URANIUM POTENTIAL OF LOWER PERMIAN ARKOSIC FACIES, NORTHERN KIOWA COUNTY, OKLAHOMA

By

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FACIES, NORTHERN KIOWA COUNTY, OKLAHOMA

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PREFACE

This thesis examines the uranium favorability, the distribution, and characteristics of the Lower Permian arkosic facies in northern Kiowa County, southwestern Oklahoma. Corporation Commission logs and electric logs were used to prepare subsurface structural maps and stratigraphic cross sections. Drill cuttings and thin-sections were used to study the petrology and diagenesis of the arkosic facies.

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CHAPTER I

ABSTRACT

A detailed study of arkosic "granite wash" sediments in northern Kiowa County in southwestern Oklahoma was undertaken in order to delineate potentially favorable areas for uranium exploration. The study included subsurface mapping of "granite wash" strata, construction of cross-sections, study of drill cuttings from oil wells, and a car-borne radiometric survey. Lower Paleozoic strata unconformably underlying the "granite wash" are complexly folded and faulted in the study area. Left-lateral strike-slip movement along the Meers (Thomas) fault is indicated by its configuration. The "granite wash" was deposited upon the Lower Paleozoic strata as alluvial fans derived from erosion of the granitic Wichita uplift.

The geological characteristics of the "granite wash" sediments compare favorably with criteria previously developed for the prospecting of sandstone-type uranium deposits. Uranium mineralization should be expected in permeable "granite wash" sediments in hydrogeochemically active zones. The Hennessey Shale Formation is not a favorable host for significant uranium mineralization.

CHAPTER II

AREA OF INVESTIGATION

The study area comprises portions of seven townships in Kiowa County, southwestern Oklahoma (Fig. 1). It covers approximately 160 square miles and lies within both the Wichita Mountain and Central Redbed Plains geomorphic provinces of Oklahoma. This area is located on the northern flank of the Wichita Mountain Uplift geologic province (Fig. 2). The rock formations investigated are the Post Oak and the Hennessey Shale. Within the study area these formations range in age from Wolfcampian to Leonardian (Fig. 3). In southern Oklahoma, rocks of the Post Oak Formation facies which occur in the subsurface are termed "granite wash", and this terminology will be followed herein.

Purpose and Methodology

The purpose of this study was to evaluate the uranium potential of the "granite wash" sequence in the study area. The area of investigation was originally delineated on the basis of anomalous occurrences of uranium in ground-water samples from the Hennessey Shale reported by Arendt _et al._ (1978); in their _Hydrogeochemical and Stream Sediment Reconnaissance Study of the Lawton NTMS Quadrangle, Oklahoma; Texas._ Because sandstone facies are not extensive in the Hennessey Shale Formation, in this area (Stith, 1968), the focus of the study was shifted to the "granite wash" which underlies the Hennessey Shale. The study

Fig. 1--Location of study area in Kiowa County.

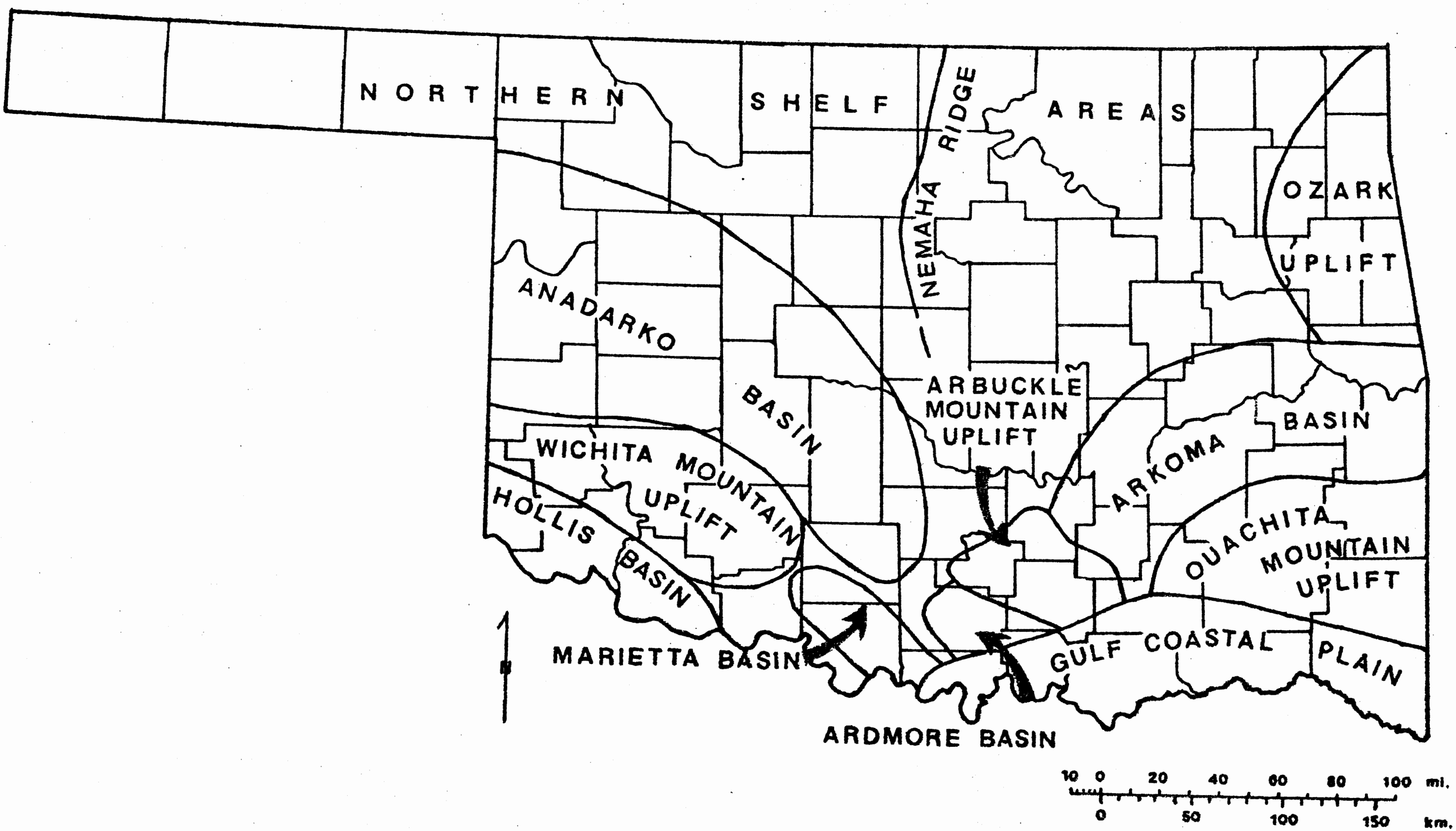

Fig. 2--Major geologic provinces (from Allen, 1980).

consisted of five main phases which are outlined below.

The first phase involved a car-borne radiometric survey of the study area and its environs using a scintrex model BGS-ls scintillation counter to determine the locations of any surface radiation anomalies.

Phase 2 comprised the subsurface mapping of the area of study. This included a structural contour map on the top and the base of the "granite wash" together with an isopach map of the "granite wash". The maps were constructed almost entirely from Oklahoma Corporation Commission drillers-log data.

Phase 3 was the construction of cross sections from data of Phase 2. Seven cross-sections were constructed on the basis of Corporation Commission log-data and two cross-sections were prepared from the small number of electric well logs available in the study area.

In phase 4 trends of photogeomorphic lineations were measured and a rose diagram of the trends was constructed.

Phase 5 constituted the description of drill cuttings from the Hennessey Shale and "granite wash" sections of five oil wells located within the study area. Thin sections of 23 "granite wash" samples were also studied.

CHAPTER III

STRATIGRAPHIC FRAMEWORK

Post Oak Formation

The Post Oak Formation was first interpreted by Taft (1904) to be a nearshore phase of the Permian redbeds of the area. Hoffman (1930) and Schoonover (1948) thought they were Pleistocene gravel deposits. Merritt and Ham (1941) interpreted the conglomerate sequence surrounding a part of the Pre-Cambrian - Cambrian gabbro-anorthosite hills in the north-central Wichita Mountains to be of Cambrian age and named it the Tepee Creek Formation. Chase (1954) re-established the Permian age of these deposits and named them the Post Oak Conglomerate. Chase (1954, Fig. 4) mapped four distinct lithofacies in the conglomerate, namely: limestone-boulder conglomerate, granite-boulder conglomerate, rhyolite-porphyry conglomerate, and conglomerate with zeolite opal cement.

Al-Shaieb et al. (1980) established the age of the Post Oak Formation which crops out in and around the eastern part of the Wichita Mountains as Leonardian of the Permian System and changed the name from Post Oak Conglomerate to Post Oak Formation because significant quantities of sandstones and mudstones occur within the unit. The granite-boulder conglomerate is very poorly exposed in the southern part of T5N, R15W in the study area. Carbonate, rhyolite porphyry and granitic clasts were noted in drill cuttings from five oil wells studied. On the basis of these well cuttings and the conglomerate exposed at the

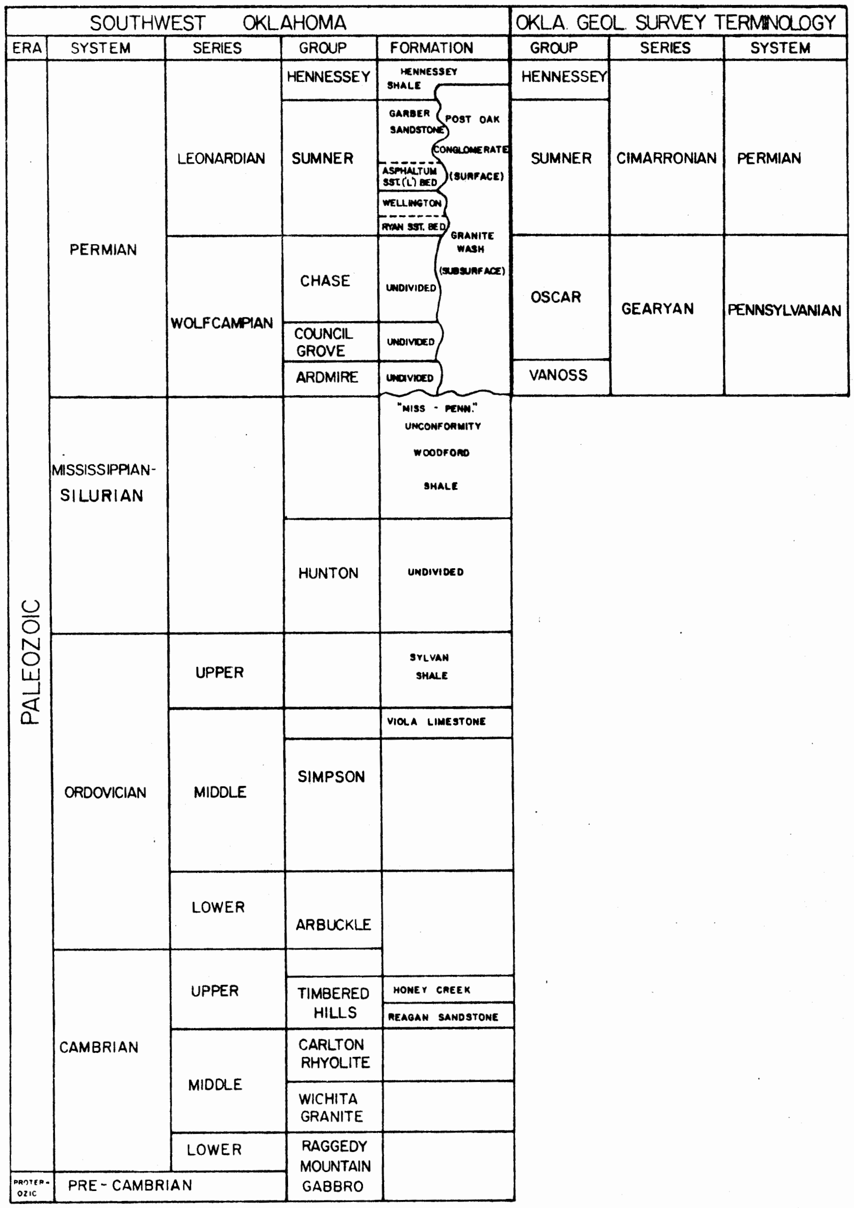

Fig. 3--Stratigraphic column.

