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BASEMENT ROCKS IN ADJOINING PARTS OF OKLAHOMA, KANSAS, MISSOURI, AND ARKANSAS

by

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A

DISSERTATION

Presented to the Faculty of the Graduate School of
The University of Texas in Partial Fulfillment
of the Requirements
For the Degree of
DOCTOR OF PHILOSOPHY

By

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BASEMENT ROCKS IN ADJOINING PARTS OF OKLAHOMA, KANSAS, MISSOURI, AND ARKANSAS

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Samples from more than two hundred and twenty wells penetrating basement rock have been examined and described from a 61,000 square mile area in adjoining parts of Oklahoma, Kansas, Missouri, and Arkansas. Twenty-five isotopic age determinations were made on twenty samples of basement rock from wells and outcrop areas.

Nine basement rock units can be defined within the study area on the basis of petrography and isotopic age.

1. "Older granite and gneiss" is a loose association of granitic rocks considered to be older than 1400 million years. The unit cannot be precisely defined within the study area.

2. The Lyon County Quartzite is a micaceous quartzite restricted to relatively small areas in the buried basement of Kansas. The age of deposition is unknown but preceded the 1400 million year age of metamorphism.

3. The Chase County Granite Group is composed largely of granite and gneissic granite. Rocks of this group underlie most of the Nemaha Uplift in Kansas and also occur considerably east and west of the Uplift. The rocks were intruded at about 1400 million years, probably as a composite batholith.

At about 1200 million years, four petrographically related rock units were intruded or extruded. The age difference between these units cannot be distinguished by isotopic ages. The four units are assembled into the Northeast Oklahoma Province, a petrographic grouping of volcanic rocks and chemically equivalent hypersolvus type epizone granites.

4. The Washington County Volcanic Group is composed mostly of rhyolite but also contains andesite and metarhyolite. The majority of the rhyolites were probably extruded as welded tuffs.

5. The Spavinaw Granite Group is composed of generally micrographic granite porphyries. The intrusions are considered to be largely sills on textural evidence and by analogy with outcrop areas elsewhere.

6. The Woodson County Granite is texturally variable. Samples from drill holes in Kansas are petrographically identical to boulders found at Rose Dome in Woodson County, Kansas.

7. The Osage County Microgranite is the most uniform

unit in the area. The microgranite occurs in a roughly circular area in Osage County, Oklahoma. The unit was probably intruded as a sill within rhyolite flows.

Two other petrographic units are interpreted as being younger than parts of the Northeast Oklahoma Province, although in the same 1200 million years isotopic age range.

8. The Vernon County Metamorphic Group is composed mostly of low rank metamorphic rocks derived from clastic sediments. The grade of metamorphism is from incipient to middle greenschist facies. Rhyolite detritus occurs in some samples.

9. The Central Oklahoma Granite Group is composed of two feldspar mesozone type granites. The unit is not distinguishable from the Chase County Granite Group on the basis of petrography.

Uplift and erosion followed the intrusion of the Central Oklahoma Granite Group. The main uplifts were along the present Nemaha Uplift and along a northeast-southwest axis from southwest Missouri to central Oklahoma. There is no evidence for any igneous or metamorphic activity between 1200 million years and the deposition of lower Paleozoic sediments.

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INTRODUCTION

A study of the buried basement of northeast Oklahoma was planned and initiated by the Oklahoma Geological Survey. In 1962 I transferred from the Oklahoma Geological Survey to the newly formed Crustal Studies Laboratory of The University of Texas where the study was expanded to include the adjoining parts of Kansas, Missouri, and Arkansas.

The successful studies of Flawn (1956) and Ham and others (1964) have demonstrated that geologically significant data can be obtained by the petrographic study of samples of basement rock from widely separated drill holes. Clearly the studies are more meaningful in areas where wells are closely spaced, basement rocks are exposed, and geophysical measurements are available. Isotopic age determinations are necessary for the correct interpretation of geologic history.

Because of its comparative simplicity the area under examination here is one of the most suitable for basement rock studies. There are approximately 61,000 square miles in this four-state area. The well control ranges from dense to very sparse. The drill holes are concentrated in areas of oil production and those regions that have proved unproductive are notably lacking in wells to basement. The greatest number of wells drilled to basement are from those areas where oil and gas is produced from sedimentary rocks immediately overlying the basement surface. Very few wells have penetrated more

than five hundred feet of basement rock, therefore a three-dimensional picture of the geology is difficult to construct. Only two wells examined, one in Missouri and the other in Kansas, penetrated more than a thousand feet.

Precambrian rocks are exposed in two small areas, the Spavinaw Granite in Mayes County, Oklahoma, first described by Drake (1897), and the controversial exposure of granite boulders at Rose Dome in Woodson County, Kansas, first described by Twenhofel (1917).

PREVIOUS WORK

The only systematic description of basement rock in the area of Figure 1 has been in Missouri. Skillman (1948) reported and described samples from two deep wells in pre-Upper Cambrian metasedimentary rocks in Vernon County. Later, Adams (1959) examined samples from basement tests throughout Missouri.

Farquhar (1957) published on basement rocks in Kansas. The data in his publication are not systematically treated and the rock distribution is presented schematically. It appears that few wells from eastern Kansas were examined; most of the samples cited are from the Central Kansas Uplift. A basement rock map of Kansas based on drillers logs has been published by Merriam and others (1961).

Basement configuration maps are available for northeast Oklahoma (Ireland, 1955; Dille, 1956), Missouri (Grenia, 1960), and Kansas (Cole, 1962). An excellent basement rock bibliography for Kansas (Merriam, 1964) is available.



Figure 1. Area (ruled) of this basement rock study.

PURPOSE, METHOD, AND SCOPE

The purpose of this study is to make a basement rock map and to infer the geologic history of the Precambrian through detailed petrographic study of samples from wells drilled in search of oil, gas, and other minerals. Every sample available was examined, even in areas of close well spacing, in order to determine the variation in the observed rock groups.

Isotopic age determinations of various suitable samples were made under a cooperative agreement with the Isotope Geology Branch, United States Geological Survey. The dating proved invaluable in differentiating rock units that are not petrographically distinguishable. Twenty-five ages were determined on samples from twenty wells and outcrops. These determinations make possible a radiometric as well as relative age sequence.

Geophysical information was used in an attempt to extend known basement rock units into areas of no control. The interpretation shown on the map (Pl. I) will be tested by future drilling.

In all four states basement well data were made available by the state geological surveys. The list for Kansas is published (Cole and others, 1961) with yearly supplements (Cole and Merriam, 1962; Cole and others, 1963). The list of wells in Arkansas is included in a more comprehensive

report on northern Arkansas by Caplan (1960). The lists for Oklahoma and Missouri were compiled and made available by the respective geological surveys. Samples were obtained almost entirely from the geological surveys of each state.

The petrographic nomenclature is that used by Williams, Turner, and Gilbert (1958). The one exception is the term granite. In this report granite is used in a more general sense and includes adamellite. Most of the samples studied in two of the rock groups are very close to the generally accepted granite-adamellite boundary. Small chips from well cuttings are inadequate for effective separation of granite from adamellite.

References to specific wells are followed by a code number (e.g., Mo-11). These numbers have been assigned in order to identify the samples more easily. Thus Mo-11 is the eleventh well from which samples were examined from Morris County, Kansas. A key to these abbreviations is included at the beginning of the petrographic descriptions (Appendix).

ACKNOWLEDGMENTS

The most important aid has been the moral and financial support of Dr. W. R. Muehlberger, director of the Crustal Studies Laboratory, The University of Texas, Austin. This laboratory has had the mission of making a basement rock map of North America. The funds for this work were supplied by the Air Force Office of Scientific Research as part of the Advanced Research Projects Agency project VELA UNIFORM under contract No. AF 49(638)-1115. This study was supported by funds from this contract.

This report could not have been made without the cooperation of the state geological surveys of Oklahoma, Kansas, Missouri, and Arkansas.

The Oklahoma Geological Survey actively supported this project by collecting all samples and the loan of all thin sections from northeast Oklahoma. Drs. W. E. Ham and Louise Jordan were particularly helpful.

Drs. D. H. Merriam and W. W. Hambleton of the Kansas Geological Survey offered all the facilities of that organization. All Kansas thin sections were purchased by the Kansas Geological Survey and are in their permanent collection at Lawrence.

Dr. W. C. Hayes loaned the thin sections and samples of basement wells from the files of the Missouri Geological Survey.

Dr. F. G. Snyder, then chief geologist for the St. Joseph Lead Company, gave the Crustal Studies Laboratory numerous basement samples from Missouri, one of which was in the study area.

W. M. Caplan of the Arkansas Geological Survey supplied the samples from the two basement wells examined in Arkansas.

Isotopic ages were determined as part of a cooperative project between the Crustal Studies Laboratory and the Isotope Geology Branch of the United States Geological Survey under the direction of S. S. Goldich, then branch chief.

The dissertation was critically read by Professors W. R. Muehlberger, S. E. Clabaugh, and P. T. Flawn of The University of Texas and Dr. W. E. Ham of the Oklahoma Geological Survey.

PETROGRAPHY AND ROCK UNITS

In the four-state area under study nine rock units can be defined on the bases of petrography and age. Several of these rock units possibly could be subdivided if there were more samples available and the wells more closely spaced or evenly distributed.

The nine rock units from oldest to youngest are:

1. "Older granite and gneiss" includes rocks that on the basis of petrography are similar to rocks in northeast Kansas and central Missouri that have been dated at about 1500 to 1900 million years (Muehlberger and others, in preparation). None of the samples in the study area have been dated. The rocks are gneisses, generally of granitic composition, and gneissic granites.
2. The Lyon County Quartzite is not widely distributed but is a distinct petrographic entity with characteristic topographic expression. One core sample yielded a total rock date by rubidium-strontium of 1400 million years and 1260 by the potassium-argon method. The rubidium-strontium age is considered to be near the age of metamorphism. The potassium-argon age may be lower due to episodic argon loss during later igneous activity.

3. The Chase County Granite Group includes some gneissic granite and granite gneiss. These rocks are found mainly along the Nemaha Uplift in Kansas but an area in southwestern Missouri is also underlain by rocks of this group. The age of the granite on the basis of six dates from widely separated samples is about 1400 million years. The granite is considered to be the agent responsible for the metamorphism of the Lyon County Quartzite.

Within this framework of older rocks, and during a narrow time interval (unresolvable by isotopic ages), four rocks were extruded or injected. These four units have the close petrographic affinity of an intrusive-extrusive complex, similar in many respects to the silicic igneous part of the Wichita Province in southern Oklahoma (Ham and others, 1964). These four petrographic units are here grouped into the Northeast Oklahoma Province. This province is a petrographic grouping of rhyolite and hypersolvus type granites. Eleven rubidium-strontium ages have been determined on ten widely separated samples from this province. The best age is 1200 million years on a least squares fit isochron. The units are ordered in sequence on petrographic and geologic evidence. The four units comprising this province are:

4. Washington County Volcanic Group: this group

is composed mostly of rhyolite but andesite occurs in certain areas. The rhyolite was converted to metarhyolite in a wide area around the margin of the Northeast Oklahoma Province.

5. Spavinaw Granite Group: this group is mainly micrographic granite porphyry thought to have been emplaced as a sill complex under a cover of rhyolite. Rocks of this unit crop out in Mayes County, Oklahoma, in five small hills and is found in drill holes along a broad pre-Paleozoic arch extending from southwest Missouri to central Oklahoma. The group includes strongly femic and sparsely femic granites.
6. Woodson County Granite: This rock is interpreted from sparse subsurface information as marking the northern limit of the Northeast Oklahoma Province. The subsurface samples are identical to granite found as boulders at Rose Dome in Woodson County, Kansas. Feldspar from a granite sample from this anomalous outcrop was dated at 1220 million years by the rubidium-strontium method.
7. Osage County Microgranite: this rock forms a roughly circular area in central Osage County, Oklahoma. The microgranite shows the least

petrographic variation of any unit in the study area. The microgranite is believed to have been intruded under a cover of rhyolite.

Two rock units are interpreted as being younger than the Northeast Oklahoma Province. They are the following:

8. Vernon County Metamorphic Group: this group is defined by a few widely spaced wells in southeastern Kansas and western Missouri. The rocks are derived largely from graywackes and shales. The metamorphic grade is lower to middle greenschist facies. Large areas are underlain by incompletely reconstituted graywackes. No samples from this group have been dated.
9. Central Oklahoma Granite Group: this is interpreted as the youngest basement rock unit in this area. Four samples of granite have been dated and all are near 1200 million years. Thus, this group is probably a product of the same magmatic episode that gave rise the Northeast Oklahoma Province.

"Older Granite and Gneiss"

In the grouping of "older granite and gneiss" are included all rocks which appear by petrographic character or geographic association to be related to older dated rocks

outside the study area. The rocks are presumed to be older than the 1400-million-year Chase County Granite Group.

Placing widely separated samples into an age group when none of the samples in the study area have been dated is at best an uncertain procedure, particularly when the unit does not contain petrographically distinctive rock types. This "group" cannot be properly defined because the critical rocks that have been dated are not in the study area. Granite and granitic gneisses in Pottowatomie County, Kansas, and Morgan County, Missouri, have been dated at 1520 to 1950 million years (Muehlberger and others, in preparation). These older granites and gneisses are not petrographically unique when compared to those of younger rock groups. The granites generally contain microcline and plagioclase with biotite as the characteristic femic mineral. Cataclastic features are common. The gneisses are either uniformly fine-grained and completely reconstituted or contain relict eyes of essential minerals with fine-grained completely recrystallized intereye material. Muscovite is a common mineral.

The bulk composition of all but one sample is granitic. The one exception, the City of Sedalia No. 11 (Pt-1), is a quartz muscovite gneiss. The origin of this rock is not clear but it may be either a pegmatitic phase of a normal igneous rock or a sedimentary rock.

Lyon County Quartzite

This unit is defined on the basis of samples from five wells in Lyon, Morris, and Marion Counties, Kansas. Probably the northern part of Lyon County is underlain by this rock type. Total rock determinations on the only core available from this group yielded ages of 1400 ± 100 million years by the rubidium-strontium method and 1260 million years by the potassium-argon method. The older age is interpreted as being closer to the original age of metamorphism. The younger age is possibly due to episodic argon loss during later igneous activity.

The basement surface in the area of inferred quartzite distribution is generally of high relief. Rocks of Arbuckle age are absent from at least part of the area. If the absence of Arbuckle age rocks indicates high-standing basement rock and thus indirectly quartzite, the quartzite is limited to a comparatively small area (see Merriam and Smith, 1961).

Quartz accounts for between 72 and 93 percent of the rock, the maximum variation observed in two thin sections from the same core. About 10 percent of the quartzite is composed of muscovite. The muscovite is well formed and occurs both as coarser intergranular concentrations and as smaller discrete flakes within quartz. The preferred orientation is good to moderate.

The quartz is mildly strained to unstrained. The

mineral boundaries are straight and smooth with no suturing or granulation. Quartz grains are generally slightly elongate parallel to the plane of micaceous foliation.

Small amounts of fine mica in the quartzite are probably the product of the alteration of feldspar. Intergranular microcline and albitic plagioclase account for only a small part of the rock. Opaque minerals, chlorite-biotite, sphene-leucoxene, zircon, epidote, and tourmaline are present in trace amounts. In samples from one well, the Leslie No. 1 "A" McConnell (Mo-7), zircons are concentrated along bands parallel to foliation, suggesting foliation is parallel to original bedding.

The area underlain by quartzite is surrounded by "older granite and gneiss" and in Marion County, by the Chase County Granite Group. The quartzite is interpreted as a relatively pure sandstone deposited in part on "older granite and gneiss" and possibly on other unknown rocks. The age of deposition cannot be fixed except that it must be before the dated period of metamorphism. The quartzite is interpreted as having been metamorphosed during the time of intrusion of the Chase County Granite Group about 1400 million years ago.

Quartzite is reported from the Central Kansas Uplift and its occurrence has been well documented by Walters (1946, 1953), Farquhar (1957), and Scott (in preparation). The ages of these rocks (Muehlberger and others, in preparation) are

within the range of that from the Lyon County Quartzite. However, this is not necessarily meaningful because there can be considerable difference between synchronous deposition and synchronous metamorphism. The Sioux Quartzite offers another large mass of rocks of the proper composition to be equivalent to the Kansas quartzites. This correlation is little more than idle speculation over a relatively great distance.

Chase County Granite Group

More than forty wells have penetrated granite, gneissic granite, and granite gneiss along the Nemaha Uplift in Kansas and in southwest Missouri. The geographic center of the area underlain by these rocks in Kansas is in Chase County. The group is therefore named for this county.

This group underlies about 7500 square miles of the study area; the limits are only partly defined. The granitic rocks are interpreted as having intruded the Lyon County Quartzite and "older granite and gneiss." The form of the intrusion is not known. However, the large size of the rock mass indicates that it may have been emplaced as a complex multiple batholith. Probably the Chase County Granite Group includes several granite masses that could be mapped separately if the rocks were exposed.

Six age determinations on five samples from the Chase County Granite Group are all near 1400 million years. Five of

the determinations were by the rubidium-strontium method and one by potassium-argon.

The proposed multiple batholith is further complicated by intrusion of granites at 1200 million years. These younger granites are perhaps responsible for the gneissic character of local samples from the Chase County Granite Group.

No cores were obtained from the numerous wells along the Nemaha Uplift. The rocks are medium to coarse-grained so that cutting chips are composed of only a few mineral grains at best. Therefore, the texture of these rocks, particularly in gross aspect, is not well known. Preferred orientation, for example, can be very subtle and the evidence for its presence in a thin section of cutting chips is rarely conclusive. Thus, in the following discussion the mineralogy is reasonably well known but the important gross textural relations are not.

The granites are a two-feldspar variety containing both microcline and plagioclase. Biotite is the most common femic mineral but hornblende is not rare and pyroxene is present in some samples. Quartz accounts for about one-fourth of the rock. Where present, the effects of cataclasis and crystalloblastic growth are incipient to intense. Effects of cataclasis are from the strain-reconstitution of quartz to well-developed linear mortar structure. Crystalloblastic growth is either the intergranular development of relatively

fine biotite or comparatively large poikiloblastic muscovite. The recognition of incipient metamorphism is limited to wells from which good samples were obtained.

Point counts of the cutting chips from this group is not a particularly effective method of determining the actual composition because of the coarse grain size of the granites. Cutting chips composed of more than one mineral were preferentially chosen in order to determine the texture; chips containing femic minerals are valuable because accessory minerals are commonly clotted near or within femic minerals. Thus a modal analysis is likely to show a relative enrichment of femic minerals and a low quartz content as compared to actual rock composition.

An average of all point counts probably gives the most accurate approximation of rock composition, reducing the sample bias somewhat. The average (Table 1) shows 41 percent microcline and microcline perthite, 26 percent quartz, 21 percent plagioclase, and 2.8 percent sericite-epidote-clay minerals derived from feldspar as alteration products. These minerals comprise over 90 percent of the rock in almost every sample and in some samples over 95 percent of the rock.

Other primary minerals include biotite, hornblende, pyroxene, magnetite-ilmenite, sphene, apatite, zircon, fluorite, and rutile. Secondary minerals include chlorite, muscovite, pyrite, sphene-leucoxene, sericite-epidote-clay minerals,

calcite, dolomite, and epidote. Some biotite and amphibole are interpreted as being secondary on the basis of textural relations and crystal form.

Microcline is generally clear or faintly clouded. This clouding is the result of vacuoles and alteration material that cannot be identified because of the small size. The perthitic microcline contains both patch and string types. "Grid" twinning is generally well developed. Larger microcline crystals locally contain poikilitically-enclosed plagioclase, quartz, femic minerals, and rarely, microcline of a different orientation. Hematite dust is rare as inclusions and is more common in the plagioclase portions of the perthite. In more altered samples abundant hematite dust imparts a reddish color to the mineral.

The plagioclase is near An_{20} in composition, is commonly faintly zoned in larger crystals, and typically contains sericite and disseminated hematite. Cores of larger crystals or zones near the rim are commonly intensely altered to a fine micaceous mat. The alteration in the nonzoned crystals is characterized by mottled sericitic replacement with no apparent pattern. Some plagioclase crystals poikilitically enclose other minerals near the margins.

Quartz is typically in mildly to intensely strained single or multiple crystals. In the more highly sheared rocks the quartz is reduced to a finely granular mosaic with moderate

elongation of grains in the plane of shearing.

Myrmekite is common in the margins of larger microcline crystals, particularly where they are in contact with plagioclase. The plagioclase in the myrmekite is characteristically clear and unaltered, poorly twinned, and contains no hematite. This appearance is more characteristic of the plagioclase found in metamorphic rocks. The common occurrence of myrmekite along shear linears suggests that the development of myrmekite is promoted by shearing.

Primary biotite is in well-formed books and is olive-green to brownish-green. Locally it is altered to chlorite with the development of sphene-leucoxene along cleavages.

Biotite that is interpreted as secondary (i.e., non-magmatic) is commonly in an intergranular position. The biotite is in part found as delicate subradial or branching books replacing portions of the adjacent feldspar but largely restricted to intergranular areas. Delicate vermicular intergrowths are found with small unoriented quartz crystals enclosed in the outer branching portions of well crystallized subradial biotite. There does not appear to be any sure criterion to indicate whether the biotite interpreted as secondary is of deuteric or metamorphic origin.

Hornblende is either a common, strongly pleochroic type or a paler more blue-green variety suggestive of a higher sodium content. Poikilitically enclosed quartz is not uncommon,

particularly in samples containing pyroxene. Other femic minerals are abundant in rocks containing these sieved crystals of hornblende. A tremolitic amphibole, interpreted as secondary, is found locally as a relatively fine aggregate of crystals replacing a single hornblende crystal. Hornblende never occurs as the sole femic mineral and only rarely is more abundant than biotite.

Pyroxene is a rare mineral but is relatively abundant where present. It is generally a colorless variety with low extinction angles suggestive of an orthopyroxene. It is invariably associated with a partial or total corona of common hornblende. Zircon and opaque minerals are locally present as inclusions. The larger crystals are intergranular between quartz and feldspar but smaller pyroxene, generally associated with similar sized discrete hornblende crystals, is found as inclusions in feldspar. Calcite replaces pyroxene extensively. Reddish indeterminant alterations are also common. Minor schiller structure and twinning are present in the larger pyroxene crystals.

Muscovite is common only in the foliated gneissic granites. It is associated with biotite but does not occur with hornblende in any of the samples examined. This observation suggests that bulk composition may in part control the occurrence of muscovite. It occurs in an intergranular position and as discrete flakes included in feldspar and more

Table 1. Average modal composition of the Chase County Granite Group and the Central Oklahoma Granite Group.

	Chase County Granite Group (in percent, average of 13 modes)	Central Oklahoma Granite Group (in percent, average of nine modes)
Microcline and perthite	41.3	35.0
Plagioclase	21.0	29.8
Quartz	26.1	25.5
Biotite	4.3	3.5
Chlorite	0.4	1.3
Hornblende	1.0	0.7
Sericite-epidote-clay minerals	2.8	1.9
Calcite	0.7	trace
Apatite	trace	trace
Zircon	trace	trace
Opaque minerals	0.2	0.3
Sphene-leucoxene	0.2	0.3
Sphene	trace	0.1
Muscovite	0.3	0.2
Myrmekite	1.0	trace
Epidote	trace	0.7
TOTAL	99.3	99.3
Microcline / Total feldspar	66.3	54.0
Quartz+feldspar+sericite-epidote-clay minerals	91.2	92.2
Biotite+chlorite+hornblende	5.7	5.5

rarely in quartz. The muscovite appears to be crystalloblastic in many of the samples as well formed books oriented parallel to a plane of shearing. Muscovite also occurs as small radial or subradial bursts of relatively fine shreds.

Other primary accessory minerals are clotted or concentrated near femic minerals. Zircon and apatite are particularly common near femic and opaque minerals. Zircon and apatite are the most consistent trace minerals. It is possible that the reason they are not reported from all thin sections of granite is that the area available for study on some is insufficient. Fluorite is a rare mineral that is generally associated with other intergranular accessory minerals. Rutile is difficult to identify positively because it is almost invariably in tiny needles of reddish color that are so small that their optical properties are masked by the host mineral. All these minerals are present in trace amount and together rarely contribute 0.1 percent of the rock volume.

Sphene is in well-defined wedges or as intergranular anhedral crystals. The alteration, particularly common in the wedges, is to small discrete clouded sphene-leucoxene crystals set in a calcite matrix. Sphene-leucoxene commonly replaces ilmenite.

The opaque minerals that have been identified are magnetite, ilmenite, hematite, and pyrite. Pyrite is in secondary blebs and veinlets. Magnetite-ilmenite is typically

associated with other accessory minerals. Hematite is found as a replacement of magnetite, as disseminated dust in feldspars, veinlets in more altered samples, and accompanying the chloritization of biotite.

Epidote replaces feldspar as small discrete granules or as well developed crystal aggregates or as single crystals in an intergranular position. Muscovite is commonly associated with epidote in an intergranular position and fine sericite generally accompanies the epidote in feldspars.

The degree of preferred orientation in coarse-grained rocks cannot be defined using cutting chips of random orientation on a thin section. The preferred alignment can be due to either primary flowage during emplacement of the granite or crystalloblastic growth during metamorphism accompanied by shearing stress. It is comparatively easy to distinguish the two where definite shearing can be detected parallel to mineral orientation. Muscovite is the mineral that is most commonly aligned in the plane of shearing.

The texture of samples in a rock group containing granite and mineralogically equivalent gneiss is naturally diverse. The granite is typically hypidiomorphic and is probably in part porphyritic. Straight smooth grain boundaries are the rule. The quartz is strained and finally reduced to a lineated chertose mosaic as the degree of shearing and metamorphism increased. This is accompanied by the development of mortar

structure between large grains. Muscovite, biotite, and epidote are commonly developed along zones of failure. Most of the slippage occurs between large grains. Because most femic minerals are in an intergranular position they are commonly recrystallized. Relicts of feldspar and quartz are set in a granular matrix of quartz-feldspar containing preferentially oriented micas in the most extensively sheared rocks. Examples of these shear-metamorphic features are found in Kansas samples from Cs-4, Cs-7, Cs-13, Cs-16, most wells in T20S-R7E, Gr-2, Gr-7, and several wells in southern Butler County. These features are locally very common and are found to some degree in approximately half of the samples examined.

However, the majority of samples have essentially hypidiomorphic texture that locally shows minor cataclastic features. The geographic distribution of the gneissic features is not well defined. Granite that is apparently undisturbed is found in areas of predominantly gneissic granite.

The gneissic features are believed to have been generated during the emplacement of the Central Oklahoma Granite Group, about 1200 million years ago. The youngest reliable age in Kansas is in the 1200 million year range and there is little evidence for any intermediate event (Muehlberger and others, in preparation). It is known that 1200 million year old granite was intruded in central Butler County (Bt-32) and farther west along the Central Kansas Uplift (Muehlberger and

others, in preparation). On the basis of available evidence this is the most reasonable time for the gneissic features to develop unless they are autometamorphic and related to the igneous activity at 1400 million years. Suitable samples with sufficient new mica are not available to prove which is the correct explanation.

The large-scale granitic intrusions of the Chase County Granite Group at about 1400 million years characterizes an area at least 150 miles in length and extending an unknown distance to the east and west. A granite drilled in Vernon County, Missouri (Ve-1) about 170 miles east of the Nemaha Uplift is petrographically similar and is the same age as the granites along the uplift. Granitic rocks and quartzites to the west along the Central Kansas Uplift also have this age range. Thus granites dated in the 1.4 b.y. age range of the Chase County Granite Group are found 230 miles west and 170 miles east of the actual Nemaha Uplift. These granites are not known to be continuous and probably represent an extremely complex series of intrusions emplaced in a comparatively small time interval. The exact extent of this magmatic episode is not known. The form of the intrusions is unknown but is possibly a batholithic complex.

The petrographic character of the Chase County Granite Group is not particularly distinctive when compared to other large batholithic complexes in the buried basement of

the central United States. Microcline-plagioclase granites containing about one quarter quartz and generally less than seven percent biotite are exceptionally common in intrusions of different ages from southern Oklahoma to Nebraska. The 1400 million year old granite complex was the framework upon and into which the Northeast Oklahoma Province rocks were emplaced and extruded.

Northeast Oklahoma Province

The four units comprising the Northeast Oklahoma Province represent a grouping of petrographically related intrusive-extrusive rocks. These units are: the Washington County Volcanic Group, the Spavinaw Granite Group, the Woodson County Granite, and the Osage County Microgranite. The rocks of these units are closely related in time and space and are a sequence of hypersolvus type granites and chemically equivalent volcanic rocks.

Eleven isotopic age determinations on rocks from this province all fall into a relatively narrow range at about 1200 million years. Relative ages of the units within the province cannot be resolved on the basis of the ages determined. The relative ages of these units presented here are not based on direct geologic observations. The sequence is based on analogies with well known outcrop areas and geologic reasoning.

Table 2. Comparison of average modal composition (in percent) of three units of the Northeast Oklahoma Igneous Province.

	1	2	3a	3b	3c
Groundmass	59.4	51.7*	81.1	60.0	73.2
Perthite	33.5	20.2	7.9	16.3	----
Plagioclase	trace	11.6	4.3	8.2	10.9
Quartz	2.2**	6.6**	2.2**	8.1**	trace
Chlorite	2.7	3.5	0.7	1.5	1.9
Biotite	----	trace	----	----	trace
Amphibole	trace	0.4	----	----	0.4
Basaltic hornblende	----	----	----	----	1.1
Pyroxene	----	trace	----	----	1.6
Sphene-leucoxene	0.6	0.4	0.5	0.4	trace
Opaque minerals	0.6	0.8	0.3	0.5	2.6
Sericite-clay-zeolite	trace	3.0	1.6	4.6	6.1
Epidote	trace	1.1	0.2	trace	1.4
TOTAL	99.0	99.3	98.8	99.6	99.2
Number of modes	12	27	32	10	5

* Micrographic quartz-feldspar

** Phenocrysts or discrete quartz only

1. Osage County Microgranite
2. Spavinaw Granite Group
3a. Rhyolite of the Washington County Volcanic Group
3b. Metarhyolite of the Washington County Volcanic Group
3c. Andesite of the Washington County Volcanic Group

These rocks are the basement for nearly all of northeastern Oklahoma and a large part of northwestern Arkansas, southeastern Kansas, and southwesternmost Missouri. These shallow intrusive and extrusive rocks are probably a relatively thin veneer on other unknown basement rocks. Thus this province is a shallow cut through the basement while those units around it are a deeper cut through the basement complex due to more extensive erosion.

Washington County Volcanic Group

Introduction

A large portion of northeastern Oklahoma and southeastern Kansas is underlain by volcanic rocks and their metamorphosed equivalents. Washington County, Oklahoma, is centered in the northern part of this area and is inferred to be totally underlain by this rock group.

The group is composed of three subgroups based on rock type: rhyolite, andesite, and metarhyolite. Rhyolite porphyries and their equivalent tuffs are by far the most common and widespread rock type. Andesite is restricted to an area in Craig and Ottawa Counties in Oklahoma and Labette and Cherokee Counties in Kansas and to a single well in Barry County, Missouri. The metarhyolites occupy a broad subsurface band essentially between normal rhyolite and other rock groups extending from western Pawnee County, Oklahoma, to Cherokee

County in southeastern Kansas. Another small area of metarhyolite is found to the south around southern Sequoyah County, Oklahoma.

Farquhar (1957) and Ham (1961) described andesitic volcanic rocks in Craig County, Oklahoma. Their reports suggest a more intermediate general character to volcanic rocks but the composition of the andesites is not typical of the rock group as a whole.

Rhyolite

The rhyolites are typically porphyritic with tuffaceous phases. Perthite and sodic plagioclase are the most common phenocrysts but quartz, magnetite-ilmenite, and chloritized femic minerals are also present in lesser amounts. The groundmass is diverse in texture but is invariably a quartz-feldspar intergrowth or devitrification product.

The perthite comprises an average of about eight percent of the rock volume. The shape of these phenocrysts is diverse but subhedral shapes are the most common. Composite phenocrysts (glomerocrysts) composed of numerous crystal units have irregular common boundaries with no apparent crystallographic arrangement among optic units. The outer margins locally have subhedral or euhedral outlines but complete rounding of these composite phenocrysts is more common.

In one sample from the Empire No. 1 Thompson in

Washington County (Ws-6), feldspar with anomalous optical properties was found. This feldspar is clear and unaltered, which is most unusual. The 2V of this crystal is 20-25°, suggesting a sanidine with approximately one-third albite molecule (Tuttle, 1952). This rare occurrence together with delicate relict structures preserved from devitrification is the best evidence for the undisturbed character in the majority of the rhyolites.

The perthite phenocrysts are generally clouded with hematite dust and minor alteration. This alteration can rarely be resolved under the microscope but appears in many samples to result from the formation of vacuoles. In the more extreme examples of weathering the hematite is leached from the perthite and the perthite is reduced to a semiopaque mat of generally indeterminant clay-mica alterations. The average size of the perthite phenocrysts is about five millimeters in length, but composite phenocrysts about one centimeter long are found in core samples (Sq-2, Pw-7, Pw-1) and are probably not uncommon in the rock group.

Plagioclase phenocrysts account for about 4.3 percent of the rock volume and are rarely absent. In samples in which plagioclase was not identified there is an excellent chance that it was originally present but has been completely replaced by sericite, clay-zeolites, and epidote. The composition is generally intermediate albite to intermediate

oligoclase, but rarely exceeds An_{20}. The shape of the plagioclase is subhedral to rounded. Composite phenocrysts containing five or more optic units are not uncommon. Sericitic alterations are most common with attendant hematite dust. The hematite dust is not as abundant in plagioclase as it is in perthite nor as evenly distributed. Sericite is in fine mats of unoriented shreds that mottle the plagioclase. In examples of extreme alteration the plagioclase is completely replaced by sericite containing lesser clay-zeolites and epidote. The average size of these phenocrysts is about the same as the perthite.

Quartz phenocrysts comprise an average of about two percent of the rock volume. These phenocrysts account for as much as twelve percent in rare samples but are absent in over a third of the rhyolites collected. Subhedral shapes are the most common but rounded and resorbed forms characterize many samples. Euhedral forms are commonly cracked and filled with groundmass material. In certain crystals long wormlike embayments destroy an otherwise euhedral form. The average size of the quartz is less than that of the feldspars, ranging between one and two millimeters in diameter.

Magnetite-ilmenite granules are found as smaller, less numerous phenocrysts in many rhyolites. The ilmenite is commonly replaced by sphene-leucoxene and more rarely magnetite is replaced by hematite. Partial or total inclusions of

apatite and zircon are not uncommon. The size of these phenocrysts is generally less than one millimeter.

Relicts of former femic minerals are found as phenocrysts in some samples but are quite rare. These phenocrysts never contain even the smallest relict of the original material. Either chlorite or a complex mixture of sericite-muscovite, chlorite, secondary biotite, and opaque minerals now replace the femic mineral. From the general outlines of these pseudomorphic replacements, biotite appears to be the most likely original mineral but hornblende is a possible parent for some of them.

Lithic fragments form a substantial part of some of the tuffaceous rhyolite but are, as a rule, very difficult to identify positively. The fragments are all rhyolitic in composition and almost all are of groundmass material. The groundmass must be of substantially different texture from the host in order to be recognized.

Epidote, calcite, apatite, zircon, sphene-leucoxene, chlorite, secondary biotite, and pyrite are present as accessory minerals but average only small or trace amounts. Epidote is locally in abundance as veins and replacement crystals. Pyrite and calcite are of secondary origin and are irregular in distribution. Chlorite, by far the most common and abundant of these accessory minerals, occurs as disseminated flakes in the groundmass, in fibrous mats and/or replacement veins,

and in irregular masses both in the groundmass and phenocrysts.

Some of the groundmass textures are derived from the devitrification of glass while others appear to have been crystallized initially without having passed through a glassy state. The groundmass is generally reddish to tan owing to hematite, limonite, and microlites. This color is leached in samples collected immediately below the overlying sediments in a number of wells, leaving the rhyolites a dull gray color. The groundmass is composed essentially of quartz and feldspar but the amount of quartz appears to vary considerably.

Devitrified rhyolites are locally conspicuously banded even in fine cutting chips. The banding is of two general types: mineralogic inhomogeneity and color bands caused by differences in iron mineral content. The mineralogic inhomogeneity is caused by flow differentiation into quartz-rich and quartz-poor bands. In this type of banding there is generally a moderate color banding with the feldspar-rich bands carrying more hematite. The mineral inhomogeneity causes the bands to devitrify in different patterns. The feldspar-rich bands are more likely to give rise to spherulites. The glasses that were originally homogeneous except for color banding devitrify with the delicate patterns transecting the flow bands with little or no break in structure. The simple color banding gives rise to much more delicate and closely spaced bands than do the inhomogeneous types.

Relict eutaxitic structures are common, particularly in samples from Washington County. The welded and distorted shards are pinched and wrapped around phenocrysts. Well defined undisturbed shards are not found. Amygdules and irregular fillings of chlorite, quartz, and opaque minerals are particularly common in the welded tuffs.

Relict perlitic cracks and primary spherulites are not common even in the strongly banded former glasses.

The rhyolites that apparently did not pass through a vitric phase or were devitrified under the influence of heat and vapors soon after extrusion are most commonly felsophyric in texture. The quartz is intimately and randomly intergrown with feldspar, partly with delicate rod-like quartz. Locally this texture is gradational with other types. Vague spherulites together with fine acicular quartz are common in portions of the felsophyric texture.

Andesite

In the eastern part of the northern area underlain by volcanic rock seven wells penetrated intermediate volcanic rocks. Two of these in Craig County, Oklahoma, (Crg-1, Crg-2) are welded andesite tuff carrying phenocrysts of andesine, basaltic hornblende, and magnetite-ilmenite set in a devitrified matrix of distorted shards with little or no primary quartz.

Farther north and east in Labette and Cherokee Counties, Kansas, and Ottawa County, Oklahoma, andesite, basaltic andesite, and an altered andesite were penetrated. The fresh rocks contain phenocrysts of augite, both fresh and uralitized, and very sparse plagioclase phenocrysts. In none of these samples was the plagioclase sufficient in quantity or freshness to determine the composition. The groundmass is composed dominantly of feldspar colored reddish by hematite dust but which also contains abundant small former femic minerals which are now chloritized and uralitized. The groundmass texture is pilotaxitic to felted.

The alteration of the andesite is extreme, particularly in the core holes of The Eagle-Picher Company (Kansas Ck-5, Ck-7, Ck-8; Oklahoma Ot-6). In these core holes it could be argued on the basis of individual petrography that the rocks were not originally an andesite, so extensive has been the alteration. However, it can be seen in these cores that fresh andesite grades into the altered rock and they must have a common origin. The alteration is in the form of silicification, sericitization of feldspars and crystalloblastic growth of new red-brown biotite and epidote. The welded andesite tuffs contain highly sericitized andesine phenocrysts but the groundmass remains essentially undisturbed.

The welded andesites carry considerably more abundant phenocrysts, averaging more than twenty-five percent of

the rock volume, while the flow-rock andesites generally carry considerably less than ten percent phenocrysts.

The occurrence of a normal rhyolite within a mile of the andesites suggests that the andesites represent a phase that was locally extruded in a dominantly rhyolitic terrain. No metamorphic equivalents of the andesites have been found and the intense alteration of the andesites is considered hydrothermal. Possibly the alteration of the andesites is associated with the emplacement of the Tri-State lead-zinc ores in post-Mississippian time. It is interesting to note that the inferred eastern limit of the andesites is coincident with the richest part of the Tri-State ores.

Metarhyolite

In the area of rhyolite bordering the Central Oklahoma Granite Group to the south and west and with the Woodson County Granite to the north, the rhyolites are converted to hornfelsic mineralogic equivalents. Although the rhyolite is metamorphosed adjacent to the Woodson County Granite, this rock unit is not considered to be the agent responsible for the conversion for reasons explained later.

The rhyolite is gently reconstituted to an assemblage suggesting lower greenschist facies. The rocks show no foliation and thus are not schists. They are genuine hornfels in the petrographic sense but are not considered to be the

product of contact metamorphism. The area 130 miles long and about 35 miles wide underlain by metarhyolite is too large for anything but regional metamorphism. Contact aureoles rarely exceed more than a few hundred feet in width (Williams, Turner, and Gilbert, 1958, p. 163) and it is virtually impossible to believe that all the metarhyolites are within a few hundred feet of the metamorphic agent and yet this agent was not penetrated in a single well. The petrographic evidence suggests that metamorphism took place with low water pressure (muscovite is lacking) and no shearing stress (the rocks are not foliated). The rhyolites may have had only the water locally available during the time of reconstitution.

Phenocrysts account for a larger part of the rock volume in the metarhyolites than in the normal rhyolites. Perthite, plagioclase, and quartz account for an average of more than thirty percent of the metarhyolites and less than fifteen percent average in the unmetamorphosed rhyolites. This may be due to secondary growth but is considered unlikely because the phenocrysts in the metarhyolites are not larger, simply more numerous. The abundance of phenocrysts is about that of the most tuffaceous rhyolites. The phenocryst-rich metarhyolites are concentrated in Kansas and may owe their appearance to a tuffaceous origin. The evidence for such speculation has been destroyed by the groundmass reconstitution.

Phenocrysts are dominantly perthite, plagioclase, and quartz with lesser amounts of magnetite-ilmenite and chlorite pseudomorphs. These are set in a granoblastic mosaic of quartz-feldspar.

Perthite appears to have been affected by the metamorphism in certain Kansas samples. Parts of the perthite have been cleared of hematite dust and alterations while other parts are apparently unaffected. The cleared parts have the appearance of microcline but the characteristic twinning is lacking. About sixteen percent of the rock volume is composed of perthite phenocrysts.

Plagioclase is intermediate albite to sodic oligoclase in composition. About eight percent of the rock is plagioclase as phenocrysts with an additional four percent of feldspar alterations that are largely derived from plagioclase. The plagioclase is characteristically mottled and clouded with fine indeterminant alterations, hematite dust, epidote granules, and mats of sericite shreds.

Quartz phenocrysts are particularly common in the metarhyolites from Kansas, averaging about eight percent of the rock. These are typical volcanic quartz phenocrysts, embayed to subhedral, and with cracks filled by reconstituted groundmass material.

Chlorite appears to be a retrograde product and is probably derived from biotite. It is very rarely in clean

crystalloblastic crystals but contains included granular sphene-leucoxene. Some smaller chlorite crystals are locally poikiloblastic, with included groundmass material near the margins. Chlorite is also found as veinlets and disseminated shreds in the groundmass. Small amounts of actinolitic amphibole are associated with chlorite in some samples.

Some of the phenocrysts of both feldspar and quartz may have undergone secondary metamorphic growth as evidenced by a partial rim of included groundmass material around certain phenocrysts. These rims are very rarely uniform, occurring around selected phenocrysts while nearby phenocrysts show no such effects. The included groundmass material may be due to late magmatic growth rather than to crystalloblastic enlargement.

The groundmass is composed almost entirely of a granoblastic mosaic of quartz and feldspar. The average grain size is from 0.03 to 0.07 millimeters in maximum dimension and is quite uniform in size. The groundmass feldspars are clouded with hematite dust and are indeterminant but appear to be mostly perthite.

Magnetite-ilmenite phenocrysts are now mostly converted to sphene-leucoxene and hematite and locally contain partial or total inclusions of apatite and zircon. In addition to these larger crystals, numerous opaque mineral granules the size of the groundmass quartz-feldspar are present.

Epidote is found as small granules within the plagioclase associated with sericitic alterations. Larger crystals of epidote are present as thin veinlets and irregular discrete crystals in the groundmass.

Small crystals of sphene are found as concentrations in the groundmass.

The MacMillan No. 1 Clark (Ck-2) in Cherokee County, Kansas, penetrated a metamorphosed rhyolitic arkose. This rock contains fragments of metarhyolite as well as abundant quartz and feldspar. Originally more shaly intervals contain abundant sericitic mica with clasts of quartz, feldspar, and lithic detritus set in a micaceous matrix. This is interpreted as a local detrital zone within the rhyolite that was later metamorphosed at the same time as the extrusive rhyolite.

Isotopic age

The age of these volcanic rocks is the same as the other rock units in the Northeast Oklahoma Province, about 1200 million years. Five rubidium-strontium determinations were made on four samples from this group and all fell into this age range. Three determinations were made on normal rhyolites, and two determinations were made on one specimen of slightly metamorphosed rhyolite. The andesites were not dated.

Distribution

These volcanic rocks cover a large area. The inferred distribution is over about 18,000 square miles. Of this area less than 500 square miles are known to be underlain by andesite. Approximately 4600 square miles are underlain by metarhyolite. The topographic relief on these volcanic rocks exceeds 1500 feet in a single township. It is difficult to infer an average thickness of less than half a mile for the volcanic rocks over this large area with the topographic relief present. The volume of rhyolite and related rocks is thus on the order of 9000 cubic miles minimum. This is the estimated present area and volume after extensive erosion.

It is quite possible that this rhyolite area is only a small part of a larger extrusive sequence that may have stretched from an unknown distance east of southeastern Missouri to eastern New Mexico. The rhyolite in Missouri is statistically older than those in Oklahoma and those in the Texas Panhandle are slightly younger (Muehlberger and others, in preparation). Although these areas are not continuous now, about 700 million years has been available to erode and segment what may have originally been a gigantic, single, but complex, volcanic field, dwarfing any modern rhyolitic analogy.

The maximum drilled thickness of rhyolite in the

study area is 475 feet in the Empire Gas and Fuel No. 1 Thompson (Ws-6). This is surely only a fraction of the total thickness present today even after extensive erosion. The rhyolites in Missouri are thick but there is no published reliable estimates. The volcanic rocks in the Texas Panhandle have a drilled thickness (base not reached) of 3449 feet in the Whittenburg No. 1 Whittenburg in southern Carson County.

In order to distribute silicic volcanic rocks over such a large area a welded tuff origin is reasonable for a substantial part of the sequence even though the petrographic evidence for a welded tuff origin cannot be demonstrated in the majority of samples obtained.

Spavinaw Granite Group

This group is named for the Spavinaw Granite that crops out in five small hills in Mayes County, Oklahoma. Merritt (1960) has described the petrology of the outcropping granite and presented a chemical analysis. These five small hills are high knobs protruding through the overlying Ordovician Cotter Dolomite. The granite exposed in these small hills is surprisingly representative of a number of samples collected from wells along a broad, pre-sediment arch that extends from central Oklahoma east-northeastward one hundred and fifty miles to southwesternmost Missouri.

Samples from thirty-eight wells define a generally

micrographic granite porphyry comparatively rich in femic minerals. Some samples, considered to be phases of the normal type, contain very sparse femic minerals and are virtually lacking in calcium-bearing minerals. The micrographic texture and perthitic character of the potassium feldspar remains essentially constant in all phases.

This group is inferred to underlie approximately 8700 square miles. The form of the intrusions cannot be determined from the drill holes but the porphyritic and micrographic character of the rock give clues to the type of intrusion. The uniform texture over such a large area requires a form of intrusion by which a uniform rate of chilling can take place. The only form of intrusion which will fulfill these requirements is a sill. The large part of the Spavinaw Granite Group is interpreted as such. It would be carrying this reasoning too far to expect the granite to be a single sill emplaced in a single impulse. In the Wichita Mountains numerous granites can be mapped as multiple sill injections favoring the base of the rhyolite as the plane of intrusion. These sills are connected with small irregularly shaped plutons. The Spavinaw Granite Group is interpreted in an analogous manner. There is, in fact, less textural variation in samples from the Spavinaw Granite Group than in the Wichita Granite Group.

The three main constituents--quartz, plagioclase,

and perthite--generally comprise more than ninety percent of the rock (Table 2). All samples available in sufficient quantity for modal analysis have perthite in considerable excess of free plagioclase. The free plagioclase is almost entirely in the form of phenocrysts. In general the quartz content (determined by considering the micrographic intergrowths as one-third quartz) averages about 24 percent, but samples with as little as 13.3 percent or as much as 42.1 percent have been modally determined. Samples containing more than 30 percent quartz tend to be coarser grained and grade from discrete quartz with intergrown margins to comparatively rude micrographic intergrowths. A characteristic alteration of the femic-rich granites is caused by intense clouding of the feldspars, chloritization of femic minerals, and the hematite dust, all of which give to the rocks in thin section a semi-opaque appearance. The alteration makes petrography and modal analysis difficult, imprecise, and frustrating.

The plagioclase is calcic albite to intermediate oligoclase in composition and most commonly between An_{10}-An_{15}. Generally forming phenocrysts, the plagioclase is only rarely found in the groundmass except when associated with late mineralization such as albite veins or with quartz as a replacement. The shape of the plagioclase phenocrysts is variable but the smaller crystals tend to be euhedral while the larger ones are irregular in shape, commonly with a perthite rim.

Alterations mottle the plagioclase extensively in the form of sericite but clay-zeolites and epidote granules are also present. Inclusions of femic minerals or their alteration products are not uncommon in the larger irregularly shaped crystals.

Perthite is delicately twinned, with the shaggy appearance of a mesoperthite. Patch and string-type perthites are not present. The general appearance is that of an exsolved, high-temperature sanidine. This is supported by the identical appearance of perthite in the granites and in the rhyolites. Certain samples (Rog-4-1, Ot-2-1) contain feldspars with a low 2V, although the perthite is otherwise a normal type. These 2V measurements of 20-30° suggest a sanidine structural state (Tuttle, 1952).

In the granites rich in femic minerals free (non-intergrown) quartz is in minor proportions, averaging less than one percent of the rock volume. The discrete quartz is essentially not strained and is in single crystals.

Primary accessory minerals include magnetite-ilmenite, hornblende, pyroxene, biotite, sphene, apatite, and zircon. Secondary minerals include calcite, dolomite, siderite, feldspar alterations, pyrite, chlorite, tremolitic amphibole, sphene-leucoxene, hematite, epidote, and fluorite. Of these accessory minerals chlorite, magnetite-ilmenite, feldspar alterations, and epidote are the most abundant and locally

constitute over ten percent of the rock. Apatite needles are rarely absent and are particularly abundant in the strongly femic granites.

The original femic minerals are generally completely chloritized. However, fresh augite is present in samples from three wells in Tulsa, Okmulgee, and Creek Counties (Ck-3, Tu-9, Om-5) and occurs in outcrop samples from Mayes County. Common hornblende is exceptionally rare but secondary tremolite-actinolite is common. The replacement by chlorite and tremolite-actinolite naturally masks the original femic mineral but to interpret from the outlines of the pseudomorphs, both pyroxene and hornblende were the characteristic femic minerals. Biotite is uncommon but in a few samples it is intergrown with chlorite as a replacement of former femic minerals. Sparse strongly pleochroic, red-brown biotite can be interpreted as primary in samples from at least one well (Rog-3). Chlorite and tremolite-actinolite may replace a femic mineral as a single large crystal or as a delicate fibrous mat of interlaced crystals.

Sphene-leucoxene is associated with chlorite as an alteration by-product of an originally titaniferous femic mineral. Sphene-leucoxene also replaces portions of the ilmenite. Primary sphene is sparse but is found as well crystallized late anhedral masses in some samples.

Carbonates replace feldspars in small blebs and is

also found as well crystallized veinlets and patches within other minerals. In one sample (Ck-4-1) having a very low plagioclase content, siderite has formed, possibly because sufficient calcium was not available. Both calcite and dolomite are found but the latter is comparatively rare.

Iron oxides are never absent from these granites. In the femic-poor granites magnetite-ilmenite are generally in sparse anhedral crystals or even lacking in the sample studied. However, disseminated hematite dust is universal in the perthite and to a lesser extent in the plagioclase. Titaniferous iron oxide is generally converted to sphene-leucoxene and, in the most altered samples, magnetite is converted to hematite.

The feldspar alterations are clays, micas, and zeolites with replacements of epidote also contributing to the degradation of the feldspars. The normal appearance of the feldspars, particularly perthite, under the microscope is one of extreme turbidness. Plagioclase is more transparent than perthite due to less disseminated hematite and mottled alteration rather than uniform clouding. These alterations are chiefly a fibrous mat of sericite shreds but locally fine clay minerals and sparse zeolites are petrographically identified. In samples near the basement-sediment surface, weathering leached the reddish color and in some samples reduced the feldspars to a semi-opaque mat of extremely fine alteration

material that cannot be resolved under the microscope.

Epidote is a common and relatively abundant secondary mineral occupying several textural positions. It is found as relatively small crystals, some clouded, replacing both plagioclase and perthite feldspars. Well crystallized intergranular and vein epidote is a major mineral in certain granite samples (e.g., Cke-3-1). Epidote is also associated with chlorite and tremolite-actinolite in the alteration of a former femic mineral.

The texture is porphyritic and micrographic. Phenocrysts of both plagioclase and perthite are set in a variable micrographic intergrowth of quartz and perthite. The micrographic intergrowth is delicately radial around phenocrysts, as in some finer grained samples, and is rarely coarse enough to separate quartz from perthite in a mode. The general composition suggests that the normal Spavinaw Granite would plot in the broad thermal saddle between the ternary eutectic and syenite composition on a quartz-albite-orthoclase diagram. Strict application of the experimental work of Tuttle and Bowen (1958) is not completely justified because these granites contain too much calcium plagioclase.

Rock types other than granite in this group are exceptionally rare. Diabasic intrusives, so common in similar Wichita Mountain granites, were not found in the Spavinaw Granite Group. Aside from syenite and quartz syenite in wells

in Rogers and Okmulgee Counties (Rog-3, Om-5), and a trachytic cutting chip and a dioritic cutting chip in Cherokee County (Cke-1, Cke-3), no other rock types were found in this group. Syenite and quartz syenite was drilled in the Daniels and Smith No. 2 Vierhiller (Rog-3) as distinct intervals within a normal granite sequence of about eight hundred feet in drilled thickness. These are interpreted as younger dikes intruding the granite. The trachyte in the Pine No. 1 Lemon (Cke-3) is represented by only a single cutting chip and is possibly analogous to the syenite dikes. The diorite found in the M and F No. 1 Thompson (Cke-1) is more difficult to interpret. In the Spavinaw outcrop relatively small masses (about 5 millimeters in length) of dioritic composition are noted. Possibly these are small xenoliths, either accidental or cognate, caught up in the granite magma and the subsurface occurrence is similarly interpreted.

Certain analogies and differences can be noted when comparing the Spavinaw and Wichita granites. Both are porphyritic perthite granites interpreted as epizone sills intruded under a cover of rhyolite. Several granites in the Wichita Mountains are typically micrographic. The Wichita Mountain granits are lower in femic minerals and higher in quartz than the Spavinaw Granite (Ham and others, 1964).

The granites of the St. Francois Mountains are petrographically more closely related to the Wichita granites

(Snyder and Wagner, 1961) even though they are similar in age to the Spavinaw Granite and not to the Wichita granites.

Woodson County Granite

Granite boulders are found in Woodson County, Kansas, on what is widely known as Rose Dome. Exactly how these boulders arrived at their present position has accounted for much speculation, both private and published. Even a brief historical account of the changing and postulated ideas would require considerable space. Suffice it to say that there are or were proponents of: ice rafting, forceful post-Pennsylvanian intrusion, crypto-volcanic emplacement, erosional hills, and boulders carried by a peridotite intrusion (see review by Merriam, 1963, p. 152-154). In view of the isotopic age of 1220 million years on feldspar from Rose Dome a Precambrian age for the granite is seemingly required. This date does not answer the question of how these boulders arrived at their present location surrounded by sediments of Pennsylvanian age.

The general petrographic similarity of rocks found at Rose Dome to samples drilled in pre-sediment wells in this area support the thesis that these boulders are Precambrian rocks brought to their present position in post-Pennsylvanian time. Samples collected by Paul Franks of the Kansas Geological Survey from the boulders show a great variation in

texture and appearance. In general the granite boulders are at least in part composed of granite "clasts" set in a finely spherulitic matrix of minor proportions. These "clasts" are diverse but uniformly granite, some micrographic, others xenomorphic to hypidiomorphic, and many are porphyritic. All variations in the available subsurface samples can be found in the boulders. The finely spherulitic matrix is here interpreted as pseudotachylite which would require a tectonic origin for this outcrop. This interpretation, if correct, does not answer all the questions but at least rules out several explanations.

Seven wells in Kansas and one in Jasper County, Missouri, penetrated granites characterized by variable texture but uniform mineralogy. Several features suggest late mineralization and some brecciation in widely distributed samples. No cores were obtained from this rock group but the fine- to medium-grained character of most of the granites make cutting chips more useful than in the study of the Chase County Granite Group.

The major constituents are microcline perthite, plagioclase, and quartz with lesser amounts of biotite, chlorite, feldspar alterations, muscovite, iron oxides, sphene-leucoxene, apatite, zircon, epidote, and calcite. The percent of major minerals appears to vary considerably but this may not be real, but due only to the relatively small area in most cutting chip

thin sections. The relative and absolute amounts of minor minerals is exceptionally variable, particularly in late or secondary minerals, e.g., calcite and epidote.

The perthite is generally a microcline mesoperthite although the typical twinning is not well developed. The most distinctive feature of the perthites is the uniform clouding caused by disseminations of small discrete alterations and hematite dust. This uniform clouding is found in all samples and is a common feature of perthite granites in the south-central United States. This feature serves to distinguish these granites from those along the Nemaha Uplift.

The plagioclase is generally sodic oligoclase in composition and contains more extensive recognizable alterations than the perthite, largely in the form of sericite and epidote granules. Alteration is locally intense and may be a weathering type phenomenon. Late albite has been introduced into certain samples of granite. This late plagioclase is exceptionally fresh and is in an intergranular position. This albite is possibly deuteric and is associated in part with quartz.

Quartz is generally unstrained and is in a variety of textural relations with feldspar. In some samples part of the quartz has a very late (deuteric) appearance. In one sample (Cw-1) chloritized amphibole prisms are included within the late quartz.

Minor minerals are irregular in abundance and are not consistently present. Biotite and its alteration product chlorite are the most common and abundant femic minerals. Femic minerals account for an average of less than three percent of the rock, although some samples have as high as 5.6 percent. The granite can be characterized as femic-poor.

The texture of the granite is not consistent and in some samples is very difficult to interpret. Both strongly micrographic and hypidiomorphic granites have been penetrated. In some samples (e.g., Cw-1) the quartz-feldspar intergrowths are distinctively different from those of normal eutectic crystallization. The quartz-feldspar boundaries are not smooth, regular, and cuneiform but have very ragged outlines of irregular shape. Late planar quartz veins, some sheared and brecciated, are not uncommon. The general textural relations are those of a granite crystallizing in a variety of closely related conditions giving rise to diverse textures. These were later modified by moderate mineralization and shearing-brecciation, possibly in more than one episode.

The Woodson County Granite is possibly the most difficult rock unit in the area to interpret and defend. Samples are few and the variations are many. The granite has the appearance of an epizonal intrusion by analogy with the Spavinaw Granite and the Wichita Granite Group. The form of the intrusion or intrusions is possibly sill-like with irregular

thin sections. The relative and absolute amounts of minor minerals is exceptionally variable, particularly in late or secondary minerals, e.g., calcite and epidote.

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The microgranite covers about 320 square miles, the smallest area occupied by any rock group. Two isotopic age determinations average about 1200 million years. These dates together with the petrographic kindred of rhyolite and Spavinaw and Woodson County Granite place the rock type firmly in the Northeast Oklahoma Province as part of the hypabyssal-intrusive-extrusive complex.

The microgranite is strongly porphyritic, containing abundant phenocrysts of perthite and lesser quartz. The phenocrysts comprise between 30 and 45 percent of the rock and average about 36 percent.

Perthite phenocrysts are generally irregular in outline with ragged margins. These phenocrysts locally contain small masses of finely divided chlorite. Some are faintly zoned, apparently caused by a change in the ratio of plagioclase to K feldspar. A high percentage of composite phenocrysts containing as many as five optic units are present. The extreme alteration of feldspar phenocrysts which characterizes the Spavinaw Granite Group does not occur in the microgranite. However, the perthite is invariably clouded with hematite dust and tiny vacuoles that are very evenly distributed. Recognizable alteration products are not abundant.

