oil Company	Fields Mahler #1-98	12475	2849
Roberts	15	Apache Exploration Corp.	Mahler Ranch 108 #1	12132	2629.5
Roberts	16	Diamond Shamrock Corp.	Frank M. Chambers et al. #1-174	11254	2481
Roberts	17	Amarillo Oil Co.	Jones Ranch #1-3	11350	2485
Roberts	18	Brookwood Oil Co.	Payne #1	11638	2571.5
Roberts	19	Alpar Resources	Clark #1	6400	2880.5
Roberts	20	James F. Smith	Mills #1-A	3649	2665
Roberts	21	C. C. Lee	D. D. Payne #1	11860	2716
Roberts	22	Clarean Petroleum Corp.	J. D. Lard #1	8950	2556
Roberts	23	Pauley & Kidd	Osborne #1	6061	2664
Roberts	24	Colorado Interstate Gas Co.	Morrison #1	5800	2761
Roberts	25	Humble	Morrison #1	9510	2807
Roberts	26	J. M. Huber Corp.	Ledrick Ranch #2	12050	2687
Roberts	27	Gulf	Henry #1	9850	2817

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Roberts	28	Rip C. Underwood	R. L. Flowers #1-70	9846	2958
Roberts	29	Amarillo Oil Co.	Christie-Tipps #1	11600	2836
Roberts	30	Texaco Inc.	B. F. A. Byrum "C" #1	11403	2897.5
Roberts	31	Amarillo Oil Company	Christie & Tipps #1-38	11052	2957
Roberts	32	Amarillo Oil Co.	Christie - Tipps #2	11230	2930
Roberts	33	Phillips	Cowan "C" #1	11460	3033
Roberts	34	Gulf Oil Corp.	Ida Clark et al, "A" #1	10100	2862
Roberts	35	Federal Petroleum, Inc.	Theis #1	11800	2846
Roberts	36	Cities Service	Theis #1	11758	2891
Roberts	37	Pan American	A. A. Smith #1	9926	3180
Roberts	38	Gulf Oil Corp.	C. H. Clark #K-3	10250	3094
Roberts	39	Helmerick & Payne, Inc.	Everett #1	6624	3129
Roberts	40	J. M. Huber et al	Byrum #1	11110	2630
Roberts	41	Amerada	Gill #1	4575	2844
Roberts	42	Amerada	Gill #1	4572	2837
Roberts	43	Pioneer Prod. Corp.	Witherspoon #1	4720	2987
Roberts	44	Gulf Oil Corp.	J. P. Osborne #2	7000	2966.4
Roberts	45	Phillips Petro. Co.	Edge 'B #10	6299	3082
Roberts	46	Brookwood Oil Co.	Fathertree #1	10010	3122
Roberts	47	Phillips	Jenkie #1	11730	3167
Roberts	48	Amarillo Oil Co.	#1-B	8183	3134
Sherman	55	Shamrock O&G Corp.	Olga C. Utley "A" #1	6525	2908
Sherman	56	Gulf Oil Corp.	Blakeunit #1	3250	3420
Wheeler	1	Victory Petroleum Company	#1 Circle Dot Ranch	15362	2766
Wheeler	2	Amoco	#1-C Walser	15290	2761
Wheeler	3	Phillips	#1 Hefley "A"	16477	2706
Wheeler	4	Pioneer	#1 Earl Williams	14552	2702
Wheeler	5	Kerr-McGee	#1 George	20163	
Wheeler	6	Kerr-McGee Corporation	#1 Dobbs	17587	2626
Wheeler	7	Kerr-McGee	#1 Reid	18803	2624
Wheeler	8	Kerr-McGee	#1 Holt	18087	2546
Wheeler	9	Kerr-McGee	#1 Elmore	19170	2569