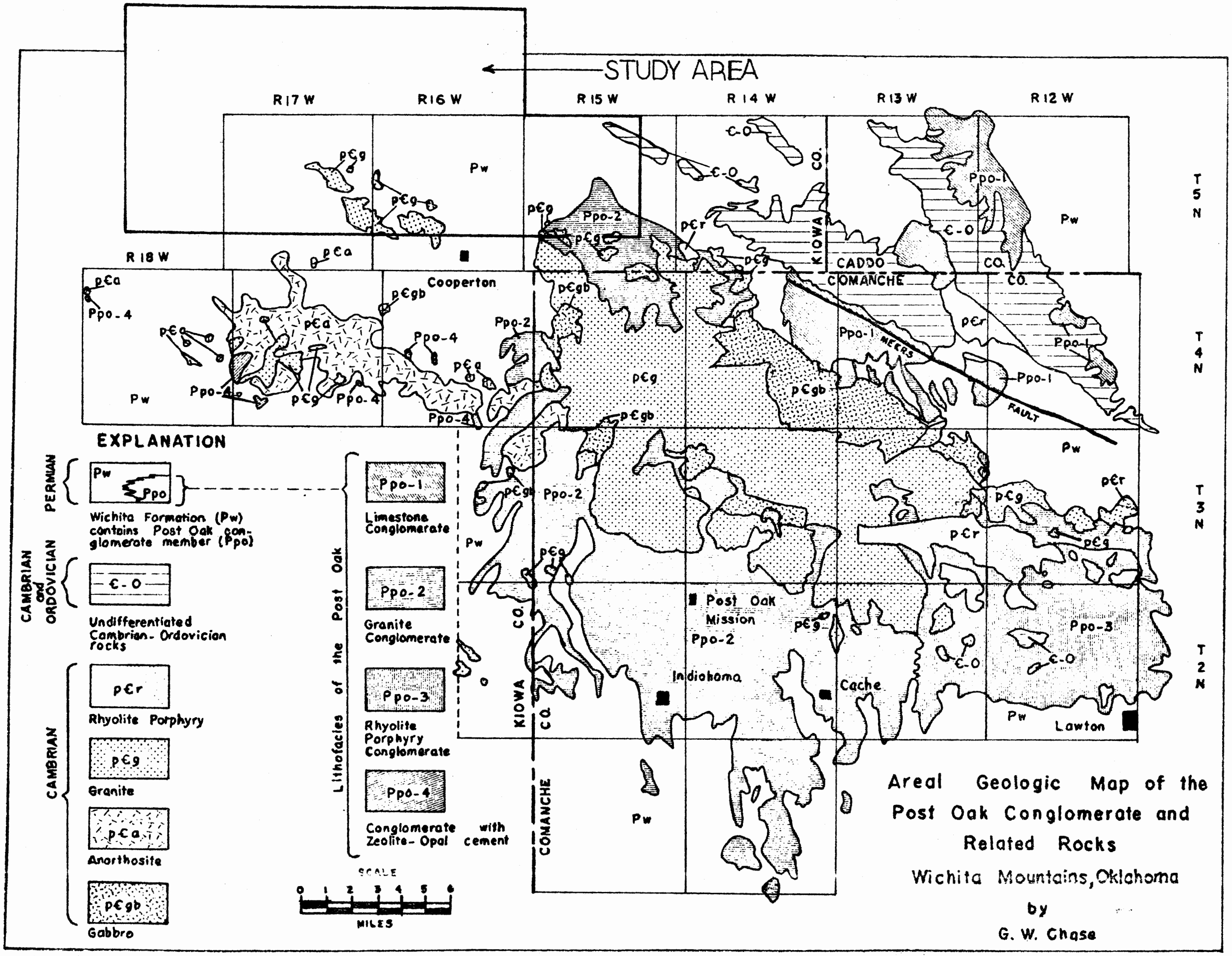

Fig. 4.--Lithofacies of Post Oak Formation (from Chase, 1954).

surface, it appears that the most common Post Oak lithofacies types in the study area are granite and rhyolite porphyry conglomerate.

Al-Shaieb *et al.* (1980) established the age of the Post Oak Formation at the surface to be of Leonardian age. The gradational lateral and downward contacts between the Hennessey Shale and the "granite wash" confirms the age of the upper part of the formation as equivalent to the Hennessey Shale and/or Upper Leonardian in the study area. At greater depths the age of the "granite wash" is uncertain. Arkose distribution maps of the Virgilian through Leonardian time (Al-Shaieb and Shelton, 1976) show that Pre-Cambrian - Cambrian igneous rocks and Cambrian through Mississippian sedimentary rocks were exposed over the entire study area during Virgilian time. This exposure was reduced during the Wolfcampian and by Leonardian time these rocks were reduced in area until they were exposed in a similar fashion to the present-day Wichita Mountains and Limestone Hills. Based on this information, it is considered probable that within the study area, the "granite wash" probably ranges in age from Lower Wolfcampian to Upper Leonardian.

The broad Wolfcampian to Leonardian age range of these conglomerates and the absence of laterally extensive lithostratigraphic marker units make it necessary to refer to the subsurface deposits as "granite wash". The term Post Oak Formation refers to surface exposures which also are of Leonardian age. The "granite wash" unconformably overlies Lower Paleozoic sediments ranging in age from the Cambrian Timered Hills Group to the Devonian-Mississippian Woodford Shale Formation, together with the Cambrian igneous intrusives that make up the Wichita Mountains. In the study area the "granite wash" ranges in thickness from 0 to 1,400 feet.

Hennessey Shale

Within the study area, the Permian Hennessey Group is represented by the Hennessey Shale, which is assigned to the upper portion of the Leonardian Series (Havens, 1977). The Hennessey Shale grades laterally and downward into the "granite wash", as stated previously. Most of the study area is underlain directly by Hennessey Shale excepting for minor amounts of Post Oak Conglomerate, Quaternary alluvium, and Cambrian igneous intrusives.

Gould (1905) defined the Enid Formation as all the rocks from the base of the Permian to the base of the Blair Formation. Gould and others (1926) elevated the Enid Formation to group status and divided it into the Stillwater, Wellington, Garber, Hennessey, Duncan, and Chickasha Formations. The Garber-Hennessey contact in the study area and Kiowa County was described by Sawyer (1929) as being located within several hundred feet of red shale and thin sandstone. Schweer (1937) assigned the Duncan and Chickasha Formations to the El Reno Group together with other younger formations. This left the Hennessey Shale Formation as the uppermost member of the Enid Group. Miser (1954) included the Garber Sandstone, Wellington Formation, and the upper part of the Pontotoc Group under the heading of "Wichita Formation" in the southwestern portion of the state. The Enid Group has been divided into the Hennessey and Sumner Groups by Havens (1977). The Sumner Group, which is roughly time equivalent to the Wichita Formation, is undivided and composed of undifferentiated "granite wash" in the area of this study. The Hennessey Group in this area is approximately 100 to 700 feet thick.

CHAPTER IV

STRUCTURAL HISTORY

General

Several aulacogens (the failed-arm troughs radiating from triple RRR junctions) mark the southern edge of the early Paleozoic North American continent. The Wichita aulacogen, which includes the Anadarko Basin, the Wichita Mountains, the Arbuckle Mountains, and numerous other smaller uplifts and basins in southern Oklahoma is one of these (Burke and Dewey, 1973; Hoffman et al., 1974, Powell and Phelps, 1977; Al-Shaieb et al., 1977; Hanson and Al-Shaieb, 1980) (Fig. 5).

Plate tectonic theory states that aulacogens begin as rift valley grabens on upwarped domes developed over mantle plumes. Extensional stresses in the upwarped domes produce normal faults and grabens near the surface. The grabens tend to divide the uplift into three segments, thus forming a triple junction located near the center of the uplift. Since the uplift is in a region of high heat flow, the rifting process is accompanied by igneous activity. Thus the early stage of aulacogen formation is characterized both by this igneous activity and by the deposition of continental clastics within the rift valleys. The Raggedy Mountain Gabbro, Wichita Granite, and Carlton Rhyolite represent this initial stage in the Wichita aulacogen (Hanson and Al-Shaieb, 1980).

If the uplift occurs in continental crust that is undergoing breakup, two of the three grabens will link with adjacent triple junctions and

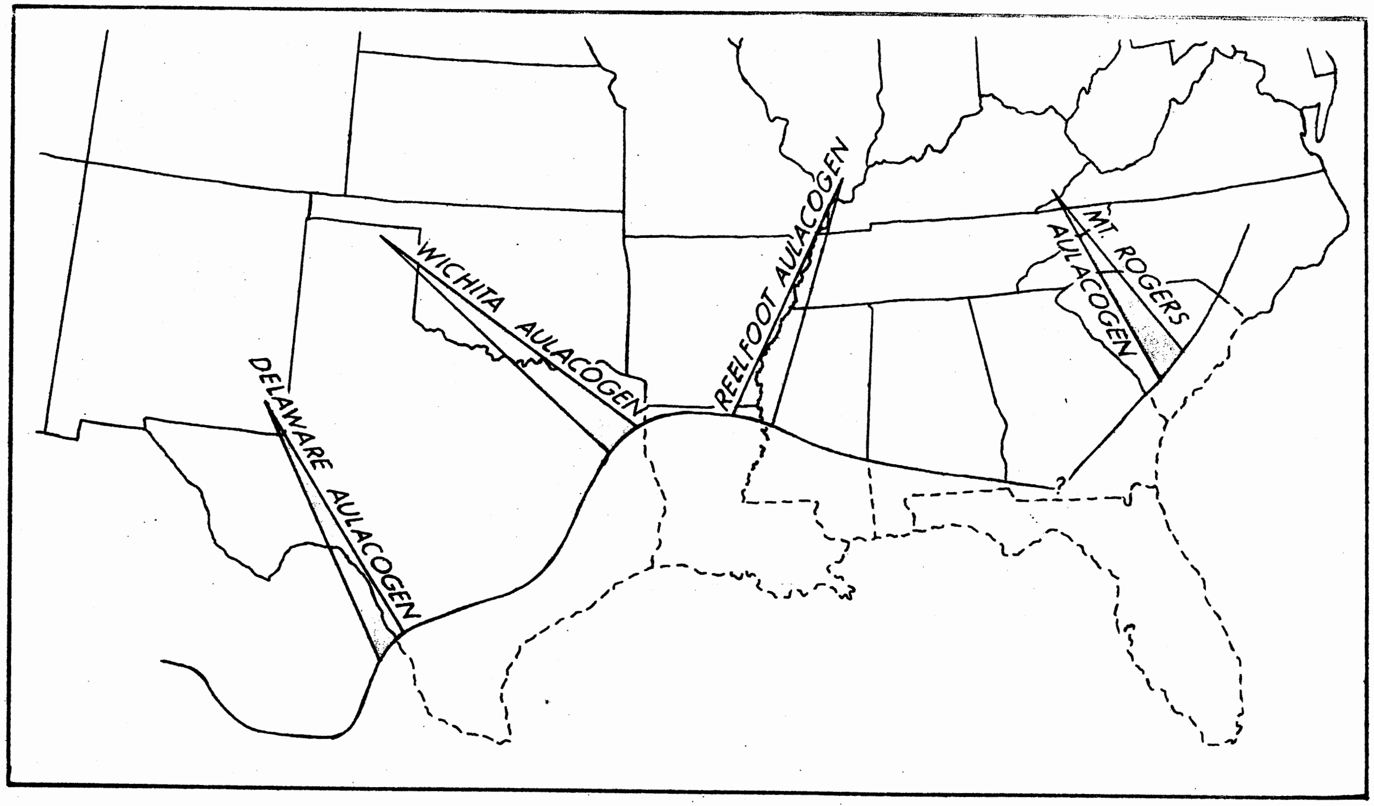

Fig. 5--Aulacogens marking the rifted early Paleozoic North American continental margin (from Walper, 1977).

continue to spread. Oceanic crust will form along the axes of such widening grabens. Spreading across the third graben system may cease at an early stage. During the ensuing "sagging stage" (Hoffman, 1973) (Fig. 6) the aulacogen is inundated by the sea because the continental margin subsides as it moves away from the spreading center and cools. As the aulacogen is a zone of weakness in the lithosphere, it subsides at a faster rate than the adjacent craton and thus receives more sediment. This sagging stage is usually characterized by the deposition of carbonates; deposits can be as much as twice the thickness of comparable strata on the stable craton.

In the southern Oklahoma aulacogen subsidence from the Cambrian to the Mississippian resulted in the deposition of up to 9,500 feet of mainly carbonate sediments. This carbonate sequence is evidenced by the Cambro-Ordovician Arbuckle Group through the Mississippian-Silurian Hunton Group in the Anadarko Basin (Fig. 3).

The subsequent deformation stage of aulacogen development occurs only if the rifted margin is involved in an episode of plate convergence and continental collision. Compressive stresses generated by plate collision then reactivate old fault trends in the aulacogen and produce both vertical and transcurrent movements. In the Wichita aulacogen compressive stresses were related to the subduction which cuased the formation of the Ouachita Orogenic system (Hoffman _et al_., 1974; Al-Shaieb _et al_., 1977). A complex system of paired basins and uplifts resulted (Walper, 1977). Such compression in the southern Oklahoma aulacogen produced the Wichta Mountain uplift, the folded and faulted Arbuckle Mountains, and the Anadarko, Hollis Ardmore and Marietta Basins. Deformation in the Wichita Mountain - Anadarko Basin area of the Wichita aulacogen began early in Pennsylvanian time