A core from the Texaco No. 16 WS Kohpay (Os-27) contains rounded perthite phenocrysts up to 2.1 centimeters in length that are apparently not uncommon. The occurrence of

these megacrysts could not be recognized in cuttings and it is not known if these large ovoid composite phenocrysts are characteristic of the group. The average phenocryst of perthite is about 5 millimeters in length.

Quartz phenocrysts, though conspicuous, account for less than 5 percent of the rock volume and between 2.5 and 15 percent of the phenocrysts. The shape is typically rounded and embayed with ragged margins. The groundmass quartz immediately surrounding the phenocrysts may be optically continuous. The average size of these phenocrysts is about 1.5 millimeters in diameter.

The groundmass is composed chiefly of quartz and perthite. The texture is unusual and no petrographic term adequately describes the relationship. The quartz in large part is in the form of rods or "spicules." These rods have a length to width ratio of 5:1 or greater. This highly rod-like shape gives a texture that is perhaps best called hypidiomorphic-acicular and is the most distinctive feature of the microgranites. Locally, certain samples of rhyolites have a similar texture but is generally much finer and less well defined and mixed with normal felsophyric texture.

Chlorite is in masses of fine fibrous unoriented shreds, generally in an intergranular position. Secondary biotite with the same fibrous habit is locally associated with chlorite. No primary femic mineral was identified in

any samples obtained from the microgranite. Textural position and general outlines suggest that chlorite is a deuteric replacement of magmatic biotite. This is supported by the occurrence of associated granular sphene as a reaction by-product.

Accessory minerals are hematite, magnetite-ilmenite, zircon, apatite, sphene-leucoxene, fluorite, calcite, pyrite, biotite, sericite, and epidote. Free plagioclase is exceptionally rare, occurring as sparse phenocrysts in samples from only two wells.

The perthite is distinctly reddish owing to the finely disseminated hematite dust. Recognizable alterations in the groundmass are rare though sericite masses locally occur between crystals. The perthite phenocrysts are more extensively clouded than the groundmass feldspar. The phenocrysts locally contain minor epidote granules and sericite flakes and in extreme alteration, mottled clay-like masses. Calcite blebs replace irregularly both in the groundmass and phenocrysts.

Magnetite-ilmenite is in small highly irregular granules and in larger smooth crystals associated with accessory minerals. Leucoxene replaces all or most of the ilmenite.

Apatite and zircon are the most widely distributed magmatic accessory minerals. In some samples the zircons are

exceptionally slender and elongate and may be slightly metamict.

The genuine uniformity of the microgranite is surprising even though the areal extent is relatively small compared to other units recognized in the map area. Were the unit exposed there may well be considerable variation that could be mapped locally. In comparison, the total outcrop of all igneous rocks in the Wichita Mountains is about 400 square miles.

The exact manner in which a distinct rock type can be so petrographically uniform over such an area is limited. If this is a single pluton intruded as a roughly circular mass subsequently truncated by erosion, then there should be considerable variation in texture and grain size between samples from wells near the margins and those drilled nearer the center. This, however, is not the case. We must call upon a type of intrusion that is able to crystallize uniformly over a large area. A relatively thin sill fulfills this requirement. A sill intruded under a cover of rhyolite would crystallize under similar conditions over a wide area. The relatively small amount of magma near a given point would limit the amount of heat and volatiles available to cause contact effects in the rhyolite. No contact effects can be recognized in samples of rhyolite drilled in the immediate area of the microgranite.

Thus, the Osage County Microgranite is interpreted as a relatively thin sill intruded under a cover of rhyolite at shallow depth, probably less than a mile. It is quite possible that the microgranite was intruded within the thick rhyolite sequence. Isotopic ages demonstrate that the rhyolite and microgranite are in the same magmatic cycle and the microgranite may have been caused by a rhyolite feeder that did not reach the surface but chose instead a plane of weakness between rhyolite flows in which to inject the magma.

The area was later broadly domed in pre-Upper Cambrian time and the rhyolite cover was removed by erosion. The area shows a history of continued minor instability in upper Paleozoic time which is discussed later.

The age relations between the microgranite, Spavinaw Granite, and Woodson County Granite are not known because they are nowhere in contact. From isotopic ages and general petrographic appearance it can be stated with reasonable assurance that they are essentially synchronous. The very small amount of free plagioclase and low femic mineral content suggest, in the classic differentiation scheme, that the microgranite is possibly the youngest intrusive rock in the Northeast Oklahoma Igneous Province.

Vernon County Metamorphic Group

In Vernon County, Missouri, and adjoining Bourbon

County, Kansas, four wells have penetrated low-rank metasedimentary rocks. The two wells in Missouri penetrated nearly one thousand feet of the metasedimentary rocks (Skillman, 1948). Included in this well defined, close geographic entity is a group of more fully reconstituted, higher grade metasedimentary and metabasic rocks found in south-central Kansas. It is eighty-four miles from the most westerly well in Bourbon County to the most easterly well in Greenwood County, thus it is possible that the two areas are unrelated. Samples were not obtained from one well in northern Woodson County and another in Allen County that report schist and metamorphic rock (Coles and others, 1961, p. 156). These samples, if properly identified, cut the maximum distance between wells penetrating rocks of this group to thirty-six miles.

The Silver City area in Woodson County contains an exposure of peridotite. This peridotite is 65±5 million years old (as reported by Merriam, 1963, p. 154). The metamorphic cobbles in the peridotite have been interpreted as altered sandstone of the Douglas Group (Virgilian) rather than Precambrian metamorphic rocks (Merriam, 1963). This interpretation is desirable because the area directly beneath the Silver City intrusion is inferred to be underlain by Woodson County Granite rather than Vernon County metamorphic rocks.

The lower rank metamorphic rocks in Vernon and Bourbon Counties are derived from sandy argillaceous sedimentary

rocks. The two wells in Missouri contain rocks that are at best incipiently metamorphosed near the top of the drilled interval but have more crystalloblastic growth in the lower portions of the wells.

Most of the sand-size clasts in these wells are composed of quartz, feldspar, and lithic fragments. The quartz is in part exceptionally strained; a single clast was noted having a sweeping extinction exceeding 90°. This is exceptionally delicate detritus and it is difficult to believe that it has been transported any great distance. Uniformly clouded mesoperthite is found as well as clear microcline and partly sericitized plagioclase. The lithic clasts are volcanic, clay or shale, and metamorphic rock fragments. The clasts are relatively well to poorly sorted in the feldspathic quartzites containing an irregular amount of micaceous matrix. In the two Missouri wells no strictly argillaceous intervals were sampled, as all samples contain a few sparse sand or silt-sized clasts floating in the micaceous matrix. The micaceous matrix appears to be mostly a gently reconstituted white mica. Chlorite has grown in some of the more sandy intervals in an intergranular position.

Detritus in the samples from these wells can be shown to be at least partly locally derived. The mesoperthite can be from the rhyolite or possibly the Woodson County Granite, and the microcline, plagioclase, and strained quartz from

the "older granite and gneiss" or the Chase County Granite Group. The rhyolite lithic detritus has an obvious source in the nearby volcanic terrane but the origin of the clay or shale pellets cannot be so easily inferred. They may be locally derived from within the sedimentary rocks themselves.

The wells penetrating rocks of this group in Bourbon County, Kansas, are about ten and twenty miles due southwest from the wells in Missouri. The closest well--the Perry No. 1 Burney (Bb-1)--contains very similar rocks. The metagraywackes found in this well contain more feldspar and lithic detritus than quartz and all are set in a micaceous matrix. Lithic fragments in this rock are metarhyolite and various fine siliceous metasedimentary clasts.

The Oklahoma Natural Gas No. 1 Stephenson (Bb-3) contains considerably finer-grained sedimentary rocks than any of the wells in this area. No sand-sized material was found in the nearly six hundred foot penetration. Most of the intervals examined were composed of phyllite and phyllitic siltstone. Bedding is marked in certain intervals (e.g., Bb-3-5) caused by mineral and size variations. These bedding layers are as thin as 0.1 mm in width. The upper portion of the drilled interval is reddish from hematite but between 1924-1930 feet a transition to a greenish color is noted. The greenish color is due to chlorite and in the upper portions the hematite appears to have formed at the expense of the

chlorite, possibly as a weathering phenomenon. The new minerals in these phyllitic rocks are chlorite, epidote, smoky grey-green tourmaline, and muscovite. Feldspar detritus was not identified as silt-sized particles. Quartz and relatively minor iron oxide are the only recognizable grains. The bulk of the rock is composed of fine chlorite and white micas.

To the west, in Greenwood and Butler Counties, metasedimentary rocks of this same approximate bulk composition were penetrated as well as metabasic rocks. The metabasic rocks are placed into this group more as a matter of convenience than a conviction of their close relation with the metasedimentary rocks.

The Orlando No. 1 Breitkreutz in Greenwood County (Gr-3) penetrated 1290 feet of fine-grained schists. These schists contain both biotite and muscovite, sparse garnet and tremolite, and abundant quartz. Feldspar was not identified in most samples but some fine alteration material may represent a former feldspar. The bulk composition is probably pelitic and equivalent to the sedimentary rocks in the east.

The Phillips No. 5-6 DeMalonie and Sowden (Gr-1) farther northwest in Greenwood County penetrated metagraywacke with clasts of quartz, feldspar, and rock fragments set in a matrix of reconstituted clay, now quartz-mica-feldspar. The lithic detritus is derived from siliceous metasedimentary rocks, possibly related to the Lyon County Quartzite, and from

altered granitic fragments.

The metasedimentary rocks in Butler and Segwick Counties are more diverse in grade and mineralogy. The Bedell and Catt No. 2A Stollei (Sg-5) contained a normal hypidiomorphic granite within a schist sequence. This granite is interpreted as belonging to the Central Oklahoma Granite Group, which is probably the main agent in the conversion of the sedimentary rocks to schists. In this area the rocks are completely reconstituted and generally contain both microcline and plagioclase as well as biotite and quartz. In these rocks, therefore, muscovite is replaced in the assemblage by microcline.

Metabasic rock has been drilled in a small area in T. 25 S., R. 5 E. in Butler County. The narrow, high gravity anomaly coincident with these wells suggests a considerable volume of these rocks, yet they are restricted in areal extent. These rocks are derived from porphyritic basic rocks, probably basalts. The large plagioclase phenocrysts are now relict and are much altered, containing in particular abundant epidote granules. The groundmass is fully recrystallized, containing a mildly pleochroic hornblende and an olive-green biotite surrounded by a quartz-plagioclase mosaic. In certain cutting chips the biotite appears to have good preferred orientation and a suggestion of banding.

The sedimentary rocks, on the basis of sparse well

control, are coarser near the northern limit of the group and finer grained to dominantly argillaceous near the southern limit. This suggests that the northern area may have been closer to the main source of the detritus. The sedimentary rocks are interpreted as being marine in origin, largely by analogy with other shale-graywacke sequences. This reason has been used by Ham and others (1964, p. 120-122) in interpreting the Tillman Metasedimentary Group of southern Oklahoma.

The Vernon County Metamorphic Group is interpreted as a post-rhyolite deposit because it contains rhyolite fragments in the coarser sedimentary rocks. These lithic clasts are few in number and are not particularly clear cut petrographically, i.e., there are none with perlites, eutaxitic structure, or shard shapes. Some of the rhyolite detritus is metamorphosed, and some is not, but in a single sample all are metamorphosed or essentially untouched. This group, as previously noted, is a very tentative association characterized by large areas of no control. However, the general character and bulk composition are similar. The nature of the basin into which the sedimentary rocks were deposited is not known. The sedimentary rocks in the basin were considerably in excess of 1000 feet because the drilled thickness of the group is over 1200 feet in one well and erosion has undoubtedly taken a considerable toll. There is no discernible change in metamorphic grade in this well (the Orlando No. 1 Breitkreutz, Gr-3) in

the samples examined. The samples obtained from wells drilled in the northern part of the area underlain by the metasedimentary rocks are considerably more arenaceous than those to the south which contain mostly pelitic samples with some fine sand and silt. The floor on which these sediments were deposited is at least in part "older granite and gneiss" and the Chase County Granite Group. A germane question is the relationship of the two units--the rhyolite and the sedimentary rocks--that were deposited on the surface and are inferred to be closely related in time. Fragments of rhyolite are present in the sedimentary rocks, therefore the rhyolite, or at least part of it, is older than some of the sedimentary rocks. It is possible the sedimentary rocks are all post-rhyolite in age. It is also possible that the depositional basin was isochronous with the sedimentary rocks deposited in a marine depression bordering the "highlands" of the volcanic field. Although the sedimentary rocks are considered marine by analogy, this does not preclude a vastly different origin such as a contintental basin adjacent to the volcanic field.

There is a tendency to make most depositional basins geosynclines. There are certain similarities between these sediments and typical geosynclinal deposits. These graywackes and shales are in part products of "flash" deposition with little or, at best, modest sorting and winnowing. Exceptionally fragile detritus is contained in certain graywack intervals.

The sedimentary rocks were deeply buried at one time. This deep burial is necessary in order for the sedimentary rocks to be regionally metamorphosed. While I tend to think of regional metamorphism as occurring at shallower levels than Fyfe, Turner, and Verhoogen (1958, p. 173) it is difficult to envisage less than two or three miles of cover during recrystallization. If this is valid then one must call upon "several" miles of cover to fulfill this requirement and the cover is most likely to be more sedimentary rock. If the cover was not sedimentary rock then it must be some other surface rock for which there is no evidence.

No isotopic age determinations were made on samples from this group. Nonetheless, the age of metamorphism is inferred with a reasonable degree of confidence to be 1200 million years. The rhyolite was extruded around 1200 million years and those close to the metasedimentary rocks are metamorphosed to an equivalent grade, although there are difficulties in comparing a quartzo-feldspathic and a pelitic assemblage, particularly in incompletely metamorphosed rocks. Thus, the sediments can be inferred to have been metamorphosed in post-rhyolite time. The intrusions of the Central Oklahoma Granite Group, known to occur in Butler County on the basis of isotopic age determinations, are the most likely agent responsible for the metamorphism. Those sedimentary rocks farthest away from known Central Oklahoma granites are the least

metamorphosed.

Central Oklahoma Granite Group

The Central Oklahoma Granite Group is based on cuttings and cores from fifteen wells in Kansas and Oklahoma. This group is interpreted as the youngest igneous unit in the study area. It partly rims the shallow extrusive-intrusive complex and represents deeper erosion around the margins of the Northeast Oklahoma Province.

The very large area and great distances over which these rocks occur in the basement almost certainly require a multiple intrusion by a composite batholith. There is a marked petrographic similarity of this group to the Chase County Granite Group. Although the average modes of the two rock groups vary in the plagioclase-microcline ratio, individual granites within each group overlap considerably and no criterion was found by which individual samples could be placed uniquely into one of the two groups. The only easy distinction is a difference in isotopic age.

Six age determinations were made on four samples from the Central Oklahoma Granite Group and all cluster closely around 1200 million years; distinctly younger than the 1400 million year age of the Chase County Granite Group. These dates, however, are not distinguishable from those obtained from samples from the 1200 million year Northeast Oklahoma

Province. The petrology of the Central Oklahoma Granite is suggestive of a mesozonal batholitic type emplacement rather than the epizonal granite of the Northeast Oklahoma Province. Thus, this group is associated with the shallow igneous rock in time but not in space and represents a distinct environment of its own.

This rock group is considered the youngest in the area because (1) rocks of the Washington County Volcanic Group are converted to metarhyolite where in contact with the Central Oklahoma Granites and (2) the extension of the Vernon County Metamorphic Group into Greenwood and Butler Counties, Kansas, is characterized by more fully recrystallized rocks in proximity to known Central Oklahoma Granites. The rhyolite is converted to metarhyolite at the contact with the Central Oklahoma Granite Group and the Woodson County Granite. Although the Woodson County Granite is thought to be younger than the rhyolite, it is not interpreted as the major metamorphic agent affecting the rhyolite. Epizone granites, such as occur in Woodson County, typically do not cause regional metamorphism, only contact effects, as shown by analogous conditions in the Wichita Mountains (Ham and others, 1964, p. 47-50). The rhyolite is converted to metarhyolite in areas far removed from the Woodson County Granite in Haskell and LeFlore Counties and farther south, out of the study area, in Pontotoc County, Oklahoma. These southern areas are, however,

in inferred contact with the Central Oklahoma Granites. Certainly a mesozone granite has the large volume of magma and therefore the heat and volatiles near a given point to promote regional recrystallization, that are lacking in an epizone intrusion.

The granites of the Central Oklahoma Granite Group characteristically contain both microcline and plagioclase as opposed to the perthitic character of other Oklahoma rock groups. The rocks vary considerably in their grain size and percent of minerals but the mineralogy is reasonably uniform. The unit is not well-defined petrographically largely because of widely separated samples and a relatively coarse grain size which is not completely suitable for modal analysis even in core samples. As previously stated, these granites are indistinguishable from those of the Chase County Granite Group on the basis of petrography.

Microcline is generally clear and unaltered and relatively free of hematite dust. Patch and string-type perthite is not uncommon but the mesoperthite of the epizone granites is never present. Twinning is well defined. Some Carlsbad twins are present, particularly in the largest crystals. Plagioclase and quartz are found as inclusions within some of the larger microcline crystals.

Plagioclase is intermediate to sodic oligoclase in composition and is in part faintly zoned. Alteration is more

extensive than in the microcline. Alteration is patchy in part but relatively uniform sericitization with accompanying hematite dust is also found. Certain zones and cores of crystals are particularly susceptible to sericitization.

Quartz is moderately strained to unstrained. Small inclusions of rutile (?) and other tiny undetermined specks are not uncommon.

The texture shown by these major components is hypidiomorphic with straight smooth grain boundaries and essentially no mortar structure. The one exception to this undeformed character is the extensively sheared granite gneiss drilled in the Cities Service No. 5 Farley (Ok-1) in the Oklahoma City field. This rock contains relict augen of essential minerals separated by highly sheared material. The quartz is in fine aggregates reduced from a single crystal. The general nature of the shear-reconstitution suggests that the deformation took place under considerable heat and pressure. This would mean that the rock was not deformed by the faulting which bounds the Oklahoma City field on the east but was sheared in Precambrian time. Perhaps the Precambrian shearing predetermined the orientation of the late Paleozoic faulting.

Biotite and hornblende are the common femic minerals. Biotite is generally olive-green or red-brown and the hornblende is a common type with no distinctive characteristics.

Chlorite replaces biotite extensively as pseudomorphs and mantles of chlorite on biotite are not uncommon. Associated with the chloritization along cleavage in chlorite is granular sphene-leucoxene and less common and abundant epidote.

Other primary accessory minerals are sphene, magnetite-ilmenite, apatite, zircon, and fluorite. These accessory minerals are generally clotted near the femic minerals. Secondary minerals include feldspar alterations, epidote, carbonate, pyrite, and muscovite.

The rocks in this group are generally medium to coarse-grained, averaging larger than five millimeters where grain size can be determined. The average mode, determined from two cores and seven cutting chip intervals (Table 1), shows that microcline accounts for only about 54 percent of the total feldspar. The general proportions suggest that the rock name should be adamellite or quartz monzonite according to most classifications. However, this sets up an artificial boundary within the rock group and as previously discussed the more general name granite is preferred for all samples with the understanding that the term is used in a broader sense.

The Central Oklahoma Granites are similar in many ways to the rocks cropping out in the main Belton-Tishomingo Anticline in the Arbuckle Mountains. The similarities are so great that one is hard pressed to find a significant

petrographic difference. However, they are not the same for the same reason that the Central Oklahoma Granites are not equivalent to the Chase County Granites, because they are not the same isotopic age. Isotopic age determinations from the Tishomingo Granite (Tilton and others, 1962) and from the Troy Granite (Muehlberger and others, in preparation) show conclusively that the rocks cropping out in the core of the eastern Arbuckle Mountains are about 1350 million years old and more nearly the equivalent in age of the Chase County Granites than the Central Oklahoma Granites.

GRAVITY AND MAGNETIC INVESTIGATIONS

Published regional gravity maps for Oklahoma (1964), Kansas (1959), and Missouri (1943) and magnetic maps for both Missouri (1943) and Oklahoma (1964) and for smaller areas in Kansas are available. The gravity information has been summarized by maps contoured at a five milligal interval for Oklahoma and Kansas and at one milligal for Kansas. The Missouri map cannot be directly matched with those of Kansas and Oklahoma because a different density was used in the calculation of the Bouguer anomaly. These maps are useful, but they are also frustrating when compared to known basement rock distribution. They demonstrate the impossibility of attempting to construct a basement rock map from existing published geophysical data.

A bibliography of geophysics in Oklahoma is available (Roark, 1964). Magnetic investigations have been published for areas in Kansas by Jakosky and others (1942), Dreyer (1947), Merriam and Hambleton (1955), and Keller and Henderson (1963). The usefulness of small area coverage is limited unless there are numerous basement samples available or the area includes an inferred basement rock contact.

The primary problem in applying gravity information to basement rock data is that to a first approximation all the major rock types have overlapping densities. Rocks having densities outside the limits of major rock types are probably not

thick enough to cause a significant anomaly at a five-milligal interval. The one exception to this is an area of metabasic rock coincident with a ten to fifteen milligal anomaly in T. 25 S., R. 5 E., Butler County, Kansas. In most areas the possible cause of the anomaly cannot be determined because of a lack of basement rock samples.

One strong circular anomaly in Osage County, Oklahoma, the so-called "Osage Island" (Cook, 1956), has good basement sample control. With certainty it can be determined that the rock unit coincident with the anomaly, the Osage County Microgranite, does not cause the anomaly. Thus something deeper must cause the anomaly. On the basis of seismic reflections, Lynn and the Tulsa Geophysical Society (1962), suggest that the "Osage Island" is caused by an "antiroot" or bump on the Moho surface of about 10 km. This interpretation is supported by the lack of a well defined magnetic anomaly over the gravity maximum.

Magnetic anomalies shown on the regional maps are not well covered by wells to basement. Two of the largest in Oklahoma, a strong negative anomaly in western Creek and Lincoln Counties and a positive anomaly in Pottawatomie and Cleveland Counties have no wells to basement directly over the anomalies. It is not known if samples from wells drilled on the flanks represent a reflection of the cause of the anomalies.

Magnetic susceptibility and density measurements, listed in Table 3, offer an idea of the expected range in the samples obtained. These data also present an unusual situation. In general the area underlain by rocks of the Washington County Volcanic Group is characterized by positive magnetic relief while those areas underlain by the rocks of the Spavinaw Granite Group are characterized by negative relief. However, the granite has an average magnetic susceptibility more than an order of magnitude greater than the average rhyolite susceptibility.

However, within the Spavinaw Granite Group the correlation between measured and inferred susceptibilities and anomalies is better. The susceptibilities measured from samples of the Spavinaw granites are strongly bimodal and the fresh rocks yield susceptibilities either less than 800×10^{-6} cgs units or greater than 2000×10^{-6} cgs units. This bimodal susceptibility appears to cause the gently curved narrow anomalies in the area surrounding the outcrop of the Spavinaw Granite. The granite drilled in the center of a -200 gamma anomaly in southern Craig County (Crg-5) was not determined because of insufficient sample, but the rock is one of the purest quartz-feldspar granites found in the Spavinaw Granite Group and probably would have a lower susceptibility than any measured sample from the group.

Thus, it can be shown that basement rocks influence

gravity and magnetic characteristics of an area. However, numerous evenly distributed basement rock wells are necessary to determine the influence, and there does not appear to be any basement rock explanation for some of the anomalies. Geophysical data offered little aid in constructing this basement rock map because of overlapping properties and the layered character of some of the rock units. The cause of the lack of correlation between rock type and gravity and magnetic observations is that the geologic basement rock map is on a unique plane, the basement surface, while gravity and magnetic observations are affected by the entire rock column.

Table 3. Magnetic susceptibility* and density** determinations of Oklahoma basement rocks.

Well	Location	Thin Section Number	Magnetic Susceptibility X 10^{-6} cgs Units	Density
Washington County Volcanic Group:				
Okla. Nat. Gas No. 1 Stockton	20-11N-26E	Sq-2-1	84	2.70
USSRAM No. 1 Marshall	23-13N-19E	Ms-1-1	116	
DeMier No. 3-A Bruner	6-19N-12E	Tu-1-1	54	2.67
DeMier No. 1-A Country Club	28-20N-12E	Os-22-1	16	2.66
		Os-22-2	51	2.65
Keener No. 29 Osage "A"	8-20N-12E	Os-6-1	1.9	
Gulf No. 65 Boston	1-21N-7E	Os-24-1	106	2.70
		Os-24-2	67	2.61
Sinclair No. 46 Jones	20-21N-8E	Pw-1-1	58	2.61
DeMier No. 1-A Zink	5-21N-11E	Os-17-1	172	2.75
Sunray DX 21-NW-32-21-12	32-21N-12E	Os-41-1	1.9	
		Os-41-2	46	
Texaco No. 25 WS Adkisson	32-21N-13E	Tu-4-1	216	
Big Four No. 5 Bird	33-22N-7E	Os-16-4	41	2.69
Sunray No. S-3 Osage	24-22N-10E	Os-1-2	8.3	

Well	Location	Thin Section Number	Magnetic Susceptibility X 10^{-6} cgs Units	Density
Washington County Volcanic Group: (Cont.)				
Texas No. 13 SWD Bennett	12-23N-7E	Os-29-1	72	
Cities Service No. 1 SWD Lot 292	8-24N-11E	Os-32-1	141	
Phillips No. 1 SWD Higgins "A"	23-25N-8E	Os-30-1	8	
Delaware No. WS-1 Pilot	20-27N-15E	Nw-1-3	7.5	
		AVERAGE	66.66	2.67
Osage County Microgranite:				
Norbla No. 2 Lyman	24-22N-9E	Os-23-1	187	2.69
Pure No. 191 Osage Hominy	9-23N-8E	Os-4-2	8.6	
Texaco No. 16 WS Kohpay	29-25N-8E	Os-27-1	130	2.61
Mid-Continent No. 1 Osage Tr201	31-25N-10E	Os-7-1	33	
		AVERAGE	89.6	2.65
Spavinaw Granite Group:				
Schermerhorn No. 1 Tiger	24-16N-12E	Om-5-1	2147	
Gulf No. 1-S Berryhill	17-17N-12E	Ck-3-1	753	
M and F Oil No. 1 Thompson	35-19N-21E	Cke-1-2	375	

Well	Location	Thin Section Number	Magnetic Susceptibility X 10^{-6} cgs Units	Density
Spavinaw Granite Group: (Cont.)				
Spavinaw Granite	15-22N-21E	Mayes County	2022	2.70
			739	2.66
			487	
			515	2.72
Davis and Miller No. 1 Knight	34-23N-21E	May-3-1	540	2.61
Southern Union No. 1-C Atchison	5-20N-11E	Os-26-1	144	2.65
3-B Oil No. 1 Helmik	12-26N-21E	Crg-4-5	5340	
		AVERAGE	1306	2.67
Central Oklahoma Granite Group:				
Hembree No. C-3 Hembree	19-7N-5E	Pt-1-1	1225	
Pan American No. 1 Tackett Unit	28-8N-23E	Lef-1-1	1929	2.64
Anderson-Prichard No. 28 Welch	17-28N-1E	Ky-1-1	33.5	
Sinclair No. 19 Hartley	18-22N-3W	Gf-1-1	1360	
		AVERAGE	1136	

*Magnetic susceptibility measurements determined by Dr. J. A. E. Norden of the University of Oklahoma.

**Density measurements determined by T. L. Rowland of the Oklahoma Geological Survey.

ISOTOPIC AGES

Twenty-five isotopic age determinations on twenty samples from the area under examination were made by the Isotope Geology Branch, United States Geological Survey, under the supervision of Dr. S. S. Goldich, then branch chief. The dates, analytical data, and the techniques used will be reported in a separate paper (Muehlberger and others, in preparation) covering a much larger area in the southern Midcontinent region. The discussion here will be limited to some of the more qualitative aspects and geologic interpretation of the age data.

The actual determined ages and analytical errors are presented in Table 4. The errors are larger than are generally reported for the simple reason that the samples are from subsurface cuttings and cores chosen for their geographic distribution, the availability of sufficient sample, and the representativeness of a rock group rather than for a favorable ratio of rubidium to strontium. In collecting from the outcrop, samples can be chosen that are not only representative of the rock mass but with a low common strontium content as well. If the whole rock has a less than desirable ratio of rubidium to strontium, separate minerals can be dated which have a more favorable ratio. However, when one is dealing with cuttings and cores the sample is small, and the mineral that is available in sufficient quantity must be dated even

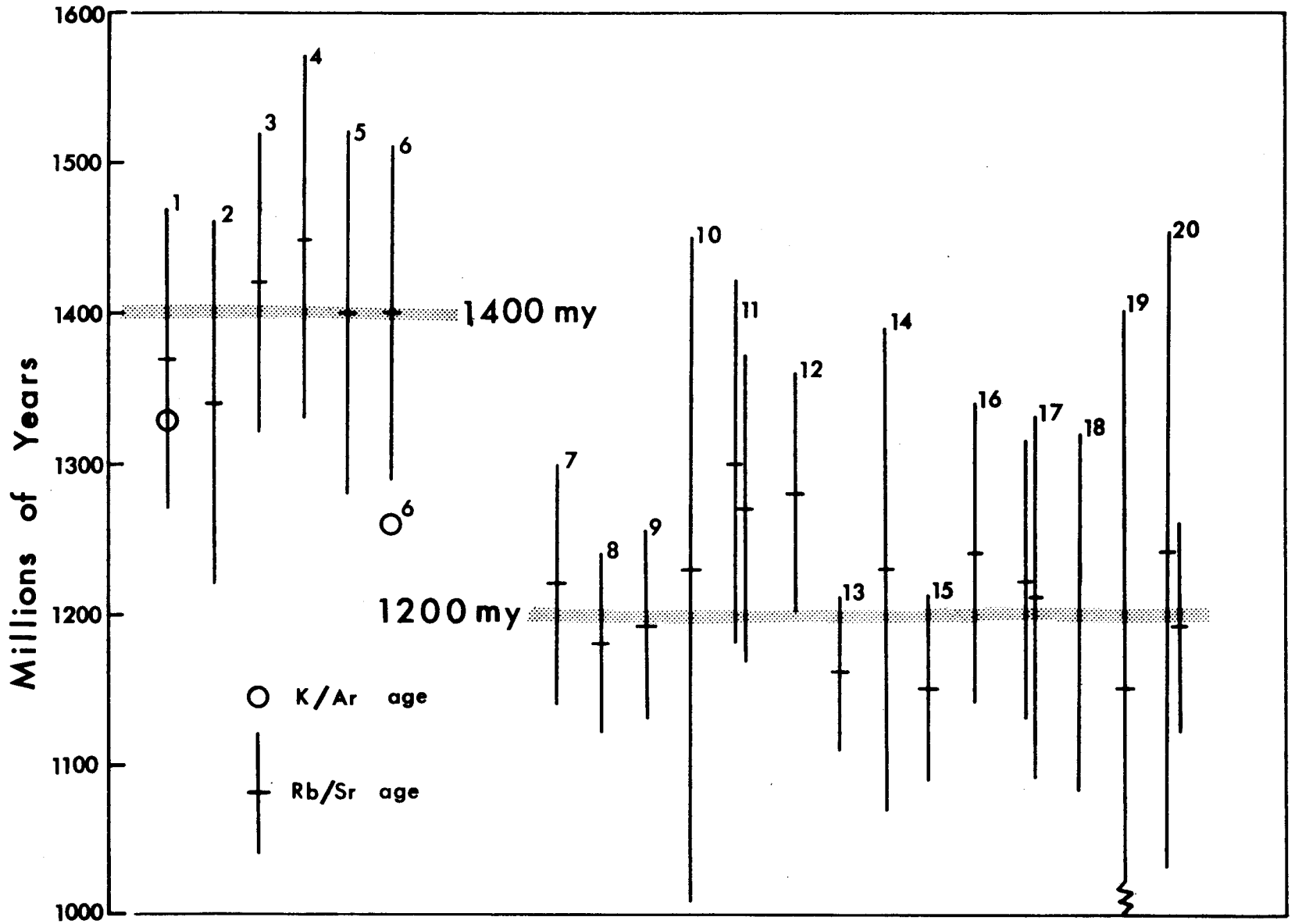


Figure 2. Isotopic ages determined from the study area.

though it may be known beforehand that the result will be less than ideal.

The dates together with the analytical errors are graphically plotted in Figure 2. Two main periods of thermal activity appear reasonably obvious from this plot, one at about 1200 million years and another at about 1400 million years. These two periods reflect the two large-scale igneous events that are recognizable over most of the map area.

Dates in both groups overlap the other age range because of high analytical error, but when used in conjunction with petrography and regional rock distribution they show a clear cut distinction between the ages of these two episodes. On this basis, the ages are not interpreted as a continuum of activity but two separate and distinct periods.

In dating samples from this area both cuttings and cores were used. There is no age pattern associated with the type of sample used. In fact there is a very uniform distribution of dates from cutting chips below and above the average dates of 1200 and 1400 million years. The conclusion here is that dates obtained from carefully chosen cutting chips are as reliable as dates determined from core samples. The one exception may be whole rock determinations of strongly metamorphosed coarse-grained rocks, because of the difficulty in choosing cutting chips which, as a total, accurately reflect the true mineral percentages.

Each of the age determinations will be briefly discussed in the order shown on Figure 2 to place it in context with those petrographically and geographically related to it. The petrography is presented in Appendix.

Chase County Granite Group:

1. St. Joseph Lead Co. Core Hole, 6-34N-29W, Vernon County, Missouri (Ve-1). An excellent, fresh granite that is near an adamellite in composition. The whole rock was dated at 1370 ± 100 million years by the rubidium-strontium method. Alteration of potassium-bearing minerals is very minor. A deep olive-green biotite that contains minor chloritic alterations was dated at 1330 million years by the potassium-argon method. The whole rock date is interpreted as being near to the time of actual intrusion. The potassium-argon date indicates that the rock was probably not affected by the later 1210 million year event.

2. Lario No. 13 "A" Wenrich, 22-32S-2E, Sumner County, Kansas (Sm-3). Feldspar, a partly perthitic microcline, was dated by the rubidium-strontium method at 1340 ± 120 million years. This is the youngest date obtained from this group. There is evidence for later thermal activity in late or secondary (metamorphic) biotite and epidote growth. This sample is located fairly close to the inferred contact with the 1200 million year plutonic rocks, which may account

for the relatively young age and apparent later crystal growth. Nevertheless, the age is interpreted as firmly within the 1400 million year range.

3. Stanolind No. 1 Veal, 30-17S-7E, Morris County, Kansas (Mo-12). This granite appears somewhat gneissic but not necessarily from metamorphic effects. The microcline is fresh and irregularly perthitic and was dated at 1420 ± 100 million years by the rubidium-strontium method. This date is interpreted as being near the age of crystallization.

4. Amerada No. 1 Lostuller, 1-20S-7E, Chase County, Kansas (Cs-19). This granite has definite signs of later shearing accompanied by the development of mortar structure and myrmekite along sheared zones. The microcline from this rock was dated by the rubidium-strontium method at 1450 ± 120 million years. This is the oldest age obtained from this rock group and is considered to be near the actual age of emplacement. The later effects are possibly associated with the 1200 million year event that can be demonstrated about twenty-five miles to the southwest.

5. Cities Service No. 1 Church, 13-23S-5E, Butler County, Kansas (Bt-8). This granite has the imprint of later activity firmly marked upon it. Strained quartz and sutured mineral boundaries with myrmekite development are common. The microcline from the rock was dated by the rubidium-strontium method at 1400 ± 120 million years. This date is interpreted

as being near the actual age of emplacement. The shearing is attributed to the 1200 million year event which is inferred to be less than five miles to the south.

Lyon County Quartzite:

6. Leslie No. 1 McConnell, 14-16S-9E, Morris County, Kansas (Mo-7). The whole rock age of this muscovitic quartzite is 1260 million years by potassium-argon and 1400 ± 110 million years by rubidium-strontium. These dates are essentially on muscovite for only small amounts of feldspar alterations are present and no other potassium minerals are recognized. The low potassium-argon age may be due to leakage of argon or partial episodic loss of argon during later thermal activity. The rubidium-strontium date falls into line with other dates in this area but it should be remembered that the dating of metasedimentary rocks is suspect unless a firm initial strontium ratio can be fixed. This initial ratio cannot be fixed in this sample and is assumed to be the same ratio as in igneous rocks.

Northeast Oklahoma Igneous Province, Woodson County Granite:

7. Rose Dome outcrop, 13-26S-15E, Woodson County, Kansas (Wd-0). This date was determined by the rubidium-strontium method to be 1220 ± 80 million years on feldspar from a microgranite porphyry. The potash feldspar is a microcline perthite and appears to be fresh. The age is interpreted

as the age of formation of the granite. Obviously later movement of some sort caused the granite to arrive at its present location in the midst of sedimentary rocks of Pennsylvanian age. The sample dated does not petrographically reflect the later movement nor, in the interpretation here, in a change of isotopic ratio.

Washington County Volcanic Group:

8. Sinclair No. 46 Jones, 20-21N-8E, Pawnee County, Oklahoma (Pw-1). This rhyolite porphyry contains minor alteration in the phenocrysts but the rock generally has a fresh appearance. The total rock age is 1180 ± 60 million years by rubidium-strontium. There is no evidence for metamorphism in this rhyolite and the age is interpreted as being near the age of extrusion-crystallization.

9. Cities Service No. 1 SWD Lot 292, 8-24N-11E, Osage County, Oklahoma (Os-32). This rhyolite porphyry is strongly flow banded and delicate devitrification structures are undisturbed. The rubidium-strontium date on the whole rock was 1190 ± 60 million years and is interpreted as near the age of crystallization.

10. Oklahoma Natural Gas No. 1 Stockton, 20-11N-26E, Sequoyah County, Oklahoma (Sq-2). This rhyolite porphyry shows what may well be incipient metamorphic effects, in the reconstituted (granoblastic) groundmass and the development of

epidote as discrete groups of crystals. A total rock rubidium-strontium determination yielded an age of 1230 ± 220 million years. The large analytical error is due to a high common strontium content which is reflected by the epidote development. Although the rock appears reconstituted there does not appear to have been a substantial amount of material added or subtracted and the rock may well have behaved as a closed system. The close agreement with other ages from similar rocks suggests that the age is near the age of extrusion and it is thus interpreted.

11. Porter No. 20 Miller, 33-23N-3E, Pawnee County, Oklahoma (Pw-7). The dates of 1270 ± 100 and 1300 ± 120 million years were determined on a single metarhyolite core by the rubidium-strontium method. These are the oldest dates obtained from the Washington County Volcanic Group. The analytical error nonetheless places these dates within the range of other rhyolite dates. These dates are very similar to determined ages of Missouri rhyolites which are statistically older than those in northeast Oklahoma. It is possible that this is an outlier of Missouri-type rhyolites. However, the date on this rock is interpreted here as reflecting the age of the Washington County Volcanic Group.

Spavinaw Granite Group:

12. Spavinaw Granite outcrop, 15-22N-21E, Mayes

County, Oklahoma (May-0). Though petrographically dissimilar to the average Spavinaw Granite, the date of 1280 ± 70 million years on feldspar by the rubidium-strontium method is within the range of other dates obtained from this group. The date is interpreted as reflecting the age of crystallization.

13. Central Commercial No. 3 Hay, 10-17N-10E, Creek County, Oklahoma (Ck-4). This femic-poor micrographic granite was dated at 1160 ± 50 million years by the rubidium-strontium method on total rock. The very small analytical error indicates a very low calcium-common strontium content for this very pure quartz-perthite granite. The date just overlaps the 1280 ± 70 million year date from the outcrop Spavinaw Granite. The date is interpreted as being near the age of crystallization.

14. Daniels and Smith No. 2 Vierhiller, 36-21N-16E, Rogers County, Oklahoma (Rog-3). This micrographic granite porphyry was dated at 1230 ± 160 million years by the rubidium-strontium method on feldspar. The rock is typical of many examples of the Spavinaw Granite Group and the age is interpreted as being near the age of crystallization.

Osage County Microgranite:

15. Texaco No. 16 WS Kohpay, 29-25N-8E, Osage County, Oklahoma (Os-27). This core of the Osage County Microgranite was dated at 1150 ± 60 million years by the rubidium-strontium

method on whole rock. This is one of the lowest ages obtained from this province but the analytical error overlaps all other ages. The rock is a rather pure quartz-perthite rock and the low calcium content is reflected in the small analytical error. The date is interpreted as near the age of intrusion.

16. Norbla No. 2 Lyman, 24-22N-9E, Osage County, Oklahoma (Os-23). This microgranite was dated by the rubidium-strontium method to be 1240 ± 100 million years on feldspar. These cuttings are probably very representative of the rock because all indications are that the rock is exceptionally uniform. The date is interpreted as being near the age of intrusion for the Osage County Microgranite.

Central Oklahoma Granite Group:

17. Anderson-Prichard No. 28 Welch, 17-28N-1E, Kay County, Oklahoma (Ky-1). The rubidium-strontium method was used to date the feldspar at 1220 ± 90 million years and the whole rock at 1200 ± 120 million years. This coarse-grained example of the Central Oklahoma Granite Group is interpreted as crystallizing at about 1200 million years. There is no evidence to support the possibility that this may be an example of the Chase County Granite Group that has undergone a severe metamorphic event at 1210 million years. The granite is generally fresh but the biotite has been extensively chloritized.

18. Pan American No. 1 Tackett Unit, 28-8N-23E, LeFlore County, Oklahoma (Lef-1). The feldspar from this medium-grained granite was dated at 1200 ± 120 million years by the rubidium-strontium method. The rock is exceptionally fresh and the date is considered to be near the age of intrusion. This rock is petrographically similar to the Troy Granite in the Arbuckle Mountains but is younger in age.

19. Cities Service No. 5 Farley, 19-11N-2W, Oklahoma County, Oklahoma (Ok-1). The feldspar from this sheared granite gneiss was dated at 1150 ± 250 million years by the rubidium-strontium method. This is the lowest date obtained from this rock group although the analytical error places the date well into the range of others in this group. The shearing may contribute to the low age and it is possible that this rock may be more closely related to the 1350 million year granites of the Arbuckle Mountains and has undergone a period of intense metamorphism and shearing at about 1200 million years that reset the isotopic ratios.

20. Gulf-Gross No. 1 Forgy, 11-26S-4E, Butler County, Kansas (Bt-32). The feldspar from this granite was dated at 1240 ± 210 million years and the biotite at 1190 ± 70 million years, both by the rubidium-strontium method. This granite has the imprint of later thermal activity with some shearing features. The correspondence of the biotite and feldspar dates suggests that the age of crystallization in near

1200 million years. Thus, it is interpreted as a member of the Central Oklahoma Granite Group although it is found in Kansas along the Nemaha Uplift and has 1400 million year dates both to the north and south of it.

Table 4. Isotopic age determinations.

	Operator and Farm	Location	Rb/Sr Age Millions of Years	K/Ar Age Millions of Years	Sample Type Rock Group
1	St. Joseph Lead Co. Core Hole	6-34N-29W Vernon Co. Missouri	1370±100 (T)	1330 (B)	Core CCGG
2	Lario No. 13 "A" Wenrich	22-32S-2E Sumner Co. Kansas	1340±120 (F)		Cuttings CCGG
3	Stanolind No. 1 Veal	30-17S-7E Morris Co. Kansas	1420±100 (F)		Cuttings CCGG
4	Amerada No. 1 Lostuller	1-20S-7E Chase Co. Kansas	1450±120 (F)		Cuttings CCGG
5	Cities Service No. 1 Church	13-23S-5E Butler Co. Kansas	1400±120 (F)		Cuttings CCGG
6	Leslie No. 1 McConnell	14-16S-9E Morris Co. Kansas	1400±110 (T)	1260 (T)	Core LCQ
7	Rose Dome Outcrop	14-26S-15E Woodson Co. Kansas	1220±80 (F)		Outcrop WCG

	Operator and Farm	Location	Rb/Sr Age Millions of Years	K/Ar Age Millions of Years	Sample Type Rock Group
8	Sinclair No. 46 Jones	20-21N-8E Pawnee Co. Oklahoma	1180±60 (T)		Core WCVG
9	Cities Service No. 1 SWD Lot 292	8-24N-11E Osage Co. Oklahoma	1190±60 (T)		Cuttings WCVG
10	Oklahoma Nat. Gas No. 1 Stockton	20-11N-26E Sequoyah Co. Oklahoma	1230±220 (T)		Core WCVG
11	Porter No. 20 Miller	33-23N-3E Pawnee Co. Oklahoma	1270±100 (T) 1300±120 (T)		Core WCVG
12	Spavinaw Granite Outcrop	15-22N-21E Mayes Co. Oklahoma	1280±80 (F)		Outcrop SGG
13	Central Commercial No. 3 Hay	10-17N-10E Creek Co. Oklahoma	1160±50 (T)		Cuttings SGG
14	Daniels and Smith No. 2 Vierhiller	36-21N-16E Rogers Co. Oklahoma	1230±160 (F)		Cuttings SGG
15	Texaco No. 16 WS Kohpay	29-25N-8E Osage Co. Oklahoma	1150±60 (T)		Core OCM

	Operator and Farm	Location	Rb/Sr Age Millions of Years	K/Ar Age Millions of Years	Sample Type Rock Group
16	Norbla No. 2 Lyman	24-22N-9E Osage Co. Oklahoma	1240±100 (F)		Cuttings OCM
17	Anderson Prichard No. 28 Welch	17-28N-1E Kay Co. Oklahoma	1220±90 (F) 1210±120 (T)		Core COGG
18	Pan American No. 1 Tackett Unit	28-8N-23E LeFlore Co. Oklahoma	1200±120 (F)		Core COGG
19	Cities Service No. 5 Farley	19-11N-2W Oklahoma Co. Oklahoma	1150±250 (F)		Cuttings COGG
20	Gulf-Gross No. 1 Forgy	11-26S-4E Butler Co. Kansas	1240±210 (F) 1190±70 (B)		Cuttings

(F) - feldspar
(T) - total rock
(B) - biotite

CCGG - Chase County Granite Group
LCQ - Lyon County Quartzite
WCG - Woodson County Granite
WCVG - Washington County Volcanic Group
SGG - Spavinaw Granite Group
OCM - Osage County Microgranite
COGG - Central Oklahoma Granite Group

PRECAMBRIAN STRUCTURE

Structural features in the basement rocks and not in the overlying sediments are considered to be Precambrian in origin. Strictly speaking, they are older than the covering Cambrian to Ordovician rocks. Some of these features were later reactivated during the Paleozoic while others do not appear to have any recognizable influence on the sedimentary rocks.

Where rhyolite is absent it must be because of removal by differential erosion, because rhyolite is the highest "stratigraphic" or stratiform unit in northeast Oklahoma. This assumes the volcanic rock was distributed over a much larger area during the time of extrusion. Thus today, areas underlain by rhyolite are relative structural lows and areas where the rhyolite is absent are relative structural highs. This assumes that the basement surface is essentially a flat plane and that relief does not substantially affect rock distribution. These are reasonable assumptions over such large areas with demonstrably moderate relief.

The most striking feature in northeast Oklahoma is the broad arch trending northeast across the area. Spavinaw Granite forms the core of the arch and it is flanked by rhyolite. This is here named the Spavinaw Arch. Presumably the rhyolite which once covered the arch has been removed by erosion. The axis of the arch is parallel to Paleozoic faults

on the southwest nose of the Ozark Uplift.

The Spavinaw Arch is disrupted in western Okmulgee and southern Osage Counties. Four interpretations of this disruption and the possible structural implications are presented in Figure 4. The faults in the first interpretation are parallel to later Paleozoic faults along the Nemaha Uplift and the Cushing structure in western Creek County. The folds in the second interpretation are parallel to the Spavinaw Arch. The third interpretation is based upon faults parallel to the arch. The last interpretation is a simple right lateral wrench fault. The wrench fault interpretation is possibly the most voguish but also the most difficult to support. The late Paleozoic en echelon fault sets, if interpreted as megatension gashes, trending north through northeast Oklahoma suggest a wrench fault at depth. These fault systems require a left lateral, not a right lateral fault. At present this basement study has not revealed any evidence to bear on the origin or formation of these curious fault sets.

The area underlain by the Osage Microgranite is interpreted as a broad dome from which the rhyolite has been removed. This structural feature is here named the Osage Dome. The dome is coincident with a very strong positive gravity anomaly. This Osage anomaly (Cook, 1956) occurs in an area where the Chattanooga Shale is absent (Leatherock and Bass, 1936). Although the microgranite does not cause the anomaly,

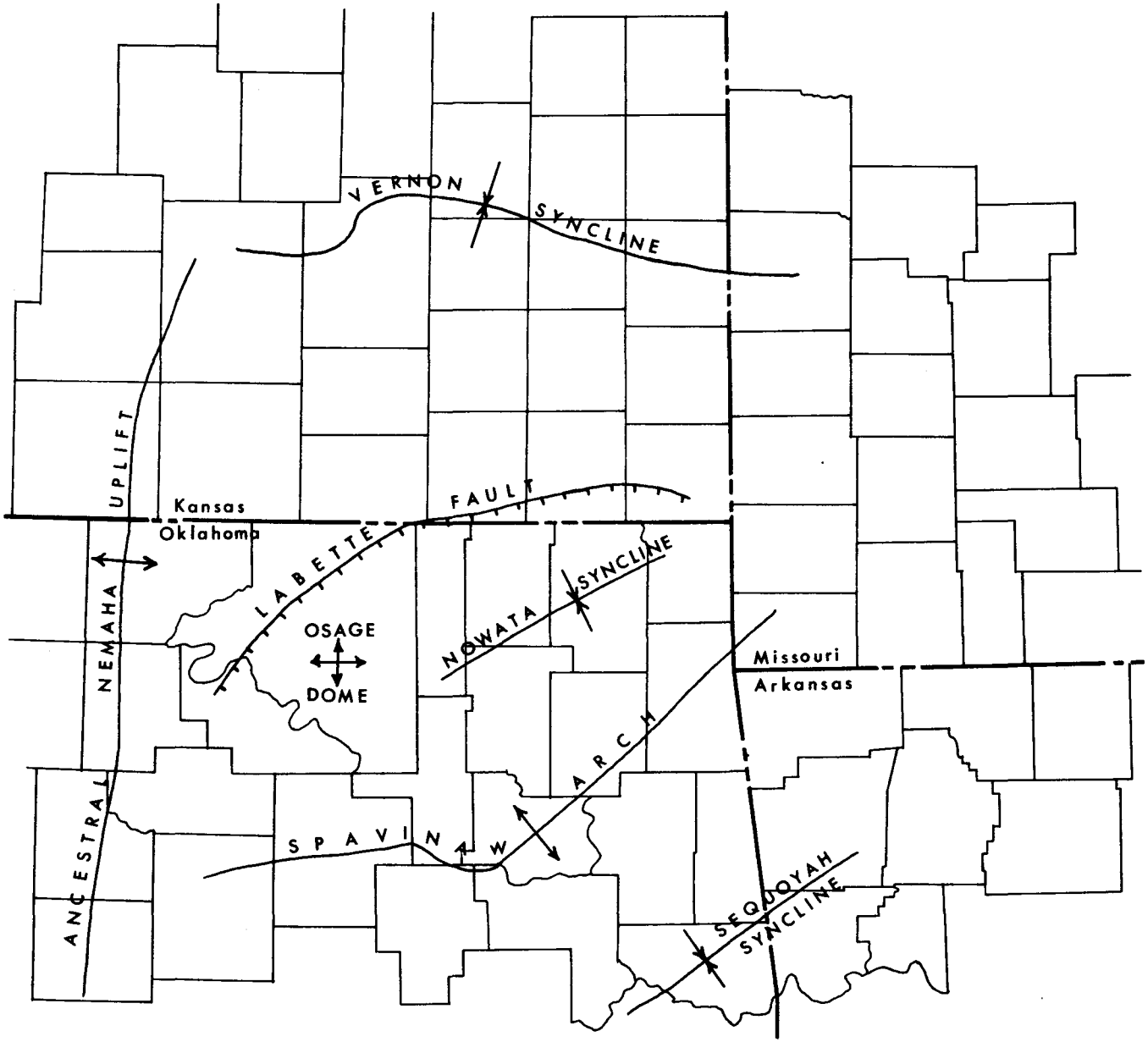
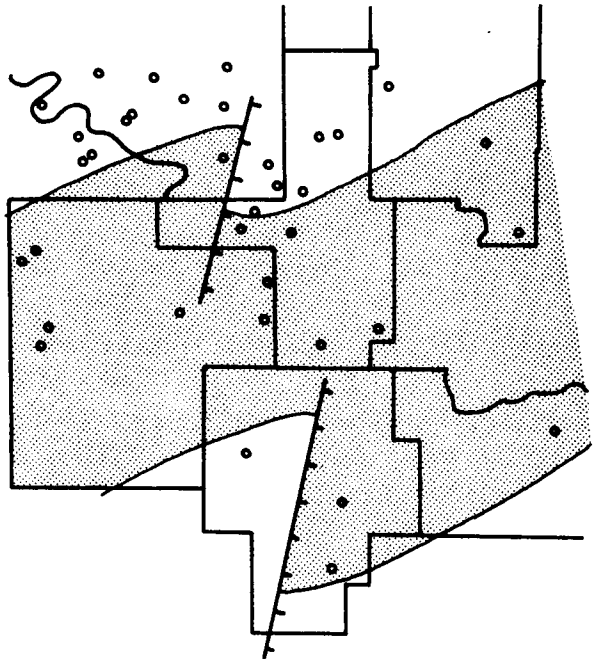
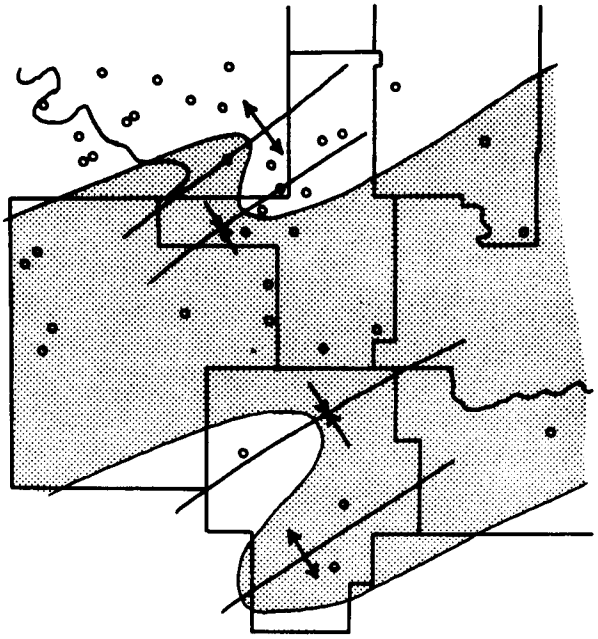


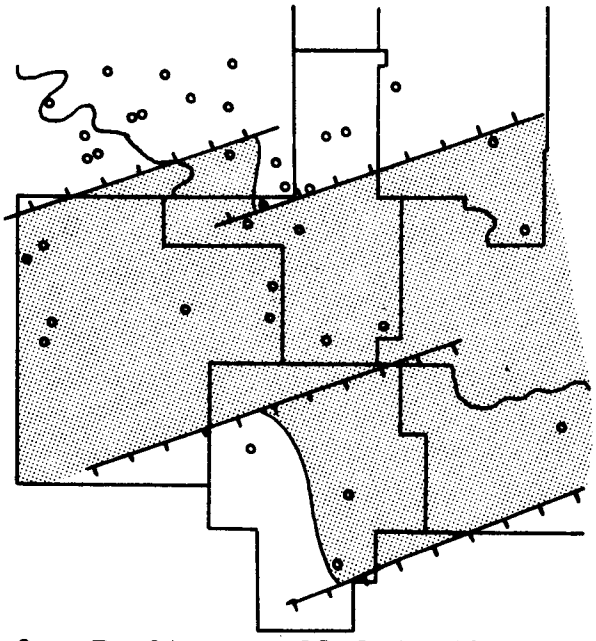
Figure 3. Precambrian structural features.



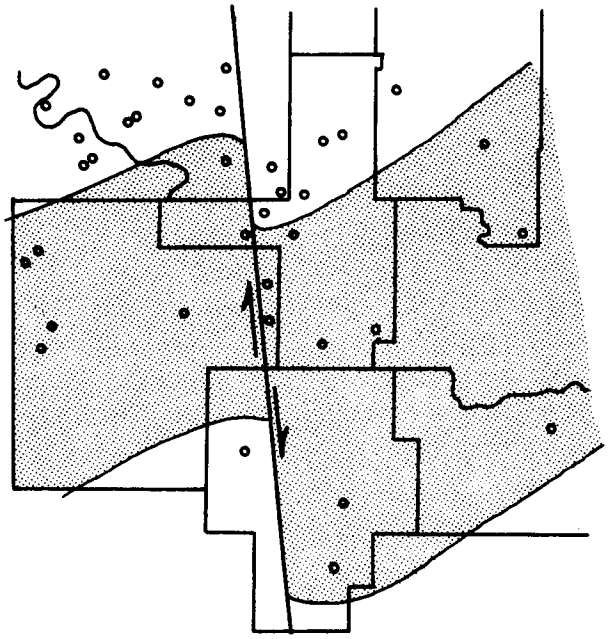
1. Faults parallel to the Nemaha and Cushing structures



2. Folds parallel to the Spavinaw Arch



3. Faults parallel to the Spavinaw Arch



4. Right lateral wrench fault

Figure 4. Four possible explanations for the disruption of the Spavinaw Arch.

it possibly reflects instability due to a deeper source as suggested by Lynn (1962).

Other than the faults that are known on the surface only one basement fault can be inferred with any degree of confidence. This is the long, gently curving fault separating the rhyolite from metarhyolite striking east-northeast from Pawnee County, Oklahoma to Cherokee County, Kansas. This fault is here named the Labette Fault for the county in Kansas through which the fault is inferred to strike. Metarhyolites occur only north of the fault, there is a high gravity gradient parallel to the fault, and one well just north of the fault penetrated a granite which also suggests some kind of tectonic anomaly. These all support and are the evidence for a fault. There is no evidence that it was active in Paleozoic time. The fault is shown in Plate I as a normal fault but the orientation of the fault plane is not known. The Labette Fault may have been activated during the intrusion of the Central Oklahoma granites as a compensating fault along the flank of the major batholithic intrusion.

The two broad areas of rhyolite on the flanks of the Spavinaw Arch are caused by preservation in structural lows interpreted here as synclines. The northern structure is named the Nowata Syncline for the county through which the structure extends. The axis of the syncline is parallel to the Spavinaw Arch and is interrupted on the southwest by the Osage Dome.

The syncline is separated in subcrop from the metarhyolite by the Labette Fault which marks the northwest boundary of the structure. The structure south of the Spavinaw Arch is here named the Sequoyah Syncline for the county through which the structure extends. The available basement samples in this area are more sparse and the limits of the syncline are poorly defined.

The Nemaha Uplift is a prominent Paleozoic feature that is underlain by a distinctive rock type, coarse grained granites of either the Central Oklahoma Granite Group or the Chase County Granite Group. This suggests that the Nemaha Uplift was a positive structural area in post-rhyolite pre-sediment time. The ancestral Nemaha Uplift is necessary to remove rhyolite and other cover and expose the more deeply emplaced granites. It appears that the Paleozoic structural expression is a reactivation, although the nature of the Precambrian Uplift is not known. The ancestral uplift is more easily documented in Oklahoma, the evidence in Kansas is more obscure because available samples are sparse off the uplift and because there is no distinctive difference between rocks on and adjoining the uplift.

The area underlain by the Vernon County Metamorphic Group is a Precambrian basin of sedimentation that remained as a relative structural low. This sedimentary trough is poorly defined but appears to be in part coincident with a

modest Paleozoic uplift that affected sedimentation, the Bourbon Arch. The structural low in which the metasedimentary rocks are preserved is here named the Vernon Syncline.

It is possible that the southern boundary of the Vernon County Metamorphic Group is a fault contact to preserve the relatively thick sedimentary pile that is present in a narrow band.