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Wheeler	10	Kerr-McGee Corporation	#1 Leo Lee	16000	2607
Wheeler	11	Kerr-McGee	#1 Parks	16309	2550
Wheeler	12	Arkla	#1-29 Boydston	16336	2533
Wheeler	13	Sunray Mid-Continent	#1 Britt	7200	2540
Wheeler	14	Arkla	#1-5 Britt	19619	2503
Wheeler	15	Amarillo Oil	#1 McCoy	19000	2541
Wheeler	16	C.I.G. Exploration	#1 Luther Willis	16246	2582
Wheeler	17	Texaco Inc.	#1 H. J. Finsterwald	16677	2595
Wheeler	18	Phillips	#1 Thorn "A"	16075	2694
Wheeler	19	Phillips	#1 Horn "A"	16855	2696
Wheeler	20	Phillips Petroleum Company	#1 Dyson "A"	18080	2724
Wheeler	21	Phillips Petroleum Company	#A-1 Carwile	17702	2739
Wheeler	22	Pioneer Production Company	#1 Shinn Unit	14450	2847
Wheeler	23	Phillips	#1 Bailey A	13963	2817
Wheeler	24	Brookwood Oil Company	#1 Taylor	8009	2855.1
Wheeler	25	Yucca Petroleum	#1-72 Trimble	4550	2804
Wheeler	26	Skelly	#1 Murrell	12650	2691
Wheeler	27	Standard of Texas	#1 Grady Harris	12977	2678
Wheeler	28	Pan American Petr. Corp. & Standard Oil of Tx.	Mobeetie Op. Unit 1	12575	2649
Wheeler	29	Pan American Pet. Corp.	#1 Sims Unit	7444	2660
Wheeler	30	Gulf	#1 Harold Lee	7440	2645
Wheeler	31	Pan American Petr. Corp.	#4 Patterson Unit	12006	2618
Wheeler	32	Pan American Petr. Corp.	#1 Patterson Unit	7500	2603
Wheeler	33	Brooks Hall Oil Co.	#1 Kyle	11345	2603
Wheeler	34	T. C. Canan & O. B. Kiel Jr. & Morgan Bros.	#1 I. E. Duncan	7710	2652
Wheeler	35	Union of Cal.	#123 Bullard	7499	2577
Wheeler	36	Roy King	#1 Hurn	4499	2566
Wheeler	37	Shenandoah Oil	#1 Van-Zandt-Cox	12740	2530
Wheeler	38	Gulf	#1 J. L. Bailey "A"	11010	2664
Wheeler	39	Basin Petroleum	#1 S. E. Mobeetie	13499	2595
Wheeler	40	Basin Petroleum Corporation	#1 S. E. Mobeetie	14505	2595
Wheeler	41	Basin Petroleum	#1 S. E. Mobeetie	13723	2561
Wheeler	42	Arkla	#1-28 Tiner	15746	2492

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Wheeler	43	Standard Oil Company of Texas	#1 Wheeler Unit	18438	2451
Wheeler	44	Arkla	#1-16 Collins	18900	2454
Wheeler	45	Arkla	#1-24 L. Reid	13730	2379
Wheeler	46	Phillips Petroleum Company	#1 Farris "C"	16510	2445
Wheeler	47	Amarillo Oil	#1-58 Lancaster	18900	2555
Wheeler	48	Glover Hefner Kennedy Oil Company et al.	#1-43 Walker	20303	2475
Wheeler	49	Arkla	#1 Frye	18870	2307
Wheeler	50	Chevron	#1 Young	20920	2186
Wheeler	51	Amarex	#1 Davidson	17075	2483
Wheeler	52	Mobil	#1 M. W. Walker	17773	2365
Wheeler	53	Helmerick & Payne, Inc.	#1 Pyle-Davis	15008	2415
Wheeler	54	Getty Oil Company	#1 S. K. Williams	17250	2545
Wheeler	55	Phillips	#1-C Douglas	16320	2625
Wheeler	56	Gulf Oil Corporation	#1 Sivage	14600	2587
Wheeler	57	Amarex	#1-35 Johnson-Bullington	14050	2598
Wheeler	58	Colorado Interstate Gas	#1 Johnson	13754	2613
Wheeler	59	Shamrock	#5 McAdams	3024	2564
Wheeler	60	Mobil Oil Company	#18 J. P. Koons	2325	2466
Wheeler	61	Cabot Corp.	#1 Porter	4500	2332
Wheeler	62	Texas City Refining, Inc.	#1 Hall	10200	2452
Wheeler	63	Johnny Grimm	#5 Laycock	2104	2314
Wheeler	64	Johnny Grimm	#2 Porter	4001	2295
Wheeler	65	Phillips	#1 G. W. Porter	7142	2405
Wheeler	66	Sinclair-Prairie	#1 Henderson	8514	2272
Wheeler	67	Cabot Corp.	#1 Reeves	5038	2300
Wheeler	68	Alpar Resources	#1 Blake	5700	2285
Wheeler	69	Rip C. Underwood	#1 I. R. Gray	11840	2250
Wheeler	70	Walden & Phelps	#1 Tindall	2258	2259
Wheeler	71	Penzoil	#1 Bell	14928	2148
Wheeler	72	K. E. Lister, et al.	#1 Harris	8912	2238
Wheeler	73	Coquina Oil Corporation	#1 Burrell	21753	2275
Wheeler	74	Freeport Oil Company	#1 S. Fabian	21195	2155
Wheeler	75	Chevron	#1 Mildred Davidson	21640	2163

APPENDIX C (cont.)