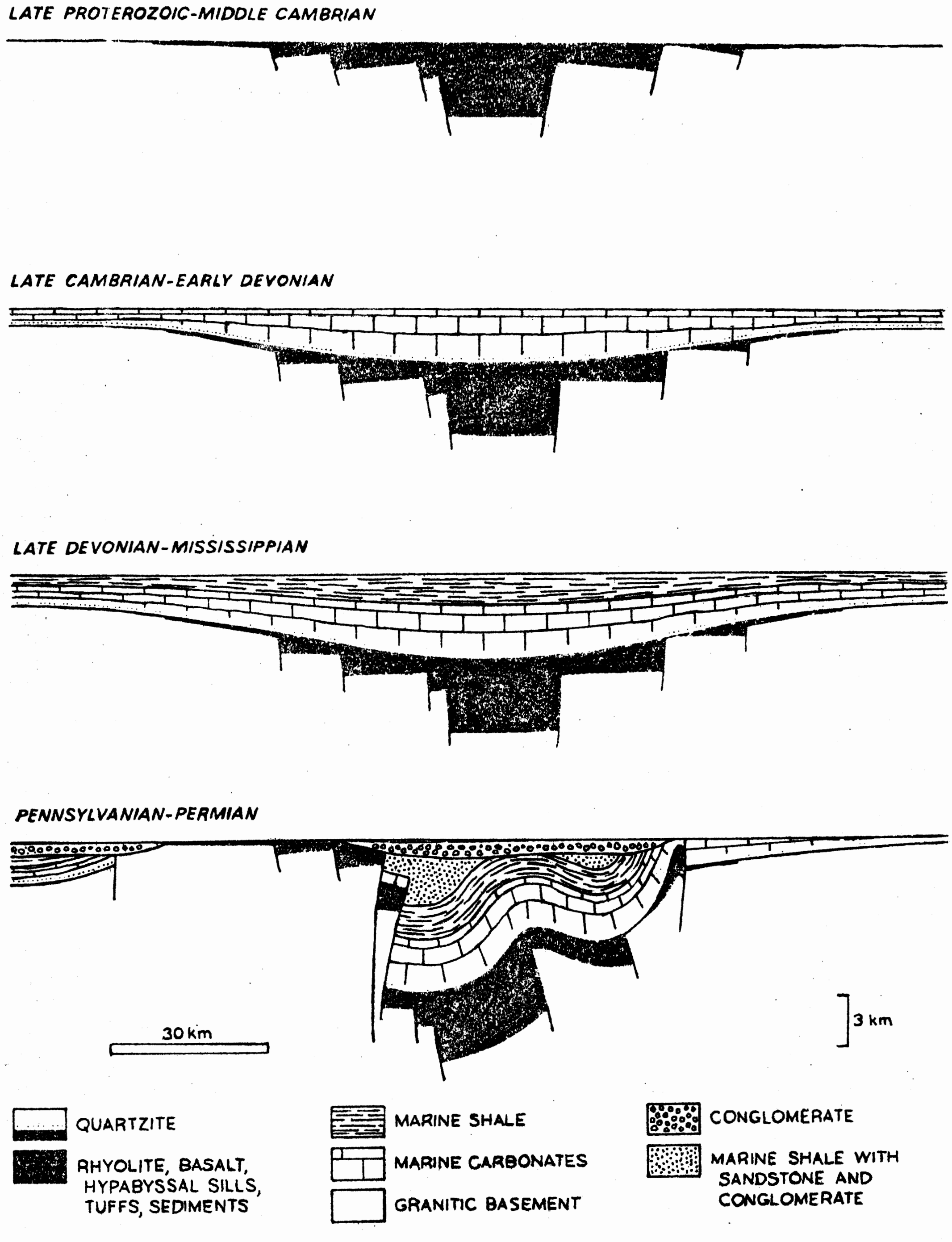

Fig. 6--Evolution of the southern Oklahoma aulacogen. Aulacogen began with block faulting and volcanism and associated intrusive activity, evolved into downwarp, and finally was deformed into major uplift area and associated basin (from Hoffman et al., 1974).

and continued into the Permian (Wolfcampian) time. During this period arkosic sediments including the "granite wash" and Post Oak Formation, were shed from the uplifted Wichita Mountains into adjacent basins.

Structure in the Area Studied

The study area straddles the central horst of Cambrian igneous rock and the frontal Wichita fault system. This system is a complex of faults which extends for 200 miles, demarcating the northern flank of the Wichita Mountains, and forming a zone from 7 to more than 10 miles wide (Harlton, 1963). It is characterized by faulted and folded Cambrian through Mississippian rocks overlain unconformably by Permian "granite wash" and Hennessey Shale. The Meers (Thomas) fault is the most important rupture in the study area. Vertical displacement along the fault has been reported to be as great as 20,000 feet (Evans, 1979). This enormous structure forms the dividing line between the frontal Wichitas and the Wichita Mountains. The trend of the fault varies from N72°W in the southeastern part of the study area to N15°W in the northeast (Plate 2). This change in trend has played an important role in the local structural configuration of the area.

Several episodes of deformation have been postulated to have occurred during Pennsylvanian and Early Permian time. There has also been discussion concerning the nature of fault movements in the region. The first stratigraphic evidence of deformation is in the form of Early Pennsylvanian (Morrowan) carbonate conglomerates derived from the Criner uplift. Similar conglomerates were deposited throughout Pennsylvanian and Early Permian time. Pennsylvanian deformation was dominated by displacement along major high-angle fault zones (such as the Meers (Thomas) fault), which commonly exceed 60 miles in length (Wickham, 1978). These major faults were probably initiated in the Cambrian as normal faults, bounding the rift valley. They were rejuvenated during the Pennsylvanian and Early Permian.

Several models have been proposed to explain the structural style of the area. Wickham (1978) reviewed the following: (1) horizontal compression across the trend of the aulacogen leading to vertical displacements with only minor horizontal movement; and (2) strike-slip displacements along major faults parallel to the trend of the aulacogen.

The structural evidence cited by Wickham (1978) strongly supports the strike-slip or wrench fault hypothesis in the eastern part of the aulacogen. Donovan (personal communication, 1980) has evidence that suggests left-lateral strike-slip movement to the east of the study area in the Blue Creek Canyon. However, he thinks that vertical movements previously occurred in this region. Both Wickham (1978) and Donovan (1980) describe folds that do not parallel the major faults but intersect them. The compressional stress field necessary to fold the strata with the observed orientation indicate left-lateral displacements on the major faults.

Stratigraphic evidence (Wickham, 1978) also indicates left-lateral movement. A facies boundary in the Oil Creek Formation of the Simpson Group appears to be offset in a left-lateral sense for a distance of 40 miles.

Evidence also points to a left-lateral movement along the Meers (Thomas) fault in the study area. The rose diagram (Fig. 7) of photogeomorphic lineations shows a bimodal distribution of lineations which conform to the fracture pattern expected to develop (Fig. 8) within the

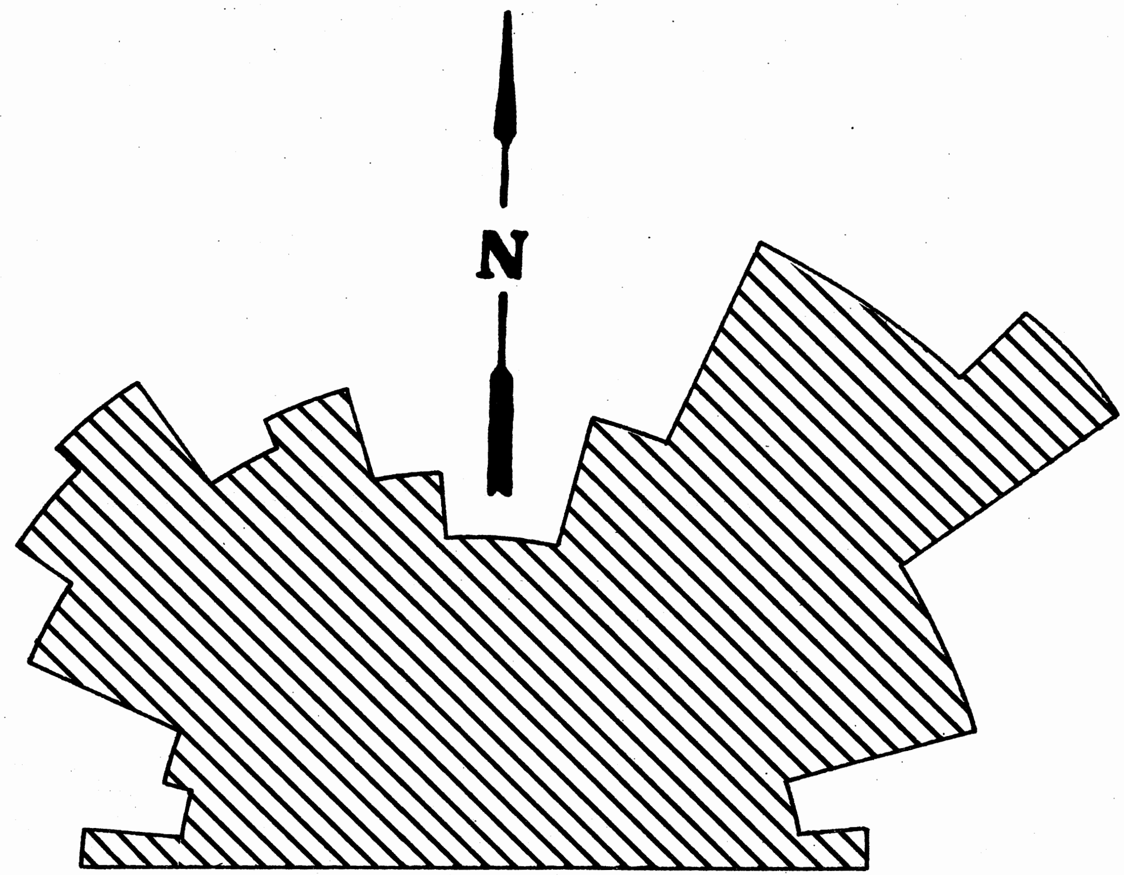

Fig. 7--Rose diagram of measured trends of photogeomorphic lineations.

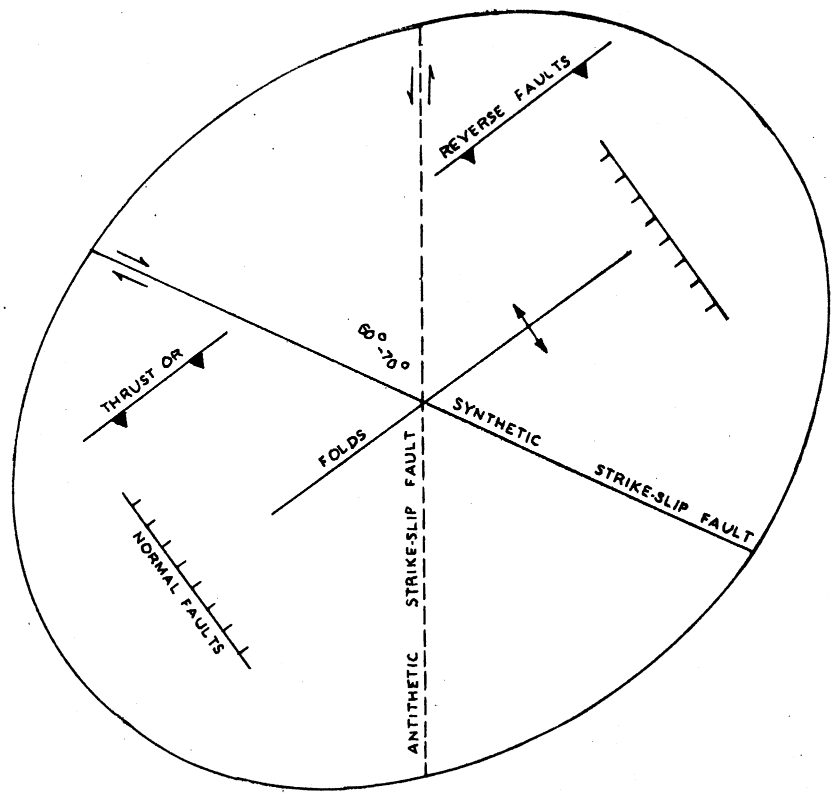

Fig. 8--Forces and composite of structures that can result from wrenching deformation combined schematically with strain ellipse. Depicts right-lateral movements; view in reverse for left-lateral (from Harding, 1974).

stress field necessary to generate strike-slip movements (Moody and Hill, 1956). The configuration of the Meers (Thomas) fault also suggests strike-slip movement. Where the fault is parallel with the direction of principle shear it shows a smooth linear profile in plan view (as in the southeastern part of the study area, Plate 2). In this case a narrow zone of faulting exists and only the vertical sense of displacement is clearly seen (Evans, 1979). The structure of the Paleozoic rocks in T7N, R16W and R17W (just north of the study area) is that of closely-spaced complex horst and graben structures paralleling the fault zone (Harlton, 1963). This is similar to the structure expected in those parts of the study area where only vertical displacement is apparent.

Where the fault turns to a more northerly direction, as in the north-central section of the study area, the basement appears to be offset in several places (Plate 2). The northern block of sedimentary rocks has moved against the relatively stable basement block creating a zone of compression. The reaction of the basement block has been expressed as NE-SW trending offsets, probably along reactivated faults and fractures within the basement. The reaction of the sedimentary rocks cannot be documented due to the lack of subsurface data. The structure proposed by Evans (1979) in this situation is that of overturned folds and multiple thrusts. This structural style is found in the Apache field of southern Caddo County, Oklahoma which is east of the study area along the Wichita Mountain front.

Wickham (1978) points out that vertical displacements are commonly associated with major strike-slip faults. Structural relief within the Wichita aulacogen seems large; however, it is a relatively small percentage of the horizontal displacement if the 40 miles of displacement proposed earlier is in fact a correct estimate.

Harlton (1963) reported the occurrence of a large fault block of sedimentary rocks within the basement block southeast of the town of Hobart. This corresponds approximately to T6N, R18 W in the study area. A "granite wash" thickness map (Plate 2) and a structural contour map (Plate 3) both show a thickening of "granite wash" sediments plus a marked drop in elevation of the Mississippian-Pennsylvanian unconformity in this township. This may represent a downdropped block of basement which was subsequently filled with "granite wash" sediments, rather than a downdropped block of sedimentary rocks within the basement block.

CHAPTER V

PETROLOGY AND DIAGENESIS

Introduction

Investigation of the petrology and diagenesis of the "granite wash"-Post Oak Formation was limited to the study of drill-bit cuttings obtained from five oil wells located within the study area. The names and locations of these wells are listed in Appendix B.

The drill cuttings were examined in two stages. Stage 1 was the lithological logging and petrologic description of the drill cutting using a binocular microscope (Plates 16-21). The original samples were collected at 10-foot intervals. No electric or lithologic logs were available for these wells. As a result, only the determination of gross changes in lithology (greater than 10 feet) was possible. Twenty three grain mount thin sections were examined in stage 2.