The boundary between the "older granite and gneiss" with younger rocks in Missouri is roughly coincident with the Paleozoic structural grain. The "embayment" of Mississippian age rocks with a linear northeastern contact with rocks of Ordovician age through Webster, Greene, and Polk Counties is possibly a reflection of the Precambrian contact.

The above demonstrates that there is control exerted by Precambrian structure on later structure and sedimentation. There is not the close control of structure by basement rocks found in southern Oklahoma. However, by comparison with the major tectonic features of southern Oklahoma there is very little structure to control in the study area.

CONFIGURATION OF THE BASEMENT SURFACE

The present configuration is a combination of inherited buried topography and later modification by Paleozoic folding and faulting. In Lyon, Chase, Butler, and Morris Counties, Kansas, there are small areas along the Nemaha Uplift from which Reagan and Arbuckle Group rocks have been removed during upper Paleozoic uplift and erosion (Merriam, 1963, p. 173). Only in these small areas has the configuration been modified by Paleozoic erosion. There is no area in Oklahoma where erosion reached and exposed the Precambrian rocks (Jordan, 1962).

The excellent and detailed map of Coles (1962) of basement configuration in Kansas shows several prominent structural elements. In the area under consideration the most striking feature is the Nemaha Uplift, an arch with a series of faults down to the east. This uplift is shown to be a series of discrete knobs with intervening saddles.

Because of the rugged topography on the basement surface (see also Ireland, 1955; Dille, 1956) the best approach to the post-Precambrian structure is not the basement surface but the top of the Arbuckle Group as an indicator of later movement. The map of Merriam and Smith (1961) on the top of Arbuckle rocks in Kansas shows a gentle westward homoclinal dip from eastern Kansas to the Nemaha Uplift with no major discontinuities. However, the pattern is more

complex immediately to the east of the Nemaha Uplift. This complication is reflected in the gravity information of Woollard (1959).

Topography in Oklahoma appears to show very little evidence of large scale Paleozoic movement. The gentle doming of the Ozark Uplift and the Nemaha Uplift are prominent as is the deep downwarp of the Arkoma Basin. It appears that the ruggedness of topography shown in the published maps of Ireland and Dille are at least in part "controlled" by the density of well data. That is, where control is sufficient a rugged topography is indicated and in areas of sparse control a general smoothness is dictated.

However, certain generalities can be made concerning the influence of rock type on basement surface features, taking into account the spotty well control. The areas underlain by the Spavinaw Granite are characterized by relatively large features with major relief (up to 1800 feet in some areas) while those areas underlain by rhyolite or microgranite are characterized by smaller scale, broken features with relatively modest relief. This situation is not unique. The Wichita Mountains offer a close analogy in that hills supported by rhyolite are smooth, comparatively modest in relief, and individually smaller than the hills supported by granite.

There does not appear to be much control of topography by basement rocks in Kansas. However, in eastern Morris

and northwest Lyon Counties basement is directly overlain by rocks of the Simpson Group. The absence of the rocks of Reagan and Arbuckle age can be attributed to high-standing basement rocks during deposition. Muscovitic quartzite underlies these areas and these quartzites undoubtedly stood as islands not covered until Simpson time.

Some linear topographic features are close to possible boundaries between basement rock units. In areas where topographic expression warrants consideration as a rock group boundary, and there is no evidence to the contrary, the inferred contact has been shifted to coincide with this expression.

Thus the present basement rock surface is the result of tectonic warping and faulting of an inherited topography. The topography reflects the basement rock types and their particular resistance or susceptibility to erosion and their tendency for characteristic topographic expression.

SUMMARY

The "older granite and gneiss" is the oldest unit that can be recognized in the study area. The unit cannot be defined from samples in this area and is a loose assemblage of rocks considered to be older than 1400 million years. Virtually nothing is known of the origin of the rocks. Granite gneiss, granitic gneiss, and gneissic granite comprise the rock types found in this unit.

On a surface of "older granite and gneiss" and possibly other rock types for which there is no evidence, a relatively pure quartz sand was deposited. This sandstone was metamorphosed at about 1400 million years to form the Lyon County Quartzite. The age of deposition cannot be fixed but is obviously older than the 1400 million year age of metamorphism. There are similar masses of quartzite to the west along the central Kansas Uplift and to the north the Sioux Quartzite. However the correlation is speculative at best and no definite conclusions can be made in this regard.

The rocks of the Chase County Granite Group were emplaced at about 1400 million years. The igneous activity that gave rise to these rocks also supplied the heat to metamorphose the Lyon County Quartzite. The rocks of the group are mainly granite and gneissic granite with some granite gneiss. Rocks of this age occur over an area at least 400 miles long and 100 miles wide. However, the rocks are not

everywhere present in this large area having been partly obliterated or covered by younger rocks. The granites were probably emplaced as a multiple batholith.

A period of uplift and erosion can be inferred after this period of granitic igneous activity and metamorphism. This is largely to satisfy apparent geometric relations with younger volcanic rocks resting unconformably on rocks of the Chase County Granite Group.

These 1400 million year old granites are the framework into and onto which rocks of the Northeast Oklahoma Province were injected and extruded. This is a petrographic province composed of rocks closely related in time and space. They represent an epizone granite-volcanic complex similar in many respects to the silicic part of the Middle Cambrian Wichita Province of southern Oklahoma. All the ages determined on rocks of this province are 1200 million years within analytical error. The units included in the Northeast Oklahoma Province are: the Washington County Volcanic Group, the Spavinaw Granite Group, the Woodson County Granite, and the Osage County Microgranite.

The Washington County Volcanic Group is composed mostly of rhyolite porphyry but andesite and metarhyolite are also included. The volcanic rocks underlie approximately 18,000 square miles. The thickness is not known but is undoubtedly substantial. The very large area now underlain by

rhyolitic rocks has undoubtedly been considerably diminished from its original size by subsequent erosion. The rhyolites are interpreted largely as originating as welded tuffs although this cannot be demonstrated in the majority of samples. The andesite appears to be a local phase of the more acidic volcanic rocks. The metarhyolite is found in broad areas around the outer margin of the normal rhyolite.

The rhyolites and other volcanic rocks are interpreted as the host for three intrusive granite units. These remaining members of the Northeast Oklahoma Province show characteristics of hypersolvus type epizone intrusions.

The Spavinaw Granite Group is subareally exposed along a broad presediment arch extending from southwestern Missouri to central Oklahoma. These granites are estimated to underlie about 8700 square miles. The rocks of this group are characteristically micrographic and porphyritic. The textural variation is not great. To account for the lack of variation the intrusion form for the granites is interpreted as mostly sills. This is essentially the only form of intrusion which, following subsequent uplift and erosion, allows a distinctive "chilled" texture to occur over such a large area. This suggests that the broad arching was indeed gentle so that erosion just skimmed off the rhyolite and did not cut deeply into the granite.

The Woodson County Granite is found in drill holes

near the northern limit of the Northeast Oklahoma Province. These samples are mineralogically and texturally identical to granite occurring as boulders at Rose Dome in Woodson County, Kansas. These boulders have been dated as Precambrian. The textural evidence suggests that this occurrence of granite surrounded by Pennsylvanian sedimentary rocks has a tectonic explanation and is possibly due to an explosion phenomenon.

The Osage County Microgranite is the most distinctive and uniform rock unit in the province. It occurs over a 320 square mile area that is coincident with a strong positive gravity anomaly. Although the microgranite does not cause the anomaly there is probably an interrelationship. The microgranite is porphyritic and has a distinctive groundmass texture characterized by rod-like quartz development. The microgranite was probably intruded between layers of rhyolite.

Two rock groups are interpreted as being younger than the Northeast Oklahoma Province. These are the Vernon County Metamorphic Group and the Central Oklahoma Granite Group.

The Vernon County Metamorphic Group is composed largely of a graywacke-shale sequence. The degree of metamorphism varies from incipient to upper greenschist facies. One small area in Butler County, Kansas, is underlain by metabasaltic rock placed in this group as a matter of convenience. Rhyolite detritus is found in some of the samples and indicates

that the sediments are in part younger than the rhyolite. The sediments are interpreted as marine in origin by analogy with other areas although some vastly different origin is quite possible.

The Central Oklahoma Granite Group is the youngest basement rock unit in the area. Isotopic age determinations show it is the same age range as the Northeast Oklahoma Province. The evidence for this as the youngest unit is the metamorphism of other rock units where in contact with the Central Oklahoma Granite Group. These rocks cannot be petrographically distinguished from those of the Chase County Granite Group. Like the latter group the Central Oklahoma Granite Group is interpreted as having intruded as a complex multiple batholith. It is probably the mesozone expression of the extrusive-epizone Northeast Oklahoma Province.

The 700 million years following the intrusion of the Central Oklahoma Granite Group and before deposition of Upper Cambrian and younger sediments was a comparatively uneventful time. Uplift and erosion along certain axes, such as the Nemaha Uplift, can be demonstrated in order to obtain the present basement rock distribution. No igneous or metamorphic activity occurred after the 1200 million year intrusions. Following the invasion of lower Paleozoic seas very little took place to affect the basement rocks. In upper Paleozoic time gentle warping and minor faulting displaced

the basement. This movement was the last event that affected the basement. The basement rocks were as they are today--among the most geologically simple and regular in the United States.

Table 5. Basement rock wells.

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Pottawatomie Pt-1	Hembree No. C-3 Hembree	19-7N-5E SE SW SE	7755 -6828	7781 26	Granite	COGG
Haskell Hk-1	Pan. Amer. Petr. No. 1 Williams Unit	36-8N-22E E/2 SE NW	9606 -8940	9817 211	Metarhyolite porphyry	WCVG
LeFlore Lef-1	Pan. Amer. Petr. No. 1 Tackett Unit	28-8N-23E C SW NE	9248 -8722	9272 24	Hornblende granite	COGG
Sequoyah Sq-2	Okla. Nat. Gas No. Stockton	20-11N-26E SE SE	6143 -5640	6146 3	Rhyolite porphyry	WCVG
Okmulgee Om-2	Hamon and Cox No. 19 E. Reynolds	26-12N-13E SW SE SW	4330 -3702	4358 28	Micrographic micro-granite	SGG
Okmulgee Om-2	Mid-Cont. Petr. Co. No. 9 Daniels	12-13N-13E NW NW SW	3540 -2850	3594 54	Micrographic granite porphyry	SGG
Muskogee Ms-1	USSRAM Explor. Co. No. 1 Marshall	23-13N-19E NW NW SE	3274 -2673	3294 20	Altered rhyolite porphyry	WCVG
Sequoyah Sq-1	T. J. Foster No. 1 Burkee Mabee	15-13N-25E SW SW NE	3190 -1845	3213 23	Rhyolite porphyry	WCVG
Okmulgee Om-3	The Texas Co. No. 19 Texas Fee Net 2	11-14N-11E SE SW NW	3847 -3029	3868 21	Rhyolite porphyry	WCVG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Muskogee Ms-4	W. H. Pine No. 1 Klein	32-15N-18E NE NW SW	3481 -2846	3496 15	Micrographic migro-granite porphyry	SGG
Creek Ck-6	Sellers Petr. Co. No. 2 Tarr	3-16N-7E SE NE NW	4450 -3418	4505 55	Micrographic granite porphyry	SGG
Okmulgee Om-5	Schermerhorn No. 1 Tiger	24-16N-12E NE SE SE	2628 -1950	2640 12	Micrographic micro-granite porphyry	SGG
Tulsa Tu-3	Kewanee Oil Co. No. 16 Stewart	4-16N-13E C S/2 NE NW	2396 -1732	2398 2	Micrographic micro-granite porphyry	SGG
Okmulgee Om-4	Wood Oil Co. No. 1 Miller	32-16N-14E NE SE NW	4110E -3300E	3915	Not basement	SGG
Wagoner Wg-1	Emrich and Austin No. 1 Carter	5-16N-16E SW NE NW	3092 -2519	3098 6	Micrographic granite porphyry	SGG
Cherokee Cke-3	W. H. Pine No. 1 Lemon	33-16N-21E C SW SE	2083 -1393	2093 10	Micrographic granite porphyry	SGG
Creek Ck-2	Cosden Oil Co. No. 17 Barnett	22-17N-7E NE NW SE	3660 -2649	3704 44	Micrographic granite porphyry	SGG
Creek Ck-4	Central Commercial No. 3 Hay	10-17N-10E SW NW SW	4200 -3417	4282 82	Micrographic granite porphyry	SGG
Creek Ck-3	Gulf Oil Corp. No. 1-S Berryhill	17-17N-12E SE NW NE	3918 -3198	3932 14	Pyroxene micrographic granite porphyry	SGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Tulsa Tu-2	Wilcox Oil and Gas No. 1 Hulputta	27-17N-14E NW NW NW NW	3360 -2754	3400 40	Micrographic granite porphyry	SGG
Payne Py-1	Deep Rock Oil Co. No. 3 Little Chief	4-18N-5E NE NW NE	3593 -2775	3600 7	Micrographic granite porphyry	SGG
Creek Ck-7	Sand Springs Home No. 13 Atkins	4-18N-7E NE SW NW	3640 -2815	3811 171	Micrographic micro-granite porphyry	SGG?
Creek Ck-8	Riverside (Owens) No. 2 Yarhola	8-18N-7E NW SW SE	3793 -3045	3810 17	Micrographic micro-granite porphyry	SGG?
Creek Ck-1	Gulf Oil Corp. No. G-26-S N. Glenn U. No. 2	29-18N-12E SE NW SE	3898 -3158	3904 6	Micrographic granite porphyry	SGG
Payne Py-2	Magnolia Petr. Co. No. 10 Main	34-19N-4E SW NW NW	4146 -3206	4151 5	Micrographic granite porphyry	SGG
Payne Py-3	Wood Oil Co. No. 1 Curley Chief	33-19N-5E SW SW SE	3757 -2939	3792 35	Micrographic granite porphyry	SGG
Tulsa Tu-9	Dotson, et al. No. 1-B Jefferson	23-19N-11E SE SE NE	3010 -2191	3015 5	Pyroxene micrographic granite porphyry	SGG
Tulsa Tu-1	F. DeMier No. 3-A Bruner	6-19N-12E SW SW SE	2700 -2018	2726 26	Altered welded rhyolite tuff and rhyolite porphyry	WCVG
Tulsa Tu-5	Texas Co. Tulsa Refinery	23-19N-12E C SE NW	3435 -2800E	3460 25	Micrographic granite porphyry	SGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Rogers Rog-1	Reed and Sons No. 1-A Koenig	27-19N-17E SE SE NW SE	2397 -1772E	2415 18	Granite	SGG
Cherokee Cke-1	M and F Oil Co. No. 1 Thompson	35-19N-21E C SE NE	1800 -1000E	1935 135	Micrographic granite porphyry	SGG
Cherokee Cke-2	R. Begeman No. 1 Begeman Ranch	20-19N-23E NW SE NW	1399 -292	1426 27	Micrographic micro-granite porphyry	SGG
Pawnee Pw-3	Tidal-Osage No. 8 Arnold	3-20N-8E NE SE SW	3206 -2305	3217 11	Rhyolite porphyry	WCVG
Pawnee Pw-4	Minnehoma No. 1 Richards	9-20N-8E NE NW NW	3046 -2027	3072 26	Welded rhyolite tuff	WCVG
Osage Os-26	Southern Union Prod. No. 1-C Atchison	5-20N-11E SE SE NW	3233 -2454	3245 12	Micrographic granite	SGG
Osage Os-6	Keener Oil Co. No. 29 Osage "A"	8-20N-12E NE NE NE	2158 -1236	2161 3	Welded rhyolite tuff	WCVG
Osage Os-33	Winona Oil No. 27 Osage	9-20N-12E C W/2 E/2 NE	2730 -2004	2770 40		
Osage Os-22	DeMier Oil Co. No. 1-A Country Club	28-20N-12E C SE NW	2632 -1894	2654 22	Banded rhyolite porphyry	WCVG
Tulsa Tu-6	Dowell, Inc. No. 1 Fee	31-20N-13E SW SE NW	3296 -2569	3310 14	Micrographic granite porphyry	SGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Mayes May-2	Dixon No. 1 Drew	8-20N-19E SW NE NW	1302 -632E	2395 1093	Granite?	SGG
Delaware Dr-2	M and F Oil Co. No. 1 Ransom	18-20N-22E SW NW SW	2184 -1165	2215 31	Micrographic granite porphyry	SGG
Osage Os-24	Gulf Oil Corp. No. 65 Boston	1-21N-7E SE SW NE	2963 -2181	3000 37	Rhyolite porphyry	WCVG
Pawnee Pw-1	Sinclair O and G No. 46 Jones	20-21N-8E C SE SW	2929 -1968	2945 16	Rhyolite porphyry	WCVG
Osage Os-13	Gled Oil Co. No. 2 Osage	9-21N-9E C SW	2576 -1600	2667 91	Rhyolite porphyry	WCVG
Osage Os-14	Moore Oil and Ohio Oil No. 24 Osage	9-21N-0E N/2 SW SW	2536 -1626	2646 110	Microgranite porphyry	OCM
Osage Os-17	F. De Mier No. 1-A J. Zink	5-21N-11E N/2 SW NW	2924 -2030	2995 71	Altered rhyolite porphyry	WCVG
Osage Os-41	Sunray DX Oil Co. 21-NW-32-21-12	32-21N-12E NW NE NW	2554 -1906	2578 24	Welded rhyolite tuff	WCVG
Tulsa Tu-7	Superior Oil Co. No. 1 Blakemore	26-21N-13E SW NW SW	1363 -709	1462 99	Rhyolite porphyry	WCVG
Tulsa Tu-8	Superior Oil Co. No. 2 Blakemore	26-21N-13E NE SW SE	1566 -906	1586 20	Rhyolite porphyry	WCVG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Tulsa Tu-4	Texaco, Inc. No. 25-WS Adkisson	32-21N-13E C N/2 NE	2742 -2120E	2812 70	Rhyolite tuff flow	WCVG
Rogers Rog-3	Smith and Daniels No. 2 Vierhiller	36-21N-16E SE SE NE	2246 -1596E	3109 863	Micrographic micro-granite and granite porphyry with syenitic dikes	SGG
Osage Os-16	Big Four Petr. Co. No. 5 Bird	33-22N-7E SE NW SW	3760 -3003	3835 75	Altered rhyolite porphyry	WCVG
Osage Os-20	Red Bank Oil Co. No. 2 Little	14-22N-8E SW SE NW	3422 -2561	3429 7	Microgranite porphyry	OCM
Osage Os-23	Norbla Oil Co. No. 2 Lyman	24-22N-9E NW SE SW	2933 -2066	2972 39	Microgranite porphyry	OCM
Osage Os-15	Tidal-Osage No. 26 Wildhorse	33-22N-10E C W/2 NW	2622 -1793	2670 48	Rhyolite porphyry	OCM
Osage Os-1	Sunray Oil Co. S-3 Osage	34-22N-10E S/2 S/2 SW	3210 -2370	3235 25	Rhyolite porphyry	WCVG
Osage Os-2	Okmar Oil Co. No. S-1 Boren	34-22N-10E SE SE NE	3485 -2621	3485	Rhyolite porphyry	WCVG
Osage Os-25	Bay Oil Co. No. 1 Osage (White)	9-22N-11E SW NE SW	2129 -1203	2131 2	Rhyolite porphyry	WCVG
Rogers Rog-2	Lucien Conner No. 2 Nichols "A"	25-22N-14E NW SE SE	2514 -1853	2636 122	Rhyolite porphyry	WCVG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Pawnee Pw-2	Watchorn Oil and Gas No. 11 Miller	33-23N-3E NW NE SE	4570 -3604	4582 12	Rhyolite porphyry	WCVG
Pawnee Pw-7	Porter Oil and Gas No. 20 Miller	33-23N-3E SW SE SW	4678 -3673	4697 19	Rhyolite porphyry	WCVG
Osage Os-29	Texas Co. No.13 SWD Bennett	12-23N-7E SW SE NW	3468 -2464	3542 64	Rhyolite porphyry	WCVG
Osage Os-9	Pure Oil No.192 Osage-Hominy	8-23N-8E SE NW SE	2572 -1612	2575 3	Microgranite porphyry	OCM
Osage Os-5	Pure Oil No.190 Osage-Hominy	8-23N-8E SW NE SE	2536 -1590	2595 59	Microgranite porphyry	OCM
Osage Os-4	Pure Oil No.191 Osage-Hominy	9-23N-8E SW SW	2602 -1614	2612 10	Microgranite porphyry	OCM
Osage Os-28	J. G. Buell No. 14 Osage	25-23N-8E NE SW SE	2383 -1523	2390 7	Microgranite porphyry	OCM
Osage Os-18	Amerada Petr. Co. No. 1 Hardy	7-23N-11E NW NW SE	2349 -1405	2384 35	Microgranite porphyry	OCM
Osage Os-11	Cities Service No. 1-S S. Barnsdall U.	8-23N-11E NW SE NE	3007 -2242	3032 25	Rhyolitic arkose	WCVG
Mayes May-1	J. L. Milligan No. 1 Lee	17-23N-19E SE SE SE	1897 -1197+	1957 60	Micrographic granite porphyry	SGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Mayes May-6	J. Bander No.1 Brixie(Brixey)	15-23N-20E SW SW SE	1649 -979E	1685 36	Micrographic granite porphyry	SGG
Mayes May-3	Davis and Miler No. 1 Knight	34-23N-21E NE SW NE	1600 -944	1622 22	Micrographic granite porphyry	SGG
Delaware Dr-1	Commercial Oil Co. No. 1 Gardner	17-23N-25E NW NW NW	1019 +26	1023 4	Micrographic granite porphyry	SGG
Osage Os-10	Texas Co. No. 1-S Smith Tr. "A" 26	28-24N-7E NW NE SE	3757 -2677	3772 15	Rhyolite porphyry	WCVG
Osage Os-19	Marland and Gled No. 2 Kohpay	16-24N-8E SE SE NE	2480 -1451	2585 105	Microgranite porphyry	OCM
Osage Os-32	Cities Service Oil No. 1-SWD Osage Lot 292	8-24N-11E NW SE SW	2804 -2031	2821 17	Banded rhyolite porphyry	WCVG
Osage Os-8	Ohio Oil Co. No.S-1 Osage B-82	25-24N-11E NW NE NW	2854 -1936	2864 10	Rhyolite porphyry	WCVG
Washington Ws-3	Reinhardt and Donovan No. 1 Abel	27-24N-13E C SW SE	3000 -2390E	3002 2	Rhyolite porphyry	WCVG
Craig Crg-5	Dye-Henry No. 1 Ross	20-24N-21E NW SW NE	1755 -899	1764 9	Granite	SGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Kay Ky-2	Continental Oil Co. No. Brett "A"	8-25N-2E SW NE SE	5310 -4310	5349 39	Granite	CoGG
Osage Os-40	Atlantic Ref. Co. No. 9-V569	19-25N-8E NW NE SW	2830 -1741	2838 8	Rhyolite porphyry	WCVG
Osage Os-30	Phillips Petr. No. 1-SWD Higgins "A"	23-25N-8E SW SW SW	3628 -2730	3663 35	Welded rhyolite tuff	WCVG
Osage Os-27	Texaco, Inc. No.16-W S Kohpay	29-25N-8E NE NE NE	2813 -1723	2849 36	Microgranite porphyry	OCM
Osage Os-7	Mid-Continent No.1 Osage Tr.201	31-25N-10E NE SW SW	2525 -1625E	2565 40	Microgranite porphyry	OCM
Osage Os-12	Ohio Oil Co. No. 87 Osage Unit "C"	20-25N-11E SW NW SW	3013 -2063	3034 21	Rhyolite porphyry	WCVG
Washington Ws-4	Empire Gas and Fuel No. 3 McElmore	25-25N-12E NE SW NE	2340 -1585	2368 28	Rhyolite porphyry (tuff?)	WCVG
Osage Os-21	Kewanee Oil No. WS-1 Botts	14-26N-6E NW SW SW	4472 -3252	4478 6	Metarhyolite (tuff?)	WCVG
Washington Ws-7	Greene and Jones No. S-1 Hildebrand	20-26N-13E NW NW	1987 -1217E	2367 380	Welded rhyolite tuff	WCVG
Craig Crg-3	Frankfort Oil No. 1 Bluejacket	4-26N-19E NW NW NW	2102 -1267	2129 27	Rhyolite porphyry	WCVG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Craig Crg-4	3-B Oil Co. No. 1 Helmik	12-26N-21E NW NW	1769 -1019E	1946 -177	Micrographic granite porphyry	SGG
Osage Os-3	Phillips Petr. Co. No. 17 Mott	11-27N-5E NE NE SE	4568 -3416	4610 42	Metarhyolite porphyry	WCVG
Washington Ws-2	Taylor, F. C. No. 6-B Garrett	3-27N-13E C NE SW	2270 -1523	2289 19	Welded rhyolite tuff	WCVG
Washington Ws-8	Bonaventure No. S-1 Chamberlain	8-27N-14E SE SE NW	2276 -1478	2298 22	Rhyolite porphyry	WCVG
Nowata Nw-1	Delaware Consolidated No. WS-1 Pilot Flood Tr.	20-27N-15E NW NW NE	2480 -1730E	2509 29	Rhyolite porphyry	WCVG
Kay Ky-1	Anderson Pritchard No. 28 Welsh	17-28N-1E NW NE SW	4405 -3259	4407.5 2.5	Granite	COGG
Kay Ky-3	Marland Refg. et al No. 1 Joynson	18-28N-3E C/NE SE	4780 -3613	4827 47	Metarhyolite porphyry	WCVG
Washington Ws-5	Barnsdall Oil Co. No. 7 Rigdon	30-28N-13E C/SW	2548 -1858E	2565 17	Welded rhyolite tuff	WCVG
Craig Crg-2	Wackerle Oil Co. No. 4 Hood	19-28N-20E SE SW SE	1493 -655	1590 97	Welded andesite tuff	WCVG
Craig Crg-1	Frankfort Oil Co. No. 1 Van Ausdel	31-28N-20E SE NE NW	1692 -833	2014 322	Welded andesite tuff	WCVG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Ottawa Ot-4	Amer. Zinc Demo No.2 (A2-2)	8-28N-22E NW NE SE	291±3 +479±	305 14	Micrographic granite porphyry	SGG
Ottawa Ot-5	Amer. Zinc Demo No.7 (A2-7)	8-28N-22E NW NE SE	345 +430±3	355 10	Micrographic granite porphyry	SGG
Ottawa Ot-1	City of Miami No. 3 Goodrich Rubber	24-28N-22E SE NE SW	1045 -247	1055 10	Micrographic granite porphyry	SGG
Washington Ws-6	Empire Gas and Fuel No. 1 Thompson	22-29N-13E NW SE SE	2700 -1925	3175 475	Rhyolite tuff	WCVG
Ottawa Ot-3	Commerce Mining and Royal. Bird Dog Mine	13-29N-22E SW SE SE	1185 -363	1206 21	Micrographic granite porphyry	SGG
Ottawa Ot-2	Commerce Mining and Royal. No. 159 Beaver	19-29N-23E SW SW SE	1762 -929	1773 11	Micrographic granite porphyry	SGG
Ottawa Ot-7	Eagle-Picher No.43-C A. Beaver	19-29N-23E NE NW NE	1610 -777	1657 47	Microgranite porphyry	SGG
Ottawa Ot-6	Eagle-Picher No.P-5 Golden Hawk	20-29N-23E SW SW SE	1730 -898	1797 67	Andesite porphyry	WCVG
Oklahoma Ok-1	Cities Service Oil No. 5 Farley	19-11N-2W SW NE NW	8260 -7011	8344 84	Sheared granite and diabase	COGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Oklahoma						
Noble Nb-1	Shell Oil Co. No. 1 Magney	17-20N-2W C/SW SW	7062 -5793	7084 22	Granite	COGG
Noble Nb-2	Stanolind No. 1 Shoop	27-22N-2W NW SW SE	6445 -5405	6446 1	None observed	----
Garfield Gf-1	Sinclair O and G No. 19 Hartley	18-22N-3W SW SW NW	5461 -4346	5954 493	Granite	COGG
Kansas						
Douglas Dg-2	Duffens No. 1 Stanley	3-14S-21E NW NE NW	2463 -1532	2503 40	Muscovite-quartz-feldspar-schist	OGG
Johnson Jo-2	Seminole No. 1 Harrington	12-14S-22E NE NE SW	2407 -1381	2450 43	Granitic gneiss	OGG
Lyon Ly-1	Johnston No. 1 Venning	32-15S-10E SW SW SE	3359 -1964	3360 1	Muscovitic quartzite	LCQ
Osage Os-2	Elmhurst No. 1 Badger	4-15S-16E SE NE NW	2740 -1566	3015 275	Granite gneiss	OGG
Dickinson Dk-3-1	Hutchinson No. 1 Daetwiler	33-16S-4E NE SW SW	3108 -1723	3114 6	Granite, possibly gneissic	CCGG
Morris Mo-4	Lincoln No. 1 Breckbill	24-16S-5E NE SE SE	3066 -1594	3069 3	Gneissic granite	CCGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Kansas						
Morris Mo-5	General Utilities No. 1 Heigle	11-16S-7E NW NW SE	less than 2045	2069 24+	Muscovite granite gneiss	OGG?
Morris Mo-6	Westgate-Greenland No.1 Orphans Home	15-16S-7E SE SE SE	2155 -695	2170 15	Granite gneiss?	OGG?
Morris Mo-7	Leslie No.1 "A" McConnell	14-16S-9E SE SE SE	3132 -1868	3169 37	Muscovitic quartzite	LCQ
Morris Mo-8	Gruenerwald No. 1 Johnson	33-16S-9E C NE SE	3089 -1851	3103 14	Granite gneiss	OGG?
Lyon Ly-2	Bulla No. 1 Richards	6-16S-10E NE NE NE	3224 -1874	3234 10	Muscovitic quartzite	LCQ
Lyon Ly-3	Midge No. 1 Day	16-16S-10E NE NE SE	3110 -1717	3134 24	Muscovitic quartzite	LCQ
Miami Mi-1	Arroyya (McDonald) No. 1 Lee	16-16S-23E SW SW SW	2283 -1389	2707 424	Granite gneiss	OGG
Morris Mo-9	Rex and Morris No.1 Anderson Ranch	12-17S-6E NE NE NE	2104 -646	2135 31	Granite, possibly gneissic	CCGG
Morris Mo-10	Westgate-Greenland No. 1 Meyers	23-17S-7E SE SW SW	2155 -632	2244 89	Gneissic granite	CCGG
Morris Mo-11	Stanolind No. 1 Carpenter	29-17S-7E SW SE SE	2140 -654	2153 13	Granite	CCGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Kansas						
Morris Mo-12	Stanolind No. 1 Veal	30-17S-7E NE NE SE	1875 -433	2005 130	Gneissic(?) granite	CCGG
Morris Mo-13	Empire No. 1 Moffett	34-17S-7E NW NW SE	2525 -1002	2607 82	Granite	CCGG
Chase Cs-2	Federal No. 1 Whitney	15-18S-6E NW NW SW	2424 -940	2435 11	Granite?	CCGG
Chase Cs-3	National Refining No. 1 Whitney (Case?)	19-18S-6E C NE SW	 -940	2435 11	Granite?	CCGG
Chase Cs-4	Preston and Pasewalke No. 2 Lipps	25-18S-6E SW SW SE	2030 -614	2093 32	Granite gneiss(?)	CCGG
Chase Cs-5	Urschal No. 1 Lipps	27-18S-6E NE NE SE	2285 -813	2342 57	Granite	CCGG
Chase Cs-7	Preston and Pasewalke No. 1 Lipps	32-18S-7E NE NE SW	2260 -911	2262 2	Sheared granite	CCGG
Marion Mr-1	Anderson-Prichard No. 1 Jost	22-19S-2E SW NW SW	3062 -1662	3081 19	Quartzite	LCQ
Chase Cs-10	Kingwood No. 1 Elliston	21-19S-6E NW SW SE	2442 -1014	2465 23	Granite?	CCGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Kansas						
Chase Cs-11	Backus No.1 "A" Thurston	17-19S-7E SE SE NE	1921 -615	2018 97	Epidotized granite	CCGG
Chase Cs-12	Rex No. 1 Wells	19-19S-7E SW SW NW	1857 -511	1877 20	Granite, gneissic?	CCGG
Chase Cs-13	Stanolind No. 1 Davis	29-19S-7E NE NE SW	1775 -447	1798 23	Sheared granite or granite gneiss	CCGG
Chase Cs-14	Derby No. 1 Poor Farm	34-19S-7E SE SW SW	1705 -507	2501 796	Granite?	CCGG
Chase Cs-15	Leader No. 1 Breese	35-19S-7E SW SE NE	1922 -579	1940 18	Granite, gneissic?	CCGG
Chase Cs-16	Elmhurst No. 1 Allen	24-19S-9E SW NE SW	3385 -2149	3610 225	Banded(?) granite gneiss	CCGG
Chase Cs-17	Prairie No. 1 McLinden	25-20S-5E SE NW NW	3020 -1700	3060 40	Granite(?)	CCGG
Chase Cs-18	Martin No. 1 Winsor	2-20S-6E SW SW NW	2516 -1105	2532 16	Pyroxene-hornblende granite	CCGG
Chase Cs-19	Amerada Lostuller	1-20S-7E NE NE NE	2805 -1380	2825 20	Granite (gneiss?)	CCGG
Chase Cs-20	Wichita Natural (Empire) No. 1 Kaufman	2-20S-7E NE NE NE	less than 1830	3055	Granite (gneiss?)	CCGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Kansas						
Chase Cs-23	Alladin No. 1 Drummond	15-20S-7E SE SE SW	2340 -861	2409 69	Granite (gneiss?)	CCGG
Chase Cs-24	Vickers No. 1 Nicoll	16-20S-7E SW SW NW	1883 -506	1990 107	Granite and altered basic rock	CCGG
Chase Cs-25	Stanolind No. 1 Finley	20-20S-7E SW SW NE	1752 -436	1774 22	Granite gneiss	CCGG
Chase Cs-26	Strickler No. 1 Harshman	29-20S-7E NE NW SE	1905 -477	1935 30	Granite (gneiss?)	CCGG
Marion Mr-11	Adair No. 6 Davis	25-21S-4E CSL SW SW	3085 -1705	3134 49	Granite (gneiss?)	CCGG
Marion Mr-13	Hawn No.5 Jeffers Steel	20-21S-5E NW NE NE	2968 -1620	2975 7	Pyroxene granite	CCGG
Marion Mr-6	Phillips No. 1 Clark	15-22S-4E NE NW SE	3239 -1761	3247 8	Granite (gneiss?)	CCGG
Greenwood Gr-1	Phillips No. 5-6 De Malonie and Sowden	12-22S-10E SW NW NW	3285 -2056	3475 190	Metagraywacke	VCMG
Butler Bt-2-1	Cities Service No. 36 Lathrop	17-23S-4E SE SW NW	3130 -1761	3213 83	Feldspar-quartz-mica schist	VCMG
Butler Bt-5-1	Phillips No. 23 Scully	17-23S-4E SW SE NE	3572 -2179	3585 13	Muscovite-feldspar-quartz hornfels(?)	VCMG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Kansas						
Butler Bt-8	Cities Service No. 1 Church	13-23S-5E NW SW SE	2182 -669	2574 392	Granite (gneiss?)	CCGG
Butler Bt-10	Adair No. 1 Methodist Church	14-23S-5E E/2 NE NE	2234 -721	2286 52	Granite (gneiss)	CCGG
Butler Bt-11	Adair No. 1 "B" White	15-23S-5E NE NE SE	2210 -726	2239 29	Granite	CCGG
Butler Bt-13	Adair No. 1 Lilley	15-23S-5E NE NE SW	2340 -860	2424 84	Granite	CCGG
Butler Bt-14	Adair No. 2 "B" White	15-23S-5E SW SW SE	2325 -847	2341 16	Granite (gneiss?)	CCGG
Butler Bt-15	McCullough and Empire No. 1 Lilley	23-23S-5E SW NW NW	2230 -765	2320 90	Granite	CCGG
Butler Bt-16	Trapp and Smith No. 1 Covey	24-23S-5E NE NE SW	2228 -730	2395 167	Granite	CCGG
Greenwood Gr-7	Cities Service No. 99-5 Teeter	16-23S-9E SW NE SW	3634 -2039	3663 29	Muscovite granite gneiss	CCGG
Greenwood Gr-2	Phillips No. 2 "D" Beal	21-23S-11E S/2 SE	3115 -1946	3177 62	Muscovite granite gneiss	CCGG
Butler Bt-20	Bedell and Catt No. 1 "B" Mellor	12-24S-3E NE NW NW	3465 -2101	3525 60	Granite (gneissic?)	CCGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Kansas						
Butler Bt-21	Raymond No. 2 Classen	18-24S-4E SE NE NW	3526 -2199	3570 44	Biotite schist	VCMG
Butler Bt-23	Ramsey No. 1 Ramsey	8-24S-5E SW SW NE	3315 -1832	3356 41	Granite and schist? Banded gneiss?	COGG VCMG
Greenwood Gr-3	Orlando No. 1 Breitkreutz	4-24S-10E SW NE SW	3484 -2110	4774 1290	Mica schists	VCMG
Sedgwick Sg-1	Continental No. 1 Casey	15-25S-1E SW SW NW	4205 -2752	4224 19	Biotite phyllite	VCMG
Butler Bt-24	White Eagle No. 1 "A" Stone	2-25S-5E NE NW SW	3170 -1832	3182 12	Leucodiorite	VCMG?
Butler Bt-26	Cities Service (Empire) No. 155 Wilson	8-25S-5E SW SE NW	3030 -1631	3067 37	Muscovite granite gneiss	CCGG
Butler Bt-28	Saco No. 11 "A" Draper	27-25S-5E NE SW SW	3357 -2012	3418 61	Basic gneiss	VCMG
Butler Bt-29	Cities Service (Empire) No. 3 Atkins	29-25S-5E C SE NE	less than 3015 655+	3670	Basic gneiss or schist	VCMG
Butler Bt-30-1	Cities Service (Empire) No. 1 Murray	30-25S-5E C NE SE	3273 -1888	3700 427	Sheared granite gneiss? Metarhyolite?	CCGG?

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Kansas						
Butler Bt-31	Cities Service No. 1 "S" Pierport	33-25S-5E NW SW SE	3076 -1691	3096 20	Basic hornfels	VCMG
Woodson Wd-6	Delk No. 2 Newbold	29-25S-16E SW SE SE	2386 -1316	2447? 61	Micrographic granite	WG
Bourbon Bb-1	Perry No. 1 Burney	21-25S-25E C SE	1860? -1100	1995 135?	Metagraywacke	VCMG
Sedgwick Sg-3	Kewanee No. 4 "A" Schramm	34-26S-1E NE SW SW	4188 -2864	4224 36	Granite	COGG
Sedgwick Sg-4	Murfin No. 5 Weiskirch	11-26S-2E SW SE SE	4009 -2657	4011 2	Mica-quartz-feldspar hornfels	VCMG
Sedgwick Sg-5	Bedell and Catt No. 2 "A" Stollei	13-26S-2E SW NE NW	4055 -2661	4082 27	Granite and biotite schist	VCMG
Butler Bt-32	Gross No. 1 Williams-Forgy	11-26S-4E NW SW NW	2807 -1435	2824 17	Granite	COGG
Butler Bt-34	Gulf No. 58 Shumway	11-26S-4E SW SW NE	2618 -1246	2628 10	Granite	COGG
Butler Bt-36	Allison No. 1 Davis	15-26S-4E NW SE SW	3254 -1965	3262 8	Granite	COGG
Butler Bt-37	Murfin No. 6 Gray	15-26S-4E SE NW NE	3072 -1735	3085 13	Granite	COGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Kansas						
Butler Bt-50	Cities Service No. 289 Koogler	20-26S-5E N/2 N/2 NE	3270 -1943	3296 26	Gneissic granite	COGG
Butler Bt-39	Great Southern No. 4 "S" Dickinson	16-26S-8E NW SE NE	3562 -2188	3575 13	Granite gneiss	CCGG
Bourbon Bb-3	Okla. Natural No. 1 Stevenson	16-26S-24E SW SW NE	1805 -872	2403 598	Phyllites and metasiltstones	VCMG
Butler Bt-42	Brunson and Spines No. 1 Winzer	16-27S-4E NE NE NW	3551 -2316	3581 30	Granite	COGG?
Wilson Wl-1	Wentworth and Glare No. 1 McFadden	26-27S-16E NW NW SW	2366 -1351	3351 986	Micrographic granite	WCG
Sedgwick Sg-8	Raymond No. 9 Blood	29-28S-1E SE SW	4437 -3167	4454 17	Granite	CCGG
Neosho Ne-2	Allen Van No. 3 Coombs	30-28S-21E SE SE SW	1980 ?	2004 24	Granite	WCG
Crawford Cw-1	La Salle No. 1 Goble	20-28S-25E SE SE NW	1838 -893	1862 24	Granite	WCG
Butler Bt-47	Hartman and Derby No. 1 Nibel	22-29S-3E SE SE SE	4117 -2838	4135? 18	Granite	CCGG
Butler Bt-49	Rex and Morris No. 1 Mann	6-29S-4E SE SW SE	3157 -1873	3171 14	Granite	CCGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Kansas						
Wilson Wl-3	Fredonia No. 3 Smith	10-29S-15E SE SE NW	2203 -1208	2246 43	Metarhyolite	WCVG
Cowley Co-4	Texaco No. 4 Goodrich	21-31S-4E NW SE SE	4187 -2976	4188 1	Granite porphyry	CCGG
Elk Ek-2	Halstead (Kingwood) No. 1 Osborn	8-31S-11E CSL NW NW	2933 -1902	2987 49	Metarhyolite on granite	WCVG WCG
Elk Ek-3	Kenny and Cox No. 1 Bryant	33-31S-13E NW NE SE	2690 -1690?	2701 11	Metarhyolite	WCVG
Labette Lb-2	Glore No. 1 Wert	17-31S-21E C NE SE	1886 -1030	1893 7	Granite	WCG
Cherokee Ck-1	Ackerd No. 1 Harley	30-31S-22E SE SE NE	1845 940	1852 7	Granite	WCG
Sumner Sm-1	Amerada No. 13 Gassoway	14-32S-2E CSL SE SW	3342 -2160	3530 188	Granite	CCGG
Sumner Sm-3	Lario (Barnsdall) No. 13 "A" Wenrich	23-32S-2E NW SE NW	3459 -2275	3870 411	Granite	CCGG
Montgomery Mt-4	Frankfort No. 1 Carter	23-32S-14E NE NE NW	2475 -1657	2487 12	Metarhyolite	WCVG
Montgomery Mt-5	Stevens and Crissell No. 1 Uitts	18-32S-16E NE NE NE	2312 -1488	2703 391	Metarhyolite	WCVG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Kansas						
Montgomery Mt-8	E. W. Hayes No.10 Atlas Cement	5-33S-16E NW SW NE	1344 -563	1354 10	Metarhyolite	WCVG
Montgomery Mt-9	Illine No. 1 Reece	12-33S-16E NW NW SE	1762? ?	? ?	Metarhyolite	WCVG
Cherokee Ck-2	MacMillan No. 1 Clark	13-33S-21E NE SE SE	1906 -1081?	1927 21	Meta-arkose and rhyolitic meta-arkose	WCVG
Cherokee Ck-3	City of Columbus No. 4 Fee	13-33S-23E C NE NW	1771 -870	1783 12	Micrographic granite porphyry	WCG
Chautauqua Ch-3	Sinclair Prairie No. 9 Brown	26-34S-11E SE SW NW	3085 -2035	3200 115	Metarhyolite	WCVG
Montgomery Mt-14	Emery No. 1 Gillam	4-35S-15E C NE NE	2355 -1605	2405 50	Micrographic granite porphyry	WCG?
Labette Lb-3	Neosho Valley No. 3 Wackerle	1-35S-19E C SE NW	1318 -342	1351 33	Andesitic basalt	WCVG
Cherokee Ck-5	Eagle Picher Kansas Exploration	12-35S-23E NE NE	1944 -1085	? ?	Altered andesite?	WCVG
Cherokee Ck-6	Eagle Picher Webber	12-35S-23E SE SE	1644 -782	? ?	Altered rhyolite porphyry	WCVG
Cherokee Ck-7	Eagle Picher Wilber	14-35S-23E NE NW	1795 -945	? ?	Trachyte or andesite porphyry	WCVG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Kansas						
Cherokee Ck-8	Eagle Picher King Band	11-35S-23E NW SW	1714 -873	? ?	Andesite	WCVG
Missouri						
McDonald Mn-1	Younts et al. No. 1 Chrisco	10-21N-34W SE SW NE	1448 -435	1502 54	Micrographic granite porphyry	SGG
Barry Br-1	Barry Oil and Gas No. 1 Jenkins	23-24N-26W NW NW SE	1704 -639	1932 228	Altered andesite? Altered granite gneiss	WCVG?
Jasper Js-1	City of Carthage No. 6 Fee	3-28N-31W NE NE SW	1810 -855	1854 44	Granite	CCGG
Jasper Js-2	Atlas Powder No. 4 Fee	36-28N-32W NW SW SE	1735 -765	1747 12	Granite	WCG
Barton Bt-2	Barton Co. No. 1 Rodell	1-30N-33W SW SW SW	1685 -787	1810 125	Granite	CCGG
Barton Bt-1	Beamer No. 1 Fee	29-32N-30W C SW SW	1840 -850	1888 48	Granite	CCGG
Polk Pk-1	Springfield and Boliver No. 1 Karlan	25-33N-23W SE SW SW	1750 -610	1833 83	Granite	OGG
Hickory Hk-1	Hickory Oil No. 1 Wilson	2-37N-21W C NE SW	1531 -505	1733 202	Granite	OGG

Code Number	Operator and Farm	Location	Basement Depth -SLD	Total Depth Penetration	Rock Type	Rock Group
Missouri						
Vernon Ve-1	St. Joseph Lead Core hole	6-34N-29W ?	?	?	Biotite granite	CCGG
Vernon Ve-2	Nevada Oil Co. No. 1 Henshaw	31-37N-32W NW SE NE	1065 -202	2018 953	Metasediments	VCMG
Vernon Ve-3	Waymire No. 1 Stubble-field	31-37N-32W NW SE SW	1405 -605	2331 926	Metasediments and syenite	VCMG
Bates Ba-1	Wakefield No. 2 Philbrick	14-38N-31W SE SW SW	1640 -850	1680 40	Granite gneiss	OGG
Bates Ba-2	Rich Hill No. 1 Philbrick	23-38N-31W NW NW	1575 -798	3480 1905	Granite gneiss and chlorite schists	OGG
Pettis Pt-1	City of Sedalia No. 11 Fee	22-45N-21W SW NW	1515? -746?	1520 5?	Muscovite quartz gneiss	OGG
Arkansas						
Madison Md-1	Independent Oil and Gas No. 1 Banks	6-16N-27W NE SE NE	2392 -847	2515 123	Rhyolite porphyry	WCVG
Benton Bn-1	Ozark Production No. 1 Curry	33-18N-33W SW SW	2205 -1015	2236 31	Rhyolite porphyry	WCVG

Table 6. Key to county abbreviations used in text and Plate I.

KANSAS		OKLAHOMA		MISSOURI	
Bb	Bourbon	Cke	Cherokee	Bt	Barton
Bt	Butler	Crg	Craig	Br	Barry
Ch	Chautauqua	Ck	Creek	Ba	Bates
Cs	Chase	Dr	Delaware	Hk	Hickory
Ck	Cherokee	Gf	Garfield	Js	Jasper
Co	Cowley	Hk	Haskell	Mn	McDonald
Cw	Crawford	Ky	Kay	Pt	Pettis
Dk	Dickinson	Lef	LeFlore	Pk	Polk
Dg	Douglas	May	Mayes	Ve	Vernon
Ek	Elk	Ms	Muskogee		
Gr	Greenwood	Nb	Noble		
Jo	Johnson	Nw	Nowata	ARKANSAS	
Lb	Labette	Ok	Oklahoma	Bn	Benton
Ly	Lyon	Om	Okmulgee	Md	Madison
Mr	Marion	Os	Osage		
Mi	Miami	Ot	Ottawa		
Mt	Montgomery	Pw	Pawnee		
Mo	Morris	Py	Payne		
Ne	Neosho	Pt	Pottawatomie		
Os	Osage	Rog	Rogers		
Sg	Sedgwick	Sq	Sequoyah		
Sm	Sumner	Tu	Tulsa		
Wl	Wilson	Wg	Wagoner		
Wd	Woodson	Ws	Washington		

A P P E N D I X

Rock Descriptions

The many pages that follow contain brief petrographic descriptions and an interpretation of the relationship of samples from each well within the rock group to which it belongs. As casual reading, these descriptions are at best dreary, however, they are the basis of all interpretation and are placed here for those few interested geologists and geophysicists who need specific and accurate information.

The minerals listed are given in terms of volume point counted. In thin sections with inadequate material, the minerals are placed in the estimated order of their abundance. In porphyritic rocks groundmass is given first and phenocrysts after with other constituents. There is no completely satisfactory way to treat these in a uniform way since some material, e.g., chlorite pseudomorphs after femic minerals, are not unique to either groundmass or phenocrysts.

The accuracy of the point counts is at best debatable as to their relationship to the rock encountered. The cutting chips are probably quite representative of the general composition in fine-grained rocks. In coarser-grained rock the area of a standard thin section may be unrepresentative of the rock mass. In sampling coarser rock a bias is introduced because chips composed of all or nearly all quartz were rarely picked for thin sectioning. Chips containing

more than one mineral and/or femic minerals were picked in order to determine texture and to identify all or most accessories that are generally clotted around or in femic minerals. Thus the samples are probably quartz-poor and femic-rich in comparison with the original rock mass.

Those thin sections that do not contain sufficient area for point counting make even a qualitative estimation a difficult task.

The descriptions are thus presented with the understanding that there are problems essentially dependent on the unavoidable method of obtaining samples from drill holes and interpreting what is obtained.

Wells in this appendix are arranged first by state and second by county. The counties are alphabetically arranged within each state. The wells are arranged within each county by county code number, i.e., Tu-1, Tu-2, etc.

Oklahoma

Frankfort No. 1 Van Ausdel, 31-28N-20E, Craig County

Crg-1-1, cuttings, 1692-1715 feet

WELDED ANDESITE TUFF..... Feldspathic groundmass, 62.5; andesine, 17.8; feldspar alterations, 12.2; epidote, 3.7; opaque minerals, 2.2; chlorite, 0.8; sphene-leucoxene, 0.8; basaltic hornblende, 0.2; quartz, tr.; apatite, tr.; zircon, tr.; calcite, tr.

Very abundant phenocrysts of andesine and less common basaltic hornblende are set in a groundmass of welded tuff fragments apparently composed of feldspar. Iron oxide granules are particularly numerous, are about 0.04 mm and are also present as dust-like particles. The andesine phenocrysts are generally partly altered with roughly half highly replaced. The plagioclase ranges from sodic to calcic andesine. Phenocrysts of basaltic hornblende contain much iron ore replacement. Plagioclase phenocrysts are both broken and embayed. Several cutting chips are highly altered and silicified. In these chips the andesine is universally altered and contains abundant chlorite, epidote and secondary silica. Some cutting chips have altered zones suggesting erratic mineralization. Grain size: Phenocrysts to 2 mm; groundmass, average microcrystalline. Texture: Eutaxitic-porphyritic.

Crg-1-3, cuttings, 1815-1890 feet

WELDED ANDESITE TUFF..... Groundmass, 66.4; andesine, 13.7; feldspar alterations, 10.1; opaque minerals, 2.9; chlorite, 2.7; epidote, 2.4; basaltic hornblende, 1.1; quartz, tr.; sphene, tr.; apatite, tr.; zircon, tr.; biotite, tr.; calcite, tr.

Very similar to the previous interval. This rock is even more altered than the tuff above. Epidote, chlorite, secondary fibrous biotite, and sphene are common in the groundmass in amygdule-like fillings and replacing phenocrysts. Silica veinlets cut irregularly through the rock leaving an alteration band on either side. Apatite is particularly common as discrete grains. Andesine is highly altered and fresh phenocrysts are rare. Fluxion structure marked around phenocrysts where distorted shards have devitrified. Some fragments in groundmass appear to be volcanic rock debris but devitrification makes identification difficult. Grain size: Phenocrysts to 2.0 mm; groundmass, average microcrystalline. Texture: Porphyritic-eutaxitic.

Crg-1-7, cuttings, 1978-2014 feet

WELDED ANDESITE TUFF..... Groundmass, 62.5; andesine, 22.5; feldspar alterations, 8.1; opaque minerals, 5.9; basaltic hornblende, 4.1; chlorite, 1.8; epidote, tr.; sphene, tr.; apatite, tr.; actinolitic amphibole, tr.

The groundmass in this interval is devitrified feldspar with stained hematite. Fluxion structure is particularly marked around phenocrysts. Andesine is highly altered with some phenocrysts being almost completely a mat of tiny sericite shreds. Phenocrysts of basaltic hornblende contain abundant opaque replacements. Actinolitic amphibole is secondary in a replacement of either chlorite or basaltic hornblende but the lack of opaque minerals suggests replacement of chlorite. Andesine is varied in shape and several fragments are composed of several crystals. Minor silica veins cut the rock. Epidote is common in veins and replacing feldspar. Grain size: Phenocrysts to 1.5 mm; groundmass, average microcrystalline. Texture: Porphyritic-eutaxitic.

First described by Ham (1961), the rock in this well is the most highly flow banded of the andesites and one of the two welded tuffs of this composition. The andesite is an example of the Washington County Volcanic Group.

Wackerle No. 4 Hood, 19-28N-20E, Craig County

Crg-2-1, cuttings, 1493-1517 feet

WELDED ANDESITE TUFF..... Groundmass, plagioclase; opaque minerals; feldspar alterations; chlorite; quartz; calcite; apatite.

This is highly altered welded tuff probably of andesitic composition. Opaque minerals are extremely abundant as a cloud of tiny granules. Only small patches of unaltered plagioclase remain. Some chlorite-opaque minerals pseudomorphs suggest replacement of basaltic hornblende. Groundmass is stained with hematite and has good fluxion structure around the phenocrysts. Very fine chertose quartz is abundant in the groundmass probably secondary introduction. Grain size: Phenocrysts to 1.5 mm; groundmass, average microcrystalline. Texture: Porphyritic-eutaxitic.

Crg-2-2, cuttings, 1517-1530 feet

WELDED ANDESITE TUFF..... Groundmass, plagioclase; feldspar alterations; opaque minerals; chlorite; sphene-leucoxene; calcite; K-feldspar?; quartz; apatite; zircon.

Abundant plagioclase phenocrysts are irregular in shape and altered by clay-sericite. Former femic phenocrysts (basaltic hornblende?) are replaced by chlorite and opaque minerals. Calcite replaces portions of the groundmass and is in small veinlets associated with chlorite. Apatite is particularly common as discrete crystals and associated with iron oxides. Magnetite granules are altered to hematite and sphene-leucoxene. Chertose replacement of groundmass is erratic. Potash (?) feldspar is present in a vein-like mass. Grain size: Phenocrysts, to 1.5 mm; groundmass, average microcrystalline. Texture: Porphyritic-eutaxitic.

Only two miles north of the other welded andesite tuff (Crg-1) this rock is an example of the Washington County Volcanic Group.

Frankfort No. 1 Bluejacket, 4-26N-19E, Craig County

Crg-3-1, cuttings, 2102-2128 feet

RHYOLITE PORPHYRY..... Groundmass, 86.0; perthite, 9.6; plagioclase, 2.2; quartz, 1.2; sphene-leucoxene, 0.4; calcite, 0.4; chlorite, 0.2; opaque minerals, tr.; feldspar alterations, tr.; biotite, tr.; zircon, tr.; epidote, tr.; apatite, tr.

Phenocrysts of perthite, quartz and plagioclase are set in a silicified flow-banded groundmass of irregular texture. Quartz phenocrysts have fuzzed outlines near silicified portions of the groundmass. The groundmass has contorted banding around phenocrysts and may have originally been a welded tuff groundmass. Opaque minerals are in granules and filling small unoriented cracks in groundmass. Grain size: Phenocrysts to 2 mm; groundmass, average microcrystalline. Texture: Porphyritic - banded - eutaxitic?

First described by Ham (1961) as a dacite, it now seems that rhyolite is a more accurate name. The rhyolite belongs to the Washington County Volcanic Group.

3-B Oil Company No. 1 Helmick, 11-26N-21E, Craig County

Crg-4-2, cuttings, 1790-1800 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 69.0; perthite, 15.1; plagioclase, 7.0; chlorite, 3.2; feldspar alterations, 2.6; opaque minerals, 1.2; epidote, 1.2; sphene-leucoxene, 0.5; biotite, 0.3; zircon, tr.; apatite, tr.

Large phenocrysts of highly altered plagioclase are

set in a finely micrographic goundmass of quartz-feldspar. Perthite phenocrysts are less sericitized but contain abundant hematite. The groundmass feldspars are a deep reddish color due to disseminated hematite. Epidote is common in chlorite, veinlets and discrete crystals. Both biotite and very small amounts of green amphibole relicts are present in chlorite. Calcite replaces irregularly through the rock but the favored association is with chlorite. Grain size: Phenocrysts, to 3.5 mm; groundmass, average 0.8 mm. Texture: Micrographic-porphyritic.

Crg-4-4, cuttings, 1920-1930 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 67.2; perthite, 14.5; plagioclase, 11.0; chlorite, 3.3; feldspar alterations, 2.4; sphene-leucoxene, 1.3; opaque minerals, tr.; apatite, tr.; biotite, tr.; epidote, tr.

Large phenocrysts of plagioclase are sericitized and contain less hematite than smaller perthite phenocrysts. Chloritic masses are associated with irregular fibrous sericite masses. The micrographic intergrowth around phenocrysts is very delicate and subradial. Sphene-leucoxene replaces portions of titaniferous iron ore. Biotite is all a pale green fibrous variety. Grain size: Phenocrysts to 4 mm; groundmass, average 1.0 mm. Texture: Micrographic-porphyritic.

Crg-4-6, cuttings, 1933-1934 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 69.4; perthite, 12.3; sericite-clay, 10.0; plagioclase, 4.5; sphene-leucoxene, 2.2; chlorite, 0.9; zircon, tr.; opaque minerals, tr.; apatite, tr.

Sericite replaces phenocrysts extensively and parts of groundmass. The cores of phenocrysts are particularly altered. Chlorite and a secondary pale green biotite are the only femic minerals. Some large discrete flakes of sericite are present in the groundmass. Sphene-leucoxene in skeletal-like pseudomorphs replace former ilmenite. Chlorite replaces portions of the phenocrysts irregularly. Grain size: Phenocrysts to 3 mm; groundmass, average 1.0 mm. Texture: Micrographic-porphyritic.

An example of the Spavinaw Granite Group containing a relatively modest femic mineral content.

Dye-Henry No. 1 Ross, 20-24N-21E, Craig County

Crg-5-1, cuttings, 1715-1764 feet

GRANITE..... Perthite; quartz; opaque minerals; feldspar alterations; sphene-leucoxene; chlorite.

A rather coarse rock with comparatively small cutting chips. Perthite and quartz compose 99% of the cutting chips. Small amounts of fibrous chlorite, sphene-leucoxene, and opaque minerals. The perthite is clouded with finely disseminated hematite and feldspar alterations. Masses of sericite are associated with sphene-leucoxene in one cutting chip. Grain size: 4+ mm. Texture: Hypidiomorphic?

One of the few coarse non-micrographic granites in the Spavinaw Granite Group. The femic mineral content is exceptionally small.

Gulf Oil No. G-26-S North Glenn Unit, 29-18N-12E, Creek County

Ck-1-1, cuttings, 3903-3904 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; plagioclase; perthite; chlorite; opaque minerals; feldspar alterations; pyroxene; tremolite; apatite; biotite; epidote; calcite; sphene-leucoxene; zircon.