COUNTY	WELL NO.	COMPANY	WELL NAME	DEPTH	ELEVATION
Wheeler	76	Map Pray	#1 Mills	16156	2136
Wheeler	77	Chevron	#1 G. C. Davis	21543	2138
Wheeler	78	Sinclair-Prairie	#1 Mills	4754	2147
Wheeler	79	Sinclair Prairie	#1 Mills	4742	2135
Wheeler	80	Apexco	#1 Harris	19532	2050
Wheeler	81	Sinclair O & G	#2 Mills	10505	2046
Wheeler	82	Sun	#1 McMurtry	2365	2181
Wheeler	83	Eldorado Oil & Gas Company	#11 Roberts	2226	2222
Wheeler	84	Sand Spring Home	#1 Messer	2250	2206
Wheeler	85	Pennowa Oil Company	#2 Clay	2401	2373
Wheeler	86	Galaxy Oil Company	#1 N. M. Raymond	2650	2391
Wheeler	87				
Wheeler	88				
Wheeler	89	Texas Gas	#1 McCracken	2295	2769
Wheeler	90				
Wheeler	91	Helmerich & Payne, Inc.	#1 Gierhard Unit	14602	2345

APPENDIX D

GAMMA-LOG ANOMALY INVENTORY

COUNTY	WELL NO.	NUMBER ANOMALIES	DEPTH OF ANOMALY	STRATIGRAPHIC HOST
Armstrong	5	1	4245	WCls
Armstrong	6	1	4310	WCls
Armstrong	11	2	4100, 4300	WCdolo, WCls
Armstrong	14*	1	4030	WCdolo
Armstrong	20*	3	4620, 4660, 4975	WCls, WCls, WCls
Armstrong	21*	1	4510	WCls
Armstrong	23*	1	4435	Wichita
Carson	10	2	3020, 3175	WCgw, WCgw
Carson	14	1	3840	WCdolo
Carson	16	1	4200	WCls
Carson	20	1	3755	WCls
Carson	21	1	4025	WCgw
Carson	26	1	3590	WCgw
Carson	33	2	4425, 4600	WCdolo, WCls
Carson	38	1	4745	WCgw
Carson	39	2	3925, 4515	WCgw, Penngw
Collingsworth	14	1	3450	WCgw
Collingsworth	25*	3	4435, 4535, 4625	Penngw, Penngw, Penngw
Collingsworth	26*	1	3850	WCgw
Donley	1	2	3735, 3815	Wichita-dolo, Wichita-dolo
Donley	3	1	3145	Tubb
Gray	1	1	1070	?
Gray	2	1	4770	WCgw
Gray	3	4	3750, 3900, 3920, 4845	WCls, WCls, WCls, WCgw
Gray	5	2	4075, 4735	WCls, WCgw
Gray	6	6	4060, 4165, 4175, 4275, 4375, 4545	WCls, WCls, WCls, Penngw, Penngw, Penngw
Gray	7	2	3990, 3825	WCls, WC-dolo
Gray	8	2	4775, 4970	WCgw, WCgw
Gray	9	2	3920, 4850	WCls, Penngw
Gray	14	1	4320	WCls

* = not in Amarillo Quad

APPENDIX D (cont.)

COUNTY	WELL NO.	NUMBER OF ANOMALIES	DEPTH OF ANOMALY	STRATIGRAPHIC HOST
Gray	25	2	4630, 4870	WCls, WCls
Gray	29	1	4310	WCls
Gray	31	1	4870	WCls
Gray	33	1	4870	WCls
Gray	35	2	4755, 4885	WCgw, WCgw
Gray	37	2	3725, 4240	WCgw, WCgw
Gray	39	3	3150, 3770, 4545	WCgw, WCgw, WCgw
Gray	46	3	2835, 2840, 4810	Red Cave, Red Cave, WCgw
Gray	51	1	2425	WCls
Gray	56	1	3270	WCls
Gray	60	1	3175	WCgw
Gray	64	1	2645	WCgw
Gray	74	1	3565	WCgw
Hemphill	11	2	4090, 4290	WCls, WCls
Hemphill	13	1	4665	WCls
Hutchinson	22	2	30, 200	?, ?
Hutchinson	25	2	3435, 3520	WCls, WCls
Hutchinson	32	3	3390, 4005, 5000	WCdolo, WCls, WCls
Hutchinson	38	1	2110	?
Hutchinson	39	4	3125, 3565, 3575, 3730	WCls, WCls, WCls, WCls
Hutchinson	40	1	4910	Penngw
Hutchinson	48	3	3520, 4180, 4275	WCgw, WCgw, WCgw
Hutchinson	49	3	3620, 3755, 3975	WCgw, Penngw, Penngw
Hutchinson	50	4	3668, 4585, 4775, 4835	WCls, WCgw, Penngw, Penngw
Hutchinson	52	6	3630, 4020, 4730, 4780, 4920, 4970	WCls, WCls, WCgw, WCgw, Penngw, Penngw
Hutchinson	53	5	3910, 3940, 4010, 4600, 4840	WCls, WCls, WCls, WCgw, Penngw
Hutchinson	54	4	3940, 3955, 4180, 4600	WCls, WCls, WCls, WCgw
Hutchinson	56	3	4690, 4830, 4895	Penngw, Penngw, Penngw
Hutchinson	57	3	4265, 4585, 4685	WCls, WCgw, WCgw