Petrography of the "Granite Wash"

In logging and describing the "granite wash" drill cuttings during stage 1, it became evident that the cuttings are composed primarily of granitic rock fragments, with carbonate detrital fragments comprising from 0 to 50 percent of the samples. The detrital grains examined range in size from clay to small pebble grade. Medium-sized sand grains (all compositions) are rounded to subrounded, whereas coarser grains generally exhibit angular to subangular shapes. These angular to subangular grain shapes may have resulted from fragmentation of larger sized clasts during the drilling process. The effect of such fragmentation (if it occurred) would be to decrease true depositional sorting values. Color of the cuttings ranges from red to gray, to red-gray variegated. The most common authigenic minerals are carbonates which are present in most of the cuttings described. Pyrite is also very conspicuous. It is seen corroding and replacing quartz, feldspar, granitic, and carbonate detrital grains. Much of the pyrite is tarnished due to oxidation. In appearance granitic fragments range from fresh to severely altered. The proportion of fresh granitic fragments increases with depth. Several detrital grains are impregnated and stained by "dead" oil.

Stage 2 was the study of 23 grain mount thin sections. This provided a more accurate analysis of the mineralogical constituents of the "granite wash". The thin sections were stained with a combination of alizarine red S and potassium ferricyanide. This is a carbonate stain which colors calcite (red), ferroan calcite (purple), ferroan dolomite (blue), and ankerite (dark blue). The thin sections were point-counted using the line method (Carver, 1971), and their frequency distribution determined from these points counted are shown in Table I. The "granite wash" is a polymictic conglomerate. Using Friedman's and Sanders' (1978) sandstone classification, the most common rock type was a quartz, rock-fragment conglomerate.

Detrital grains are mostly composed of granophyre, quartz, and feldspar. Granophyre fragments generally dominate at depth and are fresher than those from shallower "granite wash" strata. Carbonate selectively replaces feldspars in granophyre grains. Authigenic pyrite replaces both feldspar and quartz.

TABLE I

COMPOSITION OF CONGLOMERATES AND SANDSTONES IN "GRANITE WASH"

Well Number	Depth (feet)	Detrital Grains: Quartz	Orthoclase	Microcline	Plagioclase	Granophyre	Microperthite	Granite	Glauconite	Authigenic Minerals: Calcite	Dolomite	Pyrite	Hematite	Clays	Sand + Silt Matrix	Calcrete	Rock Name
1	170	25	8			5	2			11	11	10		tr	12	2	argillaceous, rk frag, feld, qtz, sandstone
1	210	12	8	2		5			1	1				tr	13	4	argillaceous, rk frag, feld, qtz, conglomerate
1	240	9	2			20	2				2				5	4	feld, aqz, rk frag, conglomerate
1	290	6	4			23	4			4	3	2			3	3	feld, qtz, rk frag, conglomerate
1	350	13	3			28	2	1		2	5				3		feld, qtz, rk frag, conglomerate
2	200	5	5	1	1	13	5			3		1		tr	12		argillaceous qtz, feld, rk frag, sandstone
2	250	3	2		3	8	1	1	1	3		1			3		qtz, feld, rk frag, conglomerate
2	330		1			27	5	6		4		3					feld, rk frag, conglomerate
2	360					23	7					4					rk frag, conglomerate
3	160	13	3		5	15	5	5		2	1	5		tr	10		argillaceous, feld, qtz, rk frag, conglomerate
3	180	20	1			16		1			6			tr	12		argillaceous, feld, qtz, rk frag, conglomerate
3	230	36	2			16				6	16			tr	9	8	argillaceous, feld, rk frag, qtz, sandstone
3	270	10				4				12	4					12	calcrete
4	190	35	1		1	24	10			13	7	8	3	tr	14		argillaceous, feld, rk frag, qtz, conglomerate

TABLE I (Continued)

Well Number	Depth (feet)	Detrital Grains: Quartz	Orthoclase	Microcline	Plagioclase	Granophyre	Microperthite	Granite	Glauconite	Authigenic Minerals: Calcite	Dolomite	Pyrite	Hematite	Clays	Sand + Silt Matrix	Calcrete	Rock Name
4	210	24			1	10	5			2	20	7			6	18	feld, rk frag, qtz, conglomerate
4	250	27	1	1		51	8	3		5	22			tr	25		argillaceous, feld, qtz, rk frag, sandstone
4	270					45	1	1			8	1					rk frag, conglomerate
4	320	9	1			27	6	1		8	8		5		6	8	feld, qtz, rk frag, conglomerate
5	110	7				27	5			13		8			3	5	qtz, rk frag, sandstone
5	160	29	3			10	2			1				tr	13		argillaceous, feld, rk frag, qtz, conglomerate
5	210	5			1	28				2						2	feld, qtz, rk frag, conglomerate
5	300	7			2	22	1			15		1				8	feld, qtz, rk frag, conglomerate
5	380	10				25	2			1						1	qtz, rk frag, conglomerate

The main cementing agents in the majority examined are carbonates. Illite is present as a minor cementing agent. The carbonates appear as mosaics of anhedral subequant sparite crystals, the most common being calcite. Ferroan dolomite is present in varying amounts, and in some cases is the predominant carbonate. Calcite is also observed corroding detrital grains (Figs. 9, 10, 11, 12). One calcrete horizon has replaced nearly all the detrital grains. Texturally, the calcrete fragments comprise a mosaic of microcrystalline grains with patches of coarser-grained calcite (Figs. 12, 13, 14). Detrital quartz, feldspar, and rock fragments within these pedogenic fragments exhibit corroded margins and exfoliation textures.

Identification of detrital limestone fragments is tentative. The carbonate fragments containing granophyre, quartz, and feldspar grains or which exhibit relicts of these grains represent calcrete fragments. Carbonate grains consisting entirely of dolomite may represent detrital limestone fragments or fragments of dolomitized mature calcretes. Examples of both carbonate-cemented and carbonate-free grains composed mainly of silt and sand matrix and containing up to pebble-sized detrital grains have been noted.

Diagenesis of the "Granite Wash"

Petrographic analysis indicate that the paragenetic sequence of diagenetic events in the "granite wash" sediments was as follows (Fig. 15): (1) early calcite as both a cement and as a replacement of detrital grains along with the formation of authigenic illite both as pore linings and pore fillings and minor iron oxide cement (eogenetic stage); (2) formation of authigenic pyrite followed by selective alteration of calcite to ferroan

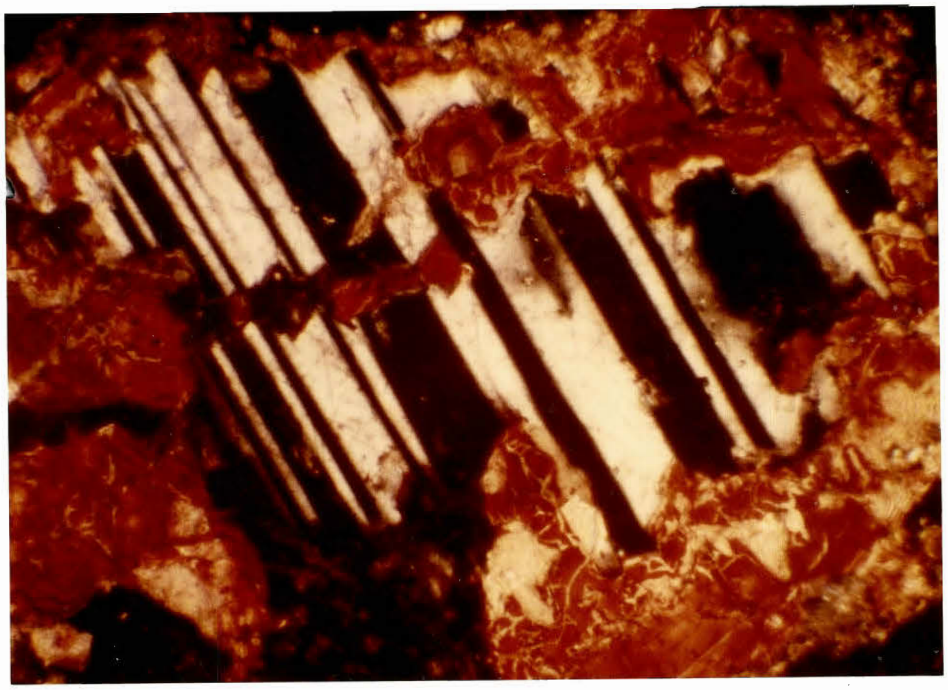

Fig. 9--Plagioclase replaced by calcite (red), crossed nicols, field of view .7 mm x . 42 mm.

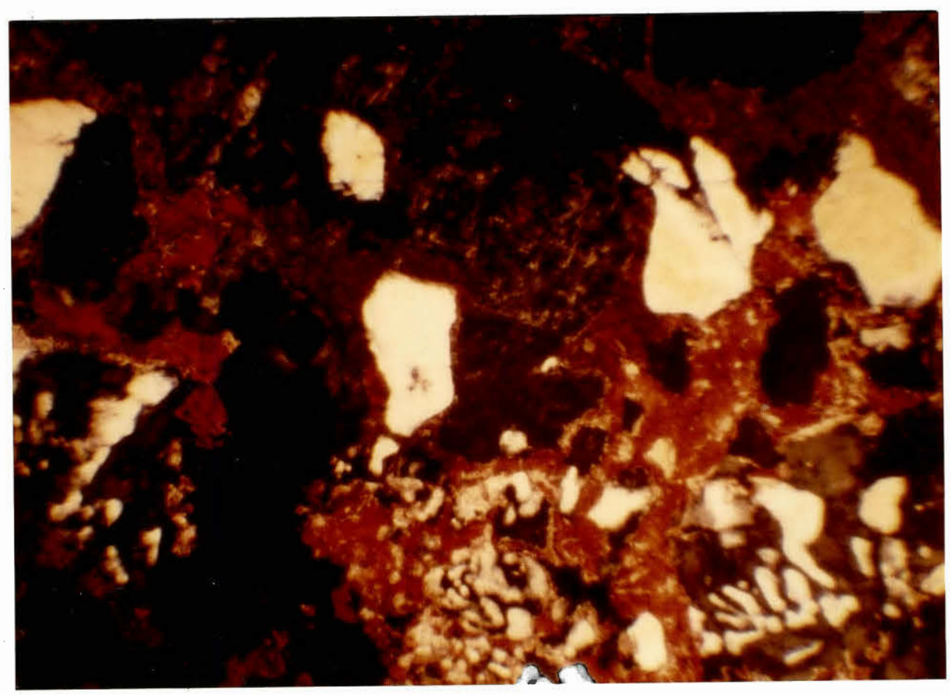

Fig. 10--Calcite (red) cemented arkosic fragment containing granophyre, quartz, and feldspar, crossed nicols, field of view 1.8 mm x 1.2 mm.

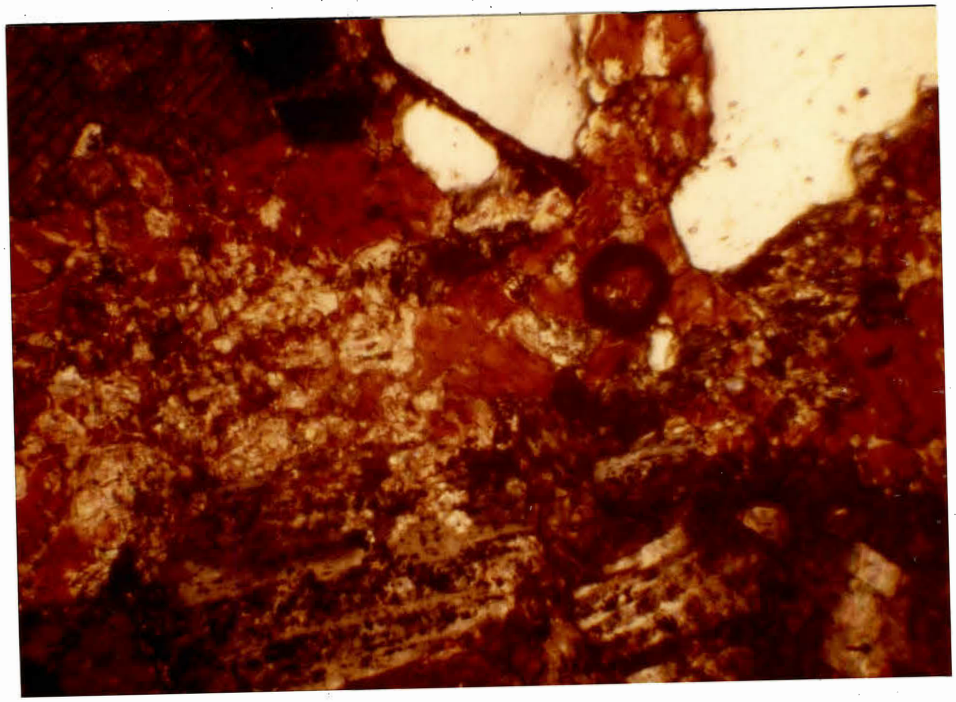

Fig. 11--Plagioclase and quartz (white) cemented and replaced by calcite (red), crossed nicols, field of view .7 mm x .42 mm.