A highly altered granite containing abundant accessory minerals. Chlorite with minor secondary biotite and tremolite replace common augite and what appears to have been an amphibole. The groundmass is very delicately spherulitic and micrographic. Phenocrysts appear to be plagioclase and perthite, all are highly sericitized in mats of shreds, plagioclase is more abundant, perthites are wormy due to differential alteration, both are subhedral. Apatite is particularly large and numerous. Numerous rodlike iron ores are in the groundmass. Epidote is associated with chlorite. Grain size: Phenocrysts to 2.5 mm; groundmass, 0.7 mm. Texture: Micrographic-porphyritic.

This rock is very similar to outcrop examples of the Spavinaw Granite Group some sixty-four miles to the northeast.

Cosden No. 17 Barnett, 22-17N-7E, Creek County

Ck-2-1, cuttings, 3664-3668 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; opaque minerals; feldspar alterations; chlorite; biotite; sphene-leucoxene; zircon.

The phenocrysts appear to be perthitic but may be "simple" orthoclase, and contain much disseminated ragged hematite and are extensively clouded. Opaque minerals are exceptionally abundant. Accessory minerals are very sparse. Small chloritic shreds are present in irregular masses and veinlets. Sphene-leucoxene replaces portions of the opaque minerals. Very fine shreds of pale green secondary biotite are present in one cutting chip. Grain size: Phenocrysts, 2+ mm; groundmass, 1 mm average. Texture: Micrographic-porphyritic.

Ck-2-2, cuttings, 3676-3704 feet

MICROGRAPHIC GRANITE PORPHYRY..... Perthite; quartz; plagioclase; opaque minerals; feldspar alterations; chlorite; carbonate; apatite.

Cutting chips are all less than 2 mm in maximum dimension. Perthite is common as phenocrysts and intergrown with quartz. Plagioclase is comparatively rare and surrounded by perthite. Perthite is turbid with abundant hematite dust and minor alterations. Plagioclase is comparatively free of hematite dust but contains areas of mottled alteration material. Quartz-feldspar intergrowths are in general poorly defined and some quartz has a late, replacement, appearance. Chlorite is in aggregates of fine shreds. A carbonate vein cuts one chip. Grain size: Phenocrysts, 2.0+ mm; groundmass, about 1.0 mm average. Texture: Micrographic-porphyritic.

This example of the Spavinaw Granite Group is located immediately on the west flank of the strong negative magnetic anomaly in Creek County.

Gulf No. 1-5 Berryhill, 17-17N-12E, Creek County

Ck-3-1, cuttings, 3920-3929 feet

PYROXENE MICROGRAPHIC MICROGRANITE PORPHYRY..... Micrographic quartz-feldspar, 60.4; feldspar and feldspar alterations, 33.2; chlorite, 3.7; opaque minerals, 1.5; pyroxene, 1.0; calcite, tr.; sphene, tr.; apatite, tr.; zircon, tr.

A very delicately micrographic-spherulitic groundmass contains highly altered perthite and plagioclase phenocrysts. Chlorite is particularly abundant as pseudomorphs. Several crystals of pyroxene, common augite, are fresh or have mottled alterations. Apatite is common. Sphene is as small granules and is associated with chlorite. Sphene-leucoxene replaces titaniferous magnetite. Many phenocrysts of feldspar

are wormy and embayed. Quartz is restricted to micrographic intergrowths. Grain size: Phenocrysts to 3.5 mm; groundmass, 0.4 mm average. Texture: Micrographic-spherulitic-porphyritic.

The presence of primary augite is unusual in the Spavinaw Granite Group and this well was drilled about 10 miles south of another well in which pyroxene-bearing granite was found (Tu-9).

Central Commercial No. 3 Hay, 10-17N-10E, Creek County

Ck-4-1, cuttings, 4205-4237 feet

MICROGRAPHIC GRANITE PORPHYRY..... Perthite, 59.6; quartz, 37.4; plagioclase, 1.6; feldspar alterations, 1.0; chlorite, 0.3; opaque minerals, tr.; epidote, tr.; sericite, tr.; zircon, tr.; apatite, tr.

This is a coarser variety of the Spavinaw granite. Large discrete quartz are present as well as in an intergrowth of quartz-feldspar. Plagioclase found as non-intergrown crystals. Perthite both in intergrowth and discrete. The boundaries between phenocrysts and intergrowth is poorly defined. Sericite flakes are well crystallized but is associated with secondary minerals. Grain size: Phenocrysts to 4.5+ mm; groundmass, 2.7 mm average. Texture: Micrographic-porphyritic.

Ck-4-3, cuttings, 4250-4282 feet

MICROGRAPHIC GRANITE PORPHYRY..... Perthite, 57.0; quartz, 37.9; siderite, 2.1; sericite, 1.4; chlorite, 1.2; opaque minerals, tr.; epidote, tr.; feldspar alterations, tr.; zircon, tr.

This rock is essentially the same as the previous interval. Quartz and perthite phenocrysts have poorly defined boundaries with the surrounding micrographic intergrowth. Coarse sericite is associated with chloritic shreds, opaque minerals and siderite. Siderite is deeply stained in part with iron oxides. Feldspars are clouded with minor opaque mineral granules and alterations. Grain size: Phenocrysts to 4.3+ mm; groundmass, 2.2 mm average. Texture: Micrographic-porphyritic.

This is an example of the femic-poor varieties of the Spavinaw Granite Group. The siderite suggests a very low calcium content which is substantiated by the absence of free plagioclase. An Rb/Sr age on the total rock yielded an age of 1160 ± 50 m.y.

Sellers No. 2 Tarr, 3-16N-7E, Creek County

Ck-6-1, cuttings, 4451-4507 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 56.1 (32.1 perthite, 24.0 quartz); perthite, 34.6; chlorite-biotite, 4.5; plagioclase, 2.0; calcite, 2.0; opaque minerals, 0.6; sphene-leucoxene, tr.; zircon, tr.; apatite, tr.; feldspar alterations, tr.; hornblende, tr.; pyrite, tr.

Exceptionally large phenocrysts of perthite are set in a micrographic groundmass. Smaller plagioclase phenocrysts are rimmed by perthite. This is one of the few rocks of the Spavinaw type that contain a coarse enough intergrowth to be differentiated with a modal analysis. Perthites are clouded with hematite dust and submicroscopic alterations. Chlorite-biotite replaces a deep green hornblende. Calcite and pyrite replace extensively in one cutting chip and calcite is commonly associated with chlorite. Apatite and zircon are associated with chloritic masses. Grain size: Phenocrysts to 6.2 mm; groundmass, 1.5 mm average. Texture: Micrographic-porphyritic.

A normal example of the Spavinaw Granite Group located on the western margin on the large negative magnetic anomaly in Creek County.

Sand Springs Home No. 13 Atkins, 4-18N-7E, Creek County

Ck-7-1, cuttings, 3661 feet

MICROGRAPHIC MICROGRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; quartz; opaque minerals; chlorite; feldspar alterations; sphene-leucoxene; zircon.

Phenocrysts of perthite and small rare rounded quartz are set in a groundmass of perthite and acicular quartz. Chloritic masses are common as unoriented shreds, some associated with sphene-leucoxene. Hematite dust is very common as disseminated specks imparting a reddish color to feldspar. Feldspars are clouded and contain clay masses and finely disseminated alterations. Grain size: Phenocrysts, 1.0+ mm; groundmass, 0.5+ mm average. Texture: Hypidiomorphic acicular-porphyritic.

The texture of this granite together with the lack of plagioclase and presence of small quartz phenocrysts suggests this rock is perhaps more closely related to the Osage Microgranites. Tentatively this rock is placed in the Spavinaw Granite Group on the basis of geographic location.

Riverside No. 2 Yarhola, 8-18N-7E, Creek County

Ck-8-1, cuttings, 3795-3800 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; quartz; chlorite; opaque minerals; feldspar alterations; calcite; sphene-leucoxene; apatite.

Patches in clear feldspar phenocrysts are highly altered by sericite and contain abundant hematite. The clear portions are suggestive of microcline perthite but twinning is absent. Chlorite replaces former femic minerals in groundmass. Accessory minerals are sparse. Small calcite blebs replace feldspars. Quartz is partly in rodlike "acicular" forms. Sphene-leucoxene and hematite are associated with titaniferous magnetite. Grain size: Phenocrysts to 3+ mm; groundmass, 0.5 mm average. Texture: Porphyritic-hypidiomorphic acicular.

Together with Ck-7, less than two miles to the northeast, this well contains a granite very closely related to the Osage Microgranites on the basis of petrography. The granite is tentatively placed in the Spavinaw Granite Group with some reservations.

M and F Oil Co. No. 1 Thompson, 35-19N-21E, Cherokee County

Cke-1-1, cuttings, 1800-1870 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 55; perthite, 14.7; plagioclase, 13.3; chlorite, 8.6; quartz, 2.2; opaque minerals, 1.9; actinolite, 1.9; epidote, 1.6; calcite, 0.5; feldspar alterations, 0.3; apatite, tr.; sphene, tr.

Phenocrysts of feldspar are set in a very delicate, subradial micrographic intergrowth. Chlorite pseudomorphs as well as secondary actinolite replacing a magmatic femic mineral are common. The feldspars are deeply colored with hematite and contain disseminated alterations as well as mottled patches completely replaced. Discrete quartz present as groups of small crystals. Epidote granules replace feldspars. Grain size: Phenocrysts to 3+ mm maximum; groundmass, 1 mm average. Texture: Micrographic-porphyritic.

Cke-1-2, cuttings, 1870-1920 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar 40.0; plagioclase, 31.2; perthite, 16.2; chlorite, 9.7; opaque minerals, 2.1; epidote, 1.6; feldspar alterations,

0.5; zircon, tr.; apatite, tr.; sphene-leucoxene, tr.; calcite, tr.

This is essentially similar to the previous interval. Actinolite is lacking at this interval--all the femic mineral is converted to chlorite. Phenocrysts of perthite and plagioclase are set in a very delicate micrographic groundmass. Feldspars contain abundant disseminated hematite and feldspar alterations. Epidote replaces portions of feldspar and is found in thin veinlets. Sphene-leucoxene is associated with chlorite and as a thin rim around titaniferous magnetite. Grain size: Phenocrysts, 4+ mm maximum; groundmass, 1 mm average. Texture: Micrographic-porphyritic.

Cke-1-3, cuttings, 1930-1935 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 44.8; plagioclase, 23.0; epidote, 12.0; perthite, 10.3; chlorite, 5.6; sphene-leucoxene, 1.9; calcite, 1.6; opaque minerals, 1.2; feldspar alterations, tr.; apatite, tr.

This interval is extensively epidotized in veins and crystalline masses. One cutting chip is dioritic in composition containing plagioclase and abundant chlorite--no quartz. Calcite is in veins and masses associated with chlorite and epidote. Quartz is in micrographic intergrowths and in coarser discrete anhedral intergranular groups. Larger phenocrysts are composite plagioclase and may contain several orientation of opitic units in subparallel orientation. Grain size: Phenocrysts, 3.7+ mm maximum; groundmass, 1 mm average. Texture: Micrographic-porphyritic.

An example of the Spavinaw Granite Group resembling the outcrop very closely.

Begeman No. 1 Begeman Ranch, 20-19N-23E, Cherokee County

Cke-2-1, cuttings, 1399-1400 feet

MICROGRAPHIC MICROGRANITE PORPHYRY..... Micrographic quartz-feldspar; plagioclase; perthite; chlorite; carbonate; feldspar alterations; sphene-leucoxene; opaque minerals; apatite; epidote.

Phenocrysts of plagioclase and perthite are set in a very delicate micrographic intergrowth of quartz-feldspar. Oligoclase phenocrysts are generally euhedral, some with a thin perthite rim. The perthite phenocrysts tend to be rounded and somewhat embayed. The feldspars are turbid with alterations and hematite dust. Small epidote granules are noted in feldspars. The former femic mineral is altered

completely to chlorite containing apatite needles. Apatite in fine needles is abundant. Small amounts of carbonate have replaced along veinlets and small irregular blebs, and is concentrated near chlorite. Grain size: Phenocryst to 2+ mm; groundmass, average 0.5 mm. Texture: Micrographic-porphyritic.

This is a delicately micrographic granite belonging to the Spavinaw Granite Group.

W. H. Pine No. 1 Lemon, 33-16N-21W, Cherokee County

Cke-3-1, cuttings, 2083-2093 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; plagioclase; feldspar alterations; secondary micas; opaque minerals; apatite; sphene-leucoxene.

Perthite phenocrysts with some zoning near the cores are extensively altered and clouded with hematite dust. Quartz is not abundant and is in part in spicular rods. Secondary micas replace former femic mineral. One cutting chip has what appears to be syenitic portions (dikelets?). Groundmass has local coarsenings but is generally delicate radial micrographic intergrowth. Apatite is unusually large. Sphene-leucoxene is associated in part with secondary replacement micas. Opaque minerals are found as ragged granules and discrete large crystals. Grain size: Phenocrysts, greater than 2.3 mm; groundmass, 0.5 mm. Texture: Micrographic-porphyritic.

The occurrence of syenitic portions is unusual in the Spavinaw Granite Group but the rock is otherwise normal.

Commercial Oil Gardner, 17-23N-25E, Delaware County

Dr-1-2, cuttings, 1022-1023 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 74.8; perthite, 11.3; feldspar alterations, 8.1; plagioclase, 4.7; sphene-leucoxene, 0.6; chlorite-biotite, 0.3; opaque minerals, tr.; epidote?, tr.; apatite, tr.; zircon, tr.; pyrite, tr.

Phenocrysts of perthite and plagioclase are set in a micrographic groundmass. Feldspar phenocrysts are mottled with advanced alterations, some are semi-opaque. Feldspar phenocrysts are numerous and are two different sizes. Secondary biotite-chlorite are sparse as are all other accessory minerals. Phenocrysts have altered cores and included rims. Some parts of groundmass approach hypidiomorphic. Grain size:

Phenocrysts to 2.5 mm; groundmass, 0.8 mm average. Texture: Micrographic-porphyritic.

This well contained rock of the Spavinaw Granite Group and is the most easterly encounter of the group in Oklahoma.

M and F Oil Co. No. 1 Ransom, 18-20N-22E, Delaware County

Dr-2-1, cuttings, 2205 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 75.4; plagioclase, 15.2; perthite, 3.2; chlorite, 1.7; feldspar alterations, 1.6; sphene-leucoxene, 1.4; carbonate, 1.0; opaque minerals, tr.; apatite, tr.

Phenocrysts of perthite and plagioclase are set in a fine micrographic groundmass. Chlorite pseudomorphs replace a former femic mineral. Sphene-leucoxene with a hematite stain replaces a former ilmenite-magnetite in skeletal and rounded large crystals. Hematite dust is finely disseminated throughout the groundmass. Phenocrysts of feldspar have fine sericite flakes and other alterations but the extreme alteration typical of this group is not noted. Carbonate masses appear to be both calcite and dolomite. Grain size: Phenocrysts greater than 2.5 mm; groundmass, 0.3 mm average. Texture: Micrographic-porphyritic.

This rock belonging to the Spavinaw Granite Group is located some twelve miles south of the outcrop.

Sinclair No. 19 Hartley, 18-22N-3W, Garfield County

Gf-1-1, cuttings, 5542-5561 feet

GRANITE..... Plagioclase; microcline; quartz; feldspar alterations; epidote; chlorite; opaque minerals; calcite; sphene; biotite; apatite.

An extremely coarse rock and small cutting chips make textural-modal determinations impossible. Large plagioclase crystals are highly altered near the cores. Sericite mats and epidote replace plagioclase extensively. Microcline, perthitic in part, is much fresher than the plagioclase (oligoclase). There is erratic but very heavy iron stain. A vein of calcite and iron stained sphene (?) crystals is present. Grain size: 4+ mm maximum. Texture: Hypidiomorphic?

Sinclair No. 19 Hartley, 18-22N-3W, Garfield County

Gf-1-5, cuttings, 5940-5951 feet

GRANITE..... Plagioclase; microcline; quartz; chlorite; biotite; feldspar alterations; opaque minerals; apatite; sphene; epidote (?).

Fresh microcline and more altered plagioclase are present in small cutting chips, largely composed of only one mineral. Biotite is associated with minor alteration chlorite. Complete pseudomorphs of chlorite after biotite contain small sphene granules. Apatite needles are common as inclusions in feldspars. Microcline is perthitic in part, with the plagioclase portion more clouded with alterations and hematite. Grain size: 3+ mm maximum. Texture: Hypidiomorphic.

This well penetrated 493 feet of two feldspar granite of the Central Oklahoma Granite Group. The samples are poor but the distinctive microcline and texture are definite indications of the group.

Pan American No. 1 Williams Unit, 36-8N-22E, Haskell County

Hk-1-2, cuttings, 9800 feet cir.

METARHYOLITE PORPHYRY..... Groundmass, 64.6; quartz, 12.2; perthite, 11.2; plagioclase (An_{11}), 7.9; epidote, 3.1; chlorite, 0.4; opaque minerals, 0.3; apatite, tr.; feldspar alterations, tr.; sphene-leucoxene, tr.

Texture of the groundmass is erratic and shows definite signs of reconstitution. Certain zones are superior in grain size and epidote granules have grown in portions of the groundmass. Abundant phenocrysts are typically volcanic. Perthite appears to be converted to microcline. Feldspars are generally fresh except for minor alterations and some introduction of epidote. The groundmass reconstitution is accompanied by a clearing of hematite dust from the groundmass. The iron is probably going into epidote. Grain size: Phenocrysts, 2.25 mm; groundmass, microcrystalline to 0.3 mm variable. Texture: Porphyritic-crystalloblastic.

A rhyolite of the Washington County Volcanic Group, this well is located only about three miles from the Pan American No. 1 Tackett Unit that penetrated coarse grained granite. The signs of reconstitution in the groundmass and conversion of K-feldspar phenocrysts to microcline in the rhyolite is believed related to the intrusion of this younger granite.

Anderson Prichard No. 28 Welch, 17-28N-1E, Kay County

Ky-1-1, core, 4406-4407.5 feet

GRANITE..... Plagioclase, 47.2; quartz, 22.5; microcline perthite, 20.2; epidote, 5.2; chlorite, 3.7; biotite, 1; sphene-leucoxene, 0.7; calcite, 0.5; apatite, tr.; zircon, tr.; opaque minerals, tr.

Plagioclase contains abundant alterations of sericite and near the cores of larger crystals sericite and epidote almost completely replace feldspar. Microcline is less altered but is slightly turbid with iron ore dust and alterations. Perfect wedges of sphene are replaced by sphene-leucoxene. Chlorite replaces partially or along margins of biotite crystals. Another variety of chlorite, nearly colorless, replaces small rounded masses of unknown origin. Primary biotite is reddish to yellow brown. Grain size: 8+ mm. Texture: Hypidiomorphic.

This thin section was cut from a small core chip and may not be representative of the rock mass from which it came. The high plagioclase content and low magnetic susceptibility is certainly not found in other samples from the Central Oklahoma Granite Group. Rb/Sr methods yielded date of 1220 ± 90 m.y. on the feldspar and 1210 ± 120 m.y. on total rock sample.

Continental No. 1 George H. Brett "A," 8-25N-2E, Kay County

Ky-2-1, cuttings, 5315-5345 feet

GRANITE..... Microcline perthite; plagioclase; quartz; biotite; hornblende; feldspar alterations; calcite; epidote; chlorite; sphene; apatite; opaque minerals; zircon.

Large perthitic microcline contains poikilitically enclosed plagioclase, quartz, opaque minerals and femic minerals in scattered crystals. Plagioclase is faintly zoned near the margins and contains mottled alterations and calcite replacement. Hornblende and associated epidote are well crystallized and occur with biotite and minor chloritic alterations. Biotite is reddish olive brown to olive green. Sphene is present in discrete crystals and as granular veins around titaniferous magnetite. Grain size: 5+ mm. Texture: Hypidiomorphic.

This is an example of the Central Oklahoma Granite Group drilled along the Nemaha Ridge.

Marland No. 1 Joynson, 18-28N-3E, Kay County

Ky-3-1, cuttings, 4790-4818 feet

METARHYOLITE PORPHYRY..... Groundmass, 79.0; microcline perthite, 18.5; quartz, 2.1; opaque minerals, 0.4; feldspar alterations, tr.; chlorite, tr.; apatite, tr.; epidote, tr.; biotite, tr.

This is a metarhyolite porphyry in which former perthitic feldspar phenocrysts have been converted to microcline perthite. Areas of recrystallization vary. Perthites are present as faint relicts in the coarser reconstituted part. Relict spherulites also present along with apparent flow bands. Thin quartz veins present as well as linear coarsenings. Quartz phenocrysts are euhedral. Small epidote crystals are in microcline. Chlorite and biotite (both secondary) are disseminated in groundmass. Groundmass and feldspars are surprisingly clear of disseminated hematite. Grain size: 2+ mm maximum; microcrystalline average. Texture: Granoblastic-relict perlitic-spherulitic and porphyritic.

The rhyolite is considered the metamorphosed phase of the Washington County Volcanic Group. The rock is a curious mixture of well defined relict textures with strong reconstitution overprinted on the groundmass. The clearing of hematite from the groundmass is a sure sign of later thermal activity. The well is located about eleven miles due east of the granite in Ky-1 and this granite is interpreted as the agent for the metamorphism.

Pan American No. 1 Tackett, 28-8N-23E, LeFlore County

Lef-1-1, core, 9270 feet

HORNBLENDE GRANITE..... Microcline perthite, 35.7; quartz, 27.9; plagioclase, 19.5; hornblende, 6.5; plagioclase alterations, 3.0; biotite, 2.2; chlorite, 2.2; opaque minerals, 1.6; sphene, 1.0; apatite, 0.2; epidote, 0.1; calcite, 0.1; zircon, tr.

Fresh microcline perthite is in contrast to plagioclase containing abundant unoriented sericite flakes. Fresher plagioclase areas, near An_{20}, are associated with the altered material. Plagioclase content increases markedly around clots of accessory minerals, hornblende, biotite, sphene, and opaque minerals. Sphene is unusually abundant and coarse. Biotite is red-brown in color and altered to chlorite near the margins. Grain size: to 7 mm. Texture: Hypidiomorphic.

This is a two feldspar granite with features associating it with the Central Oklahoma Granite Group. An Rb/Sr

determination yielded a date on feldspar of 1200 ± 115 m.y. This granite is interpreted as the agent for the alteration-metamorphism of the rhyolite in Hk-1 about three miles to the west southwest.

Spavinaw outcrop, 15-22N-21W, Mayes County

Surface

GRANITE..... Perthite, 55.0; quartz, 42.1; chlorite, 1.2; opaque minerals, 1.1; sphene-leucoxene, 0.4; epidote, 0.2; feldspar alterations, tr.; zircon, tr.; apatite, tr.

Perthite is clouded with minor alterations and hematite dust. Quartz is subrounded in shape and unstrained. Free plagioclase was not identified though some may be present in the finer intergranular, "late," material. Chlorite is in an intergranular position as a mildly pleochroic variety. Small ragged epidote granules are found both intergranular and within the feldspars. The rock has a higher quartz content and a lower plagioclase content than most outcrop samples of this granite. Grain size: 1.5 mm. Texture: Hypidiomorphic granular.

This sample from the outcrop is decidedly atypical of the rock mass. The sample was loaned by the University of Oklahoma as the sample chemically analyzed (Merritt, 1960). It does not seem possible that this is the sample analyzed on the basis of petrography. A feldspar age of 1280 m.y. by the Rb/Sr method was obtained on this sample.

Outcrop Spavinaw, 15-22N-21E, Mayes County

May-O-1, outcrop

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 48.1; plagioclase, 24.9; perthite, 13.9; amphibole, 3.1; feldspar alterations, 3.0; quartz, 2.3; opaque minerals, 1.8; chlorite, 1.7; epidote, 1.6; calcite, 0.2; apatite, tr.; zircon, tr.; sphene-leucoxene, tr.

Numerous phenocrysts of plagioclase and perthite are set in a variably micrographic groundmass. Some plagioclase contains a thin perthite rim and is variably altered, mostly to fine sericite but claylike minerals are locally present. All former femic minerals are either chloritized or converted to tremolite-actinolite with attendant carbonate. There are inclusions of chloritized femic minerals enclosed in feldspar phenocrysts. An area of plagioclase and chlorite-amphibole has the appearance of a diorite inclusion. Epidote is both

as small clouded inclusions in feldspar and larger better crystallized intergranular material. Accessory minerals are typically clotted in aggregates of chlorite, amphibole, and opaque minerals concentrated with apatite and zircon. Quartz is largely in micrographic intergrowths but some occurs as coarse intergranular material not obviously associated with any intergrowths. Grain size: to 9 mm, average 1.5 mm. Texture: Micrographic-porphyritic.

This sample closely conforms to Merritt's (1960) description of the Spavinaw Granite and is considered representative of the rock mass. It is also representative of a large number of subsurface samples.

Milligan No. 1 Lee, 17-23-19E, Mayes County

May-1-1, cuttings, 1897-1928 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 57.0; plagioclase, 19.2; perthite, 11.0; chlorite, 5.9; feldspar alterations, 4.7; sphene-leucoxene, 1.0; apatite, tr.; zircon, tr.; opaque minerals, tr.; epidote, tr.; fluorite, tr.

Phenocrysts of perthite and plagioclase are set in a coarser than average micrographic groundmass of quartz-perthite. Alteration of phenocrysts is marked. Perthite phenocrysts are generally fresher than plagioclase and grade into quartz intergrowths at the margin without optical break. Chlorite and a pale, more birefringent mica replace the former femic mineral. Hematite is found as dustlike inclusions disseminated in the feldspars. Sphene-leucoxene replaces the former titaniferous iron oxide. Grain size: Phenocrysts, 3.5 mm; groundmass, 1.0 mm average. Texture: Porphyritic-micrographic.

This is an example of the Spavinaw Granite Group that is very similar to the outcrop about fifteen miles to the southeast.

Davis and Miller No. 1 Knight, 34-23N-21E, Mayes County

May-3-1, cuttings, 1622 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 50.1; plagioclase, 23.2; perthite, 9.8; feldspar alterations, 5.9; chlorite, 5.3; actinolite, 2.3; epidote, 2.3; opaque minerals, 1.0; sphene-leucoxene, tr.; apatite, tr.; carbonate, tr.; zircon, tr.

Sodic oligoclase and perthite phenocrysts are set

in a micrographic groundmass of quartz-perthite. These feldspars are clouded with disseminated and patch alterations and hematite dust and contain discrete epidote crystals and crystalline masses. Chlorite pseudomorphs with associated tremolite replace a former femic mineral. Thin sphene rims larger titaniferous magnetite crystals. Zircon is generally associated with opaque minerals, apatite with chlorite. The cores of some feldspar phenocrysts are completely altered to a mass of finely divided micas and clay. Grain size: Phenocrysts, 2.5+ mm; groundmass, 1.7 mm average. Texture: Micrographic-porphyritic.

This well penetrated rock of the Spavinaw Granite Group only about four miles north of the outcrop.

Bander No. 1 Brixie, 15-23N-20E, Mayes County

May-6-1, cuttings, 1672-1675 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; plagioclase; perthite; epidote, opaque minerals; chlorite; feldspar alterations; apatite; sericite; sphene.

Very small cutting chips make accurate textural interpretation difficult. Very delicate micrographic intergrowth of quartz and perthite compose the groundmass. Plagioclase phenocrysts are somewhat fresher than the groundmass feldspar containing much less disseminated hematite. Epidote as granular masses and discrete crystals is very abundant. Chloritic masses, and some associated sericite, replace a former femic mineral. Grain size: Phenocrysts, 1.8+ mm; groundmass, 1.5 mm average. Texture: Micrographic-porphyritic.

This well penetrated rock of the Spavinaw Granite Group.

USSRAM Expl. Co. No. 1 Marshall, 23-13N-19E, Muskogee County

Ms-1-1, cuttings, 3294 cir. feet

ALTERED RHYOLITE PORPHYRY..... Groundmass, 91.6; perthite, 5.2; plagioclase, 3.2; quartz, tr.; opaque minerals, tr.; sphene-leucoxene, tr.; calcite, tr.; feldspar alteration, tr.; zircon, tr.; apatite, tr.

Phenocrysts of plagioclase are sparse and subhedral. Rare quartz phenocrysts are highly embayed and ragged and have a wide rim of groundmass quartz in optical orientation. Groundmass is a mosaic of quartz and feldspar in a xenomorphic intergrowth. Areas of groundmass feldspar are optically

oriented. Chlorite is disseminated through the groundmass in small bundles of shreds. Sphene-leucoxene replaces larger titaniferous opaque crystals. Phenocrysts are turbid, groundmass feldspar much clearer, suggesting possible granoblastic reconstitution. Grain size: Phenocrysts, 2.3+ mm; microcrystalline groundmass, average. Texture: Porphyritic-granoblastic.

This rhyolite was drilled within a few miles of the inferred contact with the Spavinaw Granite Group which may account for its somewhat altered appearance. Like other examples of the Washington County Volcanic Group south of the Spavinaw granites, extrusive features are lacking.

W. H. Pine No. 1 Klein, 32-15N-18E, Muskogee County

Ms-4-1, cuttings, 3481-3490 feet

MICROGRAPHIC MICROGRANITE PORPHYRY..... Micrographic quartz-feldspar; plagioclase; opaque minerals; chlorite; feldspar alterations; epidote; sphene-leucoxene; apatite.

A fine-grained porphyry placed as a granite with the reservation that it could be a coarser rhyolite. The cutting chips are very small, all less than 1.5 mm in length and most less than 1 mm. Heavy iron stain of most of the groundmass obscures what small textural relations are available. Plagioclase phenocrysts are extensively sericitized and contain small epidote granules. Micrographic intergrowth is exceptionally delicate. Chloritic masses are associated in part with apatite. Grain size: Phenocrysts, 1+ mm; groundmass, 0.3 mm average. Texture: Micrographic-porphyritic.

The finer grained Spavinaw Granites can look very similar to coarser, possibly intrusive, rhyolites. On the basis of texture and geographic location the rock is tentatively placed in the Spavinaw Granite Group.

Shell Oil No. 1 Magney, 17-20N-2W, Noble County

Nb-1-1, cuttings, 7065 feet cir.

GRANITE..... Microcline perthite, 38.2; quartz, 34.4; plagioclase, 23.6; chlorite, 2.1; opaque minerals, tr.; sericite, tr.; fluorite, tr.; sphene-leucoxene, tr.; calcite, tr.; biotite, tr.; apatite, tr.

Plagioclase contains discrete large flakes of sericite as well as mats of fine shreds. Microcline perthite is clouded with very fine alterations and finely disseminated

hematite dust. Chlorite replaces biotite in large pseudomorphs but another variety replaces small round masses in unoriented mats. Fluorite is associated with accessory mineral clots and replaces portions of feldspars. Small biotite flakes are included with quartz and are unaltered. Grain size: To 3.5 mm. Texture: Hypidiomorphic granular.

This rock is an example of the Central Oklahoma Granite Group drilled along the general axis of the Nemaha Uplift.

Stanolind No. 1 Shoop, 27-22N-2W, Noble County

Nb-2-1, cuttings, 6435-6439 feet

Very fine cutting chips are silty shale and chert--no recognizable basement rock; no recognizable feldspar.

This well reported basement rock but careful examination revealed no trace of crystalline rocks.

Delaware Consolidated WS-1 Pilot Flood Tract, 20-27N-15E, Nowata County

Nw-1-2, cuttings, 2488-2509 feet

RHYOLITE PORPHYRY..... Groundmass, 88.6; feldspar alterations, 4.5; plagioclase, 4.1; quartz, 1.3; perthite, 1.3; opaque minerals, tr.; apatite, tr.; zircon, tr.; sphene-leucoxene, tr.

Phenocrysts of sodic oligoclase, perthite and quartz are in a groundmass of reconstituted quartz-feldspar. The groundmass quartz is optically continuous areas-patch polarization, about 0.3 mm in diameter. Ragged opaque minerals and sphene-leucoxene are extremely abundant small crystals in groundmass. Some of the feldspars have been completely replaced by a clay-mica mat of alterations. Small sparse white mica flakes occur in groundmass. Quartz phenocrysts are rounded with "frayed" margins grading into groundmass quartz, the largest quartz phenocryst is cracked with groundmass filling the fracture. Chlorite is conspicuous by its absence. Grain size: Phenocrysts to 2.5 mm; groundmass, 0.015 mm average. Texture: Granoblastic-porphyritic.

This well, the only one for which samples were obtained in Nowata County, penetrated rock of the Washington County Volcanic Group.

Cities Service No. 5 Farley, 19-11N-2W, Oklahoma County

Ok-1-1, cuttings, 8300-8310 feet

SHEARED GRANITE..... Microcline perthite; plagioclase; quartz; opaque minerals; biotite; chlorite; feldspar alterations; calcite; sphene-leucoxene; apatite.

Several cutting chips are strongly lineated and mylonitized. Quartz shows shear-recrystallization of large crystals into smaller linear groups. Microcline and microcline perthite are fresh with only very minor clouding and hematite dust. Plagioclase (albite) is more altered to sericite and contains more abundant hematite dust. Some plagioclase cores are highly sericitized while the margins are much fresher. Olive green biotite has altered to chlorite with attendant sphene-leucoxene. Small calcite veins and blebs replace feldspars. Myrmekitic intergrowth is present around some large feldspars. Grain size: 4 mm maximum. Texture: Cataclastic, relict hypidiomorphic.

Ok-1-2, cuttings, 8275-8285 feet

SHEARED GRANITE..... Microcline; plagioclase; quartz; feldspar alterations; chlorite; biotite; opaque minerals; calcite; apatite; zircon.

Quartz shows extensive shear-reconstitution. Cataclastic linears curve around relict eyes of the parent granite. Large microcline crystals contain poikilitically enclosed feldspars partly replaced by calcite. Biotite with minor chlorite is in small shreds associated with linears. Several unsheared feldspars are strongly altered and contain hematite. Grain size: Relicts 4.5+ mm. Texture: Cataclastic.

Ok-1-3, cuttings, 8320-8335 feet

DIABASE..... Plagioclase; hornblende; opaque minerals, calcite; biotite; feldspar alterations; chlorite; apatite.

Hornblende replaces the former femic mineral, probably pyroxene. It occurs in large crystals as well as in masses of small crystals. The plagioclase is extensively altered to clay-zeolites. Deep red-brown biotite is present in small crystals associated with amphibole. Chlorite and secondary biotite replace hornblende. Calcite is associated irregularly with hornblende. Grain size: 2 mm. Texture: Hypidiomorphic.

Ok-1-4, cuttings, 8344 feet cir.

GRANITE AND DIABASE..... Microcline perthite; plagioclase; quartz; feldspar alterations; biotite; chlorite; opaque minerals; actinolite; calcite; sphene-leucoxene; zircon; apatite.

This is very similar to previous intervals. The diabase is porphyritic and shows some preferred orientation probably by flowage. The hornblende has a decided uralitic appearance. Plagioclase is highly altered and contains much hematite dust. Granite is less sheared and may be porphyritic. Large microcline crystals contain poikilitically enclosed plagioclase. Quartz is strained and in some cases sheared and reconstituted. Grain size: 5+ mm. Texture: Hypidiomorphic-cataclastic.

These samples are from the only well in the Oklahoma City field to penetrate basement rock. The feldspar in the granite was dated by Rb/Sr methods at 1150 m.y. The well is unusual for two reasons; the extensive shearing in the granite and the diabase intruding the granite. Diabase, so common in southern Oklahoma, was penetrated in only this well in northeast Oklahoma. It is possible that this rock was actually intruded at 1350 m.y. relating it to the Eastern Arbuckle Province and later metamorphosed with accompanying shear at 1150-1200 m.y., the age of the Central Oklahoma Granite Group. In any case the rock is closely related to this latter group and is tentatively placed in it.

Hamon and Cox No. 19 E. Reynolds, 26-12N-13E, Okmulgee County

Om-1-1, cuttings, 4345-4359 feet

MICROGRAPHIC MICROGRANITE PORPHYRY..... Micrographic quartz-feldspar, 69.0; plagioclase, 16; perthite, 5.5; chlorite, 4.0; epidote, 2.4; calcite, 1.5; opaque minerals, 1.0; sphene-leucoxene, 0.5; feldspar alterations, tr.; zircon, tr.; apatite, tr.

The rock contains abundant secondary minerals. Phenocrysts of plagioclase and perthite are set in an exceptionally fine-grained groundmass of micrographic-spherulitic quartz-feldspar rich in iron stain. Epidote replaces portions of the phenocrysts in discrete crystals and crystal aggregates. Chlorite, a pennine type, contains granular sphene-leucoxene and is a coarsely crystalline secondary alteration after a primary femic mineral. Calcite replaces portions of the groundmass and is associated with chlorite in part. Grain size: Phenocrysts, 1.5 mm; groundmass, 0.2 mm average. Texture: Micrographic-porphyritic.

The mineralogy and texture of this rock suggests it

is related to the outcrop samples of the Spavinaw Granite Group.

Midcontinent No. 9 Daniels, 12-13N-13E, Okmulgee County

Om-2-1, cuttings, 3560-3570 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; opaque minerals; feldspar alterations; quartz; chlorite; sphene-leucoxene; biotite; calcite; apatite; zircon.

Highly altered feldspar phenocrysts contain abundant hematite stain and sericite masses, particularly near the core. Most quartz is in a very delicate micrographic intergrowth, but discrete crystals are present. Chlorite, with smaller amounts of associated biotite, replaces the former femic mineral. Opaque mineral veinlets replace extensively in some cutting chips. Apatite, zircon, and chlorite are in close association with large iron oxide crystals. Small magnetite rods are common in the micropegmatite. Grain size: Phenocrysts, 1.5+ mm maximum; groundmass, 0.6 mm average. Texture: Micrographic-porphyritic.

Om-2-2, cuttings, 3580-3593 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; quartz; plagioclase; micrographic quartz-feldspar; actinolitic amphibole; opaque minerals; chlorite; epidote; biotite; sphene-leucoxene; pyrite; sphene, apatite; zircon.

This is an exceptionally interesting rock. There is abundant secondary (?) actinolitic amphibole, pale green, mildly pleochroic and in part aggregates of smaller crystals suggesting reconstitution of common hornblende or pyroxene. Associated with these reconstituted masses are chlorite, sphene and rarely a deep red-brown biotite. Apatite is exceptionally large and common. The micrographic intergrowth is usually delicate. Feldspars are altered to sericite and contain a myriad of iron-poor epidote granules. Small magnetite rods are common as inclusions within micropegmatite. An unidentified deep red-brown mineral is found as tabular blebs possibly along cleavage cracks in trace amounts. Large quartz grains are faintly strained. Sodic oligoclase is zoned in a mottled way and erratically altered. Grain size: Phenocrysts, 1.5 mm; groundmass, 0.6 average. Texture: Micrographic-porphyritic.

This is an example of the Spavinaw Granite Group

and is close to the inferred southern margin of the group.

Texaco Fee NCT No. 2 Well No. 19, 11-14N-11E, Okmulgee County

Om-3-1, cuttings, 3860 feet cir.

RHYOLITE PORPHYRY..... Groundmass, 81.1; perthite, 12.6; plagioclase, 3.5; chlorite, 0.6; sphene-leucoxene, 0.3; opaque minerals, tr.; feldspar alterations, tr.; epidote, tr.; zircon, tr.; apatite, tr.

Perthite phenocrysts are more altered in plagioclase portions. Quartz is restricted to groundmass. Hematite is exceptionally abundant as a stain on feldspars. Masses of fine grained chlorite are associated with sphene-leucoxene, magnetite, apatite, and zircon, and former femic phenocrysts. Chlorite is also disseminated through groundmass. Epidote crystals are associated with chlorite and replace some feldspars. Zircon and apatite are surprisingly abundant. Grain size: Phenocrysts, 2.2 mm; groundmass, microcrystalline. Texture: Porphyritic-felsophyric.

This rhyolite of the Washington County Volcanic Group is found as a "salient" north of some Spavinaw Granites and may have a tectonic explanation as to its preservation in this location.

Schermerhorn No. 1 Tiger, 24-16N-12E, Okmulgee County

Om-5-1, cuttings, 2628-2642 feet

PYROXENE MICROGRAPHIC MICROGRANITE PORPHYRY..... Micrographic quartz-feldspar, 66.8; feldspar alterations, 11.8; plagioclase, 10.6; perthite, 3.2; augite, 3.2; chlorite, 3.0; opaque minerals, 1.6; sphene-leucoxene, tr.; tremolite-actinolite, tr.; epidote, tr.; apatite, tr.; carbonate, tr.

Phenocrysts of perthite and plagioclase are set in an exceptionally delicate micrographic quartz-feldspar intergrowth. The intergrowth is not well defined and uniform but a near spherulitic type. The feldspars of the groundmass are turbid with hematite dust. Phenocrysts are extensively sericitized and altered. Pyroxene crystals, probably common augite, are found as discrete crystals, smaller inclusions within the feldspars and locally are partially or totally replaced by chlorite and tremolite-actinolite near margins. Sphene-leucoxene is in small granular masses with chlorite and as pseudomorphs after a titaniferous iron oxide. Two cutting chips have lighter colored syenite cutting (?) the granite. The syenite is variable in grain size, apparently

similar to the granite except for a very minor amount of quartz, since it bears the same pyroxene and the feldspars have the identical ragged, turbid appearance except for a lesser amount of disseminated hematite. Grain size: Phenocrysts, 3.0 mm; groundmass, 0.3 mm average. Texture: Porphyritic-micrographic.

This is one of the few examples of the Spavinaw Granite Group containing primary pyroxene. It is located about eight miles southeast of another pyroxene granite (Ck-3).

Sunray S-3 Osage, 34-22N-10E, Osage County

Os-1-1, cuttings, 3215-3230 feet

RHYOLITE PORPHYRY..... Groundmass, 82.5; perthite, 12.2; plagioclase, 3.1; chlorite, 0.8; sphene-leucoxene, 0.5; pyrite, 0.5; quartz, tr.; opaque minerals, tr.; feldspar alterations, tr.; zircon, tr.; apatite, tr.

Large perthite and plagioclase phenocrysts are rounded and irregular in shape and contain mottled alteration and finely disseminated hematite dust. The groundmass contains acicular quartz with feldspar. Numerous iron oxide granules and dust are in groundmass. Sphene-leucoxene replaces portions of titaniferous magnetite. Chlorite is associated with a brownish micaceous mineral, possibly an iron stained clay. Grain size: Phenocryst, 3.5+ mm; groundmass, irregularly microcrystalline. Texture: Porphyritic & acicular-felted.

Os-1-2, cuttings, 3230-3235 feet

RHYOLITE PORPHYRY..... Groundmass, 83.0; plagioclase, 12.0; perthite, 3.0; chlorite, 1.0; sphene-leucoxene, 1.0; quartz, tr.; opaque minerals, tr.; feldspar alteration, tr.; zircon, tr.; apatite, tr.

Plagioclase phenocrysts are more abundant than the previous interval. Phenocrysts are irregular to rounded in outline. Thin quartz veins cut several chips. The quartz in the groundmass is acicular in shape. Small chloritic masses are present in the groundmass. Magnetite crystals have a ragged, skeletal appearance suggesting a high titaniferous content. Numerous small opaque granules are in the groundmass. Grain size: Phenocrysts, 2+ mm; groundmass, irregularly microcrystalline. Texture: Porphyritic & acicular-felted.

This is an example of the Washington County Volcanic Group lying some two to three miles southeast of the inferred

contact of the microgranite.

Okmar Oil, 34-22N-10E, Osage County

Os-2-0, cuttings, 3395-3400 feet

RHYOLITE PORPHYRY.....

Only a few chips of rhyolite are in this sample. Most chips are carbonate with some sandy detritus. A few shaly chips are also noted. The few chips do not offer any different picture than the Os-1 in the same quarter section.

This well did not report basement rock but the thin section cut from the interval suggests it may have either just touched basement or been within a comparatively few feet of the surface. The rock is a rhyolite of the Washington County Volcanic Group.

Phillips No. 17 Mott, 11-27N-5E, Osage County

Os-3-1, cuttings, 4551-4610 feet

METARHYOLITE PORPHYRY..... Groundmass, 61.9; oligoclase, 14.8; perthite, 11.5; feldspar alterations, 7.8; chlorite, 2.6; hornblende, 1.1; sphene, tr.; epidote, tr.; opaque minerals, tr.; zircon, tr.; apatite, tr.

There is an unusual texture in this rock. Ragged phenocrysts of plagioclase with minor perthite are set in a granoblastic mosaic of quartz-feldspar. Several phenocrysts have an included rim of groundmass material enclosed near the edge of the crystal. Perthite phenocrysts are strongly clouded and contain much hematite dust. Plagioclase phenocrysts are water-clear with mottled sericite alterations. Possibly some microcline phenocrysts are present. Hornblende is olive green altering to a pale green variety and to chlorite and granular sphene. Coarser crystalline sphene also associated femic minerals, some approach euhedral wedges. Epidote is found with accessory mineral clots and replacements in feldspars. Grain size: Phenocrysts, 2+ mm; groundmass, 0.04 mm average. Texture: Porphyritic-granoblastic.

This rock is interpreted as the metamorphosed equivalent of the Washington County Volcanic Group.

Pure Oil Osage Hominy 191, 9-23N-8E, Osage County

Os-4-1, cuttings, 2605-2610 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass, 56.5;

perthite, 38.4; pyrite, 1.7; quartz, 1.0; chlorite, 0.8; feldspar alterations, tr.; calcite, tr.; opaque minerals, tr.; sphene-leucoxene, tr.; zircon, tr.; apatite, tr.

Unusually abundant and large perthite crystals are set in a rather coarse acicular groundmass of quartz-feldspar. Small rare quartz phenocrysts are rounded and appear resorbed. Chlorite-biotite masses are sparse. Opaque minerals are exceptionally common and much appears to be as secondary rather than primary crystals. The primary granules are extensively altered to sphene-leucoxene. Zircon occurs in diverse crystal forms. Feldspars contain little sericitic alteration but are clouded with vacules and hematite dust. Grain size: Phenocrysts, 4.5+ mm; groundmass, 0.4 mm average. Texture: Porphyritic-hypidiomorphic acicular.

Os-4-2, cuttings, 2610-2612 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass, 52.0; perthite, 42.5; quartz, 1.6; chlorite, 1.6; calcite, 1.4; sphene-leucoxene, 1.2; opaque minerals, tr.; biotite, tr.; feldspar alterations, tr.; apatite, tr.; zircon, tr.

Several perthite phenocrysts are composed of four or more crystal orientations in general rounded glomerophenocrysts. Calcite replaces feldspar along a vein forming a pseudointergrowth with quartz. Feldspar contains only minor clay-mica alterations but is clouded by vacules and hematite dust. Chlorite-biotite is secondary fibrous mats of fine shreds. Apatite is sparse but is exceptionally large, associated with alteration micas, sphene-leucoxene, and opaque minerals. Rounded quartz phenocrysts are present with resorbed ragged margins. Grain size: Phenocrysts, 4+ mm; groundmass, 0.5 mm. Texture: Porphyritic-hypidiomorphic acicular.

This well penetrated typical rock of the Osage County Microgranite.

Pure Oil Osage-Hominy 190, 8-23N-8E, Osage County

Os-5-1, cuttings, 2530-2593 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass, 61.5; perthite, 28.1; quartz, 4.3; calcite, 2.4; opaque minerals, 1.8; chlorite, 1.7; sphene-leucoxene, 0.3; feldspar alterations, tr.; apatite, tr.; zircon, tr.

Particularly large quartz phenocrysts are less abundant than perthite. The groundmass is an angular acicular type. Chlorite is both in apparent pseudomorphs of former

femic minerals generally with an opaque rim and irregular masses of shreds in the groundmass. Sphene-leucoxene replaces a titaniferous iron oxide. Only larger crystals of opaques were counted, smaller were referred to groundmass. Grain size: Phenocrysts, 4+ mm; groundmass, 0.2 mm average. Texture: Porphyritic-hypidiomorphic acicular.

This well penetrated typical rock of the Osage County Microgranite.

Keener Oil Osage "A" 29, 8-20N-12E, Osage County

Os-6-1, cuttings, 2155-2161 feet

WELDED RHYOLITE TUFF..... Groundmass, 94.3; quartz, 2.5; perthite, 1.2; rock fragments, 0.7; plagioclase, 0.6; sphene-leucoxene, 0.3; calcite, 0.1; opaque minerals, tr.; feldspar alterations, tr.; zircon, tr.

Phenocrysts of plagioclase perthite and quartz are set in a groundmass of quartz feldspar and abundant sericitic alterations. Relict shard character is preserved through devitrification and are largely sericitized. Fragments of rhyolite groundmass roughly the size of phenocrysts (1.5 mm) are noted in the groundmass. Iron oxides are rare, mostly converted to sphene-leucoxene. Chlorite is lacking, a most unusual condition. Spherulites are common in the groundmass. Grain size: Phenocrysts to 1.5 mm; groundmass, microcrystalline. Texture: Porphyritic-eutaxitic.

This well penetrated definitely extrusive rhyolitic rock of the Washington County Volcanic Group.

Mid-Continent No. 201 Osage, 31-25N-10E, Osage County

Os-7-1, cuttings, 2520-2560 feet

MICROGRANITE PORPHYRY..... Groundmass, 68.9; perthite, 27.9; chlorite, 1.5; opaque minerals, 1.2; quartz, 0.7; feldspar alteration, tr.; sphene-leucoxene, tr.; calcite, tr.; apatite, tr.; zircon, tr.

Large perthite and smaller less common quartz phenocrysts are set in a groundmass of acicular quartz and feldspar. The phenocrysts are irregular to rounded in outline. Zircon is particularly abundant. Chloritic masses are associated with calcite, sphene-leucoxene, apatite, and zircon. Iron oxides are in small ragged or smoothly irregular shaped crystals or as large crystals associated with accessory minerals. Feldspars are clouded and contain much finely disseminated

hematite. Sericite is rare. Grain size: Phenocrysts, 2.5+ mm; groundmass, 0.25 mm, average. Texture: Porphyritic-hypidiomorphic acicular.

This well drilled Osage County Microgranite.

Ohio Oil Co. No. 1-F Osage (No. 82), 25-24N-11E, Osage County

Os-8-1, cuttings, 2855-2863 feet

RHYOLITE PORPHYRY..... Groundmass, 81.6; perthite, 8.1; plagioclase, 6.8; quartz, 2.2; opaque minerals, 0.8; feldspar alterations, tr.; calcite, tr.; chlorite, tr.; zircon, tr.; apatite, tr.

Phenocrysts of plagioclase and quartz with minor anti-perthite are set in a flow banded devitrified groundmass of quartz-feldspar. The groundmass has a suggestion of a welded tuff but it is very faint. Some areas of the groundmass are composed wholly of tiny spherulites, closely spaced, with fuzzy margins. One plagioclase crystal has microcline patches and a general mottled extinction as if zoned, but zones are not parallel to crystal outlines. Chlorite is sparse. Magnetite phenocrysts are associated with zircon. Grain size: Phenocrysts, 2+ mm; groundmass, microcrystalline average. Texture: Porphyritic-spherulitic.

This well penetrated rhyolite of the Washington County Volcanic Group.

Pure Oil No. 192 Hominy, 8-23N-8E, Osage County

Os-9-1, cuttings, 2568-2575 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass, 58.6; perthite, 35.1; quartz, 2.3; opaque minerals, 1.3; calcite, 1.3; chlorite, 0.8; plagioclase, 0.5; sphene-leucoxene, tr.; zircon, tr.

Quartz and perthite phenocrysts with sparse sodic oligoclase are set in an acicular groundmass of rodlike quartz and angular perthite. Calcite replaces feldspar irregularly in groundmass. Perthite phenocrysts a partly composite, composed of as many as five optic units. Chlorite masses generally have an iron rich rim. Quartz phenocrysts have a ragged embayed rim, the groundmass quartz immediately surrounding the phenocrysts has the same optic orientation as the phenocrysts. Grain size: Phenocrysts, 3+ mm; groundmass, 0.3 mm average. Texture: Porphyritic-hypidiomorphic acicular.

This well penetrated typical rock of the Osage County Microgranite. The minor plagioclase was encountered in only

one other well (Os-23).

Texas Co. No. 1-5 Tract 26 (Smith), 28-24N-7E, Osage County

Os-10-1, cuttings, 3760-3771 feet

RHYOLITE PORPHYRY..... Groundmass, 77.6; perthite, 10.6; feldspar alterations, 3.9; plagioclase, 3.6; opaque minerals, 1.9; calcite, 0.7; quartz, 0.7; chlorite, tr.; apatite, tr.; zircon, tr.; sphene-leucoxene, tr.

Phenocrysts of plagioclase, quartz, and perthite are set in a highly banded groundmass showing delicate color bands as well as cruder compositional banding. Bands of coarser material are interlayered with bands showing devitrification units transecting flow lines. Devitrification has lead to areas of patch polarization. One large former phenocryst of biotite(?) is now replaced by calcite, coarse muscovite, chlorite and sphene-leucoxene. Associated with this mass is magnetite, apatite and zircon. Grain size: Phenocrysts to 2.5 mm; groundmass, average microcrystalline. Texture: Porphyritic-felsophyric.

The delicate banding suggests this is a devitrified obsidian-like glass belonging to the Washington County Volcanic Group.

Cities Service No. 1-5 S. Barnsdall Unit (Smith), 8-23N-11E, Osage County

Os-11-1, cuttings, 3013-3025 feet

RHYOLITIC ARKOSE..... Rhyolite detritus, 67.0; cementing matrix, 17.0; perthite, 7.0; quartz, 6.0; plagioclase, 2.0; calcite, 1.0; opaque minerals, tr.; zircon, tr. Mode is very approximate because of difficulties in distinguishing rhyolite fragments from the cementing matrix.

The rock is composed almost wholly of rhyolite fragments, chiefly lithic. Quartz grains are comparatively rare. Most groundmass detritus is rounded. A few granitic fragments were noted, microcline and quartz. The cementing agent is submicroscopic and probably highly compacted silica-clay. All types of rhyolite are noted some recrystallized others very fine grained devitrification products. Grain size varies in different chips but sorting appears fairly good. There appears to be no tendency to break between detrital grains. Grain size: To 1.8 mm maximum; 0.8 mm average. Texture: Clastic.

Though a strictly detrital rock this rock appears to be basement derived from dominantly rhyolitic rocks. It is

interpreted as a clastic interlayer within the volcanic rocks. Therefore it is a member of the Washington County Volcanic Group and not an arkosic detrital zone of lower Paleozoic age.

Ohio 87 Unit "C" Osage, 20-25N-11E, Osage County

Os-12-1, cuttings, 3013-3029 feet

RHYOLITE PORPHYRY..... Groundmass; perthite; quartz; feldspar alterations; plagioclase; opaque minerals; calcite, zircon. The percentages are roughly same as Os-12-2.

Quartz phenocrysts and less common perthite and plagioclase are set in a devitrified spongy groundmass of quartz-feldspar containing abundant sericite alterations. The groundmass is composed of optic units 0.3 mm in diameter. These units of "patchy polarization" are spongy appearing composed of very small granular quartz-feldspar having a common optic orientation. Hematite dust is finely disseminated in groundmass. Muscovite is in good books with opaque minerals, probably after biotite. Part of the perthite is an antiperthite with thin K-feldspar replacements in a plagioclase crystals. Sericite as partial replacements of feldspars is common. Grain size: Phenocrysts, 1.5 mm; groundmass, average microcrystalline. Texture: Porphyritic-felsophyric.

Os-12-2, cuttings, 3029-3034 feet

RHYOLITE PORPHYRY..... Groundmass, 80.0; perthite, 11.8; quartz, 5.0; feldspar alterations, 1.9; calcite, 0.6; plagioclase, 0.5; opaque minerals, 0.1; sphene-leucoxene, tr.

Very similar to the previous interval. Both intervals are unusual for their lack of chlorite. The groundmass is the spongy type of "patchy polarization" in the previous interval. Suggestion of flow lines present in some chips but the reconstitution of the glass has caused most to be destroyed. Opaque iron minerals are present only as small crystallites and some veinlets, large crystals are lacking. Accessory minerals exceptionally sparse. Grain size: Phenocrysts, 2.5 mm; groundmass, microcrystalline average. Texture: Porphyritic-felsophyric.

This well penetrated a rhyolite of Washington County Volcanic Group.

Gled Oil Co. No. 2 Osage, 9-21N-9E, Osage County

Os-13-1, cuttings, 2600 feet

RHYOLITE PORPHYRY..... Groundmass; K-feldspar; quartz; plagioclase; opaque minerals; feldspar alterations; chlorite.

Cutting chips are 0.7 mm and smaller in size making modal determination impossible. Feldspar phenocrysts are clouded with alterations and contain abundant disseminated hematite. The groundmass is a quartz-feldspar felsophyric intergrowth. The quartz is in part an acicular type. Disseminated chlorite is found in small masses. Grain size: Phenocrysts, 0.5+ mm; groundmass, average 0.1 mm. Texture: Porphyritic - acicular-felsophyric.

In the same section with a well (Os-14) interpreted as Osage County Microgranite this rock is tentatively placed in the Washington County Volcanic Group. The evidence, however, is not too firm and it could be the chilled phase of the microgranite.

Moore Oil and Ohio Oil No. 24 Osage, 9-21N-9E, Osage County

Os-14-1, cuttings, 2587-2592 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass, 58.6; perthite, 36.0; chlorite, 4.5; quartz, 1.2; opaque minerals, tr.; feldspar alteration, tr.; sphene-leucoxene, tr.; epidote, tr.; zircon, tr.; apatite, tr.

Large perthite phenocrysts contain small chlorite masses and some calcite replacement, have finely disseminated hematite, and some are zoned and appear plagioclase rich. Chlorite is a fine fibrous mat. Zircons are exceptionally elongate and partially metamict. Small amounts of epidote are present in the feldspar and chlorite. Chlorite does not appear to replace a subhedral femic but is intergranular. The groundmass tends toward micrographic texture but is hypidiomorphic-acicular. The quartz are somewhat acicular and the whole rock is very similar but coarser than Os-13 in the same section. One large quartz phenocryst is present. Grain size: Phenocrysts 4+ mm; groundmass, 0.4 mm average. Texture: Porphyritic - hypidiomorphic acicular.

This well contained the most southerly occurrence of the Osage County Microgranite.

Tidal Osage Wildhorse 26, 33-22N-10E, Osage County

Os-15-1, cuttings, 2640-2648 feet

RHYOLITE PORPHYRY..... Groundmass; perthite; quartz; sphene-leucoxene; opaque minerals; chlorite; feldspar alterations; apatite; zircon.

Irregularly shaped perthite phenocrysts are set in a microcrystalline quartz-feldspar groundmass. Quartz phenocrysts are of two types, with subhedral well defined outlines and smaller crystals with resorbed and rounded outer margins. The groundmass contains abundant ragged hematite dust. Feldspars contain little recognizable alterations but are highly clouded, containing much hematite. Small chloritic masses are largely restricted to replacements in feldspar phenocrysts. Grain size: Phenocrysts, 2+ mm; groundmass, microcrystalline average. Texture: Porphyritic-felsophyric.

This rhyolite of the Washington County Volcanic Group was drilled very near the inferred southeast boundary of the Osage County Microgranites.

Big Four Pet. Co. (Anderson) No. 5 Bird, 33-22N-7E, Osage County

OS-16-1, cuttings, 3760-3790 feet

ALTERED RHYOLITE PORPHYRY..... Groundmass, 62.0; quartz, 14.0; sericite, 13.0; perthite, 11.0; chlorite, tr.; opaque minerals, tr.; calcite, tr.; sphene-leucoxene, tr.

The rock has a simple mineralogy. Quartz phenocrysts are particularly abundant and with feldspar make up an unusually large percentage of the rock. This suggests a tuffaceous rhyolite. The groundmass has been completely reconstituted and extensively replaced by coarse sericite. Highly irregular shapes on some quartz suggest tuff while others are nearly euhedral though broken or cracked and filled with groundmass material. Perthite phenocrysts are mottled with fine sericite. The groundmass, where poor in sericite, is a chertose mosaic of quartz-feldspar unusually poor in opaque minerals. Grain size: Phenocrysts, 1.9+ mm; groundmass, microcrystalline average. Texture: Porphyritic-granoblastic.