* - not in Amarillo Quad

APPENDIX D (cont.)

COUNTY	WELL NO.	NUMBER OF ANOMALIES	DEPTH OF ANOMALY	STRATIGRAPHIC HOST
Moore	8	2	3250,3290	WCls, WCls
Moore	9	8	4100, 4110, 4430, 4535 4640, 4725, 4745, 3240	WCls, WCls, WCgw, Pennls Penngw, Pennls, Penngw, WCls
Moore	11	1	3300	WCls
Moore	15	4	2548, 3390, 3475, 3495	Tubb, WCls, WCls, WCls
Moore	20*	1	830	?
Moore	21*	1	?	Dockum
Moore	26	2	2000, 2220	?, ?
Moore	27	1	2800	WCls
Moore	28	5	2700, 3510, 4020, 4295, 4310	WCls, WCgw, WCgw, WCgw, WCgw
Moore	29	2	2835, 3090	WCls, WCls
Moore	31	4	2765, 2890, 2935, 2945	WCls, WCls, WCls, WCls
Moore	33	3	1025, 2800, 2935	Blaine, WCls, WCls
Moore	36	1	?	Dockum
Moore	41	3	2700, 3200, 3350	WCgw, WCgw, WCgw
Moore	42	1	3440	Bsmt
Moore	43	3	2320, 2655, 3395	WCls, WCls, WCgw
Moore	46	1	1760	Red Cave
Moore	47	2	1110, 1130	?, ?
Moore	50	1	3480	WCgw
Potter	7	3	115, 130, 155	Seven Rivers, Sev. Riv., Sev. Riv.
Potter	9	1	2445	WCdolo
Potter	41	1	3365	Red Cave
Potter	42	1	475	?
Randall	2	1	4745	WCdolo
Randall	4	1	?	Dockum
Randall	19*	1	465	Dockum
Roberts	10	1	4735	WCls
Roberts	25	1	3910	WCls
Roberts	27	1	4870	WCls

* = not in Amarillo Quad

APPENDIX D (cont.)

COUNTY	WELL NO.	NUMBER OF ANOMALIES	DEPTH OF ANOMALY	STRATIGRAPHIC HOST
Roberts	29	1	4265	WCdolo
Roberts	34	1	4375	WCls
Roberts	36	1	3810	WCls
Roberts	37	3	4095, 4290, 4945	WCls, WCls, WCls
Roberts	38	1	4350	WCls
Roberts	39	1	4500	WCls
Roberts	45	1	4220	WCls
Wheeler	19	1	460	?
Wheeler	22	1	4930	WCls
Wheeler	23	1	4700	WCls
Wheeler	27	5	1200, 1690, 4445, 4850, 4935	Glorieta, Glorieta, WCls, WCgw, WCgw
Wheeler	31	1	4270	WCls
Wheeler	39	1	4670	WCls
Wheeler	43	1	4960	WCls
Wheeler	46	1	4895	WCls
Wheeler	56	2	4500, 4545	WCgw, WC gw
Wheeler	62	1	3785	WCls
Wheeler	66	2	4550, 4635	WCgw, WCgw
Wheeler	67	4	3360, 3925, 4245, 4895	WCgw, WCgw, WCgw, WCgw
Wheeler	68	1	4555	WCgw
Wheeler	71	2	15, 4385	?, WCls
Wheeler	91	1	4805	WCgw

WC - Wolfcampian
ls - limestone
do - dolomite
gw - granite wash
Penn - Pennsylvanian