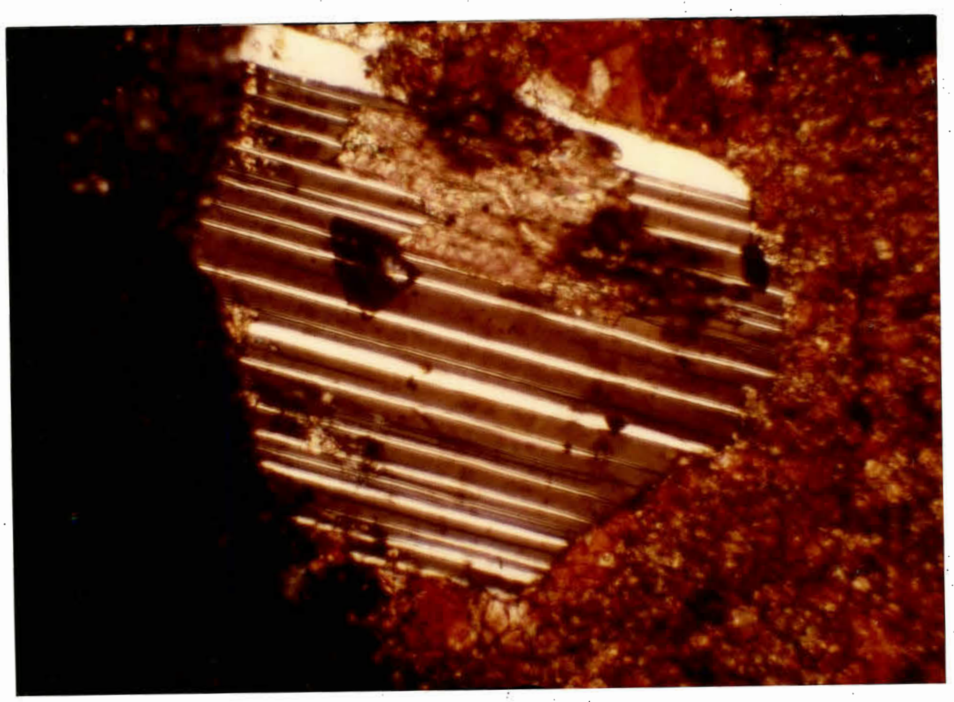

Fig. 12--Calcite (red) replacing plagioclase grain, crossed nicols, field of view .7 mm x .42 mm.

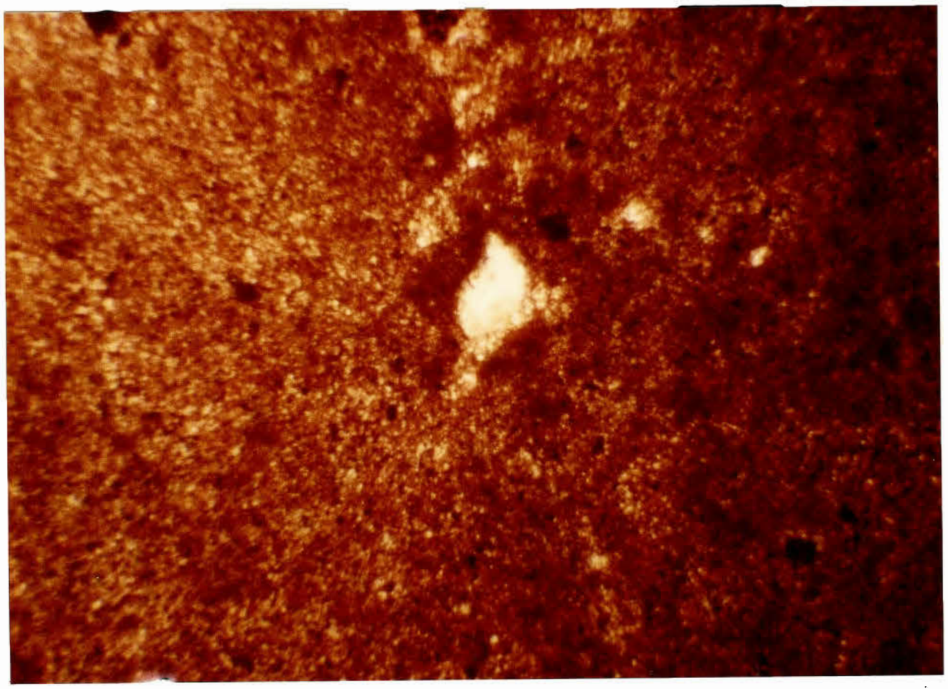

Fig. 13--Calcrete fragment; calcite (red), crossed nicols, field of view 1.8 mm x 1.2 mm.

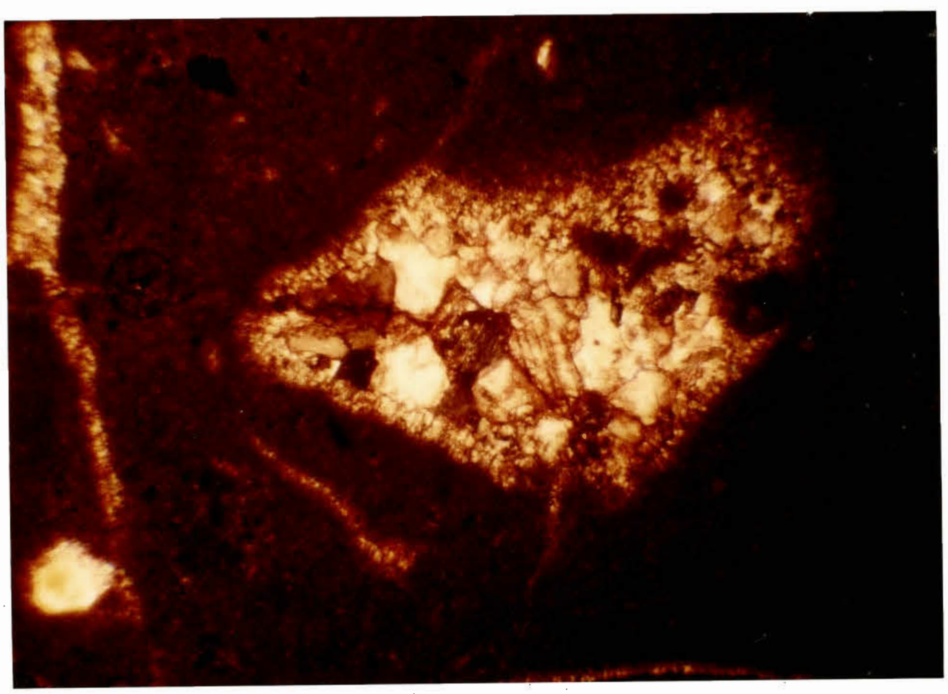

Fig. 14--Calcrete fragment with pore space infilled by sparry calcite, crossed nicols, field of view 1.8 mm x 1.2 mm.

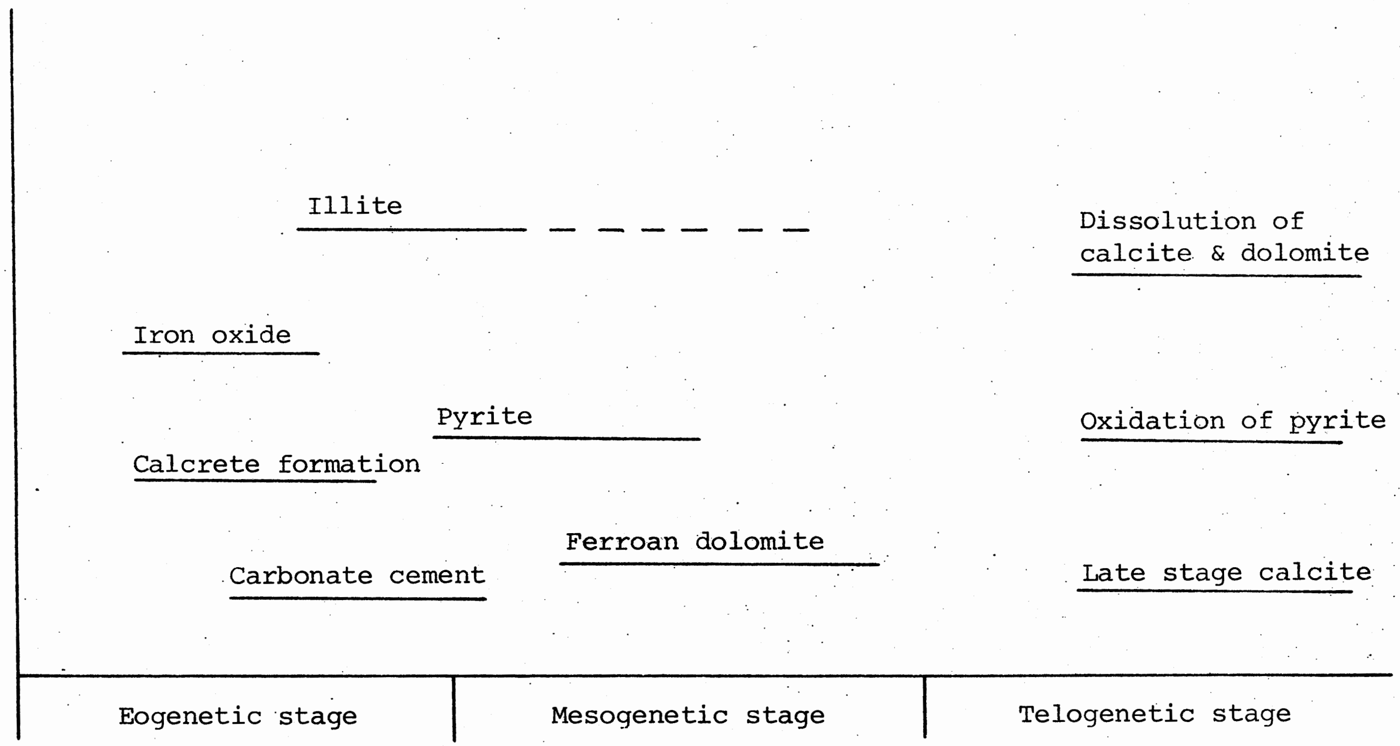

Fig. 15--Summary of general diagenetic changes in "granite wash" sediments.

dolomite (mesogenetic stage); (3) later dissolution of ferroan dolomite and calcite with subsequent precipitation of a later calcite phase in microfractures (telogenetic stage).

Early calcite cement and calcrete horizons were formed at shallow depths of burial. Calcite corroding detrital grains, within primary pore space, and calcite calcrete fragments are evidence of this (Figs. 10, 11).

Authigenic pyrite and dolomite replacement of calcite took place at greater depths and higher temperatures. Given the appropriate environment, calcite tends to be replaced by dolomite with time. Ferroan dolomite is seen replacing calcite in Figures 16 and 17.

The third and final diagenetic stage comprised fracture filling by sparry calcite accompanied by dissolution of both calcite and ferroan dolomite. Figure 18 shows calcite veins cutting across a dolomite-cemented arkosic fragment. Dissolution of a dolomite detrital grains is shown in Figure 19.

The clay to sand-sized matrices of the argillaceous "granite wash" sediments mainly have a syndepositional source of origin. It was deposited along with coarse detritus during mud flow events. A minor source of matrix may be related to post-depositional alteration of feldspars within granophyre fragments to clays, the most notable clay being illite.

Al-Shaieb _et al_. (1980) state that the post-depositional diagenetic history of the Post Oak Formation apparently involved the action of formation waters whose composition changed through time. The degree of porosity and permeability of the sediments may have also played a role in diagenesis. Post Oak Formation sediments with an appreciable matrix of detrital clay and silt show minor diagenetic changes (Al-Shaieb _et al_.,

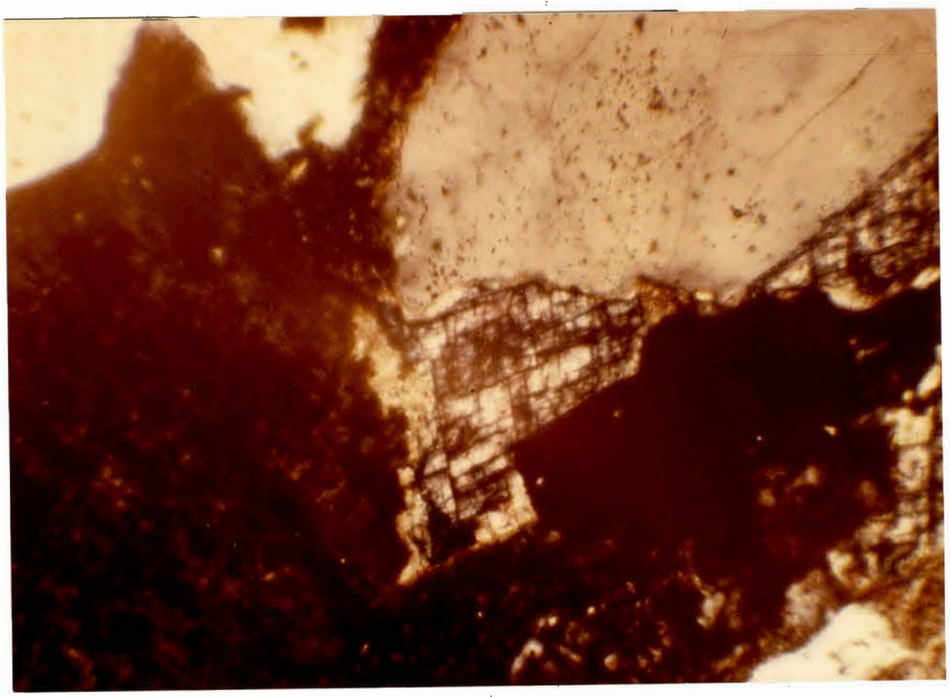

Fig. 16--Ferroan dolomite (blue) replacing calcite (red), crossed nicols, field of view .7 mm x .42 mm.