Os-16-2, cuttings, 3790-3810 feet

ALTERED RHYOLITE PORPHYRY..... Groundmass; quartz; perthite; sericite; sphene-leucoxene; chlorite; opaque minerals; zircon.

Quartz phenocrysts are both large and numerous.

Perthite phenocrysts are irregular in outline and are clouded with hematite dust and vacules. Sericitic masses appear to have some structure suggesting they may be lithic detritus in a tuffaceous rock. Some sericite flakes are larger than normal secondary micas (to 0.2 mm). Most large opaque minerals have been altered to sphene-leucoxene and are also associated with chloritic masses. The chertose mosaic groundmass appears to be a devitrification of a glass and appears to have been partly silicified. Grain size: Phenocrysts, 2.0 mm; groundmass, microcrystalline average. Texture: Porphyritic-granoblastic.

Os-16-3, cuttings, 3810-3825 feet

ALTERED RHYOLITE PORPHYRY..... Groundmass; quartz; perthite; sericite; chlorite; sphene-leucoxene; calcite; opaque minerals; zircon.

Quartz and perthite crystals are set in a highly altered groundmass rich in sericite and quartz. Quartz phenocrysts are both irregular in shape and euhedral, may be cracked with groundmass filling the crack. Perthite phenocrysts are mottled with sericite alterations, the less altered areas containing clouding vacules and hematite dust. As in the previous interval some sericite rich portions of the groundmass has structure suggesting a tuffaceous origin. Complete reconstitution of groundmass makes determination impossible. Grain size: Phenocrysts, 1.9 mm maximum; groundmass, microcrystalline average. Texture: Porphyritic-granoblastic.

Os-16-4, cuttings, 3825-3835 feet

ALTERED RHYOLITE PORPHYRY..... Quartz; perthite; groundmass; sericite; chlorite-biotite; calcite; sphene-leucoxene; opaque minerals; zircon.

Phenocrysts of perthite and quartz are set in a microcrystalline groundmass of quartz-feldspar and alterations. Some cutting chips contain very abundant, locally coarse, sericite both in the groundmass and mottled feldspar replacement. Quartz phenocrysts are subhedral to rounded and embayed. Embayments are very deep and narrow worm-like furrows and cracks filled by groundmass are not uncommon. Chlorite and minor biotite are associated in masses with sphene-leucoxene. Some of these masses are amygdule-like fillings. Grain size: Phenocrysts, 2.5 mm; groundmass, microcrystalline average. Texture: Porphyritic-granoblastic.

This well penetrated rhyolite in which the groundmass has been completely altered except for minor patches that

apparently escaped the solutions which converted so much of the groundmass to sericite-quartz. The rock is a member of the Washington County Volcanic Group.

F. De Mier No. 1-A Zink (Osage), 30-21N-11E, Osage County

Os-17-1, cuttings, 2980-2990 feet

ALTERED RHYOLITE PORPHYRY (WELDED?)..... Groundmass, 76.9; sericite, 15.8; quartz, 3.4; feldspar, 1.7; opaque minerals, 0.8; sphene-leucoxene, 0.8; epidote, 0.4; zircon, tr.; chlorite, tr.; apatite, tr.

A highly altered rhyolite porphyry possibly of a welded tuff origin. Several quartz phenocrysts have concave surfaces and relict flow bands are well defined. Most feldspar phenocrysts have been replaced by a sericite mat of small generally unoriented shreds. Small chlorite masses are associated with iron ore. Quartz veins cut several cutting chips. Some fragments in the groundmass appear to be composed of lithic groundmass fragments. Epidote replaces one feldspar phenocryst in the least sericitized cutting chip. Grain size: Phenocrysts, 1.3+ mm; groundmass, microcrystalline average. Texture: Porphyritic-relict eutaxitic?

The delicate banding strongly suggests an extrusive origin for this rhyolite of the Washington County Volcanic Group.

Amerada No. 1 Hardy, 7-23N-11E, Osage County

Os-18-1, cuttings, 2349-2359 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass; perthite; quartz; opaque minerals; feldspar alterations; chlorite-biotite; sphene-leucoxene; apatite; zircon.

Phenocrysts of quartz and perthite are set in a matrix of finer quartz-perthite. The quartz have the distinctive rodlike acicular shape but grade to hypidiomorphic in part. Perthite is generally fresh but contains hematite dust and mottled alteration. Micaceous alterations are concentrated near crystal boundaries in groundmass. Chlorite-biotite is in small intergranular masses of unoriented shreds. Grain size: Phenocrysts, 1.9+ mm; groundmass, 0.4 mm average. Texture: Porphyritic-hypidiomorphic acicular.

Os-18-2, cuttings, 2359-2384 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass, 62.5; perthite, 34.0; chlorite, 1.6; quartz, 1.5; opaque minerals, 0.4; pyrite, tr.; zircon, tr.; feldspar alterations, tr.; calcite, tr.; apatite, tr.

Large perthite and smaller less numerous quartz phenocrysts are set in an acicular groundmass. Zircons are numerous and have a very thin rodlike form. Quartz phenocrysts have a rounded embayed appearance. Chlorite masses are composed of unoriented shreds. Perthite has a reddish color and generally clouded. Sphene and sphene-leucoxene are present, the sphene-leucoxene after titaniferous magnetite. Grain size: To 4 mm; 0.4 mm average. Texture: Porphyritic-hypidiomorphic acicular.

This well penetrated Osage County Microgranite and is only one mile west of a well (Os-11) penetrating rock belonging to the Washington County Volcanic Group.

Marland and Gled No. 2 Kohpay, 16-24N-8E, Osage County

Os-19-1, cuttings, 2495-2565 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass, 58.2; perthite, 34.9; quartz, 4.3; chlorite-biotite, 1.5; feldspar alterations, 0.4; opaque mineral, 0.4; sphene-leucoxene, tr.; zircon, tr.; fluorite, tr.; apatite, tr.

Perthite and quartz phenocrysts are set in the typical acicular quartz-feldspar groundmass. Zircons have a very elongate habit. Alterations mottle feldspar and intergranular concentrations of micas with associated opaque minerals are common. Feldspars are generally uniformly turbid. Chlorite-biotite replaces a former femic mineral. Grain size: Phenocrysts, 3+ mm; groundmass, 0.5 mm average. Texture: Porphyritic-hypidiomorphic acicular.

This well penetrated Osage County Microgranite.

Red Bank No. 2 Little, 14-22N-8E, Osage County

Os-20-1, cuttings, 3419-3428 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass, 61.4; perthite, 28.7; sphene-leucoxene, 2.4; chlorite, 2.0; quartz, 1.6; opaque minerals, 0.4; zircon, tr.; calcite, tr.; apatite, tr.; feldspar alterations, tr.

Large numerous perthite phenocrysts with smaller, less abundant quartz are set in a microcrystalline acicular

groundmass. The rodlike quartz have the same optical orientation as the phenocrysts. Chloritic masses appear to replace a former femic mineral, possibly biotite. Chlorite is also disseminated in groundmass. Perthite phenocrysts are generally fresh and contain only minor clouding alterations. Sphene-leucoxene replaces titaniferous magnetite. Grain size: Phenocrysts, 2.0+ mm; groundmass, 0.05 to 0.1 mm average. Texture: Hypidiomorphic-acicular-porphyritic.

This rock is a borderline example. It is tentatively placed in the Osage County Microgranite on the basis of mineralogy and texture. However, the grain size is finer than normal and it could be equivalent to the rhyolites.

Kewanee WS-1 Botts, 14-26N-6E, Osage County

Os-21-1, cuttings, 4470-4475 feet

METARHYOLITE (TUFF?)..... Groundmass, 57.0; quartz, 16.6; perthite, 13.9; feldspar alterations, 9.3; sphene-leucoxene, 1.9; chlorite, 1.5; opaque minerals, 0.2; apatite, tr.; epidote, tr.; pyrite, tr.

Numerous large embayed phenocrysts of quartz suggest a tuffaceous origin, several appear broken and angular. The groundmass is a granoblastic mosaic reconstituted from what was probably a glass. Perthite phenocrysts remain but some feldspar phenocrysts have been entirely replaced by a turbid micaceous mass stained with hematite. Small turbid epidote granules are present in some feldspars. Chlorite pseudomorphs are probably after biotite. Grain size: Phenocrysts, 1.9+ mm; groundmass, 0.015 mm to microcrystalline average. Texture: Granoblastic-relict porphyritic.

Os-21-2, cuttings, 4475-4479 feet

METARHYOLITE (TUFF?)..... Groundmass, 58.5; perthite, 20.1; quartz, 8.2; plagioclase, 5.9; chlorite, 3.7; feldspar alterations, 2.1; sphene, 0.9; epidote, 0.6; opaque minerals, tr.; zircon, tr.; apatite, tr.; calcite, tr.

Much of the perthite is clear and is very suggestive of microcline but visible twinning is lacking. Phenocrysts of both feldspar and quartz are exceptionally numerous and add weight to a tuffaceous origin. Many feldspar phenocrysts are extensively replaced by epidote and sericite. Large chloritic masses have associated sphene granules and epidote. Groundmass is a granoblastic mosaic of quartz-feldspar. Plagioclase is found as altered phenocrysts with poorly defined twinning. Diversity of feldspars also support tuffaceous origin. Grain

size: Phenocrysts, 2+ mm; groundmass, 0.03 mm average. Texture: Granoblastic-porphyritic-relict eutaxitic?

The tuffaceous character of this metarhyolite is speculative because the groundmass has been completely reconstituted and with it positive evidence for a tuff. The rock is interpreted as the metamorphosed equivalent of the Washington County Volcanic Group.

De Mier Oil Co. No. 1-A Country Club, 28-20N-12E, Osage County

Os-22-1, cuttings, 2635-2640 feet

BANDED RHYOLITE PORPHYRY..... Groundmass, 91.0; feldspar alterations, 4.5; quartz, 2.4; perthite, 2.0; opaque minerals, 0.2; plagioclase, tr.; chlorite, tr.; zircon, tr.

Sparse phenocrysts of quartz, perthite, altered plagioclase and minor opaque minerals are set in a strongly banded groundmass of quartz-feldspar. The banding is primary flow in origin, contorted around phenocrysts. Some bands are decidedly coarser than others. Chlorite is concentrated in these coarser bands. Alteration both of groundmass and phenocryst feldspars has given rise in part to a semiopaque iron rich masses of clay-mica. Grain size: Phenocrysts to 1 mm; groundmass, microcrystalline. Texture: Porphyritic-felsophyric.

The delicate banding in this rhyolite suggests devitrification from a glass in this example of the Washington County Volcanic Group.

Norbla Oil Co. No. 2 Lyman, 24-22N-9E, Osage County

Os-23-1, cuttings, 2972 feet cir.

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass, 64.0; perthite, 29.2; chlorite, 4.1; sphene-leucoxene, 1.6; quartz, 1.5; hornblende, 0.5; zircon, 0.2; opaque minerals, 0.2; calcite, 0.1; feldspar alterations, tr.

Phenocrysts of perthite and smaller rounded quartz are set in a quartz-perthite groundmass containing chlorite pseudomorphs after a former femic mineral. Chlorite also replaces portions of the perthite phenocrysts and along veinlets. The groundmass is characterized by having the unusual rodlike acicular quartz in perthite, locally approaching a micrographic texture. Feldspars are uniformly clouded with minor alteration and hematite dust. Leucoxene-sphene replace former titaniferous iron oxides. Grain size: Phenocrysts, 4+ mm; groundmass, 0.5 to 0.7 mm average. Texture: Porphyritic - hypidiomorphic acicular.

This is a typical example of the Osage County Microgranite. The feldspar was dated by the Rb/Sr method at 1240 ± 100 m.y.

Gulf No. 65 F Boston, 1-21N-7E, Osage County

Os-24-1, cuttings, 2965-2975 feet

RHYOLITE PORPHYRY..... Groundmass, 82.7; perthite, 10.2; feldspar alterations, 2.7; plagioclase, 1.6; chlorite, 1.4; opaque minerals, 0.9; quartz, 0.2; sphene-leucoxene, 0.2; zircon, 0.1; apatite, tr.; carbonate, tr.; epidote, tr.

Phenocrysts of perthite and associated plagioclase with minor small quartz are set in a quartz-perthite characterized by areas of optically continuous quartz, 0.6 mm in diameter, in acicular forms of "patch polarization." Feldspar alterations are extensive but appear concentrated in patches. Chloritic masses are associated with a finely divided colorless alteration mineral and sphene-leucoxene. Titaniferous iron ore granules are partly altered to sphene-leucoxene and are associated with well formed zircon and apatite. Grain size: Phenocrysts to 3.0 mm; groundmass, 0.1 mm average. Texture: Porphyritic-acicular-felted.

Os-24-2, cuttings, 2970-3000 feet

RHYOLITE PORPHYRY..... Groundmass, 87.6; perthite, 9.1; plagioclase, 1.7; sphene-leucoxene, 0.7; quartz, 0.3; feldspar alterations, 0.3; chlorite, 0.2; apatite, tr.; biotite, tr.; calcite, tr.; opaque minerals, tr.; pyrite, tr.

This is distinctly different in texture and mineral percentages from the previous interval. The texture is considerably finer felted and only minor areas of patch polarization are noted. Feldspar alterations and chlorite are much more minor. Secondary biotite is in small masses and along veinlets. A calcite-quartz vein is present. Hematite is disseminated and sphene-leucoxene has replaced all large ilmenite grains. Grain size: Phenocrysts, 2.5 mm; groundmass, average 0.06 mm. Texture: Porphyritic-felted.

Like rhyolites in so many wells to the southwest of the area of the Osage County Microgranite there are a number of characteristics common to both the rhyolites and microgranite. The delicate acicular quartz rods being most common, however, even in closely spaced samples, as here, the characters are not consistent in the rhyolites. The well penetrated rock interpreted as belonging to the Washington County Volcanic Group.

Bay Oil Co. No. 1 White (Osage), 9-22N-11E, Osage County

Os-25-1, cuttings, 2129-2131 feet

RHYOLITE PORPHYRY..... Groundmass; perthite; plagioclase; opaque minerals; feldspar alterations; calcite; chlorite; sphene-leucoxene; apatite.

Phenocrysts of perthite and minor plagioclase are set in a reconstituted groundmass of quartz-feldspar. The perthites are generally fresh with some calcite replacement and contain abundant hematite dust, the plagioclase are more altered to micas and are generally more free of hematite. The groundmass has areas of optically continuous quartz in poorly defined, fine acicular forms alternating with apparently unaffected felsophyric texture. Small chloritic masses do not appear to be pseudomorphic. Grain size: Phenocrysts, 2.5 mm; groundmass, 0.06 mm average but irregular. Texture: Porphyritic-acicular-felsophyric.

This well penetrated rock of the Washington County Volcanic Group.

Southern Production No. 1-C Atchison, 5-20N-11W, Osage County

Os-26-1, cuttings, 3243-3245 feet

MICROGRAPHIC GRANITE..... Perthite, 53.0; quartz, 33.4; plagioclase, 6.9; chlorite, 5.0; sphene-leucoxene, 1.6; opaque minerals, tr.; feldspar alterations, tr.; apatite, tr.; zircon, tr.; calcite, tr.

A coarsely micrographic granite containing abundant large quartz intergrown with perthite near the margins. Opaque minerals are restricted to disseminated hematite dust and small granules while most large crystals are replaced by sphene-leucoxene. Chlorite replaces a former femic mineral possibly biotite and hornblende. Plagioclase is more altered than perthite and contains less hematite dust but abundant sericite flakes. Grain size: 4 mm. Texture: Micrographic.

This granite is a "salient bulge" into volcanic rock lying some six miles north of some rhyolites. The coarse character is not wholly expected because most granites near the margins of the Spavinaw Granite Group are chilled and fine grained. There may be a tectonic explanation for this occurrence of granite in this location.

Texaco No. 16 W. S. Kohpay, 29-25N-8E, Osage County

Os-27-1, core, 2845-2846 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass, 56.7 (55.9); perthite, 29.8 (33.1); chlorite, 6.8 (5.3); quartz, 2.3 (3.3); plagioclase, 2.0 (tr.); sphene-leucoxene, 2.0 (1.8); opaque minerals, 0.4 (0.5); zircon, tr. (0.1); apatite, tr. (tr.); epidote, tr. (tr.); feldspar alterations, tr. (tr.). The two figures behind each mineral represent two modal determinations from two thin sections cut from the same core.

Abundant phenocrysts of perthite and quartz are set in an acicular quartz-feldspar groundmass. Sparse plagioclase core are noted in some perthites. Perthite phenocrysts are in part of exceptional size as rounded ovoids, composite crystals are common. Chlorite is found as large fibrous pseudomorphs after a femic mineral or as fine intergranular shreds. Large skeletal sphene-leucoxene pseudomorphs replace former ilmenite-magnetite crystals. Zircons are very abundant as large crystals associated with chlorite and opaque minerals and delicate slender prisms usually in the quartz-feldspar groundmass. Quartz phenocrysts are smaller than 3 mm and are generally smaller than 1.5 mm, have rounded outlines and appear to be resorbed. Groundmass quartz is optically continuous near the margins of quartz phenocrysts. Grain size: To 2.3 cm; groundmass, 0.5 to 0.7 mm. Texture: Porphyritic - acicular - hypidiomorphic.

This is the only core obtained from the Osage County Microgranite. A whole rock age of 1150 ± 60 m.y. was obtained by the Rb/Sr method.

J. G. Buell No. 1 Osage, 25-23N-8E, Osage County

Os-28-1, cuttings, 2385-2388 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass; perthite; quartz; opaque minerals; calcite; chlorite; feldspar alterations; zircon.

Phenocrysts of perthite and sparse quartz are set in a quartz-feldspar groundmass characterized by rodlike acicular quartz. The perthite contains dusty hematite and is turbid with disseminated indeterminate alterations. Ragged opaque iron oxides are in an intergranular position. Chlorite is generally disseminated and is not in recognizable pseudomorphs. No free plagioclase is present. Cutting chips are too small for modal analysis. Grain size: Phenocrysts, 1.5+ mm; groundmass, 0.6-0.9 mm average. Texture:

Porphyritic-hypidiomorphic-acicular.
This well penetrated Osage County Microgranite.

Texaco No. 13 SWD Bennett, 12-23N-7E, Osage County

Os-29-1, cuttings, 3470-3510 feet

RHYOLITE PORPHYRY..... Groundmass, 77.5; perthite, 12.9; plagioclase, 4.8; chlorite, 1.7; calcite, 1.1; sphene-leucoxene, 0.8; feldspar alterations, tr.; opaque minerals, tr.

Perthite and plagioclase crystals are set in a devitrified groundmass of quartz-feldspar. Most phenocrysts have a thin ragged margin of contact with the groundmass. Areas are characterized by patch polarization. Areas of coarser groundmass are possibly associated with linear introductions of quartz. Chlorite-quartz-iron oxide masses with sphene-leucoxene are in amygdule-like fillings. The zone immediately around these areas is highly sericitized. Grain size: Phenocrysts, 3+ mm; groundmass, microcrystalline average to 0.3 mm in areas of patch polarization. Texture: Porphyritic-felsophyritic.

Os-29-2, cuttings, 3510-3539 feet

RHYOLITE PORPHYRY..... Groundmass, 77.0; plagioclase, 15.0; perthite, 4.0; chlorite, 2.0; calcite, 1.0; feldspar alterations, 1.0; sphene-leucoxene, 1.0; opaque minerals, 0.5; apatite, tr.; zircon, tr.

Plagioclase and perthite phenocrysts rounded to subhedral in outline and containing mottled alteration-replacement of calcite of sericite are set in a groundmass of devitrified quartz-feldspar. The groundmass texture varies considerably in texture and grain size. Clots of accessory minerals chlorite-apatite-iron oxides with some sphene-leucoxene are present. Some chlorite masses regular outlines suggesting pseudomorphs after femic phenocrysts. Grain size: Phenocrysts, To 4 mm; groundmass, microcrystalline to 0.5 mm in patch polarized areas. Texture: Porphyritic-felsophyric.

This well penetrated rock of the Washington County Volcanic Group and is located near the western margin of the Osage County Microgranite.

Phillips No. 1 Higgens "A" SWD, 23-25N-8E, Osage County

Os-30-1, cuttings, 3633-3652 feet

WELDED RHYOLITE TUFF..... Groundmass; quartz; feldspar; feldspar alterations; opaque minerals; biotite (?); sphene-leucoxene.

A silicified chertose groundmass contains bundles of sericite shreds and hematite dust. Detrital debris is small, all less than 0.3 mm and most is only slightly different from the coarser portion of the groundmass. Masses of reddish, very fine grained biotite(?) are disseminated through one cutting chip. Relict flow structure is vaguely preserved around clastic debris. Variation in grain size within cutting chips suggests a size differentiation by flow. Grain size: Clastic debris, 0.3 mm; groundmass, microcrystalline average. Texture: eutaxitic.

Os-30-2, cuttings, 3652-3664 feet

WELDED RHYOLITE TUFF..... Groundmass; feldspar; quartz; feldspar alterations; chlorite; sphene-leucoxene; opaque minerals; zircon.

This is very similar to the previous interval, the banding of debris sizes is marked as is the distortion of devitrified relict shards. Some clastic material is recognizable lithic rhyolite. Some rounded areas of nearly pure chertose quartz are surrounded by a rim of very fine grained chlorite rich material. Most recognizable crystal debris is quartz in angular forms but feldspar, mainly plagioclase, is present. Microcline also is found as rare grains. Grain size: Clastic debris, 0.3 mm; micrycrystalline average. Texture: Porphyritic-eutaxitic.

This definitely extrusive tuff is only about a mile from the inferred boundary of the Washington County Volcanic Group and the microgranite.

Charles Ramey No. 1 White, 8-25N-10E, Osage County

Os-31-1, cuttings, 3360-3380 feet

SHALE.....

This well reported basement rock but only a shale was found and no crystalline material was identified. The silty shale is overlain by a zirconiferous feldspathic sandstone.

Cities Service SWD No. 1 Lot 292, 8-24N-11E, Osage County

Os-32-1, cuttings, 2804-2821 feet

BANDED RHYOLITE PORPHYRY..... Groundmass, 79.7; perthite, 8.8; plagioclase, 7.2; quartz, 2.5; calcite, 0.6; opaque minerals, 0.5; sphene-leucoxene, 0.4; chlorite, 0.3; feldspar alterations, tr.; apatite, tr.

Feldspar phenocrysts are set in a strongly flow banded devitrified groundmass. Very abundant iron oxide microlites are suboriented and outline delicate banding. Compositional banding is also noted causing varying devitrification patterns. Amygdale fillings of quartz are large and oriented with banding. One large chlorite pseudomorph replaces a former femic phenocryst. Phenocrysts of plagioclase and perthite are difficult to distinguish. Some phenocrysts are composed of one large crystal with numerous small crystals clinging to it. Calcite replaces irregularly, particularly in association with chlorite. Grain size: Phenocrysts, To 1.5 mm; groundmass, microcrystalline average. Texture: Porphyritic-felsophyric.

The devitrified rhyolite is a representative of the Washington County Volcanic Group. A date of 1190 ± 60 m.y. was obtained on the whole rock by the Rb/Sr method.

Atlantic No. 9-V569, 19-25N-8E, Osage County

Os-40-1, cuttings, 2835-2838 feet

RHYOLITE PORPHYRY..... Groundmass; perthite; plagioclase; quartz; feldspar alterations; opaque minerals; calcite; chlorite; sphene-leucoxene.

Numerous feldspar phenocrysts of both perthite and plagioclase, together with rare small quartz phenocrysts, are set in a delicately acicular quartz-feldspar groundmass. The rock is characterized by fresh feldspars with only a little disseminated hematite and sericite alteration. Chlorite-opaque mineral content is exceptionally low. Small calcite blebs replace portions of the feldspar. Grain size: Phenocrysts, 2.5+ mm; groundmass, 0.07 mm but variable. Texture: Porphyritic-acicular-felted.

This well drilled a rhyolite porphyry of the Washington County Volcanic Group.

Sunray DX No. 21-NW-32-21-12, 32-21N-12E, Osage County

Os-41-1, cuttings, 2560-2575 feet

WELDED RHYOLITE TUFF..... Groundmass, 96.0; quartz, 1.2; perthite, 0.8; feldspar alterations, 0.8; pyrite, 0.7; chlorite-biotite, 0.5; opaque minerals, tr.; zircon, tr.; sphene-leucoxene, tr.

Very sparse phenocrysts of quartz and perthite are set in a quartz-feldspar groundmass showing excellent eutaxitic structure. Feldspar alterations are common replacing some feldspar phenocrysts in a fibrous mat. Locally the groundmass contains coarser material. Pyrite or chalcopyrite replaces along veinlets. Sphene-leucoxene replaces ilmenite. Grain size: Phenocrysts, 1.2 mm; groundmass, microcrystalline average. Texture: Porphyritic-eutaxitic.

Os-41-2, cuttings, 2575-2577 feet

WELDED RHYOLITE TUFF..... Groundmass, 92.3; perthite, 5.9; plagioclase, 0.7; quartz, 0.7; opaque minerals, 0.2; calcite, 0.2; sphene-leucoxene, tr.; biotite-chlorite, tr.; feldspar alterations, tr.; zircon, tr.; apatite (?), tr.

Phenocrysts of perthite with minor plagioclase and quartz groundmass of quartz-feldspar showing excellent eutaxitic structure. Distorted shards are outlined by slight compositional variation and iron oxide granules and dust. Feldspars are generally turbid. Quartz phenocrysts are embayed and rounded. Carbonate replaces irregularly in the groundmass and blebs within the feldspar. Small clots of biotite-chlorite are in veinlets and as pseudomorphs. Coarsenings in groundmass may be vug replacements. Grain size: Phenocrysts, 2.0 mm; groundmass, microcrystalline average. Texture: Porphyritic-eutaxitic.

This welded tuff is an example of the Washington County Volcanic Group and is located in an area in southeast Osage County where extrusive rhyolites are common.

City of Miami No. 3 Goodrich Rubber, 24-28N-22W, Ottawa County

Ot-1-0, cuttings, 1040 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; plagioclase; chlorite; opaque minerals; sphene-leucoxene; feldspar alterations; amphibole; calcite; apatite; zircon.

Portions of larger phenocrysts are clear surrounded

by mottled alterations and heavy iron stain. These larger crystals have a thin iron stained perthite rim. The groundmass feldspar are deep reddish with disseminated hematite. Sphene is common as a crystalline material and sphene-leucoxene is associated with chlorite. Small amounts of a green, mildly pleochroic, amphibole are present. Grain size: Phenocrysts, 3+ mm; groundmass, 1 mm average. Texture: Micrographic-porphyritic.

Ot-1-2, cuttings, 1045 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 73.6; feldspar alterations, 16.2; perthite, 9.1; plagioclase, 1.7; sphene-leucoxene, 0.8; chlorite, 0.2; opaque minerals, tr.; zircon, tr.; pyrite, tr.

Highly altered phenocrysts of plagioclase and perthite are set in a micrographic groundmass. Many phenocrysts are altered to a semiopaque mass stained with hematite. Micrographic intergrowths vary in coarseness--some very delicately radial, some nearly cuniform. Chlorite is unusually sparse. Sphene-leucoxene replaces titaniferous magnetite. Several plagioclase crystals have a deep reddish perthite rim surrounding. Grain size: 2.5 mm maximum; 1.1 mm average. Texture: Micrographic-porphyritic.

This well penetrated an example of the femic-poor variety of Spavinaw Granite Group.

Commerce Mining and Royalty No. 159 Beaver, 19-29N-23E, Ottawa County

Ot-2-1, cuttings, 1762-1772.5 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; quartz; feldspar alterations; opaque minerals; chlorite; sphene-leucoxene; pyrite.

Very small cuttings offer few textural relations. Phenocrysts are anomalous, though they contain disseminated hematite dust, most have a very low 2V suggestive of sanidine. One patch is unusually clear and has a high 2V and a suggestion of twinning, possibly microcline. Most groundmass contains low 2V feldspar. Micrographic intergrowth varies from exceptionally delicate near margins of phenocrysts to coarse. Grain size: Phenocrysts, 1.8+ mm; groundmass, 2+ mm average. Texture: Micrographic-porphyritic.

In the same section as Ot-7, this granite is distinctly different in texture from this other well and is typical of the Spavinaw Granite Group.

Commerce Mining and Royalty Bird Dog Mine No. 1, 13-29N-22E, Ottawa County

Ot-3-1, cuttings, 1190 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; feldspar alterations; plagioclase?; sphene-leucoxene; chlorite; opaque minerals; calcite; apatite; zircon?.

Highly altered feldspar phenocrysts are set in a comparatively rude micrographic groundmass. Though groundmass feldspars are turbid and stained with hematite--the phenocrysts feldspars are much more altered either to rather coarse clay minerals or as a semiopaque mica mat rich in iron. Calcite is associated with the alteration products and as an intergranular replacement. Chlorite is rare. Sphene-leucoxene replaces titaniferous iron oxide. Grain size: Phenocrysts, 1.9+ mm; groundmass, 1.5 mm average. Texture: Micrographic-porphyritic.

Ot-3-2, cuttings, 1190-1195 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 77.4; perthite, 10.3; plagioclase, 10.1; feldspar alterations, 1.9; opaque minerals, 0.3; chlorite, 0.3; sphene-leucoxene, tr.; apatite, tr.; zircon, tr.; fluorite, tr.; calcite, tr.; pyrite, tr.

This is less altered than the previous interval although phenocryst feldspars contain abundant coarse clay minerals. Chlorite is more abundant and is associated with sphene-leucoxene,apatite and, in one case, fluorite. Iron oxides are less abundant and titaniferous varieties have been converted to sphene-leucoxene. Micrographic intergrowth is comparatively rude, lacking delicate radial structure. Grain size: Phenocrysts, 1.9+ mm; groundmass, 1.5 mm average. Texture: Micrographic-porphyritic.

This rock is example of the femic-poor varieties of the Spavinaw Granite Group.

American Zinc No. 2 Demo, 8-28N-22E, Ottawa County

Ot-4-1, cuttings, 284-305 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; plagioclase; perthite; feldspar alterations; zeolite (thompsonite?); chlorite; epidote; sphene; opaque minerals; tremolite-actinolite; apatite; zircon.

Altered phenocrysts of plagioclase, some with an extensive perthite rim are set in a micrographic quartz-perthite groundmass. The plagioclase contains sericite flakes, clay masses, epidote granules, and a well crystallized zeolite, possibly thompsonite. The perthites are characteristically turbid with hematite dust and vacules, no extensive alterations can be petrographically identified. Chlorite replaces a former femic mineral. Sphene is well crystallized in an intergranular position and is in part a pale reddish color. Grain size: Phenocrysts, 3.6 mm; groundmass, average 0.7 mm. Texture: Porphyritic-micrographic.

This is one of two wells in the same quarter section. The rock is a well defined example of the Spavinaw Granite Group.

American Zinc No. 7 Demo, 8-28N-22E, Ottawa County

Ot-5-1, cuttings, 345-355 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; plagioclase; perthite; feldspar alteration; chlorite; opaque minerals; tremolite-actinolite; epidote; zeolite (thompsonite?); sphene; leucoxene; fluorite; zircon; apatite.

This rock is very similar to Ot-4-1 in the same 40 acre area. Plagioclase phenocrysts with a perthite rim contain abundant, diverse alteration and in part are completely replaced by fibrous mat of micaceous minerals. Chlorite and tremolite-actinolite replace the former femic mineral. Sphene is in crystalline masses. Leucoxene replaces former titaniferous iron oxides. Perthite is generally very turbid with hematite dust. Grain size: Phenocrysts, 3.5 mm; groundmass, 0.7 mm average. Texture: Porphyritic-micrographic.

Together with Ot-4 in the same quarter section this well penetrated rock of the Spavinaw Granite Group.

Eagle Picher Golden Hawk, 20-29N-23E, Ottawa County

Ot-6-1, core, 1797 feet

ANDESITE PORPHYRY..... Groundmass, 88.9; pyroxene, 4.8; actinolite-tremolite, 4.2; opaque minerals, 1.6; plagioclase, 0.6; micaceous alterations, tr.; pyrite, tr.; quartz, tr.; epidote, tr.; calcite, tr.; sphene-leucoxene, tr.

Phenocrysts of augite are common with more altered and less common plagioclase phenocrysts. The groundmass is an ill-defined mess composed chiefly of feldspar and

tremolite-actinolite with lesser amounts of micas, opaque minerals and sphene-leucoxene. Certain zones are silicified, rimmed by actinolite-tremolite concentrations, and contain very low birefringent chlorite, epidote, and minor calcite. Pyroxene phenocrysts are partly a composite type containing as many as nine optic units, some of these are twinned. Single crystals are more common and are partly to totally replaced by chlorite, amphibole, sphene-leucoxene, opaque minerals and minor calcite. Zoning is noted in some pyroxenes. Sparse feldspar phenocrysts are too altered for determination of composition. Grain size: Phenocrysts, 2.8 mm; groundmass, 0.05 mm average. Texture: Relict pilotaxitic - porphyritic.

Eagle Picher Golden Hawk, 20-29N-23E, Ottawa County

Ot-6-2, core, 1737 feet

ALTERED ANDESITE..... Sericite; hematite; feldspar; chlorite-biotite; quartz.

The rock is composed chiefly of mica and hematite with relicts of feldspar and quartz. The general character is highly sheared hydrothermally altered basic or intermediate rock. Large masses of micaceous alterations possibly represent former feldspar crystals, while chloritic masses are probably after a femic mineral. The shearing has destroyed any former texture. Grain size: Relicts to 0.2 mm; average microcrystalline. Texture: Cataclastic-crystalloblastic.

This well contained andesite related to the Washington County Volcanic Group and is located some twenty miles east of the welded andesite tuffs in Craig County (Crg-1, Crg-2).

Eagle Picher Anna Beaver, 19-29N-23E, Ottawa County

Ot-7-1, core, 1651 feet

MICROGRANITE PORPHYRY..... Quartz-feldspar groundmass, 71.2; plagioclase, 13.7; perthite, 10.1; chlorite, 2.3; calcite, 1.0; opaque minerals, 0.9; hornblende, 0.5; sphene-leucoxene, 0.3; apatite, tr.; epidote, tr.; feldspar alterations, tr.; zircon, tr.

Modal composition of feldspars include extensive local alterations. Alteration is unusually variable from water clear well twinned plagioclase to extensively sericitized and calcitized phenocrysts. Plagioclase is near An_{20} and commonly contains a narrow perthite rim and mottled alterations. Faint zoning is noted in some phenocrysts. Perthite contains

extensive disseminated hematite dust. Masses of chlorite and locally associated calcite replace a femic mineral probably hornblende which is fresh in some crystals. The groundmass is an intergrowth of quartz and iron-rich perthite, locally approaching micrographic texture, but generally an interlocking mosaic. Sphene-leucoxene is associated with large magnetite-ilmenite and as fine granular forms with chlorite. Grain size: Phenocrysts, 3.6 mm; groundmass, 0.3 mm average. Texture: Porphyritic--xenomorphic to micrographic.

This well contained rock having a texture not found in any other well in the Spavinaw Granite Group and may represent a chilled margin.

Sinclair No. 46 Jones, 20-21N-8E, Pawnee County

Pw-1-2, core, 2942.5 feet

RHYOLITE PORPHYRY..... Groundmass, 78.8; perthite, 10.7; plagioclase, 8.1; opaque minerals, 1.0; chlorite, 0.9; quartz, 0.3; calcite, 0.2; epidote, tr.; sphene-leucoxene, tr.; feldspar alterations, tr.; apatite, tr.; zircon, tr.

Phenocrysts of perthite and plagioclase together with sparse resorbed quartz are set in a felsophyric groundmass of quartz-feldspar containing abundant hematite. Chloritic masses appear to be pseudomorphic after a former femic mineral. The feldspars are partly altered with clouding material and contain minor small discrete epidote crystals. The groundmass has optically continuous quartz patches of acicular forms, some areas over 1.0 mm in diameter. Plagioclase is embayed and some crystals contain a perthite rim. Grain size: Phenocrysts, 1.3 cm; groundmass, microcrystalline to 0.05 mm. Texture: Porphyritic-felsophyric-acicular.

This well penetrated rhyolite of the Washington County Volcanic Group. A Rb/Sr age on total rock yielded an age 1180 ± 60 m.y.

Watchorn No. 11 Miller, 33-23N-3E, Pawnee County

Pw-2-1, cuttings, 4573-4581 feet

METARHYOLITE PORPHYRY..... Groundmass, 76.7; plagioclase, 8.9; perthite, 7.8; quartz, 3.1; epidote, 1.2; opaque minerals, 0.3; chlorite, 0.3; sphene-leucoxene, tr.; zircon, tr.; apatite, tr.

Large phenocrysts of quartz-perthite-plagioclase are set in a granoblastic mosaic groundmass of quartz-feldspar. The quartz phenocrysts are in part composed of

more than one optic unit. Epidote is common as small irregular crystals in the groundmass, and larger crystals associated with chlorite or discrete inclusions in feldspars. Sphene-leucoxene is after ilmenite and as granular masses with chlorite. Feldspars are clouded with minor alteration and disseminated hematite dust. Plagioclase phenocrysts contain only a small amount of hematite dust and are clearer. Grain size: Phenocrysts, 4.5+ mm maximum; groundmass, 0.1 mm average. Texture: Porphyritic-granoblastic.

This well, together with Pw-7 in the same section, represents a certain anomaly in that the origin of the groundmass texture is a matter for essentially unresolvable interpretation. The rock is interpreted as a metamorphosed equivalent of the Washington County Volcanic Group with the reservation that the groundmass texture may be due to primary aplitic crystallization.

Tidal-Osage No. 8 Arnold, 3-20N-8E, Pawnee County

Pw-3-1, cuttings, 3206-3215 feet

RHYOLITE PORPHYRY..... Groundmass; perthite; albite; feldspar alterations; chlorite; sphene-leucoxene; opaque minerals.

All cutting chips are smaller than 1.3 mm. Phenocrysts of plagioclase and perthite are set in a groundmass generally felsophyric in character but containing numerous rodlike quartz and vague spherulites. Phenocrysts feldspar are mottled with extensive alterations. Chlorite masses are weakly birefringent and very pale green in color. Slight variation in grain size may mean compositional banding. Grain size: Phenocrysts, 1+ mm; groundmass, microcrystalline average. Texture: Felsophyric-porphyritic-spherulitic-acicular.

This well penetrated a rhyolite of the Washington County Volcanic Group located near the inferred southern margin of this group.

Minnehoma No. 1 Richards, 9-20N-8E, Pawnee County

Pw-4-1, cuttings, 3052-3058 feet

RHYOLITE PORPHYRY (TUFF?)..... Groundmass; perthite; feldspar; opaque minerals; chlorite; feldspar alterations; sphene-leucoxene; biotite; apatite.

Flow lines are outlined by quartzose replacement and chlorite introduction. The phenocrysts of perthite and plagioclase are battered and broken in appearance and suggest

a flow tuff origin. Several composite phenocrysts of perthite are composed of several optic units. The margins of the phenocrysts are not sharp and suggest reconstitution of the quartz-feldspar groundmass. Some vague amygdaloidal appearing masses are composed of quartz-chlorite. Small shreds of biotite remain in chlorite. Pyrite replaces along linear cracks. Grain size: Phenocrysts, To 1.5 mm; groundmass, microcrystalline average. Texture: Porphyritic - relict amygdaloidal-felsophyric.

Pw-4-2, cuttings, 3058-3072 feet

WELDED RHYOLITE TUFF..... Groundmass; perthite; plagioclase; quartz; opaque minerals; feldspar alterations; sphene-leucoxene; chlorite; biotite; epidote; apatite?.

Flow bands are vague but are outlined by secondary mineralization, essentially iron rich trends and chlorite. Highly irregular shaped perthite phenocrysts are rounded to elongate. Micaceous masses replace portions of the quartz-feldspar groundmass. Iron oxides are not in phenocrysts but as small ragged crystallites or secondary veinlets. Secondary spherules of chlorite contain interlayered biotite. Albitic plagioclase phenocrysts contain abundant disseminated hematite and clouding by alterations. Irregular and abundant phenocrysts suggest clastic origin with subsequent reconstitution. Grain size: Phenocrysts, 1.7 mm; groundmass, microcrystalline average. Texture: Relict eutaxitic-porphyritic-felsophyric.

This rhyolite of the Washington County Volcanic Group shows relict extrusive characters.

Porter No. 20 Miller, 33-23N-3E, Pawnee County

Pw-7-1, core, 4686-4691 feet

METARHYOLITE PORPHYRY..... Groundmass, 59.2; perthite, 16.8; plagioclase, 13.3; quartz, 9.7; chlorite, 0.5; opaque minerals, tr.; sphene-leucoxene, tr.; calcite, tr.; apatite, tr.; zircon, tr.; feldspar alterations, tr.; biotite, tr.

Exceptionally large and abundant phenocrysts of quartz, perthite, and plagioclase are set in a granoblastic mosaic of quartz and feldspar. Many of the phenocrysts are euhedral or composite phenocrysts composed of as many as ten optic unit in one subrounded mass. Chlorite, sphene-leucoxene with iron ore replace a former femic mineral in large clots. The groundmass is essentially structureless. Opaque minerals are in smallish granules and dust in groundmass only. Grain size: Phenocrysts, 11.0 mm; groundmass,

0.07 mm average. Texture: Porphyritic-granoblastic.

This rock, as with Pw-2, is speculatively interpreted as the metamorphosed equivalent of the Washington County Volcanic Group. The metamorphism is incipient but can be interpreted as the cause of the groundmass texture. The whole rock was dated by the Rb/Sr method at 1270 ± 100 m.y. This is the highest age obtained on any of the rhyolites.

Deep Rock No. 3 Little Chief, 4-18N-5E, Payne County

Py-1-1, cuttings, 3593-3600 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 47.6; perthite, 45.9; calcite, 2.9; chlorite, 1.2; feldspar alterations, 0.9; opaque minerals, 0.3; plagioclase, tr.; sphene-leucoxene, tr.; biotite, tr.; zircon, tr.

Large perthite crystals deeply stained with hematite, and clouded with alterations are set in an exceptionally delicate quartz-feldspar intergrowth. Coarser quartz and plagioclase in one cutting chip may be secondary. One cutting chip has a large clear perthite crystal, possibly microcline, mottled with sericite alteration. Small discrete quartz is present in rounded crystals suggestive of resorbed phenocrysts. Accessory minerals are sparse. Grain size: Phenocrysts, 2.5+ mm; groundmass, 0.8 mm average. Texture: Micrographic-porphyritic.

This well penetrated rock of the Spavinaw Granite Group.

Magnolia No. 10 Main, 34-19N-4E, Payne County

Py-2-1, cuttings, 4146-4151 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; opaque minerals; calcite; chlorite; feldspar alterations; sphene-leucoxene; epidote; apatite.

Very delicate micrographic intergrowth surrounds perthite phenocrysts. The cutting chips are all less than 2 mm in diameter and the total area of sample is very small. Feldspars are clouded with alterations and contain very abundant hematite dust. Discrete epidote crystals in enclosed in feldspars. Anhedral, ragged calcite replaces irregularly. Small chloritic masses are found irregularly through the rock in small amounts. One phenocryst is surprisingly clear and suggests microcline perthite. Grain size: Phenocrysts, 2+ mm; groundmass, 1.1 mm average. Texture: Micrographic-

porphyritic.

This well represents the most westerly encounter of the Spavinaw Granite Group.

Wood Oil Co. No. 1 Curley Chief, 33-19N-5E, Payne County

Py-3-1, cuttings, 3757-3780 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; actinolite; feldspar alterations; opaque minerals; epidote; sphene-leucoxene; chlorite-biotite.

Micrographic intergrowth is exceedingly variable in development--some is very delicate subradial around phenocrysts, other parts are a coarser cuniform type. Cutting chips do not exceed 1.9 mm. Actinolite appears to be secondary and is associated with minor chlorite-biotite. Perthite as very turbid with alterations and hematite dust. Grain size: Phenocrysts, 1.5+ mm; groundmass, 1.8+ mm average. Texture: Micrographic-porphyritic.

This well penetrated rock of the Spavinaw Granite Group.

A. W. Hembree C-3 Hembree, 19-17N-5E, Pottawatomie County

Pt-1-1, cuttings, 7755-7775 feet

GRANITE..... Plagioclase (An_{10}), 31.8; quartz, 27.8; microcline, 27.1; biotite, 7.2; feldspar alterations, 4.9; chlorite, 0.6; opaque minerals, 0.3; epidote, tr.; sphene-leucoxene, tr.; apatite, tr.; zircon, tr.; rutile ?, tr.; calcite, tr.

Locally perthitic microcline is slightly but uniformly turbid with minor alterations, while the plagioclase (An_{10}) is mildly zoned and erratically altered. Intense sericitization and epidotization accompanied by minor hematite dust is characteristic of many of the plagioclase cores while margins are much less altered or clear. Biotite is olive green, contains sphene-leucoxene granules and extensive chlorite alterations. Sphene wedges have been replaced by sphene-leucoxene granules and calcite. Quartz is generally unstrained. Small needles in biotite are probably rutile and appear crystallographically oriented. Minor shear linears are noted. Grain size: Average 3.8 mm. Texture: Hypidiomorphic.

Tentatively placed in the Central Oklahoma Granite Group, this rock could be related to the older Eastern Arbuckle Province. Mild metamorphic effects commonly shown

by the rocks of the Eastern Arbuckle Province north of the Tishomingo Anticline are lacking in this sample.

Reed and Son No. 1 A. Koenig, 27-19N-17W, Rogers County

Rog-1-1, cuttings, 2397-2415 feet

GRANITE..... Microcline perthite; quartz; plagioclase; chlorite; feldspar alterations; opaque minerals; sphene-leucoxene; biotite; epidote.

The few small cuttings do not permit modal determination or accurate textural analysis. The quartz is coarse, mildly strained and contains small unoriented trains of undetermined but apparently non-opaque minerals. The microcline perthite is clouded with alterations and contains disseminated hematite. Oligoclase contains sericite flakes and less well disseminated hematite. Original femic mineral is altered to chlorite with attendant sphene-leucoxene. Biotite is in small masses of secondary radial fibers. Epidote is in small granules. Grain size: 3mm. Texture: Hypidiomorphic.

This well is unusual in that it contains microcline perthite and slightly strained discrete quartz. The well is located near the center of the Spavinaw Granite Group and may represent a deeper level of erosion near the core of the inferred breach anticline.

Lucien Conner No. 2 Grace Nichols "A," 25-22N-14E, Rogers County

Rog-2-1, cuttings, 2514-2575 feet

RHYOLITE PORPHYRY..... Groundmass, 82.0; perthite, 11.5; chlorite, 2.3; pyrite, 2.0; plagioclase, 0.8; feldspar alterations, 0.5; opaque minerals, tr.; sphene-leucoxene, tr.; apatite, tr.; zircon, tr.

Phenocrysts of perthite and plagioclase (?) are set in an intergrowth of quartz-feldspar having little regular pattern. Chloritic masses appear pseudomorphic after a former femic mineral and are associated with granular sphene-leucoxene and other chloritic masses with iron oxides and accessory minerals. Pyrite replaces irregularly through the groundmass. The feldspar phenocrysts are extensively replaced by alterations. Grain size: Phenocrysts, 2+ mm; groundmass, microcrystalline average. Texture: Porphyritic-felsophyric.

Rog-2-2, cuttings, 2575-2612 feet

RHYOLITE PORPHYRY..... Groundmass, 88.6; feldspar alterations, 5.6; perthite, 2.0; plagioclase, 1.3; sphene-leucoxene, 1.3; chlorite, 1.0; opaque minerals, tr.; apatite, tr.; zircon, tr.

Only a few feldspar phenocrysts remain, most are completely replaced by clay-sericite in a fine-grained fibrous mat. There is considerable variation in texture of the groundmass between cutting chips. Some are acicular, some felsophyric. Chloritic masses appear to be mainly pseudomorphs after a femic mineral. Groundmass feldspars are more fresh but deep reddish due to included hematite. Grain size: Phenocrysts, 1 mm maximum; groundmass, microcrystalline average. Texture: Porphyritic - felsophyric - acicular.

Rog-2-3, cuttings, 2612-2636 feet

RHYOLITE PORPHYRY..... Groundmass, 75.6; plagioclase, 13.2; chlorite, 3.7; perthite, 2.5; sphene-leucoxene, 1.6; feldspar alterations, 1.3; opaque minerals, tr.; calcite, tr.; zircon, tr.; epidote, tr.; pyrite, tr.

Most of the phenocrysts are plagioclase but perthite is present. There is less alteration than the previous interval but some phenocrysts are completely replaced. Texture is more uniform than Rog-2-2, largely felsophyric. Sphene-leucoxene replaces titaniferous magnetite and is stained with hematite. Epidote is locally abundant associated with chlorite and other accessory minerals and as discrete granules in both the groundmass and phenocrysts. Grain size: Phenocrysts, 2 mm; groundmass, microcrystalline average. Texture: Porphyritic-felsophyric.

Rog-2-4, cuttings, 2485-2514 feet

RHYOLITE PORPHYRY..... Groundmass, 76.5; plagioclase, 9.2; perthite, 6.5; chlorite, 3.9; feldspar alterations, 3.1; opaque minerals, 1.0; sphene-leucoxene, 1.0; zircon, tr.; apatite, tr.; calcite, tr.; epidote, tr.

Perthite and plagioclase phenocrysts are set in a generally felsophyric groundmass containing locally well developed acicular quartz, very delicate radial micrographic intergrowth and vague spherulites. Phenocrysts are mottled with alterations and some contain discrete epidote granules of small size. Chlorite is associated with sphene-leucoxene, apatite and some calcite. Hematite dust is very common as a cloud of particles. Grain size: Phenocrysts, 2+ mm; groundmass, microcrystalline average. Texture: Felsophyric-acicular-

spherulitic-porphyritic.

The well penetrated rock of the Washington County Volcanic Group and is located near the southern boundary with the Spavinaw Granite Group.

Daniels and Smith No. 2 Vierhiller, 36-21N-16E, Rogers County

Rog-3-1, cuttings, 2277-2373 feet

MICROGRAPHIC MICROGRANITE PORPHYRY..... Micrographic quartz-feldspar, 69.4; plagioclase, 16.3; perthite, 8.1; chlorite, 4.0; epidote, 1.0; opaque minerals, 0.5; biotite, tr.; sphene-leucoxene, tr.; feldspar alterations, tr.; zircon, tr.; apatite, tr.; calcite, tr.

Perthite and plagioclase phenocrysts are set in a delicately micrographic groundmass. Intergrowth is radial to subradial around phenocrysts. Chlorite is found as pseudomorphs after a former femic mineral, small intergranular masses and as replacement along cleavage cracks in feldspars. Epidote is common as replacement minerals in feldspars. Minor amounts of deep olive green biotite are present as small intergranular crystals. Grain size: Phenocrysts, 3.2 mm; groundmass, 0.35 mm average. Texture: Micrographic-porphyritic.

Rog-3-3, cuttings, 2375-2377 feet

MICROSYENITE PORPHYRY..... Perthite, 63.5; plagioclase, 22.2; quartz, 7.1; calcite, 5.9; opaque minerals, 3.4; chlorite, 0.9; feldspar alterations, tr.; sphene-leucoxene, tr.; apatite, tr.; zircon, tr.

This rock in several cutting chips is a syenite--containing very small amounts of quartz. The amount is variable and in the cutting chips where quartz is most abundant some micrographic intergrowth is developed. The feldspars are more clear and unclouded with hematite dust as contrasted to deeply reddish granites. The texture is also in sharp contrast to the granites with perthite and sodic oligoclase phenocrysts in a hypidiomorphic groundmass of perthite. Calcite is an irregular replacement of the feldspars. Syenitic chips are characterized by faintly clouded but remarkably fresh perthite. This rock is possibly a local phase of the normal granite with which it appears in part gradational. Grain size: Phenocrysts, 1.5+ mm; groundmass, 0.3 mm average. Texture: Hypidiomorphic granular-porphyritic.

Rog-3-4, cuttings, 2383-2478 feet

MICROGRAPHIC MICROGRANITE PORPHYRY..... Micrographic quartz-feldspar, 64.2; perthite, 18.9; plagioclase, 9.1; chlorite, 4.4; epidote, 1.2; opaque minerals, 1.0; actinolitic amphibole, 0.9; sphene-leucoxene, 0.4; feldspar alterations, tr.; zircon, tr.; apatite, tr.; calcite, tr.

Phenocrysts of perthite and plagioclase are set in a delicately micrographic groundmass of quartz-feldspar. Chlorite is common as pseudomorphs replacing actinolitic amphibole, present as relicts. The amphibole is only mildly pleochroic and probably replaces to primary femic mineral. Feldspars are generally clouded with alterations and contain discrete epidote granules. Sphene is present as well formed crystals and as granular masses associated with leucoxene. Plagioclase is sodic oligoclase. Grain size: Phenocrysts, 4 mm; groundmass, 0.4 mm average. Texture: Micrographic-porphyritic.

Rog-3-6, cuttings, 2513-2516 feet

QUARTZ MICROSYENITE PORPHYRY..... Perthite; plagioclase; quartz; opaque minerals; chlorite; calcite; sphene-leucoxene; feldspar alterations; zircon; apatite.

Quartz content is erratic and syenitic areas appear intimately associated with more normal micrographic granite. Phenocrysts of perthite and plagioclase are set in a hypidiomorphic granular groundmass composed almost entirely of perthite. Quartz may occupy an intergranular position and, where more abundant, form a modest amount of micrographic intergrowths. Calcite common as irregular patch replacement of feldspars. Chlorite appears to be pseudomorphic after a primary femic mineral. Grain size: Phenocrysts, 2.3+ mm; groundmass, 0.3 mm average. Texture: Porphyritic-hypidiomorphic-micrographic.

Rog-3-7, cuttings, 2500-2593 feet

MICROGRAPHIC MICROGRANITE PORPHYRY..... Micrographic quartz-feldspar, 71.7; plagioclase, 13.4; perthite, 8.1; chlorite, 2.9; feldspar alterations, 2.1; opaque minerals, 1.5; calcite, 0.2; zircon, tr.; epidote, tr.; sphene-leucoxene, tr.; apatite, tr.

Phenocrysts of plagioclase and perthite are set in a micrographic groundmass, distinctly coarser than previous intervals. Some plagioclase phenocrysts have a partial rim of perthite. Epidote as distinct grains within feldspars.

Chlorite is pseudomorphic after a former femic mineral. Sphene-leucoxene replaces titaniferous portions of the iron oxides. Sphene is also present as discrete irregular crystals having a yellow-brown color. Grain size: Phenocrysts, 2.8 mm; groundmass, 0.8 mm average. Texture: Micrographic-porphyritic.

Rog-3-9, cuttings, 2611-2701 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 61.0; perthite, 12.8; plagioclase, 9.7; feldspar alterations, 7.1; chlorite, 3.6; iron ore, 1.9; epidote, 1.7; actinolitic amphibole, 0.6; calcite, tr.; apatite, tr.; zircon, tr.; biotite, tr.; sphene, tr.

Phenocrysts of both perthite and plagioclase are turbid and contain numerous epidote granules and clay-mica alterations. The groundmass feldspar contain less recognizable alteration material but contain abundant disseminated hematite dust. Chlorite is as a total and partial replacement of actinolite crystals which appear to replace a former primary femic mineral. Small amounts of strongly pleochroic red-brown biotite are present. Grain size: Phenocrysts, 3.5 mm; groundmass, 1 mm average. Texture: Micrographic-porphyritic.

Rog-3-11, cuttings, 2701-2787 feet.

MICROGRAPHIC MICROGRANITE PORPHYRY..... Micrographic quartz-feldspar, 63.3; perthite, 17.8; plagioclase, 9.9; chlorite, 5.7; epidote, 2.2; opaque minerals, 0.6; calcite, 0.4; sphene-leucoxene, 0.3; feldspar alterations, tr.; fluorite, tr.; apatite, tr.; zircon, tr.; tremolitic amphibole, tr.

Feldspar phenocrysts are set in a rather delicate micrographic intergrowth of quartz-feldspar. Epidote is particularly common and well crystallized. Sphene is slightly zoned with a reddish brown less birefringent type near the cores. Chlorite is pseudomorphic after a former femic mineral--a small relict to tremolitic amphibole remains. Groundmass is somewhat more delicate than the previous interval and tends to be radial or subradial around phenocrysts. Grain size: Phenocrysts, 2.7 mm maximum; groundmass, 0.7 mm average. Texture: Micrographic-porphyritic.

Rog-3-12, cuttings, 2801-2899 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic intergrowth,

62.4; plagioclase, 18.3; perthite, 12.9; chlorite, 2.6; epidote, 2.1; actinolitic amphibole, 0.9; opaque minerals, 0.5; apatite, 0.3; feldspar alterations, tr.; biotite, tr.; zircon, tr.; sphene, tr.

A coarser micrographic groundmass carries feldspar phenocrysts. Phenocrysts of feldspar contain numerous epidote granules and clouding alterations and hematite dust. Chlorite is associated in clots with actinolite, epidote and other accessory minerals. Sphene is in well former crystals the cores of which are mildly pleochroic reddish brown in color, and are less birefringent than the pale brown outer margins. Epidote as an intergranular replacement is well crystallized. Some plagioclase phenocrysts have a perthitic rim. Granular sphene-leucoxene is present as an alteration of titaniferous magnetite and associated with chlorite. Small amounts of discrete coarser quartz are noted, some have margins rudely intergrown. Apatite attains an unusual length, 0.7 mm. Biotite as small groups of olive green books, probably primary. Grain size: Phenocrysts, 4.2+ mm; groundmass, 1.2 mm average. Texture: Micrographic porphyritic.

This well penetrated 863 feet of basement rock and is the deepest penetration of the Spavinaw Granite Group. The syenitic intervals may be later dikes or, because of their apparent gradational character, may be segregated masses. The former interpretation appears most plausible. An Rb/Sr determination on the feldspar from the granite yielded an age of 1230 ± 160 m.y. It is interesting to note the coarsening of groundmass grain size with depth suggesting the upper part is chilled.

(Possibly) Irvin No. 1 Cox, 23-20N-14E, Rogers County (?)

Rog-4-1, cuttings, 3181-3190 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; feldspar; biotite-chlorite; opaque minerals; sphene-leucoxene; feldspar alterations.

Relatively small cutting chips in connection with a coarser than average micrographic granite porphyry make this a rather difficult rock to study. Quartz is faintly strained even in the intergrowths which is unusual. The feldspar appears to be perthite but 2V is very low. Iron dust is disseminated throughout and clouding vacules--alteration are common. Sericite mats are present as an intergranular replacement. Thin veinlets of biotite-chlorite cut several feldspars. Grain size: Phenocrysts, 3+ mm maximum; groundmass, 2.5+ mm. Texture: Micrographic porphyritic.

This well is not plotted on Plate I because it is

not sure which well the samples came from. The best indication is that they were obtained from the Irvin No. 1 Cox. In any case the interpretation is not altered and the rock is an example of the Spavinaw Granite Group.

T. J. Foster No. 1 Burke-Mabee, 15-13N-25E, Sequoyah County

Sq-1-1, cuttings, 3208 feet cir.

RHYOLITE PORPHYRY?..... Groundmass, 69.7; plagioclase, 13.3; perthite, 9.8; feldspar alterations, 3.2; chlorite, 2.9; opaque minerals, 0.7; sphene-leucoxene, 0.5; apatite, tr.; zircon, tr.; calcite, tr.

This quartz-poor rhyolite is very rich in chlorite pseudomorphs that suggests possibly this rock is allied more to the Spavinaw granites. Both perthite and plagioclase (albite) phenocrysts are very abundant. The perthite phenocrysts are wormy and rounded, the plagioclase is more nearly euhedral but are highly sericitized. Some plagioclase cores are almost completely altered. Fibrous chloritic masses are associated with opaque minerals, apatite, zircon and sphene-leucoxene. Secondary calcite masses associated with chlorite and as irregular blebs. The alteration of feldspars is extensive and the rock has a general "frayed" appearance in thin section. The groundmass is difficult to resolve but appears to be high in feldspar. It also contains some quartz in an intergrowth. Grain size: Phenocrysts, 2.0+ mm; groundmass, 0.1 mm to microcrystalline. Texture: Spherulitic-micrographic porphyritic.