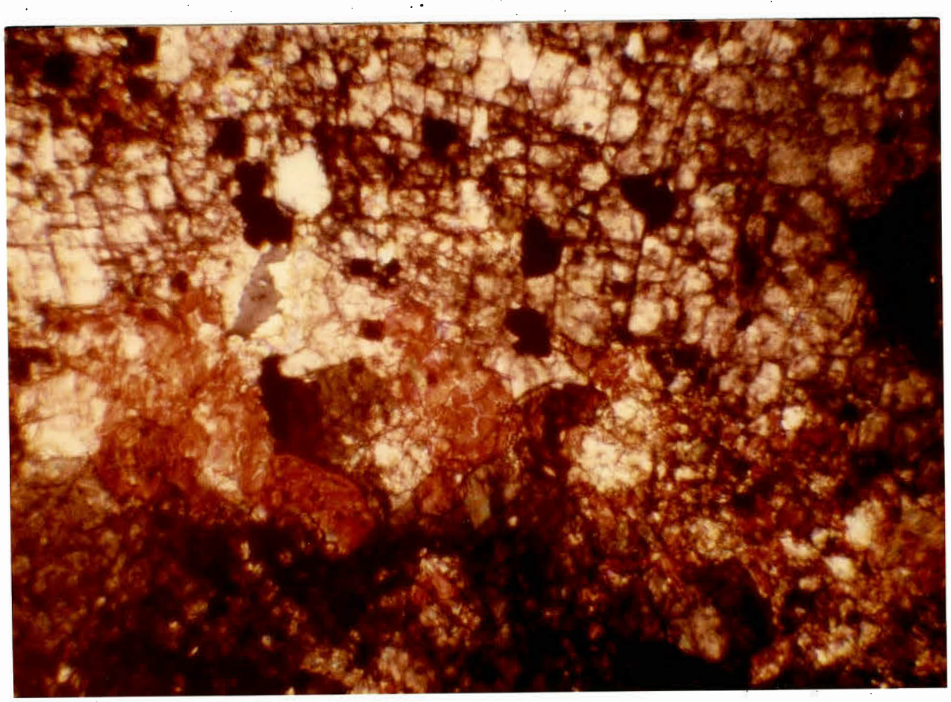

Fig. 17--Ferroan dolomite (blue) replacing calcite (red), crossed nicols, field of view .7 mm x .42 mm.

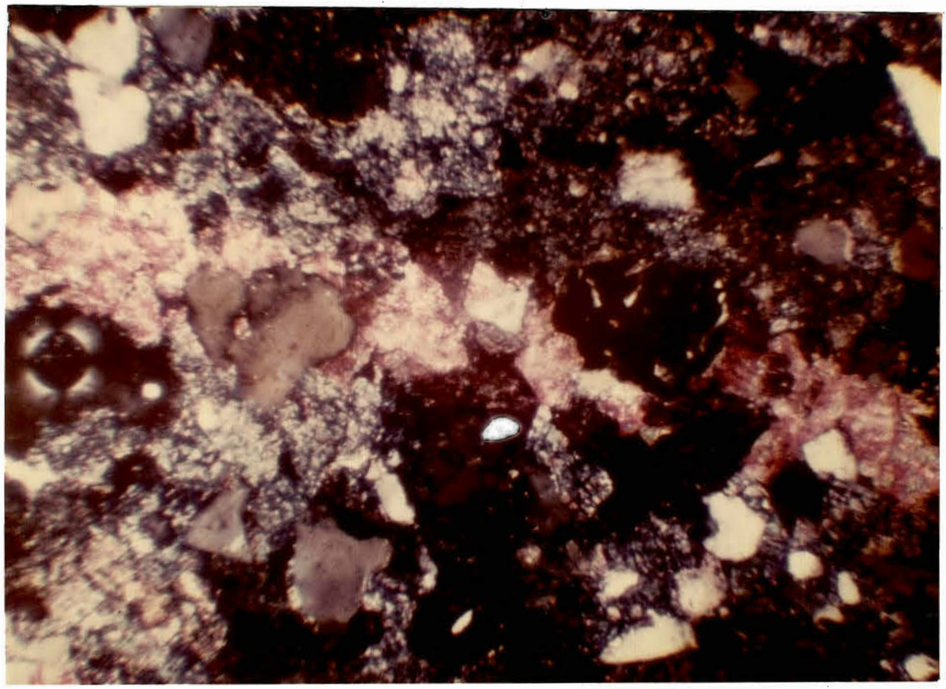

Fig. 18--Late phase calcite (red) replacing ferroan dolomite (blue), crossed nicols, field of view 1.8 mm x 1.2 mm.

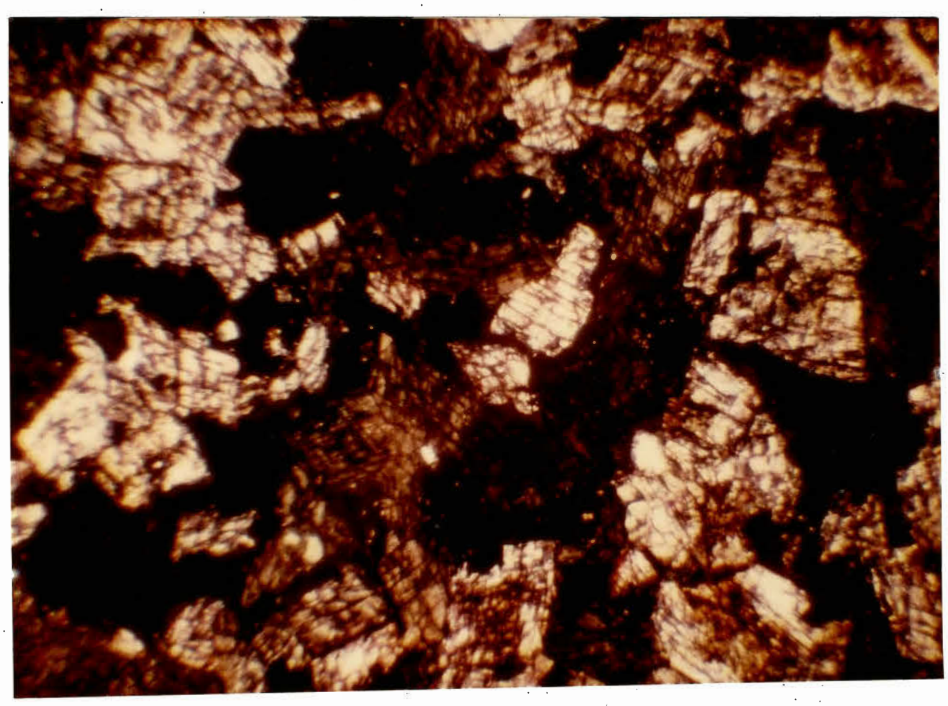

Fig. 19--Possible dissolution or plucking of detrital dolomite grain, crossed nicols, field of view 1.8 mm x 1.2 mm.

1980). Calcrete horizons indicate temporary differences in sedimentation rates and climatic conditions during deposition of these strata.

CHAPTER VI

DEPOSITIONAL ENVIRONMENT

"Granite Wash"

The Post Oak Formation-"granite wash" facies was deposited as a series of allvuial fans formed by the exposure and degradation of the Pre-Cambrian-Cambrian Wichita Mountain igneous complex together with contributions from its cover of sedimentary rocks consisting principally of Lower Paleozoic limestones. These lithotypes are now exposed to the northeast of the study area.

Alluvial fans represent a relatively small part of the stratigraphic record, but are important because of their tectonic significance. They are indicators of high relief at continental margins or within continental plates. They are localized deposits whose shape resembles segments of cones (Collinson, 1978) with the apices at the sediment sources. Alluvial fans are most widespread in the arid and semiarid parts of the world, but also occur in humid regions (Rust, 1979).

The alluvial-fan depositional environment is identified mainly by a distinctive suite of physical properties, of its constituent sediments. Bull (1972) divides alluvial fan deposits into water-laid deposits and debris flow deposits. He identifies two main types of water-laid deposits, the most common consisting of sheet-flood deposits. The latter are deposited by sediment-laden flood waters as sheets at the mouths of stream channels on a fan. These deposits consist of gravel, sand, or silt and are well sorted and may be crossbedded, horizontally laminated, or massive.

The second type of water-laid deposit identified by Bull (1972) consists of channel fill sequences in stream channels that were temporarily entrenched into the fan. These sediments are generally coarser grained and more poorly sorted than the sheets of water-laid sediments. They are most common in the upper part of the fan, because on the lower reaches of the fan there is a tendency for the floods to become unconfined and develop into sheetflood type deposits (Bull, 1972).

A third minor type of water-laid deposits is mentioned by Bull (1972). These are the highly permeable sieve deposits that cause the flow of water to diminish rapidly as a result of which infiltration of the water occurs. Hooke (1967) was the first to describe these deposits in detail. They are much less common than the other types of water-laid sediments and are difficult to identify in ancient deposits.

Rust (1979) points out it may be best to avoid subdivisions of water-laid deposits. The first two above described types of water-laid deposits can rarely be distinguished in ancient successions because channel dimensions commonly exceed those of outcrops (Bull, 1972).

Debris flow deposits are the other principal component of most alluvial fans. Debris flows are denser and have higher viscosity than water-laid deposits (Bull, 1972). Because of this, debris flow deposits are poorly sorted (Friedman and Sanders, 1978). Debris flows are promoted by steep slopes, lack of vegetation, short periods of abundant water supply, and sources providing debris with a muddy matrix (Bull, 1977). These deposits are also most common near the apices (Hooke, 1967). Debris flows are recognized by poor sorting, general lack of bedding within the flow, and uniform thickness. The poorly sorted massive beds of debris flow deposits stand out in marked contrast to the beds of water-laid sediments (Bull, 1972).

Most alluvial fans consist of both debris flow and water-laid deposits. These occur interbedded in varying proportions depending on source area conditions (Friedman and Sanders, 1978).

The overall geometry of an alluvial fan reflects the accumulation of numerous beds of differing extent and thickness, and changes in the loci of deposition caused by entrenchment and backfilling of stream channels (Bull, 1972). Adjacent fans restrict the lateral extent of individual deposits. Most fan deposits occur as a series of alluvial cones which form a piedmont slope that is sometimes called a bajada (Bull, 1972).

The "granite wash" in the study area is made up of innumberable alluvial fan deposits. They were deposited as the Wichita Mountain front receded due to erosion. Sources for the fan sediments included lithologies of the Wichita Granite Group, Carlton Rhyolite Group, and Raggedy Mountain Gabbro Group, together with the Cambrian through Mississippian sedimentary succession of the area which is composed mainly of limestones.

Evidence for an alluvial-fan environment of deposition for these deposits is based primarily on their structural setting. These deposits accumulated adjacent to fault scarps. Cross-sections through the study area indicated thick "granite wash" deposits on the downthrown sides of fault blocks (Plates 4-14). The coarse grain size of these deposits, along with the rapid lateral facies changes they exhibit, lends support to this interpretation. The sediments are texturally and mineralogically immature. Thin section data indicate a local provenance for these sediments. Since granophyres are predominant within the acid igneous rock fragments, the major source of sediment was probably the Wichita Granite Group. The microperthitic fragments may have been derived from either the Wichita Granite Group or the Carlton Rhyolite Group. Single calc-alkaline plagioclase grains may have originated from the Raggedy Mountain Gabbro. Although no detrital limestone grains were positively identified as being of Arbuckle Group origin, limestone conglomerate should be expected proximal to Arbuckle outcrops. Cross-sections (Plates 9 and 10) show a possible limestone conglomerate "granite wash" facies. Limestone conglomerate was also noted in drillers logs of several of the oil wells studied.

The fresher, poorly cemented unaltered zones of granophyric and microperthitic clasts probably represent zones of water-laid sediments whose deposition was fairly rapid. The argillaceous zones may represent zones of debris flow type deposits. Some of this matrix may be the product of the breakdown of feldspars within granitic sediments as discussed above. Calcrete horizons indicate long periods of non-deposition in parts of the fan complex due to the lateral migration of the major locus of deposition with time. These horizons are also indicative of an arid to semiarid climate (Allen, 1974). Most Quaternary examples of calcrete development have formed in the shallow subsurface of stable geomorphic levels in areas with an annual precipitation of less than 60 centimeters (Gile, 1970). Calcrete horizons have also been described by Donovan (1980) in shallow "granite wash" sediments two townships east of the study area.

Late in Leonardian time, as the Wichita Mountains ceased to be a source of sediment and as the sea transgressed over the alluvial fan deposits, marine reworking of some of these deposits should have occurred. Fans may have prograded into standing bodies of water as the sea retreated and advanced throughout the Late Pennsylvanian and Early Permian (Hansen, 1978). The overall fining-upward trend in these conglomerates may reflect increasing marine reworking. Reading (1978) states that tectonic activity is the main process which affects the coarsening-upward or fining-upward of alluvial fan deposits.

Hennessey Shale

The Hennessey Shale Formation is composed of red and green claystones, mudstones, and thin-bedded siltstones with some gypsum veins and seams. In the study area it consists mainly of shales and claystones, with a few siltstone beds and silty shale layers (Stith, 1968). "Granite wash" immediately underlies the Hennessey Shale except for a few locations where th Hennessey Shale directly overlies the Cambrian igneous complex. The Hennessey Shale was deposited in a low-energy environment as evidenced by its overall fine-grain size (Stith, 1968). The principal depositional environment represented by the Hennessey Shale Formation is shallow marine with associated tidal-flat and near-shore facies (Stith, 1978). The Hennessey Shale grades laterally into the Post Oak Conglomerate at the surface in T5N, R16W in the study area (Fig. 4) (Chase, 1954). This may represent a gradational contact between an alluvial fan facies of the Post Oak Conglomerate and a near-shore facies of the Hennessey Shale. Alternatively, the alluvial fan might have been laid down prior to the deposition of the Hennessey Shale. Conglomerates and arkoses were thought to be deposited continuously at least through the end of Hennessey Group time (Shelton and Al-Shaieb, 1976). By the close of deposition of the Hennessey Group the Wichita Mountains ceased to be a major source of coarse clastic sediment except for gravels deposited locally around isolated granite hills (Merritt, 1958). Johnson and Dennison (1973) consider that the Wichita Mountains were completely covered by El Reno Group sediments which conformably overlie the Hennessey Group.

CHAPTER VII

URANIUM POTENTIAL

"Granite Wash"

The uranium potential of the "granite wash" was evaluated on the basis of criteria established by Grutt (1971). The characteristics considered by Grutt to be favorable for the occurrence of sandstone-type uranium deposits are discussed below.

Regional Criteria

Regionally favorable criteria established by Grutt are: (1) from Permian times until the end of the Tertiary Era, the western interior of the United States was especially suited for the formation of uranium, because during this time period it was an area of general emergence and orogeny; (2) host rocks for uranium deposits seem to be limited to fluvial, marginal marine, or aeolian sandstones; (3) theoretically, granitic and tuffaceous rocks can be important sources for uranium. Facies and textures of sandstones favorable for uranium deposition are found in areas in which erosion of these rock types provided detritus; (4) unconformities play a role in the formation of uranium deposits. They promote ground-water movement over large areas; (5) the most common type of uranium host rock is that of permeable feldspathic and arkosic sandstones.

The "granite wash" is of Permian age in the study area. Ninety-five percent of the United States reserves occur in rocks of Jurassic, Triassic, and Tertiary age, but important, mineable uranium occurrences of Permian age have been found in France, Italy, Yugoslavia, and Hungary in continental clastic deposits (Barthel, 1974). The "granite wash" is a continental clastic deposit of mainly fluvial origin. It is derived from a granitic provenance (Wichita Granite Group and Carlton Rhyolite Group).

The Mississippian-Pennsylvanian unconformity which the "granite wash" overlies may have facilitated ground-water movement throughout the study area. Hydrocarbons have been transmitted along the unconformity as evidenced by oil-stained granitic exposures in the study area. Channel fill sequences within the arkosic "granite wash" may have provided the necessary permeability for transportation of uraniferous ground waters.

Locally Favorable Criteria

Locally favorable criteria postulated by Grutt (1971) consist of features, elements associated with uranium deposits, and reducing agents. A detailed description of these criteria follows: (1) medium- to coarse-grained, poorly sorted sandstones seem to be the most favorable host lithologies; (2) gray, green, or tan sandstones interbedded with gray to green mudstones are common in known uranium deposits; (3) pyrite is usually present in the host sandstone; (4) the outcrops of host sandstones are stained by limonite and hematite; (5) sandstone to shale ratios range from 1:1 to 4:1; (6) beds dip less than five degrees; (7) small- to medium-scale faults control the geometries of ore bodies by creating permeable pathways for uraniferous solutions, or by permitting reducing gases, water, or hydrocarbons derived from underlying formations to enter the host formation; (8) elements associated with uranium deposits include vanadium, molybdenum, selenium, arsenic, phosphorus, manganese, and copper; (9) reducing agents present within the host rock consist of one or more of the following: vegetal carbonaceous material, structureless humic compounds, "dead" oil in a semi-oxidized state, and/or hydrogen sulfide-bearing gas or water; (10) radioactivity anomalies which are greater than five times background; (11) samples of host rock exposures have U_3O_8 values of greater than five parts per million, with sporadic occurrences of oxidized uranium minerals; (12) ground-water anomalies greater than 10 parts per thousand million (ppb) uranium are found in host rocks in most deposits undergoing oxidation; (13) areas marginal to carbonate-cemented sandstone may be favorable exploration targets.

The "granite wash" exhibits characteristics comparable to most of the above-listed locally favorable criteria. It is typified by coarse-grained, poorly-sorted sandstones and conglomerates. The color of the "granite wash" sediments range from gray to red, to gray-red variegated. Authigenic pyrite is present throughout most of the "granite wash". Pyrite is known to be important because it reduces the pH of uraniferous ground water (Dall'aglio et al., 1974). This allows the release and reduction of uranium from uranium carbonate complexes and allows the precipitation of uraninite (Fig. 20).

Due to poor exposures of the Post Oak Conglomerate Formation, the extent of hematite and limonite staining of outcrops, U_3O_8 content, and the presence of oxidized uranium minerals could not be determined in the study area. The sandstone-shale ratios in the "granite wash" drill

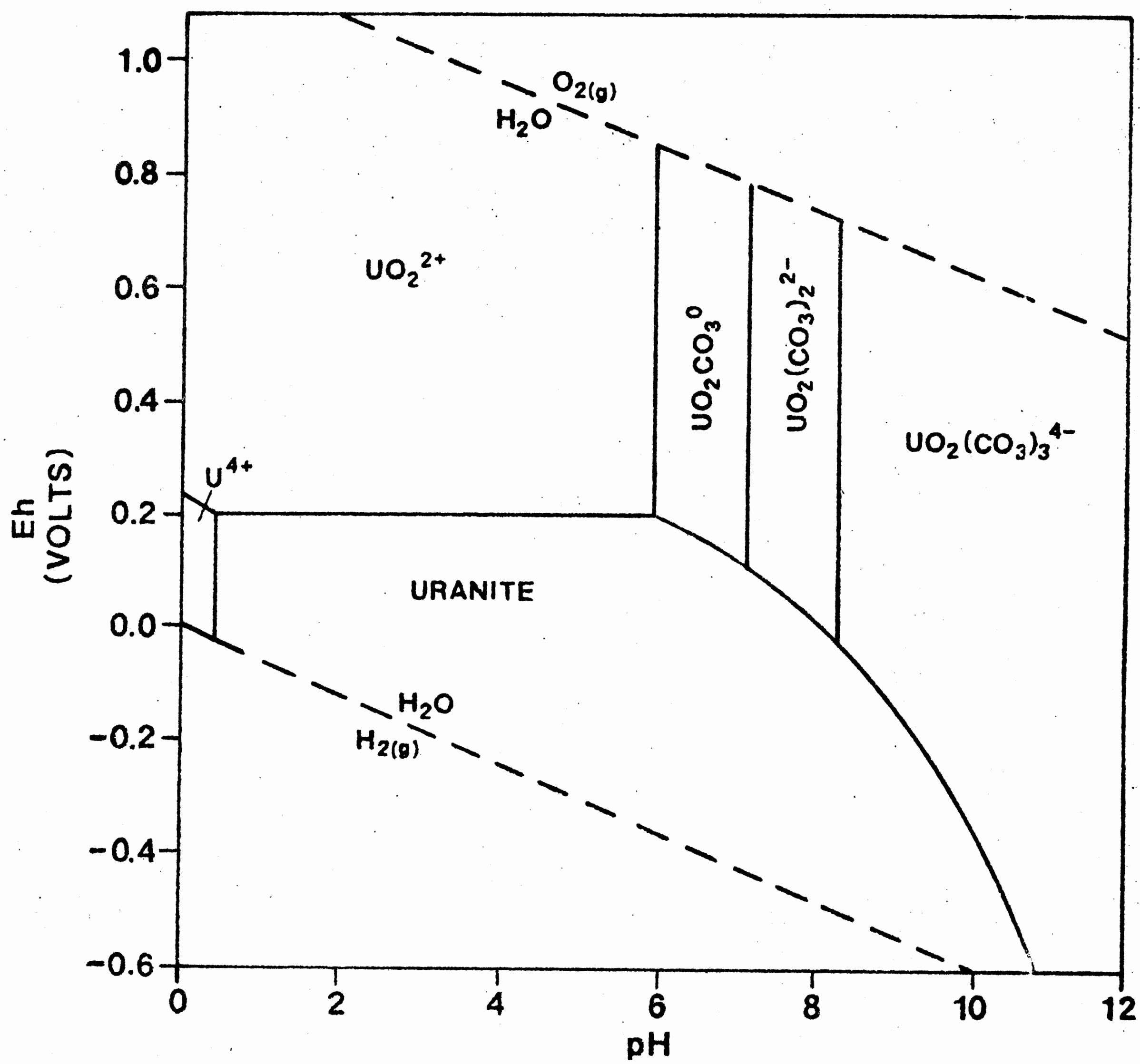

Fig. 20--Uraninite stability in typical ground water. Eh-pH diagram in the U-O_2-CO_2-H_2O system at 25°C for P_{CO_2}=10^{-2}ATM. Uraninite $UO_{2(c)}$, solution boundaries are drawn at 10^{-6}M (0.24 ppm) dissolved uranium species (from Langmuir, 1978).

cuttings commonly exceeded 4:1, but the ratios of sandstone to impermeable debris flow mudstones range from 1:1 to 4:1. The dips of the "granite wash" strata both at outcrop and in the subsurface could not be determined. The original dips of sediments deposited in alluvial fans are generally less than five degrees (Rust, 1979). The many faults in the study area may have provided pathways for migration of uraniferous solutions, and may have permitted reducing gases, water, or hydrocarbons from underlying formations to permeate the "granite wash". Oil and gas are presently being produced from "granite wash" strata in the Komalty Pool in the study area (Plate 4). The Hydrogeochemical and Stream Sediment Detailed Geochemical Survey for the Wichita Uplift Region, Oklahoma (Butz et al., 1980) identified the presence of anomalous concentrations of arsenic, molybdenum, and selenium in the ground water and stream sediments of the study area. Reducing agents present in the "granite wash" include "dead" oil and reducing gases. Zones of vegetable carbonaceous material were not noted by the author in the "granite wash" samples from the study area. Carbonaceous trash was reported in "granite wash" sediments north of the study area by Hansen (1978) and in the Post Oak Conglomerate Formation on the south side of the Wichita Mountains (Al-Shaieb and Shelton, 1976). No surficial radioactivity anomalies were found in a car-borne radiometric survey of the study area. Ground-water anomalies greater than 10 ppb, with the greatest reported value equal to 100 ppb were found in the Hennessey Shale Formation in the study area by Butz et al. (1980). "Granite wash" facies marginal to carbonate cemented "granite wash" sediments may be suitable hosts for uranium deposits. Hagmaier (1971) suggests that the soluble uranyl-carbonate complex, which is stable in bicarbonate ground-water facies, becomes unstable when calcite is precipitated by mixing of carbonate and sulfate ground-water facies. The uranyl ion is released and precipitated as pitchblend if the reducing conditions (Eh) are favorable (Fig. 20). Sulfate ground-water facies were detected by Butz et al. (1980) in the study area.

Characteristics of Selected Uranium Districts

The Uravan mineral belt in southwestern Colorado is an example of uranium deposition in alluvial fan sediments. Deposition of uranium is concentrated in the Salt Wash Member of the Morrison Formation. It was deposited as a broad alluvial fan by a distributary stream system (Fisher, 1974). Ground water moving downward due to gravity would tend to be channeled in and move downdip along more permeable beds. Urnaium carried by this water in small quantities could precipitate in places where adequate reducing conditions prevailed.

The Ambrosia Lake area within the Grants mineral belt is another example of uranium deposition in alluvial fan sediments (Kelley, Kittel, and Melancon, 1968). The largest deposits occur in the arkosic Westwater Canyon Member of the Jurassic Morrison Formation. The Westwater Canyon Member ranges from 30 to 270 feet in thickness and was deposited as coalesced alluvial fans. Fan sediments were derived from sedimentary and granitic source rocks. The deposits formed at the contact between uraniferous ground water and carbonaceous residue which was derived from decaying plant material.

Uranium deposits in the Shirley Basin in Wyoming occur in the Wind River Formation of early Eocene age. The Wind River Formation consists of conglomeratic arkose beds interlayered with clay and silt beds. The formation ranges in thickness from 0 to 500 feet and was deposited by braided aggrading streams (Melin, 1964). Calcite cement and pyrite are sparsely disseminated within the sediments which contain differing amounts of matrix (composed of clay, silt, and sand) of variable distribution. Most of the Wind River sediments were derived from granitic rocks west and/or southwest of the Shirley Basin. The main reducing agent in these deposits is coalified plant debris.

There is an obvious overall similarity between the geological characteristics of these examples and that of the "granite wash" in the study area. The type of geologic setting represented by the above-listed examples offer the best exploration targets for future uranium deposits. Uranium deposits within the "granite wash" are expected to occur within permeable sediments, especially channel fill sequences proximal to carbonate cemented sandstones and conglomerates, and in hydro-geochemically reactive zones. These may be located near sandstone pinch-outs or in grain size changes in the sandstones, or near areas where the presence of "dead" oil and/or coalified plant remains created favorable reducing conditions. In addition, localized reduced zones within calcrete horizons offer potential sites for uranium deposition (Donovan, 1977). Calcrete has been found to be a site for uranium precipitation in both Somalia and Western Australia (Dall'aglio et al., 1974).

Hennessey Shale

The Hennessey Shale Formation is unfavorable for uranium occurrence. Its shale, clay, and siltstone composition tends to retard ground-water movement. Sandstones (if present) would be lenticular in nature and laterally discontinuous. The Hennessey Shale is also red in color due to the oxidation of iron. The overall lack of reduced sediments detracts from its favorability for uranium deposition. Significant uranium deposits are not known to occur in fine-grained oxidized tidal-flat and near-shore sediments.

CHAPTER VIII

SUMMARY

1) The "granite wash" in the study area ranges in age from Lower Wolfcampian to Upper Leonardian.