This rock could be an exceptionally chilled variety of the Spavinaw Granite as suggested by the quartz poor-femic rich character of the rock. However, texture suggests it is probably related to the Washington County Volcanic Group.

Oklahoma Natural Gas Co. No. 1 Stockton, 20-11N-26E, Sequoyah County

Sq-2-1, core, 6145-6146 feet

METARHYOLITE PORPHYRY..... Groundmass, 80.5; plagioclase, 9.6; perthite, 6.0; epidote, 2.3; chlorite, 0.6; sphene, 0.5; opaque minerals, 0.4; feldspar alterations, tr.; calcite, tr.; zircon, tr.; apatite, tr.

Phenocrysts of plagioclase and perthite are set in an interlocking (granoblastic) mosaic of quartz-feldspar containing lesser amounts of chlorite, opaque minerals, epidote. Plagioclase phenocrysts contain discrete and grouped epidote

crystals and are much less clouded than perthite. Plagioclase phenocrysts generally are subhedral to anhedral and commonly have a thin rim of perthite. Perthites are clouded with vacuoles and hematite dust. Alterations of a micaceous type are rare. Epidote is unusually abundant in masses associated with chlorite. Sphene is commonly associated with the epidote. Veinlets of quartz and epidote are present. Grain size: Phenocrysts, 3.0 mm; groundmass, 0.1 mm average. Texture: Porphyritic-xenomorphic (granoblastic?).

The groundmass of this rhyolite may either be primary xenomorphic or reconstituted to a granoblastic mosaic. The rhyolite is a member of the Washington County Volcanic Group and may have been reconstituted by granite injection of the Central Oklahoma Granite Group. An Rb/Sr determination total rock yielded an age of 1230 ± 220 m.y.

Fred De Mier No. 3A Bruner, 6-19N-12E, Tulsa County

Tu-1-1, cuttings, 2715-2720 feet

ALTERED WELDED RHYOLITE TUFF..... Groundmass, 96.4; quartz, 1.3; perthite, 0.9; pyrite, 0.6; plagioclase, tr.; chlorite, tr.; opaque minerals, tr.; feldspar alterations, tr.

The variation in texture is marked. Some cutting chips are strongly flow banded presumably with distorted shards since there is nearly a complete variation to crystal fragments, obviously pyroclastic, surrounded by a structureless chertose groundmass. Groundmass is extensively silicified. Opaque minerals, mostly secondary, outline banding and replace veinlets through the groundmass. Well defined concave surfaces are not uncommon on quartz detritus. Coarser bands in the strongly flow banded portions contain numerous spherulites. Clay-sericite replace some feldspar phenocrysts completely. Grain size: Phenocrysts, 0.9 mm; groundmass, microcrystalline average. Texture: Porphyritic-spherulitic-eutaxitic.

Tu-1-2, cuttings, 2720-2725 feet

ALTERED RHYOLITE PORPHYRY..... Groundmass, 93.7; feldspar, 4.4; quartz, 1.2; opaque minerals, 0.3; sphene-leucoxene, 0.3; feldspar alterations, tr.; chlorite, tr.

Phenocrysts cannot be differentiated in every case. Phenocrysts of plagioclase and quartz with small less numerous perthite are set in a devitrified groundmass apparently silicified into a chertose mosaic. Numerous faint relict structures remain. Perlitic-like structures are replaced by coarser

feldspar and amygdules are largely quartz-feldspar with a small amount of well crystallized, strongly pleochroic chlorite. Hematite or sphene-leucoxene replace the former ilmenite-magnetite. Grain size: Phenocrysts, 1.5 mm; groundmass, microcrystalline average. Texture: Porphyritic - relict perlitic - amygdaloidal.

These rocks show excellent extrusive characters and are located near the southern margin of the Washington County Volcanic Group. The altered character may be due to the close proximity of the Spavinaw Granites.

Wilcox No. 1 Hulputta, 27-17N-14E, Tulsa County

Tu-2-1, cuttings, 3370-3375 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; plagioclase; chlorite; opaque minerals; feldspar alterations; epidote; biotite, sphene; zircon, apatite.

All cutting chips are less than 2 mm in diameter. Perthite and plagioclase phenocrysts are set in a micrographic intergrowth. Plagioclase crystals contain discrete epidote crystals and sericitic shreds. Perthite contains more disseminated hematite dust. Secondary biotite and chlorite are associated in masses. Opaque minerals replace portions of the feldspar along twinning planes. Grain size: Phenocrysts, 2+ mm; groundmass, 0.8+ mm average. Texture: Micrographic-porphyritic.

This well penetrated rock of the Spavinaw Granite Group.

Kewanee Oil Co. No. 16 Stewart, 4-16N-13E, Tulsa County

Tu-3-1, cuttings, 2396-2398 feet

MICROGRAPHIC MICROGRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; plagioclase; chlorite; opaque minerals; feldspar alterations; epidote; sphene-leucoxene; calcite; apatite; zircon.

A very delicately micrographic intergrowth is in part highly spherulitic. Perthite and plagioclase phenocrysts are turbid with hematite dust and alterations. Magnetite needles are roughly parallel inclusions within spherulitic intergrowth. Chlorite is pseudomorphic after a former femic mineral. Sphene-leucoxene has replaced titaniferous magnetite. Calcite is associated with chlorite. Epidote granules are included as alteration within phenocrysts of feldspars--mostly

plagioclase. Grain size: Phenocrysts, 2+ mm; groundmass, 0.3 mm average. Texture: Micrographic-porphyritic-spherulitic.

This is an example of the finer grained Spavinaw Granite Group and delicate spherulitic intergrowths suggest this is a chilled phase.

Texaco No. 25 WS J. M. Adkinson, 32-21N-13E, Tulsa County

Tu-4-3, cuttings, 2750-2810 feet

RHYOLITE TUFF FLOW..... Groundmass, 65.0; perthite, 12.0; plagioclase, 10.0; quartz, 9.0; feldspar alterations, 4.0; opaque minerals, 1.0; apatite, tr.; chlorite, tr.; sphene-leucoxene, tr.; zircon, tr.

Great variation in texture and mineralogy of cutting chips. All appear to be crystal to devitrified glassy tuff but eutaxitic texture is poorly preserved. In crystal rich portions, small quartz detritus is rounded and very numerous. A few large quartz phenocrysts are present. The groundmass is a deep reddish due to included hematite. Various amygdule and void fillings are largely quartz and chlorite with some feldspar. These amygdules are most abundant in the feldspar-rich, quartz-poor cutting chips. Grain size: Phenocrysts, 2.5 mm; microcrystalline average. Texture: Porphyritic - relict eutaxitic.

This well penetrated extrusive rock of the Washington County Volcanic Group.

Texas Tulsa Refinery, 23-19N-12E, Tulsa County

Tu-5-1, cuttings, 3434-3442 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; perthite; plagioclase; opaque minerals; chlorite; feldspar alterations.

Very small cutting chips make textural interpretation difficult. Plagioclase phenocrysts are slightly clouded with alteration and contain small amounts of hematite, mainly along cleavage cracks. The perthite-quartz intergrowth is delicate and not particularly uniform. Some plagioclase contains antiperthitic blebs. Opaque minerals are irregular in shape and are associated in part with minor chloritic masses. One small quartz phenocryst appears to be largely resorbed. Grain size: 1.5+ mm. Texture: Micrographic porphyritic.

This well penetrated rock of the Spavinaw Granite Group.

Dowell No. 1 Fee, 31-20N-13E, Tulsa County

Tu-6-1, cuttings, 3300-3310 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 55.2; perthite, 17.6; plagioclase, 16.9; chlorite, 6.2; epidote, 2.0; calcite, 1.0; actinolitic amphibole, 0.7; opaque minerals, 0.5; sphene-leucoxene, tr.; feldspar alterations, tr.; apatite, tr.; zircon, tr.

Perthite and plagioclase phenocrysts are set in a micrographic to hypidiomorphic groundmass chiefly of quartz-perthite. Chlorite and actinolitic amphibole are common and appear to be secondary, possibly after common hornblende. Feldspars contain abundant discrete epidote crystals; epidote is also concentrated along veinlets. Sphene-leucoxene is associated with chlorite and discrete sphene crystals are in groundmass. Small amounts of biotite are present as tiny crystals. Grain size: Phenocrysts, 2+ mm; groundmass, 0.8 mm average. Texture: Micrographic-hypidiomorphic-porphyritic.

The micrographic and chlorite rich character are typical of the Spavinaw Granite Group.

Superior Oil Co. No. 1 Blakemore, 26-21N-13E, Tulsa County

Tu-7-1, cuttings, 1363-1365 feet

RHYOLITE PORPHYRY..... Groundmass, 65.0; plagioclase, 21.0; perthite, 4.0; chlorite, 3.0; epidote, 2.0; opaque minerals, 2.0; feldspar alterations, 1.0; apatite, tr.; sphene, tr.

Phenocrysts of plagioclase and lesser amounts of perthite are set in a felsophyric intergrowth of quartz-perthite. Zoisite replaces extensively in some feldspars and is also associated as rounded, well crystallized masses associated with chlorite and may be a pseudomorph. Small amounts of calcite are associated with the zoisite. Some clear areas in plagioclase phenocrysts are surrounded by sericite masses. Phenocrysts are rounded and embayed to nearly euhedral. Grain size: Phenocrysts, 2.7 mm; groundmass, microcrystalline average. Texture: Porphyritic-felsophyric.

Tu-7-2, cuttings, 1407-1422 feet

RHYOLITE PORPHYRY.....

Relative few cutting chips of small size indicate this is essentially the same mineralogy and texture as the

previous interval. Grain size: 2.5 mm maximum; microcrystalline average. Texture: Porphyritic-felsophyric.

This well penetrated rhyolite of the Washington County Volcanic Group.

Superior No. 2 Blakemore, 26-21N-13E, Tulsa County

Tu-8-1, cuttings, 1576-1580 feet

RHYOLITE PORPHYRY..... Groundmass; feldspar; quartz; feldspar alterations; opaque minerals; chlorite-biotite; sphene-leucoxene; apatite.

Only very small cutting chips are available. Feldspar phenocrysts are almost completely replaced by clay-mica alterations. Leucoxene replaces much of the ilmenite. The groundmass is a felsophyric intergrowth of quartz and feldspar, faintly spherulitic in part. Apatite needles are numerous and comparatively large. Chlorite-biotite replaces a former femic mineral and fills a thin veinlet associated with iron oxides. Grain size: Phenocrysts, 0.9+ mm; groundmass, microcrystalline average. Texture: Porphyritic-felsophyric.

Tu-8-2, cuttings, 1580-1586 feet

RHYOLITE PORPHYRY..... Groundmass; perthite; plagioclase; quartz; feldspar alterations; opaque minerals; chlorite; epidote; sphene-leucoxene; apatite.

Essentially similar to the previous interval though feldspars are much fresher. Both perthite and plagioclase phenocrysts are present, clouded by alterations and hematite dust. The felsophyritic quartz-feldspar groundmass contains tiny disseminated epidote and chlorite. Chlorite and epidote also in coarser crystals. Plagioclase is calcic albite. Cutting chips are small, the largest smaller than 1.5 mm. Grain size: Phenocrysts, 1.1+ mm; groundmass, microcrystalline average. Texture: Porphyritic-felsophyric.

This well is in the same section as Tu-7 and is a member of the Washington County Volcanic Group.

Dotson, et al. No. 1-B Jefferson, 23-19N-11E, Tulsa County

Tu-9-1, cuttings, 3014-3015 feet

PYROXENE MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar, 64.1; perthite, 10.3; plagioclase, 9.3; chlorite, 5.0; feldspar alterations, 5.0; opaque minerals, 3.3;

epidote, 0.8; sphene-leucoxene, 0.7; pyroxene, 0.5; sphene, 0.5; actinolitic amphibole, 0.4; apatite, tr.

This is one of the few wells in the Spavinaw granite containing a primary femic mineral. Augite is found as discrete crystals and relicts mantled by chlorite. Perthite and plagioclase phenocrysts are set in a quartz-feldspar intergrowth. Chlorite and actinolitic amphibole replace most of the former augite. Sphene is in well formed anhedral crystals and with leucoxene as a replacement of ilmenite. Epidote is in small granules with other feldspar alterations in phenocrysts and as discrete intergranular crystals. Grain size: Phenocrysts, 2.5 mm; groundmass, 0.8 mm average. Texture: Micrographic-porphyritic.

The augite in the Spavinaw Granite Group is unusual but this well together with two others almost due south (Ck-3, Om-5) are characterized by this distinctive mineral.

Taylor No. 6-B Garrett, 3-27N-13E, Washington County

Ws-2-1, cuttings, 2280-2289 feet

WELDED RHYOLITE TUFF..... Groundmass; perthite; plagioclase; quartz; rock fragments?; chlorite; opaque minerals; feldspar alterations; sphene-leucoxene; carbonate; epidote; zircon; apatite.

Numerous phenocrysts of perthite, plagioclase, quartz, and possibly rhyolite rock fragments are set in a highly banded groundmass. The banding is very delicate but is best shown in polarized light due to devitrification patterns. The phenocrysts in some chips are exceptionally variable size and have a broken appearance. Large chlorite pseudomorphs associated with sphene-leucoxene replace former femic phenocrysts. Feldspars are turbid with alterations and hematite dust. Grain size: Phenocrysts, 2.7 mm; groundmass, microcrystalline average. Texture: Porphyritic-eutaxitic?

This is one of several definitely extrusive rocks in this area and is a representative of the Washington County Volcanic Group.

Reinhart and Donovan No. 1 Abel, 27-24N-13E, Washington County

Ws-3-1, cuttings, 2995-3007 feet

RHYOLITE PORPHYRY..... Groundmass; perthite; quartz; albite; opaque minerals; chlorite-biotite; feldspar alterations; epidote; sphene-leucoxene; zircon.

Phenocrysts of perthite and plagioclase are set in a groundmass of quartz-feldspar deeply colored with hematite. The groundmass is slightly coarser than most rhyolites and delicate micrographic intergrowths are associated with the non-intergrown felsophyric type. Chlorite-biotite in fibrous masses, both are secondary. Some deeper olive green biotite may be primary. Thin quartz veinlets cut rhyolite. Clay-mica alterations are irregular in feldspars and are generally mottled. Grain size: Phenocrysts, 1.2+ mm; groundmass, 0.1 mm average. Texture: Porphyritic-micrographic-felsophyric.

This well penetrated rhyolite of the Washington County Volcanic Group.

Empire Gas and Fuel No. 3 McElmore, 25-25N-12E, Washington County

Ws-4-1, cuttings, 2250-2340 feet

RHYOLITE PORPHYRY (TUFF?)..... Plagioclase; quartz; K-feldspar; opaque minerals; feldspar alterations; zircon; groundmass.

Small phenocrysts of feldspar and quartz are set in a flow banded devitrified groundmass with suggestions of a welded tuff origin. Banding is apparent even though cutting chips are very small, all less than 1.5 mm. One small chip of micrographic granite is present and is deep reddish in contrast of grey color of rhyolite. Chlorite and alteration micas not identified. Feldspars are clouded slightly and contain small amounts of hematite dust. Grain size: Phenocrysts, 0.7+ mm; groundmass, microcrystalline average. Texture: Porphyritic - felsophyric - relict eutaxitic.

Ws-4-2, cuttings, 2340-2350 feet

RHYOLITE PORPHYRY (TUFF?)..... Groundmass; plagioclase; perthite; quartz; opaque minerals; sphene-leucoxene; pyrite; zircon.

Phenocrysts of perthite, plagioclase and quartz are set in a highly flow banded devitrified groundmass. Many secondary and a few primary spherulites are found in the groundmass. Some banding suggested tuffaceous origin but well defined proof is lacking. Ragged opaque microlites are present throughout the groundmass and tend to outline the flow bands. Chlorite is absent. Grain size: Phenocrysts, 0.7+ mm; groundmass, microcrystalline average. Texture: Porphyritic - spherulitic - felsophyric - relict eutaxitic.

Ws-4-3, cuttings, 2350-2368 feet

RHYOLITE PORPHYRY (TUFF?)..... Groundmass; plagioclase; perthite; quartz; opaque minerals; sphene-leucoxene; pyrite; zircon.

Delicate banding suggests devitrified welded tuff. Phenocrysts of quartz perthite and perthite are set in a groundmass composed of quartz-feldspar in a partly spherulitic and partly felsophyric intergrowth. Titaniferous magnetite granules are partly altered to sphene-leucoxene. The evidence for tuff origin is better in this interval than the other two, though they are very similar. Grain size: Phenocrysts, 1.5+ mm; groundmass, microcrystalline average. Texture: Porphyritic-relict eutaxitic.

This well contained rhyolites that had features suggestive of a tuffaceous origin. Individually the evidence is not strong but jointly they cannot be disregarded. It is therefore interpreted as a tuffaceous rhyolite of the Washington County Volcanic Group.

Barnsdall (Roxanna) No. 7 Rigdon, 30-28N-13E, Washington County

Ws-5-1, cuttings, 2548-2552 feet

RHYOLITE TUFF..... Groundmass 44.5; perthite, 15.1; plagioclase, 14.7; quartz, 13.1; rock fragments, 6.8; sphene-leucoxene, 2.4; feldspar alterations-calcite, 1.6; opaque minerals, 1.2; zircon, tr.; apatite, tr.

A very high percentage of crystalline debris together with less common rock fragments of volcanic origin combine to make this a tuff. There is little well defined evidence for welding or ash flow origin but the general groundmass appearance suggests possible ash flow movement. Large whole embayed quartz phenocrysts are present with smaller quartz fragments. The feldspars are iron rich and contain micaceous alterations. Hematite particularly common in groundmass. Groundmass is a dense felsophyric intergrowth. Grain size: Phenocrysts, 2.2 mm; groundmass, microcrystalline average. Texture: Porphyritic - eutaxitic-felsophyric.

Ws-5-2, cuttings, 2552-2556 feet

WELDED RHYOLITE TUFF..... Groundmass; perthite; quartz; plagioclase; feldspar alterations; opaque minerals; chlorite; sphene-leucoxene; apatite; zircon.

There is a suggestion of welding and distortion in groundmass, particularly around phenocrysts. Large phenocrysts of perthite, plagioclase and quartz are present with rare fragments of chlorite containing abundant sphene-leucoxene. Opaque minerals replace in linear trends cutting both groundmass and phenocrysts. Feldspar phenocrysts are highly altered and some are completely replaced by a fibrous mat of sericite-clay. Groundmass contains abundant finely disseminated hematite. Grain size: Phenocrysts, 1.8 mm; groundmass, microcrystalline average. Texture: Eutaxitic-porphyritic.

The high percentage of debris in this welded tuff is unusual in the Washington County Volcanic Group.

Empire Gas and Fuel Thompson, 22-29N-13E, Washington County

Ws-6-1, cuttings, 2700-2703 feet

RHYOLITE TUFF..... Groundmass; perthite; quartz; plagioclase; opaque minerals; feldspar alterations; chlorite; sphene-leucoxene; apatite; zircon.

The groundmass is a structureless mosaic of quartz and feldspar varying in grain size. Some of the phenocrysts have a decidedly clastic appearance suggesting tuffaceous origin. The groundmass is rich in opaque minerals, both hematite and magnetite blebs, and contains small chloritic masses with associated apatite and sphene-leucoxene. Sericite flakes are well developed in some perthite phenocrysts. Grain size: Phenocrysts, 1.4+ mm; groundmass, microcrystalline but variable. Texture: Porphyritic-eutaxitic.

Ws-6-2, cuttings, 2772-2781 feet

RHYOLITE TUFF..... Groundmass; perthite; quartz; plagioclase; sericite; opaque minerals; chlorite; calcite; sphene-leucoxene; zircon.

Small cutting chips make this interval difficult to define texturally. "Phenocrysts" of quartz, perthite and plagioclase together with what appears to be altered groundmass fragments are set in a chertose mosaic of iron rich quartz-feldspar. Chlorite is in small fibrous masses in groundmass. Sericite is found both in groundmass and included within phenocrysts and clastic particles. Vague flow lines outlined by opaque mineral trails, contorted around phenocrysts. One large feldspar is delicately veined with sericite and calcite. Grain size: Phenocrysts, 2.0+ mm; average, microcrystalline but variable. Texture: Porphyritic-eutaxitic.

Ws-6-3, cuttings, 2839-2853 feet

RHYOLITE TUFF..... Plagioclase; quartz; sanidine; opaque mineral; chlorite; feldspar alterations; sphene; epidote; apatite.

This is a most unusual rock because of the occurrence of a sanidine-like feldspar, clear, unaltered and with an anomalous 2V, about 20°. It is much less altered than normal perthite. Plagioclase phenocrysts are sericitized. Groundmass is a quartz-feldspar mosaic rich in hematite. Magnetite phenocrysts have a thin rim of sphene. Sericite and minor epidote replacement is noted in groundmass. Some phenocrysts have concave surfaces suggesting pyroclastic origin. Sanidine was not positively identified in two previous intervals. Grain size: Phenocrysts, 1.0+ mm; groundmass, microcrystalline average. Texture: Porphyritic-eutaxitic.

This well is unusual in that it contained a sanidine-like feldspar with an anomalous 2V. This strongly suggests the rock has not been disturbed since extrusion except for simple devitrification. This rhyolitic rock is a member of the Washington County Volcanic Group.

Green and Jones S-1 Hillebrand, 20-26N-13E, Washington County

Ws-7-1, cuttings, 2167-2175 feet

RHYOLITE PORPHYRY (TUFF?)..... Groundmass; plagioclase; perthite; quartz; opaque minerals; feldspar alterations; pyrite; sericite.

Suggestion of eutaxitic texture is firm but definite proof is lacking, largely because of devitrification. Perthite phenocrysts are partly altered and some plagioclase is rimmed by perthite. Pyrite fills in linears roughly parallel to flowage. Banding in groundmass is marked and very delicate. Devitrification patterns are varied and in part controlled by banding. An area of sericite-opaque mineral-sphene appears to replace a former micaceous mineral, perhaps biotite. Flow banding very marked. Grain size: Phenocrysts, 1+ mm; groundmass, microcrystalline average. Texture: Porphyritic-eutaxitic - spherulitic.

Ws-7-2, cuttings, 2345-2357 feet

RHYOLITE PORPHYRY (TUFF?)..... Groundmass; perthite; plagioclase; pyrite; quartz; opaque minerals; chlorite; feldspar alterations; sphene-leucoxene; calcite; zircon; sericite.

This is basically very similar to the previous

interval. Banding is marked even though the cutting chips are very small. Perthite phenocrysts are more clouded with vacuoles and hematite dust than plagioclase. Contorted banding around phenocrysts is suggestive of devitrified eutaxitic texture. Flakes of sericite and small amounts of calcite are included in plagioclase. Chlorite-sericite and sphene replace a mica, probably biotite. Spherulites are present in some feldspar rich devitrification bands. Grain size: Phenocrysts, 1.5 mm; groundmass, microcrystalline average. Texture: Porphyritic - felsophyric - relict eutaxitic.

Ws-7-3, c ngs, 2221-2226 feet

WELDED RH TE TUFF..... Groundmass, 77.5; perthite, 11.4; quartz, 3 plagioclase, 3.9; pyrite, 3.3; opaque minerals, tr.; feld alterations, tr.; zircon, tr.; sphene-leucoxene, tr.; chlo -biotite, tr.

storted shards very well defined wrapping around phenocrys of perthite plagioclase and highly embayed to broken an ngular quartz. The titaniferous iron oxide has been alte to sphene-leucoxene. Feldspar phenocrysts contain abun t disseminated hematite. Sericite flakes are in unoriente hreds within feldspars. Chlorite-biotite is as minor sec ary masses. Some coarser veins suggest mineralogic ban g. Grain size: Phenocrysts, 1.7 mm; groundmass, microcrys a. line average. Texture: Porphyritic-relict eutaxitic

Ws-7-6, c ings, 2257-2262 feet

WELDED RI LITE TUFF..... Groundmass, 88.3; perthite, 6.2; quartz, ; plagioclase, 1.8; pyrite, 1.3; opaque minerals, tr.; fel ar alterations, tr.; sphene-leucoxene, tr.; zircon, tr.

devitrified groundmass contains relict distorted shards c orted around phenocrysts of quartz-plagioclase and perthite Rude compositional banding is noted by much coarser bands wi n the generally submicroscopic devitrification products Large opaque granules form phenocrysts as well as being di minated through the groundmass. Zircon is included within m netite. Leucoxene replaces portions of the titaniferous mag stite. Grain size: Phenocrysts, 3 mm; groundmass, microcrystalline average. Texture: Porphyritic-eutaxitic.

This is one of the deepest penetrations of rhyolite, some 380 feet, in the Washington County Volcanic Group.

Bonaventure S-1 Chamberlain, 8-27N-14W, Washington County

Ws-8-1, cuttings, 2280-2290 feet

RHYOLITE PORPHYRY..... Groundmass, 82.2; plagioclase, 8.5; perthite, 7.1; chlorite, 1.2; pyrite, 0.5; sphene-leucoxene, 0.3; epidote, 0.2; feldspar alterations, tr.; opaque minerals, tr.; apatite, tr.; calcite, tr.; zircon, tr.

Phenocrysts of perthite and plagioclase are set in a quartz-feldspar groundmass deeply colored with disseminated hematite. The groundmass is quartz-poor in relation to most of the rhyolites. Epidote granules replace portions of the plagioclase. Sphene and sphene-leucoxene replace titaniferous magnetite and is associated as small granules with chlorite. Calcite replaces in irregular masses. Chlorite masses are in pseudomorphic masses after a femic mineral and disseminated through the groundmass. Apatite is particularly abundant. Pyrite is found as a thin vein. Grain size: Phenocrysts, 1.7 mm; groundmass, microcrystalline average. Texture: Porphyritic-felsophyric.

This well penetrated rhyolite of the Washington County Volcanic Group.

Kansas

Perry No. 1 Burney, 22-25S-25E, Bourbon County

Bb-1-1, cuttings, 1945-1950 feet

METAGRAYWACKE..... Matrix and related material, 55.1; undifferentiated feldspar, 15.1; lithic debris, 14.6; quartz, 7.1; plagioclase, 6.1; opaque minerals, 2.0; chlorite, tr.; calcite, tr.

Diverse mineral and lithic fragments are set in a matrix of sericite and quartz. The sericite, formerly clay, has a rude preferential orientation. The mineral clasts are chiefly quartz, plagioclase, perthite and sparse microcline. Lithic debris is diverse, rhyolite groundmass fragments, siliceous metamorphic rocks, argillite (?), chert, and myrmekite. Calcite in poorly crystalline masses replaces parts of the matrix. Hematite is common in the matrix, general as disseminated dust and veins rather than granules. Small masses of chloritic micas are associated with sericite. Grain size: To 0.5 mm. Texture: Crystalloblastic-relict clastic.

Perry No. 1 Burney, 22-25S-25E, Bourbon County

Bb-1-2, cuttings, 1990-1995 feet

ARKOSIC METAGRAYWACKE..... Sericite-matrix material, 39.5; feldspar, 20.2; epidote, 13.0; quartz, 11.1; lithic debris, 9.9; sphene-leucoxene, 4.0; opaque minerals, 1.6; chlorite, 0.8; pyrite, tr.

This interval differs from the previous in the abundance of epidote, sphene-leucoxene, and magnetite. The reconstitution appears more complete with lithic fragments either less abundant or more recrystallized. Sericite-quartz matrix separates most grains and rounded sericite masses may be clay pellets in origin. Epidote replaces portions of the matrix and feldspar clasts. Plagioclase, perthite and quartz are most abundant as arenaceous minerals. Sphene is in granular masses. Chlorite masses are feebly birefringent. Grain size: To 0.5 mm. Texture: Crystalloblastic-relict clastic.

The occurrence of lithic detritus of rhyolite origin is exceptionally important in this example of the Vernon County Metamorphic Group and proves that the sediments are at least in part later than some of the rhyolites.

Oklahoma Natural Gas No. 1 Stephenson, 16-26S-24E, Bourbon County

Bb-3-1, cuttings, 1823-1827 feet

HEMATITIC ARGILLITE OR PHYLLITE..... Sericite; hematite; quartz; feldspar.

Fine grained rock consisting of fine sericitic micas and sparse silt sized clasts of quartz and feldspar. Hematite is exceptionally common as disseminated flakes with concentrations along "bedding" and as granule forms. Some distortion is noted suggesting folding after incipient metamorphism. Some shears are outlined by hematite. Some clastic mica is noted of superior size generally rimmed with hematite. Grain size: To 0.04 mm. Texture: Lepidoblastic-relict clastic.

Oklahoma Natural Gas No. 2 Stephenson, 16-26S-24E, Bourbon County

Bb-3-2, cuttings, 1915-1922 feet

PHYLLITE AND PHYLLITIC METASILTSTONE..... Sericite; quartz; hematite; chlorite; epidote; tourmaline.

Some bedding is noted, marked by more silty layers and more argillaceous beds. Several chips are composed of sheared quartz. The purity of the chips suggests these are quartz veins later deformed rather than sandy intervals. Chloritic flakes with sericite are the largest crystalloblastic mineral. Masses of chlorite with attendant hematite appear as reddish blotches. Definite preferred orientation of micas is marked. Small olive-green tourmalines are present. Grain size: To 0.1 mm. Texture: Lepidoblastic-relict clastic.

Oklahoma Natural Gas No. 1 Stephenson, 16-26S-24E, Bourbon County

Bb-3-3, cuttings,

PHYLLITE AND PHYLLITIC METASILTSONE..... Sericite; quartz; chlorite; opaque minerals; tourmaline; epidote; sphene; zircon.

The first interval picked from greenish rock. The greenish color is due to chlorite. In chips cut normal to foliation the chlorite is oriented parallel to shear planes cutting foliation at 60°-45°. Preferred orientation of white

mica is good. Silty chips contain quartz detritus averaging 0.06 mm with most grains separated by a mica matrix. Green tourmaline and small epidote prisms are sparse but consistent crystalloblastic minerals. Opaque minerals are found as silt size granules. Grain size: 0.06 mm average. Texture: Lepidoblastic-relict clastic.

Oklahoma Natural Gas No. 1 Stephenson, 16-26S-24E, Bourbon County

Bb-3-4, cuttings, 2066-2070 feet

PHYLLITE AND PHYLLITIC METASILTSTONE.....
About the same as the previous interval.

Oklahoma Natural Gas No. 1 Stephenson, 16-26S-24E, Bourbon County

Bb-3-5, cuttings, 2171-2176 feet

PHYLLITE AND PHYLLITIC METASILTSTONE..... Sericite; quartz; chlorite; opaque minerals; tourmaline; calcite; zircon.

Several chips show a bedding that is caused by mineral variation and grain size differences. Most sericitic micas have a preferred orientation parallel to bedding. Bedding is in part very delicate, some less than 0.1 mm in width. Coarser intervals contain unoriented chlorite. In general the suggestion is mimetic growth in fine intervals but where coarser silt interfered, growth was random. Grain size: To 0.06 mm. Texture: Lepidoblastic-relict clastic.

Oklahoma Natural Gas No. 1 Stephenson, 16-26S-24E, Bourbon County

Bb-3-6, cuttings, 2366-2374 feet

PHYLLITE AND PHYLLITIC METASILTSTONE..... Quartz; sericite; opaque minerals; chlorite; epidote; calcite; sphene-leucoxene.

The silty intervals contain quartz detritus surrounded by fine micaceous minerals. Phyllite chips contain preferentially oriented micas, some containing brown spots and chloritic masses. Quartz veins cut host rock, some are brecciated, others unstrained and faintly zoned with an epidote rich margin. Small epidote granules are found in the micaceous matrix. Tourmaline was not identified. Sphene-leucoxene granules are common in some chips. Grain size: To

0.12 mm. Texture: Lepidoblastic-relict clastic.

This well 598 feet of incipiently metamorphosed clastic rock. The coarse metagraywackes found in the Perry No. 1 Burney (Bb-1) about nine miles to the northeast were not identified. The upper portion of the basement, to about 1928 feet, is characterized by a very reddish color caused by oxidation of the iron minerals. The lower portion is characteristically greenish, caused by chlorite. The well drilled rock of the Vernon County Metamorphic Group.

Cities Service No. 36 Lathrop, 17-23S-4E, Butler County

Bt-2-1, cuttings, 3195-3200 feet

FELDSPAR-QUARTZ-MICA SCHIST..... Quartz; plagioclase; microcline; biotite; opaque minerals; muscovite; carbonate; feldspar alterations; tourmaline; apatite.

Biotite and muscovite are set in a granular matrix of quartz-feldspar. The biotite and muscovite do not appear to share a common preferred orientation though both appear preferentially oriented. Muscovite is in larger sieved crystals while biotite is in small numerous books. Larger areas of quartz mosaic may be relict clasts. Smoky tourmaline with dusty inclusions are common. Carbonate invades in coarse crystals and is associated with mats of unoriented biotite mica shreds. Opaque iron oxides are common as disseminated granules. Feldspars are slightly altered and contain disseminated hematite. Grain size: To 0.3 mm. Texture: Lepidoblastic.

This well penetrated rock interpreted as belonging to the Vernon County Metamorphic Group. It is in the same section with the Phillips No. 23 Scully (Bt-5) containing a similar metamorphic rock.

Phillips No. 23 Scully, 17-23S-4E, Butler County

Bt-5-1, cuttings, 3585 feet cir.

MUSCOVITE-FELDSPAR-QUARTZ HORNFELS (?)..... Quartz; muscovite; plagioclase; microcline; chlorite; opaque minerals; calcite; biotite; pyrite; leucoxene; apatite.

Poikiloblasts of muscovite and plagioclase are conspicuous in some chips. There is a banding of composition and grain size but there is no apparent preferred orientation of muscovite or chlorite. The granoblastic mosaic of faintly banded quartz-plagioclase-microcline is variable in grain size but larger rounded quartz in fine matrix may be relict clasts.

Plagioclase poikiloblasts are roughly 1 mm in diameter and contain more alterations and disseminated hematite. Grain size: 0.5-1.0 mm. Texture: Poikiloblastic-granoblastic.

The lack of preferred orientation in this thin section may be due to the orientation of the cutting chips. A careful examination of the samples did not resolve the question. The rock is considered a member of the Vernon County Metamorphic Group.

Cities Service No. 1 Church, 13-23S-5E, Butler County

Bt-8-1, cuttings, 2200-2210 feet

GRANITE (GNEISSIC?)..... Microcline; quartz; plagioclase; feldspar alterations; biotite; iron oxides; calcite; pyrite; leucoxene; zircon.

Microcline is fresh and contains some string perthite. Small but persistent amounts of myrmekite are developed near the margins of large plagioclase. Discrete plagioclase is more clouded with alterations and disseminated hematite dust. Biotite is in small shreds along secondary veinlets. Quartz is in aggregates, is faintly strained and in part appears to be sheared and reconstituted. Granite is very poor in accessory minerals. Grain size: 5+ mm. Texture: Hypidiomorphic.

Cities Service No. 1 Church, 13-23S-5E, Butler County

Bt-8-2, cuttings, 2335-2345 feet

GRANITE (GNEISS?)..... Microcline; quartz; plagioclase; opaque minerals; feldspar alterations; biotite; zircon.

This rock is basically similar to the previous interval. Accessories are exceptionally sparse. Plagioclase is very near An_{20}. Shear-reconstitution is seen in quartz and aggregates of fine myrmekite;sutured quartz boundaries are common. No primary femic mineral remains and most biotite-chlorite is in crystalline veinlets of tiny shreds. Smaller plagioclase crystals are clouded with alterations while at least on large crystal is essentially free of alterations and opaque minerals. Grain size: 4+ mm. Texture: Hypidiomorphic.

Cities Service No. 1 Church, 13-23S-5E, Butler County

Bt-8-3, cuttings, 2540-2545 feet

GRANITE (GNEISS?)..... Microcline; quartz; plagioclase; biotite; feldspar alterations; opaque minerals; chlorite; zircon.

This rock is similar to previous intervals. Biotite is more abundant and in part appears to be crystalloblastic and partly poikiloblastic. Biotite is deeply colored and strongly pleochroic. Chlorite alterations are conspicuous in some biotite books but not in those that are crystalloblastic. Quartz is mildly strained. Microcline is slightly perthitic. Finer aggregates of myrmekite present in some cutting chips. Suturing-reconstitution of quartz, associated in part with myrmekite, suggest gneissic fabric. Grain size: 5+ mm. Texture: Hypidiomorphic.

This granite contained feldspar dated at 1.40 ± .12 b.y. by Rb/Sr methods. This is considered to be the initial age of the rock and thus is a member of the Chase County Granite Group. The metamorphic effects are considered to be related to the 1.2 by episode that is interpreted as having metamorphosed the rock of the Vernon County Metamorphic Group immediately to the south.

Adair No. 1 Methodist Church, 14-23S-5E, Butler County

Bt-10-1, cuttings, 2238-2245 feet

GRANITE (GNEISS?)..... Microcline; quartz; plagioclase; biotite-chlorite; feldspar alterations; opaque minerals; zircon.

Microcline contains some patch perthite, is generally fresh and locally contains numerous secondary biotite veinlets. Secondary biotite is common as mildly pleochroic unoriented shreds and coarser books. Plagioclase is extensively altered. Minor myrmekite is present. Quartz is faintly strained and has sutured boundaries. One cutting chip contains sericitized plagioclase as an aggregate, this suggests some crude banding. Grain size: 5+ mm. Texture: Hypidiomorphic.

The rock in this well is similar to the Cities Service No. 1 Church (Bt-8) about a mile to the east and is interpreted as a member of the Chase County Granite Group.

Adair No. 1-B White, 15-23S-~~15E~~ 5E Butler County

Bt-11-1, cuttings, 2220-2239 feet

GRANITE..... Microcline; quartz; plagioclase; biotite; feldspar alterations; opaque minerals; calcite; leucoxene-sphene; pyrite; apatite.

Microcline contains some string perthite and contains only minor alterations. Plagioclase is more altered and contains abundant hematite dust. Myrmekite is common. A mildly pleochroic biotite is apparently secondary along veinlets and a deep green-brown variety is strongly pleochroic is probably also secondary in masses. Quartz shows straining, sutured boundaries and general shear-reconstitution features. Magnetite-ilmenite granules have altered to sphene-leucoxene and hematite. Grain size: 3.5+ mm. Texture: Hypidiomorphic.

This well penetrated rock of the Chase County Granite Group.

Adair No. 1 Lilley, 15-23S-5E, Butler County

Bt-13-1, cuttings, 2378-2384 feet

GRANITE..... Microcline; plagioclase; quartz; hornblende; biotite; feldspar alterations; opaque minerals; chlorite; sphene-leucoxene; calcite; orthophroxene(?); apatite; zircon.

The femic mineral content is higher than "normal" granites in this area. Some hornblende, a deep olive-green variety, appears primary. A paler variety has a distinctly blue pleochroism of a sodic amphibole is associated with common hornblende. Biotite is also diverse--both a deeply colored olive-green and a pale green mildly pleochroic variety being present. A very mildly pleochroic hyperstene(?) is found in one chip. Microcline is fresh. Quartz is strained. Some of femic minerals appear to be secondary growth penetrating other minerals possibly under shearing conditions. Grain size: 4+ mm. Texture: Hypidiomorphic.

The possible pyroxene in this granite and indeed the general texture and mineralogy are similar to the Hawn No. 5 Jeffers Steel (Mr-13) and the Martin No. 1 Winsor (Cs-18) to the north. This well is in the same section with two other wells (Bt-11, Bt-14) that contain no suggestion of pyroxene. The rock is interpreted as a member of the Chase County Granite Group.

Adair No. 2B White, 15-23S-5E, Butler County

Bt-14-1, cuttings, 2335-2340 feet

GRANITE (GNEISS?)..... Microcline; plagioclase; quartz; feldspar alterations; opaque minerals; chlorite-biotite; calcite; sphene-leucoxene; zircon.

Most of the cutting chips on this slide are composed dominantly of microcline. Chips are generally small, all less than 3 mm. Feldspar alteration mainly restricted to the plagioclase and are associated with hematite dust. Quartz shows some extensive shear-reconstitution suturing. Biotite-chlorite appear to be a replacement of an original biotite and now contains abundant hematite. Small amounts of myrmekite are present. Grain size: 3+ mm. Texture: ?

This well penetrated rock of the Chase County Granite Group.

McCullough and Empire No. 1 Lilley, 23-23S-5E, Butler County

Bt-15-1, cuttings, 2785-2790 feet

GRANITE..... Microcline; plagioclase; quartz; calcite; feldspar alterations; chlorite; hornblende; opaque minerals.

Both microcline and plagioclase are fresh. Plagioclase is near An_{20}. Biotite-chlorite is partly replaced by calcite. Hornblende in short stubby crystals is included in feldspar, parts are replaced by biotite-chlorite. Myrmekite developed around plagioclase crystals. Quartz is generally not strained. Grain size: 2.2+ mm. Texture: Hypidiomorphic.

The well penetrated rock of the Chase County Granite Group.

Trapp and Smith No. 1 Covey, 24-23S-5E, Butler County

Bt-16-1, cuttings, 2235-2245 feet

GRANITE..... Microcline; quartz; feldspar alterations; biotite; opaque minerals; zircon.

Cutting chips are small and mostly single mineral fragments. Some large quartz shows numerous shear linears. Alterations are mottled in feldspar and are accompanied by hematite dust. Microcline is partly perthitic. Plagioclase is not present in the slide and probably absent through sample bias. Grain size: 5+ mm. Texture: ?

This well penetrated rock interpreted as belonging

to the Chase County Granite Group and together with Bt-15,one mile to the west,is very close to the inferred southern boundary of the main part of this rock group.

Bedell and Catt No. 1-B Mellor, 12-24-3E, Butler County

Bt-20-1, cuttings, 3500-3510 feet

GNEISSIC GRANITE..... Microcline; plagioclase; quartz; muscovite; feldspar alterations; opaque minerals.

Only a little opaque mineral is present, the remainder of the rock is an amazingly pure quartz-feldspar-muscovite rock. Muscovite is in large intergranular books and in crystalloblastic smaller crystals within feldspars, chiefly plagioclase. Orientation of secondary muscovite is crystallographically controlled. Quartz straining and linears of shear-reconstitution with bent plagioclase twinning express the tectonic imprint. Grain size: 3.5+ mm. Texture: Hypidiomorphic-lepidoblastic?

Bedell and Catt No. 1-B Mellor, 12-24S-3E, Butler County

Bt-20-2, cuttings, 3520-3525 feet

MICA-FELDSPAR-QUARTZ SCHIST OR HORNFELS..... Plagioclase; quartz; microcline; biotite; muscovite; chlorite; opaque minerals; feldspar alterations; tourmaline; calcite; leucoxene; apatite.

Considerable variation in the amount and type of mica present. Chloritic micas appear to have preferred orientation. Biotite and muscovite rich chips do not appear to have a preferred orientation but this may be due to orientation of chips or the slide. Feldspars are clouded,plagioclase with hematite dust and fresh microcline. Quartz is abundant and not strained. Calcite is a common vein material. Tourmaline is olive green. Magnetite granules are partly altered to hematite. Grain size: 0.3 mm average. Texture: Lepidioblastic? granoblastic?

Rock interpreted as originally a normal granite above metamorphic rock that is possibly a sediment in origin is always difficult to interpret. It is possible the schist or hornfels is actually a conconstituted granite but it does not offer petrographic support. There may also be a tectonic (fault) explanation but there is no evidence for this either. The schist or hornfels may be an inclusion or xenolith caught up in the granite. The latter is interpreted as a member of the Chase County Granite Group.

Raymond No. 2 Classen, 18-24S-4E, Butler County

Bt-21-1, cuttings, 3565-3570 feet

BIOTITE SCHIST..... Plagioclase; quartz; microcline; biotite; muscovite; opaque minerals; calcite; feldspar alterations; pyrite; sphene-leucoxene; apatite; fluorite ?; epidote ?; zircon ?.

Red brown biotite has a strong preferred orientation in a granoblastic mosaic of quartz-feldspar. Feldspars are poorly twinned and plagioclase appears faintly altered. Pyrite is conspicuous as thin veinlets. Magnetite is in granules. Calcite is in thin blebs and veinlets. One very large poikiloblast of muscovite is present in one cutting chip together with biotite of superior size. Another slide (Pc-54) shows a garnet porphroblast, sheared zones and quartzose bands. Grain size: 0.2 mm average. Texture: Lepidoblastic.

The well is tentatively interpreted as an extension of the Vernon County Metamorphic Group along the Nemaha Uplift.

Ramsey No. 1 Ramsey, 8-24-5E, Butler County

Bt-23-1, cuttings, 3345-3356 feet

GRANITE AND SCHIST? BANDED GNEISS?..... Microcline; quartz; plagioclase; biotite; feldspar alterations; opaque minerals; hornblende; pyroxene; calcite; chlorite; garnet; apatite.

Exceptionally small cutting chips all less than 0.5 mm, are of diverse origin. Some are normal granite with myrmekite, microcline, plagioclase,quartz and red-brown biotite. Other chips are schist containing biotite of about the same properties as in the granite, plagioclase, quartz, and microcline. Smaller amounts of pyroxene, hornblende, and a single garnet were noted. Rock could be banded granite gneiss. Grain size: ? Texture: ?

The well is tentatively interpreted as schist of the Vernon County Metamorphic Group intruded by granite of the Central Oklahoma Granite Group.

White Eagle No. 1A Stone, 2-25S-5E, Butler County

Bt-24-1, cuttings, 3177-3180 feet

LEUCODIORITE..... Plagioclase 90.0; hornblende, 9.1; feldspar alterations, 0.4; opaque minerals, 0.4; pryoxene, tr.; epidote, tr.

An exceptionally fresh plagioclase hornblende rock

with minor pyroxene relicts. The hornblende is pale green and very mildly pleochroic. Small amounts of epidote and sericite are associated with plagioclase. The plagioclase is intermediate labradorite, is well twinned and exceptionally variable in size. The coarser crystals are subhedral, smaller are anhedral. One granule of pyrite with associated hematite and a sphene rim is associated with hornblende. Grain size: To 3.2 mm. Texture: Xenomorphic-hypidiomorphic.

This leucodiorite is a unique rock for this area and none other even vaguely resembling it was found. It is placed in the Vernon County Metamorphic Group strictly on geographic association.

Empire (Cities Service) No. 155 Wilson, 8-25S-5E, Butler County

Bt-26-1, cuttings, 3045-3050 feet

MUSCOVITE GRANITE GNEISS..... Microcline; quartz; plagioclase; muscovite; biotite; feldspar alterations; chlorite; opaque minerals.

Cataclastic zones of shear-reconstitution are prominent in every cutting chip. Lepidoblastic muscovite is well crystallized in large books and as smaller crystals in shear zones. Biotite is reddish brown in both large books and small oriented aggregates. Small amounts of myrmekite present. Opaques are sparse and appear to be mostly hematite. Feldspar alterations are minor and are most common in plagioclase as mottled fine clay-mica. Grain size: To 2.1 mm. Texture: Cataclastic-lepidoblastic.

This rock is interpreted as a member of the Chase County Granite Group later metamorphosed by the 1.2 b.y. episode reflected in the granite about seven miles to the southwest.

Saco No. 11A Draper, 27-25S-5E, Butler County

Bt-28-1, cuttings, 3370-3380 feet

BASIC GNEISS..... Plagioclase; amphibole; biotite; sphene-leucoxene; epidote; feldspar alteration; opaque minerals; quartz; chlorite.

Relict plagioclase laths are altered in some chips and contain minor hornblende as crystalloblastic inclusions. Hornblende and biotite appear to have a common preferential orientation. The material between plagioclase relicts is a granoblastic mosaic of quartz-feldspar containing sphene

granules and epidote. No magnetite recognized but hematite forms a stain and thin veins on chip containing shear linears. These shears are younger than the metamorphism, possibly Paleozoic. Grain size: Relicts to 1.8 mm. Texture: Crystalloblastic-lepidoblastic.

Saco No. 11A Draper, 27-25S-5E, Butler County

Bt-28-2, cuttings, 3400-3417 feet

BASIC GNEISS..... Plagioclase; biotite; hornblende; calcite; feldspar alterations; sphene; epidote; quartz; opaque minerals.

Large relicts of altered plagioclase are reduced to clay-mica masses with some poorly crystalline epidote in more advanced cases. Biotite dominates some chips while hornblende is more abundant in others. Calcite with well defined twinning is prominent in some chips. Variation of texture, grain size and mineral content suggest this is a banded gneiss. A granular mosaic of quartz-feldspar surround relicts of plagioclase. Some aggregates of quartz are free of mica or hornblende. Grain size: Relicts 2.8+ mm. Texture: Lepidoblastic.

These incompletely metamorphosed basic igneous rocks are placed in the Vernon County Metamorphic Group from a point of convenience rather than a conviction of their association. This is one of three wells in a few square miles penetrating very similar rocks and is situated on the flank of a positive gravity anomaly.

Cities Service (Empire) No. 3 Atkins, 29-25S-5E, Butler County

Bt-29-1, cuttings, 3605-3615 feet

BASIC GNEISS OR SCHIST..... Plagioclase; hornblende; biotite; epidote; sphene; feldspar alterations; calcite; quartz; opaque minerals; apatite.

Large relicts of plagioclase are altered to clay-sericite masses containing epidote granules. Sphene masses are composed of small granules some with an iron ore core. Biotite is olive brown and appears to have a preferred orientation. Hornblende is mildly pleochroic pale green. A quartz-plagioclase granoblastic mosaic composes the interrelict material. The suggestion is of a banded gneiss in which hornblende and biotite share a distinct but less than perfect preferred orientation. Grain size: Relicts 0.9+ mm. Texture: Lepidoblastic.

This well penetrated incompletely metamorphosed basic rock and a member of the Vernon County Metamorphic Group.

Empire (Cities Service) No. 1 Murray, 30-25S-5E, Butler County

Bt-30-1, cuttings, 3275-3285 feet

SHEARED GRANITE GNEISS? METARHYOLITE?..... Quartz; microcline; plagioclase, biotite; feldspar alterations; opaque minerals.

Relicts of microcline, quartz, and plagioclase are set in a granoblastic mosaic of quartz and possibly feldspar. Quartz relicts are highly strained. Biotite with a high degree of preferred orientation is in layers and concentrations of fine flakes. The total general composition is granitic and the suggestion is a highly sheared granite recrystallized during shearing. This would account for the composition of "clasts." The alternative is a metarhyolite but the relatively high biotite content would be somewhat anomalous. Grain size: Relicts to 1 mm; mosaic average 0.02 mm. Texture: Lepidoblastic-relict porphyritic? cataclastic?.

This well is tentatively interpreted as having penetrated sheared granite of the Chase County Granite Group. The shearing-metamorphism is thought to be associated with the intrusion of 1.2 b.y. granite about three and a half miles to the southeast.

Cities Service No. 1 "S" Pierpont, 33-25S-5E, Butler County

Bt-31-1, cuttings, 3092-3096 feet This well heavily Mineralized in Arbuckle too.

BASIC HORNFELS..... Plagioclase; biotite; hornblende; epidote; sphene-leucoxene; feldspar alterations; calcite; quartz.

Relicts of plagioclase are clouded with alterations. Crystalloblastic biotite and hornblende do not appear to have a preferred orientation but this may be due to the orientation of the cutting chip or a genuine lack of foliation. Epidote is common in linear concentrations and finely granular disseminated crystals in the granoblastic mosaic of quartz-feldspar and in plagioclase relicts. Sphene-leucoxene is in globular masses of extremely fine crystals, some as linear veinlike occurrences. This rock contains more plagioclase relicts and less granular mosaic than those occurring to the north. Grain size: Relicts to 1.0 mm. Texture: Granoblastic.

This rock together with the two to the north (Bt-28, Bt-29) penetrated the metabasic phase of the Vernon County Metamorphic Group.

Gross No. 1 Williams-Forgy, 11-26S-4E, Butler County

Bt-32-1, cuttings, 2811-2813 feet

GRANITE..... Microcline, 37.8; plagioclase, 34.6; quartz, 17.8; biotite, 5.6; feldspar alterations, 1.5; epidote, 1.4; sphene-leucoxene, 0.7; opaque minerals, 0.1; zircon, tr.; apatite, tr.; calcite, tr.; chlorite, tr.

Cataclastic features are strained quartz and some mortared boundaries. Microcline is fresh and perthitic. Plagioclase is near An_{20} and is clouded with mottled alteration especially near crystal cores and discrete sericite flakes. Olive-green biotite is moderately pleochroic, appears in part very late or crystalloblastic. Some chloritic pseudomorphs are associated with it. Sphene-leucoxene with associated hematite replaces portions of the iron ore. Low quartz content probably due to sample bias on a coarse rock. Epidote is in well crystallized masses. Large sphene wedges now replaced by leucoxene-calcite. Grain size: 4+ mm. Texture: Hypidiomorphic.

This is an extremely important well in the interpretation of central Butler County. The biotite was dated by the Rb/Sr method at 1.19 ± .07 b.y. and the feldspar at 1.24 ± .21 b.y. also by the Rb/Sr method. This is the main evidence for the occurrence of the Central Oklahoma Granite Group in Kansas and thus relating the metamorphism of the sediments to this 1.2 b.y. episode.

Gulf No. 58 Shumway, 11-26S-4E, Butler County

Bt-34-1, cuttings, 2625-2628 feet

GRANITE..... Plagioclase, 38.6; microcline, 35.0; quartz; 18.0; biotite, 6.0; leucoxene, 0.9; chlorite, 0.4; opaque minerals, 0.3; apatite, tr.; zircon, tr.; epidote, tr.; calcite, tr.; feldspar alterations, tr.

Microcline is fresh with perthitic patches as strings. Plagioclase, near An_{20}, is more altered and alteration seems to outline twinning with calcite and sericite flakes. Olive-green biotite is moderately pleochroic and is altered in part to chlorite. Quartz is strained and some chips have shear-reconstitution linears. Large sphene crystals are altered to leucoxene and calcite. Deep chocolate brown pleochroic haloes surround both zircon and apatite in biotite. Biotite appears to have had secondary growth invading feldspars adjoining biotite. Grain size: 7.5+ mm. Texture: Hypidiomorphic.

This rock is in the same section as the Gross No. 1

Williams-Forgy (Bt-32) and is interpreted as an example of the Central Oklahoma Granite Group.

Allison No. 1 Davis, 15-26S-4E, Butler County

Bt-36-1, cuttings, 3258-3262 feet

GRANITE..... Microcline; plagioclase; quartz; biotite; leucoxene; feldspar alterations; opaque minerals; hornblende; chlorite; epidote; calcite; sphene; zircon; apatite.

This rock is similar to other granites in this township, and is characterized of perthitic microcline and more extensively altered plagioclase. The plagioclase is near An_{20} and has a peculiar mottled zoning. Large sphene wedges are replaced by leucoxene and calcite. Olive-green biotite contains inclusions of epidote, zircon and apatite and has minor chlorite alterations. Quartz is sparse probably due to sampling bias. Small amount of hornblende is associated with biotite enclosed in a plagioclase. Grain size: 6+ mm. Texture: Hypidiomorphic.

This rock is interpreted as a member of the Central Oklahoma Granite Group.

Murfin No. 6 Gray, 15-26-4E, Butler County

Bt-37-1, cuttings, 3080-3083 feet

GRANITE..... Microcline; plagioclase; quartz; biotite; epidote; feldspar alterations; calcite; leucoxene; opaque minerals; sphene; zircon; apatite.

An abundance of late or secondary minerals modifies this granite. Well crystallized epidote replaces part of some feldspars and is associated with sphene and calcite. Biotite appears to be in part secondary-crystalloblastic and is associated with sphene, calcite, epidote, iron ore and leucoxene. Microcline is fresh and perthitic; plagioclase contains sericitic alteration in tiny flakes. Apatite contains clouding opaque inclusions. Quartz is generally strained and some shear lines are noted. Grain size: 6+ mm. Texture: Hypidiomorphic.

This well is in the same section as the Allison No. 1 Davis (Bt-36) and is interpreted as an example of the Central Oklahoma Granite Group.

Great Southern No. 45 Dickinson, 16-26S-8E, Butler County

Bt-39-1, cuttings, 3675 feet cir. 3575 TD.

GRANITE GNEISS..... Quartz, 36.5; microcline, 24.8; plagioclase, 23.0; biotite, 8.2; feldspar alterations, 4.1; calcite, 1.9; epidote, 1.1; hornblende, 0.3; sphene, 0.3; opaque minerals, tr.; zircon, tr.; apatite, tr.; chlorite, tr.

Large quartz crystals have been reduced to smaller aggregates and straining is marked in the larger relicts. The biotite appears to be reconstituted to finer grained mosaic suboriented and in some cases crystalloblastically invading surrounding minerals. Microcline is clear, but contains small veinlets of calcite. Plagioclase contains epidote granules, calcite and sericite alterations. Small amounts of a secondary (?) blue-green amphibole is associated with biotite masses. Zircon is unusually abundant. Biotite, especially "newer" biotite, may have a rude preferred orientation. Grain size: 6+ mm. Texture: Hypidiomorphic-cataclastic.

This gneiss is considered to be a granitic rock of the Chase County Granite Group later modified at about 1.2 b.y. by the intrusion of younger granite found to the west.

Brunson and Spines No. 1 Winzer, 16-27S-4E, Butler County

Bt-42-1, cuttings, 3570-3580 feet

GRANITE..... Microcline, 36.9; plagioclase, 28.1; quartz; 27.3; feldspar alterations, 4.2; chlorite, 2.6; muscovite, 0.4; opaque minerals, 0.3; leucoxene, 0.2; biotite, 0.1; apatite, tr.; zircon, tr.; calcite, tr.

Fresh microcline is only sparsely perthitic. Plagioclase is more altered, particularly near the cores of larger crystals with disseminated clouding and hematite as well as sericite flakes. Biotite is partly altered to chlorite and is associated with secondary or very late muscovite. Quartz is moderately strained. Opaque minerals are sparse, and are associated in part with leucoxene. Grain size: 4.5+ mm. Texture: Hypidiomorphic.

This well is interpreted as having penetrated rock of the Central Oklahoma Granite Group and is near the highly speculative inferred boundary between this group and the Chase County Granite Group to the south.

Hartman and Derby No. 1 Nibel, 22-29S-3E, Butler County

Bt-47-1, cuttings, 4120-4125 feet

GRANITE..... Plagioclase; microcline; quartz; biotite; feldspar alterations; chlorite; calcite; opaque minerals; sphene-leucoxene; zircon; apatite.

The feldspars in most cutting chips are intensely altered possibly from weathering. The feldspar is reduced to sericite masses with hematite dust and recognizable clay aggregates. Large microcline contains poikilitically enclosed plagioclase and quartz and has patches of calcite. Quartz is mildly strained. Biotite is olive green and altered to chlorite. Grain size: 2.0+ mm. Texture: Hypidiomorphic.

This well together with the Rex and Morris No. 1 Mann (Bt-49) is located about half way between granite dated at about 1.2 b.y. and granite dated at about 1.34 b.y. along the Nemaha Uplift. It is tentatively placed in the Chase County Granite Group.

Rex and Morris et al. No. 1 Mann, 6-29S-4E, Butler County

Bt-49-1, cuttings, 3170-3172 feet

GRANITE..... Microcline, 62.2; quartz, 19.1; plagioclase, 12.4; biotite, 4.0; feldspar alterations, 1.1; leucoxene-sphene, 0.4; chlorite, 0.3; calcite-dolomite, tr.; opaque minerals, tr.; apatite, tr.; muscovite, tr.; zircon, tr.

Fresh microcline is partly perthitic and larger grains contain poikilitically enclosed quartz and plagioclase. Quartz is moderately strained. Plagioclase is near An_{20} and is partly altered particularly near the cores of crystals with sericitic masses and discrete flakes. Biotite is olive brown and contains small amounts of chloritic alterations. Some crystalline masses of calcite contain small dolomite rhombs. Grain size: 6+ mm. Texture: Hypidiomorphic.

This well, like the Hartman and Derby No. 1 Nibel (Bt-47), is interpreted tentatively as having penetrated rock of the Chase County Granite Group.

Cities Service No. ~~259~~ 289 Koogler, 20-26S-5E, Butler County

Bt-50-1, cuttings, 3290-3296 feet

Top 3270

GNEISSIC GRANITE..... Quartz, 29.6; plagioclase, 26.2; microcline, 20.8; biotite, 18.4; feldspar alterations, 3.6; epidote,

0.7; leucoxene, 0.4; sphene, 0.3; opaque minerals, tr.; zircon, tr.; apatite, tr.; hornblende, tr.; calcite, tr.

The general impression is a granite altered by later reconstitution and shearing and is considerably finer grained than most granites of this area. Most crystals have an irregular possibly granoblastic appearance. Masses of biotite are unusually abundant and composed of smaller plates, some obviously invading surrounding minerals. Biotite also occurs in large apparently primary books. Small amounts of olive green hornblende are interlayered with the more red-brown biotite. Plagioclase contains disseminated sericite alterations while microcline is fresh. Epidote and sphene-leucoxene are common near and within biotite. Grain size: To 3.2 mm. Texture: Hypidiomorphic.

Although this rock was drilled only about four miles southeast of the Gross No. 1 Williams-Forgy (Bt-32) the gneissic character is marked and it is interpreted as a member of the Chase County Granite Group.

Sinclair Prairie No. 9 Brown, 26-34S-11E, Chautauqua County

Ch-3-2, cuttings, 3079-3085 feet

METARHYOLITE PORPHYRY..... Groundmass; plagioclase; perthite; quartz; feldspar alterations; opaque minerals; chlorite; epidote; sphene-leucoxene; actinolite; zircon; apatite.

Phenocrysts of quartz, perthite, and plagioclase are found as relicts surrounded by a granoblastic quartz-feldspar matrix. The groundmass mosaic has marginally embayed most phenocrysts but they are essentially unaffected. Veinlike coarsenings in the groundmass are present but it is generally very fine grained. A former femic mineral (possibly biotite) has been converted to chlorite with some attendant sphene. Actinolite is in small sparse seived crystals; it is very pale, mildly pleochroic and weakly birefringent. Opaque minerals are mostly hematite and are small granules and dusty inclusions in feldspars. Sphene-leucoxene replaces an ilmenite and is associated with an unidentified isotropic or semi-isotropic material. The perthites are clouded with microalterations and hematite dust while the plagioclases are sericitized, contain less hematite and small epidote granules. Grain size: Phenocrysts, 1.5 mm.; average 0.01 mm. Texture: Relict porphyritic-granoblastic.

This metarhyolite is located about six miles north of the inferred boundary with the normal rhyolites of the Washington County Volcanic Group.

Federal No. 1 Whitney, 15-18S-6E, Chase County

Cs-2-1, cuttings, 2424 feet

GRANITE?..... Microcline; quartz; feldspar alterations; opaque minerals; biotite.

The slide is composed of essentially single mineral grains generally smaller than 0.3 mm. The quartz appears unstrained. Plagioclase was not identified but some alteration material may be replacing it. Microcline is in part fresh and sparsely perthitic. Biotite is a deep reddish olive brown in color. Grain size: 1+ mm. Texture: Questionable.

This is apparently granite of the Chase County Granite Group.

Preston and Pasewalke No. 2 Lipps, 25-18S-6E, Chase County

Cs-4-1, cuttings, 2060-2065 feet

GRANITE (GNEISS?)..... Microcline; quartz; plagioclase; feldspar alterations; opaque minerals; chlorite-biotite.

Microcline is generally fresh and distinctly twinned. Plagioclase is sparse, clouded with alteration and hematite stain. Several chips show extensive shearing--reconstitution and suggest a possible gneissic fabric. Quartz is generally strained. Small amounts of relict chlorite-biotite are found in the sheared zones. Grain size: Less than 1.4 mm. Texture: Cataclastic--gneissic?

This is an example of the Chase County Granite Group and the type of shearing noted in this rock is typical of the irregular gneissic effects within the group.

Urschel No. 1 Lipps, 27-18S-6E, Chase County

Cs-5-1, cuttings, 2301-2303 feet

GRANITE..... Microcline; quartz; plagioclase; biotite; feldspar alterations; chlorite; hornblende; opaque minerals; epidote.

Cutting chips are small and mostly single grains. Quartz is unstrained. Microcline is fresh while plagioclase, near An_{20}, is faintly turbid with alterations. Biotite is in fresh books and as a fine secondary aggregate of shreds replacing along cleavage and grain boundaries. Hornblende in part is associated with the finer biotite and is also as discrete, well formed crystals. One shear linear is noted as well as a modest amount of myrmekite. Grain size: 2+ mm. Texture:

Questionable.

This well penetrated rock of the Chase County Granite Group.

Preston and Pasewalke No. 1 Lipps, 32-18S-7E, Chase County

Cs-7-1, cuttings, 2260-2262 feet

SHEARED GRANITE..... Microcline; plagioclase; hornblende; quartz; chlorite; feldspar alterations; opaque minerals; biotite; calcite; sphene-leucoxene; apatite; zircon.

The rock brecciated and sheared extensively. Most chips appear to have been derived from a quartz poor rock of granitic composition. One chip, possibly a relict eye or segregation is abundant hornblende surrounded by plagioclase-microcline and an altered zone. Some chips are strongly lineated by shearing, others are breccias with mineral fragments in an iron rich rock paste. Secondary chlorite as well as pseudomorphs are common. Grain size: Relicts to 0.8 mm. Texture: Cataclastic.

This rock represents an "end member," one of the most extensively sheared granites in the Chase County Granite Group.

Backus No. 1A Thurston, 17-19S-7E, Chase County

Cs-11-1, cuttings, 1955-1965 feet

EPIDOTIZED GRANITE..... Microcline; plagioclase; epidote; quartz; biotite; chlorite; opaque minerals; sphene-leucoxene.

Extensive replacement by epidote of feldspars and along grain boundaries is marked and some chips are 80% epidote in fine crystalline aggregates. Vermicular chlorite in small masses replaces portions of quartz and feldspar usually associated with epidote. Quartz is generally strained. Biotite occurs in one mass larger than 2.5 mm as an aggregate of olive reddish green crystals containing small amounts of opaque minerals, possibly this is a primary segregation. Plagioclase is intermediate albite and contains more epidote than the microcline. Grain size: Less than 3.5 mm. Texture: Relict hypidiomorphic.

This well is interpreted as having penetrated epidotized rock of the Chase County Granite Group.

Rex No. 1 Wells, 19-19S-7E, Chase County

Cs-12-1, cuttings, 1875-1877 feet

GRANITE..... Microcline, 53.0; quartz, 19.4; plagioclase, 15.1; biotite, 5.7; hornblende, 3.8; feldspar alterations, 2.5; sphene-leucoxene, 0.2; opaque minerals, tr.; apatite, tr.; chlorite, tr.

Quartz is modestly strained with some dislocation noted. Microcline is partly perthitic and contains mottled alterations. Plagioclase is more altered than the microcline and near some cores is completely replaced by a sericite mat. The femic minerals are not typically igneous and may be retrograde or crystalloblastic from a later thermal event. Vermicular "intergrowths" of myrmekite and biotite and/or hornblende as well as radiating fibrous biotite suboriented in a linear plane is present. Biotite-hornblende invade along cleavage cracks and replace interiors of feldspar crystals. Small amounts of calcite replace hornblende and what may have been a pyroxene. Chlorite appears to be retrograde from biotite and hornblende. Grain size: To 8.5 mm. Texture: Hypidiomorphic.

This rock has an example of the curious radiating biotite and associated hornblende that characterizes several samples drilled along the Nemaha Uplift. The origin of this structure is not clearly defined.

Stanolind No. 1 Davis, 29-19S-7E, Chase County

Cs-13-1, cuttings, 1878 feet cir.

SHEARED GRANITE OR GRANITE GNEISS..... Microcline perthite; quartz; plagioclase; calcite; hornblende; biotite; feldspar alterations; chlorite; opaque minerals; sphene-leucoxene; apatite.

Very large microcline perthite comprises one chip that may be a phenocryst in a comparatively coarse rock. The large crystal is about equal microcline-plagioclase (sodic oligoclase) and both are fresh with only minor alterations. Plagioclase crystals are more altered near the core and contain hematite dust. Brecciation and shearing reconstitution are common. Larger feldspars are cracked and bent, quartz is strained and reduced to a fine aggregate. Hornblende is mildly zoned with darker cores. Fresh biotite is red-brown but is mostly altered to a green variety. Calcite replaces much of the femic minerals. Grain size: To 7.5 mm. Texture: Cataclastic-relict hypidiomorphic and porphyritic?

This is an example of the more sheared varieties of

the Chase County Granite Group.

Leader No. 1 Breeze, 35-19S-7E, Chase County

Cs-15-1, cuttings, 1927-1937 feet

GRANITE (GNEISSIC?)..... Microcline perthite; quartz; plagioclase (near An_{20}); calcite; biotite; chlorite; sphene-leucoxene; opaque minerals; feldspar alteration; apatite; zircon.

Large crystals of patch perthite microcline are generally fresh. Plagioclase crystals are extensively but not uniformly altered, patches of fresh material and rim around altered core are common. Biotite is mildly altered but one chip contains abundant calcite after a femic mineral--possibly hornblende. Quartz is mildly strained but is composed of irregularly sized aggregates suggesting shear-reconstitution. Some biotite appears to be crystalloblastic as it invades feldspar crystals. Grain size: 5+ mm. Texture: Hypidiomorphic.

This granite shows definite signs of later activity from both shearing and the biotite invading the feldspar. The granite is interpreted as a member of the Chase County Granite Group. The later effects may be due to the 1.20 b.y. episode.

Elmhurst No. 1 Allen, 24-19S-9E, Chase County

Cs-16-1, cuttings, 3418 feet

BANDED (?) GRANITE GNEISS..... Microcline; quartz; plagioclase; biotite; sphene; tremolite-chlorite; opaque minerals; feldspar alterations; sericite; calcite; epidote.

Large relicts are seen as essentially single mineral grains mainly plagioclase with bent twins and brecciated microcline. Most of the chips are fine grained; some are finely schistose; others are highly strained mineral aggregates with cataclastic boundaries. Shear linear of fine material are common as are aggregate quartz mosaics. Sphene is in small but well crystallized anhedral grains. Chlorite and tremolite together with a red brown biotite have erratic distribution. Grain size: To 2.0 mm; average 0.3 mm. Texture: Cataclastic-granoblastic.

This rock is found near the inferred eastern boundary of the Chase County Granite Group. The gneiss, however, may be related to the "older granites and gneiss" because of the more extreme deformation of the rock.

Prairie No. 1 McLinden, 25-20S-5E, Chase County

Cs-17-1, cuttings, 3060 feet

GRANITE..... Microcline; plagioclase; quartz; feldspar alterations; opaque minerals; chlorite biotite; apatite.

Extremely fine cutting fragments make textural determination impossible. Iron stain on most fragments is probably from the drill bit. Microcline is partly perthitic and like most plagioclase is turbid with alterations. Quartz is unstrained. Chlorite-biotite masses replace former femic mineral. Apatite occurs as tiny needle inclusions. Grain size: ?. Texture: Questionable.

This rock is interpreted as a member of the Chase County Granite Group.

George Martin No. 1 Winsor, 2-20-6E, Chase County

Cs-18-1, cuttings, 2530-2532 feet

PYROXENE HORNBLENDE GRANITE..... Plagioclase, 36.3; microcline, 35.6; quartz, 22.4; hornblende, 3.5; biotite, 0.8; pyroxene, 0.7; opaque minerals, 0.4; feldspar alterations, 0.4; apatite, tr.; zircon, tr.

Large microcline crystals with minor string perthite contain poikilitically enclosed hornblende, plagioclase, quartz, and pyroxene. Hornblende in part is a strongly pleochroic variety with the blue-green color of a sodium rich type and is in part a non-pleochroic tremolitic type. The latter may be derived from pyroxene occurring as sparse crystals with common hornblende. A reddish biotite occurs as wormy crystals as well as ordinary books. Suggestion of crystalloblastic growth is present but it may represent late magmatic replacement. One cutting chip is essentially a hornblende rich hornfels in appearance. It may be an inclusion or segregation but the assemblage is quartz poor and the hornblende has good seive texture suggesting a basic inclusion converted to a hornfels. Grain size: 5.5+ mm. Texture: Hypidiomorphic.

It is difficult to suspect any great later thermal activity acting on this granite, otherwise the pyroxene would certainly be replaced. The texture is unusual as is the occurrence of pyroxene and both may be related to the interpreted basic inclusion causing contamination effects on the granite.

GRANITES.....

In 20S-7E, Cs-19 to Cs-26.

These granites are characterized by a mild but persistent metamorphic features. Chiefly these features are mortared boundaries, strained quartz, reconstituted linears, secondary crystalloblastic biotite and minor amphibole. Biotite is mostly secondary when in an intergranular position though some may be primary. I interpret them as crudely foliated gneisses. The altered rock in Cs-24 is possibly a basic host rock; this is partly substantiated by cutting chip in Cs-18. Microcline is generally fresh and at least partly perthitic in all wells. Plagioclase in albitic to intermediate oligoclase and is more extensively altered. The shearing in the rock is not considered Paleozoic but Precambrian and the age equivalent of the biotite. All shear zones are fully healed, no mylonitic material is present.

Amerada No. 1 Lostuller, 1-20S-7E, Chase County

Cs-19-1, cuttings, 2825 feet cir.

GRANITE (GNEISS?)..... Plagioclase, 36.5; quartz, 33.2; microcline, 27.5; biotite, 1.4; feldspar alterations, 0.8; muscovite, 0.3; chlorite, 0.3; calcite, tr.; opaque minerals, tr.; apatite, tr.; zircon, tr.

Large microcline and plagioclase crystals suggest a porphyritic texture. Quartz is faintly strained. Mortared boundaries and vague biotite lineation suggest a gneissic fabric. Feldspars are generally turbid. Development of myrmekitic intergrowth locally marked. Chloritic alterations mottle biotite. Small amounts of secondary muscovite appear to be porphroblastic within plagioclase crystals. With deep olive brown biotite is a mildly pleochroic secondary (?) variety. Grain size: 3.5 mm. Texture: Hypidiomorphic--porphyritic?

Even though later activity has left a mark on this granite, mortar boundaries, muscovite development, etc., the feldspar was dated at 1.45 ± .12 b.y. by Rb/Sr methods. Thus it is related to the Chase County Granite Group. The later effects are possibly reflections of the 1.20 b.y. episode found to the south in Butler County.

Wichita Natural (Empire) No. 1 Kaufman, 2-20S-7E, Chase County

Cs-20-1, cuttings, 2195-2200 feet

GRANITE (GNEISS?)..... Microcline; quartz; feldspar alterations;

plagioclase; biotite; sphene-leucoxene; opaque minerals; chlorite; hornblende; calcite; zircon.

Fresh microcline and plagioclase with mottled alteration have partly mortared boundaries. Myrmekitic intergrowths are locally significant. Mortared boundaries particularly marked around large feldspar crystals. Biotite appears rudely oriented. Hornblende with mottled pleochroism is crystalloblastic and partly seived. Chlorite with opaque minerals and leucoxene replace biotite. Some biotite appears secondary along grain boundaries. Quartz generally unstrained. Grain size: To 5 mm. Texture: Hypidiomorphic.

This rock is a member of the Chase County Granite Group.

Alladin No. 1 Drummond, 15-20S-7E, Chase County

Cs-23-1, cuttings, 2352-2368 feet

GRANITE (GNEISS?)..... Microcline; plagioclase; quartz; biotite; hornblende; feldspar alterations; sphene-leucoxene; chlorite; opaque minerals; sphene; calcite; apatite.

Alteration is advanced in some cutting chips while others are fresh. More altered cutting chips contain abundant disseminated hematite dust and feldspars are exceptionally turbid. Myrmekite developed around some microcline. Shear planes are invaded by calcite. Calcite also associated with biotite-chlorite. Some biotite is secondary growing normal to mineral boundaries and invading adjacent minerals. Titaniferous magnetite is altered to leucoxene and hematite. Quartz is faintly strained. Grain size: 3.7+ mm. Texture: Hypidiomorphic.

The alteration of this granite, at least in part, is probably a weathering phenomenon. The rock is a member of the Chase County Granite Group.

Vickers No. 1 Nicol, 16-20S-7E, Chase County

Cs-24-1, cuttings, 1917-1927 feet

GRANITE..... Microcline; plagioclase; quartz; chlorite; feldspar alterations; opaque minerals; sphene; calcite; apatite; zircon.

Cutting chips are inhomogeneous and this probably reflects coarse grain size. Quartz is sparse probably due to sampling bias. Myrmekite is common near large microcline crystals. Microcline is perthitic in part and contains minor mottled alterations. Plagioclase is generally altered more

extensively. Some brecciation is noted. Chlorite is generally secondary along fractures and pseudomorphic after biotite. Grain size: 5+ mm. Texture: Hypidiomorphic.

Vickers No. 1 Nicoll, 16-20S-7E, Chase County

Cs-24-3, cuttings, 1944-1947 feet

ALTERED BASIC INCLUSION?..... Feldspar alterations; chlorite; calcite; opaque minerals; plagioclase; biotite; epidote; quartz; apatite; zircon.

This interval appears to be a highly altered rock intruded by granite. Most cutting chips are calcite-opaque mineral-feldspar alterations with a suggestion of relict fabric. Apatite and minor quartz are accessories. One cutting chip is a fresh biotite-plagioclase rock apparently a fresh variety of the altered zones. In this chip calcite replaces a former amphibole with attendant chlorite. One granite fragment has an end composed of rock similar to altered rock. Interpretation is an inclusion or relict of a basic rock converted to a hornfels then altered by later solutions. Grain size: Varied. Texture: Relict granoblastic?.

The interpretation of this well is of a dominantly granitic rock containing an inclusion or xenolith of a basic hornfels, now much altered. The Martin No. 1 Winsor (Cs-18) a few miles to the northwest was interpreted as having penetrated a similar rock. The granite is an example of the Chase County Granite Group.

Stanolind No. 1 Finley, 20-20-7E, Chase County

Cs-25-1, cuttings, 1775 feet

GRANITE GNEISS..... Microcline; quartz; plagioclase; opaque minerals; biotite; feldspar alterations; sphene-leucoxene; calcite; chlorite.

Large microcline crystals contain poikilitically enclosed plagioclase and quartz and is perthitic. Shear linears of granular material cut large feldspars. These linears have no mylonized material. Quartz in large crystals have been reduced to a granular mosaic. Biotite concentrated along linears but appears fresh, unbent, and is probably post deformational. Plagioclase is more altered than microcline. Myrmekite present small amount. Grain size: 4.5+ mm. Texture: Hypidiomorphic-cataclastic.

The later features of cataclasis and new biotite are

well developed in this example of the Chase County Granite Group.

Strickler No. 1 Harshman, 29-20S-7E, Chase County

Cs-26-1, cuttings, 1915-1930 feet

GRANITE (GNEISS?)..... Microcline, 56.9; quartz, 26.4; plagioclase, 15.9; chlorite, 1.8; calcite, 0.8; feldspar alterations, tr.; sphene, tr.; opaque minerals, tr.; zircon, tr.

Quartz is extensively strained in large crystals. Some mortar-reconstitution is present along feldspar boundaries. Small amounts of antiperthite microcline in large plagioclase. Microcline is both a patch and string perthite. Altered poikilitically enclosed plagioclase is in microcline. Chlorite is in a secondary intergranular position and does not appear to be pseudomorphic after a primary femic mineral. Calcite fills small veinlets. Grain size: 5+ mm. Texture: Hypidiomorphic-cataclastic.

This rock is a member of the Chase County Granite Group.

Ackerd No. 1 Harley, 30-31S-22E, Cherokee County

Ck-1-1, cuttings, 1849-1852 feet

GRANITE..... Perthite; quartz; plagioclase; feldspar alterations; chlorite; biotite; opaque minerals; sphene-leucoxene; calcite; apatite.

Perthite is turbid with minor alterations and abundant hematite dust. Plagioclase contains much less hematite dust but has sericite flakes as alterations. Quartz is essentially unstrained and is in part rudely micrographic. Secondary biotite is only mildly pleochroic, reddish variety found in a veinlet. Chloritic masses are sparse and contain associated sphene-leucoxene and hematite with minor apatite needles. Grain size: Indeterminate. Texture: Hypidiomorphic, slightly micrographic.

The texture and mineral appearance of the rock in this well are typical of the Woodson County Granite.

MacMillan No. 1 Clark, 13-33S-21E, Cherokee County

Ck-2-1, cuttings, 1900-1912 feet

META-ARKOSE..... Sericite-chlorite; quartz; perthite;

plagioclase; metarhyolite detritus; biotite; opaque minerals; pyrite; amphibole; sphene-leucoxene; zircon.

Relict clasts of quartz, feldspar and metarhyolite are surrounded by micaceous minerals. Grain size and mineralogic percentages vary, suggesting a relatively thin bedded argillaceous unit. The micas are largely sericite and chlorite and are poorly crystalline. Biotite is partly sieved but for the most part is ratty in appearance containing numerous dusty inclusions and frayed edges but is probably crystalloblastic. An actinolitic amphibole is associated with chlorite. Opaque minerals and sphene-leucoxene are common as small granules. Grain size: Relicts to 0.8 mm. Texture: Crystalloblastic-relict clastic.

MacMillan No. 1 Clark, 13-33S-21E, Cherokee County

Ck-2-2, cuttings, 1917-1919 feet

METARHYOLITE ARKOSE..... Quartz, 70.3; metarhyolite detritus, 12.2; feldspar, 12.0; sericite, 3.5; chlorite, 1.3; opaque minerals, 0.6; sphene-leucoxene, tr.; zircon, tr.

Quartz-feldspar and metarhyolite detritus is well sorted with mica and other intergranular material. Sericite and chlorite are developed to varying degrees in cutting chips. The question of where the rhyolite groundmass detritus was metamorphosed before or after deposition is not readily answerable from petrographic considerations. Grain size: To 1.4 mm. Texture: Relict clastic-crystalloblastic.

This well is unique in the rock type penetrated. The metasediments are interpreted as a possible clastic bed within a dominantly rhyolitic terrane. The state of recrystallization is very similar to that found in the metarhyolites and this rock is considered a member of the Washington County Volcanic Group.

City of Columbus No. 4 Fee, 13-33S-23E, Cherokee County

Ck-3-1, cuttings, 1770-1778 feet

MICROGRAPHIC GRANITE PORPHYRY..... Perthite, 52.6; quartz, 41.3; feldspar alterations, 3.9; plagioclase, 0.8; chlorite, 0.7; opaque minerals, tr.; zircon, tr.; pyrite, tr.; sphene, tr.

Phenocrysts of unintergrown quartz, perthite, and sericitized plagioclase are surrounded by micrographic quartz-feldspar. The quartz content is high and is possibly due in part to sampling bias but abundant quartz phenocrysts support

the abnormally high content. Chlorite is strongly pleochroic. Feldspars are mottled with almost complete alterations of clay-micas. Some plagioclase appears to be mottled with secondary (?) antiperthitic potash feldspar. The larger plagioclases phenocrysts have sericite flakes as mats and discrete flakes. Grain size: Phenocrysts, to 4 mm; groundmass, 2.5 mm. Texture: Porphyritic-micrographic.

This granite is very similar to certain samples from the Rose Dome and is therefore interpreted as an example of the Woodson County Granite.

Eagle Pitcher Kansas Exploration, 12-35S-23E, Cherokee County

Ck-5-1, core, 2018 feet

META-ANDESITE?..... Quartz; sericite; biotite; opaque minerals; feldspar.

A fine-grained rock of questionable origin. Rudely banded, the finer layers are essentially micaceous containing both biotite in larger flakelets and exceptionally fine-grained sericite, possibly after a feldspar. The coarser layers are chertose quartz and red-brown crystalloblastic biotite with minor quartz feldspar and chertose sand size clasts (?) or relicts. The rock has a sheared appearance with biotite concentrated along shears. Patches of micaceous material appear to be after feldspar masses. Grain size: Relicts to 0.4 mm; average 0.06 mm. Texture: Crystalloblastic.

The origin of this rock cannot be resolved strictly on the basis of petrography but when compared with rocks in other wells in the area the best explanation appears to be a highly altered-metamorphosed andesitic rock. Thus it is interpreted as related to the Washington County Volcanic Group.

Eagle Pitcher Kansas Exploration, 12-35S-23E, Cherokee County

Ck-5-2, core, 1956 feet

ALTERED ANDESITE (?)..... Sericite; quartz; sphene-leucoxene; pyrite; calcite; epidote; apatite.

The rock is extensively altered and the origin is not clear cut. Quartz is in a granular mosaic surrounded by sericite. In the quartz poor portions of the rock sericite and possibly a bleached biotite with epidote and sphene-leucoxene comprise most of the interval. Masses of sub-oriented sericite shreds may be a replacement of single feldspar crystal. Grain size: To 0.2 mm. Texture: Questionable.

Eagle Pitcher Webber, 12-35S-23E, Cherokee County

Ck-6-1, core, 1658 feet

ALTERED RHYOLITE PORPHYRY..... Groundmass 69.8; quartz, 12.3; perthite, 12.0; micaceous alterations, 3.4; plagioclase, 1.8; sphene-leucoxene, 0.4; opaque minerals, 0.2; chlorite-biotite, tr.; apatite, tr.; zircon, tr.; epidote, tr.

Phenocrysts of quartz, perthite, and minor plagioclase are set in a silicified groundmass. The groundmass has less altered zones of felty appearing quartz-feldspar and has faint but persistent relict eutaxitic structures remaining. Quartz is subhedral to embayed and has cracks filled with micaceous material or groundmass. Perthites have a characteristic carlsbad twin in some cases, are only minorly altered and also show linear cracks filled with sericitic micas. Portions of the groundmass are extensively sericitized. One stylolite appearing crack is filled with sericite and is the center for a zone of alteration. Small masses of fibrous chlorite with an associated opaque mineral appears to be after a former femic mineral. Grain size: To 2.5 mm. Texture: Porphyritic-relict eutaxitic.

This rhyolite has none of the alteration features noted in the andesitic rock in this area. The close geographic association of this normal rhyolite with andesite suggests that the Washington County Volcanic Group had intermediate outpourings in a dominantly rhyolitic terrane.

Eagle Pitcher Wilbur, 14-35S-23E, Cherokee County

Ck-7-1, core, 1858 feet

TRACHYTE OR ANDESITE PORPHYRY..... Groundmass; plagioclase; perthite; chlorite; quartz; opaque minerals; epidote.

Masses of felted feldspars containing no identifiable intergrown quartz are surrounded by highly altered and silicified material. The highly altered portion appears to be a mosaic of quartz containing chlorite, opaque minerals, epidote, sphene-leucoxene and small feldspar relicts. The more altered portions are cut by shear zones filled by opaque minerals. In less altered portions relict perthite phenocrysts are together with large masses of well crystallized epidote aggregates, chalcedonic quartz and chlorite fillings all set in a felted feldspar groundmass which is deep red with disseminated hematite dust. Grain size: Relicts to 1.8 mm. Texture: Relict felted.

This is an example of the intermediate phase of the Washington County Volcanic Group.

Eagle Pitcher Wilbur, 14-35S-23E, Cherokee County

Ck-7-2, core, 1870 feet

ALTERED ANDESITE (?) OR TRACHYTE (?)..... Groundmass; perthite-plagioclase; epidote; quartz; opaque minerals; chlorite.

Zones of relatively unaltered plagioclase-perthite containing abundant epidote as amygdular fillings and replacement masses. These relatively altered zones alternate with a delicate mosaic apparently of quartz. Masses of fine fibrous chlorite containing small quartz (?) blebs and well crystallized epidote. Perthite relicts are largely replaced by epidote. The whole rock has the appearance of an intensely altered and mineralized andesite or other non-quartz bearing volcanic rock. Grain size: To 1.0 mm. Texture: Relict felted.

Eagle Pitcher King Brand, 11-35S-23E, Cherokee County

Ck-8-1, core, 1809 feet

ANDESITE..... Groundmass, plagioclase (sodic andesine); epidote; chalcedonic quartz; chlorite; opaque minerals; apatite.

Sub-oriented, highly altered laths of plagioclase show marked contorted flow patterns. The interlath material is opaque minerals and epidote. No femic mineral was identified. Amygdules of chalcedonic quartz and chlorite are common. Large (1 cm) yellow green spheroids are caused by an epidote enrichment. Epidote is also found in amygdules and as replacement of former pyroxene (?) phenocrysts. The albite in the plagioclase with abundant secondary alteration suggests later metasomatic alteration. Grain size: Average 0.2 mm. Texture: Pilotaxitic-trachytic.

This well penetrated the andesitic phase of the Washington County Volcanic Group and is very similar to rocks penetrated in surrounding wells.

Texaco No. 4 Goodrich, 21-31-4E, Cowley County

Co-4-1, cuttings, 4187 feet

GRANITE PORPHYRY..... Microcline; quartz; plagioclase (Ab_{5-10}); chlorite; sphene-leucoxene; feldspar alterations; opaque minerals; carbonate; zircon; apatite.

Some chips are uniformly medium grained, others are composed of a single mineral suggesting a porphyritic texture.

Microcline is exceptionally fresh and in part perthitic. Quartz is very mildly strained. Plagioclase is more altered, containing sericite mats and discrete flakes and contains some disseminated hematite dust. Chlorite replaces biotite. Sphene wedges are altered to a granular aggregate of sphene-leucoxene and a low birefringent fibrous mineral or calcite. Grain size: 1.5 mm; average to 6 mm. Texture: Hypidiomorphic-porphyritic.

This well penetrated rock of the Chase County Granite Group.

La Salle No. 1 Goble, 20-28S-25E, Crawford County

Cw-1-1, cuttings, 1848-1859 feet

GRANITE..... Microcline perthite, 59.4; quartz, 28.0; chlorite, 5.6; plagioclase, 4.2; opaque minerals, 1.4; leucoxene, 0.7; feldspar alterations, 0.4; apatite, tr.; zircon, tr.; epidote, tr.; sphene, tr.

This is an unusual rock with strong secondary mineralization marks. The quartz intergrowths with perthite do not have the smooth distinct boundaries that a typical graphic intergrowth has but a ragged highly irregular boundary. Much chlorite is after biotite, other types are masses of vermicular crystals and still others appear to replace a crystalloblastic amphibole in quartz. Feldspar are turbid with alterations and hematite dust but contain clear plagioclase, generally in close association with quartz. Patches in the feldspars are completely replaced by clay minerals. Grain size: 6.5+ mm. Texture: Micrographic.

This rock appears to be a Woodson County Granite.

Hutchinson No. 1 Daetwiller, 33-16S-4E, Dickinson County

Dk-3-1, cuttings, 3114 feet cir.

GRANITE, POSSIBLY GNEISSIC..... Microcline perthite, 58.1; quartz, 34.1; plagioclase, 6.1; biotite, 0.9; feldspar alterations, 0.3; calcite, tr.; zircon, tr.; opaque minerals, tr.; apatite, tr.; chlorite, tr.

Large microclines are partly perthitic and mottled with minor alterations. Plagioclase is near An_{20} and contains discrete sericite flakes as well as fibrous mats of sericite, particularly near the cores of crystals. Quartz is strained with reconstituted sutured boundaries. Biotite is found as large deep olive green books and as intercrystalline crystals with preferred orientation, commonly associated with calcite.

Small amounts of myrmekite are present as intergranular crystals. Grain size: 7.2+ mm. Texture: Hypidiomorphic--cataclastic.

The slight cataclastic features are common in Chase County Granite Group in this area.

Duffens No. 1 Stanley, 3-14S-21E, Douglas County

Dg-2-1, cuttings, 2463-2492 feet

MUSCOVITE-QUARTZ-FELDSPAR SCHIST..... Microcline; muscovite; quartz; plagioclase; biotite; opaque minerals, feldspar alterations; sphene-leucoxene.

Most cutting chips are composed of a quartz-feldspar mosaic containing preferentially oriented muscovite flakes. Several chips contain feldspar faintly reddish in color, in these mica content is low and the feldspars are difficult to determine. Most chips have water clear feldspars, mostly microcline but albite is also present. There are sparse large biotite poikiloblasts. A sparse hematitic opaque mineral is in small granule forms. Grain size: 0.3 mm average. Texture: Lepidoblastic.

This rock is placed in the "older granites and gneiss" although it is neither. The composition, however, is granitic and it does not appear to fall into any rock group that can be defined within the study area.

Halstead (Kingwood) No. 1 Osborn, 8-31S-11E, Elk County

Ek-2-2a, cuttings, 2963-2968 feet

GRANITE..... Perthite; quartz; plagioclase; epidote; chlorite; opaque minerals; feldspar alterations; sphene-leucoxene.

Small cutting chips are composed of perthite-plagioclase and quartz with small amounts of chlorite and associated hematite. Epidote in small aggregates and discrete crystals have formed in some feldspars. Sphene-leucoxene and hematite have replaced the titaniferous iron oxides. Feldspars are clouded with alterations and hematite dust. One small shear-reconstitution linear is noted. Grain size: Indeterminate. Texture: Hypidiomorphic.

Halstead (Kingwood) No. 1 Osborn, 8-31S-11E, Elk County

Ek-2-2b, cuttings, 2963-2968 feet

METARHYOLITE PORPHYRY..... Groundmass, 58.9; perthite, 15.2; quartz, 11.2; plagioclase, 7.7; feldspar alterations, 3.4; opaque minerals, 2.3; chlorite, 1.4; leucoxene, tr.; pyrite, tr.

The rock is altered in varying amounts. Several chips are extensively altered with development of sericitic micas in the groundmass, clouding of phenocrysts and groundmass feldspars by alteration and hematite dust. Quartz phenocrysts have ragged margins and appear in part to have undergone secondary growth incorporating some groundmass quartz. Grain size: To 1.8+ mm; 0.2 mm average. Texture: Relict porphyritic--granoblastic.

This well penetrated metarhyolite in the upper part and in the last sample contained both metarhyolite and granite. The metarhyolite is a member of the Washington County Volcanic Group and the granite an example of the Woodson County Granite, which is probably intruded into and/or under the rhyolite.

Kenny and Cox No. 1 Bryant, 33-31S-13E, Elk County

Ek-3-1, cuttings, 2690-2701 feet

METARHYOLITE PORPHYRY..... Groundmass; microcline perthite; quartz; plagioclase; feldspar alterations; opaque minerals; chlorite; sphene-leucoxene; calcite; apatite.

Phenocrysts of quartz, microcline perthite, and plagioclase are set in a granoblastic mosaic of quartz-feldspar. The mosaic is the reconstitution of a probable glassy groundmass. Small chlorite books are probably derived from replacement of a former femic mineral but small masses of shreds also occur in veinlets with calcite. Small amounts of sericite are developed in the groundmass and in some feldspars replacement is extensive. Phenocrysts are abundant. Grain size: To 1.6+ mm; 0.03 mm average. Texture: Relict porphyritic--granoblastic.

The metarhyolite in this well is considered the metamorphosed equivalent of the Washington County Volcanic Group.

Phillips No. S-6 DeMalonie and Sowder, 12-22S-10E, Greenwood County

Gr-1-1, cuttings, 3475 feet cir.

METAGRAYWACKE..... Quartz; muscovite-sericite; biotite; carbonate; opaque minerals; plagioclase; rock fragments; K-feldspar.

Relict clasts of feldspar, quartz and rock fragments are set in a crystalloblastic matrix of quartz-mica-feldspar (?). The micas show a high degree of preferred orientation, the quartz-feldspar is a simple mosaic. Porphyroblasts of idioblastic magnetite are common in the matrix and some chips contain abundant disseminated hematite flakes concentrated near porphyroblasts and along linears. Biotite is of superior size in some clasts. Rock fragments appear to be mainly chert and altered granitic detritus. Carbonate is in crystalline masses. Grain size: 0.6 mm. Texture: Clastic-lepidoblastic.

Nearly one hundred miles to the east similar rock was drilled in Bourbon County, Kansas. This well is interpreted as having penetrated metagraywacke related to these and together with the Orlando No. 1 Breitkreutz (Gr-3) represent the only fragile link with the rocks in Bourbon County and those to the west in Butler County. These metasediments are interpreted as members of the Vernon County Metamorphic Group.

Phillips No. S-6 DeMalonie and Sowder, 12-22S-10E, Greenwood County

Gr-1-2, cuttings, 3455-3460 feet

METAGRAYWACKE..... Quartz; carbonate; plagioclase; rock fragments; K-feldspar; biotite; pyrite; sericite; chlorite; opaque minerals; tourmaline.

Clasts of quartz, feldspar and rock fragments are set in a crystalloblastic matrix of recrystallized clay now a quartz-feldspar-mica assemblage. Crystalloblastic biotite books and smaller sericite flakes together with minor dusty green tourmaline are set in a quartz-feldspar mosaic. Carbonate invades several rock chips and replaces extensively. Magnetite porphroblasts are common. Rock fragments are mostly chert or chertose, several large quartz clasts are strained but not in the plane of foliation and suggest the straining is inherited. Grain size: To 3.1 mm. Texture: Clastic-lepidoblastic.

Phillips No. 2D Beal, 21-23-11E, Greenwood County

Gr-2-1, cuttings, 3145-3155 feet

MUSCOVITE GRANITE GNEISS..... Microcline; quartz; plagioclase; muscovite; feldspar alterations; opaque minerals; chlorite.

In general the rock is a normal granite of this area except for coarse muscovite having a rude preferred orientation. Microcline is coarsely twinned and is associated with an untwinned orthoclase (?) containing hematite along cleavage cracks and disseminated. Plagioclase is sodic oligoclase. Quartz has some shearing features. Some feldspars, particularly the oligoclase, contain muscovitic flakes as crystalloblastic growths. Grain size: 3.5+ mm. Texture: Hypidiomorphic-lepidoblastic?

This gneiss is very similar to the Cities Service No. 99-S Teeter (Gr-7) and is interpreted identically, a granite of the Chase County Granite Group metamorphosed by the 1.2 b.y. episode that is believed responsible for the metamorphism of the geographically associated metasedimentary rocks.

Orlando No. 1 Breitkreutz, 4-24S-10E, Greenwood County

Gr-3-1, cuttings, 3934-3939 feet

MICA SCHIST..... Quartz; biotite; muscovite; iron oxides; pyrite; tourmaline; apatite.

Very fine-grained muscovite and biotite are set in a mosaic of quartz. Feldspar was not identified but may be present. Biotite is reddish brown and with muscovite has a high degree of preferred orientation. Pyrite is common in granules. Clouds of opaque dust particles are possibly pyrite. Olive green tourmaline are found in long prisms with inclusions and a brighter less olive green color near the core. One cutting chip shows fracture planes with hematite mineralization along the cracks. Grain size: 0.06 mm average. Texture: Lepidoblastic.

Orlando No. 1 Breitkreutz, 4-24S-10E, Greenwood County

Gr-3-2, cuttings, 4039-4046.5 feet

GARNET-MICA SCHIST..... Quartz; biotite; muscovite; garnet; iron oxides; pyrite; calcite; tremolite; chlorite; tourmaline; sphene.

Most chips are essentially similar to the previous

interval. Muscovite is less abundant. Red-brown biotite with good preferential orientation is set in a granular mosaic of quartz. Pyrite is in large granules. Dusty opaque inclusions cloud some linears parallel to foliation. Tourmaline and sphene are discrete crystals without apparent orientation. Several chips are notably coarser,containing garnets 1.5 mm in diameter as highly sieved poikiloblasts. Some chlorite alterations are associated with the garnet. Tremolite is found near garnet as is fine sericite. The rock is possibly crudely banded with the garnetiferous coarser chip form sparse bands with a dominantly mica schist sequence. Grain size: 0.06 mm average. Texture: Lepidoblastic-poikiloblastic.

This well penetrated 1290 feet of basement rocks and every sample examined is a rather simple mica schist probably derived from a pelitic sediment. It is interpreted as a westward extension of the Vernon County Metamorphic Group.

Orlando No. 1 Breitkreutz, 4-24S-10E, Greenwood County

Gr-3-3, cuttings, 3489-3498 feet

BIOTITE SCHIST..... Biotite; quartz; muscovite; feldspar alterations (?); chlorite; sphene-leucoxene; opaque minerals.

Most cutting chips are oriented parallel to foliation and are difficult to work with. Silt to fine sand size particles are surrounded by a finely crystalline biotite and lesser amounts of muscovite. Some chips are exceptionally fine grained and appear to be composed of crystalloblastic micas and exceptionally fine feldspar alterations (?); no recognizable clasts are present. No feldspar was recognized positively but some might be present. Grain size: To 0.05-0.10 mm. Texture: Lepidoblastic.

Orlando No. 1 Breitkreutz, 4-24S-10E, Greenwood County

Gr-3-4, cuttings, 3526.5-3536.5 feet

BIOTITE SCHIST..... Biotite; feldspar alterations; quartz; opaque minerals; muscovite; tourmaline; sphene-leucoxene; zircon.

Essentially similar to the previous interval this schist contains quartz in fine sand size particles, possibly clasts, set in a biotite rich matrix containing abundant fine feldspar alterations, apparently as pseudomorphs. Shear linears with preferentially oriented micas cut one chip normal to foliation. Green tourmalines with inclusions near the core are common. Abundant opaque minerals and iron oxides

are as disseminated specks, small granules, and irregular linear bands. Grain size: To 0.15 mm; average 0.07 mm. Texture: Lepidoblastic.

Orlando No. 1 Breitkreutz, 4-24S-10E, Greenwood County

Gr-3-5, cuttings, 3547-3551 feet

BIOTITE SCHIST..... Biotite; quartz; feldspar alterations; muscovite; opaque minerals; tourmaline; sphene-leucoxene.

Some cutting chips are clouded with a myriad of tiny opaque dust particles. Mildly pleochroic reddish brown biotite appear to have good preferred orientation. Some deformation of foliation is noted but it is mild. Quartz stringers cut some chips. Olive green tourmaline is present in small amounts but as common small crystals. Muscovite is associated with biotite and has the same orientation as the biotite. Quartz and feldspar alteration make up the material between biotite. Grain size: Average 0.1 mm. Texture: Lepidoblastic.

Orlando No. 1 Breitkreutz, 4-24S-10E, Greenwood County

Gr-3-6, cuttings, 3702-3727 feet

BIOTITE SCHIST..... Biotite; quartz; feldspar alterations; opaque minerals; sphene-leucoxene; muscovite; tourmaline.

Two large cutting chips are oriented parallel to foliation and are difficult to work with. Reddish brown biotite is mildly pleochroic and is associated with muscovite in lesser amounts. Olive green tourmaline is slightly zoned with an inclusion and a smoky grey color near the core of crystals. Iron oxides are common as disseminated crystals, dust and one veinlet. Feldspar alterations in fine aggregates are common. Quartz is generally in single crystals. Grain size: 0.08 mm average. Texture: Lepidoblastic.

Orlando No. 1 Breitkreutz, 4-24S-10E, Greenwood County

Gr-3-7, cuttings, 3762-3766 feet

BIOTITE SCHIST..... Quartz; biotite; muscovite; feldspar alterations; sphene-leucoxene; opaque minerals; tourmaline.

Essentially similar to previous intervals in mineral content and texture. Mildly pleochroic biotite and lesser muscovite are preferentially oriented. Small granular

masses of sphene-leucoxene and opaque minerals are disseminated through the schist. Quartz is in small crystals and appears associated with finely crystalline feldspar alterations. No feldspars were identified. Tourmaline is present as olive green crystals with inclusions near the core. Grain size: 0.06 mm average. Texture: Lepidoblastic.

Orlando No. 1 Breitkreutz, 4-24S-10E, Greenwood County

Gr-3-8, cuttings, 3859 feet

BIOTITE SCHIST..... Quartz; biotite; muscovite; feldspar; opaque minerals; sphene-leucoxene; feldspar alterations; tourmaline.

A considerably fresher rock than in previous interval with only minor feldspar alterations. Several of the chips are oriented normal to foliation. Proportions of biotite-muscovite vary considerably and in absolute abundance to other minerals. Feldspar is generally water clear and very difficult to distinguish from quartz. Twinning is obscure or lacking but all feldspar appears to be albite with the potassium tied to the muscovite. Tourmaline is less common than in previous intervals. Grain size: 0.07 mm; average to 0.2 mm. Texture: Lepidoblastic.

Cities Service No. 99-5 Teeter, 16-23S-9E, Greenwood County

Gr-7-1, cuttings, 3640-3660 feet

MUSCOVITE GRANITE GNEISS..... Microcline; quartz; plagioclase; muscovite; opaque minerals; feldspar alterations; zircon.

The rock appears to be fairly normal granitic in composition. The texture is completely reorganized if the original rock was a granite. Lepidoblastic muscovite is common and shows a rude preferred orientation. Quartz is faintly strained and has shear-reconstitution zones. Microcline is slightly perthitic. Plagioclase is sparse, well twinned, near An_{20}, and slightly turbid with alterations. Zircon is common. Grain size: 1.2+ mm. Texture: Lepidoblastic.

This well together with the Phillips No. 2D Beal (Gr-2) is a granitic rock with strong reconstitution features. The features are much more well defined than those of the granites along the Nemaha Ridge to the west. The gneiss is associated with metasedimentary wells (Gr-1, Gr-3) of the Vernon County Metamorphic Group and is interpreted as a more metamorphosed example of the Chase County Granite Group.

Seminole No. 1 Harrington, 12-14S-22E, Johnson County

Jo-2-1, cuttings, 2432-2446 feet

GRANITIC GNEISS..... Microcline; plagioclase; quartz; biotite; hornblende; feldspar alterations; sphene; opaque minerals; epidote; chlorite; apatite; zircon.

Relicts of microcline, plagioclase and quartz are set in a quartz-feldspar mosaic containing abundant biotite, hornblende and sphene. These latter are dimensionally oriented in the matrix and wrap around relict grains. Sphene is particularly well formed and is partly subhedral to nearly euhedral. Biotite is olive-green and strongly pleochroic. Hornblende is slightly bluish in color and in part poikiloblastic. Minor biotite is converted to chlorite. Feldspars are erratically altered, microcline is generally fresh, and plagioclase (sodic oligoclase) is sericitized. Grain size: 1+ mm, variable. Texture: Lepidoblastic-gneissic.

This gneiss is an example of the "older granites and gneiss." The well defined cataclastic features are common among this group.

Glore No. 1 Wert, 17-31S-21E, Labette County

Lb-2-1, cuttings, 1885-1887.5 feet

GRANITE..... Perthite; quartz; plagioclase; feldspar alterations; opaque minerals; chlorite; leucoxene.

Small cutting chips are all less than 1.2 mm in diameter and are mostly single mineral chips. Very minor metarhyolite fragments are noted but virtually all the chips are granite in origin. Perthite is clouded with alterations and hematite dust. Plagioclase has a more clear appearance but contains discrete or mats of sericite flakes. Titaniferous magnetite is altered to hematite and leucoxene. Quartz is essentially unstrained. Grain size: Greater than 1.2 mm. Texture: Indeterminate.

This granite on the basis of mineral appearance is placed with the Woodson County Granite. The metarhyolite fragments may be detrital because the inferred boundary of the metarhyolite lies only a few miles southwest and certainly could be a contributor to the basal sandstone over true basement or they may represent caving from a higher zone of in situ metarhyolite but the shallow penetration (17 feet) would make this circumstance fortuitous at best.

Neosho Valley No. 3 Wackerly, 1-35S-19E, Labette County

Lb-3-1, cuttings, 1330-1340 feet

ANDESITIC BASALT..... Groundmass, 85.8; epidote, 4.7; chlorite, 4.0; augite, 3.2; opaque minerals, 1.2; calcite, 0.7; apatite, tr.; talc, tr.

Phenocrysts of augite and pseudomorphs of chlorite and magnetite-hematite are set in a felty microcrystalline groundmass of feldspar and relatively minor chlorite. The groundmass contains exceptionally numerous opaque granules and is a reddish color due to disseminated hematite dust. Possible pseudomorphs of olivine are composed of chlorite with hematite rims and replacement along former cracks. Epidote is associated with chlorite and as irregular masses of fine crystals in the groundmass. Calcite veins and irregular blebs are common. Plagioclase cannot be determined due to poor crystallinity. Grain size: Phenocrysts, to 1 mm; groundmass, microcrystalline. Texture: Porphyritic-pilotaxilic.

This volcanic rock is located about ten miles north of welded andesite tuff in Craig County, Oklahoma (Crg-2) and is interpreted as an example of the intermediate phase of the Washington County Volcanic Group.

Johnson No. 1 Venning, 32-15S-10E, Lyon County

Ly-1-1, cuttings, 3360 feet

MUSCOVITIC QUARTZITE..... Quartz; muscovite; feldspar, epidote; opaque minerals.

Quartz grains are slightly strained but have straight smooth boundaries and are not sutured. Muscovite shows a moderate degree of preferred orientation and is generally in well formed books, most is concentrated in an intergranular position but small flakes are included within quartz crystals. Feldspars, apparently both an albitic plagioclase and a microcline are sparse as an intergranular mineral. Small amounts of hematite dust are included within the feldspars. Very minor epidote is associated with muscovite. Grain size: To 0.7 mm, variable. Texture: Lepidoblastic.

This example of the Lyon County Quartzite is found within two miles of another similar quartzite (Ly-2). It is overlain by rocks of the Simpson Group and represents a topographically superior hill over which Reagan and Arbuckle rocks were not deposited.

Bulla No. 1 Richards, 6-16-10E, Lyon County

Ly-2-1, cuttings, 3225-3230 feet

MUSCOVITIC QUARTZITE..... Quartz, 92.8; muscovite, 6.3; opaque minerals, 0.9.

Quartz is faintly oriented preferentially. In the plane of this orientation are linear trains evidently of opaque dust. These trains go through many mineral grains. Straining of a mild sort is also present. Micas show a rude preferred orientation in the plane of dimensional quartz alignment. The muscovite is generally well distributed but some larger concentrations of coarser flakes are noted. Opaque minerals replace along some cracks. Grain size: To 1.1 mm; 0.4 mm average. Texture: Crystalloblastic.

This is an example of the Lyon County Quartzite and is overlain by rock of the Simpson Group.

Midge No. 1 Day, 16-16S-11E, Lyon County

Ly-3-1, cuttings, 3125-3130 feet

MUSCOVITIC QUARTZITE..... Quartz; muscovite; chlorite-biotite; microcline; plagioclase; hematite; sphene-leucoxene.

Muscovite in small flakes is distributed rather evenly and shows a modest preferential orientation in most cutting chips. Quartz is dimensionally oriented in the plane of mica foliation. Strained quartz is relatively minor and is most pronounced in elongate grains. Several small masses of chlorite-biotite with associated hematite are found as fibrous mat of tiny shreds and appear to be secondary, i.e., post-metamorphic. Microcline and albite are sparse and appear concentrated near accessory minerals. Grain size: 0.15 mm to 0.5 mm. Texture: Lepidoblastic.

This well is the most easterly encounter of the Lyon County Quartzite.

Anderson-Prichard No. 1 Jost, 22-19S-2E, Marion County

Mr-1-1, cuttings, 3071-3081 feet

QUARTZITE..... Quartz; mica; pyrite; sphene; opaque minerals; zircon.

Most quartz shows extensive shearing-straining and reconstitution with the development of mortared boundaries. Small mica flakes are generally intergranular. Zircon is detrital. Pyrite replaces along grain boundaries and linears.

Sphene in small aggregates of fine crystal,is irregularly distributed. Mica does not appear to have a good preferential orientation. Grain size: To 0.7 mm; 0.2 mm average. Texture: Granoblastic.

This rock is tentatively placed in the Lyon County Quartzite but is the only example found west of the Nemaha Ridge and may be more closely related to the quartzites found in Barton County to the west.

Phillips No. 1 Clark, 15-22-4E, Marion County

Mr-6-1, cuttings, 3240-3245 feet

GRANITE (GNEISS?)..... Microcline, 41.6; quartz, 24.1; plagioclase, 12.5; myrmekite, 12.5; feldspar alterations, 2.2; chlorite, 2.2; calcite, 2.0; biotite, 1.1; zircon, 0.4; leucoxene, 0.2; opaque minerals, 0.2; apatite, tr.

Some faint banding suggested by mineral inhomogeneous in cutting chips. Myrmekite is common near boundaries of microcline crystals. Microcline is only slightly altered and is perthitic. Plagioclase is more altered to clay-micas and contains some calcite patches. Zircon is unusually abundant. Red-brown biotite is generally fresh but is associated with finely divided calcite and chloritic masses. Calcite-chlorite masses may represent replacement of pyroxene. Leucoxene replaces ilmenite. Grain size: 3.5+ mm. Texture: Hypidiomorphic.

This well drilled rock of the Chase County Granite Group.

Adair No. 6 Davis, 25-21-4E, Marion County

Mr-11-1, cuttings, 3100-3110 feet

GRANITE (GNEISS?)..... Microcline; plagioclase; quartz; biotite; opaque minerals; sphene-leucoxene; chlorite; feldspar alterations; calcite.

Deep olive green biotite is crystalloblastic along a veinlet in feldspars and in larger well crystallized masses, some vermicular. Smaller fibrous masses are reddish and strongly pleochroic. Microcline is generally fresh, slightly perthitic and contains poikilitically enclosed altered plagioclase. Myrmekite common along some plagioclase-microcline boundaries. One cutting chip is cut by numerous cataclastic linears with mineral fragments in a reddish semi-opaque rock paste matrix. Grain size: 4.5+ mm. Texture: Hypidiomorphic.

The granitic rock has features of high pressure-

temperature deformation as well as simple brecciation, probably associated with Paleozoic faulting. The rock is interpreted as a member of the Chase County Granite Group.

Francis Hawn No. 5 Jeffers Steel, 20-21S-5E, Marion County

Mr-13-1, cuttings, 2970-2975 feet

PYROXENE GRANITE..... Quartz, 28.1; plagioclase, 27.6; microcline, 24.9; amphibole, 5.9; pyroxene, 5.1; biotite, 3.6; calcite, 2.6; opaque minerals, 2.2; sphene, tr.; feldspar alterations, tr.; zircon, tr.; apatite, tr.; chlorite, tr.

A wild and wonderful granitic rock!! Feldspars are generally fresh and contain only minor alterations. Myrmekite locally present. Pyroxene is mantled by hornblende. Texture is very unusual. Mostly oriented pyroxene with associated zircon, apatite and iron ore is partly separated from the hornblende by semi-vermicular quartz. Calcite replaces pyroxene extensively in some chips. Well crystallized red-brown biotite is associated with hornblende and a secondary fibrous variety is found as an alteration of the pyroxene. Textures are interpreted as igneous. Grain size: 5+ mm. Texture: Hypidiomorphic.

The high femic mineral content is probably due in part to sample bias. The pyroxene in the granite and indeed the total texture is very similar to that in the Martin No. 1 Winsor (Cs-18) about 12 miles to the northeast. The granite does not appear to have been affected by the later activity reflected in the granites T20N, R7E but is nonetheless interpreted as a member of the Chase County Granite Group.

McDonald No. 1 Lee, 16-16S-23E, Miami County

Mi-1-1, cuttings, 2297-2304 feet

GRANITE GNEISS. Microcline; quartz; plagioclase; feldspar alterations; chlorite-biotite; opaque minerals; epidote; sphene-leucoxene.

The rock is a granular mosaic of essentially quartz-feldspar. Varience in cutting chips suggest it is crudely banded. Locally mica development is also oriented suggesting the banding. Feldspar alterations replace some portions of the mosaic completely. Plagioclase is considerably less abundant than microcline. Opaque minerals appear mostly secondary and as a hematite stain with feldspar alterations. There are two cutting chips of marked different appearance. They look like altered tuffs and are of unknown origin. Grain

size: Maximum, 1.6 mm; average, 0.2-0.4 mm. Texture: Gneissic.

McDonald No. 1 Lee, 16-16S-23E, Miami County

Mi-1-2, cuttings, 2350 feet

GRANITE GNEISS..... Microcline; plagioclase; quartz; feldspar alterations; biotite; opaque minerals; carbonate; chlorite; sphene-leucoxene; muscovite; apatite; zircon.

Microcline is well twinned, clear of extensive alterations and contains poikilitically enclosed quartz and plagioclase. Minor myrmekite is developed. Discrete sericite flakes are common in plagioclase (calcic albite). Quartz is moderately strained and appears to have been sheared and reconstituted in part. Some microcline is mildly strained. Biotite is reddish brown and may have a slight preferred orientation, chlorite replaces portions of the biotite. Minor finely crystalline muscovite is locally developed in an intergranular position. Grain size: To 4 mm. Texture: Granoblastic.

McDonald No. 1 Lee, 16-16S-23E, Miami County

Mi-1-3, cuttings, 2378-2380 feet

GRANITE GNEISS..... Microcline; quartz; plagioclase; feldspar alterations; biotite; opaque minerals; carbonate; muscovite; sphene-leucoxene; zircon.

Feldspars are erratically and in some chips extensively altered to a semi-opaque mat of alterations. In fresher chips microcline is water clear and the plagioclase contains extensive alterations. Feldspars in shear linears are more altered. Red-brown biotite shows good preferred orientation in properly oriented cutting chips. Quartz is only mildly strained but shearing effects are noted in several cutting chips. Grain size: 1+ mm. Texture: Lepidoblastic.

McDonald No. 1 Lee, 16-16S-23E, Miami County

Mi-1-4, cuttings, 2440-2480 feet

GRANITE GNEISS..... Microcline; quartz; plagioclase; biotite; feldspar alterations; muscovite; opaque minerals; chlorite; epidote; sphene-leucoxene.

Extensive foliation is shown in some chips as well as a late brecciation at some later time. Alterations are extensive in some chips and plagioclase is reduced to a semi-opaque mat while microcline is exceptionally fresh. One very large (1.5 mm) magnetite crystal is noted in a strongly banded chip. Coarse muscovite is associated with biotite. Some poikiloblastic microcline encloses quartz and minor muscovite. Grain size: To 2 mm. Texture: Granoblastic-lepidoblastic.

The alteration effects in samples not near the basement surface are most unusual in metamorphic rocks and suggests later hydrothermal activity or deep weathering along brecciation-shear planes. The gneiss is placed in the "older granites and gneiss."

Frankfort No. 1 Carter, 23-32-14E, Montgomery County
E/w 818 EKB NE NE NW My dope from E Log
Mt-4-1, cuttings, 2975-2985 feet Qal 1650 Pt 2400-1582
TD 2487

METARHYOLITE PORPHYRY..... Groundmass, 66.0; perthite, 12.5; plagioclase, 9.9; feldspar alterations, 6.7; chlorite-biotite, 2.0; quartz, 1.9; carbonate, 0.4; sphene-leucoxene, 0.3; opaque minerals, tr.; apatite, tr. No sample — Library

Abundant phenocrysts of feldspar, quartz and chlorite pseudomorphs are set in a finely granoblastic groundmass of quartz-feldspar. The plagioclase phenocrysts are highly altered to sericite shreds and epidote granules. The perthite is much less altered and contains exceptionally clear areas that are suggestive of microcline, though grid twinning is not present. Hematite dust is common. Chlorite contains sphene-leucoxene granules along cleavage. Quartz in phenocrysts has subhedral outlines but is typically embayed. Grain size: 3 mm; 0.04 mm average. Texture: Relict porphyritic-granoblastic.

This well penetrated the metamorphosed equivalent of the Washington County Volcanic Group.

Stevens and Crissell No. 1 Uitts, 18-32S-16E, Montgomery County

Mt-5-1, cuttings, 2314-2318 feet

METARHYOLITE PORPHYRY..... Groundmass, 50.5; perthite, 25.7; quartz, 8.1; feldspar alterations, 7.7; plagioclase, 6.7; chlorite, 1.4; opaque minerals, 0.3; sphene-leucoxene, tr.; pyrite, tr.; apatite, tr.; calcite, tr.; zircon, tr.; epidote, tr.