2) Evidence points to left-lateral strike-slip movement along the Meers (Thomas) fault.

3) Permian arkosic "granite wash" strata were deposited as a series of alluvial fans.

4) The "granite wash" sediments were derived from the granitic Wichita Mountains uplift with minor contributions from Lower Paleozoic limestones.

5) Complex diagenetic patterns, including dissolution features of grains in the "granite wash" are a function of ground water circulation and hydrocarbon migration.

6) Petrographic analysis confirmed the presence of calcrete horizons in the "granite wash". The calcretes represent carbonate formation on sediment starved areas of the fan complex and are indicative of an arid to semiarid climates.

7) Characteristics of the "granite wash" in the study area compare favorably with previously discussed regional and local criteria for prospecting for sandstone-type uranium deposits.

8) Specifically, uranium mineralization in the "granite wash" should be expected within water-laid sediments in hydrogeochemically reactive

zones. Calcrete horizons may also be sites of mineralization.

(9) The Hennessey Shale Formation is not a favorable host rock for any significant uranium mineralization.

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APPENDIXES

APPENDIX A

CORPORATION COMMISSION LOGS USED IN STRATIGRAPHIC

CROSS-SECTIONS AND SUBSURFACE MAPS

5N 15W

NE, NE, 4, Shadid Production
Lone Wolf #1

SW, SE, NW, 6, Arizona Explorations, Inc.
Tucker #1

NW, SW, NE, 7, Parker, Rogers 'etal.
Messinger #1

NW, NW, NW, 9, Gotebo Production Corp.
Ewing #1

SW, SE, SE, 10, Paul Pfrimmer
Mace #1

NW, SE, NW, 14, Mohoma Oil Co.
Pirlle

SW, SW, SW, 14, Harold Grant
Evatt #1

SW, NE, SE, 18, Seiber-Miller
Scott #1

SW, NE, NW, 20, Hirsch, Huntley & Hirsch
Hirsch, Huntley + Hirsch #1

5N, 16W

NW, SE, NE, 1, C.I. Holliman
Tucker #1

NW, SW, SW, 2, B.B. Farris
Geis, #1

NW, NE, NW, 2, Rex Whistler
Hult #3

SW, SW, NW, 5, G.K. Woods
Mitchell #1

NW, SW, NE, 15, Charles O. Henderson
Jackson #1

SW, SW, NE, 16, Olympic Petroleum Company
Straub #1

NE, SW, NE, 16, Charles O. Henderson
Stringer #1

NW, NW, SE, 25, E.O. Willis
Rhea #1

6N, 16W

SW, NW, NW, 13, Geo.L. Ashelman
School Land #1

SW, SW, SW, 16, Malernee Oil Co., etal
State Land #1

SW, NW,SW, 17, Boyd Laughlin
Prough #2

NW, SW, NW, 17, B.L. Hoover
Weigandt #2

NW, SE, NE, 18, Nichols and Searle, Inc.
Weigandt #18

SW, SE, SE, 18, Obele Oil Company
Obele-Ditmars #3

NE, SE, NW, 18, Searle, Hoover, Nichols
Weigandt #5

NE, NW, SW, 19, Neel W. Carbaugh
Laufer #3

NE, SW, NW, 19, Carco Oil Company
Webster #3

SE, SE, SW, 19, J.T. Bowman + A.E. Bowman
Laufer #1

NE, NE, NE, 19, C. + S. Oil + Drilling Co.
Fuchs, #1

SE, SE, SE, 20, Charles O. Henderson
Cook #1

SE, SE, SE, 3, A.R. Cole
Rogers #1

SE, NE, SE, 3, A.R. Cole
Rogers #2

SW, NW, NW, 3, A.R. Cole
Hancock #2

SE, NE, NE, 4, Garrett + Hi-Fi Drilling
Zimmerman #1

NW, SW, NW, 4, A.R. Cole & Fred Garret
Zimmerman #2

NW, NW, NW, 4, Jackson + Garrett
Zimmerman #1

NW, SE, SE, 4, Eugene W. Pace
Baumgart #1

NW, NE, SE, 4, C.H. Green
Keith #1

SW, NE, SE, 5, John H. Chalmers
Heller #1

NW, NW, SW, 5, Bluebird Oil Co., Inc.
Heller #1

NE, NW, NW, 5, Kiowa Oil of Texas, Inc.
Sims #1

NE, NE, SE, 6, M.A. Walker
Freeman #1

SW, SW, NE, 6, Strother Petroleum
Harris #3

NE, NE, SE, 7, R.H. Darrow
Carter #1

NW, NW, NW, 8, Haskins & Knickerbocker
Schmidt #1

SE, SE, SE, 9, V.B. Likins
Aetna Life Insurance Co. #1-A

NE, NE, SW, 10, L. Payne
Rogers #2

SE, SE, NE, 12, Wywell Co.
Robertson #1

SW, SE, NE, 12, Wywell Co.
Robinson #2

NW, NE, NW, Olan Tyson
Ferris #1

SE, NW, NW, 14, Harper Wood & Glen Wolfe
Smith #1

NE, NW, NW, 15, B.H. Waggoner
Rogers #1

NE, NE, SE, 16, W.W. Allman
Smelser #1

SW, SW, SE, 21, J.D. Harris
Clark #1

NE, SW, NW, 22, Joe M. Bashara
Hampton #1

5N 17W

NW, SW, NE, 2, Frank Walters
Walker #2

SE, NW, NE, 4, American Minerals + Oil, Inc.
Harrison #1

NE, NE, NW, 6, Frank W. Bowdle
Hebensperger #1

NW, NW, NW, 8, Skinner + Skinner
Ard #1

NE, NW, SW, 11, R.L. Michael
Porter #1

SW, SW, NE, 12, Gordon Galloway
Block #1

SW, NE, SW, 18, A.B. Edwards
Curtis #1

NW, SW, NE, 20, John N. Fidel
Farrar #1

5N, 18, 19W

SE, SE, SW, 1, Caudill-Bed Rock Pattnership
Walker, #1

NW, NW, NW, 20, Clifton Thomas, Trustee
Leavell #7

NE, NE, SW, 20, R.W. Harris
Grant #2

SW, NE, NW, 21, Curtis Pryor
State #1

SW, SE, SE, 21, W. Duckworth
State #2

NW, SW, NW, 21, Olan Tyson
State #1

NE, NW, SE, 23, R.W. Harris
State #1 "Janz"

NE, NW, SW, 24, Dublin-Kiel
Rainy Mt. School Reserve #1A

NE, NW, NE, 26, Callihan Interests, Inc.
Parr #1

NE, SW, NW, 27, Caraway etal
Schmidt #1

NE, SE, NW, SE, 28, Jennings + Clogg
State #1

NE, SW, SW, 28, Lowell Hudson Oil Col, Inc.
State Land #2B

NE, NE, SW, 28, B.L. Hoover
State School Land #2

NW, NW, SW, 28, B.L. Hoover
Stateland #1

NW, NE, NW, 29, Joe B. Bourland
Ditmars #5

NW, SW, SW, 29, Carl Short etal
Prough #5

NW, NE, NW, 30, Julkirk Corp.
Krigbaum #5E

NE, SE, SE, 30, L.H. Armer
Fuchs #7

SE, NW, SE, 30, Hobart Production Co.
Fuchs #12

NW, SW, NE, 30, Clyde C. Aylesworth
Fuchs #2

SW, SW, SW, NE, 30, Oil + Gas Inc. of Texas
Fuchs #9

NW, SE, NE, 31, W.E. Pittman etal
Burton A #24

SW, NE, NW, 31, L.L. Lindsey
Dudgeon #3

NW, NW, SW, 31, Frank W. Burger
Dudgeon #1

SE, NE, NE, 31, Olan Tyson
Burton, #1

NE, NW, SE, 31, T.H. McGilless
Burton #1

SE, NE, SE, 31, Strother Petroleum
Burton #2

SE, NE, SE, 31, Strother Petroleum
Burton #1

NW, NW, NW, 32, Carl Short etal
Parr #3

NE, NE, SW, 32, Joe B. Bourland
Burton #2

NE, NE, SW, 32, B + B Production Co.
Burton #1

NW, NW, NE, 32, M.B. Chastain
Parr #1

NW, NE, NW, 33, B.L. Hoover
Oklahoma State #1

NW, NW, NE, 33, Richard T. Garrison etal
State #1

SE, SE, NW, 33, B.B. Banner
School Land #2

NW, SW, SW, 34, Rex Whistler
Baker #1

6N, 17W

NW, SW, SE, 13, O. Seldon Baker
Baker #4

NW, SW, SE, 13, O. Seldon Baker
Baker #1

SW, SE, SE, 13, A.E. Pearson etal
State #10

NE, NW, SW, 13, Earl Sossamon
State "D" Lease #5

SE, NW, NE, 13, Curtis Pryor
State #1

SW, NE, SW, 13, Earl Sossamon
State "C" #6

SE, SE, SE, 14, Anderson-Prichard Oil Corp.
School Land #1

NE, NE, SE, 14, Joe B. Bourland
State #1

NW, NW, NE, 14, S.D. Butcher + Delta Pet. Corp.
State #4

NE, SW, NW, 14, San Diego Oil Co.
State #3

NE, NE, NE, 14, R.W. Harris
State #1 "Daisy D"

SW, NW, SE, 14, R.W. Harris
State School Land #1

SW, SW, SW, 15, Pete Hall Production
Hobbs 1A

NE, SW, NW, 15, J.V. Teague
Hobbs #1

NE, SE, NE, 15, Forth Worth Oil Company
Weigandt #2

SE, NE, SE, 15, R.W. Harris
Greb #1

SE, SE, SE, 17, J.S. Person etal
Barnes #1-17

NE, NE, NE, 18, H.J. Sherman, Etal
McCurdy #1

SE, SE, SE, 19, Northern Star Seed Farms
Senter #1

NW, SW, SE, 21, J.S. Person etal
Barnes #1-21

NE, NE, NE, 22, Cabot Carbon Company
Parr #1

NE, SW, NW, 22, Earl Sossamon
Parr #1

SE, SW, NW, 23, J.K. Griffith
School Land B #5

SE, SW, SE, 23, W.E. Pittman etal
School Land #1

SW, NW, NE, 23, Oklahoma Pipe + Supply
State #2

NW, NE, NE, 23, Chambers + Kennedy
State #1

NW, NE, NW, 23, J.K. Griffith
School Land #2

NE, NE, NE, 23, Willie Bendorf
State #1

SE, NE, NW, 24, R.W. Harris
State School Land #2 "Bingham"

SW, NE, NE, 24, Earl Sossamon
State "A" Lease #2

NE, SE, NE, 24, Clifton Thomas
State #4

SW, SE, NE, 24, H.C. Andrewski
State #4

NE, NE, SE, 25, A.L. Myrick
School Land #1

SE, NW, NW, 25, W.E. Pittman etal
Sec. 25 School "B" #1

SW, SW, SE, 26, Marshall & Wiskirchen
Kerr #1

NE, NE, SE, 26, Marshall + Wiskirchen
Kerr #3

NE, NE, NE, 26, Conka Prod. Co.
Krigbaum #1

SE, SE, SE, 30, F.C. Berry
Wobrock #1

SE, SE, NW, 31, Kermit Smith
Terry #1

CEN, NW, SE, 31, Caudill-Bed Rock Partnership
Koeppe #1

SW, SE, SW, 33, Bigan + Burgess Oil Co., Inc.
Miggins #1

NE, NW, NW, 34, V.R. Wyatt + Jack Choate
Scott #2

NE, NE, SE, 35, W.H.U. Oil Co.
Walker #1

NE, NE, NE, 36, W. Ross Pierce
State #1A

SE, SW, NE, 36, W. Ross Pierce
State #1

<u>6N, 18W</u>

NE, NE, NW, 13, Stauffer Petroleum Company
Clarence Mayo

NE, SW, SW, 14, The Reinhart + Donovan Company
E.A. Dugger #1

NE, SE, NE, 24, Earl Sossamon
Mothersead #1

NW, NW, NW, 25, L.M. White
Bradfield #1

SW, NE, NE, 36, Ruby L. Myles
Goforth #1

CE, SW, SW, 36, William-Copeland, Inc.
Braun #1

APPENDIX B

LOCATION OF ELECTRIC-LOGS

USED IN CROSS-SECTIONS

Cross section J-J'

28-6N-16W, Jennings and Clogg, State #1

5-5N-16W, Bluebird Oil Co., Heller #1-A

8-5N-16W, Troy Douthitt, Geis #1

26-5N-16W, Elton Flake, Maclain #1

Cross section H-H'

24-6N-18W, Pete Hall Drilling Co., Hobart Airport #2

21-6N-17W, Mercer, Huffine, and Krohn, Kutz #1

22-6N-17W, Pearson and Polk Drilling, Parr #1

25-6N-17W, May Petroleum, State #2-A

30-6N-17W, R.W. Harris, Kriegbaum, #2-A

28-6N-16W, Jennings and Clogg, State #1

26-6N-16W, Groendyke, Snider, and Pennington, Baker #1

36-6N-16W, Pete Hall Drilling Co., Staley #1

APPENDIX C

LOCATIONS OF WELLS FROM WHICH SAMPLES WERE AVAILABLE FOR STUDY

11-5N-16W, Amerada, Cooper Valley Prospect, Corehole #1

14-5N-16W, Amerada, Cooper Valley Prospect, Corehole #2

2-5N-16W, Amerada, Cooper Valley Prospect, Corehole #3

7-5N-15W, Amerada, Cooper Valley Prospect, Corehole #4

10-5N-16W, Amerada, Cooper Valley Prospect, Corehole #5

VITA

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