Diverse phenocrysts are set in a granoblastic mosaic

of quartz-feldspar. Microcline perthite, plagioclase, quartz and chlorite are in part embayed by the mosaic. Quartz is typical volcanic types partly euhedral with irregular embayed areas. Alteration of feldspars is varied, some are extensively clouded while others contain only mottled alterations. Chlorite pseudomorphs contain abundant sphene-leucoxene along cleavage traces and is probably after a titaniferous biotite. Microcline perthite is probably derived from sanidine. Grain size: 3.5+ mm phenocrysts; average, 0.04 mm. Texture: Relict porphyritic-granoblastic.

Stevens and Crissell No. 1 Uitts, 18-32-16E, Montgomery County

Mt-5-3, cuttings, 2423-2425 feet

METARHYOLITE PORPHYRY. Groundmass, 48.1; microcline perthite, 15.9; plagioclase, 15.2; quartz, 11.0; feldspar alterations, 6.3; chlorite, 1.4; sphene-leucoxene, 0.3; opaque minerals, 0.2; amphibole, tr.; apatite, tr.; sphene, tr.; zircon, tr.; epidote, tr.; calcite, tr.

Phenocrysts of microcline perthite, quartz, plagioclase and minor chlorite-amphibole are set in a granoblastic mosaic of quartz-feldspar. Perthite has mottled alteration and disseminated hematite dust; plagioclase contains discrete sericite flakes as well as fibrous sericite mats and mottled calcite replacement. Quartz is unstrained with typical volcanic habit. Minor actinolitic amphibole is associated with chlorite. Sphene is associated with opaque granules while sphene-leucoxene is along cleavage in chlorite. Grain size: To 2.5 mm; average, 0.07 mm. Texture: Relict porphyritic-granoblastic.

Stevens and Crissell No. 1 Uitts, 18-32S-16E, Montgomery County

Mt-5-4, cuttings, 2702-2703 feet

METARHYOLITE PORPHYRY..... Groundmass; perthite; plagioclase; quartz; feldspar alterations; chlorite; opaque minerals; sphene-leucoxene; amphibole; epidote; apatite; zircon.

This rock is essentially similar to the previous intervals; quartz, perthite, plagioclase and chlorite-actinolitic amphibole are set in a granoblastic quartz-feldspar matrix. Perthite is partly microcline. Actinolitic amphibole is pale brown to green and occurs not only as former phenocrysts but as small rounded crystalloblasts in the matrix.

Pennine type chlorite pseudomorphs contain granular sphene-leucoxene along cleavage. Quartz is embayed and in part shows good euhedral form. Epidote is associated with dolomite. Feldspars contain irregular but extensive alterations except for microcline which is clear. Grain size: 3+ mm; average, 0.05 mm. Texture: Relict porphyritic-granoblastic.

This well penetrated 391 feet of metarhyolite of the Washington County Volcanic Group and this is the maximum penetration of this phase of the group.

Hayes 10 Atlas Cement, 5-33S-16E, Montgomery County

Mt-8-1, cuttings, 1345-1346 feet

METARHYOLITE PORPHYRY..... Groundmass; perthite; quartz; plagioclase, feldspar alterations; chlorite; epidote; opaque minerals; calcite; sphene; apatite; zircon.

Phenocrysts of quartz, perthite, and plagioclase are set in a granoblastic granular groundmass of quartz-feldspar. The phenocrysts of plagioclase are extensively altered with sericite and epidote. Perthite contains mottled clear patches suggestive of microcline. Opaque minerals are mostly disseminated hematite and a hematite intergranular stain, but larger granules associated with zircon and apatite and minor alterations are present. Chlorite masses contain granular sphene along cleavage planes. Grain size: 2.1 mm maximum; 0.03 mm average. Texture: Relict porphyritic-granoblastic.

The well penetrated metarhyolite of the Washington County Volcanic Group.

Illine No. 1 Reece, 12-33S-16E, Montgomery County

Mt-9-1, cuttings,

METARHYOLITE PORPHYRY..... Groundmass; perthite; plagioclase; quartz; feldspar alterations; opaque minerals; chlorite; epidote; apatite.

The cutting chips are all exceptionally fine generally 0.5 mm in maximum dimension. Phenocrysts of perthite, plagioclase and quartz are set in a granoblastic mosaic groundmass of quartz-feldspar. The groundmass feldspars are turbid and stained with hematite. Phenocrysts of plagioclase are sodic oligoclase and carry extensive alteration and hematite dust. The perthites are of two types: clear with minor mottled alterations with a microcline appearance and the second type a turbid mesoperthite contains abundant hematite.

Small chlorite flakes, some possibly poikiloblastic, are present. Grain size: 0.8+ mm; average 0.05 mm. Texture: Granoblastic-relict porphyritic.

This thin section was cut from a single sample obtained from this well and is an example of the metamorphosed rhyolite of the Washington County Volcanic Group.

Emery Construction Co. No. 1 Gilliam, 4-35-14E, Montgomery County

Mt-14-1, cuttings, 2360-2370 feet

MICROGRAPHIC GRANITE PORPHYRY..... Perthite, 55.6; quartz, 30.1; plagioclase, 10.5; chlorite, 0.9; opaque minerals, 0.8; muscovite, 0.5; biotite, 0.4; feldspar alterations, 0.4; sphene-leucoxene, 0.2; calcite, tr.; epidote, tr.; pyrite, tr.

Phenocrysts of plagioclase, perthite, and quartz are distinct from groundmass only because they are not intergrown, giving the rock a porphyritic appearance even though the discrete crystals are not significantly larger than intergrown crystals. Plagioclase contains micas flake and rare iron poor epidote granules. Perthite is generally clouded with minor alterations and disseminated hematite dust. Secondary muscovite in relatively large flakes is associated with strongly pleochroic iron-stained chlorite and finely granular biotite. These micas were probably reconstituted from a chlorite alteration of an original femic mineral. Pyrite is found as veinlets. Sphene-leucoxene replaces ilmenite. Grain size: Phenocrysts, 2.5 mm; groundmass, 2.0 mm. Texture: Micrographic-porphyritic.

This well contains a rock that is not easy to interpret. It is located at the approximate boundary between rhyolite and metarhyolite and possibly is a sliver caught in the fault that is inferred between these rock units. It is tentatively placed with the Woodson County Granite.

Lincoln No. 1 Breckbill, 24-16S-5E, Morris County

Mo-4-1, cuttings, 3068-3069.5 feet

GRANITE..... Microcline perthite, 49.6; plagioclase, 21.0; quartz, 12.5; feldspar alterations, 9.5; biotite, 5.4; calcite, 1.2; sphene-leucoxene, 0.7; opaque minerals, tr.; hornblende, tr.

Perthitic microcline is slightly turbid and microcline appears more altered than the plagioclase portions of the perthite. Free plagioclase is more altered than microcline

and parts are converted to a sericite mat or, more rarely, a vermicular intergrowth of low birefringent clay mineral. Calcite blebs and tiny flakes also replace feldspars. Quartz is strained. Biotite is a deep olive green color and is in part poikilitic, containing quartz-feldspar. The biotite may be crystalloblastic-poikiloblastic. A small amount of blue-green hornblende is associated with biotite. Grain size: 5.7+ mm. Texture: Hypidiomorphic.

The crystalloblastic appearance of part of the femic minerals is very common in the Chase County Granite Group.

General Utilities No. 1 Heigle, 11-16-7E, Morris County

Mo-5-1, cuttings, 2045-2046 feet

GRANITE GNEISS..... Microcline, 51.7; quartz, 31.2; plagioclase, 8.2; feldspar alterations, 3.7; muscovite, 3.3; biotite, 1.1; sphene-leucoxene, 0.8; pyrite, tr.; calcite, tr.; zircon, tr.; opaque minerals, tr.; chlorite, tr.

Granoblastic microcline is exceptionally fresh and delicately twinned. Quartz is strained. Plagioclase contains extensive alterations of sericite and locally is converted to a vermicular clay mat. Muscovite and biotite appear to have a strong preferential orientation. Small amounts of myrmekite are present, chiefly in finer grained portions (linears?) of the rock. Grain size: 1.7 mm. Texture: Gneissic.

This gneiss is tentatively placed in "older granites and gneiss" chiefly because of the common muscovite and its preferred orientation. There is little evidence for a strong thermal-cataclastic event in this area after the emplacement of the Chase County granites and the suggestion is that the conversion to gneiss may have been caused by these granites.

Westgate Greenland No. 1 Orphan Home, 15-16-7E, Morris County

Mo-6-1, cuttings, 2160-2163 feet

GRANITE GNEISS?..... Quartz; microcline; muscovite; biotite; feldspar alterations; opaque minerals; chlorite; sphene-leucoxene; apatite.

Relatively small cutting chips of granite are apparently quartz rich possibly through sampling bias. Microcline is generally fresh, plagioclase was not identified, some microcline is perthitic. Fresh biotite is noted with very minor alterations. Muscovite is partly in flakes of exceptional size. Several cutting chips are composed of the overlying sandy dolomite. One cutting chip of granite is

extensively altered and probably is a weathering phenomena. Hematite-magnetite is in small granules and appears secondary. Apatite is found as numerous tiny inclusion needles. Grain size: 2+ mm. Texture: Hypidiomorphic.

This rock is tentatively placed in "older granites and gneiss" as is the muscovite granite gneiss immediately to the northeast (Mo-5).

Leslie No. 1 "A" McConnell, 14-16S-9E, Morris County

Mo-7-1, core, 3145 feet

MUSCOVITIC QUARTZITE..... Quartz, 91.5; muscovite, 7.7; fine micas, 0.8; opaque minerals, tr.; zircon, tr.; epidote ?, tr.; tourmaline, tr.

Quartz is generally unstrained or mildly strained. Straight smooth boundaries are between quartz grains with little or no suturing. Muscovite is well formed with larger books intergranular in position and smaller flakes within quartz. Patches of fine micaceous minerals may be a replacement of former feldspars. Heavy minerals are apparently concentrated along layers parallel to preferred orientation of muscovite. Zircon is rounded. One tourmaline is strongly colored green-brown variety. Grain size: To 0.7 mm but variable. Texture: Lepidoblastic.

This is the only sample dated from the Lyons County Quartzite. A whole rock K/Ar age was 1.26 b.y. and whole rock Rb/Sr yielded an age of 1.40 b.y. The K/Ar age is possibly low because of the argon leakage from altered micas.

Kansas, Gruenerwald No. 1 Johnson, 33-16S-9E, Morris County

Mo-8-1, cuttings, 3100-3103 feet

GRANITE GNEISS..... Microcline; quartz; plagioclase; biotite; feldspar alterations; opaque minerals; chlorite; carbonate; sphene-leucoxene; zircon; rutile ?.

Large relicts of quartz, microcline, plagioclase and aggregates of these minerals are separated by finer material probably derived from the crystallization of shear linears. Red-brown biotite locally converted to chlorite is preferentially oriented in some cutting chips and apparently not in others. Fine aggregates of flakes of biotite replace some feldspars. Carbonate, calcite and possibly dolomite, is an intergranular mineral and also as fine flakelets in feldspar. Feldspars are generally fresh but contain local or mottled alterations. Grain size: To 3.5 mm. Texture:

Gneissic.

The rock in this well is interpreted as belonging to "older granites and gneiss."

Rex and Morris No. 1 Anderson Ranch, 12-17S-6E, Morris County

Mo-9-1, cuttings, 2120-2130 feet

GRANITE..... Microcline perthite; plagioclase; quartz; chlorite; opaque minerals; feldspar alterations; zircon; apatite; sphene-leucoxene.

Cutting chips have fairly uniform mineralogy but grain boundaries have marked contrasts--some are straight and smooth while other cutting chips show a very delicate and well formed mortar structure at the boundaries. Quartz is partly sheared and reconstituted in the larger grains. Myrmekite is exceptionally well developed near the margins of some plagioclase-microcline boundaries. Both plagioclase, near An_{20}, and microcline are generally fresh and contain only minor mottled alterations and hematite dust. Chlorite has replaced all of the former femic mineral. Grain size: 3.5+ mm. Texture: Hypidiomorphic.

The generally unaltered character of the granite with minor shear phenomena is typical of the Chase County Granite Group in this area.

Westgate and Greenland No. 1 Meyers, 23-17S-7E, Morris County

Mo-10-1, cuttings, 2220-2240 feet

GNEISSIC GRANITE..... Microcline; quartz; plagioclase; biotite-chlorite; opaque minerals; calcite; feldspar alterations; sphene-leucoxene; zircon.

The original granite has been extensively altered by later mineralization and shearing. Most shear linears are now composed of aggregates of myrmekite. Chlorite-biotite has replaced the former femic minerals and also invades along cracks in feldspars and intergranular in myrmekitic linears. Quartz is mostly unstrained. Microcline is fresh with only minor mottled alterations. Plagioclase is sparse except for myrmekite. Zircon is mildly metamict. Grain size: 4+ mm. Texture: Hypidiomorphic-gneissic.

Myrmekite appears to be concentrated along late shearing in many examples of the Chase County Granite Group.

Stanolind No. 1 Carpenter, 29-17S-7E, Morris County

Mo-11-1, cuttings, 2150-2153 feet

GRANITE..... Microcline; oligoclase; quartz; calcite; feldspar alterations; biotite; opaque minerals; apatite.

Well developed microcline is faintly zoned and contains mottled alterations. Plagioclase (near An_{20}) is somewhat more altered, containing cracks filled by calcite. Feldspar alterations are varied from gentle clouding to a mosaic of clay minerals. Small amounts of myrmekitic intergrowth developed. Extensive alteration of biotite has yielded a green variety, rather than the red-brown primary type, and is associated with opaque minerals, calcite and extensive feldspar alterations. Inclusion trains transect mineral boundaries; these appear to be bubble trains. Grain size: 4.5+ mm. Texture: Hypidiomorphic.

This well penetrated rock of the Chase County Granite Group.

Stanolind No. 1 Veal, 30-17-7E, Morris County

Mo-12-1, cuttings, 2000-2005 feet

GNEISSIC (?) GRANITE..... Microcline; plagioclase; quartz; biotite; hornblende; calcite; feldspar alterations; opaque minerals; zircon.

This rock is similar to that in Mo-11-1. Plagioclase is more altered than microcline. Hornblende is associated with biotite. Deep brown biotite is altered to a green variety. Small amounts of actinolitic amphibole are also noted. The clotted amphibole and biotite show some orientation suggesting a possible gneissic granite. Some of the microcline is decidedly perthitic (string type). Grain size: 4.5+ mm. Texture: Hypidiomorphic.

The orientation of the femic minerals is the only sign of gneissic character and may be fortuitous arrangement of a cutting chip or primary flow folding. The rock is a member of the Chase County Granite Group. An Rb/Sr determination on the feldspar yielded a date of 1.42 ± .1 b.y. and is the most northerly date of this age range.

Empire No. 1 Moffitt, 34-17S-7E, Morris County

Mo-13-1, cutting, 2530-2535 feet

GRANITE..... Microcline; quartz; plagioclase; biotite; opaque

minerals; calcite; chlorite; feldspar alterations; muscovite; apatite.

The cutting chips are all of inferior size and textural relationships are not clear. Microcline is generally clear with minor perthite containing more alterations. Plagioclase is near An_{20} and contains abundant sericite flakes and clouding alterations. Femic and opaque minerals are in irregular clots. Biotite is both primary as reddish green books and as secondary aggregate associated with minor chlorite and pale greem amphibole. Calcite replaces portions of the femic minerals. Quartz is unstrained. Grain size: 1.8+ mm. Texture: Hypidiomorphic?

The rock in the well is of the Chase County Granite Group.

Allan Van No. 3 Coombs, 30-28S-21E, Neosho County

Ne-2-1, cuttings, 2000-2004 feet

GRANITE..... Microcline perthite; quartz; plagioclase; feldspar alterations; chlorite; opaque minerals.

Only a few cutting chips of inferior size make determination of fabric and grain size impossible. The feldspars are intensely altered, in part reduced to a semi-opaque clay mass. One chip is a brecciated granite. Hematite occurs as clouding dust in feldspars and as a partial replacement of magnetite granules. Grain size: Indeterminate. Texture: Questionable.

The poor samples offer little to define the character of this rock, but the mineralogy and appearance suggest it is a Woodson County Granite.

Elmhurst No. 1 Badger, 4-15S-16E, Osage County

Os-2-1, cuttings, 2740-2745 feet

GRANITE GNEISS..... Microcline; quartz; plagioclase; muscovite; opaque minerals; chlorite; pyrite; feldspar alterations; biotite; sphene-leucoxene; calcite; zircon.

Large relicts of microcline, quartz, and minor plagioclase are generally separated by reconstituted cataclastic linears. The linears are now a granoblastic mosaic of quartz-feldspar, partly as a pseudomicrographic intergrowth appearing material. Fine muscovite flakes are developed in the linears and are locally abundant with a mild to distinct preferred orientation. Sphene-leucoxene replaces a former titaniferous iron oxide. Chlorite is very sparse, biotite occurs as a fine

secondary rim around iron ore. Grain size: Relicts to 2.1 mm. Texture: Cataclastic.

This is an example of "older granites and gneiss" and is the only basement rock sample obtained in Osage County.

Continental No. 1 Casey, 15-25S-1E, Sedgwick County

Sg-1-1, cuttings, 4217-4229 feet

BIOTITE PHYLLITE..... Quartz; sericite; biotite; calcite; iron oxides; pyrite; tourmaline; leucoxene.

Fine biotite flakes and poorly crystalline sericite shreds have a high degree of preferred orientation and are associated with quartz in granules. Calcite invades along disrupted foliation associated with minor microfolds. A dark appearance is caused by clouds of opaque inclusions only a few microns and less in diameter. Small pale olive green tourmaline is sparse. Pyrite is in larger granules. Hematite is secondary staining along cracks. Grain size: 0.03-0.05 mm average. Texture: Lepidoblastic.

A metasediment probably derived from a pelitic composition. The rock is tentatively interpreted as an extension of the Vernon County Metamorphic Group.

Kewanee No. 4 "A" Schramm, 34-26S-1E, Sedgwick County

Sg-3-1, cuttings, 4195-4205 feet

GRANITE..... Plagioclase; microcline; quartz; biotite; feldspar alterations; hornblende; sphene; opaque minerals; epidote; pyrite; calcite; chlorite; apatite; zircon.

This granite containing perthitic microcline, sodic oligoclase, quartz and biotite as the coarse minerals. Feldspar alterations are generally mottled and locally extensive. With the olive brown biotite in coarse books is finer biotite of the same type associated with accessory mineral clots. The accessory clots contain magnetite, leucoxene, crystalline sphene, abundant zircon and apatite, and hornblende. Some biotite and blue-green hornblende near these clots appears to replace feldspars along cleavage planes. Small amounts of fine myrmekite occur near the margins of some large feldspars. Mineral distribution in cutting chips is highly variable. Grain size: 6+ mm. Texture: Hypidiomorphic.

The general lack of later features suggests this rock is related to the Central Oklahoma Granite Group.

Murfin No. 5 Weiskirch, 11-26S-2E, Sedgwick County

Sg-4-1, cuttings, 4011 feet cir.

MICA-QUARTZ-FELDSPAR HORNFELS..... Quartz; microcline; plagioclase; biotite; muscovite; epidote; sphene; calcite; opaque minerals; chlorite; leucoxene.

The grain size is variable in chips and the finer grained rock has some superindividuals. The majority of the rock is composed of a granoblastic mosaic of quartz-plagioclase-microcline with smaller amounts of micas. Both muscovite and a mildly birefringent biotite are present and are partly poikiloblastic. The feldspars are generally fresh. Magnetite-ilmenite granules, partly altered to hematite and leucoxene, are common in some chips. Epidote is an intergranular mineral. Origin of the rock is questionable. Grain size: 0.05 mm; average to 0.4 mm. Texture: Granoblastic.

The assemblage suggests this rock was derived from a quartzo-feldspathic to pelitic assemblage but may have been modified by granitic intrusions found in the area. The hornfels is considered to be a member of the Vernon County Metamorphic Group.

Bedell and Catt No. 2A Stollei, 13-26S-2E, Sedgwick County

Sg-5-1, cuttings, 4080-4082 feet

GRANITE..... Quartz, 32.4; microcline, 30.3; plagioclase, 29.2; biotite, 5.0; feldspar alterations, 1.7; muscovite, 1.1; sphene-leucoxene, 0.2; opaque minerals, tr.; zircon, tr.; pyrite, tr.; apatite, tr.; rutile, tr.

Perthitic microcline and intermediate oligoclase are partly altered with the plagioclase more containing extensive sericite flakes and clays. Biotite is red-brown and has hematite along cleavage surfaces. Quartz is faintly strained and contains hairlike reddish needles of rutile (?). Muscovite is associated in part with biotite and is also a discrete intergranular mineral, evidently very late or possibly crystalloblastic. Sphene-leucoxene is associated with iron ore. Grain size: 9.5+ mm. Texture: Hypidiomorphic.

Bedell and Catt No. 2 "A" Stollei, 13-26S-2E, Sedgwick County

Sg-5-2, cuttings, 4080-4082 feet

BIOTITE SCHIST..... Microcline, 35.6; quartz, 30.5; biotite, 17.2; plagioclase, 15.6; feldspar alterations, 1.1; pyrite,

tr.; leucoxene, tr.; opaque minerals, tr.; apatite, tr.; zircon, tr.; epidote, tr.; calcite, tr. The mode is only an approximation.

Lepidoblastic red-brown biotite is surrounded by a granoblastic mosaic of quartz-plagioclase-microcline. Small amounts of alteration material are noted but the rock is fresh as a whole. Leucoxene has replaced most of the titaniferous iron oxides. Small rounded zircons are common and are difficult to distinguish from epidote in similar habit. Grain size: To 0.7 mm; average, 0.2 mm. Texture: Lepidoblastic.

The granite intruding the metasedimentary rock is interpreted as belonging to the Central Oklahoma Granite Group. The metasediment is probably derived from a pelitic to quartzofeldspathic rock but has undoubtedly been modified in bulk composition by the invading granite. The metasediment is considered to be a member of the Vernon County Metamorphic Group.

Raymond No. 9 Blood, 29-28S-1E, Sedgwick County

Sg-8-1, cuttings, 4440-4450 feet

GRANITE..... Microcline, 53.6; quartz, 24.4; plagioclase, 15.5; biotite, 4.3; feldspar alterations, 2.1; sphene, 0.2; opaque minerals, tr.; zircon, tr.; calcite, tr.; chlorite, tr.; epidote, tr.

Microcline is in part perthitic and is fresh. Plagioclase contains extensive mottled sericitization. Quartz is moderately strained in large crystals and is also in small round poikilitically enclosed crystals in feldspars. Biotite is in large, well formed bookswith only a trace of alterations. Opaque minerals are exceptionally sparse. Grain size: 6+ mm. Texture: Hypidiomorphic.

This well penetrated rock tentatively placed in the Central Oklahoma Granite Group.

Amerada No. 13 Gassoway, 14-32S-2E, Sumner County

Sm-1-1, cuttings, 3348-3358 feet

GRANITE..... Plagioclase; microcline; quartz; chlorite; biotite; feldspar alterations; epidote; hornblende; opaque minerals; leucoxene; calcite; zircon; apatite.

Fresh partly perthitic microcline is in contrast to turbid plagioclase containing hematite dust, sericite flakes and epidote granules. Olive-green biotite in large books is partly altered to chlorite. Other masses of chloritic material may be replacing either biotite or hornblende and in part are

associated with calcite masses. Small amounts of hornblende are present. Some feldspars have been completely reduced to a clay-mica mass. Quartz is mildly strained. Grain size: 3.5+ mm. Texture: Hypidiomorphic.

Amerada No. 13 Gassoway, 14-32S-2E, Sumner County

Sm-1-2, cuttings, 3498-3503 feet

GRANITE..... Microcline perthite; plagioclase; quartz; biotite; chlorite; feldspar alterations; epidote; opaque minerals; leucoxene.

This is essentially similar to the previous interval. No large biotite books or hornblende remains, all have been converted to chlorite. Small masses of biotite are composed of aggregates of books and may be secondary (crystalloblastic). Epidote occurs as small granules and as crystals of superior size within plagioclase. Grain size: 2.5+ mm. Texture: Hypidiomorphic.

This well was drilled less than two miles northeast of the Lario No. 13A Wenrich (Sm-3) that was dated at 1.34 b.y. and the rock in this well is considered the same age and thus a member of the Chase County Granite Group.

Lario (Barnsdall) No. 13A Wenrich, 22-32S-2E, Sumner County

Sm-3-1, cuttings, 3475-3485 feet

GRANITE..... Plagioclase, 32.2; microcline, 30.2; quartz, 22.9; feldspar alterations, 7.7; biotite, 5.3; chlorite, 1.0; opaque minerals, 0.3; sphene-leucoxene, 0.3; apatite, tr.; calcite, tr.

Perthitic microcline contains poikilitically enclosed quartz and plagioclase. Plagioclase is generally altered containing mottled matting of micas with hematite stain. Reddish olive-green biotite is in large books altered in part to chlorite. A few quartz are extensively strained with incipient shear linears, most are moderately strained. Opaque minerals are sparse but a few crystals are associated with biotite-chlorite. Modal analysis was combined with Sm-3-2 to obtain more area. Grain size: 5+ mm. Texture: Hypidiomorphic.

Lario (Barnsdall) No. 13A Wenrich, 22-32S-2E, Sumner County

Sm-3-2, cuttings, 3835-3856 feet

GRANITE..... Plagioclase, 32.2; microcline, 30.2; quartz, 22.9; feldspar alterations, 7.7; biotite, 5.3; chlorite, 1.0; opaque minerals, 0.3; sphene-leucoxene, 0.3; epidote, 0.1; apatite, tr.; zircon, tr.

Microcline is partly perthitic in larger crystals, contains disseminated alterations and hematite dust. Minor epidote crystals are crystalloblasts within feldspars. Plagioclase contains extensive alterations, particularly near the cores of larger crystals. Large fresh books of olive-green biotite are in part associated with a mildly pleochroic secondary biotite in vermicular aggregates and as replacement or masses and veinlets in feldspar. Chlorite replaces the margin of large biotites. Quartz is mildly strained and one cutting chip shows brecciation on a minor scale. Grain size: 6+ mm. Texture: Hypidiomorphic.

The feldspar from this granite was dated at 1.34 ± .12 b.y. by the Rb/Sr method. This is the most southerly date of this magnitude along the Nemaha Ridge and thus the rock is related to the Chase County Granite Group. The 1.35 b.y. date is not found in Oklahoma except in the Arbuckle Mountains, about 200 miles to the south.

Wentworth and Glare No. 1 McFadden, 26-27S-16E, Wilson County

Wl-1-1, cuttings, 3098-3100 feet

MICROGRAPHIC GRANITE..... Microcline perthite, 42.2; quartz, 33.6; plagioclase, 18.1; feldspar alterations, 3.9; chlorite, 1.9; epidote, 0.1; sphene, 0.1; opaque minerals, tr.; apatite, tr.

Both plagioclase and microcline perthite are clouded with alterations and hematite dust. In addition the plagioclase contains sericite flakes and epidote granules. Sphene occurs in well formed crystals as well as granular aggregates along cleavage planes in chlorite. Quartz is in large discrete crystals and as micrographic intergrowths in microcline perthite. Epidote occurs in large crystals associated with chlorite. Biotite occurs as small relicts in chlorite. Grain size: 3.5+ mm. Texture: Hypidiomorphic-micrographic.

Wentworth and Glare No. 1 McFadden, 26-27S-16E, Wilson County

W1-1-2, cuttings, 3235-3245 feet

GRANITE..... Microcline perthite, 37.7; plagioclase, 30.8; quartz, 24.5; epidote, 5.4; feldspar alterations, 0.9; chlorite, 0.3; leucoxene, 0.2; opaque minerals, 0.1; apatite, tr.

Clouded microcline perthite contains disseminated alterations and hematite dust. Plagioclase is less altered, is well twinned, is sodic oligoclase in composition and contains mainly sericite flakes and sparse hematite dust. Quartz is generally unstrained and is in part micrographic. Epidote as crystalloblastic growths within feldspars is prominent. Several chips are a granite breccia. Evidence suggests, though not positively, that the epidote is younger than brecciation. Grain size: 3.4+ mm. Texture: Hypidiomorphic-micrographic.

This rock is very similar to certain phases of the granite found at Rose Dome about nine miles to the northwest. It is interpreted, therefore, as a Woodson County Granite.

Fredonia No. 3 Smith, 10-29S-15E, Wilson County

W1-3-1, cuttings, 2222-2226 feet

METARHYOLITE PORPHYRY..... Groundmass, 60.7; microcline perthite, 13.0; quartz, 12.5; plagioclase, 8.3; feldspar alterations, 2.9; opaque minerals, 1.5; chlorite, 0.8; leucoxene, 0.3; zircon, tr.; apatite, tr.; biotite, tr.; calcite, tr.

Phenocrysts of quartz, microcline perthite, plagioclase and former femic minerals are set in a granoblastic mosaic of quartz-feldspar. Alteration of feldspars is variable. Microcline perthite is in part clear and partly clouded with hematite dust and alterations. Quartz is embayed and shattered, some concave surfaces are prominent. Large chlorite pseudomorphs replace a former femic mineral possibly biotite. Primary biotite occurs as a single book included in a quartz phenocryst. One large magnetite crystal contains numerous included and attached zircon and apatite. Grain size: Phenocrysts, to 3.2 mm; groundmass, average 0.06 mm. Texture: Relict porphyritic-granoblastic.

This well is the most northerly encounter of the metamorphosed equivalent of the Washington County Volcanic Group.

J. J. Delk No. 1 Newbold, 29-25S-16E, Woodson County

Wd-6-1, cuttings, 2403-2411 feet

MICROGRAPHIC GRANITE..... Quartz, 42.9; microcline perthite, 39.0; plagioclase, 14.1; chlorite, 3.5; opaque minerals, 0.1; feldspar alterations, tr.; calcite, tr.; sphene-leucoxene, tr.; zircon, tr.; apatite, tr.

Microcline perthite partly intergrown with quartz is turbid with alterations and hematite dust. Plagioclase, intermediate oligoclase, is less altered but contains discrete sericite flakes. Large quartz crystals are in part optically continuous with adjoining micrographic growth. Quartz also contains fine grained sheared appearing inclusion although the quartz is not sheared. One chip has prominent shear linears with reconstitution along shear planes. Small amounts of mildly pleochroic chlorite replace a former femic mineral. Grain size: 3.5+ mm. Texture: Micrographic-hypidiomorphic.

This well penetrated a granite similar to that occurring at Rose Dome and is an example of the Woodson County Granite.

Rose Dome Granite, 13-26S-15E, Woodson County

Wd-Out, surface Zenolith!

MICROGRANITE PORPHYRY..... Quartz, 35.2; perthite, 31.4; plagioclase, 25.3; feldspar alterations, 5.7; biotite-chlorite, 1.1; biotite, 0.7; opaque minerals, 0.6; sphene-leucoxene, tr.; apatite, tr.; zircon, tr.

Phenocrysts of plagioclase, perthite and quartz are set in a hypidiomorphic to xenomorphic groundmass composed mostly of quartz and perthite. Plagioclase is slightly zoned from intermediate to sodic oligoclase in composition and contains extensive alterations of micas, zeolites, and epidote. Perthite is in part well defined microcline and is lightly dusted with alterations and hematite specks. Quartz is essentially unstrained. Biotite is poorly crystalline and altered to fine shreds of chloritic micas. Secondary veins of hematitic chlorite-biotite are common but thin. Sphene-leucoxene replaces some of the opaque minerals. Grain size: Phenocrysts, to 9 mm; groundmass, 0.6-0.8 mm. Texture: Porphyritic, hypidiomorphic to xenomorphic.

This is the sample from the Rose Dome that was dated. There are large textural variations in the outcrop samples and this sample is not necessarily typical. The feldspar was dated by Rb/Sr at 1220 million years. The outcrop samples are related to samples drilled in wells in this area and grouped into the Woodson County Granite.

Missouri

Barry Oil and Gas Co. No. 1 Jenkins, 23-24N-26W, Barry County

Br-1, cuttings, 1848-1869 feet

ALTERED ANDESITE?..... Feldspar; chlorite; opaque minerals; carbonate; sphene-leucoxene; quartz; micas.

Cutting chips appear to be of diverse origin. Several are composed of highly iron stained indeterminate feldspar, chlorite, opaque minerals and sphene-leucoxene. The general relict texture suggests an igneous rock of andesitic composition. The general feldspar configuration is lathlike with intergranular chlorite. Other cutting chips are phyllite, or slate, and an interlocking mosaic of quartz. These may be local shear and silicification modifications of the andesitic (?) rock. Grain size: To 2 mm. Texture: Variable.

Barry Oil and Gas Co. No. 1 Jenkins, 23-24N-26W, Barry County

Br-1, cuttings, 1874 feet

ALTERED GRANITE GNEISS..... Feldspar alterations; microcline; quartz; plagioclase; biotite; calcite; muscovite; opaque minerals.

Relicts of quartz, plagioclase, and microcline are set in a clay-mica rich paste of alterations containing larger biotite and minor muscovite flakes. The general appearance is of broken crystals in the clay-mica. The biotite appears to be relict and is preferentially oriented in part. The matrix micas do not have a preferred orientation. Two cutting chips composed of all feldspar (perthite) with minor alterations. Another cutting chip is granite gneiss without extensive alterations. Grain size: To 4 mm. Texture: Cataclastic.

Barry Oil and Gas Co. No. 1 Jenkins, 23-24N-26W, Barry County

Br-1, cuttings, 1893 feet

ALTERED ANDESITIC? ROCK..... Calcite; chlorite; micas; opaque minerals; sphene-leucoxene; quartz.

This is essentially similar to the interval 1848-1869 feet. Feldspars appear to be completely replaced by alterations with a hematite stain. Chlorite is extensively replaced by calcite. Several chips are slate appearing with good preferred orientation of exceptionally fine micas. One cutting chip is essentially hematite with included "clasts" of

quartz and rock fragments. The suggestion in the chlorite rich chips by relict texture is of an intermediate or possibly basic igneous rock extensively mineralized and altered. Grain size: Microcrystalline. Texture: Variable.

Barry Oil and Gas Co. No. 1 Jenkins, 23-24N-26W, Barry County

Br-1, cuttings, 1913 feet

ALTERED ANDESITIC? ROCK..... Chlorite; opaque minerals; carbonate; quartz; feldspar; micas; sphene-leucoxene.

One chip has possibly the best relict texture of any in this well--it appears to be relict subophitic. The other chips are typical of this well, diverse and not straight forward. Some appear to be argillite or sandy argillites. All chips are reddish with hematite, and some are composed of chlorite-hematite only. Calcite replaces chlorite extensively in some cutting chips. Fine chertose chips with preferentially oriented micas appear to be sheared with relict knots. Grain size: Relicts to 0.6 mm. Texture: Relict subophitic?-crystalloblastic-cataclastic.

These intervals were picked and prepared by the Missouri Geological Survey. The altered andesite? is an interpretation of a rock of uncertain origin. The bulk composition and relict textures are the basis for this interpretation. The granite gneiss from 1874 feet does not fit with any interpretation and in the middle of any sequence so obviously unrelated petrographically challenges explanation. Possibly there is a mechanical explanation, i.e., mixed samples, or a boulder or xenolith carried by the andesite. The rock is interpreted as an andesitic example of the Washington County Volcanic Group.

E. F. Wakefield No. 2 Philbrick, 14-38N-31W, Bates County

Ba-2, cuttings, 1640-1680 feet

GRANITE GNEISS..... Microcline; plagioclase; quartz; biotite; feldspar alterations; epidote; muscovite; chlorite; siderite; calcite; opaque minerals; sphene-leucoxene.

Relicts of plagioclase and microcline are surrounded by a crystalloblastic mosaic of quartz-feldspar containing preferentially oriented biotites and lesser muscovite. Quartz is in aggregates and is strained in part. One microcline crystal appears poikiloblastic containing very abundant included diverse minerals. Epidote is associated with biotite and as discrete crystals. Fine aggregates of clay minerals

replace portions of the fine feldspars. Large muscovite flakes are concentrated near the core of plagioclase relicts. Grain size: Relicts to 2 mm. Texture: Lepidoblastic.

This well penetrated rock interpreted as belonging to "older granite gneiss" and is about a mile north of a similar well (Ba-1).

Rich Hill Oil Co. No. 1 Philbrick, 23-38N-31W, Bates County

Ba-1, cuttings, 1720-1815 feet

GRANITE GNEISS..... Microcline; quartz; plagioclase; biotite; epidote; muscovite; feldspar alterations; opaque minerals; sphene.

Large relicts of plagioclase containing both fine alteration mats and discrete muscovite flakes are generally set in a granular mosaic of smashed and reconstituted quartz-feldspar. In the reconstituted shear linears are myrmekite, biotite, epidote and muscovite. Large quartz has been reduced to an aggregate of smaller crystals with sutured boundaries. The finer aggregates are dimensionally oriented in the plane of shear. Grain size: Relicts greater than 4 mm. Texture: Cataclastic-crystalloblastic.

This is interpreted as an "older granite gneiss" showing more effects of shearing than the metasediments to the south in Vernon County.

Beamer No. 1 Fee, 29-32N-30W, Barton County

Bt-1, cuttings, 1850-1860 feet

GRANITE..... Microcline; quartz; feldspar alterations; opaque minerals.

Relatively few cutting chips of a comparatively coarse rock does not offer a particularly representative view of this rock. No accessory minerals are noted, only microcline and quartz are well formed. There are sericite mats cutting some chips and completely separate fresh minerals in others. Hematite dust causes a turbid appearance to the microcline. Quartz does not appear strained. Grain size: 3+ mm. Texture: Hypidiomorphic?.

Beamer No. 1 Fee, 29-32N-30W, Barton County

Bt-1, cuttings, 1860-1888 feet

GRANITE..... Microcline; plagioclase; quartz; feldspar alterations; biotite; chlorite; opaque minerals; epidote; sphene; fluorite; apatite; zircon.

This is a much more useful thin section than the previous interval. Microcline is fresh and contains only minor alterations. Plagioclase, An_{25}, is mottled with relatively minor alterations in some crystals and is extensively altered in others. Biotite is reddish olive brown and is partly altered to chlorite with the development of granular sphene. Quartz is very mildly strained. Grain size: 5+ mm. Texture: Hypidiomorphic.

This well penetrated rock interpreted as belonging to the Chase County Granite Group.

Barton Co. No. 1 Rodell, 1-30N-33W, Barton County

Bt-2, cuttings, 1635 feet, 1765 feet, 1810 feet

GRANITE?..... Microcline; plagioclase; quartz; feldspar alterations; opaque minerals.

Three thin sections contain a total of six small cutting chips. The rock appears to be granitic in composition. Grain size: ?. Texture: ?.

Tentatively the rock is interpreted as an example of the Chase County Granite Group.

Hickory Oil Co. No. 1 May Wilson, 2-37N-21W, Hickory County

Hk-1, cuttings, 1530-1730 feet

GRANITE..... Microcline, 47.9; plagioclase, 28.8; quartz, 20.4; biotite, 1.9; muscovite, 0.7; apatite, 0.3; opaque minerals, tr.; feldspar alterations, tr.; chlorite, tr.; zircon, tr.; epidote, tr.

Clear microcline is well twinned and contains poikilitically enclosed quartz biotite and plagioclase. Enclosed plagioclase is clouded with alterations while discrete crystals are somewhat fresher though mottled with alterations. Small amounts of intergranular muscovite appear secondary. Biotite is strongly pleochroic olive-green and in part altered to chlorite. There is late material surrounding and separating crystals; this is partly myrmekitic and possibly plagioclase. Grain size: 3.5+ mm. Texture: Hypidiomorphic.

The rock encountered in this well is tentatively interpreted as an "older granite and gneiss."

City of Carthage No. 6 Fee, 3-28N-31W, Jasper County

Js-1, cuttings, 1807-1823 feet

GRANITE..... Microcline; quartz; plagioclase; feldspar alterations; opaque minerals; chlorite; biotite; zircon; sphene-leucoxene; apatite.

Microcline is generally fresh but contains disseminated hematite and minor alterations. The plagioclase is extensively altered and in some crystals is almost completely replaced by a sericite mat. Chlorite is found as a vermicular aggregate of shreds and as well crystallized probable pseudomorphs associated with biotite. Zircon is associated with magnetite and appears slightly metamict. One cutting chip is finer grained but mineralogically identical to other chips. Grain size: Less than 3.7 mm. Texture: Hypidiomorphic.

The two feldspar character and presence of clear microcline suggests this rock is equivalent to the 1400 m.y. granite in Vernon County (Ve-1) and is thus an example of the Chase County Granite Group.

Atlas Powder Co. No. 4 Fee, 36-28N-32W, Jasper County

Js-2, cuttings, 1735-1747 feet

GRANITE..... Perthite; quartz; feldspar alterations; opaque minerals; chlorite-biotite; carbonate; sphene-leucoxene; plagioclase.

Microcline perthite has ill defined grid twinning and is uniformly clouded with disseminated alterations and hematite dust. Small clots of complete alteration clay-mica replace patches of the feldspar. Quartz is large and essentially unstrained. Secondary chlorite-biotite appear as small pseudomorphs as well as secondary veinlets. Small fresh biotite flakes are included in quartz as are small muscovites. No plagioclase was identified except for a small inclusion in quartz. Grain size: 4+ mm. Texture: Hypidiomorphic?.

The presence of perthite and very minor free plagioclase allies this rock petrographically to the Woodson County Granite and is the most easterly occurrence of this rock type.

Younts et al. No. 1 Chrisco, 10-21N-34W, McDonald County

Mn-1-1, cuttings, 1490-1500 feet

MICROGRAPHIC GRANITE PORPHYRY..... Micrographic quartz-feldspar; plagioclase; perthite; feldspar alterations; opaque minerals; epidote; amphibole; chlorite; apatite; sphene.

Phenocrysts of perthite and plagioclase are set in a delicately micrographic quartz-perthite groundmass. Perthite is uniformly dusted with extensive hematite and clouding alterations, while the plagioclase is more altered, contains less hematite and much recognizable sericite. Hornblende with minor chlorite and some associated epidote. Sphene is crystalline, pale reddish in color, and as granular aggregates associated with opaque minerals. Grain size: Less than 1.7 mm. Texture: Porphyritic-micrographic.

This well penetrated rock of the Spavinaw Granite Group. It is the most easterly encounter of this group.

City of Sedalia No. 11, 22-45N-21W, Pettis County

Pt-1, cuttings, 1515-1520 feet

MUSCOVITE-QUARTZ GNEISS..... Quartz; muscovite; biotite; opaque minerals; sphene-leucoxene; sillimanite?; rutile?; zircon.

The majority of the rock is quartz-muscovite in coarsely crystalline chips suggesting a banded gneiss. Quartz contains sillimanite? and rutile? needles. Sillimanite violates the phase rule with muscovite and excess water but they are never in contact. Zircons are rounded and discrete. Biotite is comparatively sparse and reddish brown in color. Quartz is mildly strained. Muscovite appears to have a good preferential orientation. Grain size: To 2 mm. Texture: Granoblastic-lepidoblastic.

A rock interpreted as an "older granitic gneiss" but the origin of this rock is not necessarily a granite in origin. The degree of metamorphism and shearing is roughly equivalent to that found among the "older granite and gneiss."

Springfield and Bolivar Oil and Gas No. 1 Karlan, 25-33N-23W, Polk County

Pk-1, cuttings, 1750 feet

GRANITE..... Microcline; quartz; plagioclase; biotite; feldspar alteration; opaque minerals; sphene-leucoxene.

Small cutting chips of an apparently coarse granite make textural determination difficult. Most boundaries are characteristically mortar type suggesting a later event. The biotite appears very late or even secondary. Microcline is generally fresh while plagioclase, near An_{20}, is mottled with extensive alterations. Quartz is partly strained. Grain size: 2.2+ mm. Texture: Hypidiomorphic-cataclastic.

The straining of quartz and other cataclastic features suggest this is an "older granite and gneiss" into which the Chase County granites were introduced.

St. Joseph Lead Co. core hole, 6-34N-29W, Vernon County

Ve-1-1, core,

BIOTITE GRANITE..... Quartz, 28.8; microcline perthite, 28.5; plagioclase, 26.5; biotite, 9.3; feldspar alterations, 2.5; hornblende, 1.8; opaque minerals, 0.8; chlorite, 0.8; fluorite, 0.3; apatite, 0.2; carbonate, 0.2; zircon, tr.; sphene, tr.

Plagioclase is of variable composition between intermediate to calcic oligoclase. Alterations are erratic in plagioclase but are locally extensive to sericite and epidote with some carbonate replacement. Microcline is generally fresh containing only minor alterations. Patch perthite is common. Clots of biotite and hornblende are exceptionally well developed and are associated with other accessory minerals. Apatite, zircon and sphene are particularly abundant. Only small amounts of chlorite are present, some as vermicular masses and as pseudomorphs. Grain size: 6 mm. Texture: Hypidiomorphic.

Both biotite (1330 m.y.) and whole rock (1370 m.y.) were dated in this sample. The petrographic similarity to the Chase County Granite Group and the positive isotopic age correlation make this the most easterly positive encounter of this group.

Nevada Oil and Gas No. 1 Henshaw, 31-37N-32W, Vernon County

Ve-2, cuttings, 1118 feet

ARKOSIC QUARTZITE..... Quartz; microcline; plagioclase; rock fragments; opaque minerals; pyrite; chlorite.

Quartz, feldspar and rock fragments are cemented by a finely sericitic mica matrix. The quartz fragments are generally strained but some have straight extinction; a lack of orientation of straining suggests the straining is inherited. Several stained quartzes have overgrowths, also strained and

these are possibly inherited as well. One quartz is strained through 100° in sweeping extinction that a higher power is shown to be aggregates now of sheared quartz. Microcline and plagioclase are generally fresh. Rock fragments include micrographic granite, rhyolite?, sericite masses, chert, quartzite. Sericite fragments are rounded and composed of microcrystalline sericite shreds, some appear to have good preferred orientation but this is not uniform within a cutting chip and is not oriented among themselves indicating the preferential orientation is inherited. Grain size: To 0.7 mm; 0.4 mm average. Texture: Clastic-crystalloblastic.

Nevada Oil and Gas No. 1 Henshaw, 31-37N-32W, Vernon County

Ve-2, cuttings, 1906 feet

FELDSPATHIC QUARTZITE AND SANDY ARGILLITE..... Quartz; plagioclase; rock fragments; microcline; pericite; opaque minerals.

Two slides of one large chip each are cut from this interval--one is essentially similar to the previous interval, the other is a sandy argillite. Differences are: lesser microcline, more rock fragments, and finer size fraction. Quartz are partly strained but the intense straining is not present. Rhyolite? fragments appear to be common and are slightly metamorphosed. In the argillaceous chip highly angular crystal and lithic sand clasts float in a sericitic matrix. Grain size: Microcrystalline to 0.38 mm. Texture: Clastic-crystalloblastic.

In the same section as the Stubblefield well (Ve-3), there are numerous petrographic similarities. Skillman (1948) originally described this well and its relationship to the Stubblefield well. It is an example of the Vernon Metamorphic Group.

A. W. Waymire No. 1 Stubblefield, 31-37N-32W, Vernon County

Ve-3, cuttings

The following is a resumé of some fifty thin sections from this well collected by the Missouri Geological Survey. Most of the slides are of poor quality containing very few or only one cutting chip per slide. The well was first described by Skillman (1948) and some of those petrographic identifications are significantly different from my interpretation.

<u>1420 feet</u> - one chip,an argillite containing a few fine sand

size quartz fragments. Fine micaceous material with iron stain and opaques make up 95+% of the chip.
1430 feet - two chips of feldspathic quartzite containing mostly quartz, some highly strained, with lesser feldspar (perthite, microcline, and plagioclase) and fragments,now fine micaceous material,possibly an argillite.
1465 feet - three chips, two are exceptionally small, of feldspathic quartzite essentially similar to the previous interval but containing a small amount of chloritic micas and some larger muscovite probably detrital.
1495 feet - two chips of metagraywacke contain quartz and feldspar fragments with minor rock detritus set in a micaceous matrix. The mica appears to be reconstituted but has no preferred orientation. Magnetite is in small euhedral crystals. All detritus appears to be granitic in composition.
1515 feet - one chip of argillite composed of dominantly fine micaceous material with no preferred orientation, containing a few small detritus of quartz. Muscovite of superior size are noted in the fine mica paste and these may be porphoblasts but are more likely detrital.
1521 feet - one cutting chip of argillaceous feldspathic quartzite is composed of various feldspars mostly with uniform alterations and quartz detritus together with micaceous material. A few lithic fragments are present and appear to be metamorphic in origin--one possibly a metarhyolite.
1621 feet - one chip of sandy argillite containing fine quartz detritus set in a micaceous matrix. It appears that biotite is beginning to form in the matrix along with the muscovite. Abundant larger magnetite and sphene-leucoxene are present as masses in the matrix.
1715 feet - one chip of sandy argillite essentially similar to the previous slide.
1745 feet - one chip of feldspathic quartzite containing some exceptionally strained quartz detritus. Feldspars are diverse and most lithic detritus is metamorphic--some possibly rhyolitic in origin. Crystalloblastic chlorite and fine muscovite are found in an intergranular position.
1770 feet - three small fragments are of feldspathic quartzite containing in addition to that in the previous interval, argillaceous detrital grains.
1790 feet - several tiny fragments are apparently from an argillaceous quartzite or metagraywacke.
1835 feet - one chip of argillite containing a multiple quartz grain and a few other sand or silt size particles set in a micaceous paste.
1845 feet - one small chip of feldspathic quartzite apparently similar to previous intervals.
1920 feet - two small chips of metagraywacke composed of

diverse rock and mineral detritus set in a mica paste matrix. A moderate amount of carbonate has replaced some portion of the rock.

1935 feet - three small chips of metagraywacke containing more micaceous paste matrix than the previous interval but otherwise apparently similar.

1965 feet - several cutting chips of metagraywacke are composed of generally finer sand size particles set in a siliceous-micaceous matrix. Much chloritic material is in masses and is reminiscent of glauconite pellets in part. Small detritus makes determination of lithic fragments difficult but metamorphic. Large micas are in the matrix but are possibly detrital.

1975 feet - several chips of metagraywacke are essentially similar to the previous interval. Detritus is somewhat coarser and is mostly quartz, some extensively strained. Muscovite, metaargillite pellets, feldspars, sphene-leucoxene and lithic fragments are also present set in a reconstituted micaceous matrix. Chloritic masses are reminiscent of glauconite pellets and are strongly colored but weakly birefringent. One chip is composed of epidote-quartz and is probably a vein of this composition.

1980 feet - a variety of cutting chips are basically similar to previous intervals but are diverse in grain size and percent of micaceous matrix suggesting that this is a thin-bedded sequence of argillite-graywacke-quartzite.

1985 feet - one chip composed of a fine graywacke contains diverse mineral grains set in a micaceous matrix. Bands of darker color may be shears but evidence is not firm.

2025 feet - Several good size cutting chips of feldspathic quartzite containing sand size particles averaging about 1 mm in diameter. Most fragments are highly strained quartz but micaceous pellets, various feldspars, and lithic detritus are also present. Some chips are argillaceous and one has a layer where detrital micas are abundant and preferentially oriented. Chloritic micas in fine shreds and opaque minerals are found in an intergranular position.

2035 feet - one cutting chip of fine-grained metagraywacke contains a secondary chlorite veinlet.

2085 feet - one cutting chip of feldspathic quartzite contains chloritic micas that appear more olive-green, as opposed to previous apple-green, in color and I have the feeling that they are very near biotite in composition but never quite made the grade.

2130 feet - two tiny cutting chips are composed of sand particles surrounded and separated by magnetite. Quartz and metamorphic rock fragments appear to be the most common detritus.

2210 feet - two chips are composed of feldspar with minor

chlorite, opaque minerals, muscovite, zircon and sphene-leucoxene. The feldspars are moderately altered. Both plagioclase and perthite are present. The rock is interpreted as a syenite.

2215 feet - three small chips of feldspar of irregular grain size. Some of the material intergranular to the large crystals are very fine grained. The feldspars are generally uniformly clouded with dusty inclusions of hematite and minor alterations. The rock is identified as a syenite.

2221-2331 feet - eight thin sections each containing one core type chip are represented in this interval. This is the result of shooting the bottom 100 feet of the well referred to by Skillman (1948, p. 5). Of the eight sections three are sedimentary in origin and five are igneous. The textural variation of the syenite is great, some are porphyritic chilled types, others are hypidiomorphic. The sediments are feldspathic quartzites and metagraywackes containing detritus of single strained quartz as large as 3.6 mm in length. Extensive straining and some granulation with minor crystalloblastic chlorite is common. Micaceous pellets and intergranular material are locally coarse. Minor lithic detritus is metamorphic in origin. Other chips are much finer metagraywackes with mineral clasts set in a micaceous matrix. Some extensive shearing is noted. Another cutting chip appears silicified with straight smooth boundaries on large unstrained quartz enclosing some micaceous material, some apparently relicts.

The syenite and textural variations are composed of albite (Ab_{2-6}) and perthite with relatively minor chlorite, opaque minerals, calcite, sphene-leucoxene, and zircon. No quartz was positively identified. Muscovite in radiant fibrous bundles is well developed as intergranular material. The percent of chlorite and muscovite are variable and one chip is composed almost completely of feldspar. Note that this rock interpreted here as a syenite was reported as the J shale that had been albitized and mineralized.

2235 feet - one small cutting chip appears to be a chilled syenite? containing abundant fine chlorite and sphene-leucoxene.

2245 feet - one cutting chip is essentially similar to previous interval.

2275 feet - one cutting chip on each of two slides is apparently a chilled syenite.

2295 feet - three tiny cuttings are composed of chilled syenite. Another slide from the same interval is composed of epidote probably a vein or segregation in the host rock.

2300 feet - two small chips of syenite are basically similar to some of the "core chip" samples.

2310 feet - two slides containing a total of four fragments

composed of syenite.

A thick section of clastic rocks metamorphosed to low rank metagraywackes and argillites. The sediments are generally immature and poorly sorted. The lowest intervals appear to be syenites rather than the albitized slates interpreted by Skillman. The only other syenites in the area studied are in Rogers County, Oklahoma (Rog-3). This well forms the chief basis for the formation of the Vernon County Metamorphic Group.

Arkansas

Ozark Produce Company No. 1 Curry, 33-18N-33W, Benton County

Bn-1-1, cuttings, 2210-2222 feet

RHYOLITE PORPHYRY..... Groundmass; plagioclase (An_{16}); perthite; quartz; opaque minerals; chlorite; feldspar alterations; epidote; apatite; zircon.

The groundmass appears to be exceptionally quartz rich intergrown with feldspar. Local coarsenings accompany quartz-rich portions. Perthite and plagioclase phenocrysts are partly altered. A perthite rim surrounds some of the plagioclase which is not otherwise zoned. Hematite dust is more abundant in perthite. Chlorite is mostly disseminated in the groundmass as weakly birefringent masses of shreds. Grain size: Phenocrysts, 2.0+ mm; groundmass, 0.05 mm average. Texture: Porphyritic-felted.

Not as clear-cut an example as might be hoped for in this extension of the Washington County Volcanic Group; the rock appears to be most closely related to this group.

Independent Oil and Gas No. 1 Banks, 6-16N-27W, Madison County

Md-1-1, cuttings, 2500-2504 feet

RHYOLITE PORPHYRY..... Groundmass; plagioclase (An_{11}); perthite; chlorite; opaque minerals; feldspar alterations; sphene-leucoxene; epidote; apatite.

Phenocrysts of altered plagioclase and sparse perthite are set in a quartz-feldspar groundmass. The texture of the groundmass is not well defined--parts appear to have optically oriented rodlike quartz. Feldspars are altered and contain hematite dust. Plagioclase contains sericite flakes and epidote granules. Chlorite masses replace portions of some feldspar phenocrysts and is in the groundmass as probable pseudomorphs after a femic mineral and disseminated shreds. The opaque granules are partly surrounded by sphene-leucoxene. Grain size: Phenocrysts, 2+ mm; groundmass, 0.02 mm average. Texture: Porphyritic-felted.

Interpreted as an example of the Washington County Volcanic Group. This rhyolite is somewhat coarser than the normal volcanic rock in this group.

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VITA

Rodger Espy Denison was born in Fort Worth, Texas, on November 11, 1932. He graduated from high school from Wentworth Military Academy in Lexington, Missouri, in 1950. He received a B.S. in geology from the University of Oklahoma in 1954. From 1955 to 1957 he was stationed in Korea with the U.S. Army, attaining the exalted rank of First Lieutenant of infantry. In 1957 he returned to the University of Oklahoma and was awarded a M.S. in 1959. In December of 1957 he married Caroline Holmes. They have two daughters. From 1958 to 1962 he worked for the Oklahoma Geological Survey with a year out in 1960-61 to attend the University of California at Berkeley. In 1962 he entered The University of Texas working toward a Ph.D. in geology. Since the fall of 1964 he has worked for the Socony Mobil Field Research Laboratory, Dallas, Texas, as a petrographer-geochronologist.

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plate 1

BASEMENT ROCKS IN ADJOINING PARTS OF OKLAHOMA, KANSAS, MISSOURI, AND ARKANSAS

by
RODGER E. DENISON

EXPLANATION

Basement rocks are overlain by sediments of Cambro-Ordovician age except in areas of late Paleozoic uplift and erosion.

unconformity

OGG — Central Oklahoma Granite Group

(Medium to coarsely crystalline granites containing both microcline and plagioclase. Biotite is the typical femic mineral but hornblende is locally abundant. Locally sheared and intruded by diabase.)

VCM — Vernon County Metamorphic Group

(Chiefly low-rank pelitic to quartzo-feldspathic metasediments but including metabasic rocks in Butler County. The rocks in Vernon and Bourbon Counties are incompletely metamorphosed, while those in Butler and Sedgwick Counties are completely converted to lower and middle greenschist facies assemblages. Locally intruded by Central Oklahoma Granite.)

Northeast Oklahoma Province

WCV — Washington County Volcanic Group

(Chiefly porphyritic rhyolite and welded tuff carrying phenocrysts of perthite, plagioclase, and quartz. Andesite and andesite tuff are locally abundant. The rhyolite is converted to metarhyolite (altered pattern), particularly near the contact with the Central Oklahoma Granite Group.)

SG — Spavinaw Granite Group

(Micrographic granite porphyry having femic-rich and femic-poor phases, containing plagioclase and perthite. Augite is the only primary femic mineral present and is mostly chloritized. The granite crops out in Mayes County, Oklahoma.)

OCM — Osage County Microgranite

(Micrographic porphyry containing phenocrysts of perthite and lesser quartz. Free plagioclase is typically lacking. The groundmass is characterized by rod-like acicular quartz intergrown with perthite.)

WCG — Woodson County Granite

(Perthite granite characterized by irregular texture. The granite in the subsurface is identical to granite occurring as boulders on the surface at Rose Dome in Woodson County, Kansas.)

unconformity

CCG — Chase County Granite Group

(Medium to coarse grained microcline-bearing granite, gneissic granite, and minor granite gneiss. Metamorphic effects are indicent to marked.)

LCQ — Lyon County Quartzite

(Muscovitic quartzite)

OGG — "Older Granite and Gneiss"

(Varied granite and gneiss)

1200 MILLION YEARS

1400 M.Y.

> 1400 M.Y.

Inferred contact

Speculative contact

Inferred basement fault hachures on downthrown side

• BT-32 — *Control well from which basement rock samples were examined. See Table for county code number.*

1190 Rb/Sr age in millions of years
1330 K/Ar age in millions of years
B Biotite
F Feldspar
W Whole rock

SCALE
0 10 20 30 40 50
MILES

INDEX MAP

KANSAS MISSOURI OKLAHOMA ARKANSAS

HYPOTHETICAL BASEMENT ROCK CROSS SECTION A–A'

NORTH — Sea Level — -5000' — -10,000'

KANSAS | OKLAHOMA

SHAPE OF THIS GRANITE MASS IS SCHEMATIC

Upper Cambrian and younger sediments

CHARACTER OF BASEMENT BENEATH SPAVINAW GRANITE UNKNOWN

NATURE OF BASEMENT SURFACE UNKNOWN
NUMEROUS SURFACE FAULTS PROBABLY CUT THE BASEMENT

A' SOUTH — Sea Level — -5000' — -10,000'

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